Basic concepts of myofascial trigger points (TrPs)

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CHAPTER CONTENT

Myofascial trigger point (TrP) overview

Myofascial trigger points (TrPs) are one of the most overlooked and ignored causes of acute and chronic pain (Hendler & Kozikowski 1993), and at the same time, constitute one of the most common musculoskeletal pain conditions (Hidalgo-Lozano et al. 2010, Bron et al. 2011a). There is overwhelming evidence that muscle pain is commonly a primary dysfunction (Mense 2010a) and not necessarily secondary to other diagnoses. Muscles feature many types of nociceptors, which can be activated by a variety of mechanical and chemical means (Mense 2009). As a primary problem, TrPs may occur in absence of other medical issues; however, TrPs can also be associated with underlying medical conditions, e.g. systemic diseases, or certain metabolic, parasitic, and nutritional disorders. As a co-morbid condition, TrPs can be associated with other conditions such as osteoarthritis of the shoulder, hip or knee (Bajaj et al. 2001) and also injuries such as whiplash (Freeman et al. 2009). Pain elicited by muscle TrPs constitutes a separate and independent cause of acute and especially chronic pain that may compound the symptoms of other conditions and persist long after the original initiating condition has been resolved. TrPs are also associated with visceral conditions and dysfunctions, including endometriosis, interstitial cystitis, irritable bowel syndrome, dysmenorrhea and prostatitis (Weiss 2001, Anderson 2002, Doggweiler-Wiygul 2004, Jarrell 2004). The presence of abdominal TrPs was 90% predictive of endometriosis (Jarrell 2004).

Throughout history TrPs have been referred to by different names (Simons 1975). The current TrP terminology has evolved during the past several decades (Simons et al. 1999, Dommerholt et al. 2006,

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Dommerholt & Shah 2010). Although different definitions of TrPs are used among different disciplines, the most commonly accepted definition maintains that 'a TrP is a hyperirritable spot in a taut band of a skeletal muscle that is painful on compression, stretch, overload or contraction of the tissue which usually responds with a referred pain that is perceived distant from the spot' (Simons et al. 1999).

From a clinical viewpoint, we can distinguish active and latent TrPs. The local and referred pain from active TrPs reproduces the symptoms reported by patients and is recognized by patients as their usual or familiar pain (Simons et al. 1999). Both active and latent TrPs cause allodynia at the TrP and hyperalgesia away from the TrP following applied pressure. Allodynia is pain due to a stimulus that does not normally provoke pain. In latent muscle TrPs, the local and referred pain do not reproduce any symptoms familiar or usual to the patient (Simons et al. 1999). Active and latent TrPs have similar physical findings. The difference is that latent TrPs do not reproduce any spontaneous symptom. In patients with lateral epicondylalgia, active TrPs commonly reproduce the symptoms within the affected arm (Fernández-Carnero et al. 2007), but patients may also present with latent TrPs on the non-affected side without experiencing any symptoms on that side (Fernández-Carnero et al. 2008).

Although latent TrPs are not spontaneously painful, they provide nociceptive input into the dorsal horn (Ge et al. 2008, 2009, Li et al. 2009, Wang et al. 2010, Xu et al. 2010, Zhang et al. 2010, Ge & Arendt-Nielsen 2011). The underlying mechanism is not clear at this point in time and requires more research. Certain regions within a muscle may only be connected via ineffective synapses to dorsal horn neurons and referred pain may occur when these ineffective synapses are sensitized (Mense 2010b). Latent TrPs can easily turn into active TrPs, which is at least partially dependent on the degree of sensitization and increased synaptic efficacy in the dorsal horn. For example, the pain pressure threshold of latent TrPs in the forearm muscles decreased significantly after only 20 minutes of continuous piano playing (Chen et al. 2000). Active TrPs induce larger referred pain areas and higher pain intensities than latent TrPs (Hong et al. 1997). Active TrPs and their overlying cutaneous and subcutaneous tissues are usually more sensitive to pressure and electrical stimulation than latent TrPs (Vecchiet et al. 1990 1994).

Both active and latent TrPs can provoke motor dysfunctions, e.g. muscle weakness, inhibition, increased motor irritability, spasm, muscle imbalance, and altered motor recruitment (Lucas et al. 2004, 2010) in either the affected muscle or in functionally related muscles (Simons et al. 1999). Lucas et al. (2010) demonstrated that latent TrPs were associated with impaired motor activation pattern and that the elimination of these latent TrPs induces normalization of the impaired motor activation pattern. In another study, restrictions in ankle range of motion were corrected after manual release of latent TrPs in the soleus muscle (Grieve et al. 2011).

Neurophysiological basis of muscle referred pain

Referred pain is a phenomenon that has been described for more than a century and has been used extensively as a diagnostic tool in the clinical setting. Typically, pain from deep structures such as muscles, joints, ligaments, tendons, and viscera is described as deep, diffuse, and difficult to locate accurately in contrast to superficial types of pain, such as pain originating in the skin (Mense 1994). Pain located at the source of pain is termed *local pain or primary pain*, whereas pain felt in a different region away from the source of pain is termed *referred pain* (Ballantyne et al. 2010). Referred pain can be perceived in any region of the body, but the size of the referred pain area is variable and can be influenced by pain-induced changes in central somatosensory maps (Kellgren 1938, Gandevia & Phegan 1999). Referred pain is a very common phenomenon in clinical practice; most patients with chronic pain present with what is commonly described as 'a summation of referred pain from several different structures.' Understanding at least the basic neurophysiological mechanisms of muscle referred pain is required to make a proper diagnosis of myofascial pain and to manage patients with TrPs.

Clinical characteristics of muscle referred pain (Arendt-Nielsen & Ge 2009, Fernández-de-las-Peñas et al. 2011)

1. The duration of referred pain could last for as short as a few seconds or as long as a few hours, days, or weeks, or occasionally indefinitely.

2. Muscle referred pain is described as deep, diffuse, burning, tightening, or pressing pain, which is completely different from neuropathic or cutaneous pain.
3. Referred pain from muscle tissues may have a similar topographical distribution as referred pain from joints.
4. The referred pain can spread cranial/caudal or ventral/dorsal.
5. The intensity of muscle referred pain and the size of the referred pain area are positively correlated to the degree of irritability of the central nervous system or sensitization.
6. Referred pain frequently follows the distribution of sclerotomes, but not of dermatomes.
7. Muscle referred pain may be accompanied by other symptoms, such as numbness, coldness, stiffness, weakness, fatigue, or musculoskeletal motor dysfunction. The term referred pain is perhaps not complete and a preferred term can be 'referred sensation' as non-painful sensations such as burning or tingling would still be considered referred phenomena from TrPs.

Mechanisms and neurophysiological models of referred pain (Arendt-Nielsen & Ge 2009)

> *Muscle referred pain is a process of central sensitization which is mediated by a peripheral activity and sensitization, and which can be facilitated by sympathetic activity and dysfunctional descending inhibition*
>
> Arendt-Nielsen & Ge 2009

The exact neuropathways mediating referred pain are not completely understood. Several neuro-anatomical and neurophysiological theories regarding the appearance of referred pain have been suggested. All models agree that nociceptive dorsal horn or brainstem neurons receive convergent inputs from different tissues. Consequently, higher brain centers cannot identify the input source properly. Most recent models have included newer theories in which sensitization of dorsal horn and brainstem neurons also play a relevant and central role. We briefly summarize the most common theories below.

Convergent-projection theory

Ruch (1961) proposed that afferent fibers from different tissues, such as skin, viscera, muscles, and joints, converge onto common spinal neurons, which can lead to a misinterpretation of the source of nociceptive activity from the spinal cord. The source of pain of one tissue can be misinterpreted as originating from other structures. The convergent-projection theory would explain the segmental nature of muscle referred pain and the increased referred pain intensity when local pain is intensified. This theory does, however, not explain the delay in the development of referred pain following the onset of local pain (Graven-Nielsen et al. 1997a).

Convergence-facilitation theory

The somatosensory sensitivity changes reported in referred pain areas could, in part, be explained by sensitization mechanisms in the dorsal horn and brainstem neurons, whereas the delay in appearance of referred pain could be explained since the creation of central sensitization needs time (Graven-Nielsen et al. 1997a).

Axon-reflex theory

Bifurcation of afferents from different tissues was suggested as an explanation of referred pain (Sinclair et al. 1948). Although bifurcation of nociceptive afferents from different tissues exits, it is generally agreed that these pathways are unlikely to occur (McMahon 1994). The axon-reflex theory cannot explain the delay in the appearance of the referred pain, the different thresholds required for eliciting local pain vs referred pain, and the somatosensory sensitivity changes within the referred pain areas.

Thalamic-convergence theory

Theobald (1949) suggested that referred pain may appear as a summation of input from the injured area and from the referred pain area within neurons in the brain, but not in the spinal cord. Several decades later, Apkarian et al. (1995) described several pathways converging on different sub-cortical and cortical neurons. There is evidence of pain reduction following anesthetization of the referred pain area, which suggests that peripheral processes contribute to referred pain, although central processes are assumed to be the most predominant.

Central hyper-excitability theory

Recordings from dorsal horn neurons in animal models have revealed that new receptive fields at a distance from the original receptive field emerged within minutes after noxious stimuli (Hoheisel et al. 1993). That is, following nociceptive input, dorsal horn neurons that were previously responsive to only one area within a muscle began to respond to nociception from areas that previously did not trigger a response. The appearance of new receptive fields could indicate that latent convergent afferents on the dorsal horn neuron are opened by noxious stimuli from muscle tissues (Mense 1994), and that this facilitation of latent convergence connections induces the referred pain.

The central hyper-excitability theory is consistent with most of the characteristics of muscle referred pain. There is a dependency on the stimulus and a delay in appearance of referred pain as compared with local pain. The development of referred pain in healthy subjects is generally distal and not proximal to the site of induced pain (Arendt-Nielsen et al. 2000). Nevertheless, several clinical studies have demonstrated proximal and distal referred pain in patients with chronic pain (Graven-Nielsen 2006). The differences between healthy individuals and persons with chronic pain may indicate that the pre-existing pain could induce a state of hyper-excitability in the spinal cord or brainstem resulting in proximal and distal referred pains.

Neurophysiological aspects of muscle/TrPs

The nature of TrPs

Taut bands

TrPs are located within discrete bands of contractured muscle fibers called *taut bands*. Taut bands can be palpated with a flat or pincer palpation and feel like tense strings within the belly of the muscle. It is important to clarify that contractures are not the same as muscle spasms. Muscle spasms require electrogenic activity, meaning that the α-motor neuron and the neuromuscular endplate are active. A muscle spasm is a pathological involuntary electrogenic contraction (Simons & Mense 1998). In contrast, a taut band signifies a *contracture* arising endogenously within a certain number of muscle fibers independent of electromyogenic activity, which does not involve the entire muscle (Simons & Mense 1998).

In 1997, Gerwin and Duranleau first described the visualization of taut bands using sonography, but until recently it was not yet possible to visualize the actual TrP (Lewis & Tehan, 1999) mostly due to technological limitations (Park & Kwon 2011). With the advancement of technology, more recent studies have found that TrP taut bands can be visualized using sonographic and magnetic resonance elastography (Chen et al. 2007, 2008, Sikdar et al. 2009, Rha et al. 2011). Chen et al. (2007) demonstrated that the stiffness of the taut bands in patients with TrPs is higher than that of the surrounding muscle tissue in the same subject and in people without TrPs. Sikdar et al. (2009) showed that vibration amplitudes assessed with spectral Doppler were 27% lower on average within the TrP region compared with surrounding tissue. They also found reduced vibration amplitude within the hypoechoeic region identified as a TrP. In summary, TrP taut bands are detectable and quantifiable, providing potentially useful tools for TrP diagnosis and future research.

Although TrPs and taut bands can now be visualized, the mechanism for the formation of muscle taut band is still not fully understood. The probable mechanisms of taut band formation have been summarized by Gerwin (2008). The current thinking is that the development of the taut band and subsequent pain is related to local muscle overload or overuse when the muscle cannot respond adequately, particularly following unusual or excessive eccentric or concentric loading (Gerwin et al. 2004, Gerwin 2008, Mense & Gerwin 2010). Muscle failure and TrP formation are also common with sub-maximal muscle contractions as seen for example in the upper trapezius muscles of computer operators (Treaster et al. 2006, Hoyle et al. 2011) or in the forearm muscles of pianists (Chen 2000). The failure of the muscle to respond to a particular acute or recurrent overload may be the result of a local energy crisis. Muscle activation in response to a demand is always dispersed throughout the muscle among fibers that are the first to be contracted and the last to relax. These fibers are the most vulnerable to muscle overload. Unusual or excessive eccentric loading may cause local muscle injury. In sub-maximal contractions, the Cinderella Hypothesis and Henneman's size principle apply (Kadefors et al. 1999, Chen et al. 2000, Hägg, 2003, Zennaro et al. 2003, Treaster et al. 2006, Hoyle et al. 2011). Smaller motor units are recruited first and de-recruited last without any substitution of motor units. This would lead to local biochemical changes without muscle breakdown, especially in those parts of the muscle that are not substituted and therefore most heavily worked (Gerwin 2008).

Under normal circumstances, acetylcholine (ACh) is released in a quantal fashion, which is a calcium-dependent process (Wessler 1996). ACh stimulates specific membrane-bound protein molecules, such as nicotinic ACh receptors (nAChR), which leads to miniature endplate potentials (MEPP). A summation of MEPPs causes a depolarization of the muscle membrane, an action potential, stimulation of ryanodine and dihydropyridine receptors in the T-tubuli, activation of the sarcoplasmic reticulum, a release of calcium, and eventually a muscle contraction. The nAChRs are temporarily inhibited following stimulation by ACh (Magleby & Pallotta 1981).

With myofascial pain, an excessive non-quantal release of ACh is released from the motor endplate at the neuromuscular junction. Acetylcholinesterase (ACh-esterase) is inhibited, while nAChRs are up-regulated. These and several other factors are thought to cause the localized muscle fiber contractures in the immediate vicinity of the involved motor endplates. It is conceivable that the limited non-quantal release of ACh is sufficient to trigger contracture without inhibiting the nicotinic ACh, dihydropyridine and ryanodine receptors, which would provide a mechanism for sustained contractures (Dommerholt 2011).

The potential role of calcitonin gene-related peptide (CGRP) in myofascial pain and other pain conditions, such as migraines, cannot be underestimated. CGRP is found in higher concentrations in the immediate environment of active TrP (Shah et al., 2008). It is a potent microvasular vasodilator involved in wound healing, prevention of ischemia, and several autonomic and immune functions (Smillie & Brain 2011). CGRP and its receptors are widely expressed in the central and peripheral nervous system. For example, CGRP Type I is produced in the cell body of motor neurons in the ventral horn of the spinal cord and is excreted via an axoplasmatic transport mechanism. CGRP is also released from the trigeminal ganglion and from trigeminal nerves within the dura and as such contributes to peripheral sensitization (Durham & Vause, 2010). It also stimulates the phosphorylation of ACh receptors, which prolongs their sensitivity to ACh (Hodges-Savola & Fernandez 1995). In addition, CGRP promotes the release of ACh and inhibits ACh-esterase.

Interestingly, myofascial tension, as seen with TrPs, may also stimulate an excessive release of ACh, which suggests the presence of a self-sustaining vicious cycle (Chen & Grinnell 1997, Grinnel et al. 2003). Experimental research of rodents demonstrated that excessive ACh in the synaptic cleft leads to morphological changes resembling TrP contractures (Mense et al. 2003). Consuming excessive amounts of coffee in combination with alcohol triggers a similar response pattern, which has been attributed to the ability of caffeine to release calcium ions from the sarcoplasmic reticulum (Oba et al. 1997a, 1997b, Shabala et al. 2008).

There is some evidence that TrPs are also associated with increased autonomic activity (Ge et al., 2006), which is likely to be due to activation of adrenergic receptors at the motor endplate (Gerwin et al. 2004). Stimulation of these adrenergic receptors triggered an increased release of ACh in mice (Bowman et al. 1988). Nociceptive stimuli of latent TrPs can lead to autonomic changes such as vasoconstriction (Kimura et al. 2009). The local or systemic administration of the alpha-adrenergic antagonist phentolamine to TrPs caused an immediate reduction in electrical activity, suggesting that TrPs indeed have an autonomic component (Hubbard & Berkoff 1993, Lewis et al. 1994, McNulty et al. 1994, Banks et al. 1998). Such increased autonomic activity may facilitate an increased concentration of intracellular ionized calcium and be responsible again for a vicious cycle maintaining TrPs (Gerwin et al. 2004, Gerwin 2008). Muscle spindle afferents may also contribute to the formation of TrP taut bands via afferent signals to extrafusal motor units through H-reflex pathways (Ge et al. 2009), but are not considered to be the primary cause of TrP formation.

Local twitch response

Manual strumming or needling of a TrP usually result in a so-called local twitch response (LTR), which is a sudden contraction of muscle fibers in a taut band (Hong & Simons 1998). LTRs can be observed visually, can be recorded electromyographically, or can be visualized with diagnostic ultrasound (Gerwin & Duranleau 1997, Rha et al. 2011). The number of LTRs may be related to the irritability of the muscle TrP (Hong et al. 1997), which in turn appears to be correlated with the degree of sensitization of muscle nociceptors by bradykinin, serotonin, and prostaglandin, among others. Hong and Torigoe (1994) reported that, in an animal model, LTRs could be elicited by needling of hypersensitive trigger spots, which are the equivalent of TrPs in humans. LTRs were observed in only a few of the control sites. In addition, LTRs could not be elicited after transection of the innervating nerve. LTRs are spinal cord reflexes elicited by stimulating the sensitive site in the TrP region (Hong et al. 1995). Audette et al. (2004) reported that dry needling of active TrPs in the trapezius and levator scapulae muscles elicited bilateral LTRs in 61.5% of the muscles, whereas dry needling of latent TrPs resulted only in unilateral LTRs.

Eliciting LTRs has been advocated for effective TrP dry needling (Hong 1994). Following LTRs, Shah et al. (2005) observed an immediate drop in concentrations of several neurotransmitters, including CGRP and substance P, and several cytokines and interleukins, in the extracellular fluid of the local TrP milieu. The concentrations did not quite reach the levels of normal muscle tissue. The reductions were observed during approximately 10 minutes, before they appeared to slowly rise again. Due to the short observation times, it is not known whether the concentrations stabilized or increased again over time.

Muscle pain

Muscle pain follows noxious stimuli, which activate specific peripheral nociceptors. Nociceptive impulses are transmitted through second order neurons in the dorsal horn, through the spinal cord, and to primary and secondary somatosensory areas in the brain, including the amygdala, anterior cingulated gyrus, and the primary sensory cortex. Locally, activation of receptors leads to the release of neuropeptides, which also causes vasodilatation and increases the permeability of the microvasculature (Snijdelaar et al. 2000, Ambalavanar et al. 2006). When neuropeptides are released in sufficient quantity they trigger the release of histamine from mast cells, BK from kallidin, serotonin (5-HT) from platelets, and PGs from endothelial cells (Massaad et al. 2004), which leads to a vicious cycle as these chemicals also activate peripheral nociceptive receptors and potentiate dorsal horn neuron sensitization. As such, muscle nociceptors play an active role in muscle pain and in the maintenance of normal tissue homeostasis by assessing the peripheral biochemical milieu and by mediating the vascular supply to peripheral tissue.

The responsiveness of receptors is indeed a dynamic process and can change depending upon the concentrations of the sensitizing agents. As an example, under normal circumstances, the BK receptor, knows as a B2 receptor, triggers only a temporary increase of intracellular calcium and does not play a significant role in sensitization. When the BK concentration increases, a B1 receptor is synthesized, which facilitates a long-lasting increase of intracellular calcium and stimulates the release of tumor necrosing factor and other interleukins, which in turn lead to increased concentrations of BK and peripheral sensitization (Calixto et al. 2000, Marceau et al. 2002). There are many interactions between these chemicals making muscle pain a very complicated phenomenon. Babenko et al. (1999) found that the combination of BK and 5-HT induced higher sensitization of nociceptors than each substance in isolation.

Referred pain occurs at the dorsal horn level and is the result of activation of otherwise quiescent axonal connections between affective nerve fibers dorsal horn neurons, which are activated by mechanisms of central sensitization (Mense & Gerwin 2010). Referred pain is not unique to myofascial TrPs but, nevertheless, it is highly characteristic of myofascial pain syndrome. Usually referred pain happens within seconds following mechanical stimulation of active TrPs suggesting that the induction of neuroplastic changes related to referred pain is a rapid process. Kuan et al. (2007a) demonstrated that TrPs are more effective in inducing neuroplastic changes in the dorsal horn neurons than non-TrPs regions.

The multiple contractures found in muscles of patients with myofascial pain are likely to compress regional capillaries, resulting in ischemia and hypoxia. Recent Doppler ultrasound studies confirmed a higher outflow resistance or vascular restriction at active TrPs and an increased vascular bed outside the immediate environment of TrPs (Sikdar et al. 2010), which is consistent with the measurement of decreased oxygen saturation levels within TrPs and increased levels outside the core of TrPs (Brückle et al. 1990). Hypoxia may trigger an immediate increased release of ACh at the motor endplate (Bukharaeva et al. 2005). Hypoxia also leads to a decrease of the local pH, which will activate transient receptor potential vanilloid (TRPV) receptors and acid sensing ion channels (ASIC) via hydrogen ions or protons. Because these channels are nociceptive, they initiate pain, hyperalgesia and central sensitization without inflammation or any damage or trauma to the muscle (Sluka et al. 2001, 2002, 2003, 2009, Deval et al. 2010). Research at the US National Institutes of Health has confirmed that the pH in the direct vicinity of active TrPs is well below 5, which is sufficient to activate muscle nociceptors (Sahlin et al. 1976, Gautam et al. 2010). Different kinds of ASICs play specific roles (Walder et al. 2010) and it is not known which ASICs are activated in myofascial pain. It is likely that multiple types of ASICs are involved in the sensory aspects of TrPs (Dommerholt, 2011), such as the ASIC1a, which processes noxious stimuli, and the ASIC3, which is involved in inflammatory pain (Shah et al. 2005, Deval et al. 2010). A low pH down-regulates ACh-esterase at the neuromuscular junction and can trigger the release of several neurotransmitters and inflammatory mediators, such as CGRP, substance P, BK, interleukins, adenosine triphosphate (ATP), 5-HT, prostaglandins (PG), potassium and protons, which would result in a decrease in the mechanical threshold and activation of peripheral nociceptive receptors. A sensitized muscle nociceptor has a lowered stimulation threshold into the innocuous range and will respond to harmless stimuli like light pressure and muscle movement. When nociceptive input to the spinal cord is intense or occurs repeatedly, peripheral and central sensitization mechanisms occur and spread of nociception at the spinal cord level results in referred pain (Hoheisel et al. 1993).

Sensitization mechanisms of TrPs

TrP as a focus of peripheral sensitization

As stated, muscle pain is associated with the activation of muscle nociceptors by a variety of endogenous substances, including several neuropeptides and inflammatory mediators, among others. In experimental research, different substances are commonly used to elicit local and referred muscle pain (Babenko et al. 1999, Arendt-Nielsen et al. 2000, Arendt-Nielsen & Svensson 2001, Graven-Nielsen 2006). In fact, induced referred pain areas obtained in these experimental studies have confirmed the empirical referred pain patterns described by Travell and Simons (Travell & Rinzler 1952, Simons et al. 1999).

Peripheral sensitization is described as a reduction in the pain threshold and an increase in responsiveness of the peripheral nociceptors. Scientific evidence has shown that pressure sensitivity is higher at TrPs than at control points (Hong et al. 1996), suggesting an increased nociceptive sensitivity at TrPs and peripheral sensitization. The concentrations of BK, CGRP, substance P, tumor necrosis factor-α (TNF-α), interleukins 1β, IL-6, and IL-8, 5-HT, and nor-epinephrine were significantly higher near active TrPs than near latent TrP or non-TrP points and in remote pain-free distant areas (Shah et al. 2005, 2008). These chemical mediators may partly be released from peripheral sensitized nociceptors that drive the pain, but also from the sustained muscle fiber contraction within the taut band (Gerwin 2008). Interestingly, the concentrations of these biochemical substances in a pain-free area of the gastrocnemius muscle were also higher in individuals with active TrPs in the upper trapezius muscle compared to those with latent TrPs or non-TrPs (Shah et al. 2008). These studies confirm not only the presence of nociceptive pain hypersensitivity in active TrP, but also establish that TrPs are a focus of peripheral sensitization. Substances associated with muscle pain and fatigue, are apparently not limited to local areas of TrPs or a single anatomic locus. Li et al. (2009) reported nociceptive (hyperalgesia) and non-nociceptive (allodynia) hyper-sensitivity at TrPs, suggesting that TrPs sensitize both nociceptive and non-nociceptive nerve endings. Nevertheless, painful stimulation induced higher pain response than non-noxious stimulation at TrPs (Li et al. 2009).

Wang et al. (2010) reported that ischemic compression, which mainly blocked large-diameter myelinated muscle afferents, induced increased pressure pain and referred pain thresholds at the TrP, but not at non-TrP regions. After decompression, the pressure sensitivity returned to pre-compression levels. In other words, non-nociceptive large-diameter myelinated muscle afferents may be involved in the pathophysiology of TrP pain and hyperalgesia (Wang et al. 2010). As non-nociceptive afferents are involved in proprioception, excitation of the large-diameter myelinated afferents by TrPs may explain the presence of altered proprioception in some patients with chronic musculoskeletal pain.

TrP nociception induces central sensitization

Central sensitization is an increase in the excitability of neurons within the central nervous system characterized by allodynia and hyperalgesia. Hyperalgesia is an increased response to a stimulus that is normally painful. Allodynia and hyperalgesia are observed in patients with TrPs. In fact, emerging research suggests a physiological link between the clinical manifestations of TrPs, such as hyperalgesia and consistent referred pain, and the phenomenon of central sensitization, although the causal relationships and mechanisms are still unclear. Additionally, Arendt-Nielsen et al. (2008) demonstrated that experimentally-induced muscle pain is able to impair diffuse noxious inhibitory control mechanisms (Arendt-Nielsen et al. 2008), supporting an important role of muscle tissues in chronic pain.

Mense (1994) suggested that the presence of multiple TrPs in the same or different muscles or the presence of active TrPs for prolonged periods of time may sensitize spinal cord neurons and supra-spinal structures by means of a continued peripheral nociceptive afferent barrage into the central nervous system. Both spatial and temporal summations are important in this pattern. Although the relationship between active TrPs and central sensitization has been observed clinically for many years, neurophysiological studies have been conducted only during the last decade. Kuan et al. (2007a) reported that spinal cord connections of TrPs were more effective in inducing neuroplastic changes in the dorsal horn neurons than non-TrPs. In addition, motor neurons related to TrPs had smaller diameters than neurons of normal tissue. It appears that TrP may be connected to a greater number of small sensory or nociceptive neurons than non-TrP tissues (Kuan et al. 2007a). Mechanical stimulation of latent TrPs can induce central sensitization in healthy subjects, suggesting that stimulation of latent TrPs can increase pressure hypersensitivity in extra-segmental tissues (Xu et al. 2010). Central sensitization also increased the TrP pressure sensitivity in segmentally related muscles (Srbely et al. 2010a). Additionally, Fernández-Carnero et al. (2010) reported that central sensitization related to TrPs in the infraspinatus muscle increased the amplitude of electromyographical (EMG) activity of TrPs in the extensor carpi radialis brevis.

Current evidence suggests that TrPs induce central sensitization, but sensitization mechanisms can also promote TrP activity. It is, however, more likely that TrPs induce central sensitization, as latent TrPs are present in healthy individuals without evidence of central sensitization. Finally, active TrP pain is, at least partially, processed at supra-spinal levels. Recent imaging data suggest that TrP hyperalgesia is processed in various brain areas as enhanced somatosensory activity involving the primary and secondary somatosensory cortex, inferior parietal, and mid-insula and limbic activity, involving the anterior insula. Suppressed right dorsal hippocampal activity is present in patients with TrPs in the upper trapezius muscle compared to healthy controls (Niddam et al. 2008, Niddam 2009). Abnormal hippocampal hypo-activity suggests that dysfunctional stress responses play an important role in the generation and maintenance of hyperalgesia from TrPs (Niddam et al. 2008). Current data suggest that a TrP is more painful than normal tissue because of specific physiological changes, peripheral and central sensitization, and not because of anatomical issues.

Muscle referred pain is a process of reversible central sensitization

A sensitized central nervous system may modulate referred muscle pain. Infusions with the N-methyl-D-aspartate (NMDA) antagonist ketamine in individuals with fibromyalgia reduced their referred pain areas (Graven-Nielsen et al. 2000). As noted previously, the appearance of new receptive fields is characteristic of muscle referred pain (Mense 1994). Since the referred pain area is correlated with the intensity and duration of muscle pain (Graven-Nielsen et al. 1997b), muscle referred pain appears to be a central sensitization phenomenon maintained by peripheral sensitization input for example from active TrPs.

It is important to realize that central sensitization is a reversible process in patients with myofascial pain, although animal studies suggest that central sensitization is an irreversible process (Sluka et al. 2001). Several clinical studies have demonstrated that sensitization mechanisms related to TrPs may be reversible with proper management. TrP injections into neck muscles produced a rapid relief of palpable scalp or facial tenderness, which would constitute mechanical hyperalgesia and allodynia, and associated symptoms in migraine (Mellick & Mellick 2003). Anesthetic injections of active TrPs significantly decreased mechanical hyperalgesia, allodynia, and referred pain in patients suffering from migraine headaches (Giamberardino et al. 2007), fibromyalgia (Affaitati et al. 2011), and whiplash (Freeman et al. 2009). In addition, dry needling of primary TrPs inhibited the activity in satellite TrPs situated in their zone of referred pain (Hsieh et al. 2007). Dry needling of active TrPs has been shown to temporarily increase the mechanical pain threshold in local pain syndromes (Srbely et al. 2010b), suggesting a segmental anti-nociceptive effect of TrP therapy.

The cause of the rapid decrease in local and referred pains with manual TrP therapy observed in clinical practice is not completely understood, but may be, at least partially, the result of the mechanical input from the needle, which would cause local stretching of muscle fibers, elongation of fibroblasts, and micro-damage to tissues. The resolution of referred pain is related to the decrease in nociceptive input to the dorsal horn of the spinal cord, and interruption of the spread of pain through convergence and central sensitization. Nevertheless, the reversal in referred pain is surprisingly fast, and suggests that long-standing central sensitization can be reversed instantaneously with proper treatment. This effect may be related to the upregulation of the endocannabinoid or endorphin system as a result of myofascial manipulation and other soft tissue therapies (McPartland 2008). Empirically, dry needling and TrP injections have a much quicker result than strict manual TrP release techniques, presumably due to increased specificity of the stimulus (Dommerholt & Gerwin 2010). In spite of methodological limitations of many studies, there is ample evidence that manual techniques are effective (Hains et al. 2010a, 2010b, Hains & Hains 2010, Bron et al. 2011b, Rickards 2011) without any indication that one particular manual technique would be superior to another (Fernández-de-las-Peñas et al. 2005, Gemmell et al. 2008).

Accumulated evidence indicates that referred pain is a reversible process of central nervous system neuroplasticity (Arendt-Nielsen 2000), which is maintained by increased peripheral nociceptive input from active TrPs. It is conceivable that the degree of central sensitization may influence whether a patient will eventually be diagnosed with myofascial pain, fibromyalgia, or neuropathic pain. Multiple factors can influence the degree of sensitization including descending inhibitory mechanisms, sympathetic activity, or neuropathic activation. In clinical practice it is commonly seen that patients with less central sensitization require a fewer number of treatments.

Sympathetic facilitation of local and referred muscle pain

There is a growing interest in the association between TrPs and the sympathetic nervous system. Rabbit (Chen et al. 1998) and human studies (McNulty et al. 1994, Chung et al. 2004) showed that an increased sympathetic efferent discharge increased the frequency and the amplitude of EMG activity of muscle TrPs, while sympathetic blockers decreased the frequency and amplitude of EMG activity. Others reported that sympathetic blockers decreased TrP and tender point pain sensitivity (Bengtsson & Bengtsson 1988, Martinez-Lavin 2004), which is consistent with the observed increased concentrations of norepinephrine at active TrPs (Shah et al. 2005).

Ge et al. (2006) reported that sympathetic facilitation induced a decrease in the pressure pain thresholds and pressure threshold for eliciting referred pain and an increase in local and referred pain intensities, suggesting a sympathetic-sensory interaction at TrPs. Zhang et al. (2009) found an attenuated skin blood flow response after painful stimulation of latent TrPs compared with non-TrPs, which may be secondary to increased sympathetic vasoconstriction activity at latent TrPs.

TrP sensitivity appears to be maintained by sympathetic hyperactivity, although once again, the mechanisms of this interaction are not completely understood. Increased sympathetic activity at TrPs may enhance the release of norepinephrine and ATP, among others (Gerwin et al. 2004). Another possible mechanism suggests that the increased level of muscle sympathetic nerve activity may lead to a delayed resolution of inflammatory substances and change the local chemical milieu at TrPs (Macefield & Wallin 1995). As it was discussed previously, Gerwin et al. (2004) suggested that the presence of α and β adrenergic receptors at the endplate could provide a possible mechanism for autonomic interaction (Maekawa et al. 2002), although this has not been confirmed in humans.

Pathophysiology of TrPs: the integrated hypothesis

The activation of a TrP may result from a variety of factors, such as repetitive muscle overuse, acute or sustained overload, psychological stress, or other key or primary TrPs. Particular attention has been paid to injured or overloaded muscle fibers following eccentric and intense concentric contractions in the pathogenesis of TrPs (Gerwin et al. 2004). Hong (1996) hypothesized that each TrP contains a sensitive locus, described as a site from which a LTR can be elicited when the TrP is mechanically stimulated, and an active locus described as an area from which spontaneous electrical activity (SEA) is recorded. In this model, the sensitive locus contains nociceptors and constitutes the sensory component, while the active locus consists of dysfunctional motor endplates, which would be the motor component (Simons et al. 1995, Simons 1996, Hong & Simons 1998).

Muscle trauma, repetitive low-intensity muscle overload, or intense muscle contractions, may create a vicious cycle of events, wherein damage to the sarcoplasmic reticulum or the cell membrane leads to an increase of the calcium concentration, a shortening of the actin and myosin filaments, a shortage of ATP, and an impaired calcium pump (Simons et al. 1999, Gerwin et al. 2004). In 1981, Simons and Travell developed the so-called 'energy crisis hypothesis' which reflects this vicious cycle. Since 1981, the energy crisis hypothesis has evolved into the so-called *integrated trigger point hypothesis*, which is based on subsequent scientific research (Simons, 2004). The integrated hypothesis is the most accepted theoretical concept, although other models have been proposed (Dommerholt & Franssen 2011). The integrated hypothesis is a work in progress and continues to be modified and updated as new scientific evidence emerges (Gerwin et al. 2004, McPartland & Simons 2006).

The integrated hypothesis proposes that abnormal depolarization of the post-junctional membrane of motor endplates causes a localized hypoxic energy crisis associated with sensory and autonomic reflex arcs that are sustained by complex sensitization mechanisms (McPartland & Simons 2006). The first EMG study of TrPs, conducted by Hubbard and Berkoff (1993), reported the presence of spontaneous EMG activity in a TrP of the upper trapezius muscle. The authors described two components of this spontaneous EMG activity, namely a low amplitude constant background activity of 50 μV, and intermittent higher amplitude spike-like of 100–700 μV. Others confirmed the constant background activity of 10–50 μV and occasionally 80 μV in animal TrPs (Simons et al. 1995, Chen et al. 1998, Macgregor et al. 2006) and in human TrPs (Simons 2001; Couppé et al. 2001, Simons et al. 2002). The origin of this spontaneous electrical activity (SEA) is still controversial; however, clear evidence supports that SEA originates from motor endplate potentials (EPP). Simons concluded that the SEA is the same than endplate noise (EPN) (Simons, 2001, Simons et al. 2002). EPN is more prevalent in active TrPs than in latent TrPs (Mense & Gerwin, 2010). EPN seems to reflect a local depolarization of the muscle fibers induced by a significantly increased and abnormal spontaneous release of ACh (Ge et al. 2011). Kuan et al. (2002), in an animal model, showed that SEA can be decreased by botulinum toxin, which inhibits the release of ACh at the neuromuscular junction. Additionally, analysis of the motor behaviors of a TrP shows that the intramuscular EMG activity at TrPs exhibits similar motor behaviors to the surface EMG activity over a TrP, which supports that the origin of the electrical activity is derived from extrafusal motor endplates and not from intrafusal muscle spindles (Ge et al. 2011). An interesting study found higher pain intensities and pain features similar to TrPs when noxious stimuli were applied to motor endplate areas compared with silent muscle sites (Qerama et al. 2004). Kuan et al. (2007b) reported a high correlation between the irritability, pain intensity and pressure pain thresholds, and the prevalence of EPN loci in a TrP region of the upper trapezius muscle. Lower pressure pain thresholds were associated with greater SEA. From a clinical perspective, several studies showed that treatment of TrPs can eliminate or significantly reduce EPN (Kuan et al. 2002, Gerwin et al. 2004, Qerama et al. 2006, Chen et al. 2008, Chou et al. 2009). Findings from these studies support that TrPs are associated with dysfunctional motor endplates (Simons et al. 2002). It should be noted that motor endplates are distributed throughout the entire muscle and not just in the muscle belly as frequently is assumed (Edstrüöm & Kugelberg, 1968). In studies of cats and rats, motor endplates were identified in 75% of the soleus muscle (Bodine-Fowler et al, 1990, Monti et al. 2001). In the anterior tibialis muscle of a cat, motor endplates were located in 56–62% of the muscle (Monti et al. 2001).

Regarding the motor component of the TrPs, the intramuscular and surface EMG activity recorded from a TrP showed that the SEA is similar to a muscle cramp potential, and secondly, that the increase in local muscle pain intensity is positively associated with the duration and amplitude of muscle cramps (Ge et al. 2008). Localized muscle cramps may induce intramuscular hypoxia, increased concentrations of algogenic mediators, direct mechanical stimulation of nociceptors, and pain (Simons 1998). Therefore, it seems that TrP pain and tenderness is closely associated with sustained focal ischemia and muscle cramps within muscle taut bands (Ge et al. 2011)

Although current evidence supports that dysfunctional motor endplates are clearly associated with TrPs, recent evidence suggests that muscle spindles may also be involved in this complex process. Ge et al. (2009) found that intramuscular TrP electrical stimulation can evoke H-reflexes, and that greater H-reflex amplitudes and lower H-reflex thresholds exist at TrPs compared to non-TrPs. The lower reflex threshold and higher reflex amplitude at TrPs could be related to a greater density or excitability of muscle spindle afferents (Ge et al. 2009). Nevertheless, the mechanisms underlying increased sensitivity of muscle spindle afferents at TrPs are still unclear. The increased chemical mediators in the TrPs (Shah et al. 2005) may contribute to an increased static fusimotor drive to muscle spindles or to increased muscle spindle sensitivity (Thunberg et al. 2002).

Other hypothetical models

Although the integrated trigger point hypothesis is the most prominent and most accepted model, other hypothetical TrP models have been developed. Recently, Hocking postulated the *central modulation hypothesis* and suggested that plateau potentials are critical in the understanding of the etiology of TrPs (Hocking 2010). According to Hocking, cell membranes may continue to trigger action potentials without synaptic excitation as a result of plateau potentials (Hocking 2010). In other words, a sustained α-motoneuron plateau depolarization would lead to the formation of TrPs. Hocking identified two underlying central nervous system mechanisms. So-called *antecedent* TrPs are thought to be the result of central sensitization of C-fiber nociceptive withdrawal reflexes, visceromotor reflexes, or nociceptive jaw-opening reflexes, and occur in withdrawal reflex agonist muscles. *Consequent* TrPs would be due to compensatory reticulospinal or reticulo-trigeminal motor facilitation and occur in withdrawal reflex antagonist muscles. A critical difference with the integrated TrP hypothesis is that in the central modulation model myofascial pain is not a disorder of the motor endplate, but a nociception-induced central nervous system disorder leading to centrally maintained α-motoneuron plateau depolarizations (Hocking 2010). There are several aspects of the integrated TrtP hypothesis that are also part of the central modulation hypothesis, such as the presence of the energy crisis and low-amplitude motor endplate potentials. When Hocking presented his hypothesis initially, he also suggested several research projects to test the hypothesis. Further research is indeed needed to test this interesting hypothesis.

Srbely (2010) developed the *neurogenic hypothesis*, which is based primarily on his research (Srbely & Dickey, 2007, Srbely et al. 2008, 2010a, 2010b). According to the neurogenic hypothesis, TrPs are neurogenic manifestations of primary pathologies in the same neurological segment. Srbely (2010) suggests that central sensitization is the underlying cause of myofascial pain syndrome. The notion that the inactivation of TrPs can reverse central sensitization is interpreted as evidence of the neurogenic hypothesis. Other than Srbely's own studies, there is no other research to confirm of dispute the neurogenic hypothesis.

Partanen et al. (2010) developed the *neurophysiologic hypothesis*, which maintains that the SEA is not recorded from motor endplates, but from intrafusal muscle spindle fibers. According to this hypothesis, taut bands are caused by inflammation of muscle spindles and sensitization of group III and IV afferents, which in turn leads to activation of the gamma and beta efferent systems (Partanen, 1999, Partanen et al. 2010). As was mentioned already, muscle spindles may be involved in the TrP etiology (Ge et al. 2009), but there is no convincing evidence that endplate noise would originate in intrafusal fibers (Wiederholt 1970). There is no research to date to confirm or dispute the neurophysiologic hypothesis.

Lastly, Gunn (1997a, 1997b) developed the *radiculopathy hypothesis*, which is discussed in detail in Chapter 14.

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Proposed mechanisms and effects of trigger point dry needling

2

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CHAPTER CONTENT

Introduction

Many physical therapists and other clinicians have adopted a contemporary pain management approach and incorporate graded exercise, restoration of movement and posture and psychosocial perspectives into the examination, assessment and therapeutic interventions of patients presenting with pain complaints (Gifford & Butler 1997, George et al. 2010, Nijs et al. 2010, Hodges & Tucker 2011). The question emerges whether movement approaches by themselves are sufficient to address persistent pain states without eliminating peripheral nociceptive input?

Current pain science research supports that pain is produced by the brain, when there is a perception of bodily danger requiring specific action (Moseley 2003). In other words, the 'issues are not just in the peripheral tissues' (Butler 1991) and considering the meaning of pain in the context of the patient's overall situation is critical (Moseley 2012). The effects of trigger point (TrP) dry needling (DN) cannot be considered without this broader biopsychosocial model (Gerwin & Dommerholt 2006). TrP DN must be approached from a pain science perspective, as it is no longer sufficient to consider TrP therapy strictly as a tool to address local muscle pathology.

As Moseley pointed out, nociceptive mechanisms that contribute to threatening information should be treated, where possible (Moseley 2003). Frequently, TrPs are a constant source of nociceptive input especially in persistent pain conditions (Giamberardino et al. 2007, Melzack 2001 Ge et al. 2011) and it follows that removing such peripheral input is indicated and consistent with the concepts of Melzack's neuromatrix (Melzack 2001). In addition to their contribution to nociception, TrPs can contribute to abnormal movement patterns (Lucas et al. 2004, 2010).

Input from muscle nociceptors appears more effective at inducing neuroplastic changes in wide dynamic range dorsal horn neurons than input from cutaneous nociceptive receptors (Wall & Woolf 1984). Several studies demonstrated that TrPs activate the anterior cingulate cortex (ACC) and other limbic structures, but suppress hippocampal activity (Svensson et al. 1997, Niddam et al. 2007, 2008). Increased activity in the ACC is common in chronic pain conditions and is even present when pain is anticipated (Hsieh et al. 1995, Peyron et al. 2000a, 2000b, Sawamoto et al. 2000, Longo et al. 2012). When treating patients with DN techniques, it is imperative to avoid creating the impression that local muscle pathology would be solely responsible for the persistent pain (Nijs et al. 2010, Puentedura & Louw 2012). Rather than explaining TrPs as a local pathological or anatomical problem, it makes

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more sense to focus on the nociceptive nature of TrPs and their role in perpetuating central sensitization. Persistent peripheral nociceptive input increases the sensitivity of the central nervous system. Unfortunately, the contributions of TrPs often are not considered and individual patients may have gone through many unsuccessful treatment regimens with multiple diagnostic pathways. They may have developed fear avoidance or kinesiophobia, poor coping skills, and an anticipation of pain (Bandura et al. 1987, Vlaeyen & Linton 2000, Wager et al. 2004, Coppieters et al. 2006). Additionally, patients' altered homeostatic systems may start contributing to the overall pain experience (Puentedura & Louw 2012) with decreased blood flow to the muscles (Zhang et al. 2009), abnormal cytokine production (Watkins et al. 2001, Milligan & Watkins 2009), constrained breathing patterns (Chaitow 2004), and abnormal muscle activation patterns (Moreside et al. 2007), among others. In some patients, the anticipation of pain and the pain associated with DN itself may activate threatening inputs, at which point DN becomes counterproductive. Fortunately, this is quite rare and for most patients TrP DN is a viable intervention (Dilorenzo et al. 2004, Affaitati et al. 2011).

Mechanisms and effects of trigger point dry needling

There are no studies of the effect of DN on the ACC and other limbic structures, but several papers suggest that needling acupuncture and non-acupuncture points does seem to involve the limbic system and the descending inhibitory system (Takeshige et al. 1992a, 1992b, Wu et al. 1999, Biella et al. 2001, Hsieh et al. 2001, Hui et al. 2000, Wu et al. 2002). DN studies of patients with fibromyalgia, which is a diagnosis of central sensitization (Clauw 2008, Dommerholt & Stanborough 2012), demonstrate that DN of a few TrPs does not only reduce the nociceptive input from the treated TrPs, but reduces the overall widespread pain and sensitivity (Ge et al. 2009, 2010, 2011, Affaitati et al. 2011). TrP DN often evokes patients' referred pain patterns and their primary pain complaint (Hong et al. 1997). Needling of TrPs in the gluteus minimus or teres minor muscles may initiate pain resembling a L5 or C8 radiculopathy, respectively (Escobar & Ballesteros 1988, Facco & Ceccherelli 2005). Needling of TrPs in the sternocleidomastoid or upper trapezius muscles may trigger a patient's migraine or tension-type headache (Calandre et al. 2006). Experimentally induced muscle pain impairs diffuse noxious inhibitory control mechanisms (Arendt-Nielsen et al. 2008) and DN does seem to effect central sensitization, presumably by altering the nociceptive processing (Kuan et al. 2007a, Mense 2010, Mense & Masi 2011). It is known that TrP DN reduces segmental nociceptive input and as such is therapeutically indicated (Srbely et al. 2010).

This chapter could end here, because the exact mechanisms of DN continue to be elusive. Since many studies and case reports have confirmed the clinical efficacy of DN, future research must be directed towards examining the underlying mechanisms (Lewit 1979, Carlson et al. 1993, Hong 1994, 1997, Hong & Hsueh 1996, McMillan et al. 1997, Chen et al. 2001, Cummings 2003, Mayoral & Torres 2003, Dilorenzo et al. 2004, Ilbuldu et al. 2004, Itoh et al. 2004, 2007, Lucas et al. 2004, Furlan et al. 2005, Kamanli et al. 2005, Mayoral-del-Moral 2005, Weiner & Schmader 2006, Giamberardino et al. 2007, Hsieh et al. 2007, Fernandez-Carnero et al. 2010, Lucas et al. 2010, Osborne & Gatt 2010, Tsai et al. 2010, Srbely et al. 2010, Affaitati et al. 2011). Slowly, bits and pieces of the myofascial pain puzzle are beginning to be explored.

Mechanically, deep DN may disrupt contraction knots, stretch contractured sarcomere assemblies and reduce the overlap between actin and myosin filaments. It may destroy motor endplates and cause distal axon denervations and changes in the endplate cholinesterase and acetylcholine receptors similarly to the normal muscle regeneration process (Gaspersic et al. 2001). Of particular interest are local twitch responses (LTR), which are involuntary spinal cord reflexes of muscle fibers in a taut band following DN, injections, or snapping palpation (Dexter & Simons 1981, Fricton et al. 1985, Hong 1994, Hong & Torigoe 1994, Simons & Dexter 1995, Wang & Audette 2000, Ga et al. 2007). Eliciting LTR is important when inactivating TrPs and confirms that the needle was placed accurately into a TrP. Several studies have confirmed that a LTR can reduce or even eliminate the typical endplate noise associated with TrPs which suggests that DN inactivates TrPs

(Hong & Torigoe 1994, Hong 1994, Chen et al. 2001). There is a positive correlation between the prevalence of endplate noise in a TrP region and the pain intensity of that TrP (Kuan et al. 2007b). Endplate noise is a summation of miniature endplate potentials and is a characteristic of TrPs (Simons et al. 1995, 2002, Hong & Simons 1998, Simons 2001, Simons 2004). Moreover, eliciting LTRs appears to reduce the concentrations of many chemicals found in the immediate environment of active TrPs, such as calcitonin gene related peptide, substance P, serotonin, interleukins, and epinephrine, among others (Shah et al. 2003, 2005, 2008, Shah & Gilliams 2008). Shah et al. (2008) had speculated that the drop in concentrations may be caused by a local increase in blood flow or by interference with nociceptor membrane channels, or by transport mechanisms associated with a briefly augmented inflammatory response. The decrease of concentrations of substance P and calcitonin gene-related peptide corresponds with the clinical observation of a reduction in pain following deep DN (Shah et al. 2008). LTRs are often visible with the naked eye and can be visualized with sonography (Gerwin & Duranleau 1997, Lewis & Tehan 1999, Rha et al. 2011).

The effects of superficial DN are often attributed to stimulation of Aδ sensory afferent fibers, which may outlast the stimulus for up to 72 hours (Baldry 2005). It is true that stimulation of Aδ nerve fibers may activate enkephalinergic, serotonergic, and noradrenergic inhibitory systems (Bowsher 1998); however, type I high-threshold Aδ nerve fibers are only activated by nociceptive mechanical stimulation and type II Aδ fibers require cold stimuli (Millan 1999). Since superficial DN is neither a painful mechanical nor a cold stimulus, it is unlikely that Aδ fibers would get activated (Dommerholt et al. 2006). When superficial DN is combined with rotation of the needle, the stimulus may activate the pain inhibitory system associated with stimulation of Aδ fibers through segmental spinal and propriospinal hetero-segmental inhibition (Sandkühler 1996). Deep DN can be also combined with rotation of the needle, after which the needle is left in place until relaxation of the muscle fibers has occurred (Dommerholt et al. 2006). The mechanical pressure exerted with the needle may electrically polarize muscle and connective tissue, and transform mechanical stress into electrical activity, which is required for tissue remodelling (Liboff 1997). It is also possible that superficial DN may activate mechanoreceptors coupled to slow conducting unmyelinated C fiber afferents. This could trigger a reduction of pain and a sense of progress and well-being through activation of the insular region and anterior cingulate cortex (Olausson et al. 2002, Mohr et al. 2005, Lund & Lundeberg 2006).

Many clinicians combine superficial and deep DN with electrical stimulation through the needles (Mayoral & Torres 2003, Mayoral-del-Moral 2005, Dommerholt et al. 2006), which may activate the peri-aqueductal grey in some patients (Niddam et al. 2007). Unfortunately, there are no evidence-based guidelines of the optimal treatment parameters, such as optimal amplitude, frequency, and duration. Stimulation frequencies between 2 and 4 Hz are thought to trigger the release of endorphins and encephalin, while frequencies between 80 and 100 Hz may release gamma-aminobutyric acid, galanin and dynorphin (Lundeberg & Stener-Victorin 2002). Several rodent studies have shown that electrical acupuncture can modulate the expression of N-methyl-D-aspartate in primary sensory neurons (Choi et al. 2005, Wang et al. 2006). The ideal needle placement for e-stim with DN has not been determined either, although White et al. (2000) recommended placing the needle-electrodes within the same dermatomes as the location of the lesion.

Summary

Although Felix Mann (2000), co-founder of the British Medical Acupuncture Society, maintained that effective treatments could be achieved by needling anywhere on the body, the underlying mechanisms of DN have not received enough serious attention of researchers and clinicians. DN does alter the chemical environment of active TrPs, reduce or eliminate endplate noise and decrease the sensitivity of TrPs, but little is known about what the needle actually does to cause these effects. Mann recommended to needle in the quadrant of the pain complaint or, if more specificity would be desired, to needle in a neighboring dermatome, myotome or sclerotome. The most effective methods would involve needling in a small circumscript area near the location of pain or directly into TrPs (Mann 2000).

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Trigger point dry needling: safety guidelines

4

Johnson McEvoy

CHAPTER CONTENT

Safety Considerations

Introduction

Dry needling (DN) is an invasive procedure that poses certain risks, in part, not generally associated with other physical therapy or chiropractic treatments. The focal point of this chapter is on safety issues associated with DN. DN can be divided into superficial dry needling (SDN) and trigger point dry needling (TrP-DN). Ultimately, the health and welfare of the patient should be the first consideration (World Health Association 2006), but the welfare of healthcare workers (HCWs) and third parties should not be overlooked. Guidelines and checklists have been employed to improve the quality and safety of complex systems and practices in, for example, aviation, engineering, medicine and surgery (Gawande 2009). A practice guideline is a formal statement about a defined task or function in clinical practice (Barlow-Pugh 2000). DN practice guidelines have been developed in Australia (ASAP 2007), Canada (CPTA 2007) and Ireland (McEvoy et al. 2012). The main focus of this chapter is on patient safety, but HCWs and third party risks are also recognized.

DN is the use of a solid filament needle for the treatment of pain and dysfunction of various body tissues. DN is an invasive technique within the scope of practice of multiple disciplines, such as

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Box 4.1

Glossary of acronyms

AE: Adverse event
DN: Dry needling
HAI: Healthcare associated infection
HCWs: Healthcare workers
NMES: Neuromuscular electrical stimulation
NSI: Needle stick injury
PENS: Percutaneous electrical nerve stimulation
PTS: Post treatment soreness
SDN: Superficial dry needling
TENS: Transcutaneous electrical nerve stimulation
TRP: Myofascial trigger points
TRPDN: Trigger point dry needling
USCDC: United States Centers for Disease Control and Prevention
WHO: World Health Organization
(McEvoy, 2012)

physical therapy, chiropractic, medicine, dentistry and acupuncture. There are a variety of conceptual models as outlined in other chapters of this book, including TrP-DN and SDN, which are commonly employed to treat pain and dysfunction associated with myofascial TrPs as described by Travell and Simons (Travell & Simons 1983, 1992, Simons et al. 1999). Clinicians may employ one or a combination of conceptual models in clinical practice.

TrP-DN is practiced by physical therapists in many countries including Canada, Chile, Ireland, the Netherlands, South Africa, Spain, Switzerland and the UK (Dommerholt et al. 2006). An increasing number of states in the USA, the American Physical Therapy Association and the American Academy of Orthopaedic Manual Physical Therapists have ruled DN to be under the scope of physical therapy practice (AAOMPT 2009, APTA 2012). Other disciplines also employ TrP-DN, such as chiropractors in the UK and in several US states, massage therapists in Australia and dentists in various countries, among others. With the increase in DN amongst clinicians internationally, it is important to focus on safety, which must be considered the number one priority. In this chapter, DN is approached from a physical therapy perspective, but the safety precautions are of course applicable to all HCWs.

Trigger point dry needling: safety

TrP-DN poses potential risks to patients, HCWs and third parties. Many of these risks are not associated with traditional non-invasive physical therapy treatments and may include bruising, pneumothorax, infection, internal tissue damage and bleeding. The term *adverse event* (AE) is used to describe any ill effect of a treatment, no matter how small, that is unintended and non-therapeutic (White et al. 1997). The severity of AEs can be graded as mild (minor), significant and serious (White et al. 2001, 2008). A mild AE is considered of short duration, reversible and does not particularly inconvenience the patient; a significant AE requires medical attention or interferes with the patient's activities; a serious AE requires hospital admission with potential persistent or significant disability or death (White et al. 2008). Quantification and qualification grading of AEs has been proposed to objectify risk and this is invaluable for patient education and informed consent. AEs can be categorized into very common, common, uncommon, rare, and very rare with corresponding quantification (Table 4.1; Witt et al. 2009). This grading is helpful when reviewing AE studies.

There are no Medline cited TrP-DN AE studies apart from one individual case study (Lee et al. 2011). Despite the lack of studies, clinician experience would suggest that significant TrP-DN AEs are rare. However, there is a need for TrP-DN AE studies to quantify risk. A prospective TrP-DN AE study amongst physiotherapists has been initiated in Ireland in 2011 (Brady et al. 2011). Though TrP-DN and acupuncture differ in terms of historical, philosophical, indicative, and practical contexts, similarities do exist in terms of solid filament needle skin penetration to varying depths within the body. In this context, acupuncture AE studies assist in identifying TrP-DN risks. Notwithstanding the differences between traditional acupuncture and TrP-DN, clinicians practicing TrP-DN should familiarize themselves with acupuncture AE studies to optimise safe practice and also for patient informed consent. Acupuncture is considered one of the safer forms of medical treatment (Vincent 2001, White et al. 2008). Despite this safety statement, AEs do occur. Peuker & Gronemeyer (2001) grouped acupuncture AEs into five categories including

Table 4.1 Qualification and quantification of adverse events

Very common	Common	Uncommon	Rare	Very rare
≥ 10%	≥ 1–10%	≥ 0.1% –1%	≥ 0.01% – 0.1%	<0.01%
>1–10	1–10/100	1–10/1000	1–10/10 000	<1 / 10 000

Adapted from Witt et al. (2009).

delayed or missed diagnosis, deterioration of disorder under treatment, vegetative reactions, infections, and trauma to tissues or organs (Table 4.2).

Table 4.2 Acupuncture adverse events

Adverse event category	Example
Delayed or missed diagnosis	Cancer
Deterioration of disorder under treatment	Increased pain
Vegetative reactions	Autonomic type reaction, nausea etc.
Bacterial and viral infections	Hepatitis B
Trauma of tissue and organs	Pneumothorax, nerve lesion

Categories adapted from Peuker & Gronemeyer (2001).

A significant number of acupuncture safety and AE studies have been published. Three studies are of particular interest to TrP-DN as they were carried out on physiotherapists and medical doctors and may best reflect clinicians with Western medical training. A summary of the main AEs is presented in Table 4.3.

White et al. (2001) reported AEs related to acupuncture in a prospective clinician survey of 32 000 treatments of 78 British physiotherapists and medical doctors. Common minor AEs included bleeding and needling pain, while uncommon minor AEs included aggravation of symptoms, faintness, drowsiness, a stuck or bent needle and headache. Significant AEs were rare or very rare (n=43) and included administrative problems (forgotten needle, forgotten patient), issues at the application site (cellulitis, needle allergy, needle site pain), cardiovascular problem (fainting), gastrointestinal problem (nausea, vomiting), neurological and psychiatric problem (anxiety, panic, euphoria, hyperesthesia, headache, slurred speech), exacerbation of symptoms (back pain, fibromyalgia, shoulder pain, vomiting, migraine). No serious AE was reported in 32 000 treatments surveyed. It was concluded that acupuncture in skilled hands is one of the safer forms of medical intervention (White et al. 2001).

Witt et al. (2009) reported AEs related to acupuncture in a prospective 229 230 patient based survey consisting of 2.2 million treatments delivered by German physician acupuncturists. AEs were reported per patient (n=229 230) and not per treatment (n=2.2 million) and this should be taken into account when comparing with White et al. (2001), who reported AE per treatment (N=32 000). A noteworthy 8.6% of patients reported at least one AE, where 2.2% of patients required medical treatment (significant or serious AE). Common side-effects included bleeding and hematoma (n=14 083; 6.1%) and pain (n=4681; 2%). Uncommon side-effects included strong pain during needling (n=490; 0.2%), vegetative symptoms (n=1663; 0.7%), nerve irritation and injury (n=601; 0.26%). Rare and very rare side-effects included local infection (n=31; 0.014%), systemic infection (n=5; 0.002%) and pneumothorax (n=2; 0.001%). As this is arguably the most comprehensive AE acupuncture study, clinicians should familiarize themselves with this study and the expansive quantification of side-effects.

Melchart et al. (2004) reported AE after acupuncture in a prospective clinician-based survey of 97 733 patients (760 000 treatments) delivered by German physician acupuncturists. Again, similar to Witt et al. (2009), the incidence of AE was reported per patient and not per treatment. Non-serious AEs were seen in 7.10% of patients included needling pain, hematoma and bleeding in 3.28%, 3.19% and 1.3%, respectively. Serious AE were reported in six of 97 733 patients including exacerbation of depression, acute hypertensive crisis, vasovagal reaction, asthma attack with hypertension, angina, and pneumothorax in two cases.

Despite the generally good safety of acupuncture, a review of acupuncture systematic reviews

Table 4.3 Selected qualification and quantification risks associated with acupuncture

Very common	Common	Uncommon	Rare	Very rare
≥ 10%	≥ 1 – 10%	≥ 0.1% – 1%	≥ 0.01% – 0.1%	<0.01%
>1–10	1–10/100	1–10/1000	1–10/10 000	<1 / 10 000
	Bleeding Hematoma Needling site pain	Inflammation Swelling Strong pain during treatment Nerve irritation Nerve injury Headache Fatigue Vertigo Nausea	Local infection Redness Itching Sweating Blood pressure changes Unconsciousness Tachycardia Breathing difficulties Vomiting	Pneumothorax Broken needle Forgotten needle Systemic infection Affected speech Disorientation

See references for further information: White et al. 2001, Melchart et al. 2004, Witt et al. 2009.

from 2000 onwards identified 95 cases of severe AEs including five fatalities (Ernst et al. 2011, Choi 2011). Peuker & Groneeyer (2001) reported on rare but serious complications of acupuncture due to traumatic lesions in a review of the literature from 1965 onwards. According to the authors, all traumatic lesions described could be avoided if clinicians had better anatomical knowledge or applied existing knowledge.

Hygiene

DN is an invasive procedure that poses infection risks to patients, clinicians and third parties which are not normally associated with manual treatments. In 2002, US healthcare-associated infections (HAI) amounted to 1.7 million recorded incidents with 98 987 deaths (Klevens et al. 2007). As many as one in 10 patients acquire a HAI (HSE 2009). Infectious agents include bacteria (e.g. *Staphylococcus*, *E. coli*), viruses (e.g. hepatitis B and C, human immunodeficiency virus), fungi (e.g. tinea pedis, *Candida albicans*), protozoa (e.g. toxoplasmosis) and prions (e.g. Creutzfeldt–Jakob disease). The *chain of infection* is a six element way of describing infectious disease transmission (HSE 2009) and consists of an infectious agent, a reservoir (infectious agent area), a portal of exit (from infected person), a means of transmission, a portal of entry (to target person), and a susceptible host.

Standard Precautions are clinical guidelines to prevent transmission of infectious agents and are published by the United States Centers for Disease Control and Prevention (USCDC) (Siegel et al. 2007, HSE 2009). The purpose of Standard Precautions is to break the chain of infection by focusing particularly, but not exclusively, on the mode of transmission, portal of entry and susceptible hosts (HSE 2009). Standard precautions require HCWs to assume that every person is potentially infected or colonized with an organism that could be transmitted in the healthcare setting and apply a set of work practices to minimize the risk of contamination (HSE 2009). Work practices relevant to DN include attention to hand hygiene, glove usage, skin preparation, management of needles and medical waste, and needle stick injuries (NSI) (Dommerholt 2011).

Hand hygiene

Hand hygiene is considered the single most important intervention to prevent transmission of infection (SARI 2005). Hand hygiene activity recommendations have been evidenced-categorized (I, II, III):

- Category I: supported by experimental, clinical or epidemiological studies based on strong theoretical basis
- Category II: supported by suggestive clinical or epidemiological studies or a theoretical-based rationale

- Category III: recommended by healthcare experts from experience.

For hand hygiene preparation, nails should be keep short and cut smoothly (II) with the avoidance of false nails or extenders (I) and nail polish (III). All wrist and hand jewelery except plain wedding bands should be removed (II) and sleeves should be short or turned up (III).

Hand decontamination should be carried out with suitable soap and water or if hands are visibly clean of contaminant, with appropriate alcohol-based hand rub or gel. Hand decontamination is recommended for the following situations:

1. When the hands are visibly soiled with dirt, soil or organic material (I), they should be washed thoroughly to remove the contaminant.
2. Before and after each patient contact (II).
3. At the beginning and end of each work shift (III).
4. After removing gloves (I).
5. After moving from a contaminated area (II).
6. After handling soiled equipment, materials or environment (II).
7. After personal bodily functions (e.g. blowing nose, after using the toilet) (I).
8. Before handling food (I).

Hand hygiene and decontamination should be a quality standard in all health care institutions (SARI 2005) and is a learned skill. It may appear rudimentary, but attention to hand decontamination technique is important and often is practiced poorly by HCWs. Handwashing with regular soap can remove dirt, but is generally ineffective in preventing antimicrobial activity, whereas alcohol-based hand rub is generally effective (Ehrenkranz & Alfonso 1991). Antimicrobial soap is somewhat more efficient than non-antimicrobial soap and produces a statistically significant reduction in microbial activity compared to non-antimicrobial soap (Montville & Schaffner 2011). However, the use of alcohol in either soap or gel is more effective than antimicrobial or bland soap without alcohol (Paulson et al. 1999). Recommendations for best practice have been made.

Handwashing with soap (Boyce & Pittet 2002, SARI 2005, HSE 2009)

1. Wet hands with water.
2. Apply an amount of suitable soap to the hands as recommended by the product manufacturer.
3. Rub hands vigorously for at least 15 seconds encompassing all surfaces of the hands and fingers.
4. Rinse hands with water.
5. Dry hands with a good quality single-use disposable paper towel.
6. Use towel to turn off faucet and dispose of in pedal bin.
7. Avoid using hot water as this may increase skin dryness and dermatitis.

Multiple-use cloth towel, either roll type or hanging style are not appropriate for the healthcare setting (Boyce & Pittet 2002).

Hand decontamination with alcohol-based hand rub (Boyce & Pittet 2002, SARI 2005)

Hands can be decontaminated with suitable alcohol-based hand rub or gel once the hands are visibly clean. Alcohol-based hand rub can be inactivated by organic material and therefore if hands are visibly soiled, they should be washed per the above recommendations. Alcohol-based hand sanitizer is usually recommended at a 70% concentration by weight of isopropanol, ethanol, or n-Propanol. Higher concentrations may increase the risk of skin dryness and dermatitis. The USCDC recommends handwashing with soap after every 5–10 applications of alcohol-based hand gel due to build-up of emollients on the hands (Boyce & Pittet 2002). Manufacturer's instructions of such products should be noted.

1. Apply product to palm of one hand and rub hands together.
2. Covering all surfaces of hands and fingers.
3. For at least 15 seconds and until hands are dry.

As HCWs wash and decontaminate their hands up to 30 times per shift (Boyce & Pitte 2002), there is a significant risk of skin irritation and dermatitis. Irritant dermatitis is a non-immunological inflammatory skin response to an external agent and may leave the skin more prone to harbor micro-organisms (SAR 2005). Prevention and management of all forms of dermatitis is important for the safety of patients and HCWs. The USCDC recommends the addition of 1–3% glycerol to alcohol-based hand gel as this can reduce or eliminate as the drying effect of the alcohol (Boyce & Pittet 2002). Advice for the prevention of occupational dermatitis in the healthcare setting includes (SAR 2005):

1. Follow manufacturer's recommendations on use of hand hygiene product.
2. Use products with low irritation potential and when able with emollient.
3. Receive feedback from HCWs on products used.
4. Use alcohol-based hand rubs with emollients.
5. Promote the use of suitable hands lotions to assist in skin hydration and replace skin lipids.

Gloves

Gloves are the main protective equipment employed during DN. Gloves should be worn without exception at least on the palpating hand or, if so preferred or legally required, on both hands. Guidelines vary in different countries and jurisdictions. There are potential arguments against the use of gloves which may include the effect on kinesthetic feedback, awkwardness, time consuming, or lack of evidence for reducing NSI. These objections are muted, however, by the requirements of Standard Precautions which require gloves to be worn for all activities when it can be reasonably anticipated to have hand contact with blood, bodily fluids or other potentially infectious materials, mucous membranes, and non-intact skin (HSE 2009). According to regulations (Standards 29 CFR) published by the United States Occupational Safety and Health Administration (OSHA):

> gloves shall be worn when it can be reasonably anticipated that the employee may have hand contact with blood, other potentially infectious materials, mucous membranes, and non-intact skin…

Due to the fact that clinicians need to compress the needle site after removal of the needle and that bleeding is the most common side-effect of DN, the use of gloves is consistent with OSHA regulations.

Gloves should be single use, disposable and conform to international community standards. Latex-free gloves should be available for clinicians and used with patients with known latex allergies. Latex-free surgical glove are being used more frequently due to latex hypersensitivity in HCWs and patients, however some may not offer the same protection as latex gloves (Boyce & Pittet 2002, Aldlyami et al. 2010). The Food and Drug Administration has approved several powered and powered-free latex gloves with reduced protein contents and synthetic gloves for latex-sensitive HCWs (Boyce & Pittet 2002). Nitrile gloves are usually preferable in those with latex allergy concerns. Gloves should be donned immediately before and removed immediately after the DN procedure is completed and if contaminated with blood or body fluids, should be disposed of in appropriate healthcare waste. Wearing gloves provides an ideal environment for bacterial growth and hands should be washed after removal of gloves.

Patient skin preparation

Patient skin disinfection is not usually required prior to DN if the skin is visibly clean, which is in line with the World Health Organization's (WHO) best practice for intradermal, subcutaneous and intramuscular needle injections (Hoffman 2001, Hutin et al. 2003, Baldry 2005, BAC 2006, ASAP 2007, White et al. 2008). Resident skin bacteria are unlikely to lead to infection if host immunity is not compromised (Hoffman 2001). Many countries do not have formal regulations regarding skin disinfection for needling procedures (Dommerholt 2011). The National Acupuncture Foundation recommends disinfecting the skin with 70% isopropyl alcohol prior to needling (Given 2009). The British Acupuncture Council Code of Safe Practice recommends to use 70% isopropyl alcohol or products which contain 0.5% chlorhexidine before needling in 'areas of the body where moisture or exudates may collect, such as the groin and genital area, ears, feet, under arms and the area below the breasts, near the mouth, nose, scalp and other hair covered areas'. In contrast, Dutch guidelines (WIP 2008, Dommerholt 2011) in line with WHO, do not recommend to disinfect the skin, with the exception when using semi-permanent needles or performing ear acupuncture. If the skin is visibly soiled it should be washed with warm water and soap and dried accordingly prior to DN. Clinicians should not needle into joints or bursae. During DN the clinicians should only touch the needle at the handle and should avoid touching the needle shaft. If this occurs the needle should be removed, disposed of and replaced with a fresh sterile needle. Similar practice should be applied if the needle lies onto the patient's skin. Multi-pack needles are not recommended for DN as their use increases the likelihood of touching the needle shaft.

Immunocompromised patients may not be suitable for DN and special consideration is required. If DN is considered suitable, skin preparation with a sterilizing solution such as 2% iodine in 70% alcohol should be used and left on the skin to dry for a minimum time of 2 minutes (ASAP 2007).

Needle and medical waste disposal

Needle and medical waste disposal should be done in accordance with local jurisdictional policies and procedures. Clinicians should be knowledgeable with local laws and regulations as standards differ internationally. In the US, regulated medical waste is material derived from animal or human sources or from biomedical research as described by UN-3291 (USDA 2009). All sharps and blood or bodily fluid soiled waste from DN needs to be disposed of in suitable waste disposal per local jurisdictional policies. Used needles are disposed of in a regulated 'sharps container' meeting regulatory standards such as UN-3291. Medical waste, such as soiled gloves or blood swabs (but no sharps objects), is placed in a suitable clinical waste bag. Both sharps containers and clinical waste bag should be disposed in accordance with local laws and procedures, which may entail the use of a licensed medical waste company.

Workstations should be designed to ensure 'sharps containers' and medical waste bags are within easy reach. Follow the instructions in relation to 'sharps containers' and do not fill above the permitted 'fill line' as this may pose a risk of NSI. Ensure such items are kept out of reach of children.

Needle stick injury

NSI is a common occupational injury amongst HCWs. In the UK, 37% of nurses reported a prevalence of NSI (Yang & Mullan 2011). In Ireland, medical interns reported a 26% incidence of NSI in the first 8 months of work with only 26% commonly using gloves in phlebotomy-like tasks (O'Sullivan et al. 2011). US based medical students reported a 59% NSI rate during their training (Sharma et al. 2009). It has been estimated that over 20 bloodborne pathogens can be transmitted from contaminated needles including hepatitis B (HBV), hepatitis C (HCV) and human immunodeficiency virus (HIV) (Yang & Mullan 2011) and therefore NSI creates a serious risk for HCWs. Surprisingly, NSI's commonly go unreported. In one study only 17.5% of incidences were reported (Hettiaratchy et al. 1998). The associated risk of infection transmission of HIV following a hollow needle NSI is about 0.3%, compared with 3% for HCV and 30% for HBV (Parsons 2000). Exposure risk increases with a larger quantity of blood, for example when the needle is visibly contaminated with the patient's blood (Rodts & Benson 1992). Furthermore, hepatitis B virus can survive for 1 week in dried blood, which underpins the importance of good hygiene techniques and needle and waste disposal (Bond et al. 1981). Other factors that increase NSI infection transmission include piercing deeply or directly into an artery or vein with the contaminated needle (CDC 1995). The risk of NSI infection with a solid filament needle would be expected to be less than a hollow needle; however, NSI risk should be taken seriously. If a NSI occurs, the USCDC recommends immediately washing the punctured area with soap and water, reporting the incident to the appropriate line manager, and seeking medical assessment as soon as possible (CDC 2011). HCWs should have hepatitis A and B vaccinations as required.

To prevent NSI related to DN practice, clinicians should account for *all* needles and ensure adequate disposal into the sharps container. Keep the sharps container within easy reach of the treatment area, and do not overfill the box. Avoid rushing, interruptions and do not needle when tired. Gloves should be worn – though they may not fully protect against a NSI, they may offer some level of protection, especially from contact with blood and bodily fluids.

The risk of NSI may extend to patients, patient family members, visitors, and other staff from a lost or forgotten needle and clinicians should ensure all needles are accounted for, safely discarded and that workstation design and access minimizes risk to third parties.

Contraindications and precautions

It is important to recognize contraindications, relative contraindications and special precautions for safe DN practice (WHO 1999, Batavia 2006, ASAP 2007, White et al. 2008). Patients should be routinely screened for current or historical presence of contraindications or precautions. Special attention should be paid to medical diagnoses and comorbidities (e.g. a patient with low immune function and history of diabetes). Further, when a contraindication is present, it is important that the clinician is not persuaded to needle by an enthusiastic patient (White et al. 2008).

Absolute contraindications

DN therapy is contraindicated and should be avoided in patients under the following circumstances (ASAP, 2007; White et al., 2008):

1. In a patient with needle phobia.
2. Patient unwilling – fear, patient belief.
3. Unable to give consent – communication, cognitive, age-related factors.
4. Medical emergency or acute medical condition.
5. Over an area or limb with lymphedema as this may increase the risk of infection/cellulitis and the difficulty of fighting the infection, if one should occur (Filshie 2001, Goodman et al. 2003).
6. Inappropriate for any other reason.

Relative contraindications

When absolute contraindications have been ruled out, clinicians should consider the relative contraindications and precautions for patient selection. This should be done in relation to the patient's characteristics and medical history, clinical reasoning, likely benefits of treatment, and whether the goals can be met with non-invasive treatments. It is the clinician's responsibility to discuss the relative risks and benefits of DN therapy with patients (White et al. 2008).

Abnormal bleeding tendency

Bleeding and bruising are among the most common side-effects of needling therapies. Therefore caution should be noted with patients with thrombocytopenia for any reason (e.g. hemophilia, blood thinning medication etc.). These patients may not be suitable for DN other than by experienced clinicians, or light needling technique may be advisable initially as a trial. It is essential to apply pressure hemostasis after needling.

Compromised immune system

Patients with a compromised immune system for any reason may be more susceptible to infection and therefore be at a greater risk of local or systemic infection from DN (ASAP, 2007; White et al., 2008). Patients who may be vulnerable to infection include:

1. Disease related immunocompromised patients (e.g. blood-borne diseases, cancer, HIV, hepatitis, endocarditis, incompetent heart valve or valve replacements etc.).
2. Immunocompromised patients from immunosuppression therapy (e.g. drug cancer therapy).
3. Acute immune disorders (e.g. acute states of rheumatoid arthritis, current infection – local or systemic etc.).
4. Debilitated patients and those with chronic illness, among others.

Vascular disease

Patients with vascular disease may be more susceptible to hematoma, bleeding, tissue trauma, infection, among others.

Diabetes

Patients with diabetes may have compromised tissue healing capabilities, sensory deficits, and poor peripheral circulation. Patients with diabetes may be more susceptible to cellulitis (Goodman et al. 2003). The presence of diabetes may influence the decision to needle or which needling techniques to use, e.g. SDN versus TrPDN, and may determine the intensity of the treatment.

Pregnancy

The use of DN therapy during pregnancy needs to be discussed thoroughly with the patient and should be used with caution especially in the first trimester (ASAP 2007). Clinicians should be aware that 20–25% of pregnancies may naturally terminate in the first trimester (ASAP 2007) and therefore erroneous connections between such occurrences and DN are possible. There is conflicting opinion of the ability of acupuncture to induce labour or spontaneous abortion (WHO 1999, ASAP 2007, White et al. 2008). In a controlled trial of women with pregnancy-related nausea (n=593), acupuncture in early pregnancy did not alter the pregnancy outcomes or health of the child (Smith et al. 2002). The European

Guidelines for the Diagnosis and Treatment of Pelvic Girdle Pain (2005) consider the use of acupuncture for low back and pelvic pain during pregnancy (Vleeming et al. 2008):

1. Contraindications, precaution, risks and benefits of treatment are considered in the usual manner.
2. Education and informed consent are of significant importance.
3. It is wise to avoid strong treatment that may threaten the patient.

Children

In addition to gaining informed consent from persons under 18 years old, parental or guardian consent must be sought when treating children under the age of 18. Follow local laws in regard to consent issues. Ensure that younger patients do not have a needle phobia and are cooperative to the procedure. It would be judicious to avoid deep DN with children under the age of 13–15, dependent upon the maturity of the child, due to the ability to understand and follow the procedure.

Frail patients

Infirm or frail patients may not tolerate DN therapy well.

Patients with epilepsy

In patients with epilepsy, caution should be taken due to tolerance of strong sensory stimulation. Patients with epilepsy should not be left unattended when needles are in situ.

Psychological status

Some patients with psychological disorders or distress may not be optimal candidates for DN. Anxiety and emotional distress may impact on the ability to safely apply DN and for patients to rationally understand, tolerate treatment or follow treatment instructions. High stress may reduce the likelihood of response to treatment (Huang et al. 2011) and may increase risk of adverse psychological or physical response to DN.

Patient allergies

Patients allergic to metals may react to metals used in monofilament needles, particularly to nickel and chromium (Romaguera & Grimalt 1979, Fisher 1986, Castelain et al. 1987). A typical monofilament needle contains approximately 8–10% nickel and 11% chromium. Relevant risks should be discussed with the patient prior to treatment. Allergic reactions to needles are relatively rare. DN treatments can still be administered by using silver- or goldplated needles. DN should be discontinued if allergic reactions still occur. Allergies to latex, as found in latex gloves, are possible and alternative gloves should be used for these patients. Latex allergies can be severe. Nitrile gloves are generally better tolerated, but some patients and HCWs may still have allergic reactions.

Patient medication

Clinicians should be aware of a patient's medical and medication history. Medications may alert the clinician to relative contraindications and may include immune suppressive drugs, psychotropic or mood altering medication, and blood thinning agents, among others.

Unsuitable patient for any reason

The clinician is privy to the overall patient characteristics and should identify other potential contraindications or safety precautions that may impact on the suitability of DN. Patient characteristics may change and clinicians need to remain cognizant of this. If there is a specific reason to suggest a patient is unsuitable for DN therapy, then DN should be avoided and reconsidered as appropriate.

Anatomical considerations

Dry needling poses potential risks to anatomical structures including organs, such as the lungs, nerves and blood vessels. Clinicians require excellent academic and practical knowledge of anatomy. All serious needling related traumatic complications, described by Peuker and Gronemeyer (2001), could have been avoided if clinicians had better anatomical knowledge or had applied existing anatomical knowledge better. It is imperative that practical anatomy skills are applied as part of routine DN practice. Clinicians should ensure they limit DN to anatomical regions they are familiar with and have been trained in. Furthermore, it may be wise when first practicing DN, to limit treatment to one side of the thorax only to prevent the unlikely but catastrophic effect of bilateral pneumothorax. Anatomical considerations include:

Pleura and lung

Pneumothorax is a rare, but serious complication of DN and has been reported in the acupuncture literature (Peuker & Gronemeyer 2001, Melchart et al. 2004, Peuker 2004, Witt et al. 2009). The risk of pneumothorax is very small if proper consideration of practical anatomy and application of needling techniques are employed. Consideration of pleural and lung anatomy is essential and clinicians should remain aware of anatomical landmarks (Standring & Gray 2008).

DN should be performed in such a manner to avoid needling towards the lung or intercostal space. When able, a pincher grip should be used such as with needling TrPs in the upper and lower trapezius, pectoral muscles, levator scapulae, and latissimus dorsi muscles. A second consideration is to needle towards bone, such as the rib or scapula, to avoid needling into the pleural space. With this technique it is vitally important to ensure the hand placement over the bone, to avoid inadvertently entering the pleura. Clinicians should remain aware of anatomical anomalies. A third option, when a pincher grip and needling over bony structures is not feasible, is to block the intercostal space with the fingers of the palpating hand, for example, when needling TrPs in the serratus anterior or rhomboid muscles.

The risk of pneumothorax is very rare when needling is practiced by well-trained clinicians skillfully applying practical anatomy.

Blood vessels

Anatomical knowledge of the vascular system is important as there is a potential to puncture blood vessels during needling. Application of practical anatomical knowledge is important. Clinicians should inspect for location of superficial veins and avoid needling these. Palpating for a pulse, where accessible, may be helpful to locate an artery. Hemostasis is important after withdrawing the needle. Special attention and caution should be paid to those with thrombocytopenia (see section above).

Nerves

Anatomical knowledge of the nervous system is important as there is a potential for injury to nerves. Needling should be performed slowly and carefully and when not sure, should be avoided in the vicinity of nerves. If a sharp electrical-type pain is felt distally from the needling site, the needle may have encountered a nerve. Special attention needs to be given in relation to the spinal cord (Yazawa et al. 1998, Lee et al. 2011) and the posterior suboccipital area due to potential brainstem access through the foramen magnum (Nelson & Hoffman 1998).

Organs

Anatomical knowledge of internal organs is important as there is potential for internal organ penetration such as the kidney with needling of TrPs in the psoas major and quadratus lumborum muscles or organs within the peritoneal cavity with needling of TrPs in the abdominal muscles.

Joints

Anatomical knowledge of joint anatomy, including capsule and bursa, is important to avoid needling into joints through the joint capsule or bursae, and causing joint infection.

Prosthetic implants

Clinicians should avoid needling into or close to joint or limb prosthetics, including internal and external fixation devices to avoid any kind of infection.

Implanted devices

Clinicians should avoid needling in the vicinity of implanted devices, including catheters, drug delivery systems, breast, buttocks, calves, and other implants, electrical devices and wires associated with such devices as spinal cord stimulators, pacemakers, and defibrillators.

Other

Clinicians should avoid needling into pathological sites such as areas with acute inflammation or infected sites, varicose veins, cysts, tumors and skin lesions, etc.

Procedural safety issues

As DN is an invasive procedure it raises the potential for procedural adverse events. Recognizing the potential for these adverse events is important.

Patient education and communication are central to good needling practice. Patient education is carried out prior to, during, and after DN. Though obvious, it is worth stressing that patients should not carry out DN on themselves.

Painful treatment

Post treatment soreness (PTS) from DN is common for 1–2 days after treatment. On occasion this may prolong to 3–4 days. This is common with TrPDN and unlikely with SDN. PTS is usually felt in the vicinity of the needled site and may at times be felt in the referral zone of the muscle. PTS may feel similar to delayed onset of muscle soreness following exercise. Patients should be educated on PTS and be prepared to avoid unnecessary distress and worry. DN should be carried out to the patient's tolerance and ability by monitoring the response by verbal and non-verbal communication. Do not encourage patients to tolerate pain during DN. Also, consider limiting the number of muscles treated initially to test the patient's response. Timing of treatment should suit patient's lifestyle, work and social commitments. As an example, consider the issues surrounding the application of DN to a needle naive athlete prior to a sporting event or a musician prior to a recital.

On the initial insertion of the needle under the skin, if the patient experiences sharp continuing pain the needle should be withdrawn and inserted again slightly away from the original site. It is likely that the needle is in close vicinity of a free nerve ending and provides an Aδ sensory nerve stimulus. If the patient feels a sharp, burning electrical or lancing pain, penetration of a nerve or blood vessel may have occurred. The needle should be withdrawn immediately and hemostasis by manual pressure should be applied for at least 30 seconds. This may attenuate muscle bleeding and therefore PTS. Consider the use of thermal modalities, active pain free range of motion, stretching, muscle re-education, and posture training after treatment as DN is usually part of a multimodal plan of care.

Bruising and bleeding

Bruising is a common side-effect of DN, which patients should be made aware of. Care should be taken to avoid penetrating blood vessels. Hemostasis by manual pressure is important after DN and this may assist in reducing bruising and PTS. If bleeding occurs on the skin site, pressure with a cotton swab until stopped and discard the swab in medical waste disposal as appropriate. An ice application can be used over the site.

Fainting and autonomic responses

Fainting during or after DN treatment is possible and may occur for a variety of reasons such as pain, psychological stress, needle averse or phobic patients, or autonomic lability. It is therefore important to treat the patient in a recumbent position. In patients with needle aversion, DN is contraindicated, unless the patient can be educated and coached into tolerating needling. If DN is experienced as a threatening stimulus, it is no longer therapeutic. SDN may be the initial choice of treatment. Avoid aggressive DN technique and maintain verbal and non-verbal communication with the patient to assess response. Watch for autonomic signs including clamminess, sweating, dizziness, increased tension, and light-headedness, among others. If these symptoms occur or the patient faints, remove the needle(s) and consider raising the patient's legs. Offer reassurance. Symptoms should abate after resting. If symptoms were to persist or if there is any concern about the patient, driving a car should be delayed and the patient may require medical assessment. Such responses will impact on the decision to carry out DN in the future.

Needle issues

Needles should be of good quality and used before the printed expiration date. Needles may bend, break or be forgotten about. These adverse procedural issues can easily be avoided. Needles should be of suitable thickness and length to suit the patient and area being treated.

Bending of the needle may occur from contacting harder tissue such as bone, fascia or a stiffened TrP zone or from a non-optimal needling technique by curving the needle. Patients should be needled in a relaxed and optimal position. Avoid curving the needle during dynamic DN techniques. If a needle bends, it should be removed and discarded and replaced with a new needle.

Needle breakage is rare, but may occur with poor quality needles or from repeated bending due to poor needling technique. In the past, when needles were sterilized repeatedly with autoclaving, needle breakage may have been more common due to metal fatigue. Therefore, good quality single use sterile needles should only be used for DN. It is recommended to avoid inserting the needle to the handle so that in the event of a breakage at the hub, the needle can be removed by tweezers. In the unlikely event of needle breakage, inform the patient to stay still and remove the needle with fingers or tweezers if accessible. If not visible, press the surrounding tissues gently to see if the needle exposes through the tissue, and if so, then remove with tweezers. If not, mark around the site of insertion with a marker or pen to locate the needle site and seek medical attention as the needle may or may not require surgical removal.

Clinicians should account for all needles used. A forgotten needle could cause tissue damage such as pneumothorax. This is more likely with static needling techniques and especially if treating several body areas simultaneously. It is advisable not to rush to avoid time pressure mistakes. Consider using a 'count them in, count them out' policy aloud. Doing this is useful to the clinician and reassuring to the patient. Tally needle packets with needles withdrawn.

There is differing opinion on whether a needle may be used more than once on the same patient in a treatment session (Dommerholt 2011). The US National Acupuncture Foundation recommends never reusing a needle on the same patient in the same treatment session to avoid autogenous infection (Given 2009). In contrast the British Acupuncture Council Code of Safe Practice advises to 'use a fresh needle for every point needled during a treatment, or if reusing the same needle, only do so where all of the sites to be needled have been swabbed before needling and where the needle (and guidetube, if used) is not placed on any other surface in between separate insertions'(BAC 2006). In this regard, clinicians should be guided by local jurisdictional rules and regulations.

Forgotten patient

If using a static needling technique and leaving the patient alone in a treatment room or cubicle, it is important not to forget the patient. Patients with needles in situ are unable to move and therefore are vulnerable. Be sure that the patient has the ability to alert the clinician verbally or with the use of a call bell. Clinicians should delineate procedures to avoid this stressful and embarrassing situation.

Infection

Due to the invasive nature of DN there is a risk of infection, though small. Clinicians should follow hygiene guidelines as outlined in the above section and appropriately select the patient. Prior to DN, the area and skin should be inspected for any signs of infection prior to initial and follow-up treatments. Infection signs may include pain, swelling, redness, heat and tenderness, and may be associated with fever and malaise. DN should be avoided with any suggestion of local or systemic infection and medical assessment sought immediately.

Pneumothorax

When needling in the vicinity of the thorax and lung fields, it is important to be aware of the rare, but potential risk of pneumothorax. This has been discussed in the above section under anatomical considerations. The symptoms of a pneumothorax may include shortness of breath, chest pain, coughing, and decreased breath sounds on auscultation or percussion. Pneumothorax symptoms may not occur for several hours after treatment. Should a pneumothorax be suspected, the patient should urgently be sent to the nearest emergency department.

Drowsiness and fatigue

A small percentage of patients may report feeling tired, fatigued or sleepy after DN. Should this occur the patient should be advised not to drive or operate machinery until this feeling has subsided. In individual patient's, if there is a history of DN-related drowsiness or fatigue, it may be best to avoid DN or when appropriate to time treatment around the patient's lifestyle. It would be important for the patient to have somebody to drive him/her home.

General guidelines for principles of practice

This section presents general guidelines for principles of practice. There are many factors relating to safe needling practice. Individual jurisdictional rules and regulations may have specific requirements and these should be taken into account when drafting local DN guidelines. The following guidelines are therefore offered as a general outline. Ultimately the responsibility of patient care solely rests with the individual clinician.

General guidelines

The following general recommendations are advised: (McEvoy et al. 2012)

1. Clinicians should ensure that DN falls under the scope of practice of their profession e.g. physical therapy, chiropractic, etc.
2. Clinicians should follow the rules of professional conduct of their professional organization and be guided by practice guidelines and ethics.
3. Clinicians should confirm they are insured for the practice of DN and remain insured.
4. Clinicians should ensure that DN teaching programs meet the requirements for practicing within their jurisdiction.
5. Clinicians should confine themselves to DN practice in body areas they have been trained during appropriate post-graduate training.
6. Clinicians should stay up-to-date with research and trends in DN practice and meet the continuing professional development requirements for their jurisdiction.
7. Clinicians should ensure they have informed consent from patients before DN therapy. Again, clinicians should follow local professional policies and procedures related to informed consent.
8. Clinicians should implement local guidelines as applicable when practicing DN.
9. Clinicians should recognize they are responsible for patient welfare and maintain high safety standards at all times.
10. Clinicians should complete an appropriate clinical assessment prior to DN and ascertain whether DN is suitable for the individual patient and the condition to be treated. Contraindications and safety precautions should be noted and DN should be avoided as appropriate.
11. Clinicians should practice DN in a sensible and reasonable manner and apply professional judgment and adequate patient selection criteria (see appropriate section).
12. Clinicians should consider DN therapy as part of a comprehensive rehabilitation program and recognize the importance of correcting perpetuating factors. Multimodal and multidisciplinary care may be required to address the complexities of patient presentations. Furthermore, clinicians should remain aware of other treatment options that may be appropriate and discuss the treatment approach and options with the patient as part of the informed consent process.
13. Clinicians should consider DN in the light of evidence-informed practice, scientific research, clinical reasoning, and patient goals (Cicerone 2005).
14. Clinicians should comply with best practice hygiene practices such as standard precautions (Siegel et al. 2007, HSE 2009) and any other additional requirements of the local jurisdiction and employer or local workplace policy.
15. Clinicians should comply with waste disposal rules and requirements for needles and body fluid and blood contaminated waste for their local jurisdiction.
16. Clinicians should comply with occupational requirements set out in safety health and welfare at work acts and policies and procedures for their local jurisdiction.
17. Clinicians should comply with best practice requirements for the management of NSI and adverse reactions and comply with local policies and procedures for their jurisdiction.

Patient selection

Choosing the correct patient for TrP-DN is a skill, based upon balancing the benefits of treatment with the patient's characteristics and presentation. The selection criteria may vary from patient to patient and in various situations and contexts. One of the fundamental safety principles is understanding the patient's contraindications and precautions to particular treatments and understanding the potential dangers (Batavia 2006). Healthcare clinicians, such as physical therapists, routinely use patient selection and clinical reasoning skills in practice to enhance safe practice. As an example, consider the selection criteria for the use of neck traction, manipulation and use of electro-physical agents, such as ultrasound etc. Many of these skills are developed throughout the physical therapist's training program and further enhanced from experience in clinical practice.

Patient selection criteria for TrP-DN have been recommended by the College of Physical Therapists of Alberta (CPTA), Canada (CPTA 2007).

Appropriate patient selection should involve consideration of the following:

1. The patient's physical therapy diagnosis and dysfunction.
2. Expectation of a reasonable benefit from DN therapy.
3. The patient's medical conditions and history and recognize conditions that require precaution or contraindication (e.g. pregnancy, low immune dysfunction, blood thinners, needle phobia).
4. The patient's ability to understand the rationale for treatment, give informed consent, provide feedback and communication to the therapist, and be able to follow instructions (e.g. lying still).
5. Capacity for the safe application and management of precautions and side-effects.

Furthermore the CPTA recommends consideration of patient characteristics including the patient's cultural background, functional and physical abilities, language and communication skills, and psychological profile (example fear of needles, stress response), and age (CPTA 2007). As an example of the importance of patients' disease characteristics and demographic profile, a study for TrP-DN for myofascial pain syndrome, demonstrated that negative prognostic predictors included long duration of pain, high intensity of pain, poor quality of sleep, and repetitive stress (Huang et al. 2011).

Principles of dry needling application

DN is a learned skill and standards and safety are promoted by routine approach to practice. This section outlines principles to promote a rational and uniform approach to practice. These principles can be modified to develop guidelines, policies and procedures. It is assumed that the clinician has selected the patient appropriately and determined that DN is appropriate. The principles of DN application include patient education and consent, procedural education, and practical application, such as positioning, palpation, technique, and after-care (McEvoy et al. 2012).

Patient education and consent

Prior to the application of DN, it is important to educate the patient on the rationale for the procedure and what to expect. The clinician should ascertain whether the patient has undergone DN therapy in the past, and if so, what was their personal experience? Informed consent should be sought from each patient. This is an excellent time for the clinician to make the patient feel at ease by demonstrating knowledge and confidence. Clinician confidence is important to reduce patient anxiety. The clinician can also gauge the patient's comfort level and answer patient's questions. Appropriate education should include elements of the following:

1. Explanation of the indication and aim of treatment.
2. A brief explanation of how the chosen DN technique potentially works (e.g. SDN or TrP-DN)
3. Explanation that DN is an invasive procedure with insertion of a monofilament needle into the skin, subcutaneous tissues and muscle as appropriate.
4. The risks of DN therapy should be clearly explained to the patient as appropriate, thus allowing the patient to offer informed consent. This should be done in such a manner to impart knowledge to the patient, but avoid instilling fear of the procedure. The patient should be informed that single use disposable needles will be utilized during treatment. Local jurisdiction informed consent policies and procedures must be followed.
5. The patient should be informed of post treatment soreness as this may be common at the local needling site for several days after treatment.
6. The patient should be given the opportunity to ask questions.
7. Persons under 18 should also have informed consent from a parent or guardian. Clinicians should follow local jurisdiction rules.
8. Patient education should outline that DN when administered by a clinician does not constitute the practice of acupuncture unless the clinician is an acupuncturist or is qualified to deliver acupuncture within the jurisdiction.

Procedural education

DN requires an optimum interaction between the patient and clinician and communication should be encouraged during the procedure. Prior to any DN application the following steps are recommended:

1. The patient is asked and encouraged to provide feedback and communicate with the clinician during treatment.
2. The patient is asked to remain still during the procedure.
3. The patient is aware that he can withdraw from treatment at any time.
4. In the case of TrP-DN, the patient should be made aware of the local twitch response (LTR) which may be perceived similar to an electric shock, cramp, or other sensation. The patient should be made aware that reproduction of the LTR is the aim of TrP-DN.
5. If static needling technique is employed, where the needle is statically in the muscle for a period of time, the patient should be informed not to move, as this may pose a risk of further penetration and tissue damage, such as a pneumothorax, etc.
6. If the patient is left resting during static needling technique, the patient should be able to call or alert the clinician easily.
7. Any further education or advice before, during or after treatment that may be important for an individual patient, should be given as part of the overall plan of care.

Practical application

Positioning

1. The patient should be treated reclined to avoid difficulty if fainting should occur.
2. The patient should be positioned suitably to allow easy palpation and access to the muscle(s) being treated.
3. Positions may include supine, prone, side-lying or a combination of these positions. It is important that the patient is comfortable and relaxed. Pillows or rolls etc. can be used for positioning.
4. It is helpful to be able to see the patient's face, but this may not always the possible. Verbal communication should be ongoing to assess the patient's response to DN procedures.
5. Clinicians should position themselves ergonomically, comfortably and ensure good body mechanics to reduce the risk of work related disorders and to assure that they are in control of the DN process.
6. Parents and guardians of children, or care takers and other individuals accompanying the patient, should be comfortable during DN procedures. It is not uncommon to see fainting or other autonomic symptoms in on-lookers when observing DN.

Palpation

Skilled palpation is the key element for identifying TrPs and for the application of safe DN. Clinicians should have excellent knowledge of practical anatomy including: muscle attachments, bony landmarks, muscle fiber directions, muscles layers, neurovascular structures, organs (e.g. pleura and lungs), joints and capsules etc.

1. The muscle(s) being treated along with anatomical landmarks should be located by skilled visual observation and palpation.
2. The clinician should be cognizant of other anatomical structures that need to be avoided including neurovascular structures, lungs, etc., and should at all times aim to avoid needling into these structures.
3. The TrP is identified by skilled palpation using relevant criteria (Simons et al. 1999, McEvoy & Huijbregts 2011) and the muscle is positioned to allow optimal tension for palpation and treatment. The muscles can be contracted to assist in locating fiber direction and differentiating from other muscles etc.
4. Flat palpation or pincer grip techniques are used as indicated. For safety, pincer grip is likely to improve safety and is preferable when appropriate. Should the clinician's hands be removed from the patient to prepare the needle, the muscle and bony landmarks should be identified again.
5. Ensure that the patient and muscle is relaxed before starting the DN procedure.
6. Should the clinician not be sure of the needle tip location or is unsure of the topographical anatomy, DN should be avoided. This could occur for example in obese patients. When in doubt, stay out.

Technique

There are various DN conceptual models and techniques and clinicians may use a combination of techniques during clinical practice. Equipment required includes needles, gloves, handsanitizer, alcohol wipes (as required), needle disposal box, cotton swabs for bleeds, and a waste disposal bag or can. General guidelines for technique are as follows:

1. Single use, sterile, suitable monofilament needles are employed. Needles should be high quality and may be tubed or untubed. We recommend to DN with tubed needles only as they reduce the risk of touching the needle shaft and the likelihood of painful needle insertion. Needles should be stored and used per the manufactures guidelines and be within date. Needle length and thickness is chosen on the basis of patient size, muscle to be needled and expected depth of penetration. When choosing needle length, clinicians should bear in mind that needles should not be inserted all the way to the handle.
2. A hygiene protocol is carried out as previously recommended and gloves are worn on at least the palpating hand or, if so preferred or required, on both hands.
3. The muscle being needled is identified and a flat or pincer grip technique is employed by the palpating hand. The needling hand holds the needle by the handle only.
4. The needle is inserted across the skin using the guide tube. The guide tube is then removed. The needle shaft should not be touched to prevent contamination.
5. The clinician should be cognisant of anatomical structures within the treatment area that are vulnerable to DN, e.g. neurovascular structures and the lung, and ensure that the needling technique avoids penetration vulnerable anatomical structures. Also, voluntary and involuntary patient movement may compromise safe DN, which is why the needling hand should always rest on the patient's body.
6. For SDN the needle is inserted to the depth for superficial needling as has been recommended by Baldry (2002, 2005) (see Ch. 12) or to a depth to engage the TrP in TrP-DN.
7. TrP-DN involves a relatively slow but deliberate steady lancing motion in and out of the muscle, which is considered a dynamic needling technique (Simons et al. 1999, Dommerholt et al. 2006). The needle is brought out to the edge of the myofascia into the sub-dermal tissue and moved back into the muscle. The main aim of this treatment is to elicit LTRs.
8. Sharp pain of a stinging, burning or electrical nature should be immediately avoided as this may signal penetration of a nerve or blood vessel.
9. DN techniques such as SDN or TrP-DN may involve static needle techniques, where the needle is left in situ for a period of time. In this case, the needle may be rotated to induce mechanical stress on the fascia or myofascia. When static needling is employed, the clinician should ensure the needle is safe at rest and not in the close vicinity of vulnerable anatomical structures. Patients should be informed to stay still and not to move. They should be able to alert the clinician as needed either vocally or by the use of a call bell. Policies should be in place to avoid forgetting a patient in a treatment room (White et al. 2001).
10. It may be acceptable that an individual needle may be withdrawn and reinserted across the skin of the same patient at the same treatment session. Clinicians should follow local policies and procedures on this practice. Again, touching the needle shaft should be avoided to prevent contamination of the needle and if this occurs the needle should be disposed of and a new needle used. Needles may become blunt from piercing soft tissue and contacting bone and in this case a new needle should be employed. Of course, a used needle should never be stored or reused.
11. The clinician should actively communicate with the patient during DN and limit treatment to the patient's tolerance. The patient should be reassured throughout the procedure. This is most important for the initial treatment for a new 'needle naïve' patient.
12. DN technique should suit the tolerance and ability of the patient. Considerations for technique include SDN vs TrP-DN, the quantity of lancing motions, intensity and speed of the lancing motion, stimulation and quantity of local twitch responses, the length of time of active needling, static needling technique, the number of needle insertions per muscle and the number or muscles treated in one session, etc. The patient's characteristics will determine much of the approach and the patient's previous experience and response should be taken into account. The patient's perceived experience of a medical treatment is related to the intensity of the pain and the pain experience within the

last 3 minutes of the procedure, therefore the treatment session should not be terminated with painful procedures (Redelmeier & Kahneman 1996, Redelmeier et al. 2003, McEvoy & Dommerholt 2012).

13. When needles are withdrawn, they should be immediately disposed of into a suitable certified 'sharps container'. Sharps containers should be filled only to the fill-line mark and should be within easy reach. Sharps containers should be disposed of per local policies and procedures with a licensed medical waste removal company or agent etc.

Aftercare

The following is recommended for DN aftercare:

1. The muscle and treatment area needled should be compressed immediately following needle withdrawal for hemostasis for up to 30 seconds or until any bleeding has stopped. A cotton swab may be used and should be discarded as appropriate.
2. If blood is present on the skin it should be cleaned with an alcohol swab, which should be discarded as appropriate. The patient should be educated on aftercare which may include limbering exercises, gentle stretching, the use of hot packs or cold packs, activity modifications, and motor retraining, as deemed necessary.
3. Any adverse reactions should be dealt with as noted in the previous sections.

Electrical stimulation via dry needles

Electrotherapy, such as transcutaneous electrical nerve stimulation (TENS), percutaneous electrical nerve stimulation (PENS) and neuromuscular electrical stimulation (NMES) can be delivered via solid filament needles for the treatment of pain, abnormal muscle tone or strengthening. Techniques have been described by Gunn (1997), Baldry (2005), White et al. (2008) and Dommerholt et al. (2006). In acupuncture delivery of electrical currents through needles is termed electro-acupuncture (ASAP 2007). Extra care should be noted with patients who have bleeding disorders as DN TENS or NMES related muscle contraction may lead to a greater susceptibility to bleeding. The following considerations should be taken into account: (ASAP 2007, White et al. 2008):

1. All contraindications and precautions for DN therapy and the individual electrical device used should be observed.
2. Use devices according to manufacturers' recommendations.
3. Use suitable single-use sterile metal-handle needles and attach the alligator clip of the electrotherapy device to the handle or directly to the shaft of a clean needle.
4. Do not connect electrical clips to contaminated needle shafts.

Contraindications, relative contraindications to electrical stimulation via DN include:

1. Patients not comfortable or phobic to either electrical stimulation or needling.
2. In the vicinity of implanted electrical devices, such as pacemakers, spinal cord stimulators (ASAP 2007, White et al. 2008).
3. Pregnant patients in the vicinity of the mid or low back, pelvis or abdomen.
4. In the vicinity of the anterior triangle of the neck, carotid sinus, vagus nerve, or in the vicinity of the recurrent laryngeal nerve (White et al. 2008).
5. In areas of sensory denervation (White et al. 2008).
6. Special caution should be used with persons with epilepsy.

Summary (Figure 4.1)

TrP-DN is an evolving and expanding treatment. Safety must be considered the number one priority. Clinicians should familiarize themselves with important aspects of DN safety including hygiene, contraindications, precautions, anatomical considerations, and procedural safety issues. Guidelines have been proposed to improve safe DN treatment. Patient selection and practical DN skills are required to ensure safe standardized treatment. Clinicians should encourage local jurisdictional guidelines to improve safety and standards.

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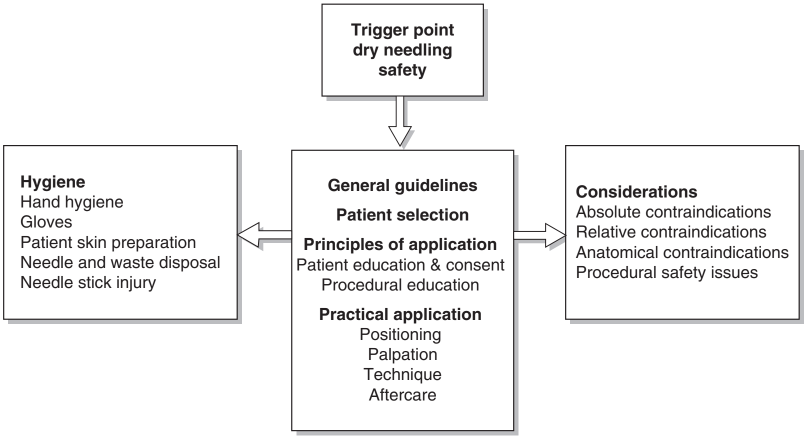

Figure 4.1 • Trigger point dry needling safety – overview.

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Professional controversies and dry needling

5

Jan Dommerholt

CHAPTER CONTENT

Introduction: scope of practice

Dry needling is a treatment technique practiced around the globe by numerous healthcare disciplines, including allopathic, osteopathic, naturopathic, podiatric, veterinary, and also chiropractic medicine, acupuncture, physical therapy, dentistry and massage therapy, among others, dependent upon the country and local jurisdictional regulations (Dommerholt et al. 2006). Dry needling, like many other treatment techniques, is not in the exclusive scope of any discipline (Dommerholt 2011, APTA Practice Department and APTA State Government Affairs 2011). A chiropractor or physical therapist who employs dry needling is practicing chiropractic or physical therapy, respectively. Uneducated patients may occasionally refer to dry needling by a physical therapist as a form of acupuncture, but they should be informed that only acupuncturists are practicing acupuncture. Similarly, some patients may assume that all spinal manipulations are chiropractic interventions, not realizing that manual physical therapists and osteopathic physicians also employ spinal manipulative interventions (Paris 2000). A technique does not define the scope of practice and no profession actually owns a skill or activity in and of itself (Association of Social Work Boards et al. 2009).

Scope of practice is generally defined as the activities that an individual healthcare provider performs in the delivery of patient care. Overlap in scope of practice is recognized by many healthcare disciplines, ranging from medical radiation technologists (QSE Consulting 2005) and nursing (Committee on Health Professions Education Summit 2003, Association of Social Work Boards et al. 2009) to physical therapy, social work, occupational therapy (Association of Social Work Boards et al. 2009, Adrian 2010, APTA Practice Department and APTA State Government Affairs 2011), and medicine (Federation of State Medical Boards of the United States 2005, Association of Social Work Boards et al. 2009). The Federation of State Medical Boards of the United States defines scope of practice as 'those health care services a physician or other health care practitioner is authorized to perform by virtue of professional license, registration, or certification' (Federation of State Medical Boards of the United States 2005). According to the Federation, 'the concept of collaboration acknowledges that scopes of practice often overlap within the health care delivery system', which 'can

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be an effective means for providing safe and competent health care' (Federation of State Medical Boards of the United States 2005). The Federation recognizes that different healthcare professionals' scopes of practice may overlap and that different disciplines can collaborate based upon shared competencies. The Pew Health Commission Taskforce on Health Care Workforce Regulation emphasized that near-exclusive scopes of practice lead to unreasonable barriers to high-quality and affordable care (Finocchio et al. 1995). Even US state statutes recognize the importance of overlap in scope, for example, the South Dakota Codified Laws acknowledge that 'a nurse practitioner may perform [an] overlapping scope of advanced practice nursing and medical functions' (South Dakota Legislature 2011). The Attorney General of Maryland confirmed that 'state law recognizes that the scope of practice of health care professions may overlap…' and confirmed that the Maryland General Assembly 'has fostered consumer choice in the selection of treatment and practitioner' by providing for overlapping scope of practice for different healthcare disciplines (Gansler & McDonald 2010). To offer high-quality, affordable and accessible healthcare, it is crucial that all healthcare providers can practice within the full scope of their professional competencies (Safriet 1994, Schmitt 2001).

Acupuncture opposition to dry needling by non-acupuncturists

In the United States, acupuncture organizations have expressed growing opposition to dry needling performed by physical therapists, chiropractors, and other non-acupuncturists (Hobbs 2007, Hobbs 2011). Although initially, reputable acupuncturists supported dry needling by physical therapists (Seem et al. 1991), more recently, it has been suggested that dry needling would constitute the exclusive practice of acupuncture, which by definition can only be practiced by acupuncturists (Hobbs 2007, 2011). Although such exclusive interpretations of scope of practice do not necessarily benefit patients and may negatively impact the overall quality of healthcare (Finocchio et al. 1995), acupuncture organizations such as the American Association of Acupuncture and Oriental Medicine (AAAOM), the Council of Colleges of Acupuncture and Oriental Medicine (CCAOM), and the Illinois Acupuncture Federation (IAF), among others, have taken a firm stand and published position papers against dry needling by physical therapists (AAAOM 2011a, 2011b, Hobbs 2011). Twenty years after the Maryland Board of Physical Therapy Examiners approved dry needling by physical therapists in 1989, the Maryland Board of Acupuncture formally questioned the physical therapy board before filing an inquiry with the state's Attorney General.

A few medical state boards, which in some states regulate acupuncture practice, have also argued against dry needling by physical therapists and chiropractors, although their own professional Federation of State Medical Boards co-published a statement in support of overlap of scope of practice (Association of Social Work Boards et al. 2009). In a letter to the Oregon Board of Physical Therapy, the Oregon Medical Board claimed that 'dry needling' is a derivative of acupuncture and is defined by the World Health Organization (WHO) as 'acupuncture', although the WHO has never released any report on dry needling (Finklestein & Haley 2009). The WHO did confirm that 'making use of acupuncture in modern medical care means taking it out of its traditional context and applying it as a therapeutic technique for a limited number of conditions for which it has been shown to be effective, without having to reconcile the underlying theories of modern and traditional medicine' and 'some physicians or dental surgeons might wish to acquire proficiency in certain specific applications of acupuncture (for example, pain relief, or dental or obstetric analgesia) and for them flexibility would be needed in designing special courses adapted to their particular areas of interest' (1999).

In fairness, it appears that physical therapists may have contributed to the growing opposition. The inquiry with the Maryland Attorney General was triggered by a Maryland-licensed physical therapist, who filed a complaint with the Maryland Board of Acupuncture regarding an acupuncturist who allegedly practiced physical therapy without a license, because the practitioner used dry needling techniques. Many physical therapists have included statements in their marketing materials that 'dry needling is not acupuncture', which would be quite irritating to acupuncturists who are convinced that dry needling is in the exclusive scope of their practice. In a few older publications, I also stated erroneously that 'dry needling is not equivalent to acupuncture and should not be considered a form of acupuncture' (Dommerholt 2004, Dommerholt et al. 2006). Following Jane Goodall's advice that 'change happens by listening and then starting a dialogue with the people who are doing something you don't believe is right', I discussed these issues with several acupuncturists in various countries. Based on the feedback I received, I formally apologized and retracted those statements in an article published in the Qi Unity newsletter, a publication of the AAAOM (Dommerholt 2008). Sadly, in spite of my apology and correction, the CCAOM did not hesitate to reference my erroneous statements in their 2011 position statement (Hobbs 2011). In more recent publications, I have indicated that it is counterproductive and inaccurate to state that dry needling would not be in the scope of acupuncture, and that within the context of acupuncture, dry needling is a technique of acupuncture (Dommerholt 2011, Dommerholt & Gerwin 2010). But, as stated previously, dry needling is not in the exclusive scope of any discipline. It is physical therapy when performed by a physical therapist, chiropractic when performed by a chiropractor, and dentistry when performed by a dentist.

Non-acupuncturists, who use dry needling techniques, often contrast dry needling with Traditional Chinese Medicine (TCM), its meridians, flow of energy, and metaphysical theoretical concepts. From a Western medical perspective, dry needling has little if anything in common with TCM (Gunn 1998, Baldry 2005). Physical therapists who write on their websites that 'dry needling is not acupuncture' most likely have no knowledge of acupuncture and in many cases have not considered the issue. Yet, according to Janz and Adams, 'the relationship between the biomedical foundation of trigger point (TrP) dry needling and clinical practice describes a variation of classical acupuncture rather than the invention of a new therapy' (Janz & Adams, 2011).

The CCAOM believes that physical therapists have recognized the benefits of acupuncture 'and its various representations such as dry needling due to the fact that they are attempting to use acupuncture and rename it as a physical therapy technique' (Hobbs 2011). The AAAOM agreed that physical therapists are 're-titling' and 're-packaging' a subset of acupuncture techniques with the terms 'dry needling' and 'intramuscular manual therapy' (AAAOM 2011a). The IAF suggested that 'simply renaming and rebranding "Acupuncture" as "Trigger Point Dry Needling" does not make it a unique technique' (AAAOM 2011b). Janz and Adams (2011) also postulated that dry needling is a pseudonym for the practice of musculoskeletal acupuncture. While these arguments may make some sense from a narrow acupuncture point of view, they lack a more global perspective.

In the TCM treatment of pain TrPs are commonly referred to as Ashi points first described by Sun Si Miao in 652 CE (Janz & Adams 2011, 2011a). Although according to the AAAOM (2011a), TrP phenomena are well known to acupuncturists as Cummings mentions in Chapter 13 of this book, the theoretical backgrounds are quite different. Whether TrPs and Ashi points represent the same phenomenon continues to be an area of debate. From a dry needling perspective, acupuncturists may well be treating TrPs when needling Ashi points (Audette & Blinder 2003, Hong 2000); however, Seem argued that American acupuncturists usually do not 'treat tender or tight spots and, hence, never really achieve myofascial release in their recurrent and chronic pain patients' (Seem 2007).

Melzack and colleagues suggested a 71% overlap between acupuncture points and TrPs based on anatomical location (Melzack 1981, Melzack et al. 1977), but acupuncturist Birch concluded that Melzack et al. erroneously had assumed that local pain indications of acupuncture points would be sufficient to establish a correlation. Instead, Birch concluded that at best there is only an 18–19% overlap between acupuncture points and TrPs (Birch 2003). Dorsher (2006) disagreed with Birch and concluded that most acupuncture points do have pain indications and can be directly compared to TrPs. He concluded that out of a total of 255 TrPs, 92% had anatomically corresponding acupuncture points and nearly 80% of these acupuncture points had local pain indications similar to their corresponding TrPs (Dorsher 2006). In a reply, Birch (2008) insisted that the presumed correspondence between acupoints and TrPs is based on a misunderstanding of the nature of both kinds of points. Several acupuncturists described similarities in between the pathways of acupuncture meridians and common referred pain patterns of TrPs (Cardinal 2004, Cardinal 2007, Dorsher & Fleckenstein 2009).

One major flaw in comparing acupuncture and TrP locations is that the TrP locations reflect only the most common locations as observed by Travell (1952). TrPs occur near motor endplates distributed widely throughout muscles, which means that there many other potential TrP locations as any clinician familiar with TrP will readily confirm (Simons 2004, Simons & Dommerholt 2007). Because TrPs do not have fixed locations, any comparison between TrPs and acupuncture points based on anatomical location is inaccurate and subject to inherent error (Dommerholt & Gerwin 2010). As different schools of acupuncture have defined over 2500 acupuncture points, it is nearly impossible not to find topographical correspondences.

Hobbs (2011) clarified that acupuncture is not necessarily 'limited to its historical roots and centuries' old theory, but is also a dynamic, evolving modern medical practice, which incorporates the use of neuro-anatomical terminology'. In other words, acupuncture is not necessarily always based on or limited to Oriental medicine concepts, although the majority of US acupuncture state statutes define acupuncture in the context of 'Oriental medicine' or 'Oriental health concepts'. Since there are so many different schools of acupuncture around the world, it is not surprising that different interpretations and orientations have been developed (Ma et al. 2005, Seem 2007). In China alone are over 80 different acupuncture schools (Ma et al. 2005). The US National Commission for the Certification of Acupuncture and Oriental Medicine (NCCAOM) reported that 80% of diplomats in acupuncture practiced Traditional Chinese Medicine and less than 40% of practitioners practiced other approaches, such as 'auricular, laser, electroacupuncture, color puncture, and TrP therapy', among others (Ward-Cook & Hahn 2010). In 2003, only 3.7% of acupuncturists used TrP therapy as their primary practice tradition (Fabrey et al. 2003).

Considering the perspective of acupuncturists that TrPs are the same as Ashi points, and that dry needling is just a new name for an old technique, it is understandable that very few schools of acupuncture specifically include the assessment, identification, and dry needling techniques of TrPs (Seem 2007). The 2002 NCCAOM acupuncture examination included only one question related to TrPs and motor points (Fabrey et al. 2003). An online review of the curricula of US acupuncture school revealed only one US acupuncture school that mentioned TrP dry needling (Dommerholt, unpublished data).

Counter-arguments

In contrast to the acupuncture perspective, it is a fact that when Janet Travell developed the concepts of myofascial pain in the 1940s, she never considered the practice and concepts of acupuncture, nor was she aware of any previous medical descriptions of TrP phenomena (Travell 1949, Travell 1952). Chiropractor Nimmo was not aware of the acupuncture literature either, when he 'rediscovered' TrPs in the 1950s (Cohen & Gibbons 1998, Schneider et al. 2001). TrPs had been described in the medical literature by multiple physicians in the course of several centuries (Simons 1975, Baldry 2005) and a TrP manual had been published in 1931 in Germany (Lange 1931). As Baldry reported, already early in the 19th century, British physicians Churchill and Elliotson published books and articles about acupuncture without considering the concepts of traditional acupuncture (Churchill 1821, 1828, Elliotson 1827). Instead, they inserted needles in points of maximum tenderness, which does resemble the current practice of TrP dry needling and the ancient practice of needling Ashi points. In 1912 prominent physician Sir William Osler recommended inserting ladies' hat pins at tender points in the treatment of low back pain (Osler 1912).

During the 1980s and 1990s, Travell did interact with acupuncturists (Seem 2007), but by then her notions of TrPs and TrP injections were already well established (Travell & Simons 1983). Even if Travell had studied acupuncture techniques, since when are different disciplines not allowed learning from each other? Acupuncturist Amaro (2007) recommended that practitioners of acupuncture 'absorb the philosophy and procedure of dry needling as an adjunct for musculoskeletal pain control'. With the advancement of knowledge of myofascial therapies, it is noteworthy that in 1988, acupuncturists Matsumoto and Birch suggested to consider acupuncture as a myofascial therapy (Matsumoto & Birch 1988). Along those lines, acupuncturist Seem studied osteopathic paradigms when he developed his 'new American acupuncture' (Seem 2007) and combined insights from osteopathy and physical therapy with acupuncture (Seem 2004). In his own words, 'the next stage in my own development of a myofascial style of meridian-based acupuncture was my encounter with the work of Dr Janet Travell' (Seem 2007).

Given that Travell was not aware of Ashi points, the statement by the AAAOM that 'a reasonable English translation of Ashi points is "TrPs", a term used by Dr Janet Travell…' (2011a), seems somewhat misleading as it insinuates that Travell used the term 'TrP' as a deliberate substitute for the term 'Ashi points'. The term TrP was coined by Steindler (1940). From a Western medical perspective, TrP dry needling interventions were not developed until the late 1970s with nearly simultaneous publications in Canada and Czechoslovakia (the current Czech Republic; Lewit 1979, Gunn et al. 1980).

Dry needling from a medical perspective developed out of TrP injection therapy (Lewit 1979) and does not require any knowledge of the theoretical foundations of traditional or modern acupuncture practice (Baldry 2005). Already in 1944, Steinbrocker suggested that the effect of TrP injections was mostly due to mechanical stimulation of TrPs irrespective of the particular type of injectate (Steinbrocker 1944). Acupuncturists who have attended dry needling workshops offered by Myopain Seminars in Bethesda, Maryland (USA) agree unanimously that they have never before been exposed to the concepts of dry needling, which is consistent with the AAAOM Task Force of Inter-Professional Standards statement that 'it is well established that Acupuncture and Oriental Medicine consists of physiological paradigms, diagnostic methods, and treatment applications that are distinctly independent and different from western medicine' (Dommerholt 2012). It is somewhat ironic that the AAAOM cited Yun-Tao Ma as proof that 'there is a literary tradition in the Field of Acupuncture that uses the term "dry needling" as a synonym for a specific, previously established Acupuncture technique' (2011a), since Dr Ma strongly emphasized that 'the modern modality known as dry-needling or biomedical acupuncture does not share any common foundation with traditional Chinese acupuncture' (Ma et al. 2005).

The perspective of acupuncturists that other healthcare providers are attempting to redefine acupuncture seems to deny the notion of original thought in the Western world. As Cummings indicates in Chapter 13, acupuncture-like therapies have been developed independently in different civilizations around the world. The concepts of TrPs and dry needling were developed independently of already existing acupuncture concepts (Cardinal 2004, 2007). Similarly, electro-acupuncture was developed in China in 1934 (Dharmananda 2002), but Duchenne developed electro-therapy as early as 1855 (Licht 1987). Would that mean that acupuncturists in China were practicing Western physical therapy or medicine when they only changed the kind of electrodes? Or, which is much more likely, perhaps they developed the same treatment strategies independent of developments earlier in Europe.

Traditional Chinese Music

Traditional Chinese Medicine dates back to the same ancient times as Traditional Chinese Music, which is often attributed to Emperor Huangdi, who lived some 4000 years ago. The origin of Chinese music may actually be much older based on recent archaeological findings of bone flutes dating back over 8000 years (Jin 2011). The development of Chinese music was just one part of Chinese civilization, and similar developmental patterns can be seen in Chinese culture, literature, science and medicine. An introduction to the development of Traditional Chinese Music may prove to be relevant to this chapter.

Some 3000 years ago, pure instrumental Chinese music already existed and served as a medium of communication with heaven within the context of a spiritual connection between heaven and the human realm (Gan). Traditional Chinese Music consisted of two distinct styles. Northern music reflected the harsh, cold and windy climate and is characterized by a high-pitched and agitated style; whereas music from the southern part of China was more lyrical and gentle in nature, corresponding to the mild weather. There were at least three heptatonic and multiple pentatonic music scales in Traditional Chinese Music. Chinese music is rarely harmonic in nature in the sense of Western music and traditionally it is heterophonic (Liang 1985). In contrast, Gan maintains that the notion that Chinese music is often pentatonic may be a misunderstanding, as the ancient scholars had actually identified five harmonic structures (Gan). The focus on the unity of heaven and human realm continued until approximately 1000 CE, when the focus of Chinese music and its development diversified and moved from a scholarly endeavor to the general public (Gan). Meanwhile in Europe, the focus of music was limited to vocal church music without any records of pure instrumental music

(Gan). It was not until the Renaissance that instrumental music was developed and appreciated in Europe.

Many musical instruments were developed in ancient China, such as the pipa, which has similarities with the lute, the horse-headed fiddle, which is a Mongolian bowed string instrument, and the erhu, a two-stringed instrument still used today in Chinese opera (Qiang 2011). There is also evidence that Marco Polo (c. 1254– 1324 CE) brought Chinese instruments back to Europe (Gan), which may have influenced European string music several centuries later.

If we consider the influence of Traditional Chinese Music on Western musical developments and apply the same kind of arguments used by acupuncturists, that dry needling is nothing but a subsystem of acupuncture, it would follow that European composers did little more than redefine and repackage Traditional Chinese Music. In other words, Bach, Scarlatti, Vivaldi, Mozart, and Beethoven composed Chinese music. In that thought process, Western musical paraphrases are nothing but variations on Chinese pentatonic and heptatonic scales. Violin builders in Cremona, Italy, such as Andrea Amati and Antonio Stradivari, apparently just redefined the concepts of the horse-headed fiddle brought to Europe by Marco Polo, making the violin nothing but a new name for an ancient Chinese instrument. Just like original thought in the Western world with respect to the development of myofascial pain concepts, TrPs, and dry needling is not really appreciated by certain acupuncture groups, original Western music would become a subsystem of Traditional Chinese Music. Critics of classical music would likely postulate that classical music is just a pseudonym for the practice of Traditional Chinese Music.

Additional concerns

While economic interests or concerns can probably not be ignored to explain at least partially why some US acupuncture groups are against dry needling by non-acupuncturists, the AAAOM and CCAOM have not raised direct competitive concerns. Nevertheless, physical therapists, chiropractors, and medical doctors do have third-party reimbursement, while many insurance companies in the USA do not cover acupuncture. Since most professions today share some skills or procedures with another profession, it is no longer reasonable to expect each profession to have a completely unique scope of practice, exclusive of all others (Association of Social Work Boards et al. 2009, Gansler & McDonald 2010). Yet, it is quite common that 'one profession may perceive another profession as 'encroaching' into their area of practice. The profession may be economically or otherwise threatened and therefore oppose the other profession's legislative effort to change scope of practice' (Association of Social Work Boards et al. 2009). Economics aside, following is a brief review of some additional concerns commonly expressed concerning dry needling by non-acupuncturists.

Public safety

One of the more common arguments against dry needling by non-acupuncturists is that such practice would constitute 'a public health hazard'. The first objective of state boards and other regulatory agencies is to protect the public as the public should have access to providers who practice safely and competently. Claims that public safety is being jeopardized do get the attention of legislators and regulatory agencies. However, there is no evidence that serious adverse reactions to dry needling are common; dry needling is a safe technique when practiced by trained healthcare providers with no significant risk to the public. The US Federation of State Boards of Physical Therapy's Examination, Licensure, and Disciplinary Database (ELDD) has no entries in any jurisdiction or discipline for harm caused by dry needling performed by physical therapists. When the Maryland Board of Acupuncture challenged the Maryland Board of Physical Therapy Examiners, dry needling had been practiced by physical therapists in that state for 20 years without any complaint filed with the physical therapy board. Thousands of physical therapists in many countries around the world have used TrP dry needling for many years without any documented serious health hazards. See Chapter 4 for an in-depth review of safety issues.

In 2010, the AAAOM revealed that its Task Force of Inter-Professional Standards had contracted a malpractice insurance company to stop coverage of physical therapists who use dry needling in their practices (Taromina & Bruno

2010). In response the insurance company issued a change in policy to 'not provide malpractice insurance to any physical therapist who inserts needles and/or utilizes the technique of dry needling' (Cigel 2009). The exact same letter was sent again when chiropractors approved dry needling in Oregon from a different insurance carrier under the same corporate umbrella (Schroeder, 2009).

It is quite striking that the AAAOM would engage in potentially illegal acts to interfere with the rights of other healthcare providers to use dry needling techniques in their respective practices. By contacting the insurance carrier, the AAAOM may have engaged in 'tortious interference with contract of business expectancy', which occurs when an entity intentionally damages the contractual or other business relationship with a third party (Anthony 2006). A contract between a healthcare provider and a malpractice insurance carrier is protected by US contract law, which recognizes that vital interests, rights and obligations are worthy of protection (Anthony 2006). Under Virginia Law, for example, to meet the requirements for tortious interference with an existing contract, four elements must be established, including: (1) existence of a valid contractual relationship or business expectancy; (2) knowledge of the contractual relationship or expectancy by the defendant; (3) intentional interference inducing or causing a breach or termination of the contractual relationship or expectancy; and, (4) resultant damage to the party whose contractual relationship or expectancy has been disrupted (Anthony 2006).

Lack of education

The typical acupuncture education 'of at least 3000 hours' is often contrasted with the hours required by the leading post-graduate education programs in TrP dry needling. The AAAOM has claimed that 'the current training programs on Dry Needle Technique for Physical Therapists in the US and in Europe are made up of a one-weekend seminar' (Taromina & Bruno 2010). While there are indeed one-weekend course programs, the vast majority of dry needling course programs are considerably longer. Before judging whether a one-weekend dry needling course would constitute a public health hazard, it is important to review the course and determine what participants are being taught and whether they would be qualified to use any dry needling techniques in their practice. There are several varieties of dry needling and it is not reasonable to use generic blanket statements.

The AAAOM compares a discipline to a technique and chooses to ignore that to learn a technique within the context of another discipline does not require another 3000 hours of education. Dependent upon the type of dry needling technique, dry needling can be taught safely and learned accurately within a relatively short time period.

Physical therapists, chiropractors, and physicians who attend post-graduate courses in TrP therapy and dry needling have already completed their professional training. If the AAAOM would compare the discipline of acupuncture to the discipline of other healthcare providers, it would become clear that most other disciplines have more extensive education. In 2004, for example, the average number of hours of education in entry-level doctoral physical therapy programs in the US was 2676. Over 95% of the 212 physical therapy schools are entry-level doctoral programs. Other healthcare providers have completed similar or even more extensive graduate training programs. According to the CCAOM, a professional acupuncture curriculum must consist of at least 1950 hours. The Council has divided acupuncture training into at least 705 hours in Oriental medical theory, diagnosis and treatment techniques in acupuncture and related studies, 660 hours in clinical training, 450 hours in biomedical clinical sciences, and 90 hours in counseling, communication, ethics, and practice management.

Chiropractic and physical therapy education programs emphasize anatomical knowledge in much more depth than typical acupuncture schools. Detailed knowledge of anatomy should be one of the major regulatory concerns to protect patients undergoing dry needling procedures. Of interest is that in acupuncture practice anatomical knowledge is also the key aspect of safe needling. According to Peuker and Gronemeyer (2001), serious complications of acupuncture could have been avoided if acupuncturists had better anatomical knowledge. Post-graduate dry needling courses build on the knowledge and skills achieved during graduate education. The post-graduate education of non-acupuncturists using dry needling techniques does not constitute a public health hazard, but post-graduate training programs should be accredited by local regulatory agencies.

It is common that new skills are initially performed as advanced skills by only a select number of professionals. Once a sufficient cohort of practitioners is utilizing the skills, they are likely to become entry-level skills and subsequently will be taught in entry-level curricula. 'It is not realistic to require a skill or activity to be taught in an entry-level program before it becomes part of a profession's scope of practice. If this were the standard, there would be few, if any, increases in scope of practice' (Association of Social Work Boards et al. 2009). The number of US states that have approved dry needling by physical therapists has grown from four in 2004 to over 26 in 2012. Several entry-level university programs in physical therapy include the basics of dry needling.

Forbidden points

In 2006, the Acupuncture Society of Virginia argued that physical therapists should not be allowed to use dry needling techniques, as they are not familiar with so-called forbidden points. In acupuncture, forbidden points are considered a contraindication in pregnant women, because they might be abortifacient. The origins of forbidden points are somewhat obscure, but generally thought to be the *Yellows Emperor's Book of Acupuncture*, the *Systematic Classic of Acupuncture and Moxibustion*, and the *Classic of Difficult Issues* (Guerreiro da Silva et al. 2011). Forbidden points are supposed to be dangerous and often these points are remote from the low back, abdomen, and pelvic area. Many modern acupuncturists recommend not needling forbidden points during the first trimester to avoid miscarriage (Dale 1997, Betts & Budd 2011). In spite of traditional points of view, systemic reviews and randomized controlled studies of inducing labor with acupuncture are inconclusive and do not support the concept of forbidden points (Tsuei et al. 1977, Smith & Crowther 2004, Smith et al. 2008, Modlock et al. 2010, Cummings 2011). If it were that easy to induce labor by needling, it would seem that abortion clinics would incorporate needling of these points into their practices.

Clean needle technique

Occasionally, acupuncture groups bring up the issue that they are not convinced that other healthcare providers are being instructed in so-called 'clean needle techniques'. All US schools of acupuncture include instruction in clean needle techniques, but a close review of these guidelines suggests that the US Clean Needle Technique Guidelines (National Acupuncture Foundation 2009) are not always consistent with Blood borne Pathogen Regulations (Standards - 29 CFR) published by the US Occupational Safety and Health Administration (United States Department of Labor) and with guidelines published by the US Centers for Disease Control and Prevention (Ehrenkranz & Alfonso 1991).

According to the Blood borne Pathogen Regulations (Standards - 29 CFR), 'gloves shall be worn when it can be reasonably anticipated that the employee may have hand contact with blood, other potentially infectious materials, mucous membranes, and non-intact skin;…' (United States Department of Labor). Considering that upon removal of the solid filament needle, clinicians need to compress the needle site which is non-intact skin, wearing gloves during dry needling procedures is consistent with OSHA regulations. The US Clean Needle Technique Guidelines recommend that the practitioner who wishes to 'close the hole' uses a clean, dry cotton ball and does not mention gloves (National Acupuncture Foundation 2009). Many acupuncture procedures are done fairly superficially compared to deep dry needling techniques, which implicitly reduces the chance of intramuscular bleeding. Nevertheless, the use of gloves is commonplace in healthcare settings and it is a bit surprising that acupuncture standards in various countries do not recommend the routine use of gloves, particularly since all large epidemiological studies have shown that bleeding is one of the most common adverse effects of acupuncture.

The US Clean Needle Technique Guidelines recommend hand washing with liquid soap and water (National Acupuncture Foundation 2009), but while hand washing with regular soap does remove dirt, it has limited, if any, antimicrobial activity, and can only remove some transient flora, which is inadequate for use in healthcare settings according to the US Centers for Disease Control and Prevention (Ehrenkranz & Alfonso, 1991). McEvoy has reviewed safety and hygiene issues in detail in Chapter 4 of this book.

Summary

US acupuncture organizations oppose dry needling by non-acupuncturists citing public safety and lack of education, among others. Recently, similar concerns were raised in Australia (Janz & Adams 2011), but in most other countries where non-acupuncturists use dry needling techniques acupuncturists have not attempted to interfere with similar scope of practice issues. It must be understood that dry needling techniques are within the scope of practice of many disciplines, including acupuncture, and statements suggesting otherwise are erroneous and counterproductive. Many of the controversies are based on a profound lack of understanding of the nature, depth of knowledge, and scope of other disciplines, turf behavior, and perceived economic impact. The analogy with Traditional Chinese Music serves to illustrate that the rationale of US acupuncture organizations is seriously flawed. Within the context of acupuncture, dry needling may well be similar to needling of Ashi points, but in the context of medicine, chiropractic, veterinary medicine, dentistry and physical therapy, dry needling is nothing but an extension of TrP injections. Non-acupuncturists need to understand the depth of current acupuncture practice; acupuncturists need to realize that dry needling by other disciplines does not pose any threat to acupuncture and to the public at large. Overlap in scope of practice will lead to high-quality and affordable healthcare (Finocchio et al. 1995). Rather than expending energy to stop dry needling by non-acupuncturists, it may be more productive to follow Amaro's advice and 'absorb the philosophy and procedure of dry needling as an adjunct for musculoskeletal pain control' (Amaro 2007).

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Deep dry needling of the head and neck muscles

6

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CHAPTER CONTENT

Introduction

Neck, head, and orofacial pain syndromes are among the most common problems seen in daily clinical practice. Headache is the most prevalent neurological pain disorder seen by medical doctors and experienced by almost everyone (Bendtsen & Jensen 2010). Orofacial pain from muscular origin is as prevalent as headaches (Svensson 2007).

The lifetime and point prevalence of neck pain are almost as high as low back pain. Neck pain affects 45–54% of the general population at some time during their lives (Côte et al. 1998) and can result in severe disability (Côte et al. 2000). The lifetime prevalence of idiopathic neck pain has been estimated to be between 67–71% indicating that approximately two-thirds of the general population will experience an episode of neck pain at some time during their life (Picavet et al. 2000). In a systematic review, Fejer et al. (2006) found a 1-year prevalence for neck pain ranging from 16.7% to 75.1%. Additionally, the economic burden of neck pain involves high annual compensation costs (Manchikanti et al. 2009).

Among the different primary headaches, migraine and frequent tension-type headache represent the most common forms (Bendtsen & Jensen 2006). Globally, the percentage of adults with headache is 10% for migraine, 38% for tension-type headache, and 3% for chronic daily headache (Jensen & Stovner, 2008). In the general population, the prevalence rate of cervicogenic headache is reported as 4.1% (Sjaastad & Bakketeig, 2008). The prevalence of cervicogenic headache is, however,

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difficult to determine, because epidemiological studies used different criteria for the diagnosis (Haldeman & Dagenais 2001). Headaches cause substantial disability for patients and their families as well as to the global society (Stovner et al. 2007). In the US, the estimated total cost in 1998 was $14.4 billion for 22 million migraine sufferers (Hu et al. 1999), whereas in Europe the estimated cost in 2004 was €27 billion for 41 million patients (Andlin-Sobocki et al. 2005).

Orofacial pain is usually and clinically associated with headaches. Its prevalence is, however, under debate, with studies showing prevalence rates between 3% and 15% in the Western population (LeResche 1997). Isong et al. (2008) determined that the prevalence of orofacial pain was 4.6% (6.3% for women, 2.8% for men).

Neck, head, and facial pain are also common clinical manifestations of subjects suffering from whiplash associated disorders (Drottning et al. 2002). Neck injuries following motor vehicle accidents comprised 28% of all injuries seen in emergency room departments in 2000 (Quinlan et al. 2004). In the USA, the incidence rate was 4.2 per 1000 inhabitants (Sterner et al. 2003), whereas the prevalence rate was 1% (Richter et al. 2000). In addition the annual costs of motor vehicle crashes during 1999–2001 were estimated in the USA at $346 billion, with $43 billion attributed to whiplash (Zaloshnja et al. 2006).

These pain syndromes have common clinical features and are usually co-morbid entities suggesting a common nociceptive pathway with sensitization mechanisms mediated through the trigeminal nucleus caudalis. The exact pathogenesis of the pain is not completely understood. Simons et al. (1999) described the referred pain elicited from trigger points (TrPs) in several muscles that can play a relevant role in the genesis of these syndromes. In this chapter we cover dry needling of TrPs in the head and neck musculature based on clinical and scientific reasoning.

Clinical presentation of TrPs in head and neck pain syndromes

Trigger points (TrPs) in headache and orofacial pain populations

In the past few years, there have been an increasing number of studies confirming the relevance of TrPs in head, neck, and face pain syndromes (Fernández-de-las-Peñas et al. 2007a). Clinicians should consider that differences in the pain characteristics of tension-type, cervicogenic, and migraine headaches implicate different structures, which may be contributing to nociceptive irritation of the trigeminal nucleus caudalis, and feature a different involvement of TrPs. For instance, tension-type headache is characterized by pressing or tightening pain, pressure or band-like tightness, and increased tenderness on palpation of the neck and shoulder muscles (ICHD-II 2004), which resemble clinical descriptions of pain from TrPs (Simons et al. 1999, Gerwin 2005). We summarize pertinent clinical and scientific evidence related to TrPs in head, neck, and face pain syndromes.

Myofascial TrPs in temporomandibular pain

There is scientific data that referred pain from masticatory muscles can be involved in orofacial pain syndromes (Svensson & Graven-Nielsen 2001). Experimental studies reproduced motor and sensory disturbances, including hyperalgesia, local, and referred pain, similar to those reported for temporomandibular pain patients after injecting irritating substances into the masseter muscle (Svensson et al. 2003a, 2003b, 2008). Svensson (2007) suggested that different muscles are involved in the pathophysiology of temporomandibular pain, such as the masseter, where for example the upper trapezius and suboccipital muscles may be more common in tension-type headaches. Nevertheless, few studies investigating the presence of TrPs in temporomandibular pain have been conducted. Wright (2000) found in a sample of 190 patients with temporomandibular pain, that the upper trapezius (60%), lateral pterygoid (50%), and masseter (47%) muscles were the most common sources of referred pain into the craniofacial region. The cheek area, ear, and forehead were the most frequently reported sites of referred pain generation. Nevertheless, this study did not include a control group and patients were not examined in a blinded fashion.

Fernández-de-las-Peñas et al. (2010) conducted a blind-controlled study where patients with myofascial temporomandibular pain and healthy controls were examined for TrPs in the neck and head muscles. They found that active

TrPs in the masticatory muscles, i.e., the superficial masseter (78%), temporalis (73%), and deep masseter (72%) were more prevalent than TrPs within the neck and shoulder muscles, i.e., upper trapezius (64%), suboccipital (60%), and sternocleidomastoid (48%) muscles (Fernández-de-las-Peñas et al. 2010). This would be expected since masticatory muscle TrPs are more likely to play a role in temporomandibular pain, whereas neck and shoulder TrPs would play a greater role in headaches. In addition, TrPs in the neck and shoulder muscles may be implicated in symptoms of the neck, which are commonly seen with patients suffering from temporomandibular pain (De Wijer et al. 1999). In fact, preliminary evidence suggests that application of treatment targeted to the cervical spine was beneficial in decreasing pain intensity and pressure pain sensitivity over the masticatory muscles and in increasing pain-free mouth opening in patients with myofascial TMD (La-Touche et al. 2009).

Myofascial TrPs in tension-type headache

Tension-type headache (TTH) is a type of headache for which there is clear scientific evidence of an etiologic role for TrPs (Fernández-de-las-Peñas & Schoenen 2009). Marcus et al. (1999) reported that patients with TTH had a greater number of either active or latent TrPs than healthy controls; however, this study did not specify in which muscles TrPs were most frequently found.

In a series of blinded-controlled studies, Fernández-de-las-Peñas et al. found that active TrPs were extremely prevalent in individuals with chronic and episodic TTH. Patients with chronic TTH have active TrPs in the extra-ocular superior oblique muscles (86%, Fernández-de-las-Peñas et al. 2005), the suboccipital muscles (65%, Fernández-de-las-Peñas et al. 2006a), the upper trapezius (50–70% Fernández-de-las-Peñas et al. 2006b, 2007b), temporalis (60–70%, Fernández-de-las-Peñas et al. 2006b, 2007c), sternocleidomastoid (50–60%, Fernández-de-las-Peñas et al. 2006b), and extra-ocular rectus lateralis muscles (60%, Fernández-de-las-Peñas et al. 2009). Additionally, patients with chronic TTH and active TrPs in these muscles exhibited more severe headaches with greater intensity, frequency, and duration than patients with chronic TTH and latent TrPs in the same muscles (Fernández-de-las-Peñas et al. 2007e). Given that temporal summation of pain is centrally mediated (Vierck et al. 1997), a temporal integration of nociceptive signals from muscle TrPs by central nociceptive neurons is probable, leading to sensitization of central pathways in chronic TTH (Bendtsen & Schoenen 2006). Couppe et al. (2007) also found a higher prevalence of TrPs in the upper trapezius muscle (85%) in patients with chronic TTH. In addition, TrPs were found in children with chronic TTH. A case series of nine 13-year old girls with TTH suggested that TrPs do play an important role in at least a subgroup of children with TTH (Von Stülpnagel et al. 2009). These girls received TrP treatments twice a week. After 6.5 sessions, the headache frequency was reduced by 67.7%, the intensity by 74.3%, and the mean duration by 77.3% (Von Stülpnagel et al. 2009). In a blinded-controlled study, Fernández-de-las-Peñas et al. (2011a) reported that in children with a mean age of 8 with chronic TTH, the suboccipital (80%), the temporalis (54%), the ocular superior oblique (28–30%), the upper trapezius (20%), and the sternocleidomastoid (12–26%) muscles harbored most TrPs. Active TrPs have been reported in episodic TTH as well, but less frequently. The most common muscles with active TrPs included the superior oblique muscle (15%, Fernández-de-las-Peñas et al. 2005), the suboccipital muscles (60%, Fernández-de-las-Peñas et al. 2006c), the sternocleidomastoid (20%), the temporalis (45%), and the upper trapezius muscle (35%, Fernández-de-las-Peñas et al. 2007d). A recent study confirmed that active TrPs are more prevalent in chronic TTH than in episodic TTH (Sohn et al. 2010). The association of active TrPs with episodic TTH does not support the hypothesis that active TrPs are always a consequence of central sensitization, since central sensitization is not as common in episodic TTH as in chronic TTH (Fernández-de-las-Peñas et al. 2006d). TrPs located in other muscles not included in these studies, such as the masseter, splenius capitis, scalene, levator scapulae muscles, may also contribute to the pain symptoms in individuals with TTH. Table 6.1 details the percentage of individuals presenting active TrPs in patients with head and neck pain syndromes discussed in the chapter.

Finally, a few studies explored the effects of the treatment of TrP in patients with chronic TTH.

Table 6.1 Percentage of subjects with active TrPs in patients with head and neck pain syndromes

Suboccipital	Upper trapezius		Sternocleidomastoid		Levator scapulae		Superior oblique		Temporalis		Superficial masseter	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Adults with chronic tension type headache (n=25)												
65%	24%	36%	20%	24%	NA	NA	86%	86%	32%	36%	NA	NA
Adults with episodic tension type headache (n=15)												
60%	14%	33%	20%	14%	NA	NA	14%	14%	46%	40%	NA	NA
Children with chronic tension type headache (n=50)												
80%	20%	20%	12%	26%	8%	12%	30%	28%	32%	72%	16%	10%
Adults with mechanical neck pain (n=20)												
50%	35%	40%	15%	25%	0%	15%	NA	NA	NA	NA	NA	NA
Adults with unilateral migraine (n=20)												
	No aff.	Affected	No aff.	Affected	No aff.	Affected	No aff.	Affected	No aff.	Affected	No aff.	Affected
25%	5%	30%	5%	45%	NA	NA	0%	50%	0%	40%	NA	NA
Adults with myofascial temporomandibular pain (n=25)												
	No pain	More Pain	No pain	More pain	No pain	More pain	No pain	More pain	No pain	More pain	No pain	More pain
60%	56%	72%	56%	40%	NA	NA	NA	NA	68%	80%	72%	80%

No aff: non-affected side; NA: not available.

Data is based on Fernández-de-las-Peñas et al. (2005a, 2006a, 2006b, 2006c, 2006d, 2006e, 2006f, 2007d, 2007f, 2010, 2011a)

Table 6.2 Variables identified for immediate success (top) and for 1-month success (bottom) including accuracy statistics with 95% confidence intervals for each variable (from Fernández-de-las-Peñas et al. 2008)

- **Headache duration (hours per day) (<8.5)**
- **Headache frequency (< 5.5)**
- **Body pain (< 47) from the SF-36 questionnaire**
- **Vitality (< 47.5) from the SF-36 questionnaire**

Number of predictor variables present	Sensitivity	Specificity	Positive Likelihood Ratio	Probability of success (%)
4+	0.37 (0.17, 0.61)	0.94 (0.68, 0.99)	5.9 (0.80, 42.9)	87.4%
3+	0.84 (0.60, 0.96)	0.75 (0.47, 0.92)	3.4 (1.4, 8.0)	80.0%
2+	0.94 (0.72, 0.99)	0.19 (0.05, 0.50)	1.2 (9.0, 1.5)	58.5%
1+	1.0 (0.79, 1.0)	0.12 (0.02, 0.41)	1.1 (0.95, 1.4)	56.4%

- **Headache frequency (< 5.5)**
- **Bodily pain (< 47) from the SF-36 questionnaire**

Number of predictor variables present	Sensitivity	Specificity	Positive likelihood ratio	Probability of success (%)
2+	0.58 (0.34, 0.79)	0.88 (0.60, 0.98)	4.6 (1.2, 17.9)	84.4%
1+	0.95 (0.72, 0.99)	0.56 (0.31, 0.79)	2.2 (1.2, 3.8)	72.1%

The probability of success is calculated using the positive likelihood ratios and assumes a pretest probability of 54%.

Moraska & Chandler (2008), in a pilot study, demonstrated that a structured massage program targeted at inactivating TrPs was effective for reducing headache pain and disability in individuals with TTH; however, this study did not include a control group. Similarly, these authors reported that the same TrP massage program improved psychological measures, particularly depression and the number of events deemed as stressful (Moraska & Chandler, 2009). Fernández-de-las-Peñas et al. (2008) developed a preliminary clinical prediction rule to identify women with chronic TTH who most likely would experience short-term favorable outcomes after TrP manual therapy. Four variables were identified for immediate success and 2 for 1-month success (Table 6.2). If all variables (4 + LR: 5.9) were present, the chance of experiencing immediate benefit from TrP treatment improved from 54% to 87.4% (Fernández-de-las-Peñas et al. 2008). However, a limitation of this study was its relatively small sample size (n=35). A second clinical prediction rule where women with chronic TTH received a multimodal therapy session identified eight variables for short-term success (Fernández-de-las-Peñas et al. 2011b). The variables are listed in Table 6.3. If five of the eight variables (5 + LR: 7.1) were present, the chance of experiencing successful treatment improved from 47% to 86.3% (Fernández-de-las-Peñas et al. 2011b). Therapeutic procedures included both joint mobilizations to the cervical and thoracic spine and soft tissue TrP therapies such as soft tissue stroking, pressure release, and muscle energy techniques applied to the neck, head and shoulder musculature: temporalis, suboccipital, upper trapezius, sternocleidomastoid, and splenius capitis muscles (Fernández-de-las-Peñas et al. 2011b). These clinical rules support the role of TrPs in the management of TTH; however, further studies validating current data are now needed.

There are a small number of studies investigating the effects of dry needling and TTH. De Abreu Venâncio et al. (2008) compared the effects of TrP injections using lidocaine to TrP dry needling in the management of headaches of myofascial origin. They found that TrP dry needling was equally effective for decreasing the intensity, the frequency and the duration of the headache, and for the use of rescue medication than injections using lidocaine alone or combined with corticoids. The same

Table 6.3 Variables identified for immediate success including accuracy statistics with 95% confidence intervals for each variable success (from Fernández-de-las-Peñas et al. 2011b)

- Age, mean < 44.5 years
- Presence left sternocleidomastoid muscle TrP
- Presence suboccipital muscle TrPs
- Presence of left superior oblique muscle TrP
- Cervical rotation to the left > 69°
- Total tenderness score < 20.5
- Neck Disability Index < 18.5
- Referred pain area of right upper trapezius muscle TrP > 42.23

Number of predictor variables present	Sensitivity	Specificity	Positive likelihood ratio	Probability of success (%)
8	0.1 (0.01, 0.2)	1.0 (0.89, 1.0)	∞	100%
7+	0.22 (0.10, 0.40)	1.0 (0.89, 1.0)	∞	100%
6+	0.53 (0.36, 0.69)	1.0 (0.89, 1.0)	∞	100%
5+	0.89 (0.73, 0.96)	0.88 (0.72, 0.95)	7.1 (3.1, 16.3)	86.3%
4+	0.97 (0.84, 0.99)	0.7 (0.53, 0.83)	3.2 (2.0, 5.2)	73.94%
3+	1 (0.87, 1.0)	0.23 (0.11, 0.39)	1.3 (1.1, 1.5)	53.6%
2+*				
1+*				

*Unable to calculate as all subjects met 1 and 2 variables.

The probability of success is calculated using the positive likelihood ratios and assumes a pretest probability of 47%.

authors also reported that TrP dry needling was equally effective as botulinum toxin A for decreasing the intensity, the frequency and duration of the pain, but less effective for the use of rescue medication (De Abreu Venâncio et al. et al. 2009). These results are similar to those by Harden et al. (2009) who reported that patients who received botulinum toxin A injections over active TrPs experienced reductions in headache frequency at short term, but the effects dissipated by week 12. Headache intensity also revealed a decrease in the botulinum toxin A group, but not in the control group (Harden et al. 2009).

Myofascial TrPs in migraine

TrPs have been also found in patients with migraine. In unilateral migraine, active TrPs in the upper trapezius (30%), sternocleidomastoid (45%) and temporalis (40%) muscles were located only ipsilateral to migraine attacks as compared to the non-symptomatic side (Fernández-de-las-Peñas et al. 2006e). TrPs in the extra-ocular superior oblique muscle (50%) were present in the symptomatic, but not in the non-symptomatic side (Fernández-de-las-Peñas et al. 2006f). A study of 92 patients with bilateral migraine showed that 94% exhibited TrPs in the temporalis and suboccipital muscles compared with 29% of controls (Calandre et al. 2006). The number of TrPs was related to the frequency of migraine headaches and the duration of the disease (Calandre et al. 2006).

Referred pain from active TrPs reproduced the pain features of migraine headache, although patients were examined when they did not have a headache (Fernández-de-las-Peñas et al. 2006e). Nevertheless, an association of TrPs with migraine does not constitute a causal relationship. The presence of TrPs indicates that peripheral nociceptive input from TrPs into the trigeminal nucleus may act as a migraine trigger. A link between pain generators of the neck, head and shoulder muscles and migraine attacks may be the activation of the trigeminal nerve nucleus caudalis, and hence the activation of the trigeminovascular system. In such instance, TrPs located in any muscle innervated by the trigeminal nerve or the upper cervical nerves may be considered as 'irritative thorns' that can precipitate, perpetuate or aggravate migraine. Obviously, other triggers also exist for migraine.

Evidence supporting a triggering role of TrPs in migraine comes from the resolution of migraine headache by treating TrPs in neck and shoulder muscles with lidocaine or saline injections (Tfelt-Hansen et al. 1981; Calandre et al. 2003). In addition, inactivation of active TrPs in migraine patients not only reduced the electrical pain threshold in the headache area of pain referral, but also reduced the number of headache attacks over the 60 days of the treatment period (Giamberardino et al. 2007). García-Leiva et al. (2007) reported that TrP injection with ropivacaine (10mg) was effective for reducing frequency and intensity of migraine attacks.

Myofascial TrPs in other headaches

TrPs have been also investigated in other headaches, such as cervicogenic and cluster headache. Jaeger (1989) found in a cohort of eleven individuals with cervicogenic headache that all patients showed at least three TrPs on the symptomatic side, especially in the sternocleidomastoid and temporalis muscles. Further, those patients who were treated reported a significant decrease in their headache frequency and intensity, which supports the role of TrPs in headache pain perception in this headache disorder (Jaeger 1989). Roth et al. (2007) described a case report where pain from TrPs in the sternocleidomastoid muscle mimicked the symptoms of cervicogenic headache. Although TrPs can obviously contribute to cervicogenic headache pain, it seems that this headache is mainly provoked by referred pain from the upper cervical joints (Aprill et al. 2002), rather than referred pain elicited by muscle TrPs. Nevertheless, this conclusion may be related to the fact that TrPs have not been properly studied in cervicogenic headache pain. Therefore, further studies are required to elucidate the role of TrPs in this headache disorder.

Calandre et al. (2008) studied the presence of TrPs in 12 patients with cluster headache. All patients showed active TrPs reproducing their headache. In this case series, TrP injection were successful in about 80% of the patients. The authors suggested that in some patients TrPs may trigger cluster headaches (Calandre et al. 2008). Ashkenazi et al. (2010) analyzed, in a systematic review, studies on peripheral nerve blocks and TrP injections for headache disorders and reported few controlled studies on the efficacy of peripheral nerve blocks and almost none on the use of TrP injections. These authors concluded that the technique, the type and the doses of the anesthetics used for nerve blockade varied greatly among studies, but in general, the results were positive. Nevertheless, this finding should be considered with caution due to the limitations of the included studies (Ashkenazi et al. 2010).

Trigger points (TrPs) in neck pain populations

Neck pain can have a traumatic or an insidious onset. A traumatic onset is seen for example following a whiplash injury. An example of an insidious cause is mechanical neck pain, which is defined as generalized neck or shoulder pain with symptoms provoked by neck postures, by movement, or palpation of the cervical muscles. Fernández-de-las-Peñas et al. (2007f) found that patients with mechanical insidious neck pain exhibited active TrPs in the upper trapezius (20%), the sternocleidomastoid (14%), suboccipital (50%) and levator scapulae (15%) muscles (Table 6.1). The presence of TrPs in the upper trapezius muscle was associated with the presence of cervical joint dysfunction at the levels of the C3 and C4 vertebrae in individuals suffering from neck pain (Fernández-de-las-Peñas et al. 2005b). Therefore, clinicians should include the assessment and treatment of joint hypomobility in the management of TrPs in individuals with mechanical neck pain (Fernández-de-las-Peñas 2009).

There is some evidence of the effectiveness of TrPs manual techniques in the management of mechanical neck pain. For instance, Montañez-Aguilera et al. (2010) reported that an ischemic compression technique was effective in the treatment of TrPs in a patient with neck pain. Bablis et al. (2008) found that the application of Neuro Emotional Technique, which is a technique incorporating central and peripheral components to alleviate the effects of distressing stimuli, may be effective for reducing pain and mechanical sensitivity over TrPs in patients with chronic neck pain. Ma et al. (2010) demonstrated that the effectiveness of a miniscalpel-needle release was superior for reducing pain in patients with TrPs in the upper trapezius muscle than acupuncture needling treatment or self neck-stretching exercises alone.

Further studies are needed to confirm clinical relevance of TrP treatment in the course of mechanical insidious neck pain.

TrPs have been also associated to neck pain of traumatic origin, such as whiplash-associated neck pain (Dommerholt et al. 2005, Dommerholt 2005, 2010). Schuller et al. (2000) found that 80% of 1096 individuals involved in low-velocity collisions reported muscle pain. In a review of the literature, Fernández-de-las-Peñas et al. (2003) found that the muscles most commonly affected by TrPs were the scalene muscles (Gerwin & Dommerholt 1998), the splenius capitis, upper trapezius, posterior neck, sternocleidomastoid (Baker 1986) and pectoralis minor muscles (Hong & Simons 1993). Ettlin et al. (2008) reported that semispinalis capitis muscle TrPs were more frequent in patients with whiplash-associated neck pain (85%) than in patients with non-traumatic neck pain (35%) or fibromyalgia (57%). TrPs in the upper trapezius (70–80%), levator scapulae (60–70%), sternocleidomastoid (40–50%), and masseter (20–30%) muscles were similar among these pain groups. The presence of TrPs in individuals with WAD can be related to the fact that these patients usually exhibit reduced cervical stability, muscle inhibition and hyperirritability of the cervical muscles (Headley 2005).

Finally, a few studies have demonstrated the effects of TrP inactivation in patients with whiplash-associated neck pain. Freeman et al. (2009) showed that infiltrations of 1% lidocaine into TrPs in the upper trapezius were effective in the short-term for increasing cervical range of motion and pressure pain thresholds in individuals with chronic whiplash-associated pain. Carroll et al. (2008) reported that injections of botulinum toxin type A over cervical TrPs decreased pain in patients with chronic whiplash-related neck pain. A randomized controlled clinical trial is currently being planned with the aim to demonstrate the effects of dry needling in patients with chronic whiplash-associated neck pain (Tough et al. 2010).

Dry needling of head muscles

Corrugator supercilii muscle

- *Anatomy*: The muscle arises from the medial end of the superciliary arch. Its fibers pass upward and lateral between the palpebral and orbital portions of the orbicularis oculi, and are inserted into the deep surface of the skin, above the middle of the orbital arch.
- *Function:* This muscle draws the eyebrow downward and medially, furrowing the forehead.
- *Innervation:* Temporal branches of the facial nerve (VII par cranial).
- *Referred pain:* It is projected over the forehead and deep into the head, inducing frontal headaches.
- *Needling technique:* The patient lies in supine. The muscle is needled with a pincer palpation. The needle is inserted perpendicular to the skin from either the medial or the lateral aspect of the muscle, directed toward its mid-portion. The needle is inserted through the skin at a shallow angle, and advanced into the muscle belly (Figure 6.1).
- *Precautions:* None.

Figure 6.1 • Dry needling of the corrugator supercilii muscle.

Procerus muscle

- *Anatomy:* The muscle arises from the fascia overlying the surface of the nasal bones and the superior parts of the upper lateral nasal cartilages, and inserts into the skin of the inferior and medial forehead.
- *Function:* This muscle wrinkles the skin of the bridge of the nose.
- *Innervation:* Buccal branches of the facial nerve (VII par cranial).

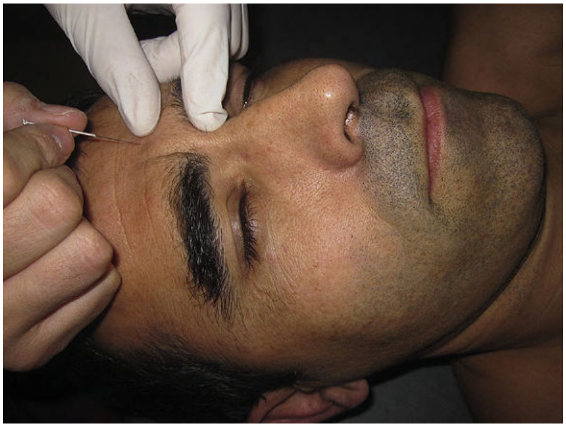

Figure 6.2 • Dry needling of the procerus muscle.

Figure 6.3 • Dry needling of the masseter muscle.

- *Referred pain:* It is projected over the forehead and deep into the head, inducing frontal headaches.
- *Needling technique:* The patient lies in supine. The muscle is needled with a pincer palpation. The needle is inserted perpendicular to the skin from superior to inferior, coming from the forehead toward the nose. The needle is inserted through the skin at a shallow angle, and advanced into the muscle belly (Figure 6.2).
- *Precautions:* None.

Masseter muscle

- *Anatomy:* The muscle extends from the inferior aspect of zygomatic process to the angle and lateral surface of the mandible (superficial layer); the mid-portion of the mandibular ramus (middle layer); and to the upper mandibular ramus and the coronoid process (deep layer).
- *Function:* It closes the mouth by elevating the mandible. The superficial layer has also a component of protrusion (forward) of the mandible whereas the deep layer has a component of retraction (backward).
- *Innervation:* Mandibular branch (V3) of the trigeminal nerve (V par cranial).
- *Referred pain:* The superficial layer refers pain to the eyebrow, the maxilla, the anterior aspect of the mandible, and to the upper or lower molar teeth; whereas the deep layer spreads pain deep into the ear and to the temporomandibular joint area.
- *Needling technique:* The patient lies in supine. The muscle is generally needled with a flat palpation, although pincer palpation may also be feasible. The needle is inserted perpendicular to the skin toward the muscle belly (Figure 6.3).
- *Precautions:* None.

Temporalis muscle

- *Anatomy:* The muscle extends from the temporal fossa (except that portion of it which is formed by the zygomatic) to the anterior border of the mandibular coronoid process and to the anterior border of the ramus of the mandible.
- *Function:* It closes the mouth by elevating the mandible. The temporalis muscle also helps lateral deviation of the mandible to the same side.
- *Innervation:* Mandibular branch (V3) of the trigeminal nerve (V par cranial).
- *Referred pain:* It is perceived deep in the temporoparietal region and inside the head causing temporal headache and maxillary toothache.
- *Needling technique:* The patient is in supine. The muscle is needled with a flat palpation. The needle is fixed with the index and middle fingers of the non-needling hand and then inserted perpendicular to the skin toward the temporalis fossa (Figure 6.4).
- *Precautions:* The superficial temporal artery should be identified and avoided.

Figure 6.4 • Dry needling of the temporalis muscle.

Figure 6.5 • Dry needling of the zygomatic muscle with pincer palpation

Zygomatic muscle

- *Anatomy:* The zygomatic major and minor muscles extend from the zygomatic bone and insert into the muscles of the mouth: the orbicularis oris, levator, and depressor anguli oris.
- *Function:* It elevates the angle of the mouth as in smiling.
- *Innervation:* Facial nerve (VII par cranial).
- *Referred pain:* It is perceived in an arc close to the side of the nose and up to the forehead.
- *Needling technique:* The patient is in supine. The muscle can be needled with a pincer or flat palpation. With the pincer palpation, one palpating digit is inside the mouth against the buccal mucosa and one digit is on the external surface of the skin. The needle is inserted perpendicular to the skin toward the zygomatic bone (Figure 6.5). With a flat palpation, the needle is fixed between the index and middle fingers of the non-needling hand, and inserted perpendicular to the skin toward the zygomatic bone (Figure 6.6).
- *Precautions:* None.

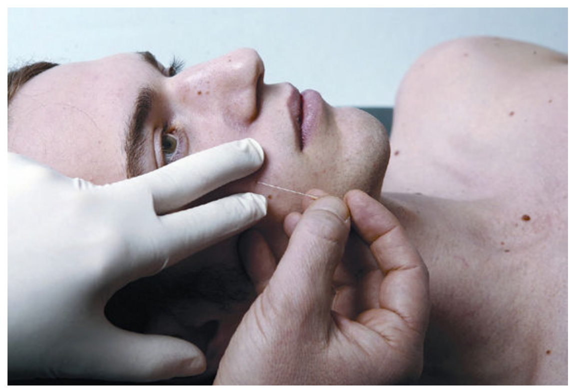

Figure 6.6 • Dry needling of the zygomatic muscle with flat palpation.

Medial pterygoid muscle

- *Anatomy:* The muscle originates on the medial surface of the lateral pterygoid plate of the sphenoid bone, the maxillary tuberosity and the pyramidal process of the palatine bone, and inserts into the lower-back part of the medial surface of the ramus and angle of the mandible (mandibular foramen).
- *Function:* It closes the mouth by elevating the mandible. It has a component of retraction (backward) of the mandible.
- *Innervation:* Medial pterygoid nerve, via the mandibular branch (V3) of the trigeminal nerve (V par cranial).
- *Referred pain:* It is projected to the eyebrow, maxilla, mandible anteriorly, and to the upper and lower molar teeth (superficial layer), and deep into the ear and to the region of the temporomandibular joint (deep layer).
- *Needling technique:* The patient is in supine. The muscle can be needled on its superior or inferior part. In our clinical practice, we prefer to needle this muscle over the medial surface of the ramus and angle of the mandible (inferior

Figure 6.7 • Dry needling of the medial pterygoid muscle.

Figure 6.8 • Dry needling of the superior division of the lateral pterygoid muscle.

part). With a flat palpation, the needle is fixed between the index and middle fingers of the non-needling hand and hence inserted through the skin at a shallow angle toward the medial surface of the ramus and angle of the mandible (Figure 6.7). It is also possible to needle the muscle through the mandibular fossa, but this is a more advanced and difficult procedure similarly to needling the inferior lateral pterygoid muscle.

- *Precautions:* None.

Lateral pterygoid muscle

- *Anatomy:* The superior division (head) arises from the infra-temporal surface of the greater wing of the sphenoid bone, and the inferior division arises from the lateral surface of lateral pterygoid plate. They insert to the internal surface of the neck of mandible, and the intra-articular cartilage of TMJ joint.
- *Function*: The superior division tracts the disc of the temporomandibular joint. The inferior division protrudes and depresses the neck of the mandible opening the mouth. In addition, the unilateral contraction causes lateral deviation of the mandible to the opposite side.
- *Innervation:* Lateral pterygoid nerve, via the mandibular branch (V3) of the trigeminal nerve (V par cranial).
- *Referred pain:* It is projected to the maxilla and the temporomandibular joint.

Figure 6.9 • Dry needling of the inferior division of the lateral pterygoid muscle.

- *Needling technique:* The patient is in supine. For the superior division, the needle is inserted perpendicular to the skin through the mandibular fossa, which is located anterior to the temporomandibular joint. The needle is directed upwards and forward deep to the zygomatic arch (Figure 6.8). For the inferior division, the patient needs to open the mouth and the needle is inserted perpendicular to the skin anterior through the mandibular fossa and directed toward the roots of the upper molar teeth (Figure 6.9).
- *Precautions:* None. Needling the temporomandibular joint can easily be avoided by accurately locating the mandibular fossa.

Figure 6.10 • Dry needling of the posterior belly of the digastric muscle.

Figure 6.11 • Dry needling of the anterior belly of the digastric muscle.

Digastric muscle

- *Anatomy:* The posterior belly arises from the mastoid notch (mastoid process) of the temporal bone at the digastric groove, whereas the anterior belly arises from the inferior border of the mandible, close to its symphysis. The two bellies are joined together by a common tendon that is indirectly anchored to the hyoid bone through a fibrous loop.
- *Function:* It protrudes and opens the mouth by descending the mandible.
- *Innervation:* Digastric branch, via the facial nerve (VII par cranial) for the posterior belly; and myolohyoid nerve, via the mandibular branch (V3) of the trigeminal nerve (V par cranial) for the anterior belly.
- *Referred pain:* The posterior muscle belly refers pain to the upper part of the sternocleidomastoid muscle, whereas the anterior belly projects pain to the four lower incisor teeth.
- *Needling technique:* The patient is in supine. For the posterior belly, the needle is inserted perpendicularly to the mastoid notch (mastoid process) towards the transverse process of the atlas (Figure 6.10). The posterior head can also be needled in the mid-belly using a flat palpation technique. Caution must be exercised to avoid needling through the muscle. For the anterior belly the head and neck of the patient are slightly extended. The muscle is then needled with a flat palpation technique. The needle is fixed between the index and middle fingers of the non-needling hand, and inserted perpendicular to the skin toward the lower part of the mandible (Figure 6.11).
- *Precautions:* When needling the posterior belly, avoid the external jugular vein.

Dry needling of neck-shoulder muscles

Trapezius muscle: upper portion

- *Anatomy:* The superior region (descending part) of the muscle arises from the external occipital protuberance, the medial third of the superior nuchal line of the occipital bone, the ligamentum nuchae, and the spinous process of C7, and inserts into the posterior border of the lateral third of the clavicle.
- *Function:* When it contracts unilaterally, it induces ipsilateral side-bending and contralateral rotation of the head and also elevation of the shoulder. When it contracts bilaterally, it extends the neck.
- *Innervation:* Accessory nerve (XI par cranial) and cervical spinal nerves C3–C4
- *Referred pain:* It spreads ipsilaterally from the posterior-lateral region of the neck, behind the ear, and to the temporal region.
- *Needling technique:* The patient is in prone or side-lying. The muscle is needled with a pincer palpation. The needle is inserted perpendicular to the skin and directed towards the practitioner's finger. The needle is kept between

Figure 6.12 • Dry needling of the upper portion of the trapezius muscle.

Figure 6.13 • Dry needling of the superior portion of the levator scapulae muscle.

the fingers in the shoulder. The needle can be inserted from anterior to posterior or posterior to anterior (Figure 6.12).

- *Precautions:* The most common serious adverse event is penetrating the lung, and producing a pneumothorax. This is minimized by needling strictly between the fingers holding the muscle in a pincer grasp, and needling directed towards the practitioner's finger.

Levator scapulae muscle

- *Anatomy:* The muscle originates from the dorsal tubercles of the transverse processes of C1 to C4 vertebrae, and inserts on the superior medial angle and adjacent medial border of the scapula.
- *Function:* It extends and side-bends the neck. When the head is turned to the opposite side and forward flexed, it rotates the head toward the midline. The muscle rotates the scapula glenoid fossa downward when the neck is fixed.
- *Innervation:* Cervical spinal nerves C3–C5, via the dorsal scapular nerve.
- *Referred pain:* It is projected to the angle of the neck and along the vertebral border of the scapula.
- *Needling technique:* The patient is in lateral decubitus position. The muscle is needed via a pincer palpation. For the superior (cervical) portion, the muscle is felt as a ropy muscle band of about 5mm diameter in lateral extent, between the anterior (ventral) border of the upper trapezius and the transverse process of C1. The needle is inserted perpendicular to the skin and directed towards the practitioner's finger (Figure 6.13). For the lower (shoulder) portion, the muscle is identified over the superior medial border of scapula. The needle is inserted through the skin at a shallow angle, directed toward the upper, medial border of the scapula (Figure 6.14).

Figure 6.14 • Dry needling of the inferior portion of the levator scapulae muscle.

- *Precautions:* Do not needle towards the rib cage to avoid creating a pneumothorax.

Sternocleidomastoid muscle

- *Anatomy:* The two heads of the muscle (sternal and clavicular) originate in the mastoid process of the temporal bone. The sternal head attaches to the anterior surface of the manubrium sterni and the clavicular head attaches to the superior border and anterior surface of the medial third of the clavicle.
- *Function:* When it contracts unilaterally, it side-bends to the same side and rotates to the opposite side the head. It also tilts the chin upward, i.e., extension of the head. When it contracts bilaterally, it flexes the neck against gravity.
- *Innervation:* Accessory nerve (XI par cranial), and cervical spinal nerves C2–C3.
- *Referred pain:* The sternal division may refer pain to the vertex, to the occiput, across the cheek, over the eye, to the throat, and to the sternum, whereas the clavicular division refers pain to the forehead and deep into the ear, inducing frontal headache and earache.
- *Needling technique:* The patient is in supine. Both heads, clavicular and sternal, are needled by pincer palpation after identifying the carotid artery. The needle is then inserted perpendicular to the skin and directed towards the practitioner's finger. The needle can be inserted from anterior to posterior or from posterior to anterior (Figure 6.15).
- *Precautions:* The carotid artery lies medial to the sternocleidomastoid muscle, next to the trachea. Lift the sternocleidomastoid away from the carotid artery and needle between the fingers holding the muscle in a pincer grasp, directing the needle as described above, to avoid needling the carotid artery.

Splenius capitis muscle

- *Anatomy:* The muscle arises from the lower half of the ligamentum nuchae and from the spinous process of C7 to T3–T4 vertebrae and insets, under cover of the sternocleidomastoid, into the mastoid process of the temporal bone and into the rough surface of the occipital bone, below the lateral third of the superior nuchal line.
- *Function:* It extends, side-bends and rotates the neck to the same side.
- *Innervation:* Dorsal rami of the cervical spinal nerves.
- *Referred pain:* It is projected to the vertex of the head.
- *Needling technique:* The patient is in lateral decubitus. One finger is placed on the taut band. The needle is inserted through the skin at a shallow angle in a caudal-medial direction and directed toward the practitioner's finger (Figure 6.16).
- *Precautions:* When needling above C2, the needle must be directed towards the mastoid process. All needling must be performed posterior to the transverse processes in a caudal-medial direction.

Figure 6.15 • Dry needling of the sternocleidomastoid muscle.

Figure 6.16 • Dry needling of the splenius capitis muscle.

Figure 6.17 • Dry needling of the splenius cervicis muscle.

Figure 6.18 • Dry needling of the semispinalis capitis and cervicis muscles.

Splenius cervicis muscle

- *Anatomy:* The muscle extends from the spinous processes of the T2–T6 vertebrae to the posterior tubercles of the transverse processes of C1–C3 vertebrae.
- *Function:* It extends the neck and rotates the head to the same side.
- *Innervation:* Dorsal rami of the cervical spinal nerves.
- *Referred pain:* It refers upwards to the occiput, diffusely through the cranium, and to the back of the orbit. Sometimes, it is projected to the angle of the neck.
- *Needling technique:* The patient is in lateral decubitus. The muscle is needed via a pincer palpation. The needle is inserted perpendicular to the skin from a posterior to anterior direction directed towards the practitioner's finger or at a shallow angle (Figure 6.17). The needle may be directed medially because the muscle is laterally away from the cervical spine foramina. The needle may be through the upper fibers of the trapezius muscle.
- *Precautions:* None.

Semispinalis capitis and cervicis muscles

- *Anatomy:* The *semispinalis capitis* muscle arises from the tips of the transverse processes of C7 and T1–T6 vertebrae and the articular processes of C4–C6, and inserts between the superior and inferior nuchal lines of the occipital bone. The *semispinalis cervicis* muscle arises from the transverse processes of T2–T6 vertebrae, and inserts into the posterior spinous processes of C2 to C5.
- *Function:* The *semispinalis capitis* extends, side-bends, and rotates the neck to the same side; whereas the *semispinalis cervicis* extends and rotates the neck to the opposite side.
- *Innervation:* Dorsal rami of the cervical spinal nerves
- *Referred pain:* Both refer pain over the posterior occiput and above the orbit.
- *Needling technique:* The patient is in lateral decubitus. The muscle is needed via a pincer palpation. The needle is inserted perpendicular to the skin from anterior to posterior direction directed towards the practitioner's finger or at a shallow angle, towards the posterior processes of cervical vertebrae or slightly laterally (Figure 6.18).
- *Precautions:* The caudal or slightly lateral direction of the needle ensures that the vertebral artery will not be penetrated and that the needle will not penetrate the cervical spine.

Suboccipital muscles

- *Anatomy:* The *rectus capitis posterior minor* muscle extends from the posterior tubercle of the atlas (C1) to the medial aspect of the nuchal

Figure 6.19 • Dry needling of the oblique capitis inferior muscle.

Figure 6.20 • Dry needling of the cervical multifidi muscles.

line on the occiput. The *rectus capitis posterior major* originates from the spinous process of axis (C2) and inserts into the lateral part of the inferior nuchal line of the occiput. The *oblique capitis superior* originates at the transverse process of the atlas (C1) and inserts into the occiput between the superior and inferior nuchal lines. The *oblique capitis inferior* begins at the spinous process of the axis (C2) and attaches to the transverse process of the atlas (C1).

- *Function:* The rectus capitis posterior major and minor and the oblique capitis superior muscles extend the head on the neck. The oblique capitis superior also assists in ipsilateral side bending. The oblique capitis inferior is an ipsilateral rotator of the head.
- *Innervation:* Suboccipital nerve, via the C1 nerve root.
- *Referred pain:* It is perceived as deep pain spreading from the occiput toward the region of the orbit, mimicking bilateral tension type headache.
- *Needling technique: Only the oblique capitis inferior muscle is safely needled* because of the proximity of the vertebral artery above the arch of the atlas. The patient is in prone. The muscle is needled in a point mid-way between the transverse process of C1 and the spinous process of C2. The needle is inserted perpendicular to the skin directly in the medial half of the muscle toward the patient's opposite eye in a slightly cranial-medial direction (Figure 6.19).
- *Precautions:* Avoid directing the needle strictly cranially or too laterally to prevent inadvertent penetration of the vertebral artery or foramen magnum.

Cervical multifidi muscles

- *Anatomy:* The muscle crosses 2 to 4 vertebral levels. The superior attachment is the posterior processes of C2 to C5, whereas the inferior attachment is the articular processes of C2 to C7 vertebrae.
- *Function:* The main function is stabilization of the cervical spine. They may assist in extension, and rotation of the cervical spine to the opposite side.
- *Innervation:* Posterior primary rami of the cervical nerves at each level.
- *Referred pain:* It spreads upward to the suboccipital region, and downward over the neck and upper part of the shoulder. Pain is perceived deep into the cervical zygapophyseal joint.
- *Needling technique:* The patient is in prone. Cervical multifidi muscles are not directly palpable; but clinicians can suspect the presence of relevant TrPs when patients report deep pain into the cervical joints. The needle is inserted perpendicular to the skin and parallel to the posterior spinous processes, about 1cm lateral to the spinous process or in a medial-caudal direction toward the lamina of the vertebra (Figure 6.20).
- *Precautions:* Avoid needling strictly medially to minimize the risk of penetrating the structures within the spinal canal (epidural or subarachnoid space, spinal cord).

Scalene muscles

- *Anatomy:* The *anterior scalene muscle* extends from the anterior aspect of the transverse processes of C3 to C6 vertebrae and inserts on the first rib anterior to the neurovascular bundle; the *middle scalene muscle* arises from the posterior aspects of transverse processes of C3 to C7 and attaches to the first rib posterior to the neurovascular bundle. The posterior scalene muscle is not needled due to its close proximity to the apex of the lung.
- *Function:* They side bend the neck to the same side. The anterior scalene also assists in rotating the head to the opposite side. Both muscles are respiratory muscles through elevation of the first rib.
- *Innervation:* The anterior scalene is innervated by cervical spinal nerves C4–C6 and the middle scalene is innervated by cervical spinal nerves C3–C8.
- *Referred pain:* The pain is referred to the upper and medial vertebral borders of the scapula, to the pectoral region and down the front and back of the arm, on the radial forearm and to the thumb and index finger.
- *Needling technique:* The patient is in supine. The muscles can be identified by having the patient sniff sharply, which activates the respiratory component of the muscle function. The anterior scalene is reached in the triangle formed by the jugular vein, lateral edge of the clavicular head of the sternocleidomastoid muscle, and the clavicle as the base, whereas the middle scalene is reached in the triangle formed by the brachial plexus, the posterior scalene and clavicle as the base. For the anterior scalene, the needle is inserted perpendicular to the skin, about 3 cm over the clavicle, directed towards the transverse processes of the cervical vertebrae (Figure 6.21). For the middle scalene, the needle should be inserted perpendicular to the skin, behind the brachial plexus, directed towards the posterior tubercle transverse processes of the cervical spine.
- *Precautions:* The scalene muscles should be needled only one fingerbreadth or more above the base of the neck to avoid a high-positioned apex of the lung.

Figure 6.21 • Dry needling of the scalene muscles.

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Deep dry needling of the shoulder muscles

7

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CHAPTER CONTENT

Introduction

Shoulder pain, shoulder complaints and shoulder disorders are frequently used terms and appear synonymous. It is clear from the definitions that there is a certain overlap between these terms. In this chapter, we will use the term shoulder pain.

Shoulder pain is a very common musculoskeletal disorder. In primary care, the yearly incidence is estimated to be 14.2 per 1000 people. The 1-year prevalence in the general population is estimated to be 20–50%. The estimates are strongly influenced by the definition of shoulder disorders, including or excluding criteria, including limited motion, age, gender, and anatomical areas. Thus, shoulder pain is widespread and imposes a considerable burden on the affected person and on society. Women are slightly more affected than men and the frequency of shoulder pain peaks between 46 and 64 years of age (Van der Windt et al. 1995). Shoulder pain tends to be persistent or recurrent despite medical treatment (Ginn & Cohen 2004). The pathophysiological mechanisms are poorly understood in spite of a growing body of knowledge of shoulder kinematics, shoulder injury mechanisms, and the technical improvement of medical imaging, including sonography, magnetic resonance imaging or more conventional techniques such as X-rays.

Most shoulder pains are caused by a small number of relatively common conditions. Although subacromial impingement is often suggested to be the most common potential source of shoulder

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pain (Neer 1972, Hawkins & Hobeika 1983), solid evidence is lacking (Bron 2008). This syndrome includes tendonitis or tendinopathy of the rotator cuff and the long head of the biceps brachii muscle, or subacromial or subdeltoid bursitis. In fact, calcifications, acromion spurs, subacromial fluid, or signs of tendon degeneration are equally prevalent in healthy subjects and in individuals with shoulder pain (Milgrom et al. 1995). Furthermore, physical examination tests of subacromial impingement are not reliable (Hegedus et al. 2007), and the results of imaging diagnostics do not correlate well with pain (Bradley et al. 2005). In addition, interventions targeting subacromial problems are, at best, only moderately effective at treating patients with shoulder complaints (Coghlan et al. 2008, Buchbinder et al. 2009, Dorrestijn et al. 2009). Other less common causes of shoulder pain are tumors, infections, and nerve related injuries.

Clinical relevance of myofascial trigger points (TrPs) in shoulder pain syndromes

Myofascial trigger points (TrPs) in patients with shoulder pain are most prevalent in the infraspinatus, upper trapezius and deltoid muscles and most of the time, multiple TrPs in more than one muscle are involved (Hsieh et al. 2007, Ge et al. 2008, Bron et al. 2011b). Ingber (2000) successfully treated the subscapularis muscle, which was thought to be the main cause of shoulder pain in three overhead athletes. Hidalgo-Lozano et al. (2010) found that the muscles most affected by active TrPs were the supraspinatus, infraspinatus and subscapularis in patients with shoulder pain with a medical diagnosis of shoulder impingement. A recent study of elite swimmers with shoulder pain showed similar findings (Hidalgo-Lozano et al. 2011a).

In an older study, Sola et al. (1955) concluded that the supraspinatus muscle was one of the least frequently involved shoulder girdle muscles both in patients and in young healthy adults. The supraspinatus muscle is rarely involved by itself, but usually appears in association with the infraspinatus or upper trapezius muscles (Bron et al. 2011b) or the subscapularis muscle (Hidalgo-Lozano et al. 2010), which very commonly harbor TrPs in patients with shoulder pain and dysfunction. In addition, other muscles, such as the levator scapulae, biceps brachii, deltoid, pectoralis minor, pectoralis major, scalene, latissimus dorsi, teres major and minor muscles may also be involved in shoulder pain. In fact, two studies demonstrated that TrPs in the latissimus dorsi and pectoralis major muscles reproduced axillary arm pain in women with breast cancer who had undergone mastectomies (Fernández-Lao et al. 2010, Torres-Lacomba et al. 2010)

Studies investigating the effect of TrP therapy in patients with shoulder pain are sparse. Recently, two randomized controlled trials showed promising results of manual TrP therapy in patients with shoulder pain (Hains et al. 2010, Bron et al. 2011a). More studies are in progress (Perez-Palomares et al. 2009). A multiple case study supported the idea that TrP dry needling may be effective in reducing shoulder pain and improving shoulder functioning in elite female volleyball players (Osborne & Gatt 2010). One study investigated the effects of TrP dry needling in patients with post-stroke shoulder pain and reported that patients in the intervention group reduced their analgesic medication use, improved their sleep and mood, and more effectively prepared them for their rehabilitation program than those in the control group (DiLorenzo 2004). Finally, a case series of patients with a diagnosis of shoulder impingement found that inactivation of TrPs in the shoulder musculature decreased shoulder pain and sensitization (Hidalgo-Lozano et al. 2011b)

Shoulder pain and movement dysfunction

Shoulder pain and disturbed movement patterns are closely related. A disturbed movement pattern of the scapular musculature, such as the upper or lower trapezius, and anterior serratus muscles may cause subacromial impingement and deep shoulder pain (Cools et al. 2003, Kibler 2006).

On the other hand there is evidence that muscle pain can create a different motor activation pattern. Falla et al. (2007) demonstrated that an injection with hypertonic saline reduced the electromyographic (EMG) activity in the painful (injected) muscle and led to hyperactivity of the muscles in the ipsi- and contralateral shoulder. These findings are consistent with the pain-adaptation model of Lund et al. (1991), which maintains that muscle pain causes a decrease of EMG activity in the agonist muscle, while it causes an increase of EMG activity in the antagonists, finally leading to motor control changes. As active TrPs cause muscle pain, they may also cause muscle inhibition and disturbances of motor activation patterns. In fact, Lucas et al. (2010) demonstrated that even latent TrPs disturb motor activation patterns.

Trigger points (TrPs) and range of motion (ROM) restrictions

Adhesive capsulitis, also referred to as primary frozen shoulder, is the most common cause of severely restricted shoulder joint mobility. Based on clinical experience of the authors of this chapter, inactivation of TrP in shoulder muscles, particularly the subscapularis muscle, frequently reduces patients' symptoms, including pain and restricted mobility, which may lead to an early and proper recovery within weeks. However, there is no scientific evidence from the literature to support this clinical experience. In a multiple case study of five patients with primary frozen shoulders, all patients improved after a subscapular nerve block and subscapularis muscle injections (Jankovic & van Zundert 2006).

Trigger points (TrPs) and stability

Another enigmatic shoulder disorder is referred to as minor, subtle, occult or functional instability, which is often associated with shoulder pain and diagnosed as secondary shoulder impingement. Patients with this disorder complain of a feeling of instability in the absence of true instability, confirmed by physical examination tests such as the apprehension test. Although not mentioned in the literature, these patients often respond well to dry needling of the adductor muscles of the shoulder, including the teres major, latissimus dorsi, and subscapularis muscles.

Figure 7.1 • Dry needling of the supraspinatus muscle in prone.

Dry needling of the shoulder muscles

Supraspinatus muscle

- *Anatomy:* The muscle originates from the supraspinous fossa of the scapula and inserts at the superior facet of the greater tubercle of the humerus.*
- *Function:* It assists in abduction and stabilizes the humeral head together with the other rotator cuff muscles during all movements of the shoulder. The muscle prevents caudal dislocation during carrying of heavy loads, such as bags and suitcases.
- *Innervation:* Suprascapular nerve, from the C5 and C6 nerve roots.
- *Referred pain:* It is projected to the mid-deltoid region, often extending down the lateral aspect of the arm and forearm, sometimes focussing strongly over the lateral epicondyle of the elbow.
- *Needling technique:* The patient lies prone (Figure 7.1) or on the uninvolved side with the arm close to the body and relaxed (in side-lying supported by a pillow; Figure 7.2). The supraspinatus muscle is only accessible through the upper trapezius muscle and is identified by flat palpation with sufficient pressure. After

*Histological studies have determined that the rotator cuff is made off multiple confluent tissue layers functioning in concert. The tendons of the supraspinatus and the infraspinatus merge together at the level of the greater tuberosity, while the infraspinatus and teres minor merge near their musculotendinous junctions. The subscapularis tendon and the supraspinatus tendon join as a sheath around the biceps tendon at the entrance of the bicipital groove (Matava 2005).

Figure 7.2 • Dry needling of the supraspinatus muscle in side-lying.

Figure 7.3 • Dry needling of the infraspinatus muscle in prone.

localization of the TrP, the needle is inserted and directed longitudinal to the frontal plane or slightly posterior towards the base of the supraspinous fossa.

- *Precautions:* The apex of the lung is in front of the scapula and clinicians should avoid needling in a ventral direction.

Infraspinatus muscle

- *Anatomy:* The muscle originates from the infraspinous fossa of the scapula and inserts at the dorsosuperior facet of the greater tubercle of the humerus.
- *Function:* It assists in external rotation and stabilizes the humeral head together with the other rotator cuff muscles and prevents upwards migration of the humeral head during all movements.
- *Innervation:* Suprascapular nerve, from the C5 and C6 nerve roots.
- *Referred pain:* It is projected to the front of the shoulder (intra-articular pain) and the mid-deltoid region, extending downwards the arm to the ventrolateral aspect of the arm and forearm and the radial aspect of the hand. The referred pain from this muscle can mimick the symptoms of carpal tunnel syndrome (Qerama et al. 2009)
- *Needling technique:* The patient lies prone (Figure 7.3) or on the uninvolved side with the arm slightly abducted (in side-lying supported by a pillow; Figure 7.4). The needle is directed towards the scapula.

Figure 7.4 • Dry needling of the infraspinatus muscle in side-lying.

- *Precautions:* In osteoporotic patients fenestration of the scapula has been reported, which would imply that clinicians should avoid needling through the scapula. In clinical practice, however, fenestration has not been an issue.

Teres minor muscle

- *Anatomy:* The muscle originates from the upper one-third of the lateral border of the dorsal surface of the scapula and inserts on the dorsal facet of the greater tubercle below the insertion of the infraspinatus muscle.
- *Function:* It has the same function as the infraspinatus muscle, but can also adduct the upper arm.
- *Innervation:* Axillary nerve, from the C5 and C6 nerve roots

Figure 7.5 • Dry needling of the teres minor muscle in prone.

- *Referred pain:* It is projected to the dorsal aspect of the shoulder and TrPs may cause numbness and/or tingling in the ulnar aspect of the forearm and hand.
- *Needling technique:* The patient lies prone with the upper arm 90° abducted. The TrP is usually located by flat palpation just caudal to the glenohumeral joint. The needle is directed to the lateral border of the scapula (Figure 7.5).
- *Precautions:* When needling in front of the scapula, clinician can easily pass through the intercostal space and enter the pleura and lung.

Subscapularis muscle

- *Anatomy:* The muscle originates from the subscapular fossa and inserts to the lesser tubercle and reinforces the transverse ligament that overlies the bicipital sulcus.
- *Function:* It is an internal rotator assisted by the pectoral major muscle. It stabilizes the humeral head together with the other rotator cuff muscles and prevents upward migration of the humeral head during all movements.
- *Innervation:* Subscapular nerve from the C5, C6, and C7 nerve roots.
- *Referred pain:* It is projected to the dorsal aspect of the shoulder extending to the dorsal aspect of the upper arm and around the wrist.
- *Needling technique:*
  - *Axillary approach*: The patient lies supine with the arm 90° abducted and 90° externally rotated. Bringing the scapula more laterally will optimize access to the muscle. The needle is directed parallel to the ribcage perpendicular to the scapula (Figure 7.6).
  - *Medial approach*: The patient lies prone with the arm in internal rotation and the forearm resting on the back at the lumbar level (Hammerlock position). The needle is inserted from medial to lateral under the scapula (Figure 7.7). The muscle can be also needled when the patient lies on the involved shoulder (Figure 7.8).

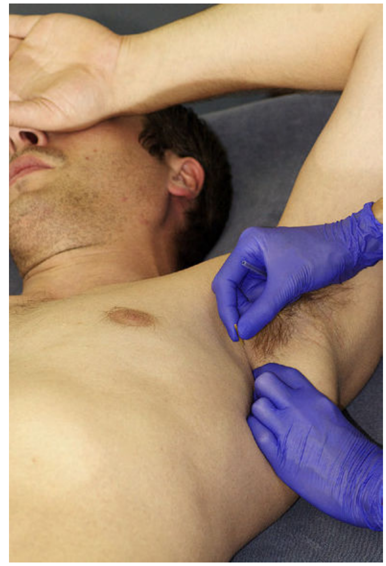

Figure 7.6 • Dry needling of the subscapularis muscle in supine (axillary approach).

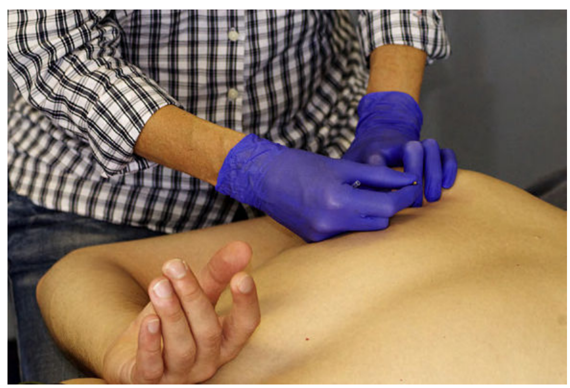

Figure 7.7 • Dry needling of the subscapularis muscle in prone (medial approach).

Figure 7.8 • Dry needling of the subscapularis muscle in side-lying (medial approach).

Figure 7.9 • Dry needling of the anterior deltoid muscle in supine.

- *Precautions:* As the subscapularis muscle is located between the ventral surface of the scapula and the ribcage, the needle has to be directed away from the ribcage to avoid entering the intercostal space.

Deltoid muscle

- *Anatomy:* The muscle originates from the lateral third of the clavicle (ventral part), the entire lateral border of the acromion (middle part), and the lateral half of the spine of the scapula (posterior part). The entire muscle inserts on the deltoid tuberosity, which is a rough triangular area midway the anterolateral border of the humerus.
- *Function:* This thick, multipennate muscle is a prime mover for abduction of the upper arm, and assists in flexion and internal rotation (ventral fibers) or extension and external rotation (dorsal fibers).
- *Innervation:* Axillary nerve from the C5 and C6 nerve roots.
- *Referred pain:* It is locally projected in the region of the affected part (anterior, middle or posterior) of the muscle.
- *Needle technique:* The anterior part can be needled in the supine position (Figure 7.9), the posterior part in prone (Figure 7.10), and the middle part can be treated in the prone, supine, or side-lying (Figure 7.11). In all positions the upper arm is slightly abducted and supported by a pillow if necessary. The needle is inserted perpendicularly through the skin directly into the taut band against the humerus.
- *Precautions:* No special precautions

Figure 7.10 • Dry needling of the posterior deltoid muscle in prone.

Teres major muscle

- *Anatomy:* The muscle originates from the posterior surface of the inferior angle of the scapula. The tendon of the teres major muscle fuses with the tendon of the latissimus dorsi muscle and inserts to the medial lip of the bicipital groove.
- *Function:* This muscle assists the latissimus dorsi muscle in extension, internal rotation and adduction of the arm.
- *Innervation:* Lower subscapularis nerve from the C6 and C7 nerve roots.

Figure 7.11 • Dry needling of the middle deltoid muscle in side-lying.

Figure 7.12 • Dry needling of the teres major muscle in prone.

- *Referred pain:* The pain is locally projected in the posterior deltoid, the posterior glenohumeral joint and over the long head of the triceps brachii, and occasionally to the dorsal forearm.
- *Needling technique:* The patient lies prone with the arm slightly abducted (Figure 7.12). The muscle is grasped between the thumb and the second and third fingers and the needle is directed ventral and lateral. It is also possible to needle this muscle in side-lying, when a pillow in front of the patient supports the arm (Figure 7.13).
- *Precautions:* There is no danger for injury of the neurovascular bundle or entering the ribcage, as long as the needle is directed ventrally and slightly laterally.

Coracobrachialis muscle (see Ch. 8)

Rhomboid muscles (see Ch. 9)

Pectoralis minor muscle

- *Anatomy:* The muscle originates from the third, fourth and fifth rib near their costal cartilages and inserts at the coracoid process of the scapula together with the coracobrachialis muscle and the biceps brachii brevis.
- *Function:* The muscle protracts and draws the scapula forward, downward and inward. It also depresses the shoulder girdle and stabilizes it against forceful upward pressure of the arm. Downward force of the pectoralis minor causes winging of the scapula. When the scapula is fixed by the trapezius and levator scapulae muscles, the pectoralis minor is an accessory respiratory muscle.

Figure 7.13 • Dry needling of the teres major muscle in side-lying.

- *Innervation:* Medial pectoral nerve from the C8 and T1 nerve roots.
- *Referred pain:* It is projected to the ventral aspect of the shoulder extending to the anterior chest region and the ulnar side of the arm to the third, fourth and fifth finger. The referred pain is almost the same as from the referred pain area of the pectoralis major. The pain may mimic angina pectoris, pain of the tendon of the biceps brachii muscle, and a golfer's elbow.
- *Needling technique:* The patient lies in a supine position. A woman with ample breasts should be asked to place her hand over the breast to draw

Figure 7.14 • Dry needling of the pectoralis minor muscle in supine.

it to the opposite side. The coracoid process should be identified and subsequently the taut bands of the pectoralis minor muscle should be identified beneath or through the pectoralis major muscle. The needle is inserted over the rib cage and directed upwards and slightly lateral towards the coracoid process. The angle of the needle is shallow, almost tangential to the chest wall (Figure 7.14). Alternatively, the muscle is grabbed between the thumb and the fingers in a pincher grip with the tips of the fingers and thumb against the ribcage to determine the proper needling angle. The needle is now directed towards the fingers, preventing the needle to enter the thorax.

- *Precautions:* As the pectoralis muscle is located over the ventral surface of the ribcage, clinicians have to be certain to avoid entering the intercostal space and penetrating the lung. The neurovascular bundle to the arm lies under the pectoralis minor muscle close to the coracoid process.

Pectoralis major muscle

- *Anatomy:* The muscle crosses three joints: the sternoclavicular, acromioclavicular and glenohumeral joint. Medially it originates from four separate attachments: the clavicular, the sternal, the costal and the abdominal attachment. Laterally it inserts into a ventral and a dorsal layer. Both layers attach to the crest of the greater tubercle of the humerus, along the lateral lip of the bicipital groove. The ventral layer, which originates from the clavicula, is laminated like playing cards. The dorsal layer, which originates from the sternal, costal and abdominal regions, is folded, reversing the order of attachment of the fibers with the inferior fibers becoming superior fibers at the attachment site. This arrangement should be kept in mind when palpating TrPs and eliciting local twitch responses.
- *Function:* The muscle protracts the shoulder girdle with the subclavius muscle and depresses the shoulder girdle with the sternal, costal and abdominal fibers. It gives internal rotation and adduction of the arm and medial flexion across the chest, and oblique upward and forward movement of the arm with the clavicular fibers.
- *Innervation:* Lateral pectoral nerve from the C5–C7 nerve roots and medial pectoral nerve from the C8 and T1 nerve roots.
- *Referred pain:* It is projected to the ventral aspect of the shoulder from the clavicular section, to the anterior chest region from the intermediate sternal fibers, and to the anterior chest and sternum from the medium sternal fibers. Breast tenderness and nipple hypersensitivity arise from the costal and abdominal fibers. Left pectoralis major TrP pain may mimick angina pectoris. At the level of the right 5–6th intercostal space, lateral to the xiphoid, Travell identified a common somatovisceral TrP associated with cardiac arrhythmias (Simons et al. 1997).
- *Needling technique:* The patient lies in the supine position with the arm slightly abducted. For some right-handed operators, the left pectoralis major may be best approached from across the table, and the right pectoralis major from the ipsilateral side of the table. A woman with ample breasts should be asked to place her hand over the breast to draw it to the opposite side. The pectoralis major has at least three separately identifiable components that each has their own referred pain pattern. The clavicular head, the sternal head and the costal head should each be examined separately. The pectoralis major muscle is grasped in the anterior axillary wall with the index and long fingers underneath the muscle, between the muscle and the chest wall. When needling the clavicular head, the needle may be inserted towards the clavicle or towards the shoulder. When needling the sternal and costal portions of the muscle, the needle is directed towards the shoulder. In all cases, the needle should be directed towards the fingers to protect

Figure 7.15 • Dry needling of the pectoralis major muscle in supine.

Figure 7.16 • Dry needling of the pectoralis major muscle in supine.

the underlying lung (Figure 7.15) and the angle of the needle should be shallow and the direction tangential to the chest wall (Figure 7.16). When needling the portions of the muscle near the costochondral junction or the insertions into the sternum and the medial costal margins, needling should be done only over a rib with the index and long fingers placed over the intercostal spaces on either side of the rib and the needle directed only towards the rib. The needle should be inserted at a shallow angle, tangential to the chest wall).

- *Precautions:* As the pectoralis major muscle is located over the ventral surface of the ribcage one has to be certain to avoid entering the intercostal space and penetrating the lung creating a pneumothorax. Patients should be instructed to go to the emergency room should they develop shortness of breath or unusual pain following treatment of the chest wall muscles. They should be instructed to tell the emergency room staff that they had a dry needling treatment in the region of the chest wall. A chest X-ray is used to confirm a pneumothorax. Insertion of the needle through the chest wall and into the lung can be more painful than dry needling. A clinically important pneumothorax is much less likely to occur when using a solid filament needle then when using a hypothermic needle.

Latissimus dorsi muscle (for trunk fibers see Ch. 9)

- *Anatomy:* The muscle originates from the spinosus processes of the lower six thoracic vertebrae and all lumbar vertebrae, the lower 3 or 4 ribs iliac crest and lumbar aponeurosis to the sacrum. It inserts at the medial edge of the intertubercular groove of the humerus in common with the teres major.
- *Function:* The muscle extends, adducts and internally rotates the arm. It assists in retraction of the scapula and downward drawing of the arm. Bilaterally, it assists to extend the spine and homolaterally, it causes a lateral tilt of the pelvis.
- *Innervation:* Thoracodorsal nerve, from the C6, C7, and C8 nerve roots.
- *Referred pain:* The inferior angle of the scapula, and the surrounding midthoracic region, the back of the shoulder down to the medial aspect of the arm, forearm and hand including the fourth and fifth fingers. Sometimes the pain refers to the lower lateral aspect of the trunk above the iliac crest.
- *Needling technique:* The patient lies prone with the arm and shoulder off the table or on the table with the hand under the pillow (Figure. 7.17). The latissimus dorsi can also be approached in supine with the arm abducted at shoulder level (Figure. 7.18). It is possible to reach this muscle in the side-lying position if the arm is supported by the patient, an assistant or a pillow (Figure. 7.19). The latissimus dorsi is grasped between the thumb and the index and long fingers. The taut bands are palpated and the needle is inserted perpendicular to the skin into the contraction knot. The muscle is followed caudally as long as it can be lifted away from the chest wall. Dry needling of TrPs over the trunk and ribcage is covered in Chapter 9.

Figure 7.17 • Dry needling of the lattisimus dorsi muscle in prone.

Figure 7.18 • Dry needling of the latissimus dorsi muscle in supine.

- Precautions: All needling is performed in a pincher palpation towards the fingers to avoid penetrating the chest wall and the lung. The fingers are positioned between the muscle and the chest wall.

Biceps brachii muscle long head (for short head see Ch. 8)

- *Anatomy:* The long head attaches to the upper margin of the glenoid fossa. The tendon passes through the glenohumeral joint over the head of the humerus. The short head attaches to the

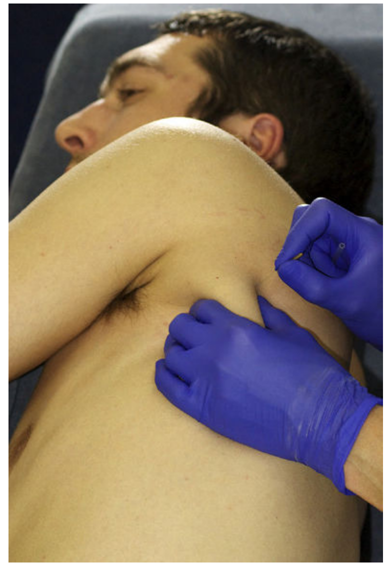

Figure 7.19 • Dry needling of the latissimus dorsi muscle in side-lying.

coracoid process of the scapula. Both heads join in a common tendon to insert at the radial tuberosity, facing the ulna in the supinated forearm.
- *Function:* The long head of the biceps seats the humerus in the glenoid fossa when the arm is extended and loaded. Both heads assist in flexion of the arm at the shoulder and abduction of the arm at the shoulder in the externally rotated (and supinated) arm. The muscle is one of the three flexors at the elbow (together with the brachialis and the brachioradialis muscles) and acts most strongly when the hand is supinated. It also supinates the forearm when the arm is flexed, but not when it is fully extended.
- *Innervation:* Musculocutaneous nerve via the lateral cord (C7, C8).
- *Referred pain:* TrPs in the biceps brachii refer pain upward over the muscle and over the anterior deltoid region of the shoulder and occasionally to the suprascapular region. TrPs also may initiate another additional pattern of milder pain downward in the antecubital space.
- *Needling technique:* The patient lies supine with the arm slightly flexed. The muscle is grasped between the thumb and index and long fingers. Taut bands are identified. The muscle should be needled from a lateral approach to avoid needling the neurovascular bundle at the medial

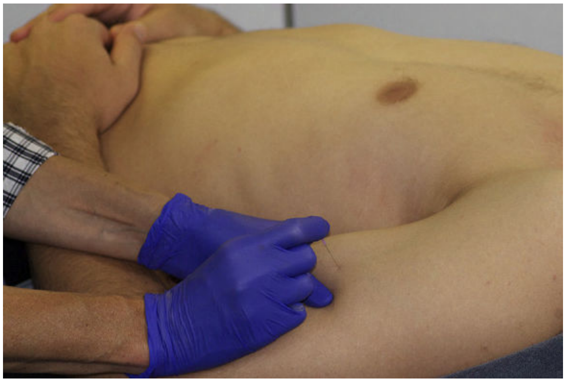

Figure 7.20 • Dry needling of the biceps brachii muscle in supine (lateral approach).

Figure 7.21 • Dry needling of the triceps brachii muscle in supine.

side. The needle is directed into the taut bands to elicit local twitch responses. The two heads of the biceps are palpated and treated separately (Figure 7.20).

- *Precautions:* Avoid the radial nerve that lies along the lateral border of the distal biceps and the brachialis muscles. To avoid needling the neurovascular bundle of the upper arm, it is preferred to needle this muscle only via the lateral approach.

Triceps brachii muscle long head (for lower portion see Ch. 8)

- *Anatomy:* The long head is the only head of the triceps muscle that crosses the shoulder joint, attaching to the scapula below the glenoid fossa where the long head originates. The three heads of the triceps muscle attach to the olecranon process of the ulna via a common tendon.
- *Function:* Adduction of the arm at the shoulder and rotation of the scapula to elevate the humeral head towards the acromion.
- *Innervation:* Radial nerve of the posterior cord (C7, C8)
- *Referred pain:* Posterior arm to posterior shoulder, upper trapezius area and dorsum of the forearm.
- *Needling technique:* The patient lies supine (Figure 7.21), prone (Figure 7.22), or side-lying (Figure 7.23) on the uninvolved shoulder. The forearm is supinated and the arm abducted to allow the triceps muscle to be held in a pincer grasp to identify the taut bands. The needle

Figure 7.22 • Dry needling of the triceps brachii muscle in prone.

Figure 7.23 • Dry needling of the triceps brachii muscle in side-lying.

is inserted into the taut bands to elicit a local twitch response.
- *Precautions:* The radial nerve runs caudal to the head of the humerus and posteriorly to the humerus under the lateral head of the triceps muscle.

Subclavius muscle

- *Anatomy:* The muscle lies beneath the clavicle over the first rib and attaches medially by a short thick tendon to the junction of the first rib with its cartilage. The muscle attaches laterally in a groove on the caudal aspect of the middle third of the clavicle.
- *Function:* It indirectly assists in protraction of the shoulder by approximating the clavicle and the first rib.
- *Innervation:* Subclavius nerve from the C5 and C6 nerve roots.
- *Referred pain:* The pain travels across the front of the shoulder and down the front of the arm and along the radial side of the forearm and hand, skipping the elbow and wrist. In addition, the dorsal and volar aspects of the thumb, the index finger and the middle finger also may hurt.
- *Needling technique:* The patient lies in the supine position. The needle is inserted and directed toward the point of maximum tenderness beneath the clavicle, usually in the middle of the muscle towards the junction of its medial and middle thirds. Strong referred pain patterns are likely to be elicited by needle penetration of TrPs (Figure 7.24).

Figure 7.24 • Dry needling of subclavius muscle in supine.

- *Precautions:* As the subclavius muscle is located over the ventral surface of the ribcage one has to be certain to avoid entering the intercostal space and penetrating the lung. The neurovascular bundle to the arm lies under the pectoralis minor muscle close to the coracoid process.

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Deep dry needling of the arm and hand muscles

8

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CHAPTER CONTENT

Introduction

Arm pain syndromes constitute a complex entity which can arise from a wide range of different conditions. Symptoms in the upper quadrant, including the neck, shoulder, arm, forearm, or hand not related to an acute trauma or underlying systemic diseases, can be provoked by trigger points (TrPs). In fact, there are several neck and shoulder muscles with referred pain pattern being perceived throughout the upper extremity, e.g. the scalenes, subclavius, pectoralis minor, supraspinatus, infraspinatus, subscapularis, pectoralis major, latissimus dorsi, serratus posterior superior and serratus anterior muscles (Simons et al. 1999). For instance, Qerama et al. (2009) demonstrated that 49% of individuals with normal electrophysiological findings in the median nerve, but with symptoms mimicking carpal tunnel syndrome, presented with active TrPs in the infraspinatus muscle with paresthesia and referred pain to the arm and fingers. In the same study, patients with mild electrophysiological signs of carpal tunnel syndrome exhibited a significantly higher occurrence of infraspinatus muscle TrPs in the symptomatic arm as compared with patients with moderate to severe electrophysiological signs (33% vs 20%). Dry needling of these muscles has been covered in Chapters 6 (scalene) and 7 (shoulder).

Additionally, TrP taut bands in the musculature of the upper quadrant can be related to neural or articular dysfunctions. For instance, since the brachial plexus runs anatomically between the anterior and the medial scalene muscles, TrPs in the scalene muscles may be related to entrapment of

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the brachial plexus (Chen et al. 1998). Similarly, shortening of the scalene muscles induced by TrPs taut bands may be related to first rib dysfunctions (Ferguson & Gerwin 2005), which means that clinicians should integrate TrP dry needling within the overall clinical reasoning process and management. In the current chapter we will cover deep dry needling of TrPs in the arm and hand muscles.

Clinical relevance of TrPs in arm and hand pain syndromes

There are several studies demonstrating the relevance of TrPs in the etiology of different arm pain syndromes. The most accepted muscle pain syndrome in the arm is lateral epicondylalgia (Slater et al. 2003). Fernández-Carnero et al. (2007) found that active TrPs in the extensor wrist musculature reproduced the pain symptoms in subjects with lateral epicondylalgia (65% extensor carpi radialis brevis, 55% extensor carpi radialis longus, 50% brachioradialis, 25% extensor digitorum communis muscle). In a subsequent study, Fernández-Carnero et al. (2008) reported that subjects with unilateral lateral epicondylalgia also exhibited latent TrPs within the unaffected elbow (88% extensor carpi radialis brevis, 80% extensor carpi radialis longus), which may be related to the development of bilateral symptoms in this patient population. A recent study found that active TrPs in the extensor carpi radialis brevis were very prevalent (68% right side; 57% left side) in women with fibromyalgia syndrome (Alonso-Blanco et al. 2011). These studies support the role of TrPs in arm pain syndromes, although further studies are needed. Additionally, when TrPs are present in the brachioradialis (Mekhail et al. 1999) or extensor carpi radialis brevis muscle (Clavert et al. 2009), entrapment of the radial nerve is feasible.

In clinical practice, an association between TrPs in the wrist flexor muscles and medial epicondylalgia is commonly seen, particularly in individuals with high muscular demands in the forearm, i.e., climbers (González-Iglesias et al. 2011), or with low-load but repetitive load, i.e., manual or office workers (Fernández-de-las-Peñas et al. 2012). Again, TrPs in the wrist flexor musculature can be also related to different nerve entrapments. For instance, as the pronator teres muscle is a common place for median nerve entrapment, commonly referred to as pronator syndrome (Lee & LaStayo 2004), tension induced by TrP taut bands may be relevant for symptoms associated with median nerve compression (Simons et al. 1999). Similarly, the median nerve can be entrapped by TrPs in the flexor digitorum profundus and superficialis muscles, whereas the ulnar nerve can be entrapped by TrPs in the flexor carpi ulnaris and flexor digitorum profundus (Chaitow & Delany 2008). Therefore, clinicians should consider muscle-nerve interrelations into their daily practice even though no study has confirmed the clinical observations.

Finally, TrPs within the intrinsic muscles of the hand, i.e., the interossei and lumbricals, can also be clinically relevant for unspecific wrist-hand pain. For instance, manual laborers or boxers who suffered a traumatic event over the wrist or the hand frequently develop TrPs in these muscles. There is clinical evidence that TrP dry needling of the intrinsic hand muscles, such as the dorsal interossei, is highly effective in these patients. TrPs in the thenar muscles are commonly seen in complaints of presumed arthritic changes in the joints of the thumb. Dry needling of TrPs in the abductor pollicis brevis may relieve the pain associated with these joint problems. Again, no scientific study has been published confirming these clinical observations.

It is important for clinicians to combine scientific and clinical-based evidence as there is no scientific evidence yet for several approaches that clinically are found to be effective. In this chapter we cover dry needling of TrPs in the arm and hand musculature based on clinical and scientific reasoning.

Dry needling of the arm and hand muscles

Coracobrachialis muscle

- *Anatomy:* The muscle originates from the coracoid process and inserts to the mid-portion of the humerus bone.
- *Function:* It assists in flexion and adduction of the arm at the glenohumeral joint.
- *Innervation:* Musculocutaneous nerve, via the lateral cord from the C5 and C6 roots. It should be noted that the musculocutaneous nerve crosses the muscle belly of the coracobrachialis underneath the pectoralis major muscle.

Figure 8.1 • Dry needling of the coracobrachialis muscle.

Figure 8.2 • Dry needling of the short head of the biceps brachii muscle.

- *Referred pain:* It is projected over the anterior aspect of the shoulder and also extends down the back of the arm and dorsum of the forearm to the back of the hand.
- *Needling technique:* The patient lies supine with lateral rotation at the shoulder. The muscle is needled via flat palpation. The needle is inserted perpendicular to the skin from medial to lateral side toward the upper third of the humerus bone (Figure 8.1). The muscle can also be needled near the coracoid process just medial to the tendon of the short head of the biceps brachii muscle.
- *Precautions:* The neurovascular bundle, which includes the median nerve, the musculocutaneous nerve which passes through the muscle, the ulnar nerve, and the brachial artery, is located dorsally and medially to the muscle and must be avoided.

Biceps brachii muscle (short head)

- *Anatomy:* The long head of the muscle originates from the superior margin of the glenoid cavity, whereas the short head originates from the coracoid process of the scapula. Both heads attach distally to the lesser tuberosity of the radius.
- *Function:* This muscle flexes the forearm at the elbow, assists flexion of the arm at the shoulder, and assists supination of the forearm when the elbow is not fully extended.
- *Innervation:* Musculocutaneous nerve, via the lateral cord from the C5 and C6 roots. It should be noted that the median nerve runs anatomically medial to the muscle belly of the biceps brachii (Maeda et al. 2009).
- *Referred pain:* It is projected mainly upward, over the muscle to the front of the shoulder (mimicking symptoms of long head bicipital tendonitis) and the common tendon of the bicep brachii muscle.
- *Needling technique:* The patient lies in supine. The muscle is needled via a pincer palpation. The needle is inserted perpendicular to the skin from medial to lateral side of the short head, and directed towards the practitioner's finger (Figure 8.2). Otherwise, the needle can be also inserted from lateral to medial side of the muscle.
- *Precautions:* The neurovascular bundle, which includes the median nerve, the musculocutaneous nerve, the ulnar nerve and the brachial artery, is located medially to the biceps brachii muscle and must be avoided.

Triceps brachii muscle (lower portion)

- *Anatomy:* The long head of the muscle originates from the scapula inferior to the glenoid fossa, the medial head originates from the medial portion of the humerus and the lateral head originates from the lateral side of the humerus. All three heads insert to the olecranon process on the ulna via a common tendon.
- *Function:* This muscle extends the forearm at the elbow (antagonist of biceps brachii). The long head may extend the arm at the shoulder joint.
- *Innervation:* Radial nerve, via the posterior cord of the brachial plexus from spinal roots C7 and C8.

Figure 8.3 • Dry needling of the lower portion of the triceps brachii muscle.

Figure 8.4 • Dry needling of the anconeus muscle

- *Referred pain:* It is projected up and down the posterior aspect of the shoulder, spreading occasionally to the upper trapezius region, and sometimes down the dorsum of the forearm, to the posterior part of the arm, spreading to the dorsum of the forearm or the fourth and fifth digits (lateral head), and to the lateral, sometimes to the medial, epicondyle (medial head).
- *Needling technique:* For the lower portion, the patient lies in prone. The muscle is needled via flat palpation. The needle is inserted perpendicular to the skin from lateral to medial side of the lateral head directed towards the posterior part of the humerus (Figure 8.3). If the muscle belly can be grasped with pincer palpation, the needling procedure can be also conducted with pincer palpation. The upper portion (which is needled via pincer palpation) is covered in Chapter 7.
- *Precautions:* The radial nerve runs deep to the lateral head of the triceps muscle (Rezzouk et al. 2002) and must be avoided. This is of particular relevance for dry needling of the upper portion of the muscle (see Ch.7).

Anconeus muscle

- *Anatomy:* The muscle originates from the side of the olecranon process and to the dorsal surface of the ulna, and inserts to the lateral epicondyle.
- *Function:* It assists the extension movement of the forearm at the elbow (agonist of the triceps brachii).
- *Innervation:* Radial nerve, via the posterior cord of the brachial plexus from spinal roots C7 and C8.
- *Referred pain:* It induces pain and tenderness locally to the lateral epicondyle.
- *Needling technique:* The patient lies in prone, with the forearm flexed about 45° at the elbow. The muscle is needled via flat palpation. The needle is inserted perpendicular to the skin directed towards the ulna bone (Figure 8.4).
- *Precautions:* None

Brachialis muscle

- *Anatomy:* The muscle originates from the distal two thirds of the humerus and inserts at the coronoid process of the ulnar tuberosity. This muscle extends into the anterior part of the joint capsule of the elbow.
- *Function:* This muscle flexes the forearm at the elbow.
- *Innervation:* Musculocutaneous nerve, via the lateral cord and by spinal roots C5 and C6.
- *Referred pain:* It is projected to the base of the thumb, and often to the ante-cubital region of the elbow.
- *Needling technique:* The patient lies supine with the elbow relaxed and slightly flexed. The muscle is needled via a flat palpation. The muscle is needled only from the lateral aspect of the arm to avoid hitting the neurovascular bundle. The

Figure 8.5 • Dry needling of the brachialis muscle

Figure 8.6 • Dry needling of the brachioradialis muscle

needle is directed medially between the biceps and triceps brachii (Figure 8.5).

- *Precautions:* The neurovascular bundle should be avoided over the medial head of the muscle.

Brachioradialis muscle

- *Anatomy:* The muscle starts from the upper two-thirds of the supracondylar ridge of the humerus and attaches over the distal radius at the styloid process.
- *Function:* In the neutral position of the forearm, the muscle flexes the forearm at the elbow.
- *Innervation:* Radial nerve, via the posterior cord of the brachial plexus from spinal roots C7 and C8.
- *Referred pain:* It is projected to the lateral epicondyle, the radial aspect of the forearm, the wrist, and the base of the thumb.
- *Needling technique:* The patient lies in supine position. The muscle is needled via pincer palpation. The needle is inserted from either the medial or the lateral aspect of the forearm and directed towards the practitioner's finger (Figure 8.6). In patients with a very thin muscle, needling in between the fingers may be a safer option for the clinician to avoid needling the opposing finger.
- *Precautions:* This muscle is the most superficial muscle over the lateral elbow. The radial nerve passes close to it (Mekhail et al. 1999) and must be avoided. Clinicians should be aware of needling their opposing finger in patients with a very thin brachioradialis muscle when they used the pincer procedure.

Supinator muscle

- *Anatomy:* The muscle originates from the lateral humeral epicondyle, the radial collateral ligament, and the annular ligament and the supinator crest of the ulna. The muscle inserts over the radial tuberosity and upper third of the radial shaft.
- *Function:* This muscle supinates the forearm. It may assist flexion at the elbow.
- *Innervation:* Radial nerve, via the posterior cord of the brachial plexus from spinal roots C7 and C8. In fact, the radial nerve crosses the fibrous arch of the supinator muscle, called the arcade of Frohse. Muscle tension induced by TrPs taut bands in this muscle can entrap the radial nerve, particularly the motor branch (posterior interosseous) (Schneider 2005, Tatar et al. 2009).
- *Referred pain:* It is projected mainly to the lateral epicondyle, the lateral area of the elbow, and sometimes can project spillover pain to the dorsal aspect of the web of the thumb.
- *Needling technique:* The patient is in supine position. The muscle is needled via flat palpation. The needle is inserted perpendicular to the skin at the dorsal aspect of the forearm at the level of upper third of the radial bone (Figure 8.7). TrP at the ventral part of the muscles can be needled in a similar fashion.
- *Precautions:* There is a risk of hitting the superficial branch of the radial nerve over the muscle or the posterior interosseous nerve, between the two heads of the muscle.

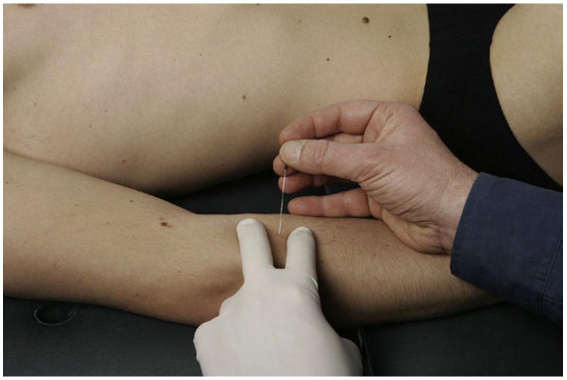

Figure 8.7 • Dry needling of the supinator muscle

Figure 8.8 • Dry needling of the extensor carpi radialis brevis muscle

Wrist and finger extensor muscles

- *Anatomy:* The wrist-finger extensors (extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum communis and extensor carpi ulnaris muscles) originate from the lateral supracondylar ridge of the humerus bone, the lateral epicondyle, the radial ligament of the elbow and the inter-muscular septa through a common tendon. The attachments are at the base of the second metacarpal bone (extensor carpi radialis longus), base of the third metacarpal bone (extensor carpi radialis brevis), the ulnar aspect of the base of the fifth metacarpal bone (extensor carpi ulnaris) and the distal phalanx of the second-fourth fingers (extensor digitorum communis).
- *Function:* These muscles extend (all muscles) and deviate the hand at the wrist to either radial (extensor carpi radialis longus) or ulnar (extensor carpi ulnaris) side. The extensor digitorum communis extends the phalanges.
- *Innervation:* Deep branch of the radial nerve (posterior interosseous nerve), via the posterior cord of the brachial plexus from spinal roots C7 and C8. In fact, the radial nerve may get entrapped in the superior-lateral aspect of the extensor carpi radialis brevis muscle (Clavert et al. 2009).
- *Referred pain:* The *extensor carpi radialis longus* muscle refers pain to the lateral epicondyle and to the dorsum of the hand next to the thumb; the *extensor carpi radialis brevis* muscle projects pain to the radial and posterior aspects of the hand and the wrist; the *extensor digitorum communis* refers pain downward to the forearm, reaching the same digit that the fibers activate, and the *extensor carpi ulnaris* refers pain to the ulnar side of the back of the wrist.

Figure 8.9 • Dry needling of the extensor digitorum muscle

- *Needling technique:* The patient lies in supine with the forearm pronated. The extensor carpi radialis longus can be needled with a pincer palpation (similar to the brachioradialis muscle). Both the extensor carpi radialis brevis and extensor digitorum muscles are needled with flat palpation. The needle is again inserted perpendicular to the skin and directed towards the radius bone. The extensor carpi radialis brevis is medial (Figure 8.8) to the extensor digitorum (Figure 8.9) muscle. For the extensor carpi ulnaris the needle is inserted perpendicular to

Figure 8.10 • Dry needling of the extensor carpi ulnaris muscle

Figure 8.11 • Dry needling of the pronator teres muscle

the skin and directed towards the ulnar bone (Figure 8.10). Since these are relatively flat muscles, needling directly over a TrP may not be as accurate as inserting the needle 1 cm or so away from the TrP and needle towards the TrP.

- *Precautions:* The radial nerve crosses over the extensor digitorum muscle and the extensor carpi radialis brevis, and should be avoided.

Pronator teres muscle

- *Anatomy:* The humeral head originates from the medial epicondyle, whereas the ulnar head originates from the medial side of the coronoid process of the ulnar bone. Both heads insert over the radius distally from the insertion of the supinator muscle.
- *Function:* This muscle pronates the forearm and assists the pronator quadratus, the primary pronator, in fast movements and to overcome resistance.
- *Innervation:* Median nerve, via the lateral cord and upper and middle trunks of the brachial plexus from spinal roots C6 and C7. In fact, the median nerve runs in between the two heads of the pronator teres muscle (Lee & LaStayo 2004).
- *Referred pain*: It is projected deep in the volar radial region of the wrist and of the forearm, over the carpal tunnel.
- *Needling technique:* The patient lies in supine with the forearm supinated. The muscle can be needled at the proximal, medial portion approximately 1–2 cm below the medial epicondyle to avoid the median and ulnar nerves. The muscle is palpated with flat palpation. The needle is inserted perpendicular to the skin and directed towards the ulna (Figure 8.11). The muscle can also be needled in its distal portion with needling toward the radius.
- *Precautions:* The median nerve runs between the two heads of the muscle and should be avoided.

Wrist and finger flexor muscles

- *Anatomy:* The wrist-finger flexors (flexor carpi radialis, palmaris longus, flexor digitorum superficialis, flexor digitorum profundus and flexor carpi ulnaris) originate from the lateral supracondylar ridge of the humerus bone, the medial epicondyle, and the inter-muscular septa via a common tendon. The attachments are: the palmar aspect of the second metacarpal bone (flexor carpi radialis); the base of the palmar fascia (palmaris longus); the ulnar aspect of the base of the fifth metacarpal bone (flexor carpi ulnaris); the second phalanx of the second-fourth fingers (flexor digitorum superficialis) and the third phalanx of the second-fourth fingers (flexor digitorum profundus). It should be noted that the palmaris longus muscle is not present in all subjects.
- *Function:* These muscles flex (all muscles) and deviate the hand at the wrist to either the radial

Figure 8.12 • Dry needling of the flexor carpi radialis muscle

Figure 8.13 • Dry needling of the flexor digitorum muscle

(flexor carpi radialis) or ulnar (flexor carpi ulnaris) side. The flexor digitorum communis flexes the phalanges.

- *Innervation:* Median nerve, via the lateral cord and upper-middle trunks of the brachial plexus from spinal roots C6 and C7; and ulnar nerve, via the medial cord and lower trunk of the brachial plexus from spinal roots C8 and T1. In fact, the median nerve can be entrapped by the flexor digitorum profundus and superficialis muscles and the ulnar nerve can be entrapped by the flexor carpi ulnaris and flexor digitorum profundus muscles (Chaitow & Delany 2008).
- *Referred pain:* The *flexor carpi radialis* muscle refers pain to the volar aspect of the wrist; the *palmaris longus* muscle projects superficial, needle-like pain over the volar area of the palm; the *flexor carpi ulnaris* muscle projects pain to the ulnar side of the volar aspect of the wrist; whereas the *flexors digitorum superficialis and profundus* muscles refer pain to the same digit that the fibers activate, e.g. the fibers of the middle finger flexor muscle refer pain through the length of the middle finger.
- *Needling technique:* The patient lies in supine with the forearm supinated. The muscles are needled with a flat palpation. The needle is inserted perpendicular to the skin and directed towards the radius for the flexor carpi radialis (Figure 8.12). The palmaris longus is slightly medial to the flexor carpi radialis. For the flexor digitorum muscles, the needle is inserted perpendicular to the skin and directed towards the interosseous membrane (Figure 8.13). For the flexor carpi ulnaris, the needle is inserted directed towards the ulnar bone (Figure 8.14).

Figure 8.14 • Dry needling of the flexor carpi ulnaris muscle

- *Precautions:* The median nerve runs between the flexor digitorum profundus and superficialis, and the ulnar nerve runs between the flexor carpi ulnaris and flexor digitorum profundus muscles. Both nerves should be avoided.

Flexor pollicis longus, extensor pollicis longus, and abductor pollicis longus muscles

- *Anatomy:* The *flexor pollicis longus* muscle originates from the proximal part of the radius, the adjacent interosseous membrane, and by a slip to the humerus, and it inserts over the base of the distal phalanx of the thumb. The *extensor pollicis longus* muscle extends from the dorsal surface of the ulna bone and the interosseous membrane to the base of the distal phalanx of the thumb. The *abductor pollicis longus* muscle originates from the ulnar side of the middle third of the radius, the lateral side of the dorsal surface of the ulna and it inserts into the radial side of the base of the first metacarpal bone.

- *Function:* The *flexor pollicis longus* muscle flexes the terminal phalanx and adducts the proximal phalanx of the thumb; the *extensor pollicis longus* muscle extends the terminal phalanx of the thumb and it helps to extend and abduct the wrist, whereas the *abductor pollicis longus* muscle abducts the first metacarpal bone and it also helps to abduct the wrist.
- *Innervation:* The *flexor pollicis longus* muscle is innervated by the median nerve, via the lateral cord and upper-middle trunks of the brachial plexus from spinal roots C6 and C7; whereas the *extensor pollicis longus* and *abductor pollicis longus* muscles are innervated by the deep branch of the radial nerve (posterior interosseous nerve), via the posterior cord of the brachial plexus from spinal roots C7 and C8.
- *Referred pain:* The *flexor pollicis longus* muscle refers pain to the proximal and distal phalanxes of the thumb; the *extensor pollicis longus* muscle refers pain to the dorsal aspect of the thumb; and the *abductor pollicis longus* muscle refers pain to the radial aspect of the wrist and the dorsal aspect of the third and fourth fingers (Hwang et al. 2005)
- *Needling technique:* The patient lies in supine. All muscles are needled with a flat palpation. For the *flexor pollicis longus* muscle the needle is inserted perpendicular to the skin and directed towards the palmar aspect of the middle third of the radius (Figure 8.15). For *extensor pollicis longus* and *abductor pollicis longus* muscles, the needle is inserted perpendicular to the skin and directed towards the dorsal aspect of the middle third of the radius (Figure 8.16). Hwang et al. (2005) used a midpoint between the lateral epicondyle and radial styloid for needling the abductor pollicis longus muscle.

Figure 8.15 • Dry needling of the flexor pollicis longus muscle

Figure 8.16 • Dry needling of the extensor pollicis longus, abductor pollicis longus or extensor indicis muscle

- *Precautions:* The median nerve runs between the flexor digitorum profundus and superficialis muscles and should be avoided. Clinicians should avoid the interosseous membrane during needle of extensor pollicis longus or abductor pollicis longus muscles. Branches of the radial nerve run over the extensor pollicis longus and abductor pollicis longus muscles, but rarely interfere with dry needling procedures.

Extensor indicis muscle

- *Anatomy:* This muscle extends from the dorsal-lateral surface of the ulna and interosseous membrane to the dorsal aspect of the second metacarpal bone.

- *Function*: This muscle extends the second finger.
- *Innervation:* This muscle is innervated by the deep branch of the radial nerve (posterior interosseous nerve), via the posterior cord of the brachial plexus from spinal roots C7 and C8.
- *Referred pain:* It refers pain to the dorsal aspect of the second finger.
- *Needling technique:* The needle is inserted perpendicular to the skin towards the dorsal aspect of the middle third of the radius, similarly to the extensor pollicis longus and abductor pollicis longus muscles (Figure 8.16). The referred pain and the muscle contraction will assist the clinician to focus the needling in one or other muscle.
- *Precautions:* Clinicians should avoid the interosseous membrane during needle.

Figure 8.17 • Dry needling of the adductor pollicis muscle

Adductor pollicis, opponens pollicis, flexor pollicis brevis and abductor pollicis brevis muscles

- *Anatomy:* The *adductor pollicis* muscle originates in the carpometacarpal region of the index and middle fingers, to the base of the proximal phalanx of the thumb. The *opponens pollicis* muscle extends from the trapezium bone of the wrist and the flexor retinaculum in the heel of the hand to wrap partially around, and attaches to the first metacarpal bone. The *flexor pollicis brevis* muscle extends from the trapezium, trapezoid, and capitate bones, and the flexor retinaculum to the palmar aspect of the first metacarpal and sesamoid bone. The *abductor pollicis brevis* muscle originates in the scaphoid bone and the flexor retinaculum and inserts to the lateral aspect of the first metacarpal and sesamoid bones.
- *Function:* The *adductor pollicis* muscle adducts the thumb toward the index finger, the *opponens pollicis* opposites the thumb pad across the palm to touch the pads of the ring or little fingers; the *flexor pollicis brevis* muscle flexes the thumb toward the palm; and the *abductor pollicis brevis* muscle abducts the thumb away the palm.
- *Innervation:* The *adductor pollicis* muscle is supplied by the deep palmar branch of the ulnar nerve, via the medial cord and lower trunk of the brachial plexus from spinal roots C8 and T1, whereas the *opponens pollicis, flexor pollicis brevis, and abductor pollicis brevis* muscles are supplied by a branch of the median nerve, via the lateral cord and upper-middle trunks of the brachial plexus from spinal roots C6 and C7.
- Referred pain: The a*dductor pollicis* muscle refers pain to the ulnar aspect of the thumb; the *opponens pollicis* muscle projects pain to the palmar aspect of the thumb, the *flexor pollicis brevis* muscle refers pain to the palmar aspect of the thumb, and the *abductor pollicis brevis* muscle projects pain to the radial aspect of the thumb.
- *Needling technique:* Generally, a short but thin needle is used for the thenar muscles such as a 0.14 × 15 mm needle. The patient lies in supine with the forearm pronated (for the adductor pollicis muscle) or supinated (for the remaining muscles). These muscles are needled with a pincer palpation. The needle is inserted perpendicular to the skin and directed to the muscle. For the *adductor pollicis* muscle the needle is inserted between the first and second metacarpal bones (Figure 8.17); for the *opponens and flexor pollicis brevis* muscles the needle is inserted via the radial aspect of the first metacarpal (to avoid palmar fascia) towards the thenar eminency (Figure 8.18); and for the *abductor pollicis brevis* muscle the needle is directed towards the radial aspect of the first metacarpal (Figure 8.19).
- *Precautions:* The *flexor pollicis longus* tendon crosses between the adductor pollicis and opponens pollicis muscles and should be avoided.

Figure 8.18 • Dry needling of the opponens and flexor pollicis muscles

Figure 8.20 • Dry needling of lumbrical, palmar and dorsal interosseous muscles

Figure 8.19 • Dry needling of the abductor pollicis muscle

Interosseous, lumbricals, and abductor digiti minimus muscles

- *Anatomy:* The *interosseous muscles* (dorsal or palmar) lie between the adjacent metacarpal bones. The *lumbrical muscles* attach proximally to the four tendons of the flexor digitorum profundus in the mid-palm, distally to the radial side of the aponeurosis on each of the four fingers. The *abductor digiti minimus* muscle arises proximally from the pisiform bone, and attaches distally to the ulnar side of the base of the first phalanx of the little finger.
- *Function:* The *dorsal interosseous* muscles moves a finger away from the midline of the middle finger (abduction); the *palmar interosseous* muscles adduct each of the other fingers toward the middle finger (adduction); the *lumbricals* inhibit flexion of a distal phalanx via the extensor mechanism; whereas the *abductor digiti minimus* abducts the little finger.
- *Innervation:* The *interosseous*, the *abductor digiti minimus* and the *third-fourth lumbricals* muscles are supplied by branches of ulnar nerve, via the medial cord and lower trunk of the brachial plexus from spinal roots C8 and T1. The *first and second lumbricals* are supplied by the median nerve, via the lateral cord and upper-middle trunks of the brachial plexus from spinal roots C6 and C7.
- *Referred pain:* The *dorsal and palmar interosseous* muscles project their pain along the side of the finger to which that interosseous muscle attaches. The *first dorsal interosseous* also projects to the dorsum of the hand and ulnar side of the little finger. Referred pain from the *lumbricals* is similar to the referred pain of the interossei. The *abductor digiti minimus* muscle pain extends along the lateral side of the little finger.
- *Needling technique:* The patient lies in supine with the forearm pronated. All muscles are needled with flat palpation. The needle is inserted perpendicular to the skin from the dorsal aspect of the hand directed towards the practitioner's finger. For the *lumbrical, palmar and dorsal interosseous* the needle is directed towards the muscle belly between the metacarpal bones (Figure 8.20); whereas for the *abductor digiti minimus* muscle the needle is directed towards the fifth metacarpal bone with pincer palpation (Figure 8.21).
- *Precautions:* None.

Figure 8.21 • Dry needling of the abductor digiti minimus muscle.

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Deep dry needling of the trunk muscles

9

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CHAPTER CONTENT

Introduction

Muscles of the trunk, linked intimately to vital human functions, aid in breathing, digestion and locomotion and provide upright postural support. Myofascial trigger points (TrPs) located in the trunk region can influence movement patterns, reflect breathing and visceral dysfunction and contribute to a wide array of commonly diagnosed musculoskeletal pain syndromes. Pain from trunk muscle TrPs may be local or diffuse, referring anteriorly or posteriorly or referring into the upper or lower extremities. For example, the referred pain from TrPs in the quadratus lumborum muscle may be confused with trochanteric bursitis, sacroiliac joint dysfunction, and coccydynia. In addition, with referral to the medial aspect of the arm, TrPs in the serratus anterior may present similarly to a radiculopathy.

The efficacy of deep dry needling on TrPs of the muscles of the trunk has been examined. Furlan et al. (2005) have assessed the methodological quality of 35 randomized controlled trials which examined the use of acupuncture and dry needling (DN) for chronic low back pain. They concluded that DN appears to be a useful adjunct to conventional therapies, but they cautioned that most of the studies were of lower methodological quality than what is recommended by the Cochrane Back Review Group. Itoh et al. (2004) concluded that deep needling was more effective in reducing pain when compared with standard acupuncture therapy or superficial needling in elderly patients presenting with chronic low back pain. Several investigators compared DN to anesthetic injection and percutaneous electrical nerve stimulation, and determined that DN was equally successful in inactivating TrPs in low back muscles and reducing pain (Perez-Palomares et al. 2010). Although the literature to date supports the inclusion of deep DN for mitigation of pain related to TrPs of the trunk, they are limited in their scope

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and number. Ongoing research and publication of case studies illustrating the applications of DN and comparing its effectiveness to other treatment options is hence warranted for improved clinical decision-making.

Clinical relevance of TrPs in syndromes related to the trunk

The most prevalent syndrome associated with the trunk is low back pain, which is a global concern with significant economic consequences. In the USA alone, the lifetime incidence is estimated at 65–80% with a small percentage of those afflicted accounting for a major portion of health-care visits (Manchikanti 2000). The role of muscles, specifically TrPs, in the etiology of low back pain is often overlooked in favor of structural disorders that can be seen on imaging. Attempting to identify a single source of pain may cause the practitioner to ignore the potential contribution of other tissues in the overall pain presentation. Instead, low back pain should be considered a summation of dysfunctions, with ligamentous instability and facet joint degeneration occurring in conjunction with development of motor control dysfunction and muscle TrPs formation (Kirkaldy-Willis 1990, Chaitow 1997, Paris 1997, Waddell 1998, Bajaj et al. 2001a, 2001b, Fernández-de-las-Peñas 2009). Fernández-de-las-Peñas (2009) examined the relationship between TrPs and facet joint hypomobility. He postulated that increased tension from taut bands may maintain abnormal facet joint compression and displacement and, conversely, abnormal sensory input from dysfunctional facet joints may reflexively activate TrPs. Mense (2008), moreover, described the persistent nociceptive input from any number of tissues of the spine leading to an increase in responsiveness of the corresponding dorsal horn neurons, and, through antidromic mechanisms, sensitization of the tissues sharing that segmental level.

Several studies have examined the role of TrPs in the etiology and maintenance of low back pain. Teixera et al. (2011) identified the presence of TrPs, primarily in the quadratus lumborum and gluteus medius muscles, in 85.7% of patients diagnosed with failed back surgery pain syndrome. Chen & Nizar (2011) reported a strong correlation between TrP prevalence and chronic back pain. The trapezius, piriformis and quadratus lumborum muscles were most commonly involved with a favorable outcome following DN intervention. These findings suggest that the persistence of pain following the removal of the etiological factor may, in fact, be due to unresolved TrPs. Cornwall et al. (2006) injected the lumbar multifidus with hypertonic saline at the L4 level to examine the referral patterns. All subjects reported local pain, with 87% reporting referred pain into the anterior or posterior thigh. Samuel et al. (2007) have established the connection between muscle-induced pain and lumbar disc disease in a study of 60 subjects with lumbar disc prolapse. These authors demonstrated a significant association between disc disease and the presence of TrPs in muscles innervated by the corresponding segmental level (i.e. L4-L5 lesions with anterior tibialis TrPs).

A primary contributing factor to low back pain and, indeed, to pain throughout the body, is dysfunctional breathing. Breathing pattern disorders, which include hyperventilation, dsypnea, paradoxical breathing, and thoracic-dominant breathing, adversely affect posture and can induce muscle pain and the development of TrPs (Chaitow 1997, 2004, Hodges & Richardson 1999, Hodges et al. 2001, Courtney 2009). Of these disorders, hyperventilation is the most commonly seen and has a variety of causes, such as airway obstruction due to asthma, loss of elastic recoil of the lungs as seen in chronic smokers, hyperthermia from fever, renal or liver failure, hormonal disturbances, deconditioning, mental stress and anxiety, or, simply, habit. Hyperventilation leads to respiratory alkalosis and an increase in the body's pH. This, in turn, results in a host of neurophysiological changes, including an increased affinity of hemoglobin for oxygen, sympathetic nervous system dominance, anxiety and panic, vasoconstriction, and smooth and skeletal muscle spasm and constriction. With reduced blood flow and diminished availability of oxygen, muscles become prone to fatigue and TrP formation. The hypoxic environment stimulates the release of nociceptive substances, e.g. bradykinin, calcitonin gene-related peptide and prostaglandins, among others, which, in turn, perpetuates TrP sensitization and pain (Dommerholt & Shah 2010). Deleterious effects on spinal stability and skeletal alignment may occur. Studies, in which strenuous exercise is simulated, revealed reduced postural functions of both the transverse abdominus and diaphragm, as respiratory demands increased. Spinal stabilizers become overloaded, making them more vulnerable to injury. Hyperactivity of accessory muscles of respiration, such as the pectoralis major and minor, upper trapezius, levator scapula and sternocleidomastoid occurs, with resulting rib cage stiffness, forward head posture, suboccipital compression, headaches, and temporomandibular joint disease (Hruska 1997, 2002, Courtney 2009, Bartley 2010). Inactivation of TrPs of the neck, thorax, abdominal wall and low back may assist in restoring normal breathing mechanics. Conversely, breathing retraining may help prevent the development of TrPs in the first place.

Muscle pain related to visceral disease occurs in more predictable, specific patterns than that of breathing dysfunction. Muscle hyperalgesia is triggered by a reflex arc, known as the visceral-somatic reflex. Noxious signals from a distended organ are thought to trigger neuroplastic changes in the dorsal horn of both sensory neurons and of neighboring efferent neurons. The resultant efferent signals create neurogenic inflammation, hyperalgesia and TrPs in somatic structures sharing the same segmental level (Gerwin 2002, Giamberadino et al. 2002, Montenegro et al. 2009). Examples of visceral disease and their associated pain referral include myocardial infarction with the left pectoralis major, ureteral colic with the iliocostalis, dysmenorrhea and interstitial cystitis with the lower abdominals, cholecystectomy with the latissimus dorsi, and pleurisy with thoracic multifidi (Boissonault & Bass 1990). The effectiveness of DN of visceral-induced TrPs is exemplified by a patient presenting with constipation. A single session of needling to the thoracolumbar multifidi and iliocostalis lumborum resulted in complete resolution of his symptoms. Because myofascial pain syndromes may predict, outlast, or mimic visceral disease, a detailed knowledge and awareness of visceral-induced pain patterns is essential for accurate differential diagnosis.

Dry needling of the trunk muscles

Pectoralis major muscle

- *Anatomy:* The pectoralis major muscle is a thick, fan-shaped muscle. Its medial attachments are comprised of four regions: the clavicular fibers, which attach to the anterior surface of the manubrium and along the medial half of the clavicle; the sternal fibers, which attach along the entire length of the sternum; the costal fibers, which attach to the first through seventh costal cartilages (sometimes the first and seventh are omitted); and the abdominal fibers, which attach to the aponeurosis of the external oblique. All fibers converge laterally to a flat, bilaminar tendon which attaches to the lateral lip of the intertuberous sulcus of the humerus. The ventral lamina is formed by fibers from the manubrium, clavicle, sternum, and second to fifth costal cartilages. The dorsal lamina is formed by fibers from the sixth, and often seventh, costal cartilages, sixth rib, sternum, and aponeurosis of the external oblique. Costal fibers join the lamina without twisting. However, the most inferior fibers of the medial attachment of the sternum and aponeurosis turn successively behind the fibers above them such that the inferior fibers at the medial attachment become the superior fibers at the lateral attachment. Further, the dorsal lamina attaches more superiorly on the humerus than the ventral lamina and blends with the capsular ligament of the shoulder joint.
- *Function:* Collectively, the fibers of the pectoralis major muscle adduct and internally rotate the humerus and flex the arm forward and medially. The sternal, costal and abdominal fibers depress the shoulder girdle. The pectoralis muscle is active in forceful inhalation.
- *Innervation:* The lateral pectoral nerve (C5–7) innervates the clavicular and sternal sections, and the medial pectoral nerve (C8–T1) innervates the abdominal section. The costal section is innervated by both the lateral and medial pectoral nerves (C7 and C8).
- *Referred pain:* The clavicular section refers pain over the anterior deltoid muscle. The intermediate sternal fibers refer pain to the anterior chest, down the inner aspect of the arm, and, possibly, to the volar aspect of the arm and ulnar side of the hand. The medial sternal section refers to the sternum, and the costal and abdominal fibers cause breast tenderness and nipple hypersensitivity. Left pectoralis major TrPs may mimic angina, while a point on the right side, in the intercostal space between ribs 5 and 6 just lateral to the xyphoid process, may be linked to cardiac arrhythmias.

Figure 9.1 • Dry needling of the pectoralis major muscle in supine.

Figure 9.2 • Dry needling of the pectoralis major muscle in supine.

- *Needling technique:* Position patient in supine with the arm abducted slightly. Women, particularly those with ample breast tissue, may be asked to place their hand over their breast and draw it slightly inferiorly or over to the opposite side. Stand or sit adjacent to the patient on the same or opposite side to be needled. When needling the costal and sternal heads, angle the needle tangentially toward the clavicle or shoulder. Maintain a shallow depth to avoid the lung (Figure 9.1). To treat muscle fibers near the costochondral junction or sternal insertion, perform the needling over a rib. Secure the taut band over a rib, between the index and middle fingers, which are placed in the intercostal spaces above and below. Direct the needle perpendicular to the rib (Figure 9.2).

Figure 9.3 • Dry needling of the rhomboid muscles in prone.

- *Precautions:* Care must be taken to prevent penetration into the lung, creating a pneumothorax.

Rhomboid major and minor muscles

- *Anatomy:*
  - Major – The muscle arises from the spinous processes and supraspinous ligaments of the second to fifth thoracic vertebrae and descends laterally to the medial border of the scapula between the root of the spine and the inferior angle.
  - Minor – The muscle runs from the distal ligamentum nuchae and the spines of the seventh cervical and first thoracic vertebrae to the base of the triangular surface of the medial end of the scapula spine.
- *Function:* Both muscles retract the medial border of the scapula superiorly and medially.
- *Innervation:* Dorsal scapular nerve C4–C5, via the upper trunk of the brachial plexus.
- *Referred pain:* Pain is projected to the medial border of the scapula and superiorly over the supraspinatus muscle.
- *Needling technique:* The patient lies prone with the arm at the side or in the hammerlock position. Secure the taut band over a rib, between the index and middle fingers, which are placed in the intercostal spaces above and below. Insert the needle perpendicular to the skin then angle it tangentially toward the rib (Figure 9.3).

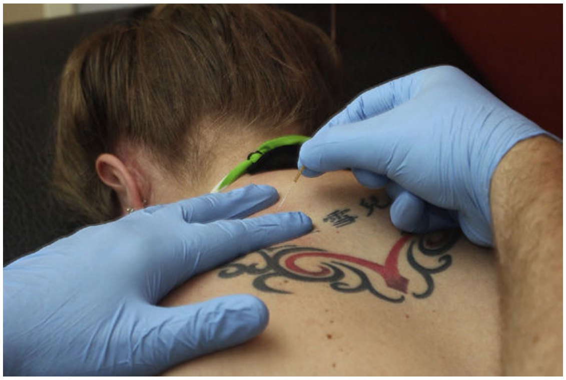

Figure 9.4 • Dry needling of the serratus posterior superior muscle in prone.

- *Precautions:* The lungs can easily be penetrated if the intercostal spaces are not blocked with the fingers. The needle should always be directed toward the rib, with the fingers remaining in the intercostal spaces.

Serratus posterior superior muscle

- *Anatomy:* The muscle arises from the distal portion of the nuchal ligament, the spinous processes and supraspinous ligaments of the seventh cervical and first two or three thoracic vertebrae. It descends laterally and ends in four digitations attached to the upper borders and external surfaces of the second, third, fourth, and fifth ribs, just lateral to their angles. This muscle can be absent in some individuals.
- *Function:* The attachments suggest it could elevate the ribs; however, its role is uncertain.
- *Innervation:* Second, third, fourth, and fifth intercostal nerves.
- *Referred pain:* Pain is projected as a deep ache to the anterior surface of the scapula, posterior aspect of the scapula and shoulder, triceps region, olecranon, ulnar side of the forearm and hand, and the entire fifth digit. It can also refer pain to the pectoralis region.
- *Needling technique:* The patient lies prone with the arm at the side or in the hammerlock position. Secure the taut band over a rib, between the index and middle fingers, which are placed in the intercostal spaces above and below. Insert the needle perpendicular to the skin then angle it tangentially toward the rib (Figure 9.4).

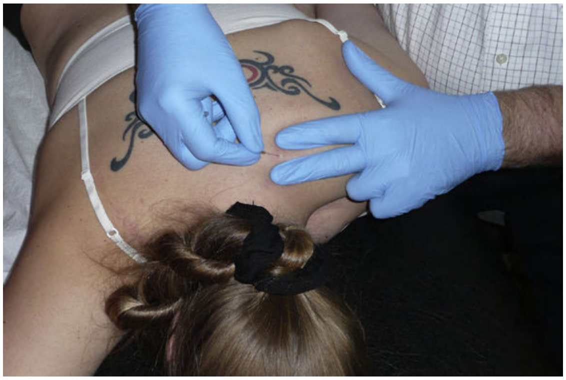

Figure 9.5 • Dry needling of the middle trapezius muscle in prone with flat palpation.

- *Precautions:* The needle should always be directed toward the rib to avoid penetration of the lung.

Middle trapezius muscle

- *Anatomy:* The muscle attaches medially to the spinous processes and the supraspinous ligaments of C7–T3. Its fibers run in a nearly horizontal direction to attach laterally to the superior lip of the scapular spine and to the acromion.
- *Function:* The superior fibers assist with scapular adduction and serve as part of the force couple for upward rotation of the scapula. The inferior fibers adduct the scapula. The entire muscle assists with scapular stabilization during flexion and abduction of the arm.
- *Innervation:* The spinal portion of the spinal accessory nerve (cranial nerve XI) supplies motor fibers. The third and fourth cervical nerves supply sensory fibers.
- *Referred pain:* TrPs may refer to the acromion. A superficial burning pain may be felt in the interscapular region.
- *Needling technique:* The patient is positioned in prone or on the uninvolved side. Secure the taut band over a rib, between the index and middle fingers, which are placed in the intercostal spaces above and below. Insert the needle perpendicular to the skin then angle it tangentially toward the rib (Figure 9.5). Another technique involves securing the taut band via a pincer grip,

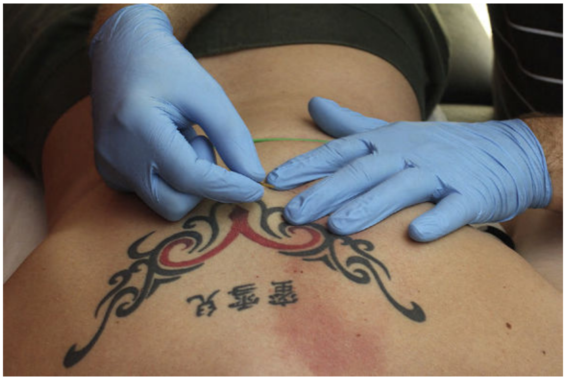

Figure 9.6 • Dry needling of the lower trapezius muscle in prone.

in which the needle is directed between the thumb and index fingers.
- *Precautions:* Avoid penetration of the lung.

Lower trapezius muscle

- *Anatomy:* The muscle attaches medially to the spinous processes and the supraspinous ligaments of T6–T12. Its fibers run superolaterally and attach to an aponeurosis on the medial end of the spine of the scapula.
- *Function:* It acts synergistically with the lower portion of the serratus anterior and the upper trapezius in upward rotation of the glenoid fossa. It adducts and depresses the scapula and assists with scapular stabilization during flexion and abduction of the arm.
- *Innervation*: The spinal portion of the spinal accessory nerve (cranial nerve XI) supplies motor fibers. The third and fourth cervical nerves supply sensory fibers.
- *Referred pain*: TrPs may refer to the posterior neck and adjacent mastoid region, to the acromion, and to the suprascapular and interscapular regions.
- *Needling technique*: The patient is positioned in prone or on the uninvolved side. Secure the taut band over a rib, between the index and middle fingers, which are placed in the intercostal spaces above and below. Insert the needle perpendicular to the skin then angle it tangentially toward the rib (Figure 9.6).
- *Precautions*: Avoid penetration of the lung.

Latissimus dorsi muscle (trunk portion)

- *Anatomy*: The muscle arises from the spinous processes of the lower six thoracic vertebrae, from the posterior layer of the thoracolumbar fascia (which is attached to the spinous processes and supraspinous ligaments of the lumbar and sacral vertebrae), and from the posterior iliac crest. It also has fibers from the iliac crest, lateral to the erector spine, and slips from the three or four lower ribs, interdigitating with the external oblique muscle. From this extensive attachment, fibers pass laterally with different degrees of obliquity to overlap the inferior scapular angle. It attaches to the intertubercular sulcus of the humerus anterior to the teres major.
- *Function*: The muscle adducts, extends, and medially rotates the humerus and draws the shoulder downward and backward. It pulls the trunk upwards and forwards when the arms are raised above the head (as in climbing) and assists in violent expiratory efforts, such as coughing or sneezing, and forcible expiration as when blowing a sustained note on a musical instrument.
- *Innervation*: Thoracodorsal nerve, from the posterior cord of the brachial plexus, C6, C7, C8.
- *Referred pain*: TrPs may project pain to the inferior angle of the scapula and surrounding mid-thoracic area, to the posterior aspect of the shoulder, the medial aspect of the arm and forearm, and to the fourth and fifth fingers. They can also refer pain to the anterior shoulder and over the lower lateral aspect of the trunk, above the iliac crest.
- *Needling technique*:
  - Version 1 – The patient lies prone with the arm resting at the side. Secure the taut band over a rib, between the index and middle fingers, which are placed in the intercostal spaces above and below. Insert the needle perpendicular to the skin then angle it tangentially toward the rib (Figure 9.7).
  - Version 2 – Position the patient in sidelying, with the side to be treated facing up and the arm placed in front of the patient. Grasp the taut band between the thumb and index and middle fingers. Insert the needle perpendicular to the skin, between the fingers, and direct the needle toward the thumb. The muscle

Figure 9.7 • Dry needling of the latissimus dorsi muscle in prone with flat palpation.

Figure 9.8 • Dry needling of the latissimus dorsi muscle in side-lying with pincher palpation.

may be followed caudally as long as it can be lifted away from the chest wall (Figure 9.8).

- *Precautions:* All needling is performed over a rib (as in version 1) or away from the chest wall (as in version 2) to avoid penetrating the lung.

Serratus anterior muscle

- *Anatomy:* The muscle arises from an extensive costal attachment and inserts on the scapula. Fleshy digitations spring anteriorly from the outer surfaces and superior borders of the upper eight, nine or ten ribs, and from fascia which cover the intervening intercostals. It attaches to the medial angle, vertebral border, and inferior angle of the scapula.
- *Function:* With the pectoralis minor, it protracts the scapula, serving as a prime mover in all reaching movements. The muscle also draws the ribs posteriorly, assisting with pushing movements. The superior portion, with the levator scapulae and upper fibers of the trapezius, suspends the scapula. The inferior portion pulls the inferior scapular angle antero-laterally around the thorax, assisting the trapezius in upward rotation, an action that is essential to raising the arm above the head. In the initial stages of abduction, it aids in securing the scapula to allow the deltoid muscle to act effectively on the humerus.

Figure 9.9 • Dry needling of the serratus anterior muscle in side-lying.

- *Innervation:* Long thoracic nerve, C5–7, which descends on the external surface of the muscle.
- *Referred pain:* TrPs can refer anterolaterally at mid-chest level, posteriorly to the inferior angle of the scapula, and down the medial aspect of the arm, extending to the palm and ring finger. They can contribute to abnormal breast sensitivity.
- *Needling technique:* Position the patient in sidelying, with the side to be treated facing up and the arm resting in front of the patient. Secure the taut band over a rib, between the index and middle fingers, which are placed in the intercostal spaces above and below. Insert the needle perpendicular to the skin then angle it tangentially toward the rib (Figure 9.9).
- *Precautions:* Avoid penetration of the lung.

Longissimus thoracis muscle

- *Anatomy*: The muscle attaches to the tips of the transverse processes of all of the thoracic

Figure 9.10 • Dry needling of the longissimus thoracis muscle in prone.

Figure 9.11 • Dry needling of the iliocostalis thoracis muscle in prone.

vertebrae and ribs 3 or 4 through 12 between their tubercles and angles. It blends with the iliocostalis lumborum. Some of its fibers are attached to the entire posterior surface of the transverse processes, the accessory processes of the lumbar vertebrae and to the middle layer of the thoracolumbar fascia.

- *Function*: This muscle works in conjunction with the iliocostalis thoracis and lumborum to extend and laterally flex the spine against gravity. Together, they contract eccentrically to control the movement as the spine is flexed forward or laterally with the aid of gravity.
- *Innervation*: Lateral and intermediate branches of the dorsal rami of the thoracic spinal nerves.
- *Referred pain*: The inferior portions of this muscle refer pain several segments caudally into the lumbar spine and into the buttock region.
- *Needling technique*: The patient lies prone with the arm at the side. The TrP is identified via flat palpation. Insert the needle slightly superior to the TrP, perpendicular to the skin, and direct the needle longitudinally at a shallow angle (Figure 9.10).
- *Precautions:* Maintain a shallow angle to avoid penetration of the lungs.

Iliocostalis thoracis and lumborum muscles

- *Anatomy*: The iliocostalis thoracis attaches proximally to the upper borders of the angles of the lower six ribs, medial to the tendons of the insertion of iliocostalis lumborum, and to the superior borders of the angles of the upper six ribs and transverse process of the seventh cervical vertebrae. The iliocostalis lumborum attaches to the inferior borders of the angles of the lower six or seven ribs. Both muscles attach inferiorly to the anterior surface of a broad aponeurosis. The aponeurosis attaches to the spinous processes of the lumbar and eleventh and 12th thoracic vertebrae and their supraspinous ligaments and laterally to the medial aspect of the posterior iliac crest and to the lateral sacral crest, where it blends with the sacrotuberous and dorsal sacroiliac ligaments.
- *Function*: Together, these muscles extend and laterally flex the spine against gravity. They contract eccentrically as the spine is flexes forward or laterally.
- *Innervation*: Lateral and intermediate branches of the dorsal rami of the thoracic and lumbar spinal nerves.
- *Referred pain*: The iliocostalis thoracis refers pain superiorly, inferiorly, and anteriorly from its TrP. It can mimic the pain of angina, pleurisy, or visceral pathology. The iliocostalis lumborum refers into the lumbar spine, buttock region and posterior hip.
- *Needling technique*:
  - Thoracis – The patient lies prone. Secure the taut band over a rib, between the index and middle fingers, which are placed in the intercostal spaces above and below. Insert the needle perpendicular to the skin then angle it tangentially toward the rib (Figure 9.11).
  - Lumborum – The patient lies prone. Identify the TrP via flat palpation. Insert the needle

Figure 9.12 • Dry needling of the iliocostalis lumborum muscle in prone.

Figure 9.13 • Demonstration of the safe needling zone for the multifidus.

slightly superior to the TrP, perpendicular to the skin, and angle it inferomedially (Figure 9.12).

- *Precautions*: Avoid penetration of the lung.

Thoracic and lumbar multifidus muscles

- *Anatomy*: This muscle group consists of fasciculi that attach most caudally to the back of the sacrum at the level of the fourth sacral foramen and to the posterior superior iliac spine and dorsal sacroiliac ligaments. In the lumbar spine, they attach to the mammillary processes and in the thoracic spine to the transverse processes. Each fasciculus runs superiorly and medially, attaching to the base or to the tip of the spinous process of the vertebrae above. The most superficial fasciculi attach three to four levels above, those deeper connect two to three levels up, and the deepest layers attach to the adjacent vertebrae.
- *Function*: Their primary action is stabilization of the spine. Acting bilaterally, the muscles extend the spine. Acting unilaterally, they rotate the vertebrae to the contralateral side.
- *Innervation*: Dorsal rami of spinal nerves, usually by medial branches.
- *Referred pain*: The thoracic and lumbar multifidus refer pain to the spinous process and the adjacent area of that segment. The lumbar multifidus can also refer pain anteriorly to the abdomen and inferiorly to the posterior thigh.
- *Needling technique*: The patient lies prone. The muscle is palpated via flat palpation

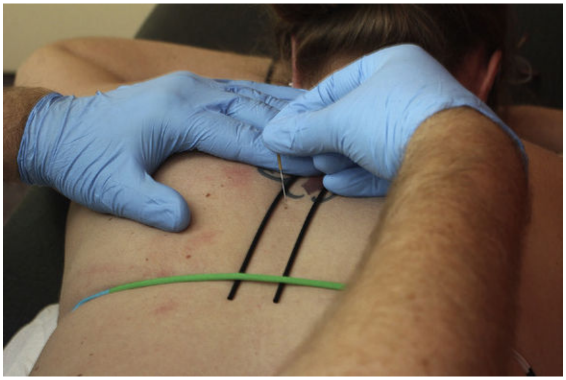

Figure 9.14 • Dry needling of the thoracic multifidus muscle.

in the valley next to the spinous processes, which is referred to as the 'safe needling zone' (Figure 9.13). Staying within the safe needling zone, the needle is inserted perpendicular to the skin then angled in a medial caudal direction towards the lamina of the vertebral body (Figure 9.14).

- *Precautions*: The safe needling zone is approximately one finger width lateral to the spinous processes on each side of the spine. Inserting the needle outside this range may cause the needle to penetrate the lung.

Serratus posterior inferior muscle

- *Anatomy:* This muscle lies deep to the latissimus dorsi muscle. Medially, it attaches to the spinous

Figure 9.15 • Dry needling of the serratus posterior inferior muscle.

processes of T11 through L2 or L3 by a thin aponeurosis. It passes obliquely in a superior and lateral direction and divides into four flat digitations. These digitations attach to the inferior, posterior surfaces of the last four ribs, just lateral to their angles. In some people, there are fewer digitations (usually the two attaching to the ninth and 12th ribs) or the entire muscle is missing.

- *Function:* By drawing the lower ribs posteriorly and inferiorly, it contributes to ipsilateral trunk rotation (acting unilaterally) and lower thoracic extension (acting bilaterally). It was previously thought to act synergistically, with the quadratus lumborum muscle, as an accessory muscle of exhalation. Vilensky et al. (2001) showed, however, that the muscle has primarily a proprioceptive function and is not involved in respiration.
- *Innervation:* Ventral rami of the ninth through 12th thoracic spinal nerves.
- *Referred pain:* Active TrPs may produce a nagging ache in the region of the lower thoracic region which may extend across the back, over the lower ribs.
- *Needling technique:* The patient lies prone or on the contralateral side to be treated. The needle is directed at a shallow angle toward the ninth, 10th, 11th or 12th rib, depending on the involved digitation. To protect the lung, cover the intercostal spaces above and below the rib with your fingers (Figure 9.15).
- *Precautions:* Care must be taken to prevent penetration into the lung, creating a pneumothorax.

Quadratus lumborum muscle

- *Anatomy:* The quadratus lumborum muscle attaches inferiorly by aponeurotic fibers to the iliolumbar ligament and the adjacent portion of the iliac crest. It attaches superiorly to the medial half of the lower border of the 12th rib and to the transverse processes of L1 through L4 and, occasionally, to the transverse process or body of T12. A second layer of this muscle occasionally is present. It attaches inferiorly to the transverse processes of the lower three or four lumbar vertebrae and superiorly to the lower border of the 12th rib.
- *Function:* By stabilizing the 12th rib and the lower attachments of the diaphragm, it acts as a muscle of inspiration and forced exhalation. Acting bilaterally, the quadratus lumborum extends the spine. Acting unilaterally, it controls contralateral side-bending through eccentric contraction. With the spine fixed, it hikes the ipsilateral hip. With the pelvis fixed, it performs ipsilateral side-bending of the spine.
- *Innervation:* The 12th thoracic and upper three or four lumbar spinal nerves.
- Referred pain: Referred pain from the quadratus lumborum tends to be deep and aching or sharp and severe. The most lateral TrPs refer along the iliac crest, to the lower portion of the abdomen, and into the groin, labia and testicles. They may refer to the greater trochanter and outer, lateral thigh. The most medial TrPs refer to the sacroiliac joint and to the lower buttock. Pain that extends across the upper sacral region may be referred from bilateral quadratus lumborum TrPs.
- *Needling technique*: The patient is in the side-lying position with the side to be treated facing up. If needed, the patient can bring the ipsilateral arm overhead with a pillow placed under the torso to improve access to the muscle. Locate the 12th rib, the iliac crest and the lumbar spine. The quadratus lumborum is identified via flat palpation, just lateral to the iliocostalis lumborum. Note that only at the L4 level is the muscle directly palpable beneath the skin. Above this level, the latissimus dorsi muscle lies between the quadratus lumborum and the skin. The needle must be long enough to reach the depth of the transverse processes (usually a 50–60 mm needle is

Figure 9.16 • Dry needling of the quadratus lumborum muscle in side-lying.

Figure 9.17 • Dry needling of the rectus abdominus muscle in supine.

adequate). The needle is aimed straight downward, in the direction of the transverse process. Strong depression of the subcutaneous tissue is required to reduce the distance from the skin to the muscle (Figure 9.16).

- *Precautions*: To avoid penetration of the kidney, as well as the more cephalic diaphragm and pleura, needle below the level of L2.

Rectus abdominus muscle

- *Anatomy*: The muscle attaches inferiorly along the crest of the pubic bone via a medial and lateral tendon. The medial tendon interlaces with the contralateral muscle and attaches to the symphysis pubis. Superiorly, the muscle attaches to the fifth, sixth, and seventh costal cartilages. The paired recti are separated in the midline by the *linea alba*. Three transverse fibrous bands, or tendinous inscriptions, interrupt the rectus abdominus muscle. Typically, they are situated at the level of the umbilicus, near the tip of the xyphoid, and midway between the two. They are rarely full-thickness.
- *Function*: Acting unilaterally, it side-bends the trunk and assists with trunk rotation. Acting bilaterally, it flexes the trunk and increases intra-abdominal pressure for activities such as exhalation, defecation, micturition, parturition, coughing and vomiting. The rectus abdominus muscle also contracts to prevent displacement of the viscera. Abdominal TrPs may prevent upright posture by pulling the trunk into flexion.
- *Innervation:* Branches of the intercostal nerves seven through 12.
- *Referred pain:* The upper rectus abdominus muscle refers pain horizontally across the back in the thoracolumbar region. It can refer also to the xiphoid process. Somatovisceral symptoms caused by upper rectus abdominus TrPs can include abdominal fullness, heartburn, indigestion, nausea and vomiting. Peri-umbilical TrPs may cause abdominal cramping or colic. The lower rectus abdominus refers pain across the low back and sacral regions and to the groin, penis, perineum, rectum and suprapubic area. Somatovisceral symptoms include spasm of the detrusor and urinary sphincter muscles, diarrhea and dysmenorrhea. A TrP located in the lower right quadrant, known as McBurney's point, mimics the symptoms of appendicitis.
- *Needling technique:* The patient lies supine with the clinician positioned contralateral to the side to be needled. Depress the abdominal wall just lateral to the taut band in the muscle and create a shelf or 'wall' by pulling the muscle toward you. The needle is inserted and directed medially toward the *linea alba*, tangential to the abdominal wall (Figure 9.17). For upper rectus abdominus TrPs, the needle is directed parallel to the lowest ribs (Figure 9.18**).** For lower TrPs, the needle is directed toward the pubic bone (Figure 9.19).
- *Precautions:* To avoid entering the abdominal cavity, maintain a shallow angle. Prevent penetration of the lung by inserting the needle parallel to the rib margin.

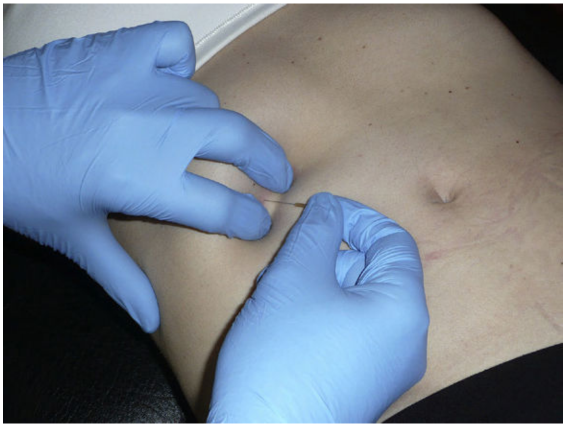

Figure 9.18 • Dry needling of the upper portion of the rectus abdominus muscle in supine.

Figure 9.19 • Dry needling of the lower portion of the rectus abdominus muscle in supine.

External and internal oblique muscles

- *Anatomy:* The external oblique muscle is the largest and most superficial of the lateral abdominal muscles. It attaches superiorly to the external, inferior border of the lower eight ribs, interdigitating with the latissimus dorsi and the lower serratus anterior. Fibers from the lower two ribs pass nearly vertically to attach to the anterior half of the iliac crest. The middle and upper fibers pass obliquely medially and caudally to join the abdominal aponeurosis, which attaches to the *linea alba*.
- The internal oblique muscle lies deep to the external oblique. Its fibers arise from the lateral two-thirds of the inguinal ligament, the anterior two-thirds of the iliac crest and the lower portion of the thoracolumbar fascia. The posterior fibers pass vertically to attach to the cartilages of the last three or four ribs. The fibers attached to the anterior iliac crest pass superiorly and medially to attach to the lines alba via the anterior and posterior rectus sheath. The medial fibers pass horizontally and arch downwards. These fibers become tendinous and fuse with the corresponding aponeurosis of the transverse abdominus, forming the conjoint tendon. This tendon attaches to the pubic crest and pectineal line.
- The transverse abdominus muscle is the deepest of the lateral abdominal muscles. Its fibers run nearly horizontally and attach anteriorly to the *linea alba*, the pubic crest and pectineal line. Laterally, its fibers attach to the lateral one-third of the inguinal ligament, the anterior three-quarters of the iliac crest, the thoracolumbar fascia, and the lower six costal cartilages, where it interdigitates with fibers of the diaphragm. Because of its depth and, therefore, close proximity to the abdominal content the transverse abdominus is not considered for intramuscular manual therapy intervention.
- *Function:* Acting unilaterally, the external oblique and internal oblique muscles side-bend the trunk to the same side. The external oblique assists with trunk rotation to the opposite side and the internal oblique assists with trunk rotation to the same side. Therefore, the external oblique pairs with the contralateral internal oblique in trunk rotation. Acting bilaterally, the external and internal oblique flex the spine. They, together with the transverses abdominus, also increase intra-abdominal pressure for defecation, micturition, parturition, forced exhalation, coughing and vomiting. These muscles contract synchronously to prevent displacement of the viscera. The external and internal obliques are active during the gait cycle, contributing to the counter-rotation of the rib cage on the pelvis.
- *Innervation:* The external and internal obliques are innervated by the intercostal nerves of T8–12. The internal oblique is also supplied by branches of the iliohypogastric and iliolingual nerves from L1.
- *Referred pain*: TrPs located in either oblique muscle refer pain to the groin and genitals. Somatovisceral responses to TrPs located in the

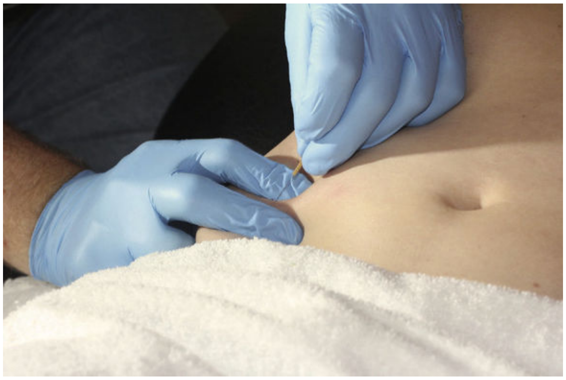

Figure 9.20 • Dry needling of the internal and external oblique muscles in supine.

external oblique include deep epigastric pain, chronic diarrhea and, in the posterior region just below the 12th rib, belching. The lower internal oblique muscle, along with the lower rectus abdominus, may contribute to spasm of the detrusor and urinary sphincter muscles.

- *Needling technique:* The patient is in supine or side-lying. Grasp the abdominal wall between your fingers to ensure that the abdominal contents remain medial. Only the muscle tissue between your fingers is needled (Figure 9.20).
- *Precautions*: Avoid entering the abdominal cavity.

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Deep dry needling of the hip, pelvis and thigh muscles

10

Dawn Sandalcidi Jan Dommerholt

CHAPTER CONTENT

Introduction

Pelvic pain is not uncommon in both the male and female population. Pain in the abdominal or pelvic regions that lasts 6 months or more and is not cyclic, is termed chronic pelvic pain (CPP). The American College of Obstetricians and Gynecologists specifies the location of CPP in the pelvis, abdominal wall at or below the umbilicus, lumbar, sacral and buttock regions (Vercellini et al. 2009). Approximately 90% of women with pelvic pain, interstitial cystitis or incontinence have painful trigger points (TrPs) in several locations including the pelvic floor, gluteal and abdominal muscles (Weiss 2001, Wesselmann 2001, Fitzgerald & Kotarinos 2003). The prevalence of CPP is estimated to be 14.7% of women between 18–50 years of age in the USA (Mathias et al. 1996).

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Men with chronic prostatitis (CP) and chronic pelvic pain syndrome (CPPS) presented with pain in the scrotal, perineal, inguinal and bladder area in 54% of cases and had tender myofascial palpation in 88% of cases (Zermann et al. 2001). Berger et al. (2007) noted that in men with CPPS, pain was not always limited to the prostate. Anderson et al. (2009) further reported that puborectalis, pubococcygeus and rectus abdominus TrPs reproduced penile pain 75% of the time and external oblique TrPs elicited suprapubic, groin and testicular pain in 80% of the cases.

The European Association of Urology and the Society of Obstetricians and Gynaecologists of Canada recommend that TrPs should be considered in the diagnosis of pelvic pain (Jarrell et al. 2005, Fall et al. 2019). Giamberardino et al. (1999) reported that patients with visceral pain and hyperalgesia are likely to have clinically relevant abdominal TrPs. Myofascial pain was identified in 78.5% of patients with interstitial cystitis and 67.9% of those patients had six or more identifiable TrPs. The most common TrPs were found in the obturator internus, puborectalis, arcus tendineus and iliococcygeus muscles (Bassaly et al. 2010). Specific TrPs were identified in the levator ani muscles in 22% and in the piriformis muscles in 14% of women with CPP.

The International Continence Society (ICS) and the European Association of Urology suggest two categories of pelvic pain: those of muscular origin and pelvic floor muscle spasm (Abrams et al. 2003, Fall et al. 2010); however, other TrPs in the abdominal, gluteal, obturator internus, iliacus, psoas, quadratus lumborum and lumbar multifidi muscles can, and frequently do, refer to the pelvic floor muscles, perineum, vagina, labia, clitoris, scrotum and penis (King-Baker 1993, King & Goddard 1994, Segura et al. 1979, Doggweiler-Wiygul 2004, Doggweiler-Wiygul & Wiygul 2002, Zermann et al. 1999, Prendergast & Weiss 2003).

Deactivation of myofascial TrPs has been supported in the literature to be effective in treating urinary incontinence, chronic prostatitis, chronic pelvic pain, sacroiliac joint dysfunction, dyspareunia, interstitial cystitis, irritable bowel syndrome, levator ani syndrome, and high tone pelvic floor (Lukban et al. 2001, Weiss 2001, Oyama et al. 2004, Anderson et al. 2005, Riot et al. 2004, Tu et al. 2006). A multicenter feasibility study confirmed that TrP therapy is effective in treating CPPS (Fitzgerald 2009). As part of the treatment plan, it is essential to assess the tone of the pelvic floor musculature by a qualified professional when treatment includes dry needling (DN). Chronic pelvic pain can be secondary to low or high tone pelvic musculature. Stability may be compromised if a low tone pelvic floor is deactivated, which may require the additional use of external support until such time the motor control is considered sufficient (Longbottom 2009).

Common pain characteristics are seen with visceral pain originating from pelvic organs and myofascial pain originating from TrPs. The segmental spinal root should also be considered in treatment. Muscle or fascia innervated by the 12th thoracic to the 4th lumbar segments can refer pain to the lower abdomen, iliopsoas, quadratus lumborum, piriformis and obturator internus muscles. The 10th thoracic through the 4th sacral segments supply innervation to the reproductive organs, abdominal wall, low back, thighs and the pelvic floor (Baker 1993, Brookhoff & Bennett 2006, Longbottom 2009).

The aforementioned evidence supports that treatment of TrPs of the pelvic floor and its related structures is an integral part of any therapy regimen. It should be noted that deactivation of TrPs is insufficient if not followed by an appropriate exercise program, which may include specific stretching, strengthening, and motor control training (Edwards & Knowles 2003, Longbottom 2009).

Dry needling of the abdominal, hip, pelvis, and thigh muscles

As in the other chapters, referred pain patterns are mostly based on the descriptions by Simons et al. (1999) with substitutions and additions by Dalmau-Carola (2005) and Longbottom (2009).

Abdominal wall muscles

The rectus abdominus, external and internal obliques muscles are discussed in Chapter 9. The transverse abdominal muscle cannot be needled in isolation of the other abdominal muscles.

Figure 10.1 • Dry needling of the gluteus maximus muscle.

Figure 10.2 • Dry needling of the gluteus medius muscle.

Hip muscles

Gluteus maximus muscle

- *Anatomy:* The muscle originates at the posterior aspect of the ilium, the lower part of the sacrum and coccyx inferior and lateral across the greater trochanter to the iliotibial band of the tensor fascia lata and the gluteal tuberosity.
- *Function:* Hip extension, lateral rotation and stabilization of the iliotibial tract.
- *Innervation:* Inferior gluteal nerve from L5, S1 and S2.
- *Referred pain:* Pain referral is along the inferior or inferior-lateral aspect of the sacrum, the gluteal fold, or insertion along the iliotibial tract. TrPs in the gluteus maximus muscle can imitate sacroiliac pain.
- *Needling technique:* The patient is prone with a pillow under the abdomen or side lying. The muscle is needled with flat palpation perpendicular to the muscle along the area of the TrP (Figure 10.1**).** Strong depression of the subcutaneous tissue is required to reduce the distance from the skin to the muscle.
- *Precautions:* Avoid needling the sciatic nerve. Depth of penetration is dependent on the amount of adipose tissue.

Gluteus medius muscle

- *Anatomy:* The muscle is found between the gluteus maximus and tensor fascia latae. It originates between the posterior and anterior gluteal lines of the ilium and inserts on the lateral border of the greater trochanter. A bursa lies under the tendinous portion over the surface of the trochanter.
- *Function:* Hip abduction and medial rotation. Insufficiency of this muscle results in a positive Trendelenburg test.
- *Innervation*: Superior gluteal nerve from L4, L5 and S1.
- *Referred pain:* TrPs may be found throughout the entire muscle with referral to the sacroiliac joint, gluteal and lumbosacral regions, and along the iliotibial tract, gluteal region, posterior thigh and posterior lower leg. It is not possible to separate referred pain patterns from the gluteus minimus muscle in the area where the two muscles overlap.
- *Needling technique:* The patient is prone or side lying. The muscle is needled with flat palpation perpendicular to the muscle along the contour of the iliac crest. Strong depression of the subcutaneous tissue is required to reduce the distance from the skin to the muscle. Needle contact at the periosteum is common (Figure 10.2).
- *Precautions:* Avoid needling the sciatic nerve. There are also deep branches of the superior gluteal vessels and nerve between the medius and minimus which should be not needled. Depth of penetration is dependent on the amount of adipose tissue.

Gluteus minimus muscle

- *Anatomy:* The muscle is found deep to the gluteus medius. It originates between the anterior

Figure 10.3 • Dry needling of the gluteus minimus muscle.

Figure 10.4 • Dry needling of the tensor fascia latae muscle.

and inferior gluteal lines of the anterior aspect of the ilium and inserts on the anterior aspect of the greater trochanter. It also has a bursa between the tendon and the insertion at the greater trochanter.

- *Function*: Hip abduction and medial rotation. Insufficiency of this muscle along with the gluteus medius results in a positive Trendelenburg test. Supports the body in single leg stance with the tensor fascia latae.
- *Innervation:* Superior gluteal nerve from L4, L5 and S1.
- *Referred pain*: Referred pain from the gluteus minimus muscle is into the iliotibial tract, gluteal region, posterior thigh and posterior one third of the lower leg. It is not possible to separate referred pain patterns from the gluteus medius muscle in the area where the two muscles overlap.
- *Needling technique:* The patient is prone or side lying. The muscle is needled with flat palpation perpendicular to the muscle along the contour of the iliac crest. Strong depression of the subcutaneous tissue is required to reduce the distance from the skin to the muscle. Needle contact at the periosteum is common (Figure 10.3).
- *Precautions:* There are deep branches of the superior gluteal vessels and nerve between the medius and minimus which should be not needled. Depth of penetration is dependent on the amount of adipose tissue.

Tensor fascia latae muscle

- *Anatomy:* The muscle originates from the anterior outer aspect of the iliac crest and the anterior superior iliac spine (ASIS), between the gluteus medius and sartorius; and from the deep surface of the fascia lata. It inserts between the two layers of the iliotibial band of the fascia latae of the middle and upper thirds of the thigh.
- *Function:* Via the iliotibial tract it extends the knee with lateral rotation of the leg, assists in flexion, abduction and medial rotation of the hip. Pelvic stabilization and posture control are its main functions.
- *Innervation:* Superior gluteal nerve from L4, L5 and S1.
- *Referred pain:* The referred pain from this muscle travels along the iliotibial tract, gluteal region or posterior lateral thigh.
- *Needling technique:* The patient is supine or side lying. The muscle is needled with flat palpation perpendicular to the muscle (Figure 10.4).
- *Precautions:* None

Obturator internus muscle

- *Anatomy:* The obturator internus muscle has a broad attachment to the anterior lateral wall of the inner pelvic brim, the rim of the obturator foramen and the obturator membrane, covering most of the obturator foramen. The pelvic surface of the obturator internus and its fascia form the anterior lateral wall of the true pelvis. The muscle exits the pelvis through the lesser sciatic foramen then makes a right angle turn, posterior to the hip joint capsule, attaching to the anterior medial surface of the greater trochanter in close proximity to the gemelli muscles.

Figure 10.5 • Dry needling of the obturator internus muscle (female).

Figure 10.6 • Dry needling of the obturator internus muscle (male).

- *Function:* The primary function of the obturator internus is to laterally rotate the hip joint when the thigh is extended and assist with hip abduction when the hip is flexed to 90°.
- *Innervation:* The muscle is supplied by the nerve to the obturator internus from L5 and S1
- *Referred pain:* The obturator internus muscle refers pain to the vagina, anococcygeal region and the posterior thigh. The patient may also have a perception of fullness in the rectum.
- *Needling technique:* In the lithotomy position, palpate the inferior border of the pubic ramus and the insertion of the adductor longus tendon. Just lateral palpate toward the obturator foramen. Angle the needle perpendicular and lateral to the muscle surface directly into the TrP taut band identified with internal or external palpation (Figure 10.5 – female and Figure 10.6 – male). Another option is side-lying on the involved side with hip and knee flexion. Palpate the ischial tuberosity. Place the fingers medially around the bony prominence then angle the needle perpendicular to the muscle surface with a slight anterior superior angle directly into the TrP taut band identified with internal or external palpation (Figure 10.7).
- *Precautions:* Avoid needling into the Pudendal (Alcock's) canal containing the pudendal and obturator nerve and vessels.

Figure 10.7 • Dry needling of the obturator internus muscle in side-lying.

Obturator externus/gemellus inferior and superior muscles

- *Anatomy:* The *obturator externus* is a flat triangular muscle that covers the external surface of the obturator membrane and adjacent bone of the ischial and pubic rami laterally and upward to the trochanteric fossa of the femur. The *superior gemellus* originates at the spine of the ischium and inferior from the ischial tuberosity. Collectively they insert into the medial surface of the greater trochanter of the femur. Functionally, the gemelli muscles can be considered to be part of the obturator internus muscle and these muscles may actually be fused together (Honma 1998).
- *Function:* Lateral rotation of the hip as well as stability of the hip and pelvis.
- *Innervation:* The obturator externus is innervated by the posterior branch of the obturator nerve from L3-L4, the gemellus superior by branches of the obturator internus nerve form L5–S2, and the gemellus inferior by branches of the quadratus femoris nerve from L4–S1.
- *Referred pain:* Referred pain patterns from this muscle are not described in detail, but are

Figure 10.8 • Dry needling of the obturator externus/gemelli muscle.

Figure 10.9 • Dry needling of the quadratus femoris muscle.

generally thought to include the proximal posterior thigh, hip and groin as well as sciatic type referral.

- *Needling technique:* The patient is positioned comfortably prone. Palpate the greater trochanter medially and insert the needle perpendicular to muscle surface directly into the TrP taut band identified by palpation. The obturator externus is found deeper and more posterior to the trochanter (Figure 10.8).
- *Precautions:* Avoid needling the sciatic nerve.

Quadratus femoris muscle

- *Anatomy:* This is a flat quadrilateral muscle that originates at the upper part of the external aspect of the ischial tuberosity and inserts above the middle of the trochanteric crest of the femur.
- *Function:* Lateral rotation of the thigh
- *Innervation:* Branches from the quadratus femoris nerve from L5 and S1.
- *Referred pain:* Referred pain patterns from this muscle are not described in detail, but are generally thought to include the proximal posterior thigh, hip and groin as well as sciatic type referral.
- *Needling technique:* The patient is positioned comfortably prone. Palpate the greater trochanter and the ischial tuberosity. The needle can be inserted perpendicular to the muscle surface at the trochanter or just medial to the ischial tuberosity running parallel to the sciatic nerve, directly into the TrP taut band identified by palpation (Figure 10.9).
- *Precautions:* Avoid needling the sciatic nerve.

Piriformis muscle

- *Anatomy:* This muscle originates at the anterior surface of the sacrum at S2–4 where it passes through and fills the greater sciatic foramen. It inserts on the upper border of the greater trochanter of the femur. The sciatic nerve typically exits the pelvis deep to the piriformis; however, variations exist and the nerve may exit above or through the piriformis muscle.
- *Function:* External rotation of the thigh or abduction if the thigh is flexed.
- *Innervation:* Branches from L5, S1 and S2.
- *Referred pain:* Referred pain travels along the path of the sciatic nerve and may include the sacroiliac region, the proximal two-thirds of the thigh, and the inguinal and intra-pelvic cavity.
- *Needling technique:* The patient is positioned comfortably prone or side lying. Identify the bony landmarks of the greater trochanter and the sacrum at S2, S3 and S4. The needle can be inserted perpendicular to the muscle surface at the trochanter or just medial to the sacrum from the sciatic notch toward the pubic symphysis directly into the TrP taut band identified by palpation (Figures 10.10 & 10.11).
- *Precautions:* Avoid needling the sciatic nerve.

Pelvic diaphragm muscles

Ischiocavernosus muscle

- *Anatomy:* The muscle is an elongated muscle arising from the inferior lateral aponeurosis

Figure 10.10 • Dry needling of the piriformis muscle (insertion).

Figure 10.11 • Dry needling of the piriformis muscle (origin).

Figure 10.12 • Dry needling of the ischiocavernosus muscle (male).

Figure 10.13 • Dry needling of the ischiocavernosus muscle (female).

over the crus of the penis or clitoris to the medial aspect of the pubic ramus and ischium. The muscle is smaller in the female than the male.

- *Function:* Compression of veins to maintain penile or clitoral erection.
- *Innervation:* Perineal branch of the pudendal nerve S2, S3 and S4.
- *Referred pain:* Perineum and the adjacent urogenital region.
- *Needling technique:* In the lithotomy position, angle the needle perpendicular to the muscle surface directing it toward the ischiopubic ramus directly into the TrP taut band identified by internal or external palpation. As an alternative, it is possible to use shallow needling of the muscle in the same direction as the fiber direction. In male patients, it is helpful to use a towel around the scrotum and have the patient move the scrotum out of the way (Figure 10.12). In female patients, move the labia to the opposite side you are treating (Figure 10.13).
- *Precautions:* Avoid needling the perineal branch of the pudendal nerve, artery and vein and the perineal branch of the posterior femoral cutaneous nerve.

Bulbospongiosus (bulbocavernosus) muscle

- *Anatomy:* This muscle originates at the superficial perineal membrane and dorsal penile or clitoral aponeurosis and attaches at the perineal body in women, and at the median raphe over the corpus spongiosum extending one third of the base of the penis in men. It is a very thin and superficial muscle.
- *Function:* It increases vascular engorgement of the penis or clitoris. In the female, it constricts the vaginal introitus. In the male, it assists with emptying urine and ejaculate from the urethra.

Figure 10.14 • Dry needling of the bulbospongiosus muscle (male).

Figure 10.15 • Dry needling of the bulbospongiosus muscle (female).

- *Innervation:* The perineal branch of the pudendal nerve from S2–S4 roots.
- *Referred pain:* It refers pain to the perineum and adjacent urogenital structures. Symptoms in the female include dyspareunia and in the male pain at the base of their penis, beneath the scrotum, pain with sitting and difficulty maintaining an erection.
- *Needling technique*: In the lithotomy position, angle the needle perpendicular to the muscle surface directly into the TrP taut band identified by palpation. Place one finger on the perineal body and the other superior lateral onto the muscle and brace the tissue. Muscle contraction can confirm placement. Alternatively, one can needle the muscle using a pincer palpation with the index finger inserted into the vagina. For male and female patients, the muscle can also be treated in a slightly tangential angle, which in women may be preferred in cases of hypersensitivity or when patients do not consent to vaginal insertion. In male patients, it is helpful to use a towel around the scrotum and have the patient move the scrotum out of the way (Figure 10.14). In female patients, move the labia to the opposite side you are treating and needle from the three to ten o'clock position (Figure 10.15).
- *Precautions:* This muscle is very thin and superficial. It is not recommended to needle the muscle at the base of the penis secondary to the close proximity of the urethra. The perineal artery and vein are located between the superficial and deep transverse perineal muscles and run superiorly.

Superficial and deep transverse perinei muscles

- *Anatomy:* The transverse perinei muscles originate from the ischium at the inferior ramus and run medially to the lateral aspect of the vagina or the median line in the male. The superficial transverse perinei is a narrower muscle, which blends with the fibers of the sphincter ani inferiorly and the bulbospongiosus superiorly at the central tendon of the perineal body. The sphincter urethra in both the male and female lie in the same plane as the transverse perinei near the urethra.
- *Function:* To fix and stabilize the central tendon of the perineal body.
- *Innervation:* Perineal branch of the pudendal nerve via S2-S4 roots.
- *Referred pain:* To the perineum and adjacent urogenital structures. In some cases rectal or coccygeal pain is observed.
- *Needling technique:* In the lithotomy position angle the needle perpendicular to the muscle surface directly into the TrP taut band identified by palpation or needle slightly tangential to the muscle surface to avoid needling through the muscle. Place one finger on the perineal body and the other on the lateral border of the ischial tuberosity and brace the tissue. Muscle contraction can confirm placement. In male patients, it is helpful to use a towel around the scrotum and have the patient move the scrotum out of the way (Figure 10.16). In female patients, move the labia to the opposite side you are treating (Figure 10.17).

Figure 10.16 • Dry needling of the transverse perinei muscle (male).

Figure 10.18 • Dry needling of the pubococcygeus muscle.

Figure 10.17 • Dry needling of the transverse perinei muscle (female).

- *Precautions:* This muscle is very thin and superficial. It is not recommended to needle the muscle at the base of the penis secondary to the close proximity of the urethra. The perineal artery and vein are located between the superficial and deep transverse perineal muscles and run superiorly. Other structures to note are the deep dorsal vein of the clitoris, a portion of the urethra and the constrictor urethra muscle, the larger vestibular glands and their ducts; the internal pudendal vessels and the dorsal nerves of the clitoris; the arteries and nerves of the bulbi vestibuli, and a plexus of veins.

Pubococcygeus muscle of the pelvic diaphragm

- *Anatomy:* The muscle originates at the back of the pubis and the anterior part of the obturator fascia. Its direction is posterior in a horizontal fashion to the coccyx and the most inferior aspect of the sacrum. At the posterior insertion the two *pubococcygei* muscles come together and form a thick, fibromuscular layer. The *puborectalis muscle* slings around the rectum to aid in defecation. The *pubovaginalis muscle* in the female arises for the anterior fibers to the perineal body to aid in vaginal wall support. The *levator prostate muscle* is the corresponding muscle in the male.
- *Function:* Collectively the pelvic diaphragm muscles constrict and elevate the lower end of the rectum and vagina and support the pelvic viscera. They also aid in forced expiration and spinal stability. The coccygei muscles pull forward and support the coccyx, after it has been pressed backward during defecation or parturition.
- *Innervation:* A branch from the fourth sacral nerve and a branch, which is occasionally from the perineal or inferior rectal portion of the pudendal nerve.
- *Referred pain:* Frequently called levator ani syndrome, pain from this region can refer to the any of the areas of the perineum (coccygeal, vaginal, and rectal) or pelvic girdle. Pain with sitting or with bowel movements is common.
- *Needling technique:* The patient should be side-lying with hips flexed to 90° with a pillow between the knees. Ask the patient to lift the gluteal muscles away from the anus. Place one finger on the perineal body and the other on the anal sphincter and brace the tissue. Angle the needle at a 45° angle toward the pubic bone perpendicular to the muscle surface directly into the TrP taut band identified by palpation (Figure 10.18).
- *Precautions:* Consider the rectum, anus and anal sphincters.

Figure 10.19 • Dry needling of the iliococcygeus muscle.

Figure 10.20 • Dry needling of the coccygeus muscle.

Iliococcygeus muscle of the pelvic diaphragm

- *Anatomy:* The muscle originates from the ischial spine and the posterior part of the tendinous arch of the pelvic fascia, and inserts into the last two segments of the coccyx and anococcygeal raphe. It is usually thin or may consist largely of fibrous tissue. The iliosacralis muscle is an accessory portion at its posterior part.
- *Function:* Collectively the pelvic diaphragm muscles constrict and elevate the lower end of the rectum and vagina and support the pelvic viscera. These muscles also aid in forced expiration and spinal stability.
- *Innervation:* A branch from the fourth sacral nerve and a branch, which is occasionally from the perineal or inferior rectal portion of the pudendal nerve.
- *Referred pain and symptoms:* Frequently called levator ani syndrome, pain from this region can refer to the any of the areas of the perineum (coccygeal, vaginal, and rectal) or pelvic girdle. Pain with sitting or with bowel movements is common.
- *Needling technique:* The patient should be side-lying with hips flexed to 90° with a pillow between the knees. Ask the patient to lift the gluteal muscles away from the anus. Place your fingers slightly inferior and lateral to the anal sphincter and brace the tissue. Angle the needle at a 45° angle toward the pubic bone perpendicular to muscle surface directly into the TrP taut band identified by palpation (Figure 10.19).
- *Precautions:* Consider the rectum, anus and anal sphincters.

Coccygeus muscle of the pelvic diaphragm

- *Anatomy:* The muscle is a triangular shape muscle that originates from the spine of the ischium and sacrospinous ligament, and inserts into the margin of the coccyx and the inferior lateral angle of the sacrum.
- *Function:* Collectively the pelvic diaphragm muscles constrict and elevate the lower end of the rectum and vagina and support the pelvic viscera. These muscles also aid in forced expiration and spinal stability. The coccygei muscles specifically pull the coccyx forward after defecation or parturition and aid in sacroiliac stability.
- *Innervation:* A branch from the fourth and fifth sacral nerves.
- *Referred pain:* Coccygeal, hip, sacroiliac or low back pain.
- *Needling technique:* The patient is place prone with a pillow under the stomach for comfort or side-lying with hips flexed to 90° with a pillow between the knees. Ask the patient to lift the gluteal muscles away from the anus. Place one finger on the coccyx and the other on the inferior lateral angle of the sacrum. Angle the needle away from the rectum perpendicular to the muscle surface directly into the TrP taut band identified by palpation (Figure 10.20).
- *Precautions:* Consider the rectum, anus and anal sphincters.

Thigh muscles

Adductor longus muscle

- *Anatomy:* The muscle is a large fan-shaped muscle originated from the front of the pubic bone between the crest and symphysis and inserts in the linea aspera in the middle one-third of the femur.
- *Function:* Adduction and medial rotation of the thigh as well as hip flexion with an extended hip.
- *Innervation:* The anterior division of the obturator nerve from L2–L4.
- *Referred pain:* Referred pain extends from the femoral triangle to the knee, but also gives rise to intra-pelvic pain (Travell & Simons 1992, Longbottom 2009).
- *Needling technique:* The patient is supine with knee flexion and hip external rotation. Grasp the muscle belly and insert the needle anterior to posterior, perpendicular to muscle surface directly into the TrP taut band identified by palpation (Figure 10.21).
- *Precautions:* Femoral nerve, artery and vein as well as the sciatic nerve.

Adductor brevis muscle

- *Anatomy:* The muscle originates posterior to the pectineus and adductor longus with a narrow attachment of the external aspect of the body and inferior ramus of the pubis between the gracilis and obturator externus. It inserts posterior laterally into the femur from the lesser trochanter to the linea aspera and directly behind the brevis and upper part of the longus.
- *Function:* Adduction and medial rotation of the thigh as well as hip flexion with an extended hip.
- *Innervation:* Obturator nerve from L2 and L3.
- *Referred pain:* It includes the area from the femoral triangle to the knee.
- *Needling technique:* The patient is supine with knee flexion and hip external rotation. Grasp the muscle belly and insert the needle in the upper aspect of the thigh between the adductor longus and pectineus in an anterior to posterior fashion toward the buttock crease, perpendicular to muscle surface directly into the TrP taut band identified by palpation. Often the adductor longus and brevis muscles can be combined via a pincher grasp (Figure 10.21).
- *Precautions:* Femoral nerve, artery and vein as well as the sciatic nerve.

Figure 10.21 • Dry needling of the adductor longus muscle.

Adductor magnus muscle

- *Anatomy:* The muscle is a large fan-shaped muscle originating from the inferior ramus of the pubis, the conjoined ischial ramus and the inferior-lateral aspect of the ischial tuberosity. It inserts with horizontal, oblique and vertical fibers at the gluteal tuberosity and linea aspera deep to the brevis and longus.
- *Function:* Adduction and medial rotation of the thigh as well as hip flexion with an extended hip.
- *Innervation:* The posterior branch of the obturator nerve and the tibial division of the sciatic nerve from L2–L4.
- *Referred pain:* TrPs may be found at the lower portion of the muscle referring pain along the anterior medial thigh or its proximal TrP may have rectal, vaginal or urethral referred pain
- *Needling technique:* The patient is supine with knee flexion and hip external rotation. The needle is inserted perpendicular to muscle surface directly into the TrP taut band identified by palpation (Figure 10.22). The muscle can also be needled in side-lying (Figure 10.23).
- *Precautions:* The femoral nerve, artery and vein along the adductor canal as well as the sciatic nerve.

Figure 10.22 • Dry needling of the adductor magnus muscle in supine.

Figure 10.24 • Dry needling of the pectineus muscle.

Figure 10.23 • Dry needling of the adductor magnus muscle in side-lying.

Pectineus muscle

- *Anatomy:* The muscle is a flat quadrangular that originates at the pectin pubis and the pubic bone between the iliopectineal eminence and the tubercle, and attaches at the lesser trochanter.
- *Function:* The muscle adducts the thigh and flexes it on the pelvis.
- *Innervation:* The anterior division of the femoral nerve from L2–L3 and the accessory obturator nerve L3 when present.
- *Referred pain:* It involves the anterior medial aspect of the thigh, pubis, lumbopelvic region and hip and is frequently referred to as athletic pubalgia.
- *Needling technique:* The patient is supine with slight hip external rotation. Palpate the femoral artery and maintain your finger there. The needle is inserted perpendicular to muscle surface directly into the TrP taut band identified by palpation just medial to the femoral artery between the adductor longus and brevis (Figure 10.24).
- *Precautions:* On the lateral aspect of the muscle avoid needling the femoral nerve, artery and vein. Medially, avoid needling the obturator nerve, which lies deep under the muscle near the origin of the adductor longus muscle.

Gracilis muscle

- *Anatomy:* The muscle originates from the medial margins of the lower half of the body of the pubis, the inferior pubic ramus and the ischial ramus and inserts to the upper part of the medial tibia just below the medial condyle. The gracilis muscle is a thin and flat muscle.
- *Function:* Flexion and medial rotation of the leg and adduction of the thigh.
- *Innervation:* Obturator nerve (L2–L3)
- *Referred pain:* TrPs in the gracilis muscle can cause a superficial stinging pain along the inside of the thigh.
- *Needling technique:* The patient is supine with slight hip external rotation. The needle is inserted perpendicular to muscle surface

Figure 10.25 • Dry needling of the rectus femoris muscle.

Figure 10.26 • Dry needling of the vastus lateralis muscle in supine.

directly into the TrP taut band identified by a flat palpation technique. The approach is similar to the approach of the adductor magnus muscle (Figures 10.22 & 10.23).

- *Precautions:* None.

Rectus femoris muscle

- *Anatomy:* The rectus femoris muscle is a fusiform muscle that originates from the anterior inferior iliac spine, from a groove about the acetabulum, and from the capsule of the hip joint. The muscle inserts at the base of the patella via a thick flat tendon. The patellar tendon is a continuation of the main tendon and connects the muscle to the tuberosity of the tibia.
- *Function:* The primary function is knee extension. It also assists with hip flexion. The rectus femoris can perform these two functions simultaneously.
- *Innervation:* Femoral nerve (L2–L4).
- *Referred pain:* Anterior thigh and knee pain.
- *Needling technique:* With the patient in the supine position, the needle is inserted perpendicular to muscle surface directly into the TrP taut band identified by the palpation technique (Figure 10.25).
- *Precautions:* The lateral circumflex femoral artery lies deep underneath the muscle, but can easily be avoided by not needling through the muscle.

Vastus lateralis muscle

- *Anatomy:* The vastus lateralis muscle is the largest muscle of the quadriceps group. It originates from the upper part of the intertrochanteric line, the anterior and inferior borders of the greater trochanter, the lateral lip of the gluteal tuberosity, and the proximal half of the upper lip of the linea aspera. In addition, fibers may arise from the gluteus maximus tendon and the lateral intermuscular septum. It attaches via a flat tendon to the base and lateral border of the patella, where it joins the compound quadriceps femoris tendon.
- *Function:* The primary function is knee extension. The vastus lateralis and vastus medialis muscles play an important role in maintaining patellar tracking.
- *Innervation:* Femoral nerve (L2–L4).
- *Referred pain:* The vastus lateralis muscle refers pain throughout the full length of the lateral side of the thigh from the iliac crest to at least midway the lower leg.
- *Needling technique:* To needle TrPs in the anterior part of the vastus lateralis muscle, the patient is in supine (Figure 10.26). To needle TrPs in the part of the muscle posterior to the iliotibial tract, the patient is in side-lying (Figure 10.27).
- *Precautions:* None

Vastus medialis muscle

- *Anatomy:* The muscle originates from the lower part of the intertrochanteric line, the linea aspera, the medial intramuscular septum, the medial supracondylar line, and the tendons

Figure 10.27 • Dry needling of the vastus lateralis muscle in side-lying.

Figure 10.28 • Dry needling of the vastus medialis muscle.

of the adductor magnus and longus muscles. The muscle inserts at the medial border of the patella.

- *Function:* The primary function is knee extension. The vastus medialis and vastus lateralis muscles play an important role in maintaining patellar tracking.
- *Innervation:* Femoral nerve (L2–L4).
- *Referred pain:* TrPs in the vastus medialis muscle refer pain to the anteromedial aspect of the thigh down to the medial aspect of the knee.
- *Needling technique:* With the patient in the supine position, the needle is inserted perpendicular to muscle surface directly into the TrP taut band identified by palpation (Figure 10.28). Note: due to the anatomical connections with the adductor magnus and longus muscles, stretching the muscle is best performed with knee flexion and hip abduction.
- *Precautions:* None.

Vastus intermedius muscle

- *Anatomy:* The vastus intermedius muscle lies underneath the rectus femoris, vastus medialis and vastus lateralis muscles. It originates at the anterior and lateral surface of the upper two-thirds of the femoral shaft and from the lower part of the lateral intermuscular septum. The muscle is commonly fused with the vastus medialis muscle. It inserts via the deeper fibers of the quadriceps tendon to the lateral aspect of the patella and the lateral condyle of the tibia.

Figure 10.29 • Dry needling of the vastus intermedius muscle.

- *Function:* The primary function is knee extension.
- *Innervation:* Femoral nerve (L2–L4).
- *Referred pain:* The muscle refers primarily to the anterior aspect of the mid-thigh.
- *Needling technique:* With the patient in supine, the needle is inserted perpendicular to muscle surface directly into the TrP taut band identified by a flat palpation technique (Figure 10.29).
- *Precautions:* None

Genu articularis muscle

- *Anatomy:* The genu articularis muscle is a small muscle underneath the tendon of the

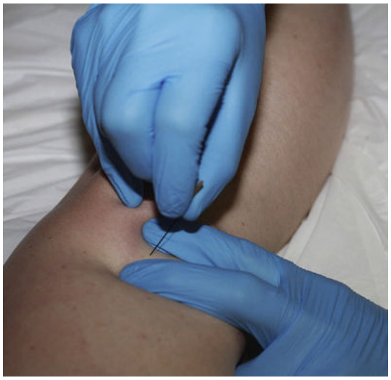

Figure 10.30 • Dry needling of the genu articularis muscle.

Figure 10.31 • Dry needling of the biceps femoris muscle.

rectus femoris muscle. The muscle is rarely described in the myofascial pain literature, but clinically may contribute to anterior knee pain. The muscle may occasionally blend with the vastus intermedius muscle. The muscle originates from the lower part of the femoral shaft and attaches to the synovial membrane of the knee joint.

- *Function:* Retraction of the suprapatellar bursa during knee extension likely to prevent compression of synovial folds between the patella and the femur.
- *Innervation:* Femoral nerve (L2–L4).
- *Referred pain:* Anterior knee pain (note that Travell and Simons did not mention this muscle and thus, did not establish its referred pain pattern).
- *Needling technique:* Needling is done through or underneath the tendon of the rectus femoris muscle toward the underlying femur (Figure 10.30).
- *Precautions:* None

Biceps femoris muscle

- *Anatomy:* The long head of the biceps femoris muscle originates from the upper part of the ischial tuberosity via a tendon it shares with the semitendinosus muscle, and from the lower parts of the sacrotuberous ligament. The short head of the muscle comes from the lateral lip of the linea aspera, but may be totally absent. The two heads merge at the distal end of the muscle and attach to the fibular head, the lateral condyle of the tibia, and the fibular collateral ligament.
- *Function:* The primary function is flexion of the knee. With the knee semi-flexed, the muscle functions as a lateral rotator of the lower leg on the knee. With the hip extended, the biceps femoris is a lateral rotator of the thigh.
- *Innervation:* Sciatic nerve (L5–S2); the long head is innervated by the tibial division, and the short head by the common peroneal division.
- *Referred pain:* Posterior thigh and knee and the upper one-third of the posterior calf.
- *Needling technique:* With the patient in the prone position with a pillow or bolster under the ankles, the needle is inserted perpendicular to muscle surface directly into the TrP taut band identified by a flat palpation technique (Figure 10.31).
- *Precautions:* The sciatic nerve lies in the middle of the posterior thigh. Needling the proximal part of the muscle is directed medially; needling the distal part of the muscle is directed laterally to avoid the sciatic nerve.

Semimembranosus and semitendinosis muscles

- *Anatomy:* The *semimembranosus muscle* originates with a flat tendon from the superolateral part of the ischial tuberosity, the biceps femoris and semitendinosus muscles, travels deep

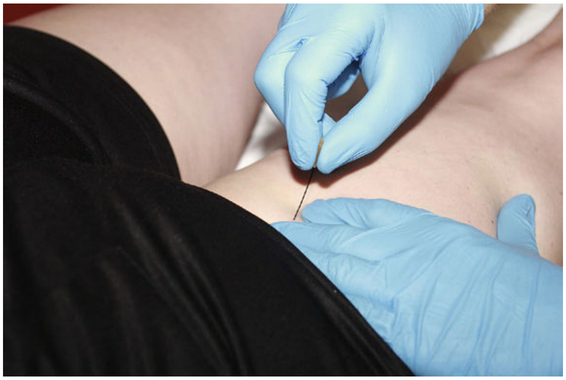

Figure 10.32 • Dry needling of the semimembranosus muscle and semitendinosis muscle.

Figure 10.33 • Dry needling of the sartorius muscle.

to the semitendinosus muscle to divide into five components and insert at the tubercle of the medial tibial condyle, the medial margin of the tibia, the fascia over the popliteus muscle, and the lateral femoral condyle where it forms much of the oblique popliteal ligament. The *semitendinosus muscle* originates from the inferomedial part of the ischial tuberosity via a tendon it shares with the biceps femoris muscle, and from an aponeurosis connecting the two muscles. The muscle inserts via a long tendon overlying the semimembranosus muscle at the upper part of the medial surface of the tibia behind the insertion of the sartorius and distal to the insertion of the gracilis (pes anserine).

- *Function:* The primary function is flexion of the knee. With the knee semi-flexed, the muscle functions as medial rotators of the lower leg on the knee. With the hip extended, the semi-hamstrings are lateral rotators of the thigh.
- *Innervation:* Sciatic nerve (L5–S2) through the tibial division.
- *Referred pain:* Posterior thigh and knee and the upper one-third of the posterior calf.
- *Needling technique:* With the patient in the prone position with a pillow or bolster under the ankles, the needle is inserted perpendicular to muscle surface directly into the TrP taut band identified by a flat palpation technique (Figure 10.32).
- *Precautions:* Avoid needling the sciatic nerve and needle into a medial direction.

Sartorius muscle

- *Anatomy:* The sartorius muscle is the longest muscle in the body. It is a narrow muscle that originates from the anterior superior iliac spine, crosses over the thigh obliquely to the medial side, and inserts at the proximal medial surface of the tibia anteriorly to the insertions of the gracilis and semitendinosus muscles (pes anserine), and to the capsule of the knee joint and the deep fascia.
- *Function:* The muscle assists in flexion of the leg at the knee, hip flexion, abduction and lateral rotation of the thigh.
- *Innervation:* Femoral nerve (L2–L3).
- *Referred pain:* TrPs in the sartorius muscle may give superficial referred pain in the course of the muscle and into the medial knee.
- *Needling technique:* With the patient in supine, direct the needle tangentially to the surface of the muscle (nearly parallel to the skin) (Figure 10.33).
- *Precautions:* The muscle crosses the femoral nerve, artery and vein.

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Deep dry needling of the leg and foot muscles

11

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CHAPTER CONTENT

Introduction

This chapter covers deep dry needling of TrPs in the leg and foot musculature. These muscles are in a particularly challenging location as they are included in the referral patterns of multiple proximal muscles, such as the gluteus minimus, glutei medius and maximus, piriformis, tensor fasciae latae, adductors longus and brevis, vastus lateralis, sartorius, semitendinosus and semimembranosus and biceps femoris muscles (Travell et al. 1992, Dejung et al. 2001),which means that TrPs in leg muscles may be activated secondarily to TrPs in these more proximal muscles (Simons et al. 1999). Furthermore, TrPs in leg muscles can act as a link in this TrP chain, starting in proximal muscles and ending in foot muscles. The TrP chain has also been described running in the opposite direction (Lewit 2010), especially when pain and dysfunction caused by TrPs in foot and calf muscles induce gait alterations that overload muscles higher in the lower limbs and in the spine.

On the other hand, muscles in the foot and leg are the first line of defense of any anatomical or biomechanical problems occurring in the foot and, consequently, become easily overloaded by these issues leading to the development and activation of TrPs (Travell et al. 1992, Saggini et al. 1996). Joint dysfunctions and inappropriate shoes can also either cause or add to these problems. In other words, the treatment of TrPs in the leg and foot muscles is necessary, but usually insufficient to solve our patients' problems, since proximal muscles, as well as many other different perpetuating

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factors, must also be addressed for a complete and long-lasting relief of the symptoms.

Clinical relevance of TrPs in leg and foot pain syndromes

Pain syndromes in the leg and foot span from simple delayed onset muscle soreness to plantar fasciitis, calf cramps, shin splints, Morton's neuroma, tendonitis of the Achilles' tendon and other tendons, posterior tibial nerve or deep peroneal nerve entrapments, compartment syndromes, ankle or foot sprains, complex regional pain syndrome type I (CRPS I), intermittent claudication, and metatarsalgia, among others. The contributions of TrPs in the leg and foot muscles to these conditions can be highly variable, but clinical impressions and some evidence suggest that TrPs do play an important role. Symptoms arising from TrPs often mimic many of these conditions, inducing erroneous diagnoses that lead to incorrect and ineffective treatments. A combination of TrPs in the tibialis posterior, the soleus, and gastrocnemius muscles, for example, may mimic an Achilles tendonitis; TrPs in the third dorsal interosseous muscle may reproduce the symptoms of a Morton's neuroma; and TrPs in the peroneal muscles may imitate the pain of an ankle sprain, and so on.

Although many different possible etiologies are proposed for calf cramps, TrPs in the calf muscles, particularly in gastrocnemius muscle, seem to be important contributors (Travell et al. 1992, Ge et al. 2008, Xu et al. 2010). A small sample (n=24) clinical trial showed that xylocaine injections of TrPs in the gastrocnemius muscle induced a significantly better long-term efficacy on calf cramps than oral quinine (Prateepavanich et al. 1999).

Plantar heel pain, often diagnosed as plantar fasciitis, is commonly due to TrPs in the calf and foot musculature. Several reports have confirmed this close relationship and proven that conservative treatment of TrPs in calf muscles is useful in the treatment of plantar heel pain and plantar fasciitis (Nguyen 2010, Renan-Ordine et al. 2011). Although there is no solid evidence on the effectiveness of invasive treatments (Cotchett et al. 2010), some reports suggest that needling and injections of TrPs in the calf and foot muscles could be helpful in the management of this condition (Imamura et al. 1998, Kushner & Ferguson 2005, Sconfienza et al. 2011).

An older study attributed medial tibial stress syndrome (shin splints) to overload of the attachments of the soleus muscle (Michael & Holder 1985). One study showed that tension in the soleus, tibialis posterior, and flexor digitorum longus muscles caused a tenting effect, that exerted a force on the distal tibial fascia directed to its tibial crest insertion (Bouche & Johnson 2007). Another study demonstrated that the plantar flexors of the ankle were significantly weaker in medial tibial stress syndrome (Madeley et al. 2007). Increased tension and weakness are two cardinal features of muscles affected by TrPs. Nevertheless, the possible involvement of TrPs in these muscles in medial tibial stress syndrome has not yet been established unequivocally, and no clinical trial to date has proven that TrP treatment can be of help in the management of this condition.

Although 'there is a strong possibility that, in muscles prone to developing a compartment syndrome, TrPs may make a significant contribution' (Travell et al. 1992), there is no actual evidence in the literature. On the other hand, the safety of using dry needling, which could potentially cause some bleeding in the muscle, has not been established either in patients with compartment syndrome; hence, more aggressive dry needling approaches, such as Hong's Fast-in and Fast-out technique, screwed-in/out techniques, or dry needling with thick needles may be considered possible contraindications.

Forty per cent of patients with CRPS in the lower extremities presented with active TrPs in their proximal muscles (Allen et al. 1999). In this study only the lumbar paraspinous and gluteal musculature were examined, which raises the question what percentage of active TrPs would have been found if other lower extremity muscles had been included in the examination. Early treatment of TrPs is usually recommended in patients with CRPS I to decrease their pain intensity and disability (Dommerholt 2004). Although the use of dry needling has never been reported in this indication, a recent report of two cases of upper limb CRPS I showed promising results with treatment of proximal TrPs with botulinum toxin injections (Safarpour 2010).

TrPs in several leg muscles, such as the popliteus, plantaris and gastrocnemius, can also contribute to posterior knee pain, which is often attributed to knee joint problems. TrPs in the proximal part of the gastrocnemius muscle are responsible for posterior knee pain in patients before (Mayoral et al. 2010) and after (Aceituno 2003) total knee replacement surgery and after knee arthroscopy (Rodríguez et al. 2005).

Further research is needed to elucidate the possible contribution of TrPs to the above conditions or to other structural problems such as hammer toes (Travell et al. 1992) or hallux valgus, or to different leg and foot nerves entrapments (Crotti et al. 2005, Saggini et al. 2007).

Figure 11.1 • Dry needling of the popliteus muscle.

Dry needling of the leg and foot muscles

Popliteus muscle

- *Anatomy:* The popliteus muscle is an obtuse triangle in shape. Laterally and proximally it attaches to the lateral condyle of the femur, to the posterior capsule of the knee joint, to the lateral meniscus, and to the head of the fibula. Medially and distally it attaches to the posteromedial surface of the tibia.
- *Function:* Medial rotation of the tibia in open kinetic chain and lateral rotation of the femur in closed kinetic chain. It also assists marginally with knee flexion.
- *Innervation:* Fibers of the tibial nerve from L4–S1 spinal nerves.
- *Referred pain:* Typically to the back of the knee.
- *Needling technique:* The patient side lies on the involved extremity with the hip and knee flexed to 90°. The muscle is palpated right behind the proximal third of the tibia and the needle is inserted towards the TrP in a lateral direction with a slight anterior superior orientation (Figure 11.1), keeping the needle close to the posterior aspect of the tibia or even touching the bone with the tip of the needle as a reference.
- *Precautions*: The neurovascular bundle is in the midline of the leg, resting on the popliteus muscle, and must be avoided by keeping the needle close to the posterior aspect of the tibia. Branches of the saphenous nerve run superficial in the region where the needle is inserted. If the needle touches any of these branches, the patient will feel a superficial electrical sensation over the medial part of the leg. Should this happen during the first millimeters of needle penetration through the skin, the needle should be withdrawn and reinserted some millimeters away.

Gastrocnemius muscle

- *Anatomy:* The muscle is divided into lateral and medial heads. Proximally, each head anchors to the corresponding condyle of the femur and to the capsule of the knee joint. Distally, both heads insert into the Achilles tendon, which attaches to the posterior surface of the calcaneus bone.
- *Function:* Plantar flexion and supination of the foot. Limited contribution to knee flexion (with the knee extended) and to knee stabilization. In closed kinetic chain it contributes to knee and ankle stability.
- *Innervation:* Tibial nerve by fibers from S1 and S2.
- *Referred pain:* Most TrPs in this muscle refer pain locally. TrPs in the belly of the medial head tend to refer pain to the instep of the foot, sometimes spreading to the lower posterior thigh, the back of the knee, and the posteromedial aspect of leg and ankle.
- *Needling technique:* The patient lies in the prone position, with the knee slightly flexed and the leg supported by a pillow. For TrPs in the central part of the medial head, a pincer palpation is used to locate and fix the taut band and the TrP and the needle is angled medially, towards the fingers located in the opposite side

Figure 11.2 • Dry needling of the medial head of the gastrocnemius muscle.

Figure 11.4 • Dry needling of the proximal part of the lateral head of the gastrocnemius muscle.

Figure 11.3 • Dry needling of the lateral head of the gastrocnemius muscle.

(Figure 11.2). For TrPs in the central part of the lateral head, a flat palpation is more commonly used to locate and fix the taut band and the TrPs. The needle is directed perpendicular to the skin aiming towards the TrP in a postero-anterior direction with a slightly lateral angulation (Figure 11.3). For TrPs in the proximal part of any of both heads, flat palpation is used to locate and fix the TrPs. The needle is directed toward the TrP in a posteroanterior orientation (Figure 11.4).

- *Precautions:* The sciatic nerve usually splits into the tibial and peroneal nerves in the lower third of the thigh. The tibial nerve, together with the popliteal vessels, runs along the popliteal fossa between the proximal parts of both heads of the gastrocnemius muscle. The peroneal nerve runs downward close to the biceps femoris muscle tendon. This means that the proximal part of the medial head of the gastrocnemius muscle (and therefore its TrPs) lies between the tibial nerve (along with the popliteal vessels) and the tendons of the semitendinosus and semimembranosus muscles. On the other hand, the proximal portion of the lateral head of the gastrocnemius muscle and its TrPs are between the peroneal nerve and the tibial nerve. If needling of these proximal gastrocnemius TrPs is considered necessary, the popliteal fossa must be palpated thoroughly prior to the needling procedure to locate the nerves and tendons. Anatomical variations, such as a premature split of the two divisions of the common peroneal nerve at the popliteal level, may be identified, and needling TrPs in the proximal part of the lateral head of the gastrocnemius muscle or into the plantaris muscle would not be indicated. The recommended position to palpate this region is shown in Figure 11.5. Clinicians should identify the available safe needling space between the semitendinosus muscle tendon and the tibialis nerve, and the space between the peroneal and tibialis nerves and their relationship with the biceps femoris muscle tendon. In the prone position, only the tendons are palpable (especially when the patient slightly contracts the knee flexors) and by using the tendons as landmark, the needle can be directed into the safe spaces.

When needling the proximal portions of the gastrocnemius muscle, it is conceivable that the needle may touch the back part of the capsule of the knee joint, hence it is recommended to increase the

Figure 11.5 • Palpation of the posterior-lateral border of the knee cap (biceps femoris).

Figure 11.6 • Dry needling of the soleus muscle with pincer palpation.

antiseptic measures to avoid creating a joint infection (see Ch. 4).

The medial sural cutaneous nerve descends between the two heads of the gastrocnemius muscle. When needling the central bellies of both heads of the gastrocnemius muscles, the midline must be avoided by angulating the needle laterally when needling the lateral head, and medially when needling the medial head.

Plantaris muscle

- *Anatomy:* Proximally, this muscle attaches to the upper part of the lateral condyle of the femur. Distally, its long tendon anchors to the medial aspect of the calcaneus, blending with the fibers of the Achilles tendon.
- *Function:* Plantar flexion and inversion of the foot. In a closed kinetic chain, it assists in knee flexion.
- *Innervation:* Tibial nerve, through a branch containing fibers from L5–S2.
- *Referred pain:* To the back of the knee, sometimes reaching mid-calf level.
- *Needling technique:* Since it is partially covered by the upper part of the lateral head of the gastrocnemius muscle, the needling technique is similar to this (see gastrocnemius muscle above and Figure 11.4).
- *Precautions:* The tibial and peroneal nerves and popliteal vessels must be avoided.

Soleus muscle

- *Anatomy:* The muscle originates in the posterior aspect of the head and proximal third of the fibula, in the popliteal line of the tibia and in the tendinous arch between both bones. The soleus fibers attach distally to a superficial tendinous sheet, which continues directly to the Achilles tendon, which in turn attaches to the posterior part of the calcaneus.
- *Function:* Plantar flexion and inversion of the foot.
- *Innervation:* A branch of the tibial nerve containing fibers from L5–S2.
- *Referred pain:* Mostly to the distal part of the Achilles tendon and the posterior and plantar surfaces of the heel. Its TrPs can also refer pain to the upper half of the calf and, very rarely, to the ipsilateral sacroiliac joint. Simons et al. (1999) mentioned an exceptional referral pattern to the ipsilateral jaw area.
- *Needling technique:* For distal medial or lateral TrPs, the whole muscle can be held in a pincer between the thumb and two fingers, with the patient either in prone (Figure 11.6) or in a side lying position. The needle is directed towards the opposite finger or thumb. Proximal TrPs can be needled towards the fibula with the patient lying on the uninvolved side (Figure 11.7).

Figure 11.7 • Dry needling of the proximal part of the soleus muscle.

- *Precautions:* When needling the medial part of the muscle, care must be taken to avoid needling the tibial nerve.

Flexor digitorum longus muscle

- *Anatomy:* Proximally, the muscle attaches to the posterior aspect of the tibia and to the deep layer of the fascia cruris (the intermuscular septum shared with the tibialis posterior muscle). Distally its four tendons attach to the base of the distal phalanx of the second, third, fourth, and fifth toes, respectively.
- *Function:* Plantar flexion, inversion, and adduction of the foot. Flexion of the distal phalanx of each of the four lesser toes.
- *Innervation:* A branch of the tibial nerve containing fibers from L5 and S1.
- *Referred pain:* Mainly to the middle of the plantar forefoot. Sometimes the pain referral includes the medial side of the ankle and calf.
- *Needling technique:* With the patient lying on the involved side, hip and knee flexed to about 90°, the TrP is palpated with a flat technique right behind the posterior surface of the tibia and the needle is inserted towards it, mainly in a lateral direction with a slightly anterior orientation (Figure 11.8), keeping the needle close to the posterior aspect of the tibia or even touching the bone with the tip of the needle as a reference.
- *Precautions:* The tibial nerve and the posterior tibial vessels lie right behind the muscle. Keeping the needle close to the bone helps to avoid contact with the neurovascular bundle.

Figure 11.8 • Dry needling of the flexor digitorum longus muscle.

Tibialis posterior muscle

- *Anatomy:* Proximally, the muscle originates on the inner posterior borders of the tibia and fibula and on the interosseous membrane. Distally, the tendon attaches to the bases of the second, third, and fourth metatarsals, the three cuneiforms, the cuboid, the tuberosity of the navicular, and the sustentaculum tali of the calcaneus.
- *Function:* Supination (inversion and adduction) and plantar flexion of the foot. Stabilization of the foot in weight bearing activities.
- *Innervation:* Tibialis posterior nerve, arising from tibialis nerve and containing fibers from L5 and S1.
- *Referred pain:* Mainly to the Achilles tendon, but often also to the sole of the foot and, less often, to the mid-calf and heel.
- *Needling technique:* The recommended needling technique is similar to the approach described above for the flexor digitorum longus muscle (Figure 11.8) with the only difference, that the needle must be inserted deeper to reach the tibialis posterior muscle (Figure 11.9). Due to the deep location of the tibialis posterior muscle, palpation of tibialis posterior's TrPs is not possible. Therefore, to determine the site of the TrP, deep posteroanterior pressure is applied through

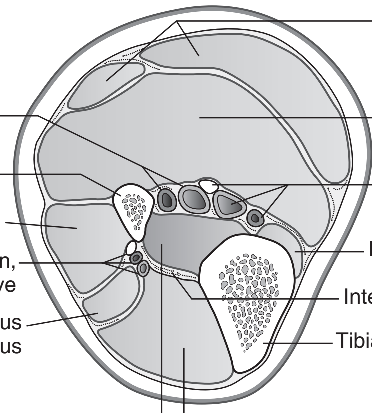

Figure 11.9 • Representation of the leg showing the muscles from dry needling.

the calf muscles in order to elicit deep tenderness that could be attributable to the tibialis posterior muscle. The needle will then be used both as a therapeutic and as a diagnostic tool to confirm the presence of the TrP. In an alternate approach, the patient is supine and the therapist sits at the patient's feet. After determining at which level the TrP may be located, the needle is inserted in an anterior to posterior direction through the tibialis anterior muscle, keeping the needle close to the tibia (Figure 11.10).

- *Precautions:* In either approach the needle must be kept close to the tibia bone to avoid touching the neurovascular bundles, including the posterior tibial vessels and tibial nerve in the recommended technique and the anterior tibial vessels and deep peroneal nerve in the alternate technique. In the recommended approach, if the needle is inserted too deep, it will pierce the interosseous membrane and could touch the deep peroneal nerve, which the patient will experience as an electrical shooting pain towards the ankle and foot.

Figure 11.10 • Dry needling of the tibialis posterior muscle with an anterior approach.

Flexor hallucis longus muscle

- *Anatomy:* The muscle originates in the lower two-thirds of the posterior surface of the fibula and in the interosseous membrane. Its tendon anchors to the base of the distal phalanx of the great toe.
- *Function:* Plantar flexion and inversion of the foot. Flexion of the distal phalanx of the first toe.
- *Innervation:* A branch of the tibial nerve that contains fibers from L5–S2.
- *Referred pain:* To the plantar surface of the first toe, including the head of the first metatarsal.
- *Needling technique:* With the patient in prone, the muscle is palpated using a flat palpation technique for tenderness, applying deep anterior pressure just lateral to the mid-line against the fibula through the soleus muscle, gastrocnemius muscles, and the aponeurosis, which at a lower level will become the Achilles tendon. If tenderness is found, the needle will both confirm and treat the TrP with an anterior and slightly lateral needling direction (Figure 11.11). The posterior aspect of the fibula is used as an anatomical landmark to assure the proper position of the needle and a sufficient depth of penetration.
- *Precautions:* Angling the needle laterally, towards the fibula, decreases the possibility of touching the peroneal vessels.

Figure 11.11 • Dry needling of the flexor hallucis longus muscle.

Figure 11.12 • Dry needling of the peroneus longus muscle.

Peroneus longus and brevis muscles

- *Anatomy:* The peroneus longus muscle arises from the head and upper two-thirds of the lateral surface of the body of the fibula and also from the intermuscular septa between it and the adjacent muscles. It inserts in the ventral and lateral sides of the base of the first metatarsal bone and of the medial cuneiform. The peroneus longus muscle is also known as the fibularis longus muscle. The peroneus brevis muscle originates in the lower two-thirds of the lateral aspect of the body of the fibula and in the adjacent intermuscular septa and is partially covered by the peroneus longus muscle. It inserts into the tuberosity at the lateral side of the base of the fifth metatarsal bone. The peroneus brevis muscle is also known as the fibularis brevis muscle.
- *Function:* Stabilization of the leg upon the foot. Plantar flexion and eversion of the foot.
- *Innervation:* Superficial peroneal nerve, through branches containing fibers from L4–S1.
- *Referred pain:* Chiefly above, behind and below the lateral malleolus of the ankle and a short distance along the lateral surface of the foot. TrPs in the peroneus longus muscle may also refer pain to the lateral aspect of the leg.
- *Needling technique:* With the patient lying on the uninvolved side, hips and knees flexed to approximately 90°, the muscle is palpated with a flat technique and the needle is inserted perpendicular to the skin, in a lateral to medial direction, towards the fibula (Figure 11.12).
- *Precautions:* In the proximal third of the peroneus longus muscle, care must be taken to avoid needling the common peroneal nerve, which lies deep to the muscle. The superficial peroneus nerve runs between peroneus brevis and tertius muscles. When needling the peroneus brevis muscle, clinicians must avoid needling in an anterior direction and needle away from the nerve.

Peroneus tertius muscle

- *Anatomy:* The muscle originates in the lower half of the anterior aspect of the fibula and in the crural intermuscular septum between it and the peroneus brevis muscle. It inserts in the mediodorsal surface of the base of the metatarsal bone of the fifth digit and in the base of the fourth metatarsal. The peroneus tertius muscle is also known as the fibularis tertius muscle.
- *Function:* Eversion and dorsiflexion of the foot.
- *Innervation*: Deep peroneal nerve, with fibers coming from L5 and S1.
- *Referred pain:* Primarily to the anterolateral side of the ankle and, sometimes, to the lateral side of the heel.
- *Needling technique:* With the patient lying in supine, the TrP is located by flat palpation and the needle is aimed in an anteroposterior direction against the fibula (Figure 11.13).
- *Precautions:* Directing the needle laterally passed the fibula must be avoided to steer clear of the superficial peroneal nerve, which runs between both the peroneus brevis and tertius muscles.

Figure 11.13 • Dry needling of the peroneus tertius muscle.

Figure 11.14 • Dry needling of the tibialis anterior muscle.

Tibialis anterior muscle

- *Anatomy:* The muscle originates in the upper two-thirds of the lateral surface of the tibia and inserts into the medial and plantar aspects of the medial cuneiform bone and into the medial surface of the base of the first metatarsal bone.
- *Function:* Dorsiflexion and supination (i.e. inversion and adduction) of the foot.
- *Innervation:* Deep peroneal nerve, with fibers coming from L4–S1.
- *Referred pain:* Generally to the anteromedial aspect of the ankle and over the great toe. Sometimes, its TrPs also refer to the shin and to the anteromedial surface of the foot.
- *Needling technique:* With the patient in the supine position, the TrP is located with a flat palpation technique and the needle is directed with a slightly medial direction toward the tibia (Figure 11.14).
- *Precautions:* The neurovascular bundle, formed by the anterior tibial artery and vein and the deep peroneal nerve, runs right behind the lateral part of the tibialis anterior muscle (see Figure 11.9). Directing the needle into a medial direction, towards the tibia, avoids contact with these structures.

Extensor digitorum longus muscle

- *Anatomy:* The muscle originates from the lateral condyle of the tibia; from the upper three-fourths of the anterior surface of the body of the fibula; from the upper part of the interosseous membrane; and from the intermuscular septa between it and the tibialis anterior muscle on the medial side, and the peroneal muscles on the lateral side. Distally, its tendon divides into four slips that insert in the second and third phalanges of the four lesser toes.
- *Function:* Dorsiflexion and evertion of the foot, and extension of the four lesser toes.
- *Innervation:* Branches of the deep peroneal nerve containing fibers from L4–S1.
- *Referred pain:* To the dorsum of the foot and toes.
- *Needling technique:* With the patient supine, TrPs are located by flat palpation and the needle is inserted close to the border of the tibialis anterior muscle in an anteroposterior direction toward the fibula (Figure 11.15).
- *Precautions:* Care must be taken to avoid touching the deep peroneal nerve, which, in the

Figure 11.15 • Dry needling of the extensor digitorum longus muscle.

Figure 11.16 • Dry needling of the extensor hallucis longus muscle.

Figure 11.17 • Dry needling of the extensor digitorum brevis and extensor hallucis brevis muscles.

proximal part of the muscle lies deep underneath the muscle. Directing the needle towards the fibula avoids contact with the neurovascular bundle.

Extensor hallucis longus muscle

- *Anatomy:* The muscle originates from the middle two-fourths of the anteromedial surface of the fibula medial to the origin of the extensor digitorum longus muscle; it also originates from the interosseous membrane. Its tendon attaches distally to the base of the distal phalanx of the great toe, and through an expansion of the tendon, it also usually attaches to the base of the proximal phalanx.
- *Function:* Dorsiflexion and inversion of the foot. Extension of the great toe.
- *Innervation:* Branches of the deep peroneal nerve containing fibers from L4–S1.
- *Referred pain:* To the distal aspect of the dorsum of the first metatarsal, sometimes spreading distally to the tip of the great toe.
- *Needling technique:* The patient is in supine. The TrP is located with a flat palpation technique and the needle is inserted close to the *lateral border* of the tibialis anterior muscle in an anteroposterior direction with a lateral angulation toward the fibula (Figure 11.16).
- *Precautions:* The deep peroneal nerve and the anterior tibial vessels are covered by the tibialis anterior muscle and **by the medial** part of the extensor hallucis longus muscle. Angling the needle laterally towards the fibula helps to avoid contact with the neurovascular bundle.

Extensor digitorum brevis and extensor hallucis brevis muscles

- *Anatomy:* Both muscles anchor proximally to the superior aspect of the calcaneus, to the lateral talocalcaneal ligament and to the cruciate crural ligament. Distally, the extensor hallucis brevis inserts in the dorsal surface of the base of the first phalanx of the great toe, and the extensor digitorum brevis ends in three tendons, which insert into the lateral sides of the tendons of the extensor digitorum longus muscle of the second, third and fourth toes.
- *Function:* The extensor digitorum brevis muscle extends the second, third and fourth toes. The oblique direction of its traction counteracts the obliquity given to the toes by the long extensor, which produces an even extension when both muscles contract. The extensor hallucis brevis extends the proximal phalanx of the great toe.
- *Innervation:* Deep peroneal nerve with fibers from L5 and S1.
- *Referred pain*: To the dorsum of the foot.
- *Needling technique*: The patient is in supine. The taut band and the TrPs are located with a flat palpation technique. The needle is directed perpendicular to the skin toward the TrPs. Most of the times the needle will make contact with the underlying bone (Figure 11.17).
- *Precautions:* The deep peroneal nerve and the dorsal vessels of the foot run medial to the extensor hallucis brevis muscle, consequently, when needling this muscle angling the needle medially must be avoided.

Figure 11.18 • Contact of the therapists for dry needling of the foot muscles.

Figure 11.19 • Dry needling of the abductor hallucis muscle.

Abductor hallucis muscle

- *Anatomy:* Proximally the muscle attaches to the medial process of the tuberosity of the calcaneus, to the laciniate ligament (flexor retinaculum of the foot), to the plantar aponeurosis, and to the intermuscular septum between it and the flexor digitorum brevis muscle. Distally, its tendon inserts together with the medial tendon of the flexor hallucis brevis muscle into the medial or the plantar side of the base of the first phalanx of the great toe.
- *Function:* Flexion and abduction of the first phalanx of the great toe.
- *Innervation:* Medial plantar nerve that carries fibers from L5 and S1.
- *Referred pain:* Chiefly to the medial side of the heel, sometimes including the instep.
- *Needling technique:* The patient is lying on the involved side. The therapist sits by the table, facing the feet of the patient. The arm of the therapist passes over the patient's involved leg and holds it firmly on the table to avoid unexpected movements of the extremity (Figure 11.18). TrPs are located using a flat palpation technique and the needle is inserted perpendicular to the skin, in a lateral direction, towards the underlying bone (Figure 11.19).
- *Precautions:* The neurovascular bundle, formed by the tibialis posterior vessels and the medial and lateral plantar nerves, passes deep to the proximal third of this muscle. Care must be taken to avoid these structures when needling this part of the muscle.

Abductor digiti minimi muscle

- *Anatomy:* Proximally, the muscle attaches to the lateral process of the tuberosity of the calcaneus, to the inferior surface of the calcaneus between the two processes of the tuberosity, to the front part of the medial process, to the plantar aponeurosis, and to the intermuscular septum between it and the flexor digitorum brevis. Distally, its tendon inserts with the flexor digiti minimi brevis into the fibular side of the base of the first phalanx of the fifth toe.
- *Function:* Abduction and flexion of the proximal phalanx of the fifth toe.
- *Innervation:* Lateral plantar nerve, through fibers from S1 and S2.
- *Referred pain:* Mainly to the plantar side of the fifth metatarsal head
- *Needling technique:* With the patient lying on the uninvolved side, the therapist position is similar as described above for needling of the abductor hallucis muscle (Figure 11.18). The taut band and the TrPs are located either by flat or by pincer palpation. In both ways the needle is directed in a medial and dorsal direction towards the underlying bone (Figure 11.20). Since the fifth toe is free to move, the local twitch responses can be seen as minor abduction and flexion movements.

Figure 11.20 • Dry needling of the abductor digiti minimi muscle.

- *Precautions:* The medial margin of the muscle is close to the lateral plantar vessels and nerves. Directing the needle towards the bone avoids touching these neurovascular structures.

Flexor digitorum brevis muscle

- *Anatomy:* Proximally, the muscle arises from the medial process of the tuberosity of the calcaneus, from the plantar fascia, and from the adjacent intermuscular septa. Distally, it divides into four tendons, one for each of the four lesser toes. At the base of the first phalanx, each tendon divides into two slips, to allow passage of the corresponding tendon of the flexor digitorum longus; the two portions of the tendon then reunite and, finally, it splits a second time, and is inserted into both sides of the second phalanx.
- *Function:* Flexion of the second phalanx of each of the four lesser toes.
- *Innervation:* Medial plantar nerve by fibers coming from L5 and S1.
- *Referred pain:* Mainly to the sole over the heads of the second through fourth metatarsals. Sporadically, pain spills over into the head of the fifth metatarsal.
- *Needling technique:* With the patient in prone, the therapist assumes the same position as described in Figure 11.18 (see above) and palpates for focal tenderness using a flat palpation technique. It is sometimes difficult to distinguish whether tenderness may be due to strain of the plantar fascia, to TrPs in the flexor digitorum brevis muscle, to TrPs in quadratus plantaris muscle, or to any combination of the three. Dry needling is a viable treatment for either condition. The needle is directed towards the palpated tender area in a plantar to dorsal direction (Figure 11.21) until the tip reaches the bone, which suggests that the three involved structures have been addressed.
- *Precautions:* The lateral plantar vessels and nerve and, to a lesser extent, the medial plantar nerve lie between the flexor digitorum brevis muscle and quadratus plantaris muscle. The needle must be handled carefully to avoid touching these structures.

Figure 11.21 • Dry needling of the flexor digitorum brevis and quadratus muscle.

Quadratus plantaris muscle

- *Anatomy:* The muscle has two heads, which are separated from each other by the long plantar ligament. The medial and larger head originates in the medial concave surface of the calcaneus. The lateral head, flat and tendinous, arises from the lateral border of the calcaneus and from the long plantar ligament. Both heads join at an acute angle and end in a flattened band which inserts into the lateral margin and upper and under surfaces of the tendon of the flexor digitorum longus.
- *Function:* The muscle assists the flexor digitorum longus in flexion of the four lesser toes, offsetting the oblique pull of this muscle. Nevertheless, the quadratus plantaris muscle may flex these four lesser toes even in the absence

of the flexor digitorum longus (Travell & Simons 1992).

- *Innervation:* Lateral plantar nerve by fibers from S2 and S3.
- *Referred pain:* To the plantar surface of the heel.
- *Needling technique:* The recommended technique is the same as described above for the flexor digitorum brevis muscle (Figure 11.21). For the quadratus plantaris muscle, the needle can also be inserted through the instep, in a medial to lateral direction, right below the bone. This technique is better tolerated by some patients and may be safer considering the neurovascular bundle; however, in our experience, this approach is much less effective and should be reserved mostly for patients with a low pain threshold.
- *Precautions*: The lateral plantar vessels and nerve and, to a lesser extent, the medial plantar nerve lie between the flexor digitorum brevis muscle and quadratus plantaris muscle. The needle must be handled carefully to avoid touching these structures

Flexor hallucis brevis muscle

- *Anatomy:* Proximally, the flexor hallucis brevis anchors to the medial part of the under surface of the cuboid bone, to the contiguous portion of the third cuneiform, and to the prolongation of the tendon of the tibialis posterior which is attached to that bone. It then divides into two portions, which insert distally into the medial and lateral aspects of the base of the first phalanx of the great toe. A sesamoid bone is present in each tendon at its insertion.
- *Function:* Flexion of the first phalanx of the great toe at the metatarsophalangeal joint. The medial head produces abduction and the lateral head adduction of the first phalanx.
- *Innervation:* Medial plantar nerve containing fibers from L5 and S1.
- *Referred pain:* Chiefly to the plantar and medial aspects of the head of the first metatarsal. Referral sometimes spills over into all of the great toe and a good part of the second.
- *Needling technique:* The patient lies on the involved side. The therapist adopts the position described above in Figure 11.18. The muscle is palpated via a flat palpation technique in search of TrPs. The needle is inserted from the medial side of the foot, right below the first metatarsal bone (Figure 11.22). When the needle hits the TrP the local twitch responses produce abrupt flexion movements of the first phalanx of the great toe.

Figure 11.22 • Dry needling of both heads of the flexor hallucis brevis muscle and the oblique head of the adductor hallucis muscle.

- *Precautions:* The proper digital nerve runs adjacent to the plantar surface of the medial head of this muscle. The needle must be handled carefully and stay close to the bone to avoid touching the nerve.

Adductor hallucis muscle

- *Anatomy:* The muscle has two heads. The oblique head arises from the bases of the second, third, and fourth metatarsal bones, and from the sheath of the tendon of the peroneus longus. Distally, it inserts together with the lateral head of the flexor hallucis brevis into the lateral side of the base of the first phalanx of the great toe. The transverse head arises from the plantar metatarsophalangeal ligaments of the third, fourth, and fifth toes, and from the transverse ligament of the metatarsus. It inserts into the lateral side of the base of the first phalanx of the great toe, blending with the tendon of insertion of the oblique head.
- *Function:* Adduction of the great toe and flexion of the proximal phalanx of the great toe.
- *Innervation:* Lateral plantar nerve by fibers from S2 and S3.
- *Referred pain:* To the sole of the foot, in the area of the first through fourth metatarsal heads.
- *Needling technique:* Since the oblique head of the muscle is in the same plane as the flexor hallucis

Figure 11.23 • Dry needling of the dorsal and plantar interossei muscles.

Figure 11.24 • Dry needling of the dorsal and plantar interossei muscles.

brevis, side by side with its lateral head, the needling technique for the oblique head of the adductor hallucis muscle is the same described above for the flexor hallucis brevis muscle (Figure 11.22), although to reach the oblique head of the adductor hallucis muscle the needle needs to be advanced further. Local twitch responses may move the great toe towards the second toe, which confirms that a TrP was needled. The transverse head is better approached from the dorsum of the foot. With the patient in the supine position and the therapist in the same position as described above for other foot muscles (Figure 11.18), the muscle is palpated with a flat palpation technique in the sole of the foot, just proximal to the metatarsal heads. When a TrP is located, the finger of the therapist stays pointing to the TrP and the needle is inserted in the dorsum of the foot, aiming at the therapist's finger, through the interosseus space that better allows reaching the TrP (Figures 11.23 & 11.24). In a way, this is a modified pincher needling technique.

- *Precautions:* The precautions for the oblique head of the adductor hallucis muscle are the same as for the flexor hallucis brevis muscle.

Dorsal and plantar interossei muscles

- *Anatomy:* There are four dorsal interossei and three plantar interossei in the foot. Proximally, each **dorsal interosseous muscle** originates in the proximal half of the two adjacent metatarsal bones and insert distally at the base of the first phalanx and at the aponeurosis of the tendon of the extensor digitorum longus. Thus, the first dorsal interosseous inserts into the medial side of the second toe and the other three insert into the lateral sides of the second, third, and fourth toes. Proximally, each **plantar interosseous** attaches to the base and medial half of the related metatarsal (third, fourth or fifth) and anchors distally to the medial side of the base of the first phalanx of the same digit and usually to the dorsal aponeurosis of that extensor digitorum longus tendon.
- *Function:* The **dorsal interossei** abduct the second, third and fourth toes, flex the first phalanges and extend the second and the third phalanges of these toes. The **plantar interossei** adduct the third, fourth and fifth toes, flex the first phalanges and extend the third phalanges of these same toes.
- *Innervation:* All interossei are innervated by the lateral plantar nerve, by fibers from S-2 and S-3.
- *Referred pain:* To the side of the digit to which the tendon anchors, to the dorsum and to the sole of the foot along the distal part of the corresponding metatarsal.

- *Needling technique:* With the patient supine and the therapist in the position described in Figure 11.18, the clinician assesses the muscles for spot tenderness using a flat palpation technique. As an alternative, the eraser part of a pencil can be used, which allows to get in between the metatarsal bones. The needle is inserted from the dorsal aspect towards the tender spot and the opposing finger using a modified pincer palpation. The needle must probe in both lateral and medial directions to explore both heads of the dorsal interosseous and the corresponding plantar interosseous (Figure 11.24). Movement of the toes should not be restricted by the palpating hand, since abduction or adduction movements produced by local twitch responses will indicate which interosseous muscle was treated.
- *Precautions:* None

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Superficial dry needling

12

Peter Baldry

CHAPTER CONTENT

Introduction

In the treatment of myofascial trigger point (TrP) pain, the Czech physician Karel Lewit was one of the first to advocate the insertion of a needle deep into the muscle in order to penetrate the TrP itself. Lewit (1979) stated 'that the effectiveness of deep dry needling (DDN) is related to the intensity of pain produced at the trigger zone and to the precision with which the site of maximum tenderness is located by the needle'. Chan Gunn, a Canadian physician, has also written extensively in support of a technique denominated 'intramuscular stimulation' (Gunn 1996). This involves inserting a needle deep into the muscle at a TrP site, but unlike Lewit, Gunn is of the opinion that it is not necessary to penetrate the TrP itself. Nevertheless, it can be a somewhat distressing procedure, because as Gunn has stated, when a needle is inserted into a tightly contracted band of a muscle, the patient may experience a peculiar cramp-like sensation as the needle is grasped, which at times can be excruciatingly painful. Furthermore, because the spasm is frequently prolonged and, due to this, the needle is so firmly grasped, it may take 10–30 minutes before it can be released. Gunn's contributions are described in detail in Chapter 14 of this book.

Another advocate of DDN is Jennifer Chu, an American physician who is strongly influenced by Gunn. She reserved DDN specifically for the alleviation of TrP pain that occurs as a secondary event following the development of either a cervical or lumbar radiculopathy (Chu 1997, 1999). Although the focus of this book is mostly on DDN, this chapter aims to describe an alternate needling approach to the management of patients with myofascial pain and TrPs.

Superficial dry needling

When starting to deactivate TrPs myself in the 1970s, it was initially my practice to employ Lewit's deep dry needling technique. However, when in the early 1980s a patient was referred to me with pain down the arm from a TrP in the anterior scalene muscle, it seemed to me unduly hazardous to push the needle into the muscle itself, because of the proximity to the apex of the lung.

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Thus, I inserted it only into the subcutaneous tissues immediately overlying the TrP. This proved to be all that was necessary; for after leaving the needle there for about 30 seconds, on taking it out, not only had the exquisite tenderness at the TrP site disappeared, but also the pain in the arm had been alleviated. This superficial dry needling (SDN) technique was then employed to deactivate TrPs present in deeper lying muscles in various parts of the body and found to be equally efficacious.

Macdonald et al. (1983), at Charing Cross Hospital in London, have provided evidence for the efficacy of SDN in a trial carried out on patients with pain arising from TrPs in the lower back. In their study, 17 patients with chronic myofascial pain in the lumbar region were divided into two groups. The treatment group had needles inserted to a depth of 4 mm at TrP sites. The control group had electrodes applied to the skin overlying TrPs with non-current carrying wires attached to a specially impressively adapted transcutaneous electrical nerve stimulation machine replete with flashing lights, dials and a cooling system that made a 'whirring' sound! The results of this trial showed that the effectiveness of SDN is significantly greater than that of a placebo.

Variable reactivity to needle-evoked nerve stimulation

Felix Mann, a medical acupuncturist in London, was one of the first to stress that the responsiveness of individuals to needle-evoked nerve stimulation is widely variable with a minority being either particularly strong or weak reactors (Mann 1992). There are now grounds for believing that the latter group of people have a genetically determined ability to secrete excessive amounts of endorphin antagonists (Peets & Pomeranz 1978, Han 1995, 2001).

Procedure recommended for the carrying out of SDN

In view of the above considerations, it is the authors' practice (Baldry 1995, 1998, 2001, 2002a, 2002b, 2005) when using SDN at a TrP site to initially insert a needle (0.3 mm in diameter and 30 mm long) into the tissues overlying the TrP to a depth of about 5–10 mm. Thus, allowing it to be self-standing, and then leaving it in place initially for about 30 seconds. An active TrP is of such exquisite tenderness that the application of firm pressure to it gives rise to a flexion withdrawal reaction (the jump sign) and often to the utterance of an expletive ('shout' sign). On withdrawing the needle pressure equal to that initially employed is reapplied to the TrP site to assess whether these two reactions have been abolished. This is usually the case, but if not, the needle is reinserted and left in the tissues for 2–3 minutes. Occasionally in a particularly weak reactor it is found necessary to stimulate even more strongly by reinserting the needle and not only leaving it there for an even longer period but also by intermittently twirling it. The reason for determining each patient's responsiveness in this way is because exceeding a patient's optimum needle stimulation requirement is liable to cause a temporary but nevertheless distressing exacerbation of pain. This having been said, it must be remembered that there is a small group of patients that are such very strong reactors that leaving a needle *in situ* for even 30 seconds is more than is required. In such cases, all that is necessary is to insert the needle into the tissues and to then immediately withdraw it.

The initial consultation

In view of all this, before SDN is embarked upon, it is necessary to inform the patient that any pain relief initially obtained may only last for 1–2 days, and that conversely, but rarely, due to the particular technique adopted, there may be a temporary exacerbation of it. The patient should also be told that needling is initially carried out once a week and that after a time, where necessary, at increasingly long intervals. It also has to be explained that the number of treatment sessions, the length of time between each one and the period for which they have to be given is dependent on whether an individual is a strong, average or weak responder, and also on the length of time the pain has been present prior to treatment being started.

Systematic search for trigger points (TrPs)

As it is essential for needling to be carried out at every TrP, it is clearly important for the search for them to be done in a systematic manner. Then, following treatment, it is necessary to palpate the muscles in the affected region, again to ensure that no TrP has been overlooked.

It is necessary at the first treatment session to deactivate only one TrP at a time, as by this means it is possible to assess whether or not the patient is a strong, weak or average responder. Then, on subsequent occasions in everyone but strong reactors, all TrPs may be deactivated simultaneously.

Muscle stretching exercises

Following each SDN, the patient should be encouraged to regularly stretch muscles that have become shortened as a result of the TrP activity. Any exercises designed to strengthen the muscles should, however, be avoided as these are liable to cause muscle overloading and the consequent reactivation of the TrP.

Measures to be taken to prevent trigger point (TrP) reactivation

Clearly any pain relief obtained by the carrying out of SDN at TrP sites will not be maintained unless any underlying postural, anatomical and biochemical disorders contributing to the initial development of TrP activity are recognized and corrected.

Postural disorders

Following treatment of TrP pain in the neck, the patient should be told to avoid postures that cause the cervical muscles to become persistently kinked, flexed or hyperextended. Examples include overloading as a result of lying in bed reading a book for a prolonged period by the light of a bed-side lamp, keeping the neck muscles persistently elevated such as when sitting at a computer for any length of time, and causing them to become kinked for a long period as result of sleeping with the head on either too few or too many pillows.

During the initial physical examination, note should be taken as to whether one shoulder is higher than the other. For if so, this may be due to a C-shaped scoliosis caused by unequal leg length, with one leg being 6 mm or less shorter than the other with, as a consequence, sagging of the shoulder on the side opposite to that of the short leg. Alternatively, if due to an S-shaped scoliosis, the leg length difference should be 1.3 cm or more with sagging of the shoulder on the same side as the short leg. In order to assess whether or not there is lower leg length inequality, the patient should stand with the legs straight and the feet together so that the relative heights of both greater trochanter and iliac crests can be compared. Alternatively, lower leg length inequality may be established by radiological examination (Travell & Simons 1992). However, although this is clearly a more accurate investigation, it is in the authors' experience not one that is always necessary.

Whenever a lower leg length inequality is found, it is necessary to decide whether this is a true one requiring the heel on the shorter side to be raised by increasing the thickness of the heel of the shoe, or if it is an apparent one due to shortening of the quadratus lumborum muscle as a consequence of TrP activity in it and therefore correctable by treating this.

Management of stress

Persistent stress may not only be a cause of TrP activity developing, but it also may cause it to persist (McNulty et al. 1994). Banks et al. (1998) have found that TrP electromyography (EMG) activity increases dramatically in response to emotional stress. It therefore often follows that treatment directed to reducing this is essential. The authors' preferred method in such a case is to employ hypnotherapy and to teach the patient to carry out autohypnosis on a regular basis in a manner similar to that employed by Hilgard & Hilgard (1994).

Biochemical disorders

Gerwin (1992, 1995) has drawn attention to the importance of those with TrP activity of excluding various biochemical disorders that are liable to cause this to persist. These include lack of vitamin B12, hypothyroidism, low serum folic acid levels and iron deficiency. With respect to the latter, Gerwin & Dommerholt (2002) reported that 'of women with a chronic sense of coldness and chronic myofascial pain, 65% had a low normal or below normal serum ferritin due to an iron intake insufficient to replace their menstrual iron loss'.

Summary

In this chapter the treatment of TrP pain with superficial dry needling has been advocated. It has been stressed that patients may be either strong, average or weak reactors. This is why initially needling should only be carried out at one TrP site at a time in order to avoid giving a strong reactor a greater stimulus than required and by so doing exacerbating the pain. It is necessary to explain to patients with this disorder that treatment is initially given once a week and that in those with a short history of pain, this is usually all that is required. In cases, however, where pain has been present for some considerable time it should be made clear that treatment is likely to be necessary at gradually increasing intervals for a much longer period. It has also been emphasized that in addition to the carrying out of SDN, it is necessary to diagnose and treat any underlying disorder that may contribute to the development of TrP activity, such as skeletal deformities, stress and biochemical deficiencies.

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Dry needling from a Western medical acupuncture perspective

13

Mike Cummings

CHAPTER CONTENT

Introduction and historical development

Dry needling: a historical perspective

Fossil evidence of trepanning suggests that man has used high threshold physical techniques in the treatment of disease since Neolithic times (Martin 2000, Parry 1936). Bone etchings from China dating back to 1600 BC are said to provide some of the earliest evidence of acupuncture techniques. Older still are the sharpened stones called *Bian shi*, although it is questioned whether or not these were actually instruments of acupuncture (Bai & Baron 2001). Harder evidence – in a softer format – comes from the silk scrolls found in Han Tomb No. 3 (dated to 168 BC) at Mawangdui, Changsha, China in the early 1970s. These manuscripts describe an early meridian system with 11 rather than 12 paired meridians and the use of moxibustion, which is a treatment involving the application of heat by burning the herb *Artemisia vulgaris*. The Pericardium meridian is missing (Chen 1997) from these early manuscripts. There is also an emphasis on information derived from tactile examination of the living body (Hsu 2005) rather than from dissection post-mortem. However, there is no description of acupuncture needling in these manuscripts (Bai & Baron 2001). The discovery of Ötzi, the Tyrolean iceman frozen from 3200 BC, suggests the use of a therapeutic needling technique, with a needle made

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from bone, which may have developed in Europe (Dorfer et al. 1999). It seems clear that acupuncture-like therapies have developed independently in different civilizations around the world and this is probably due to late evolutionary features in the mammalian nervous system, combined with intelligence, and the consequent use of tools in humans.

Children learn at a very early age to rub energetically directly over the site of acute pain to reduce the noxious sensation. In the case of a more chronic discomfort from aching, 'knotted' muscle, we tend to massage the local tissues more deeply and vigorously even though doing so may temporarily exacerbate the discomfort. This is likely to be conditioned behavior resulting from the analgesic effect of somatic sensory stimulation. With the development of stone tools it is easy to hypothesize a progression of therapeutic techniques which resulted ultimately in piercing the skin and muscle at a site of chronic pain. It may be that successful treatment of myofascial pain by piercing the body at the site of tenderness not only encouraged the practice, but also lead to the recognition of areas of the body which were most likely to harbor these tender points. In some parts of the world, people developed superficial techniques of scratching or cauterizing the skin, whereas in the Far and Middle East the technique of acupuncture developed (Cummings 2004).

Traditional acupuncture

The development of acupuncture points probably resulted from clinical observation that certain places in the body were more likely to harbor tender points than others and that treating these points by pressure or piercing could relieve pain and various other non-painful symptoms. Early physicians would have also noted that careful examination of the body surface revealed tender points in healthy subjects. Consistent patterns of pain referral from myofascial trigger points (TrPs) and the relief resulting from needling these and other muscle points would have lead them to make links between some of the points. Radiation patterns of painful medical conditions such as sciatica, other radiculopathies and possibly the consistent rashes of herpes zoster would have added to the impression that the established points were connected. These hypotheses do not explain the location of all acupuncture points, nor the paths of all the meridians, but there is clearly considerable overlap between myofascial trigger points and acupuncture points (Melzack et al. 1977), and between the pain referral patterns of the former and meridians (Dorsher 2009); although these potential correlations have caused great debate, and the theoretical backgrounds of these concepts are clearly distinct.

Acupuncture was probably used pragmatically by the Chinese and others for centuries before it became systematized within a documented form of medicine some 2000 years ago (Veith 1972). The theories developed were influenced by rational observations imposed upon a limited clinical knowledge base and in the philosophical framework of Taoism. The tendency towards syncretism resulted in the adoption and inclusion of many different theories, and over the centuries this has resulted in the development of a complex system of medicine. Whilst it can be initially unpalatable to the skeptical Western scientist, closer inspection reveals that Traditional Chinese Medicine is built on a series of logical assumptions, and although some of these are clearly wrong, many may still represent valid clinical observations.

Western medical acupuncture

Western medical acupuncture is a term with a variety of potential meanings. The most literal interpretation invokes thoughts of geographical boundaries, but the term was probably introduced to distinguish a developing system of needle therapy with a basis in Western medical science from its traditional philosophical roots which happened to be in the East. Filshie & Cummings (1999) interpret 'Western Medical Acupuncture' as the scientific application of acupuncture as a therapy following orthodox clinical diagnosis. It is important to note that the scientific evaluation of acupuncture is not restricted to the West (Han & Terenius 1982), and therefore adherence to a geographical definition is inappropriate. Probably a more accurate description of 'Western Medical Acupuncture' (WMA) is a modern scientific approach to therapy involving dry needling of tissues, which has been developed from the introduction and evaluation of traditional Chinese acupuncture techniques in the West (Cummings 2004).

More recently the definition of WMA has been reconsidered and redefined (White 2009):

> *Western medical acupuncture is a therapeutic modality involving the insertion of fine needles; it is an adaptation of Chinese acupuncture using current knowledge of anatomy, physiology and pathology, and the principles of evidence based medicine.*

Modern scientific method was established by Galileo in the 17th century when he introduced systematic verification through planned experiments to the existing ancient methods of reasoning and deduction (MacLachlan 1999). This system was adopted by the scientific community throughout the globe, and with only the addition of statistical analysis it remains established practice today. The ethical practice of medicine requires the practitioner to understand and use scientific method. However, there is great debate over the use of certain methods of testing efficacy when applied to potentially complex interventions such as acupuncture.

Neurophysiological mechanisms of the technique

Neurophysiology of acupuncture needling

The therapeutic effects of acupuncture needling are mediated through stimulation of the peripheral nervous system, and so can be abolished by local anesthetic (Chiang et al. 1973, Dundee & Ghaly 1991). In particular, stimulation of Aδ or type III afferent nerve fibers has been implicated as the key component in producing analgesia (Chung et al. 1984). The therapeutic effects of needling can be divided into four categories based on the area influenced: local, segmental, heterosegmental and general.

Local effects

Local effects are mediated through antidromic stimulation of high threshold afferent nerves, in the same way as the 'triple response', first described by Professor Sir Thomas Lewis (Lewis 1927, Rous & Gilding 1930). Release of trophic and vasoactive neuropeptides including neuropeptide Y (NPY), calcitonin-gene-related-peptide (CGRP) and vasoactive-intestinal-peptide (VIP) has been demonstrated following acupuncture in patients with xerostomia (Dawidson et al. 1998a, 1998b). It is likely that the release of CGRP and VIP from peripheral nerves stimulated by needling results in enhanced circulation and wound healing in rats (Jansen et al. 1989a, 1989b), and equivalent sensory stimulation has proved effective in human patients (Lundeberg et al. 1988).

Increased circulation resulting from nerve stimulation is probably one of the most important local effects of acupuncture, and, in rats, it appears to be principally mediated by the release of CGRP (Sato et al. 2000). The effect of acupuncture on muscle blood flow, however, may not rely solely on nerve stimulation (Shinbara et al. 2008). Under normal circumstances in healthy human subjects, blood flow in muscle and skin is increased by needling local muscle points and less affected by needling skin (Sandberg et al. 2003). But this situation may be reversed if the subject is very sensitive, for example, in patients with fibromyalgia (Sandberg et al. 2004). The increase in muscle and skin blood flow following local needling of muscle in patients with work-related trapezius myalgia appears to be lower than in healthy subjects and this may reflect the degree of sympathetic activation and hypersensitivity of these patients (Sandberg et al. 2005).

Segmental effects

Through stimulation of high threshold ergoreceptors in muscle, needling can have a profound influence on sensory modulation within the dorsal horn at the relevant segmental level. C fiber pain transmission is inhibited via enkephalinergic interneurones in lamina II, the substantia gelatinosa. Bowsher (1998) reviews the basic science literature, which supports this mechanism, and White (1999) appraises experimental and clinical evidence. Segmental stimulation appears to have a more powerful effect than an equivalent stimulus from a distant segment in modulating pain (Chapman et al.1977, Lundeberg et al.1989, Zhao 2008), local autonomic activity (Sato et al. 1993) and itch (Lundeberg et al. 1987). Aδ or type III afferent nerve fibers can be stimulated by superficial needling as well as by needling deeper tissues, but it seems that segmental stimuli from the latter (usually muscle) have a more powerful effect (Lundeberg et al. 1987, 1989, Ceccherelli et al. 1998, Zhao 2008).

When treating somatic pain, including muscle pain, in the clinical setting it is difficult to differentiate between local and segmental effects of treatment, since local needling can mediate both effects. Segmental effects are easier to illustrate when local needling is not possible, e.g. in visceral complaints. Segmental electro-acupuncture under the name percutaneous tibial nerve stimulation has been shown to affect bladder function in patients with overactive bladder symptoms (Van Balken et al. 2001, 2003, Macdiarmid et al. 2010, Peters et al. 2010).

Visceral blood flow following acupuncture has also been studied, and whilst segmental effects appear to dominate (Stener-Victorin et al. 1996, 2003, 2004, 2006), non-segmental mechanisms are also apparent (Uchida & Hotta 2008).

Heterosegmental effects

Whilst segmental stimulation appears to be the more powerful effect, needling anywhere in the body can influence afferent processing throughout the spinal cord. The needle stimulus travels from the segment of origin to the ventral posterior lateral nucleus of the thalamus, and projects from there to the sensory cortex. Collaterals in the midbrain synapse in the periaqueductal grey (PAG), from where inhibitory fibers descend, via the nucleus raphe magnus, to influence afferent processing in the dorsal horn at every level of the spinal cord. Serotonin is the prominent neurotransmitter in the caudal stages of this descending pain pathway, and the fibers synapse with the enkephalinergic interneurones in lamina II. A second descending system from the PAG travels via the nucleus raphe gigantocellularis; its fibers are noradrenergic, and their influence is mediated directly on lamina II cells, rather than via enkephalinergic interneurones. Diffuse noxious inhibitory control (DNIC) is the term introduced by Le Bars et al. to define a third analgesic system, which is induced by a noxious stimulus anywhere in the body (Le Bars et al. 1979). Heterosegmental needling exerts influence through all three mechanisms to different degrees (Bowsher 1998, White 1999), and possibly through others, as yet undefined.

General effects

These are more difficult to define, and there is clearly some overlap with heterosegmental effects. The latter term is used here to denote effects mediated at every segment of the spinal cord, as opposed to effects mediated by humeral means or by influence on higher centers in the CNS controlling general responses. Acupuncture needling has proven efficacy in the treatment of nausea and vomiting (Lee & Done 2004, Lee & Fan 2009, Vickers 1996), and this effect is likely to be mediated centrally. There is a substantial body of work that indicates the importance of β-endorphin and other endogenous opioids in acupuncture analgesia (Han & Terenius 1982, Han 2004, 2010, Zhao 2008), and correlations have been identified between the endorphin releasing effect of acupuncture and that of prolonged exercise (Thoren et al. 1990). Further correlations in terms of neuropeptide release have been noted (Bucinskaite et al. 1996), and it has been suggested that chronic activation of opioid systems by exercise, or potentially by acupuncture, may mediate enhanced immunity, with decreased upper respiratory infections and protection against some forms of cancer (Jonsdottir 1999).

Functional magnetic resonance imaging (fMRI) studies indicate general effects on limbic structures (Hui et al. 2000), and indicate the importance of the nature of the needle stimulus in achieving this effect (Hui et al. 2007, 2009, 2010). Such effects may be important in pain as well as other conditions that affect general wellbeing.

Whilst target-directed expectation (Benedetti et al. 1999) may theoretically play a role in the mechanism of acupuncture under some circumstances, the effects of acupuncture do not appear to be explained entirely by expectation (Kong et al., 2009b, 2009a). In clinical practice, context driven effects are considered important (Finniss et al. 2010), but in this environment it is challenging to untangle the direct effects of acupuncture needling on central nervous system structures from the indirect effects related to the context of treatment.

Trigger point needling

The mechanism of action of direct needling in the deactivation of trigger points is undetermined. Despite the fact that a causal relationship has not been established between direct needling of trigger points and improvement in symptoms, a discussion of the potential mechanisms involved may still be useful in developing future research questions. Simons et al. (1999) commented on the results of two trials which compare direct dry and direct wet needling of trigger points (Skootsky et al. 1989, Hong 1994) and conclude that the critical therapeutic factor in both techniques is mechanical disruption by the needle. The common factor is certainly needle insertion into the trigger point; however, Hong (1994) highlighted the importance of stimulating a local twitch response in achieving an immediate effect and with Simons cites evidence that the local twitch response is mediated by a segmental spinal reflex (Hong & Simons 1998). Fine et al. (1988) performed a rigorous experimental study in which trigger points were subject to direct wet needling, and clearly demonstrated that an opioid mechanism was involved in trigger point pain relief. In light of this evidence it seems likely that the needle works more often through sensory stimulation than through mechanical disruption, and this would be consistent with the mechanism of action of acupuncture analgesia (Han & Terenius 1982, Han 2004, 2010, Zhao 2008). Having said that, techniques vary considerably, and it is possible that the more vigorous and fast insertion trigger point needling has a direct mechanical effect on endplates, muscle spindles, or fibers themselves (see Chapter 2 for physiological mechanisms of trigger point dry needling).

Clinical research

Methodological difficulties of clinical acupuncture research

The principal methodological difficulties in clinical trials that study the efficacy of acupuncture are concerned with controls and blinding (Lewith & Vincent 1998, White et al. 2001b). For a placebo control to be credible the subjects receiving it must believe that they have had an active treatment, identical to, or at least equivalent in potency to, the active intervention. Ideally, for any needling therapy, the control should involve an inactive form of needling, but it seems clear that a needle placed anywhere in the body is likely to have some neurophysiological effect (Lewith & Machin 1983), perhaps as a result of the noxious stimulus (Le Bars et al. 1979) of a needle piercing skin, or perhaps related to context-driven and interactional effects including target-directed expectation (Benedetti et al. 1999) and complex conditioned responses (Lundeberg & Lund 2008).

An innovation in needle design (Streitberger & Kleinhenz 1998, Kleinhenz et al. 1999) appeared at first to overcome the problem of needle penetration of skin by using a blunt needle that slid up into the coiled metal of the handle. This device was credible to the subject, but in order to simulate needle retention in the body it needed to be attached to the skin. This was done by inserting it through an adhesive plaster dressing over a small plastic ring placed over the point. In practice, however, the blunt needles pushed with enough force to get through the plaster also occasionally penetrated the skin surface (Konrad Streitberger: personal communication 2001). The Park Sham Device, which consists of a plastic guide tube of adjustable height with a sticky base, was developed as an alternative method of holding the sham needle in place (Park et al. 2002), but the subject could be unmasked if a needle fell out of the device. A convincing control procedure should result in blinding of the subject, but it is almost impossible to blind an experienced therapist who is performing both real and sham needling techniques. A common way of reducing bias in this situation is to use a blind assessor. A non-penetrating needle device that blinds the practitioner as well as the subject has been developed and validated (Takakura & Yajima 2007, 2008); however, it seems that simple non-penetrating sham acupuncture procedures, such as blunted cocktail sticks tapped on the skin, can be highly effective in clinical trials (Cherkin et al. 2009), and so the measured efficacy of true acupuncture over sham techniques in clinical trials is often small and not statistically significant.

Evidence for acupuncture needling in chronic pain conditions

Chronic low back pain

A Cochrane review on acupuncture and dry needling for low back pain, which included 35 randomized controlled trials (RCTs), concluded that (Furlan et al. 2005):

> *for chronic low back pain, acupuncture is more effective for pain relief and functional improvement than no treatment or sham treatment immediately after treatment and in the short term only.*

A systematic review published in the same year also found acupuncture to be significantly more effective than sham acupuncture in chronic low back pain (Manheimer et al. 2005). More recent systematic reviews have not included meta-analysis. The Cochrane review (including meta-analysis) is being updated and the pooled results are not expected to change substantially (Andrea Furlan: personal communication 2010).

In the UK, guidelines of the National Institute for Health and Clinical Excellence (NICE) for early management of persistent non-specific low back pain between 6 months and 1 year, include consideration of 12 sessions of acupuncture over 3 months (NICE Guideline CG88 2009).

Chronic headache

The first Cochrane review on acupuncture for idiopathic chronic headache was tentatively positive (Melchart et al. 2001), but criticized for including trials on both migraine prophylaxis and chronic tension type headache. In 2009 the Cochrane review was updated and split into acupuncture for migraine prophylaxis (Linde et al. 2009a), and acupuncture for tension-type headache (Linde et al. 2009b). The authors' conclusions are as follows:

Acupuncture for migraine prophylaxis

> *In the previous version of this review, evidence in support of acupuncture for migraine prophylaxis was considered promising but insufficient. Now, with 12 additional clinical trials, there is consistent evidence that acupuncture provides additional benefit to treatment of acute migraine attacks only or to routine care. There is no evidence for an effect of 'true' acupuncture over sham interventions, though this is difficult to interpret, as exact point location could be of limited importance. Available studies suggest that acupuncture is at least as effective as, or possibly more effective than, prophylactic drug treatment, and has fewer adverse effects. Acupuncture should be considered a treatment option for patients willing to undergo this treatment.*
>
> (Linde et al. 2009a)

Acupuncture for tension-type headache

> *In the previous version of this review, evidence in support of acupuncture for tension-type headache was considered insufficient. Now, with six additional trials, the authors conclude that acupuncture could be a valuable non-pharmacological tool in patients with frequent episodic or chronic tension-type headaches.*
>
> (Linde et al. 2009b)

Osteoarthritis (OA)

A systematic review included 13 RCTs (White et al, 2007). The results from the five high quality trials (n=1334) were pooled in meta-analysis for the primary outcome, and demonstrated a significant effect of acupuncture versus sham in short-term pain. A subsequent review found very similar results in their meta-analysis (Manheimer et al. 2007), although their interpretation of the clinical relevance of the results differed entirely. The recent Cochrane review of acupuncture for peripheral joint OA (Manheimer et al. 2010) included 16 trials and 3498 participants. Twelve trials were on OA knee; three on OA hip, and one included both. The authors concluded:

> *Sham-controlled trials show statistically significant benefits; however, these benefits are small, do not meet our pre-defined thresholds for clinical relevance, and are probably due at least partially to placebo effects from incomplete blinding. Waiting list-controlled trials of acupuncture for peripheral joint osteoarthritis suggest statistically significant and clinically relevant benefits, much of which may be due to expectation or placebo effects.*

White & Cummings (2009) argued that you only test the biological plausibility of acupuncture against sham acupuncture, not its clinical relevance.

Shoulder pain

The Cochrane review on acupuncture for shoulder pain in 2005 was inconclusive but suggested that there may be a short-term benefit on pain and function (Green et al. 2005). Since then there have been two interesting trials. Vas et al. (2008) demonstrated the advantage of manual acupuncture to a single point (ST38) versus sham (mock TENS) along with physical therapy rehabilitation for shoulder pain in 425 subjects. The GRASP trial (German Randomized Acupuncture trial for chronic Shoulder Pain) tested acupuncture against a distant superficial off-point sham and conventional orthopedic care in 424 subjects with chronic shoulder pain (Molsberger et al. 2010). Acupuncture proved to be superior to sham and conventional orthopedic care, although the drop-out rate in the sham group was rather high at 45%.

Evidence for needling in myofascial pain

A systematic review published in 2001 of 23 RCTs conclusively shows, when treating myofascial pain with TrP injection, that the nature of the injected substance makes no difference to the outcome, and that there is no therapeutic benefit in wet over dry needling (Cummings & White 2001). These conclusions were supported by all the high quality trials in the review. The review did not find any rigorous evidence that needling therapies have a specific effect in myofascial pain, as authors (Cummings & White 2001) concluded:

> *The hypothesis that needling therapies have specific efficacy in the treatment of myofascial pain is not supported by the research to date, but this review suggests that any effect derived from these therapies is likely to be derived from the needle, rather than from either, an injection of liquid in general, or any substance in particular. All groups in the review in whom trigger points were directly needled showed marked improvement in their symptoms; therefore further research is urgently needed to establish the specific effect of trigger point needling, with emphasis on the use of an adequate control for the needle.*

This review has not been formally updated, but from the author's knowledge of the literature published since 2001, there would be no substantial change to the conclusions. A further review with meta-analysis including only trials of dry needling was inconclusive, although the results were compatible with a treatment effect of dry needling on myofascial TrP pain (Tough et al. 2009).

Clinical application of the technique

Safety aspects

Acupuncture involves the insertion of, usually stainless steel, needles into the body. Whilst it is often perceived by the general public as 'natural' and 'safe', along with many complementary therapies, it is neither natural nor completely safe. As with any needling therapy the serious risks are associated with the transmission of blood-borne infection, and direct trauma. Rampes and Peuker categorize adverse events associated with acupuncture as follows (Rampes & Peuker, 1999): (1) delayed or missed diagnosis; (2) deterioration of disorder under treatment; (3) pain; (4) vegetative reactions; (5) viral or bacterial infections; (6) trauma of tissues and organs; and, (7) miscellaneous.

If acupuncture is performed as a therapy by a regulated healthcare professional within his or her sphere of competence, the first two categories will be avoided.

Persistent pain attributed to acupuncture treatment is rare, but temporary exacerbation of the presenting complaint for a day or so is common (MacPherson et al. 2001a, 2001b, White et al. 2001a). Pain lasting up to 180 days after needling has been reported in a prospective study of over 2 million treatment sessions, and this was apparently due to nerve damage (Witt et al. 2009). The author has heard verbal reports of persistent neuropathic pain around needle insertion points after acupuncture; however, these events are likely to be very rare since filiform acupuncture needles do not have a cutting edge. Whilst in the past, nerves were directly targeted at some acupuncture points; contemporary practice in the West tends to avoid direct needling of nerves (White et al. 2008b).

Vegetative reactions include syncope and sedation. Syncope can be largely avoided by treating patients lying on an examination couch; however, very occasionally a profound sinus bradycardia will result in loss of consciousness of a patient who is lying down. Sedation is relatively common, and occurs in perhaps 20% of patients after their first two treatments. In maybe 5% of patients there is always some degree of sedation associated with acupuncture treatment. Sedation is rarely seen as an adverse event by the patients, and is only of concern in terms of driving home or operating machinery after treatment.

Infections associated with acupuncture treatment are rare but can be serious (White 2004). Worldwide, hepatitis B would be the most common infection related to acupuncture, but this is now very rare in the West as a result of the use of sterile disposable needles and clean techniques.

Traumatic complications of acupuncture needling are avoidable, and on occasion they have been fatal. The most frequent of the serious traumatic adverse effects is pneumothorax, which is estimated (from prospective studies) to occur between 1:200 000 (White 2004) and 1:1 000 000 (Witt et al. 2009) treatment sessions. The drawback with these estimates is that they include all acupuncture sessions, and not just those where there has been needling over the thorax.

Point selection

The two main themes in Western medical acupuncture are dry needling of TrPs and segmental acupuncture. The latter is defined as the technique of needling an area of the soma innervated by the same spinal segment as the disordered structure under treatment (Filshie & Cummings 1999). Based on neurophysiological and clinical evidence (Chapman et al. 1977, Lundeberg et al. 1987, 1989, Sato et al. 1993, Bowsher 1998, Ceccherelli et al. 1998, White 1999), the main principle in point selection is to stimulate the soma as close as is practical to the seat of the pathology, or at least within the same segment. Local TrPs, tender points or acupuncture points are chosen, and often these will overlap so that the key point to stimulate is a TrP, which is tender by definition, at the site of an acupuncture point. The Figures in this chapter illustrate commonly used acupuncture points and TrPs represented by body region. If the key element of the somatic pathology is a myofascial TrP, this is arguably the only point that it is necessary to treat. In most other cases the analgesia afforded by local needling may be enhanced by using one or more points at a distance from the pathology, in addition to the relevant local points. Distant points are chosen because they stimulate the appropriate segment, or because they are conveniently located and known to generate strong needling sensation (heterosegmental acupuncture). In individual cases, point selection may be modified by the need to avoid local conditions, e.g. skin infection, ulceration, moles and tumors, varicosities; or to avoid regional conditions such as hydrostatic edema, lymphedema, anesthetic or hyperesthetic areas, or ischemia. As a general rule, therapeutic needling should be performed in healthy tissue.

Needle technique

Sterile, single-use, disposable needles should always be used. In most cases acupuncture needling involves stimulation of muscle tissue. Needling of muscle and possibly fascial planes between muscle tissue produces a characteristic sensation, often described as a dull, diffuse ache, pressure, swelling or numbness, which can be referred some distance from the point of stimulation. Needling of other tissues of the soma, such as skin, ligament, tendon, periosteum, and the fascial covering of muscle, produces relatively localized and often sharp sensations; although there appear to be differences with age, particularly with periosteal needling. If the aim is to stimulate a point in muscle, a rapid insertion through the skin and superficial layers minimizes discomfort for the patient. Practitioners who are learning the technique find that the use of an introducer facilitates a rapid, often painless insertion. If an introducer is not used, the practitioner will stretch the skin over the point during insertion. Once through the skin, the needle should be rapidly advanced to the desired position or muscle layer, and is then stimulated by rotation back and forth combined with a varying degree of 'lift and thrust' (slight withdrawal and reinsertion) until the desired sensation is achieved. If constant stimulation of the needle is required, an electrical stimulator can be used. For the latter technique, usually a minimum of two needles are inserted, and a specially designed electro-acupuncture device is used to deliver the electrical stimulus.

Dry needling of TrPs involves a very similar procedure, although the practitioner will often lift and thrust the needle to a greater degree and with a variation in needle direction, aiming to hit the TrP precisely. When the needle directly impinges on the TrP, a local twitch is often seen or felt in the associated band of muscle, and the symptoms derived from that point are reproduced.

In clinical practice a wide variety of needling techniques have been described. These range from superficial needling to periosteal needling, with a variety of intermediate depths in muscle. Superficial needling of acupuncture points is common in Japanese forms of acupuncture, and Baldry (2005) described a superficial needling technique exclusively over TrPs

(Ch. 12). Periosteal needling was first described by Mann (1998), although he, as most Western practitioners who came after him, uses a variety of techniques (Mann 2000). As suggested above, muscle is the most common site of stimulation. Depth and strength of needling in this tissue ranges from brief, superficial stimulation of the muscle surface to deep, repetitive intramuscular stimulation. The latter is not uncommon in Chinese acupuncture, but is also promoted by some practitioners in the West, in particular by Gunn (1989, 1998), who targets motor points and paraspinal muscles (Ch. 14).

Clinical aspects

There is a range of different responses to acupuncture treatment, from no effect, in 5% or 10% of the population, at one end, to profound analgesia and improved well-being, in a similar proportion, at the other end. Empirical observation suggests that about 70% of the population have a useful response. Patient selection will clearly influence success, and a healthy patient with a short-lived myofascial pain syndrome is much more likely to have a beneficial outcome than a debilitated patient with a chronic, ill-defined and complex problem.

It is difficult to define a 'dose' for acupuncture treatment (White et al. 2008a), because on many occasions a judicious single needle insertion may have the same effect as 10 or more needles left in place for 20 minutes; and similar strength, sequential treatments often have increasing potency in the early stages of a course of treatment. Experimental work does appear to support a type of dose-response relationship for sensory stimulation (Lundeberg, personal communication 1997), but it is unlikely to be linear. There is probably a stepwise increase in potency down the following list:

1. Superficial, heterosegmental needling with minimal sensation.
2. Superficial, segmental needling with minimal sensation.
3. Deep, heterosegmental needling with strong sensation.
4. Deep, segmental needling with strong sensation.
5. Deep, segmental needling with electrical stimulation sufficient to cause muscle contraction.

Whilst acupuncture is likely to do more than simply offer pain relief, the standard pattern of effect from treatment is most easily appreciated in terms of analgesia. There may be little or no effect after the first session, as the practitioner will usually start with gentle treatment. This is to avoid aggravating the complaint in those most sensitive to needling. The initial response is seen within the first 72 hours after treatment, and its onset is often not perceived until the day after needling. Repeat treatments are performed either bi-weekly or weekly, and the interval can be lengthened with the response. Typically there is a progressive increase in the quality and duration of the effect following repeated sessions, and in chronic pain states, symptom control can be maintained for some patients with relatively infrequent treatments, perhaps every 4–6 weeks.

Prognosis

As there is limited evidence from controlled trials of the specific efficacy of needling techniques, simple audit and experience of practitioners must often be called upon as a guide in clinical practice. Myofascial pain syndromes appear to respond very well to direct needling of the relevant TrPs, with a successful outcome reported in 90% or more of cases (Cummings 1996) in a military primary care population. Musculoskeletal pain in general is helped by acupuncture in 70% of cases, but in some of the more difficult enthesopathies, response rates may be only 40–60%; and in many such cases adequate advice and rehabilitation is as important as the symptomatic treatment mediated through the needle. In chronic pain conditions with or without elements of myofascial pain we now have evidence form very large cohort studies to guide prognosis in clinical practice, and in general we see that about 50% of subjects improve to a substantial degree, e.g. a 50% reduction in headache frequency (Cummings, 2009).

Summary

Needling therapies have been applied to the treatment of pain for thousands of years, and the techniques used today probably do not differ dramatically from those applied to Ötzi in 3200 BC. Empirical evidence suggests that direct needling of TrPs is probably the most valuable needling technique, but definitive research to establish the specific action of the needle is still sought. All practitioners who treat musculoskeletal dysfunction would find the technique of needling TrPs or local acupuncture points useful, but adequate knowledge of anatomy and infection control procedures is essential (Ch. 4).

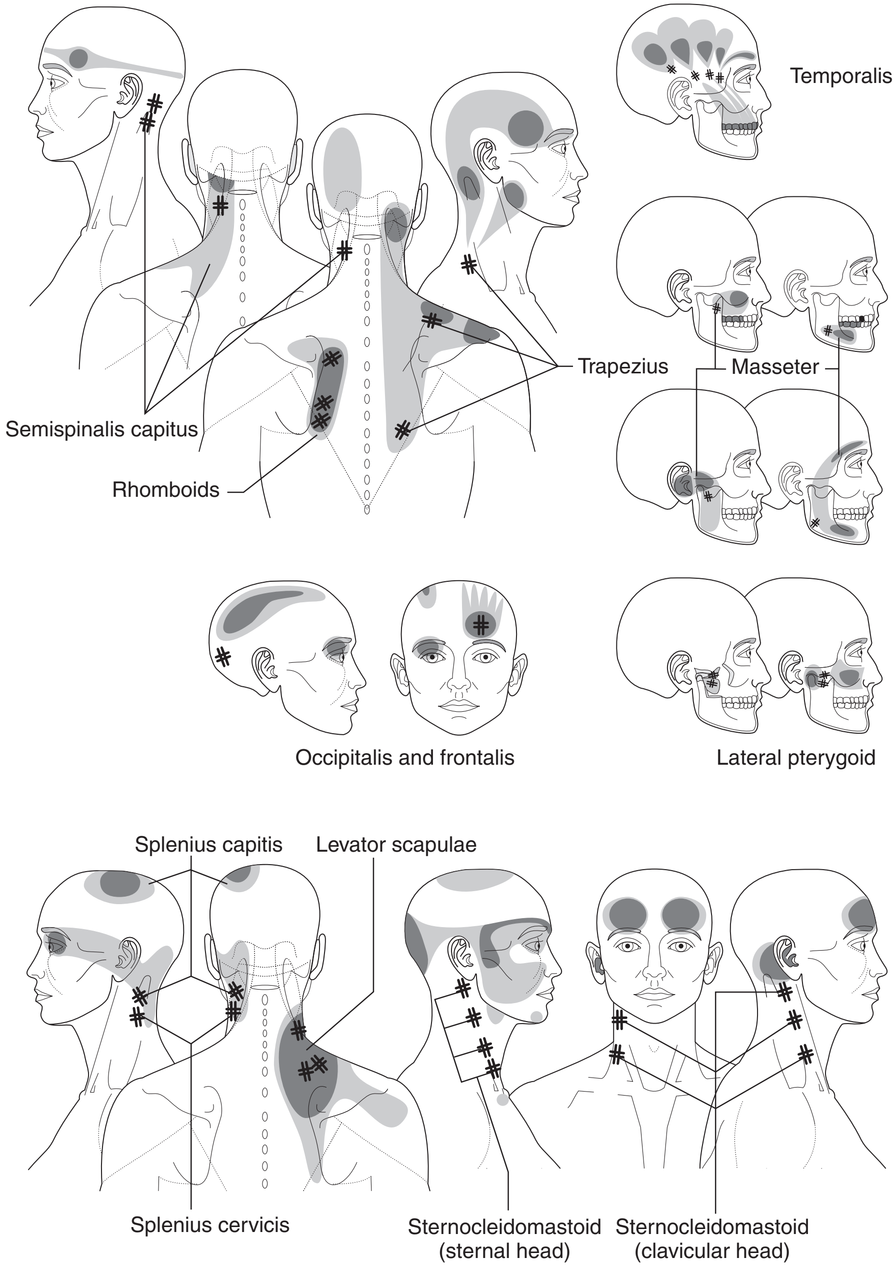

Figure 13.1 • Head, face and neck: myofascial TrPs and pain reference zones. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

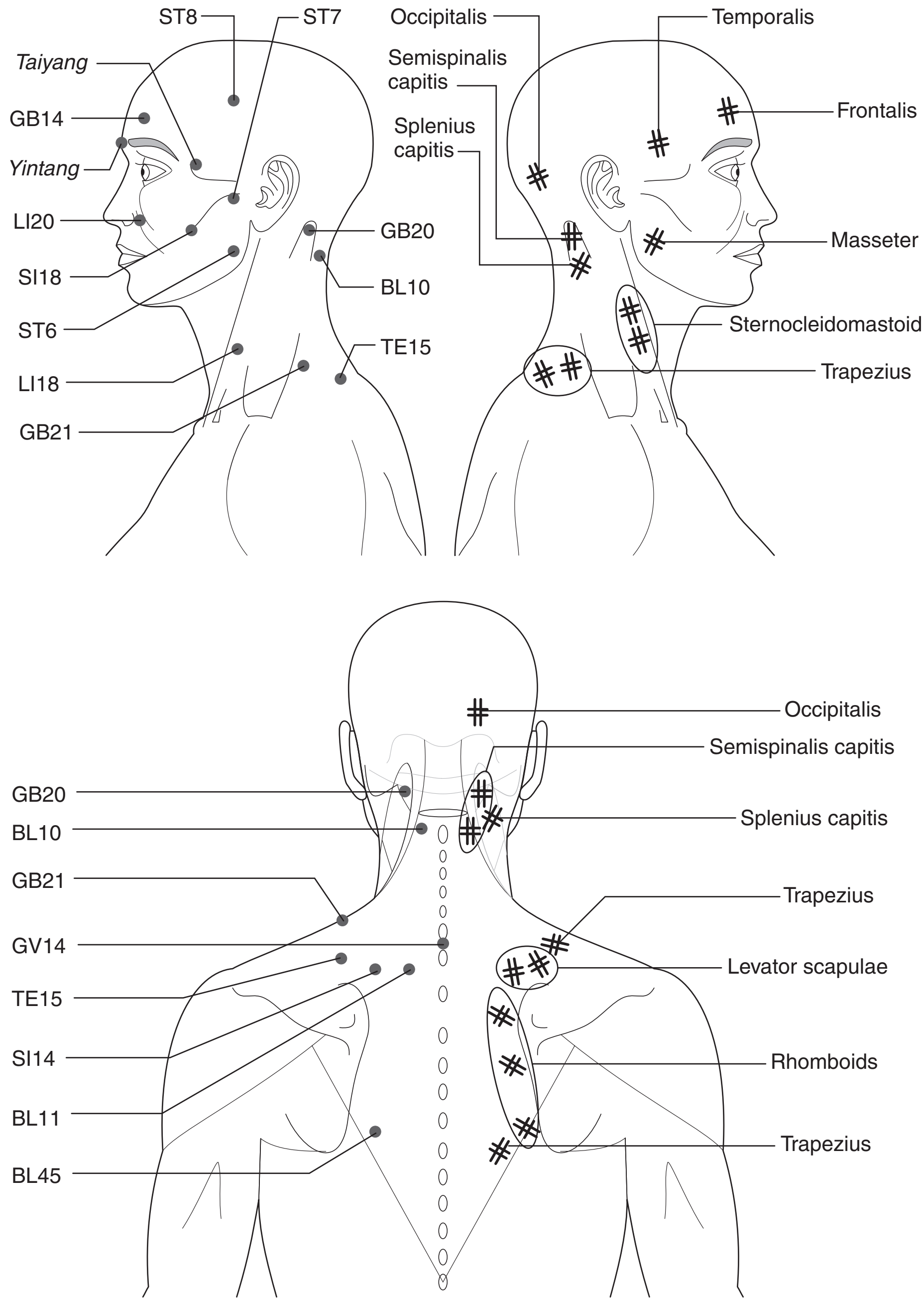

Figure 13.2 • Head, face and neck: classical acupuncture points and TrPs. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

Table 13.1 Face, head and neck

Face		
Yintang	Midpoint between the eyebrows **Angulation:** oblique inferior **Target:** procerus or periosteum Headache, hayfever, relaxation	D Vi M VII S Vi
Taiyang	1 *cun* posterior to the midpoint between the lateral end of the eyebrow and the lateral canthus of the eye **Angulation:** perpendicular **Target:** temporalis *Headache, eye symptoms*	D Vii M Viii S Vii
GB14	1 *cun* above the middle of the eyebrow, directly above the pupil when the eyes are looking straight ahead **Angulation:** oblique inferio **Target:** frontalis *Headache, eye symptoms*	D Vi M VII S Vi
LI 20	In the nasolabial groove, level with the widest part of the ala nasi **Angulation:** superiorly along groove **Target:** facial muscles *Hayfever, nasal symptoms*	D Vii M VII S Vii
ST6	1 fingerbreadth anterior and superior to the angle of the jaw, on the prominence of masseter **Angulation:** perpendicular **Target:** masseter *Dental pain, facial pain*	D C2/C3 M Viii S Viii
ST7	In the depression anterior to the temporomandibular joint and below the zygomatic arch **Angulation:** perpendicular **Target:** lateral pterygoid *Dental pain, facial pain*	D Viii M Viii S Viii
ST8	0.5 *cun* superior to the upper line of origin of the temporalis muscle, directly above ST7 and ST6 on a vertical line 0.5 cun posterior to Taiyang **Angulation:** perpendicular **Target:** epicranial tissues *Headache*	D Vi/Vii M Viii/VII S Vi/Vii
SI18	Directly below the lateral canthus of the eye in the depression at the lower border of the zygomatic bone, just anterior to the attachment of masseter **Angulation:** slightly superior **Target:** connective tissue space *Facial pain, trigeminal neuralgia*	D Vii M Viii S Vii
LI18	Between the sternal and clavicular heads of sternocleidomastoid (SCM), level with the laryngeal prominence (the tip of the Adam's apple) **Angulation:** posterior **Target:** fascial plane in SCM *Pain from sternocleidomastoid – headache or facial pain* **CAUTION: note the proximity of the carotid artery**	D C2/C3 M XI/C2/C3 S n/a

D= dermatome; M = myotome; S = sclerotome; V = trigeminal nerve; i = ophthalmic; ii = maxillary; iii = mandibular divisions; VII = facial nerve; XI = accessory nerve; n/a = not applicable.

Head and neck		
GB20	Below the occipital bone, in the depression between trapezius and sternomastoid and above splenius capitis **Angulation:** towards opposite eyebrow **Target:** semispinalis capitis *Headache, neck pain and stiffness* **CAUTION: note the position of the vertebral artery**	D C2/C3 M C1/C2 S C1/C2
BL10	1.3 *cun* lateral to the spinous process of C2, between C1 and C2 **Angulation:** towards lamina of C2 **Target:** obliquus inferior *Neck pain and stiffness* **CAUTION: note the position and depth of the spinal cord and vertebral artery**	D C3 M C1 to C5 S C2/C3
GB21	Midway between GV14 and tip of the acromion at the highest point of trapezius **Angulation:** tangential to ribs, posteriorly **Target:** upper trapezius Headache, neck pain and stiffness, anxiety **CAUTION: note the proximity of the pleura between the 1st and 2nd ribs**	D C3 M C3/C4S n/a
TE15	Midway between the points GB21 and SI13 at the superior angle of the Scapula (SI13 – tender depression superior to medial end of scapular spine) **Angulation:** perpendicular **Target:** trapezius *Shoulder pain, neck pain and stiffness* **CAUTION: note the proximity of the pleura in slim patients**	D C3 M C3/C4 S n/a
GV14	Between spinous processes C7 and T1 **Angulation:** transverse **Target:** interspinous ligament *Spinal neck pain, headache of cervical origin*	D C4/C5/T1 M C8 S C8
SI14	3 *cun* lateral to spinous process of T1 **Angulation:** tangential towards scapula **Target:** levator scapulae *Shoulder pain, neck pain and stiffness* **CAUTION: do not needle deeply unless confident of angulation relative to scapula**	D C3/C4 M C3/C4/C5 S C5
BL11	1.5 *cun* lateral to the lower border of the spinous process of T1 **Angulation:** oblique towards spine **Target:** rhomboid minor *Neck pain and stiffness, dyspnoea* **CAUTION: do not needle deeply unless confident of angulation relative to pleura**	D C4/T1 M C4/C5 S T1/T2
BL45	3 *cun* lateral to the lower border of the spinous process of T6 **Angulation:** oblique towards spine **Target:** iliocostalis thoracis Dorsal back pain, dyspnoea **CAUTION: do not needle deeply unless confident of angulation relative to pleura**	D T5/T6 M T6/T7 S T6/T7

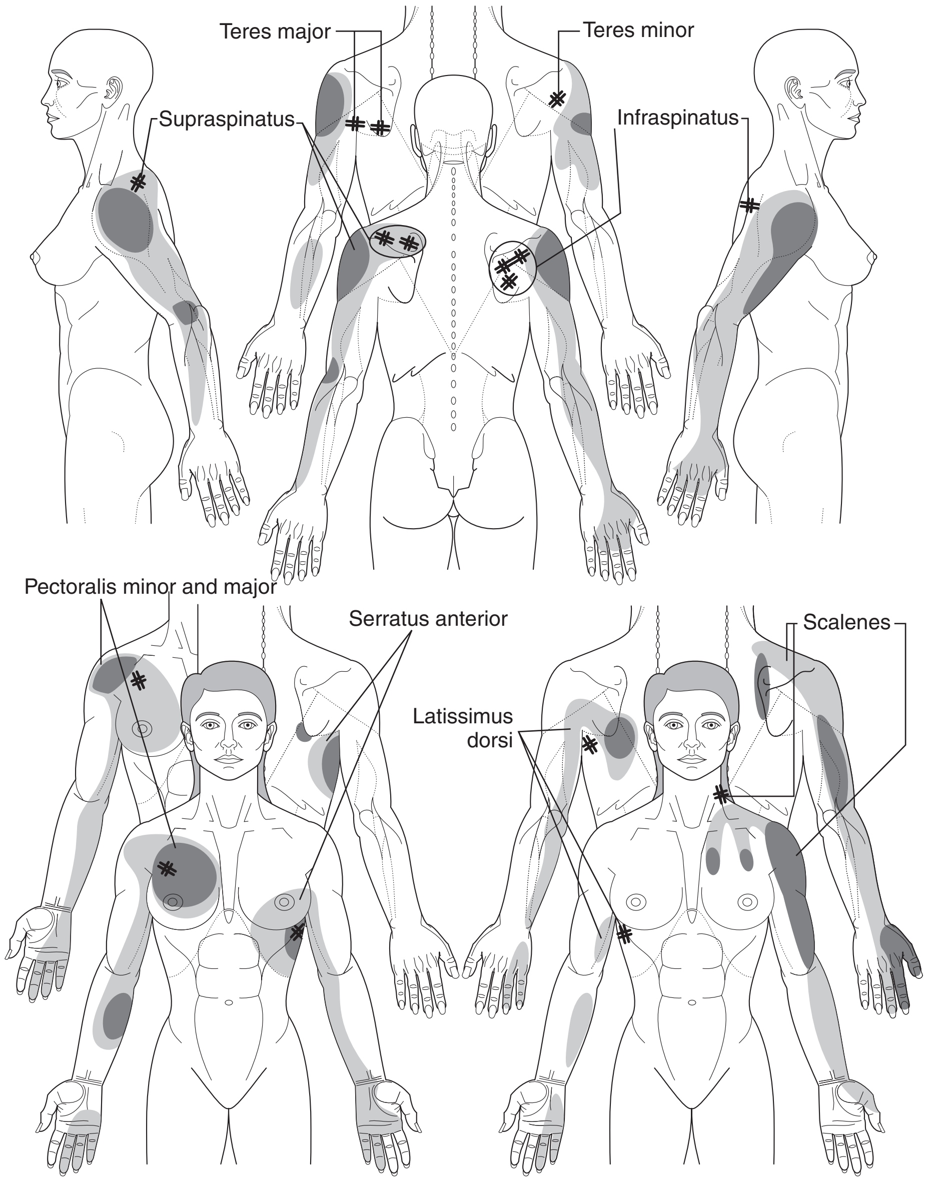

Figure 13.3 • Shoulder and arm: myofascial TrPs and pain reference zones. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

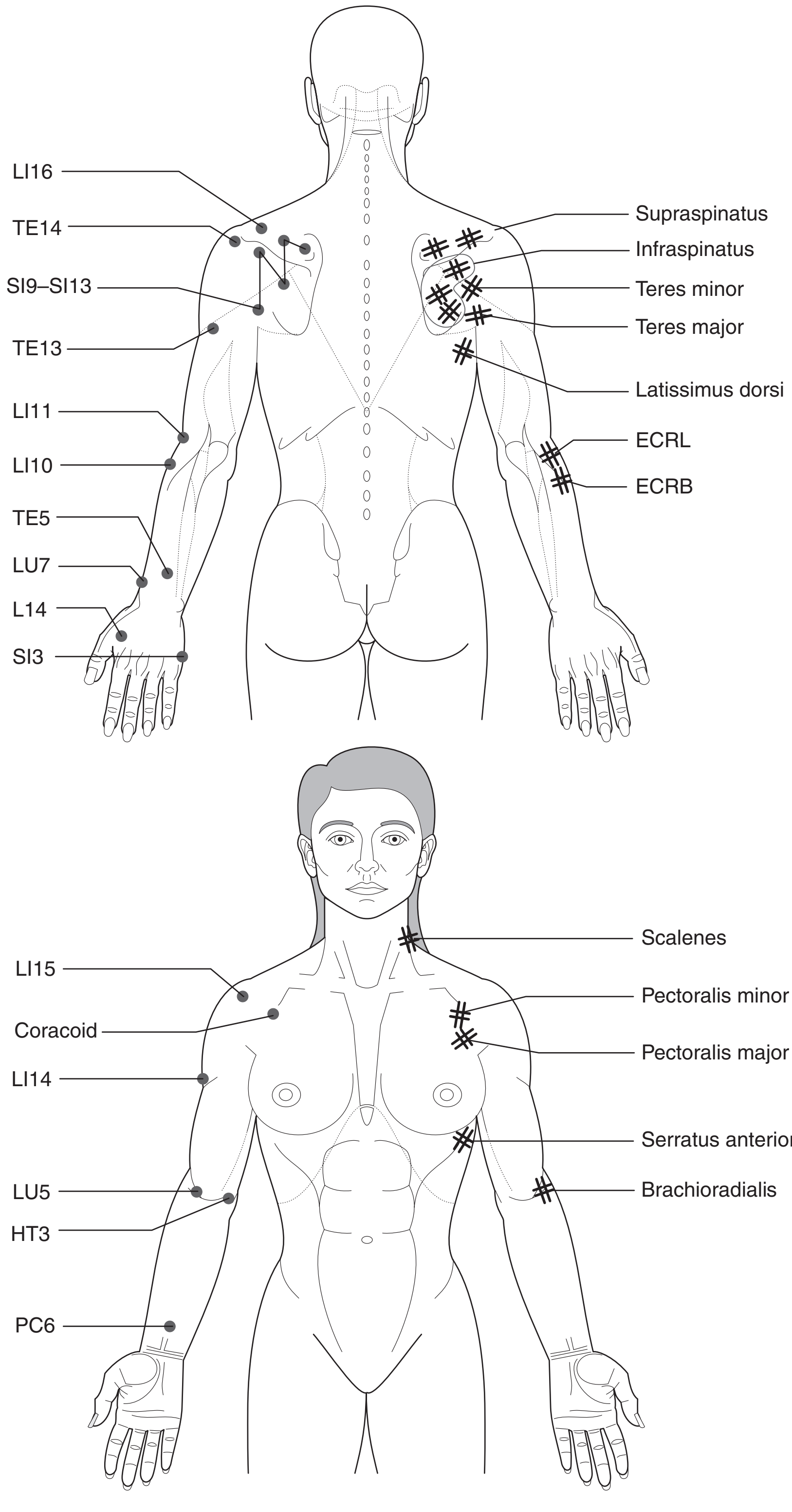

Figure 13.4 • Shoulder and arm: classical acupuncture points and TrPs. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

Table 13.2 Shoulder and arm

Posterior aspect		
LI16	In the depression medial to the acromion and between the lateral extremities of the clavicle and scapular spine **Angulation:** perpendicular **Target:** supraspinatus *Shoulder and arm pain*	D C3 M C3 to C6 S C5/C6
TE14	Posterolateral and inferior to the posterior tip of the acromion, in the depression between the middle and posterior fibres of deltoid **Angulation:** perpendicular **Target:** infraspinatus insertion *Shoulder and arm pain*	D C3/C4 M C5/C6 S C6
SI9	1 *cun* superior to the posterior axillary crease when the arm hangs by the side of the body **Angulation:** perpendicular **Target:** teres major *Shoulder and arm pain*	D T3/T4 M C5/C6/C7 S C7
SI10	In the depression below the spine of the scapula, directly superior to the posterior axillary crease when the arm hangs by the side of the body **Angulation:** perpendicular **Target:** infraspinatus *Shoulder and arm pain*	D C3/C4 M C5/C6 S C6
SI11	⅓ down a line from the midpoint of the scapular spine to the inferior angle of the scapula **Angulation:** perpendicular **Target:** infraspinatus *Shoulder and arm pain*	D C4/T1/T2 M C5/C6 S C5/C6
SI12	Directly above SI11 in the middle of the suprascapular fossa, about 1 *cun* above the middle of the superior border of the scapular spine **Angulation:** towards suprascapular fossa **Target:** supraspinatus *Shoulder and arm pain* **CAUTION: do not needle deeply unless confident of position relative to scapula**	D C3/C4 M C3 to C6 S C5
SI13	In the tender depression superior to the medial end of the scapular spine **Angulation:** towards suprascapular fossa **Target:** supraspinatus *Shoulder and arm pain* **CAUTION: do not needle deeply unless confident of position relative to scapula**	D C4/T1 M C3 to C6 S C5
TE13	On the line connecting the olecranon and TE14, 3 cun distal to TE14 on the posterior border of deltoid, 2 cun lateral to the posterior axillary fold **Angulation:** perpendicular **Target:** lateral head of triceps *Shoulder and arm pain* **CAUTION: note the proximity of the radial nerve**	D C5 M C6/C7/C8 S C6/C7
LI11	At the radial end of the antecubital crease, halfway between the biceps tendon and the lateral epicondyle **Angulation:** perpendicular **Target:** extensor carpi radialis longus *Lateral epicondylalgia, forearm pain; immunomodulation*	D C5/C6 M C5/C6 S C6/C7
LI10	2 *cun* distal to LI11, on the line connecting LI11 with LI5 (the centre of the anatomical snuff box) **Angulation:** perpendicular **Target:** extensor carpi radialis longus or supinator *Lateral epicondylalgia, forearm pain*	D C5/C6 M C5/C6/C7 S C6/C7
TE5	On the dorsal surface of forearm, 2 *cun* proximal to wrist joint, between radius and ulna, and between extensor indicis and extensor pollicis longus **Angulation:** perpendicular **Target:** connective tissue plane *Local pain; wrist and forearm; major point for central effects*	D C6 to C8 M C7/C8 S C7/C8

D= dermatome; M = myotome; S = sclerotome; n/a = not applicable

Posterior aspect		
LU7	On the radial aspect of the radial styloid, 1.5 *cun* from the wrist crease, between the tendons of abductor pollicis longus and brachioradialis **Angulation:** proximal oblique **Target:** connective tissue space *Wrist and forearm pain*	D C6 M C7/C8 S C6
LI4	On the dorsal aspect of the hand, in the middle of the 1st web space, halfway along the second metacarpal bone **Angulation:** perpendicular **Target:** 1st dorsal interosseous *General point for pain; major point for central effects* **CAUTION – the radial artery is at the apex of the 1st web space**	D C6/C7 M T1 S n/a
SI3	On the palmar aspect of the neck of the 5th metacarpal, in the tissue plane between the metacarpal neck and the hypothenar muscles **Angulation:** perpendicular **Target:** connective tissue plane *Hand pain; also used for pain elsewhere especially spinal pain*	D C8 M T1 S C8
Anterior aspect		
LI15	Anterolateral and inferior to the anterior tip of the acromion, in the groove between the anterior and middle fibres of deltoid **Angulation:** perpendicular **Target:** supraspinatus insertion *Shoulder and arm pain*	D C4 M C5 S C5
Coracoid	Anterior to the glenohumeral joint, between the fibres of deltoid and pectoralis major **Angulation:** perpendicular **Target:** coracoid *Shoulder and arm pain*	D C4 M C5/C6 S C5
LI14	Between the distal attachment of deltoid and the long head of biceps, in a tender depression, 3/5 of the distance on a line from LI11 to LI15 **Angulation:** perpendicular **Target:** connective tissue plane *Shoulder and arm pain*	D C5/C6 M C5/C6 S C5/C6
LU5	On the cubital crease of the elbow, in the depression on the radial side of the biceps tendon **Angulation:** perpendicular **Target:** brachioradialis *Elbow or forearm pain*	D C5/C6 M C5/C6 S C5/C6
HT3	At the medial end of the antecubital crease when the elbow is fully flexed **Angulation:** perpendicular **Target:** pronator teres *Medial epicondylalgia, forearm pain* **CAUTION – note the proximity of the brachial artery**	D T1 M C5 to T1 S C7
PC6	2 *cun* proximal to the distal wrist crease, between the tendons of flexor carpi radialis and palmaris longus **Angulation:** oblique proximal **Target:** flexor digitorum superficialis *Nausea and vomiting, carpal tunnel syndrome* **CAUTION: note the position of the median nerve directly below**	D C6/C8/T1 M C7/C8 S n/a

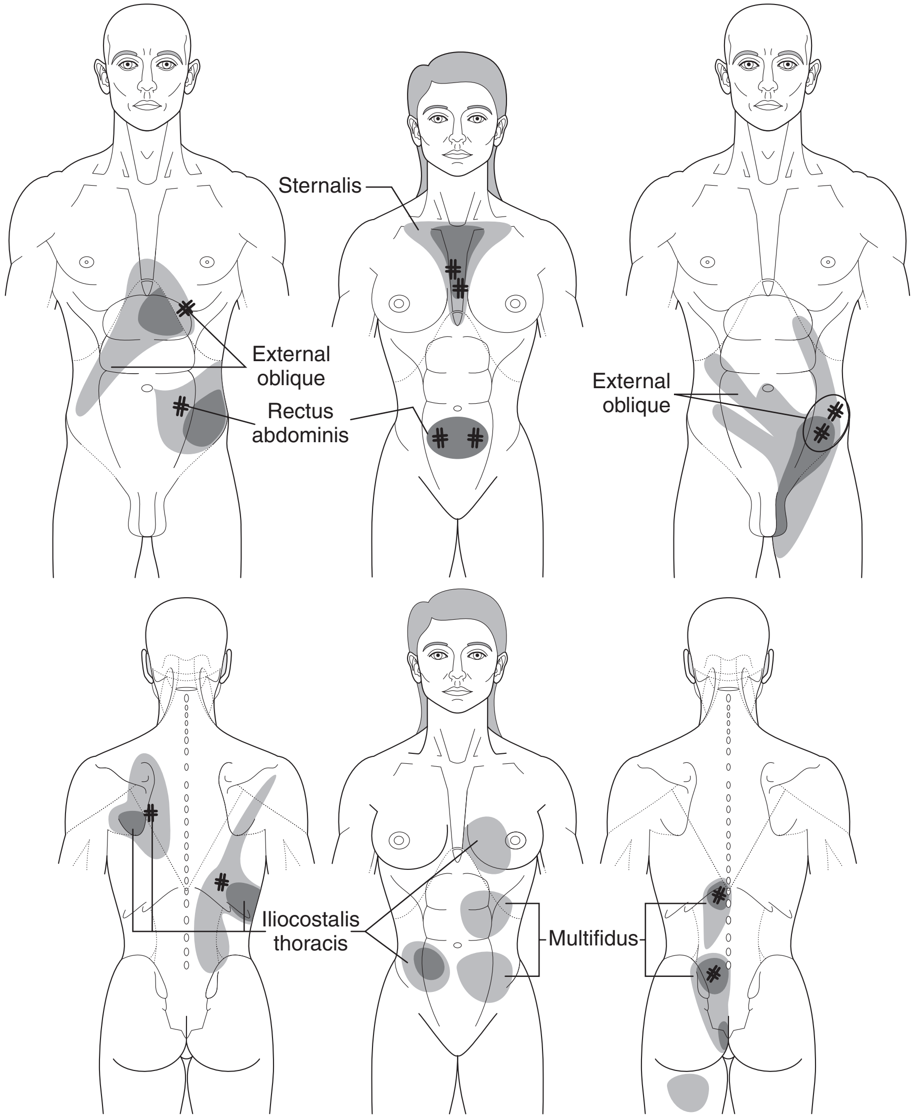

Figure 13.5 • Thorax and abdomen: myofascial TrPs and pain reference zones. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

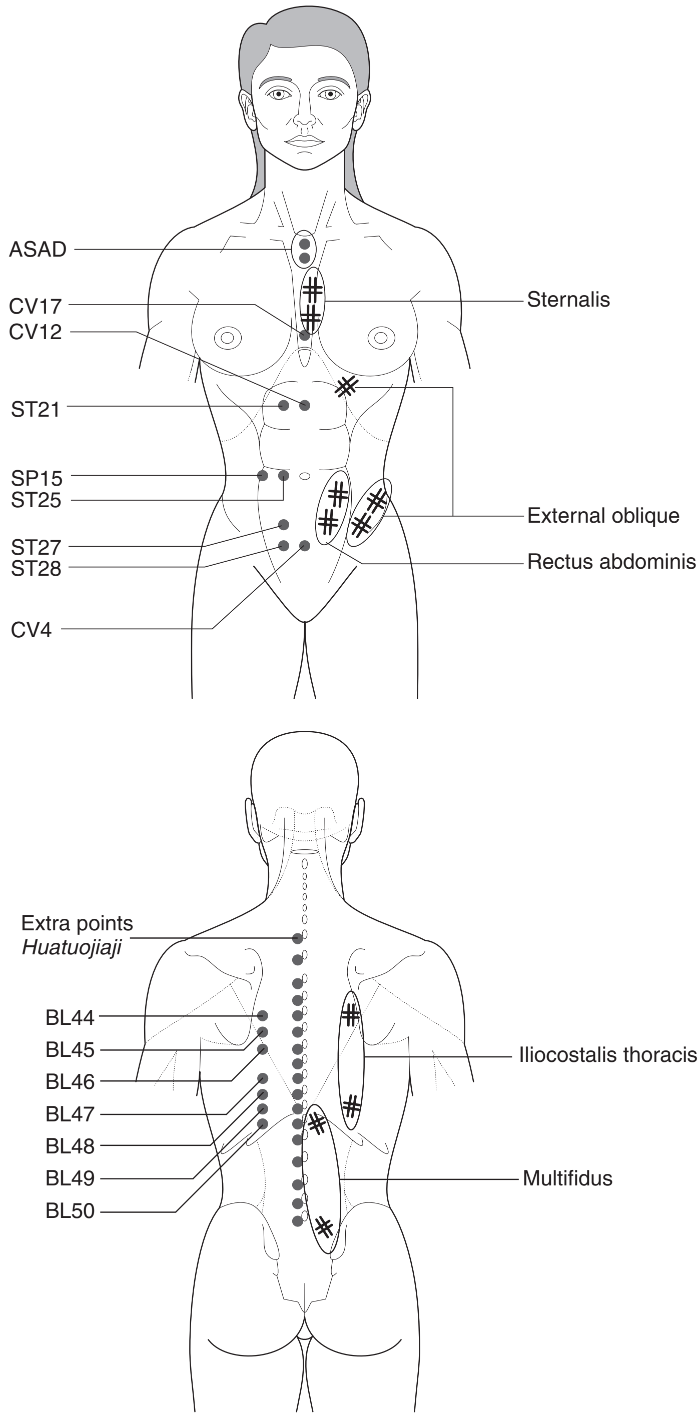

Figure 13.6 • Thorax, abdomen and spine: classical acupuncture points and TrPs. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

Table 13.3 Thorax and abdomen

Anterior aspect		
ASAD	Two points in the midline just below the sternal notch over the manubrium **Angulation:** perpendicular **Target:** periosteum of manubrium *Anxiety, sickness and dyspnoea*	D C4/T2 M C5/C6 S T1
CV17	In the center of the sternum at the 4th intercostal space (level with nipples in a man) **Angulation:** cranial oblique at 30 degrees to the sternum **Target:** periosteum of the sternum or sternalis *Chest pain; respiratory conditions* **CAUTION: a sternal foramen occurs at this point in 10% of men and 4% of women; never needle perpendicularly**	D T5 M C8, T1 S T1
CV12	On the midline of the upper abdomen, midway between the umbilicus and the lower border of the body of the sternum **Angulation:** perpendicular **Target:** linea alba *Upper gastrointestinal disorders, including nausea and vomiting* **CAUTION: avoid needling through the abdominal wall**	D T8 M T8 S n/a
CV4	On the midline of the lower abdomen, 3 *cun* inferior to the umbilicus, and 2 *cun* superior to the pubic symphysis **Angulation:** perpendicular **Target:** linea alba Lower *gastrointestinal, urological and gynaecological symptoms* **CAUTION: avoid needling through the abdominal wall**	D T11/T12 M T11/T12 S n/a
SP15	At the lateral border of rectus abdominis level with the umbilicus **Angulation:** perpendicular **Target:** linea semilunaris *Abdominal pain* **CAUTION: avoid needling through the abdominal wall**	D T10/T11 M T10/T11 S n/a
Kidney and Stomach meridians run parallel with CV with points over the abdomen at most segments – any tender point can be treated.		
ST21	2 *cun* lateral to CV12 **Angulation:** medial oblique (non-classical) **Target:** rectus abdominis *Upper abdominal pain; gastroenterological symptoms* **CAUTION: avoid needling through the abdominal wall**	D T7/T8 M T7/T8 S n/a
ST25	2 *cun* lateral to the umbilicus, halfway between the umbilicus and the linea semilunaris (SP15) **Angulation:** perpendicular **Target:** rectus abdominis *Abdominal pain; gastroenterological symptoms* **CAUTION: avoid needling through the abdominal wall**	D T10 M T10 S n/a
ST27	2 *cun* lateral to the midline and 2 *cun* inferior to the umbilicus **Angulation:** medial oblique (non-classical) **Target:** rectus abdominis *Abdominal pain; lower gastrointestinal, urological and gynaecological symptoms* **CAUTION – avoid needling through the abdominal wall**	D T11/T12 M T11/T12 S n/a
ST28	2 *cun* lateral to the midline and 3 *cun* inferior to the umbilicus **Angulation:** medial oblique (non-classical) **Target:** rectus abdominis *Abdominal pain; lower gastrointestinal, urological and gynaecological symptoms* **CAUTION: avoid needling through the abdominal wall**	D T12/L1 M T12/L1 S n/a

D= dermatome; M = myotome; S = sclerotome; n/a = not applicable.

Posterior aspect		
Huatuojiaji	A series of 17 extra points, 0.5 *cun* lateral to the lower border of the spinous processes of T1 to L5 **Angulation:** oblique towards spine **Target:** multifidus *Spinal pain; segmental acupuncture*	D T1 to L1 M T1 to L5 S T1 to L5
Bladder line – Outer	3 *cun* lateral to the midline, on a vertical line joining the medial edge of the scapula and the outer border of the lumbar erector spinae **Angulation:** oblique towards spine **Target:** iliocostalis thoracis *Dorsal back pain, ventral pain* **CAUTION: do not needle deeply unless confident of angulation relative to pleura**	D T5 to T9 M T6 toT12 S T6 toT12 – rib level
BL44	Level with the lower border of T5	
BL45	Level with the lower border of T6	
BL46	Level with the lower border of T7	
BL47	Level with the lower border of T9	
BL48	Level with the lower border of T10	
BL49	Level with the lower border of T11	
BL50	Level with the lower border of T12	

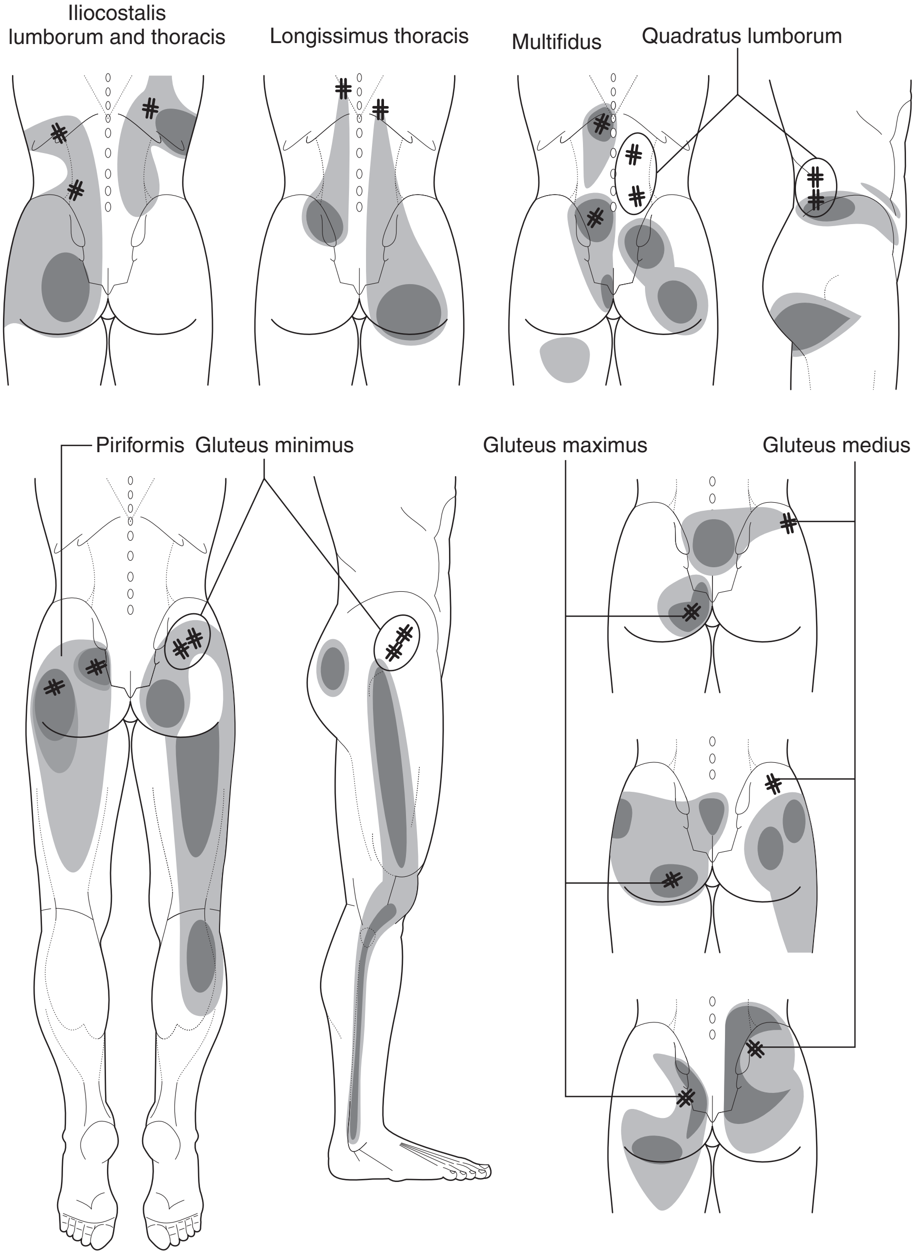

Figure 13.7 • Low back and hip girdle: classical acupuncture points and TrPs. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

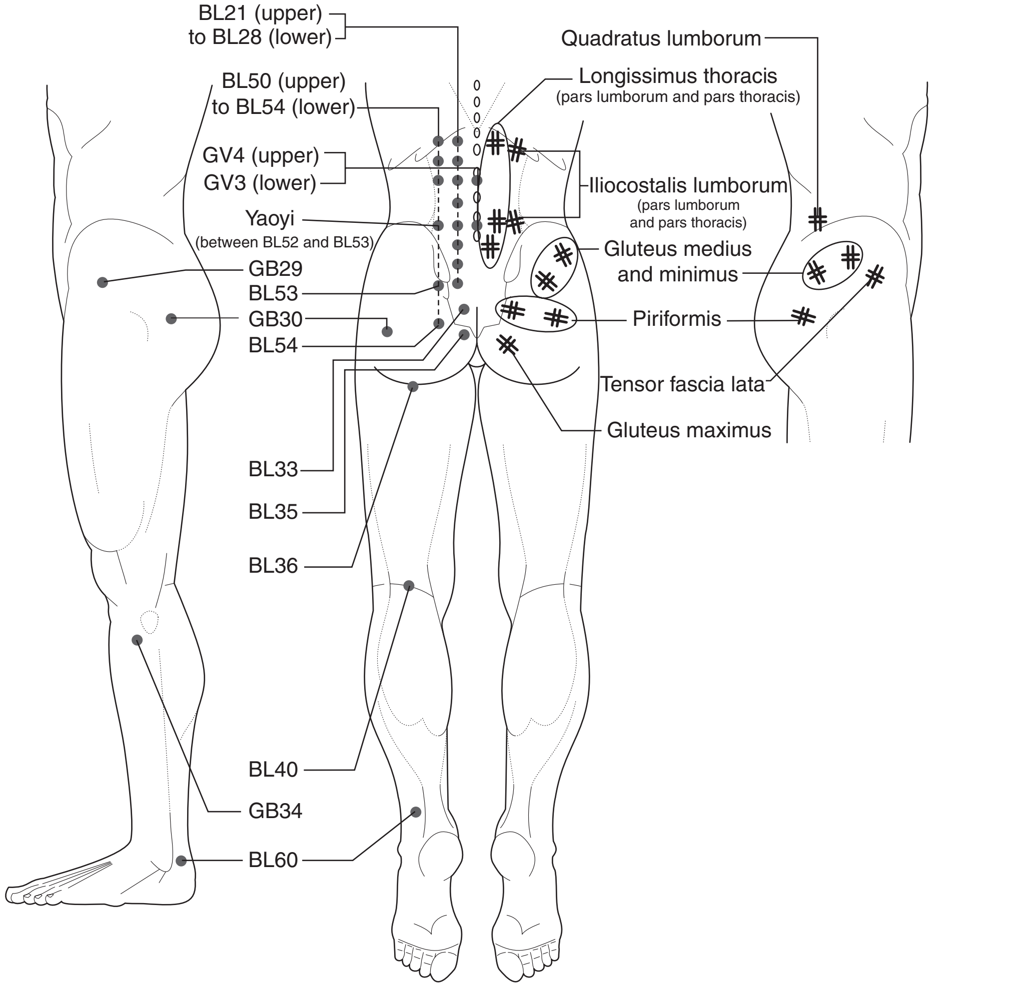

Figure 13.8 • Low back and hip girdle: myofascial TrPs and pain reference zones. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

Table 13.4 Back and hip girdle

Lateral aspect		
GB29	Midway between the anterior superior iliac spine and the greater trochanter **Angulation:** perpendicular **Target:** tensor fasciae latae *Hip girdle pain* **CAUTION: deep needling may penetrate the capsule of the hip joint**	D L2/L3 M L5/S1/S2 S L4/L5/S1
GB30	⅓ of the way from the highest point of the greater trochanter to the sacral hiatus **Angulation:** towards symphysis pubis **Target:** tensor fasciae latae *Hip girdle pain, back pain, leg pain, sciatica* **CAUTION: avoid direct needling of the sciatic nerve**	D L2/L3 M L5/S1/S2 S L4/L5/S1
GB34	In the depression just anterior and inferior to the head of the fibula **Angulation:** perpendicular **Target:** peroneus longus *Leg pain; general point for musculoskeletal pain* **CAUTION: avoid needling the common fibular nerve**	D L5 M L5/S1 S L5
BL60	In the depression midway between the lateral malleolus and the Achilles tendon **Angulation:** perpendicular **Target:** connective tissue *Leg pain, Achilles tendon pain*	D L5/S1 M L5/S1 S S1/S2
Posterior aspect		
GV4	Between spinous processes L2 and L3 **Angulation:** transverse **Target:** interspinous ligament *Spinal pain*	D T9/T10 M L2 S L2
GV3	Between spinous processes L4 and L5 **Angulation:** transverse **Target:** interspinous ligament *Spinal pain*	D T11/T12 M L4 S L4
BL line – Inner	1.5 *cun* lateral to the midline, halfway between the Outer Bladder line and the spine **Angulation:** oblique towards spine **Target:** erector spinae *Back pain*	D T9 to S2 S T12 to S2
BL21	Level with the lower border of T12	M T10/T11
BL22	Level with the lower border of L1	M T11/T12
BL23	Level with the lower border of L2	M T12/L1
BL24	Level with the lower border of L3	M L1/L2
BL25	Level with the lower border of L4	M L2/L3
BL26	Level with the lower border of L5	M L3/L4

D= dermatome; M = myotome; S = sclerotome; n/a = not applicable.

Posterior aspect		
BL27	Level with the S1 posterior foramen, or upper aspect of the posterior superior iliac spine **Angulation:** perpendicular **Target:** erector spinae or multifidus	M L4 S S1
BL28	Level with the S2 posterior foramen, or the lower aspect of the posterior superior iliac spine **Angulation:** perpendicular **Target:** erector spinae or multifidus	M L5 S S2
BL33	Over the S3 posterior foramen **Angulation:** perpendicular **Target:** S3 posterior foramen *Local pain; disturbance of pelvic organs, e.g. detrusor instability*	D S2/S3 M L5 S S3
BL35	0.5 *cun* lateral to the tip of the coccyx **Angulation:** perpendicular **Target:** sacrotuberous ligament *Coccydinia*	D S3/S4 M L5/S1/S2 S S4/coccygeal
BL36	In the transverse gluteal crease, in a depression between the hamstring muscles **Angulation:** perpendicular **Target:** hamstring attachment *Local pain, hamstring pain, sciatica*	D S2/S3 M L5/S1/S2 S L5
BL40	On the popliteal crease midway between the tendons of biceps femoris and semitendinosus **Angulation:** perpendicular **Target:** connective tissue *Local pain, sciatica*	D S1/S2 M S1/S2 S n/a
BL line – Outer	3 *cun* lateral to the midline, on a vertical line joining the medial edge of the scapula and the outer border of the lumbar erector spinae **Angulation:** oblique towards spine unless stated otherwise below *Back pain*	D T9 to S2 S n/a mostly
BL50	Level with the lower border of T12	M T10/T11
BL51	Level with the lower border of L1	M T11/T12
BL52	Level with the lower border of L2	M T12/L1
Yaoyi	Level with the lower border of L4	M L2/L3
BL53	Level with the S2 posterior foramen, or the lower aspect of the posterior superior iliac spine **Angulation:** perpendicular **Target:** gluteus medius *Hip girdle pain, back pain*	D L2/S3 M L4 to S2 S L5
BL54	Level with the S4 posterior foramen in the sciatic notch **Angulation:** perpendicular **Target:** piriformis *Hip girdle pain, back pain, leg pain, sciatica* **CAUTION: avoid needling the sciatic nerve**	D S2/S3 M L5 to S2 S S2/S3
BL60	At the level of the most prominent part of the lateral malleolus, halfway between it and the Achilles tendon **Angulation:** perpendicular toward K13 **Target:** connective tissue space *Painful conditions, especially of spine, distant point in sciatica*	D L5/S1 M L5/S1 S n/a

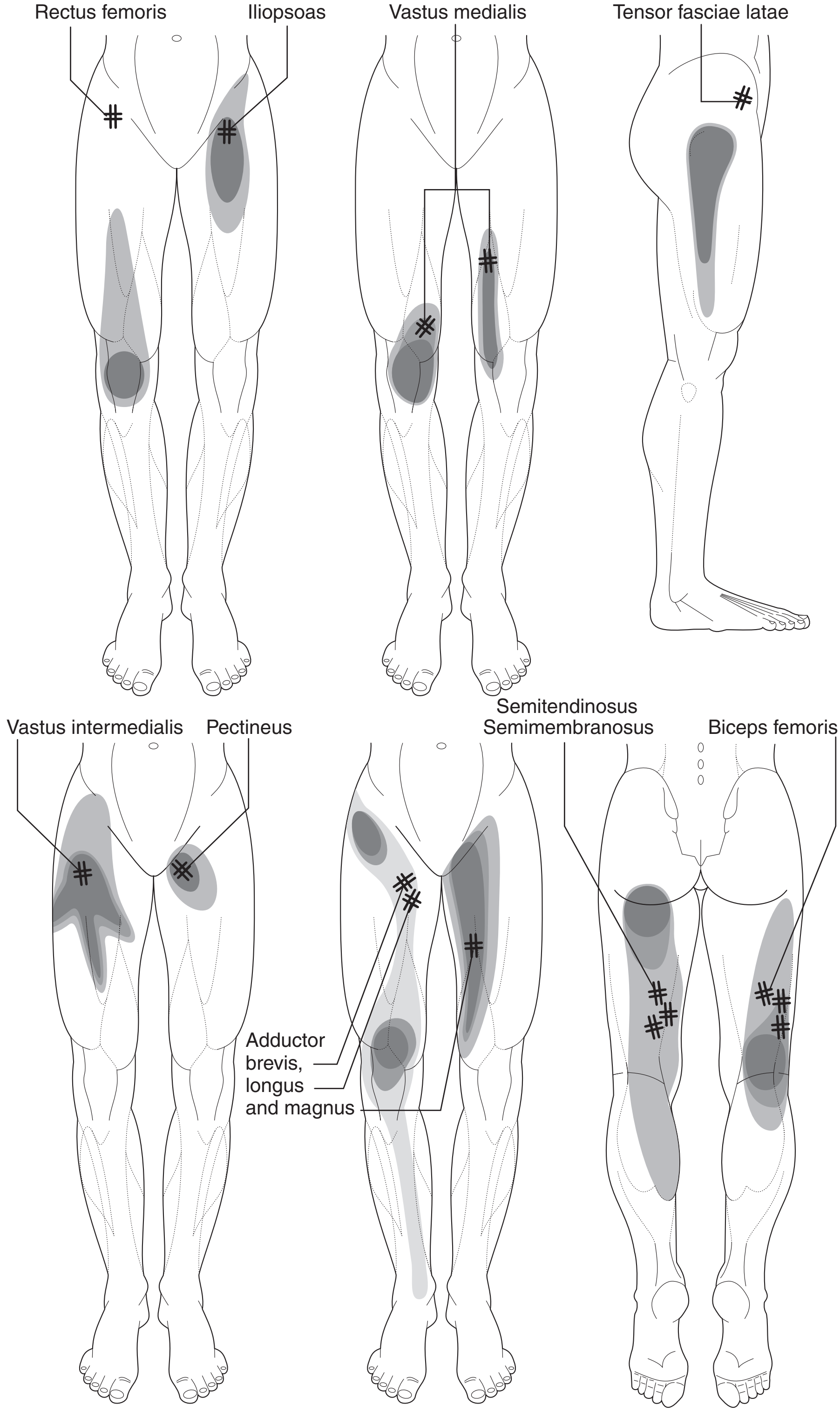

Figure 13.9 • Lower limb: myofascial TrPs and pain reference zones. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

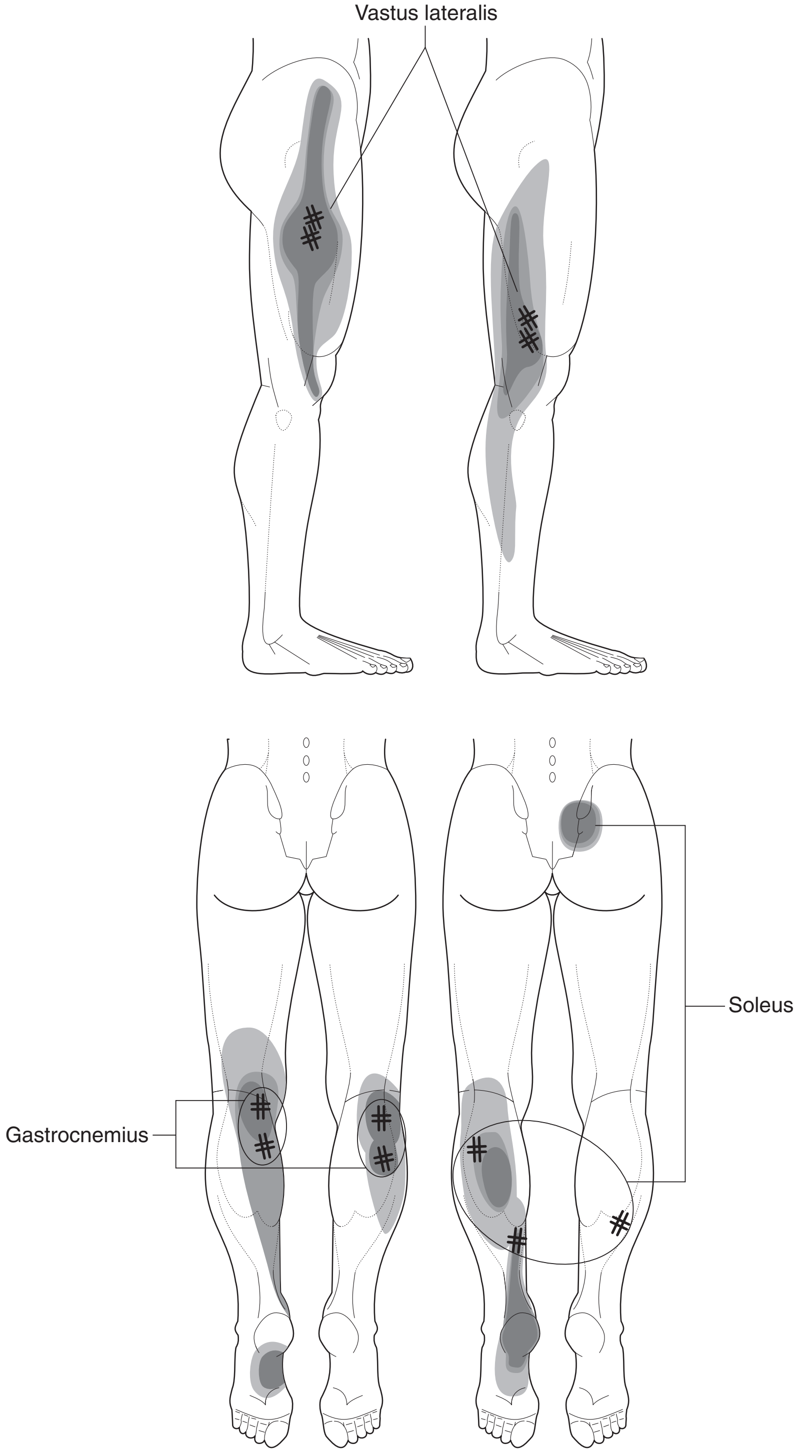

Figure 13.10 • Lower limb: classical acupuncture points and TrPs. Reprinted with permission from: White A, Cummings M, Filshie J (2008) An introduction to Western medical acupuncture. London: Churchill Livingstone.

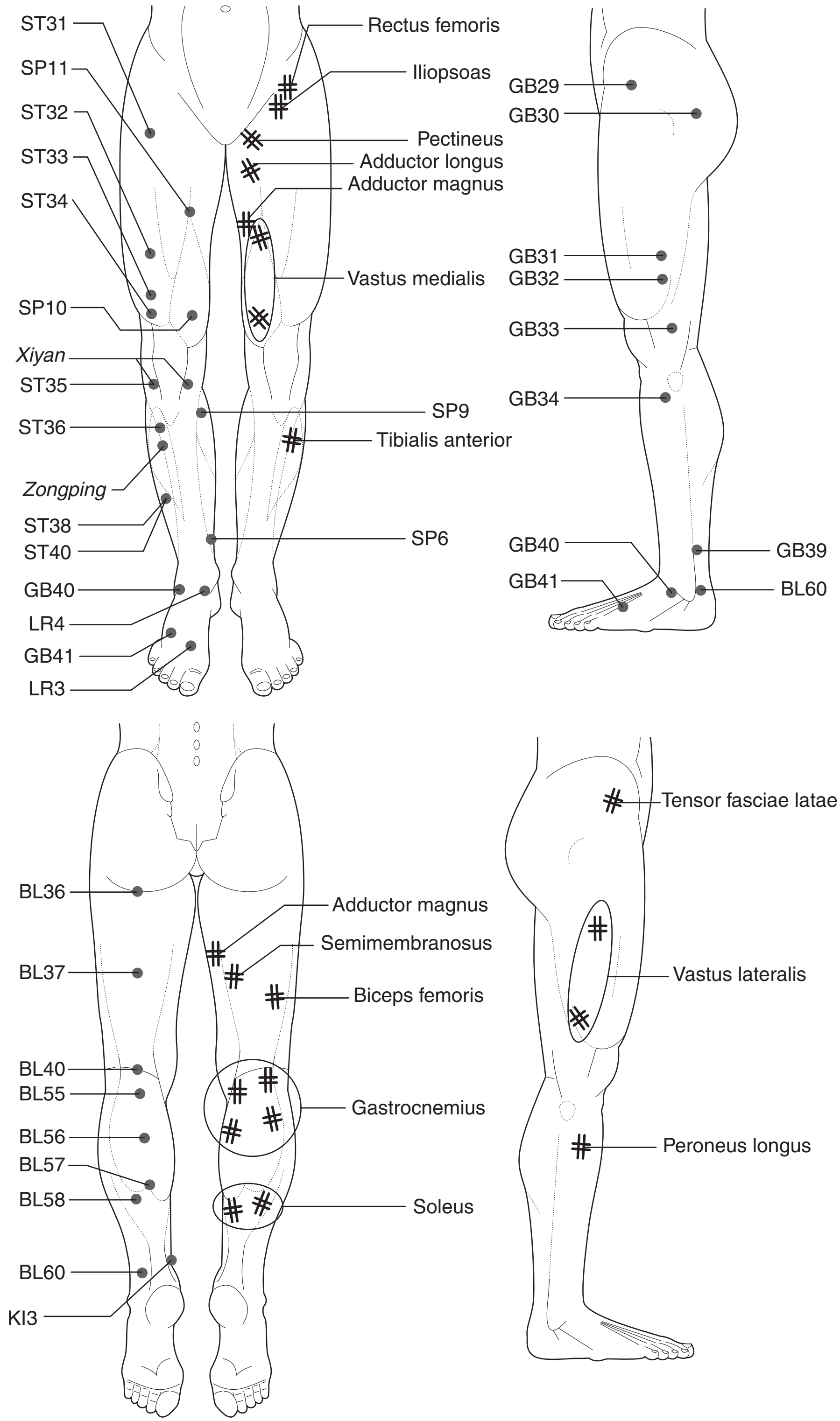
ST31
SP11
ST32
ST33
ST34
SP10
Xiyan
ST35
ST36
Zongping
ST38
ST40
GB40
LR4
GB41
LR3
Rectus femoris
Iliopsoas
Pectineus
Adductor longus
Adductor magnus
Vastus medialis
SP9
Tibialis anterior
SP6
GB29
GB30
GB31
GB32
GB33
GB34
GB40
GB41
GB39
BL60
BL36
BL37
BL40
BL55
BL56
BL57
BL58
BL60
KI3
Adductor magnus
Semimembranosus
Biceps femoris
Gastrocnemius
Soleus
Tensor fasciae latae
Vastus lateralis
Peroneus longus

Table 13.5 Lower limb		
Thigh and lower leg: anterior aspect		
ST31	In a depression just lateral to sartorius, at the junction of a vertical line through the anterior superior iliac spine and a horizontal line at the level of the lower border of the pubic symphysis **Angulation:** perpendicular **Target:** rectus femoris *Thigh pain, anterior knee pain (rectus femoris)*	D L2 M L2/L3/L4 S L3/L4
ST32	6 *cun* superior to the upper lateral margin of the patella on a line that joins the lateral border of the patella to the anterior superior iliac spine **Angulation:** perpendicular **Target:** vastus lateralis *Thigh pain*	D L2 M L3/L4 S L3
ST33	3 *cun* superior to the upper lateral margin of the patella on a line that joins the lateral border of the patella to the anterior superior iliac spine **Angulation:** perpendicular **Target:** vastus lateralis *Thigh and knee pain*	D L2/L3 M L3/L4 S L3
ST34	2 *cun* superior to the upper lateral margin of the patella on a line that joins the lateral border of the patella to the anterior superior iliac spine **Angulation:** perpendicular **Target:** vastus lateralis *Knee pain*	D L2/L3 M L3/L4 S L3
ST35	In the hollow on the lateral aspect of the patella tendon directly over the joint line **Angulation:** towards the patella tendon (non-classical) **Target:** knee capsule *Knee pain* **CAUTION – avoid needling into the knee joint**	D L3/L4/L5 M L3/L4 S L3/L4/L5
Xiyan	In the hollows on either side of the patella tendon directly over the joint line **Angulation:** towards the patella tendon (non-classical) **Target:** knee capsule *Knee pain* **CAUTION – avoid needling into the knee joint**	D L3/L4/L5 M L3/L4 S L3/L4/L5
ST36	3 *cun* inferior to the knee joint, 1 fingerbreadth lateral to the lower border of the tibial tuberosity, in the middle of the upper third of the tibialis anterior **Angulation:** perpendicular **Target:** tibialis anterior *Knee pain, abdominal problems, major combination for central effects*	D L4/L5 M L4/L5 S L4/L5
Zongping	1 *cun* inferior to ST36 **Angulation:** perpendicular **Target:** tibialis anterior *Used with ST36 for EA – major combination for central effects*	D L4/L5 M L4/L5 S L4/L5
ST40	On the anterolateral aspect of the lower leg, midway between the tibiofemoral joint line and the lateral malleolus, 2 fingerbreadths lateral to the anterior crest of the tibia **Angulation:** perpendicular **Target:** extensor hallucis longus *Local pain; a variety of traditional indications* **CAUTION – avoid needling to the depth of the anterior tibial artery**	D L5 M L5/S1 S L5/S1
SP11	6 *cun* superior to SP10, on a line connecting SP10 with SP12 **Angulation:** perpendicular **Target:** vastus medialis *Thigh and knee pain (vastus medialis)* **CAUTION – note the position of the femoral artery**	D L3 M L2/L3/L4 S L3
SP10	2 *cun* proximal to the superiomedial border of the patella, in the centre of vastus medialis **Angulation:** perpendicular **Target:** vastus medialis *Knee pain (vastus medialis)*	D L3 M L2/L3/L4 S L3
SP9	In a depression inferior to the medial condyle of the tibia and posterior to the medial border of the tibia, at the same level as GB34 **Angulation:** perpendicular **Target:** connective tissue space *Knee pain, gynaecological and urological problems*	D L3 M L2/L3/L4 S L3

Thigh and lower leg: anterior aspect		
SP6	3 *cun* superior to the most prominent part of the medial malleolus, on the medial border of the tibia **Angulation:** perpendicular **Target:** flexor digitorum longus *Gynaecological problems; major point for central effects*	D L4/S1/S2 M S1/S2 S L4/L5
LR4	Anterior to the medial malleolus, in the depression just medial to the tendon of tibialis anterior **Angulation:** perpendicular **Target:** connective tissue space *Ankle pain* **CAUTION – avoid needling into the ankle joint**	D L4/L5 M L4/L5 S L4/L5
LR3	On the dorsum of the foot, in the 1st metatarsal space, in a depression distal to the junction of the bases of the 1st and 2nd metatarsals **Angulation:** perpendicular **Target:** 1st dorsal interosseous *Local pain; headache; abdominal problems; major point for central effects* **CAUTION – the dorsalis pedis artery is at the apex of the 1st metatarsal space**	D L4/L5 M S2/S3 S L5/S1

Thigh and lower leg: lateral aspect		
GB29	On the lateral aspect of the hip midway between the anterior superior iliac spine and the greater trochanter **Angulation:** perpendicular **Target:** tensor fasciae latae or glutei *Hip girdle pain* **CAUTION – deep needling may penetrate the capsule of the hip joint**	D L2 M L4/L5/S1 S L3/L4/L5
GB30	$\frac{1}{3}$ of the way to the sacral hiatus from the most prominent part of the greater trochanter **Angulation:** perpendicular **Target:** lateral piriformis *Low back pain, hip girdle pain, sciatica* **CAUTION – avoid needling the sciatic nerve**	D L2/L3/S2 M L5/S1/S2 S L4/L5/S1
GB31	7 *cun* above the popliteal crease in the palpable furrow just posterior to the iliotibial tract **Angulation:** perpendicular **Target:** vastus lateralis or intermedius *Thigh and knee pain*	D L2 M L3/L4 S L3
GB32	In the palpable furrow just posterior to the iliotibial tract, 2 *cun* below GB32 **Angulation:** perpendicular **Target:** vastus lateralis or intermedius *Thigh and knee pain*	D L2 M L3/L4 S L3
GB33	On the lateral aspect of the knee 3 *cun* superior to GB34, in a depression between the femur and the tendon of biceps femoris **Angulation:** perpendicular **Target:** connective tissue space *Knee pain* **CAUTION – if the knee is flexed this point is close to the posterior joint margin**	D L2/L3/S2 M L4 to S2 S L3/L4
GB34	In the depression about 1 *cun* anterior and inferior to the head of the fibula **Angulation:** perpendicular **Target:** peroneus longus *Knee pain* **CAUTION – avoid deep needling since the anterior tibial artery and common fibular nerve are deep to this point**	D L5 M L5/S1 S L5
GB39	3 *cun* superior to the lateral malleolus, between the fibular shaft and the tendon of peroneus longus (use digital pressure to form a groove between the tendon and the fibula) **Angulation:** perpendicular **Target:** peroneus brevis *Lower leg and ankle pain* **CAUTION – avoid forceful ankle movement when a needle is placed in this point**	D L5/S1 M L5/S1 S L5/S1

Thigh and lower leg: anterior aspect		
GB40	In the depression anterior and inferior to the lateral malleolus **Angulation:** perpendicular **Target:** connective tissue space *Ankle pain* **CAUTION – avoid needling into the ankle joint**	D L5/S1 M L5/S1 S S1/S2
GB41	In the depression distal to the junction of the 4th and 5th metatarsals, lateral to the tendon of extensor digitorum longus that passes to the 5th toe **Angulation:** perpendicular **Target:** 4th dorsal interosseous *Forefoot pain*	D L5/S1 M S1/S2 S S2
Thigh and lower leg – posterior aspect		
BL36	In the transverse gluteal crease, in a depression between the hamstring muscles **Angulation:** perpendicular **Target:** hamstring attachment *Local pain, hamstring pain, sciatica*	D S2/S3 M L5/S1/S2 S L5
BL40	On the popliteal crease midway between the tendons of biceps femoris and semitendinosus, in the connective tissue space between the heads of gastrocnemius **Angulation:** perpendicular **Target:** connective tissue space *Local pain, sciatica* **CAUTION – note the popliteal artery and tibial nerve are deep to this point**	D S1/S2 M S1/S2 S n/a
BL55	2 *cun* inferior to BL40, on the line connecting BL40 and BL57, between the two heads of gastrocnemius **Angulation:** perpendicular **Target:** fascial plane *Calf pain*	D S1/S2 M S1/S2 S n/a
BL56	In the fascial plane between the heads of gastrocnemius, 5 *cun* below BL40, midway between BL55 and BL57 **Angulation:** perpendicular **Target:** fascial plane *Calf pain*	D S1/S2 M S1/S2 S n/a
BL57	In the depression formed below the bellies of the gastrocnemius muscle when the muscle is flexed, midway between BL40 and BL60 **Angulation:** perpendicular **Target:** musculotendinous junction *Calf pain*	D S1/S2 M S1/S2 S n/a
BL58	7 *cun* directly superior to BL60, lateral to and approximately 1 *cun* inferior to BL57, at the musculotendinous junction of the lateral head of gastrocnemius **Angulation:** perpendicular **Target:** musculotendinous junction *Calf pain*	D L5/S1/S2 M S1/S2 S n/a
BL60	At the level of the most prominent part of the lateral malleolus, halfway between it and the Achilles tendon **Angulation:** perpendicular toward KI3 **Target:** connective tissue space *Painful conditions, especially of spine, distant point in sciatica*	D L5/S1 M L5/S1 S n/a
KI3	At the level of the most prominent part of the medial malleolus, halfway between it and the Achilles tendon **Angulation:** perpendicular toward BL60 **Target:** connective tissue space *Ankle problems; urogenital problems; major point for central effects*	D L4/S2 M S2 S n/a

D= dermatome; M = myotome; S = sclerotome; n/a = not applicable.

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Intramuscular stimulation (IMS)

14

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CHAPTER CONTENTS

Introduction

Gunn Intramuscular Stimulation (Gunn-IMS) is a technique for the treatment of myofascial pain syndrome based on a comprehensive diagnostic and therapeutic model that identifies the etiology of myofascial pain as neuropathic, i.e. due to disease or dysfunction in the nervous system. Further, it identifies the nerve root as the locus of the pathology, and thus it is a radiculo-neuropathic model. It was developed by C.C. Gunn MD, in the 1970s while treating injured workers and followed from his clinical observations distinguishing those workers who succeeded in returning to work from those who failed to do so (Gunn & Milbrandt 1976a).

Gunn's model is a derived clinical model. What grew out of the desire to understand his patients' persistent pain and offer them treatment ended in a completely new way to see and treat this most universal of all human afflictions, pain. He was the first physician ever to recognize the subtle physical examination signs of neuropathy and to describe the pathophysiology of neuropathic pain (Gunn & Milbrandt 1978, Gunn 1980).

Gunn's work reflects not only the great tradition of empirical science, but also, is built upon the work of great scientists before him. In an example par excellence of the often quoted homage of scientific progress to the work of all who precede one in the history of science and medicine, 'dwarfs standing on the shoulders of giants', Gunn realized the pathophysiological explanation for what he observed clinically in the work of Walter Cannon, the distinguished early 20th century physiologist. Cannon's research on the 'The Supersensitivity of Denervated Structures, a Law of Denervation' is an important law of neuropathophysiology that, because of its posthumous publication in the non-scientific literature, had been

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previously overlooked by the medical community (Cannon & Rosenblueth 1949). While an entire field of basic and animal neuromuscular physiology research has grown out of this work known as 'Cannon's Law' (CL), it had remained a purely academic and non-clinical pursuit limited to the laboratory. Until Gunn, who has built a bridge from the research laboratory to the medical clinic and rescued CL from experimental obscurity to practical posterity.

The prevailing medical-surgical management of persistent spinal and regional musculoskeletal pain is based on what could be called the 'spondylosis-nociception-inflammation' model. This model attributes pain to nociceptive and inflammatory etiologies due to altered structure in a normal peripheral nervous system. Typical diagnoses in this model include 'disc rupture, degeneration and inflammation', 'nerve root impingement', 'facet joint arthropathy', 'rotator cuff tear', 'extensor elbow/Achilles tendonitis', 'hip bursitis', 'patella-femoral dysfunction', and 'plantar fasciitis', to name a few. Diagnosis and treatment decisions in this model are based largely on the structural findings of imaging studies (plain X-ray, CT/MRI, nuclear medicine) or the presumption of inflammation, and myofascial pain syndrome (MPS) is not thought of as bearing any relationship to these entities. This model however, cannot account for many clinically 'inconvenient' facts, including the lack of correlation between anatomic findings and pain (Savage et al. 1997; Borenstein et al. 2001) or the absence of exam findings or histological evidence of inflammation (Khan et al. 1999, Alfredson & Lorentzon 2002).

Connecting the dots between radiculopathy, neuropathy and myofascial pain, one could say that Gunn discovered the 'missing link' between three entities previously thought of as separate, even disparate. Gunn's radiculo-neuropathic-myofascial pain (RNMP) model explains many of the failures and paradoxes of the traditional model, and accounts for many of the facts that a nociceptive and inflammatory model alone cannot. These include the common clinical observations of painless nerve impingement, why pain may resolve despite imaging evidence of persistent nerve impingement or electrodiagnostic evidence of ongoing acute denervation, or why pain may persist even after surgical nerve root decompression or in the absence of detectable inflammation. Understanding persistent spinal and regional musculoskeletal syndromes as manifestations of RNMP and not inflammatory in etiology explains the common failure of anti-inflammatory therapy for these conditions. It also explains why strengthening exercise, which normally produces muscle shortening, often fails to relieve pain, and not infrequently worsens it, as it aggravates the already present muscle shortening seen in RNMP syndromes. Alternatively, it explains why such therapies as osteopathic manipulation, myofascial release, stretching, transcutaneous electrical nerve stimulation (TENS), diathermy, therapy, acupuncture, trigger point injection and spinal cord stimulation may be effective. It would predict that muscle relaxant as well as anti-neuropathic medications like gabapentin might be effective (Audette et al. 2005).

Gunn's identification of myofascial pain as essentially a neuropathic condition leads to additional insights. As a treatment for MPS, Gunn-IMS is hardly different from the other techniques of superficial and deep dry needling described in this textbook, and not only predicts but readily recognizes the efficacy of these approaches. Yet while Gunn-IMS does not differ from dry needling (DN) in much of its technique, or the 'how', it does differ substantially from other dry needling techniques in its understanding of the 'what', 'where', 'why' and 'when' of MPS. It differs in explaining 'what' causes MPS and trigger points and so how to examine the patient and thus 'what' for and 'where' to look on physical examination. This leads to a rationale for 'where' to treat the patient, i.e. in a segmental or radiculoneuropathic pattern of myotomal involvement. In its recognition of MPS as neuropathic, it proposes an explanation of 'why' Gunn-IMS, along with many other forms of counter-irritation reflex stimulation are effective in reversing neuropathic supersensitivity. Understanding the time frame for experimental reversal of neuropathic supersensitivity (Lomo & Rosenthal 1972, Lomo & Westgaard 1975), it also provides a 'when' – that is, a rationale for the expected length and course of treatment based on the severity of the physical examination findings. These and not the technique per se are what differentiate Gunn-IMS from DN.

Gunn's model recognizes the 'myofascial trigger point' (TrP), but it recognizes the TrP as just one of many clinical manifestations of RNMP. Because it is a radiculopathic model, it predicts the presence of TrPs in a myotomal distribution including the posterior ramus, and recognizes the importance of treating such points. Yet despite these differences Gunn-IMS practitioners share in common with all practitioners who treat MPS the recognition of both the prevalence of MPS and the success of treating it early and properly.

Indeed the most important aspect of Gunn's contribution is not even necessarily the technique of Gunn-IMS (although important), but that it will hopefully lead to wider recognition by the medical community of the significant incidence and prevalence of MPS in the general population. Epidemiological studies suggest that MPS is an important source of morbidity in the community (Cummings & White 2001), yet it is commonly overlooked in the clinic (Skootsky et al. 1989). This is corroborated by the fact that it is found in 85% of patients seen in chronic pain clinics (Fishbain et al, 1989). By recognizing MPS as a common cause of persistent pain beyond 3 months, the possibility of earlier recognition and proper treatment increases dramatically, and with that, the hope of stemming the epidemic tide of chronic pain that is overwhelming western medical systems. Despite all of the rich resources we have thrown at this problem by pursuing the standard paradigm of 'spondylosis-nociception-inflammation': strengthening exercise programs, imaging studies, spinal injections, surgery, multidisciplinary pain clinics, opioids, spinal cord stimulators and pumps, we have ended up with increasing suffering, impairment, opioid dependence, disability and unsustainable costs (Deyo et al. 2009). The only thing we have *not* done is recognize and treat myofascial pain early and properly. By placing myofascial pain squarely within the pathophysiological schema and thus diagnostic algorithm of spondylotic pain, myofascial pain can be properly seen as the prevalent condition that it is. Clinical presentations of myofascial pain are protean in their manifestations: pain referral, while following general patterns, are individually variable, inconsistent and sometimes enigmatic, and they can be over-shadowed by the non-specific nature of the non-pain complaints referable to autonomic mediation that suggest primary visceral pathology (Fricton et al. 1985). All of these features make it difficult to standardize case definition, thus making diagnosis elusive. Gunn's model accounts for this variability and provides an objective approach to the evaluation and treatment of these patients. Rather than a possible afterthought when the existing model fails, myofascial pain will hopefully be moved to the forefront of the algorithmic evaluation of pain that persists for more than 3 months.

Yet while Gunn-IMS is a treatment for myofascial pain, the RNMP model that it is employed within represents more than simply a technique for treating TrPs. It represents an entirely new way to understand, examine and effectively treat patients with persistent pain. As such his work represents a true paradigm shift. Gunn's RNMP model provides a unified model of peripheral neuromusculoskeletal pain that points the way to an improved treatment algorithm for these clinical and societal problems.

While Gunn has exploited CL in the service of treating pain primarily, the implications of this law and Gunn's therapeutic model go beyond the treatment of neuromusculoskeletal pain. While beyond the scope of this chapter, taken to its logical and inevitable conclusion, Gunn's model proposes a rational basis for the treatment of syndromes caused by the autonomically mediated visceral epiphenomena of segmental radiculoneuropathy, including such varied complaints as vertigo, tinnitus, irritable bowel syndrome, and infertility, to name but a few. Current research interest in the role of the nervous system in chronic, or 'para-inflammation', suggests even broader and significant implications of Gunn's model (Tracey 2002).

Gunn-IMS is a procedure that can carry significant risks, especially when treating deeper paraspinal muscle contractures or anywhere overlying the lungs or near vascular structures. Despite these risks, properly qualified health care providers, both primary care and specialist, can be taught to apply it safely and readily to many of the most commonly encountered clinical problems. In addition, Gunn-IMS, like all DN techniques, is 'low tech', inexpensive and easily employed in clinics worldwide. Yet while any practitioner can easily be taught to stick a pin into a muscle, as mentioned previously it is the understanding of 'what' may cause the TrP, 'where' and 'how' to treat the patient, 'what' responses are sought by needling, 'why' needling is likely effective, and 'when', or how often and for how long to treat the patient, that constitute the proper application of Gunn-IMS.

Neurophysiological mechanism of Gunn-IMS

In seeking to understand his clinical findings Gunn found an explanation in Cannon and Rosenblueth's 'The Supersensitivity of Denervated Structures, a Law of Denervation'. Following the identification of segmental myalgic hyperalgesia ('tenderness at motor points') as a correlate of radiculopathy (Gunn & Milbrandt 1976a), subsequent observations included the heretofore unrecognized neuropathic findings in these patients: increased muscle tone, neurogenic edema, vasomotor disturbances with hypothermia, exaggerated pilomotor and sudomotor reflexes, and dermatomal hair loss (Gunn & Milbrandt 1978).

Cannon is credited with originating the concept of the 'fight or flight' response, introducing the term 'homeostasis' and popularizing the use of barium to visualize the gastrointestinal tract. He and Arturo Rosenblueth, former head of the department of physiology and pharmacology at University of Mexico, also performed animal research demonstrating the effects of motor nerve denervation. CL quantified experimentally the pathophysiological responses to somatic and autonomic motor denervation in a variety of target end organ tissues, including skeletal and smooth muscle, spinal neurons, sympathetic ganglia, adrenal glands, sweat glands, and brain cells. These reactions can all be described as forms of supersensitivity, i.e. abnormal tissue responses to stimuli, and while Cannon investigated the effects of motor denervation (techniques to study sensory receptors did not exist then), the phenomena of neuropathic supersensitivity first described by him is the same as that which we recognize clinically in peripheral sensory neuropathies (e.g. diabetic, alcoholic) as dysesthesia, allodynia and hyperalgesia. In other words, stimuli that normally should not trigger a response now do: it is not the stimuli that are abnormal but the system that senses them.

Cannon & Rosenblueth's Law is summarized as follows:

> When a unit is destroyed in a series of efferent neurons, an increased irritability to chemical agents develops in the isolated structure or structures, the effect being maximal in the part directly denervated.

Gunn, as a practicing physician, first recognized the clinical manifestations of CL:

> This law is seldom cited to explain neuropathic pain; it deserves to be better known. It points out that the normal physiology and integrity of all innervated structures are dependent on the arrival of nerve impulses via the intact nerve to provide a regulatory or trophic effect. When this flow, which is probably a combination of axoplasmic flow and electrical input, is blocked, innervated structures are deprived of the trophic factor, which is vital for the control and maintenance of cellular function… A-trophic structures become highly irritable and develop abnormal sensitivity or super-sensitivity.
>
> (Loeser et al. 2001)

All of the tissues studied by Cannon and Rosenblueth (skeletal and smooth muscle, spinal neurons, sympathetic ganglia, adrenal glands, sweat glands, and brain cells) develop denervation supersensitivity. Their research quantified this phenomena as: (1) increased susceptibility: lessened stimuli, which do not have to exceed a threshold, can produce responses of normal amplitude; (2) hyper-excitability: the threshold of the stimulating agent is lower than normal; (3) super-reactivity: the capacity of the muscle to respond is augmented; and (4) super-duration of response: the amplitude of response is unchanged but its time course is prolonged. Numerous animal experiments have confirmed that denervation supersensitivity is indeed a general phenomenon.

In the muscle, the above responses are demonstrated by a lowered threshold to acetylcholine (ACh) inducing a contraction. It has also been shown in both striated and smooth muscle that the surface area of the muscle fiber that is sensitive to ACh increases. That is to say 'extra-junctional' areas on the surface away from the zone of innervation, normally the only area receptive to ACh stimulation, now respond to ACh. This phenomenon is detectable 4–5 days after denervation, and reaches a maximum within about a week, at which time the entire surface of the muscle fiber is as sensitive to ACh as the neuromuscular junction (Axelsson & Thesleff 1959).

Another manifestation of denervation supersensitivity in the muscle fiber is the development of spontaneous electrical activity, called fibrillation. In contrast to an action potential in the muscle fiber occurring only in response to the release of neurotransmitter, action potentials now occur spontaneously due to changes in membrane potentials and conductivity. In electromyography, spontaneous depolarizations are called 'denervation potentials', and reflect loss of motor innervation; they are seen in diseases of the anterior horn cells, nerve roots, plexus, peripheral nerve and muscle (Chu-Andrews & Johnson 1986). They are manifestations of CL, reflecting the abnormally elevated sensitivity and reactivity of the muscle membrane to both ACh and the mechanical stimuli of the electromyography needle as it provokes depolarization, a result of the disinhibiting effect of denervation. Significantly, in addition to the spontaneous depolarizations that produce action potentials, ACh *slowly* depolarizes the supersensitive muscle membrane, inducing electromechanical coupling in which tension develops slowly without generating action potentials (Eyzaguirre & Fidone 1975).

Cannon and Rosenblueth's original work was based on complete loss of motor innervation for supersensitivity to develop. Subsequently it became recognized that actual physical interruption and total denervation are not necessary: any injury or illness that impedes the flow of motor impulses for a period of time can rob the target organ of its excitatory input and cause supersensitivity in that structure and, significantly, in associated spinal reflexes (Loeser et al. 2001, Cangiano et al. 1977, Gilliat 1978). Supersensitive skeletal muscle fibers overreact to a wide variety of chemical and physical inputs, including stretch and pressure.

This process of nerve dysfunction with impaired or interrupted neural impulses and at times associated with partial denervation is not uncommon in adults, and is known as 'neuropathy', or 'nerve-sickness', literally. It is important to recognize that such a nerve still conducts nerve impulses, synthesizes and releases transmitted substances and in the case of motor nerves, evokes both muscle action potentials and muscle contraction. The causes of neuropathy are legion and include congenital, neoplasms, inflammatory, traumatic, vascular, toxic, metabolic, infectious, degenerative and idiopathic etiologies. Commonly recognized neuropathies include the peripheral sensory neuropathies associated with diabetes or alcoholism; however, the far more common cause of nerve dysfunction is trauma, including acute, sub-acute and chronic. Sciatica, a type of spondylotic traumatic compressive neuropathy, accounts for a relative incidence five times that of diabetic neuropathy in the USA (Bridges et al. 2001). Spondylosis is defined as the sub-acute or chronic (gradual, insidious) structural disintegration and morphologic alterations in the intervertebral disc and pathoanatomic changes in surrounding structures that leads to damage of the nerve roots and spinal nerves (Wilkinson 1971). Since the nerve roots and spinal nerves contain motor, sensory and autonomic fibers, it follows that the clinical manifestations of injury to them reflect the effects of neuropathy that develop to varying degrees in each of these three components, and will be discussed in subsequent sections of the chapter.

As noted earlier, in neuropathic skeletal muscle ACh slowly depolarizes the supersensitive muscle membrane, *inducing electromechanical coupling of actin and myosin in which tension develops slowly without generating action potentials*. As such, due to the extended time frame over which this occurs, no action potentials are seen on electromyography, and this shortening is called contrac*ture* rather than contrac*tion* (Eyzagguire & Fidone 1975). In addition, Gunn has proposed that radiculoneuropathic involvement of muscle spindle afferent fibers leads to hyperexcitability of the muscle spindle mechanism, potentiating the length-regulating feedback mechanism of the gamma loop and contributing to the development of these contractures (Gunn & Milbrandt 1977a). This mechanism may be amplified even further by sympathetic supersensitivity activating intrafusal fibers of the muscle spindle (Chu 1995). Dysfunction of this mechanism is sometimes referred to as the 'facilitated segment', 'somatic dysfunction', or the 'osteopathic lesion' (Korr 1975).

On physical exam these muscle contractures are palpable in the more superficial muscles, and are commonly referred to as 'taut bands', 'ropy bands' or 'contraction knots' (Baldry 2001). Deeper, non-palpable contractures are what Gunn terms 'the silent lesion' (Gunn 1996). Over time, when enough regions of the muscle develop contractures, the muscle's overall resting length shortens, at which point the patient may become aware of decreased flexibility, noting for example the need to turn their upper body to check automotive traffic behind them, as the active range-of-motion in the cervical spine is diminished. As the process of spondylosis continues over time, and is aggravated by additional acute injuries, the model postulates that smaller diameter nerve fibers develop supersensitivity and myalgic hyperalgesia develops. The patient may still be otherwise asymptomatic, with the exception perhaps of complaints of 'stiffness', and surprised by the pain elicited by palpation of these tender contractures, or 'latent TrPs' (Baldry 2001). It is this morbid but generally symptom-free phase that Gunn terms 'pre-spondylosis' (Gunn 1980). Eventually, as both the muscle shortening compresses intramuscular type III and IV nociceptors and sensitization of small nociceptor fiber advances, the patient develops active TrPs and complains of spontaneous pain.

The combined sensory and autonomic effects of RNMP manifest as all manner of subjective complaints including paresthesias (including tingling, buzzing, vibration, pressure), dysesthesias including 'pins and needles', neuralgic pain (shooting-stabbing-lancinating-paroxysmal) and itching (Stellon 2002); complaints of stiffness and swelling are attributable to muscle shortening and neurogenic edema. Physical findings may include decreased range-of-motion, myalgic hyperalgesia with generation of referred pain and either spontaneous or elicited local fasciculation, also referred to as the 'local twitch response' (LTR). There may be cutaneous hypoesthesia, and allodynia, rather than anesthesia which is present in denervation.

As over time RNMP leads to both localized intramuscular contractures and shortening of the resting length of the muscle, the persistent increased mechanical tension on the musculotendinous attachments to bone leads to what previously was labeled tendonitis, implying an inflammatory etiology, now preferably called tendonopathy or tendonosis (Khan et al. 1999). These include most of the sub-acute and chronic tendonitis and bursitis syndromes (Achilles, extensor forearm, bicipital, rotator cuff, DeQuervain's tenosynovitis, patella, gluteal) as well as such entities as iliotibial band syndrome, chondromalacia patellae, muscle tension headache, pyriformis syndrome, plantar fasciitis and temporomandibular joint. Many of these are thus seen as the effects of muscle shortening, which due to increased tension at the periosteum create pain as well as bone spurs according to Wolff's Law, which describes the process of bone deposition in response to mechanical tensile forces. Thus extensor elbow tendonosis, or 'tennis elbow', is seen not as a local pathology but the 'downstream' effect of sub-acute and chronic C6–C7 radiculoneuropathic-myofascial pain that can sometimes be treated successfully by treatment to the cervical spine alone (Gunn and Milbrandt, 1976b).

The constellation of symptoms and signs noted above collectively constitute a picture and definition of what is called MPS, myofascial pain being a term popularized by Janet Travell, MD, who also 'popularized the use of the term TrP' (Baldry 2001). The pathognomonic feature of MPS is the TrP, the hallmark of which is hyperalgesia with referred pain, and which is 'structurally...made up of a collection of dysfunctional motor endplates, juxtapositional contraction knots and neurovascular bundles with each containing blood vessels and contiguous sympathetic fibres; a motor axon and its nerve terminals; and sensory afferents attached to proprioceptors and nociceptors' (Baldry 2001).

While Gunn's model recognizes TrPs as most often found beneath motor points and the importance of directing treatment to these points (Gunn et al. 1980), the TrP is seen as just one of the many diverse manifestations of radiculoneuropathic-myofascial pain syndrome. It recognizes that needling can 'occasionally actuate muscle to fasciculation: this is usually accompanied by near-instantaneous muscle relaxation' (LTR), but also, that due to supersensitivity the entire surface of the neuropathic muscle may respond to needling. Penetration into almost any part of the muscle can lead to relaxation, but the most rewarding sites are at tender and painful points in muscle bands (Gunn, 1989b).

Gunn's finding of a correlation between tender motor points and electromyography (EMG) evidence of partial denervation radiculopathy has been corroborated by Chu using a semi-quantitative motor unit action potential (MUAP) EMG technique (Chu 1995). While EMG abnormalities were found in a myotomal distribution correlating with clinical findings of MPS, Chu suggested that single-fiber EMG (SFEMG) may be more useful than conventional EMG in establishing the cause of abnormalities as 'neurogenic, myogenic, or otherwise.' The presence and severity of motor neuroaxonal degeneration correlating with TrPs and disease duration using SFEMG technique has recently been established by Chang, who has also found evidence of spinal accessory neuropathy in cervical MPS (Chang et al. 2008, 2011).

What then is the evidence that Gunn-IMS can reverse RNMP? Evidence that neuropathic supersensitivity can be reversed was demonstrated experimentally by Lomo, who showed that ACh supersensitivity in denervated animal skeletal muscle could be abolished by graded electrical stimuli (Theslef, 1976). Figure 14.1 shows how experimental denervation affects the sensitivity of a muscle membrane to ACh (bold line). Additionally, Figure 14.1 shows how this hypersensitivity returns toward normal after electrical stimulation, and does so more quickly with continuously applied stimuli. Gunn has proposed that the 'current of injury' (the measureable microcurrent associated with damage

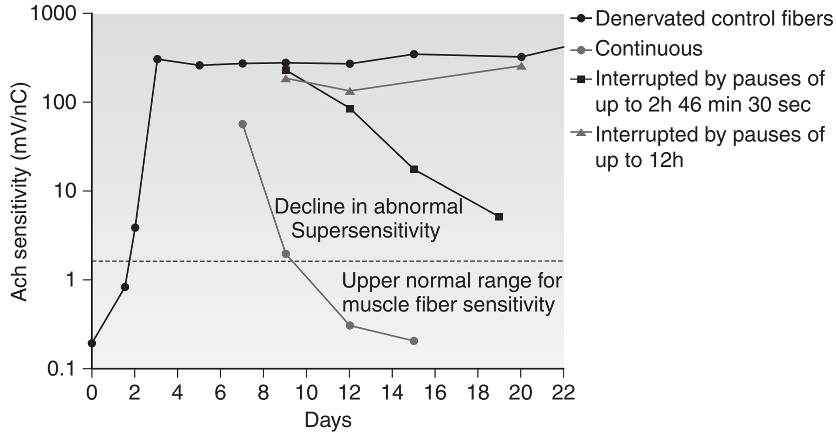

Figure 14.1 • Experimental reversal of denervation supersensitivity.

to a cell wall membrane) created by the minor muscle fiber trauma of needling provides an intrinsic source of electrical stimulation that facilitates reversal of neuropathic supersensitivity similar to that provided exogenously by Lomo (Gunn 1978).

Supporting evidence for Gunn's claim that DN can reverse neuropathic supersensitivity is found in animal studies which have shown that the spontaneous endplate activity (SEA) associated with TrPs (and predicted by a neuropathic model of MPS) can be diminished by DN (Chen et al. 2000). Chu studied the electromyographic effects of DN in humans and stated, '…that the presence of discharges of sustained or grouped endplate potentials and twitch responses are gradations of the same phenomena of achieving focal muscle contraction of varying forces at a physiological level. Stretching occurs at the myofibrillar level with breaking of the actin–myosin bonds responsible for sarcomere shortening and stiffness' (Chu 1995, 1997).

Historical development of Gunn-IMS (Fig. 14.2)

Dr Gunn began working at the Workers' Compensation Board in British Columbia, Canada in the late 1960s. Of all patients seen at the outpatient clinic, 33% were for injuries to the lumbar spine, and of these 86% were given the working diagnosis of 'low-back sprain'. Included in this group were a large number who did not have localizing radicular signs on physical examination and were not surgical candidates, yet frequently suffered prolonged disability. Dr Gunn observed that many of these patients had tenderness at points confirmed by chronaxie measurements to be motors points, and these tender motor points were usually found in multiple sites within the myotome. Further, while performing electrodiagnostic studies, subtle abnormalities consistent with neuropathy were seen in these tender muscles. This clinical work led to the publication of *Tenderness at motor points: a diagnostic and prognostic aid for low-back injury* (Gunn & Milbrandt 1976a), in which patients diagnosed with 'low back strain' who also demonstrated tenderness at motor points were found to have disability duration that approximated patients who had radicular signs, and that these groups also tended to show more severe spondylotic X-ray changes compared with patients without tender motor points. These results led to the conclusion that tenderness at motor points could be a useful diagnostic and prognostic sign in this group of enigmatic patients.

In addition to the above observations, Gunn found that many patients previously given such diagnoses as 'gluteal bursitis', 'trochanteric bursitis', 'sciatica' or 'adductor strain' could often be found to have tenderness at motor points. Having recognized the myotomal pattern of such findings, he next investigated 'tennis elbow', seeking to determine if there existed patients in this diagnostic group who, failing treatment directed at the presumptive local overload cause for their presentation, might respond to treatment directed subsequently to the cervical spine. In *Tennis elbow and the cervical spine* (Gunn & Milbrandt 1976b), Gunn concluded that treatment to the cervical spine (consisting of manual mobilization, cervical traction, isometric cervical exercises and heat and/or ultrasound) appeared to give relief to the majority, and that further, the pain was demonstrated to

1966

Dr. Gunn starts working with WCB

1970

Dr. Gunn encounters Cannon's Law

1974

Dr. Gunn travels to China to observe acupuncture

1976

Tenderness at motor points
-First mention by Gunn of tenderness at muscle motor points
-A myotomal pattern of tender motor points is observed
-Points to a connection between extended disability times, motor points & radicular involvement

Tennis elbow and the cervical spine
-Myotomal pattern of tender muscles again noted
-First mention of autonomic signs and affects of muscle shortening
-Unresolved tennis elbow pain is linked to cervical pathology
-EMG evidence supports cervical radiculopathy as a precipitating factor in some clients

1977

The neurologic mechanism of the needle-grasp in acupuncture
-Points to the view that muscle tension, causing pain is caused by deep neurologic structures (intrinsic), not superficial nociceptive structures (extrinsic)
-Introduces the term partial denervation as an extension of Cannon's Law

1978

Transcutaneous neural stimulation, acupuncture and the current of injury
-Continues to differentiate between intrinsic and extrinsic receptors and treatments
-Uses neurophysiology and the current of injury to explain why stimulation with a needle is preferred over transcutaneous stimulation

Early and subtle signs in low-back sprain
-Correlates physical findings related to neuropathic supersensitivity with low back pain
-Lists and explains the important findings when a mixed motor nerve is affected
-Confirms radiculopathy as the source of subtle findings in otherwise 'normal' patients with myalgic hyperalgesia

1980

'Prespondylosis' and some pain syndromes following denervation supersensitivity
-Names spondylosis as a cause of radiculopathy
-Radiculopathy as the cause of partial denervation supersensitivity
-Introduces 'prespondylosis' as the early stage of neural decay
-Introduces the concept of pain following neuropathy
-Runner up for the Volvo award

Dry needling of muscle motor points for chronic low-back pain
-Introduces the idea that a different classification of pain to include neuropathy was both important to understand and treat effectively. Presents the early system we now call GunnIMS
-Was submitted to the 1979 Volvo Award competition

1989

Neuropathic pain: A new theory for chronic pain of intrinsic origin
(This paper was presented to the AGM of the Royal College of Physicians & Surgeons)
-This paper represents the introduction of the neuropathic model" Dr. C.C. Gunn
-Introduces the requirement of a new classification of pain
-Mentions that needles promote the release of growth factors

Figure 14.2 • Timeline of the development of Gunn-IMS radiculopathic model.

be maximal at motor points around the elbow rather than epicondylar. He also concluded that 'the more resistant the condition, the more severe were the radiologic and electromyographic findings in the cervical spine.' These conclusions suggested that some cases of unresolved 'tennis elbow' may be related to 'reflex localization of pain' from cervical radiculopathy.

Interest in acupuncture in the West significantly increased in the 1970s, at which time Melzack and Wall's 'gate control theory of pain' first postulated the modulation of painful stimuli through stimulation of large diameter fiber afferent nerves. After traveling to China to learn about acupuncture, Dr Gunn became interested in attempting to reconcile this ancient technique with a scientific explanation. It was also becoming recognized at that time that there was a high degree of overlap between acupuncture points with motor points. In 'Transcutaneous neural stimulation, needle acupuncture & 'Teh Ch'i' Phenomenon' (Gunn 1976), Gunn reasoned that since the recognized greatest relief with acupuncture was obtained by elicitation of the subjective feeling of 'Teh Ch'i' (deep soreness, heaviness, pressure, numbness or fullness), this response was likely due in part to the mechanical stimulation of large diameter fiber muscle proprioceptors. This was consistent with the 'gate control theory of pain', and since the largest population of large fiber afferents are from muscle proprioceptors located maximally in the zone of innervation near the neurovascular hilus and underlying the motor point, treatment directed to these points would be both specific and effective.

Continuing in his effort to explain the effects of acupuncture in scientific terms, Gunn next published *'The neurological mechanism of needle-grasp in acupuncture'* (Gunn & Milbrandt 1977a), in which he proposed that in addition to the subjective feeling of 'Teh Ch'i', which is a constant finding with proper placement of the needle in the neurovascular hilus, the objective component, where the needle is seen to be 'grasped', or 'sucked in', is a more variable finding. In this paper he first introduces the concept that partially denervated, or neuropathic muscle contains a hypersensitive muscle spindle mechanism, and that 'intense needle-grasp' is probably only present in such muscles, and most obvious at tender motor points. He also reasoned that 'similar positive feedback mechanisms of hypersensitive nociceptor loops probably account for the 'Trigger Points of myofascial syndrome', and was synonymous with the osteopathic terms 'somatic dysfunction', 'facilitated segment' and 'osteopathic lesion.'

In *'Transcutaneous neural stimulation, acupuncture and the current of injury'* (Gunn 1978), Gunn references 'Cannon's Law' for the first time and proposes that many 'musculoskeletal' or 'myofascial' pain syndromes are probably related to neuropathy and 'denervation supersensitivity.' He also proposes that the intramuscular 'current of injury', the measureable electric current that is created at the site of tissue injury (e.g. that initiated by needling) may provide a therapeutic effect of reversing denervation supersensitivity similar to that shown experimentally by exogenously applied electrical stimuli (Lomo & Rosenthal 1972, Lomo & Westgaard 1975).

As his understanding of neuropathic pain continued to evolve, Dr Gunn recognized that in addition to tenderness at motor points, there were other subtle examination findings that were common in this population diagnosed with 'low-back sprain'. These findings included autonomic dysfunction of the pilomotor and sudomotor reflexes ('gooseflesh' and hyperhidrosis), vasomotor disturbances (skin mottling and cool skin), trophic edema and increased muscle tone. In *'Early and subtle signs in low-back sprain'* (Gunn & Milbrandt 1978), Gunn presented his clinical findings that in patients with tender motor points, one or more of these signs occurred in all patients, while their presence was less common and less severe in patients without tenderness at motor points or controls. In addition, these signs were present when the patients were in pain and largely resolved when they became pain free. Increased muscle tone was frequently seen in muscles of both the anterior and posterior rami, supporting a radicular locus of the lesion. Since the spinal nerve is a mixed nerve, individual findings could be explained on the basis of a variable combination of dysfunctions caused by injury to the sensory, motor and/or autonomic components, and projected intra-segmentally in the corresponding dermatome, myotome and sclerotome.

Integrating all of his previous clinical findings and published papers, Dr Gunn then completed a clinical trial of his evolving model, 'Dry needling of muscle motor points for chronic low back pain: a randomized clinical trial with long-term follow-up' (Gunn et al. 1980). Patients who had failed to improve following a course of traditional therapy (physical and occupational therapy, postural exercise, body mechanic instruction) were randomized to receive dry needling at tender motor points according to principles outlined in preceding published papers. Status was assessed at the completion of treatment (average number of treatments

7.9) and follow-up at 12 and approximately 27 weeks. Those treated with dry needling were found to be 'clearly and significantly better than the control treatment' by three separate statistical analyses of status. The next section will review the clinical evaluation of the patient with RNMP, its treatment with Gunn-IMS, and the published clinical studies that validate it.

Clinical application of Gunn-IMS

Introduction

The proper practice of Gunn-IMS requires that the clinician remains mindful of the radiculopathic model and the effects of partial denervation supersensitivity. In doing so, the practitioner will easily be able to collect signs and symptoms that focus attention on the appropriate spinal levels. Treatment directed at the affected spinal levels is mandatory in Gunn-IMS (Gunn & Milbrandt 1976b), and along with the corresponding segmentally innervated muscles exhibiting positive findings, will provide the best outcomes (Gunn & Milbrandt 1976b, Ga et al. 2007b). Neuropathic signs and symptoms will often improve, along with an increase in limited range of motion and restoration of normal movement patterns. Without ensuring that the radiculopathic model is the basis of all decisions, client outcomes and therapist satisfaction with this technique may suffer. Kim et al. (2003) documented a study where neuropathic signs and symptoms helped to identify the true cause of pain in patients where surgery had failed. In this study, failed back surgery syndrome patients were assessed with a simple and general Gunn-IMS clinical exam and treatment. All patients showed improvement in their symptoms, leaving doctors to consider Gunn-IMS as an alternative effective treatment modality for failed back surgery syndrome patients.

One of the most notable and consistent comments offered by newly certified Gunn-IMS Practitioners is how its use immediately translates into better outcomes in clinical practice. Many conditions that have been resistant to standard therapies will improve dramatically when the neuropathic component is treated using Gunn-IMS. Therapy that adheres to the tenets of Gunn-IMS will identify neuropathy, where present, and treat the myotomal level(s) affected. When a myotomal pattern is present, both proximally in the paraspinal, and distally in the distribution of the anterior ramus, radiculopathy is confirmed (Gunn 1996). The ensuing treatment must target both the erector spinae and distal myotomally linked muscles.

The information that follows is sufficient to understand how the clinical exam is used to determine the presence of neuropathy and provide basic information regarding what is required of a therapist to treat using Gunn-IMS. In order to become a safe, competent and certified Gunn-IMS Practitioner, instruction from a certified Gunn-IMS Instructor is required.

Patient history and past treatment

Gunn-IMS is the most appropriate treatment technique when the patient presents with clear signs of neuropathy. In patients where inflammation is the dominant presentation, a strategy specific for the control and resolution of an inflammatory process must be followed. The determination of pain type is simplified by reviewing the characteristics of each class of pain. Nociception produces immediate pain in the presence of noxious stimuli associated with the threat of tissue damage, and precipitates the 'fight-or-flight' behavioral response. Inflammation can produce acute pain by damage to tissue that releases chemicals that activate nociceptors, and behaviorally precipitates care, concern, and anxiety. When due to direct trauma, inflammation is a self-limited process that responds to supportive measures. Strains and sprains should typically heal within weeks. Chronic pain, by definition pain lasting more than three months, may occur in the presence of ongoing nociception, psychological factors or alterations in the central or peripheral nervous system, and behaviorally can lead to depression (Gunn 1996). A review of the injury mechanism, current presentation and overall duration will help in determining which of the classes fit the patients' pain characteristics. Current and recent use of medication is a valuable tool in understanding the class of pain. In radiculopathic patients, anti-inflammatories are often of limited use and muscle relaxants may help in the short term, both being discontinued if the side-effects outweigh the usefulness of the drug. More recently, a tour through the different (anti) neuropathic medications is often attempted with varying levels of effectiveness. In these cases, the patient often presents with a desire to further decrease their pain while decreasing their use of medications.

The patients' history will often be characterized by pain with no obvious cause. If a history of an injury is present, it may seem trivial compared to the severity and consequence of the patient's pain. The insidious nature of neuropathy is often the result of spondylosis, the most common cause of radiculopathy (Gunn 1980). Multiple diagnostic tests (X-ray, MRI, CT and EMG/nerve conduction tests) may have been ordered but offer little to correlate with the presentation of pain. There must be no obvious signs of complete denervation (e.g. severe atrophy, absent reflex, complete anesthesia) as the radiculopathic model is specific to partial denervation supersensitivity. Partial denervation, or neuropathy, causes any tissue supplied by an affected nerve to become abnormally sensitive to a variety of normally non-noxious stimuli. From the perspective of patient complaints the most common and significant tissue that develops supersensitivity is skeletal muscle (Gunn 1996). This supersensitivity causes the 'shortened muscle syndrome', creating long standing tension throughout the muscle and its tendon(s). The muscles and tendons may respond to this pull by chronically thickening (enthesopathy). The patient may have been told incorrectly that this is a tendonitis, even though the only clinical feature is tenderness and there is a lack of inflammatory signs. When the muscle exerts force on or over a bursa the popular diagnosis may be bursitis, even though repeated treatments and local injection prove unsuccessful. Past treatment, which has been directed locally, may have decreased the pain, however, the response is often short lived or minimal. The local treatments that may have proven partially effective often include massage, physical therapy and finally TrP injections. The radiculopathic model explains why these treatments may be only partially effective for this subgroup of patients. All physical methods of treatment that provide some relief in neuropathic pain are ultimately forms of energy which stimulate specific receptors, and as such they may help to decrease the supersensitivity of a neuropathic region (Gunn 1984). When the patient demonstrates a history of partial success with short acting stimulation type treatments such as massage, TENS, exercise or manipulation, Gunn-IMS may serve as the necessary additional supply of a more specific, localized, higher intensity and prolonged stimulation through the current of injury. In the case of stubborn pain when simple methods prove ineffective, Gunn-IMS is indicated (Gunn 1996). There is no need to waste time and money on expensive tests and long wait lists for specialist referrals.

Physical assessment

It is reasonable to expect that the clinical exam be straightforward, focused, and easy to carry out. Gunn-IMS is based on the recognition that neuropathy most often occurs at the level of the spinal nerve root (radiculopathy) with its three divisions (motor, sensory, autonomic). For ease of presentation the physical signs that follow are organized according to these (3) divisions. When radiculopathy is present, and pain is a presenting symptom, it is often accompanied by muscle shortening, tender focal areas in muscle (TrPs) and autonomic and trophic manifestations (Gunn 1996).

Sensory findings

Peripheral nerve supersensitivity affecting sensory fibers may present as altered pain reports. Allodynia and hyperalgesia refer to complaints of excessive muscle tenderness to typically non- or mildly noxious stimuli, for example, tenderness using flat palpation or gentle squeezing. Hyperpathia refers to client reports of prolonged duration of pain from nociceptive stimuli, reflecting the phenomenon of superduration as described originally by Cannon. Testing for hyperpathia is typically performed using a pinwheel over suspected dermatomes. The presence of these signs may be indicative of peripheral sensitization secondary to peripheral nerve dysfunction, neuropathy.

Motor findings

Observation

The observation and assessment of motor involvement are perhaps the most familiar and recognizable components of the neuropathy-radiculopathy assessment. They are important in that muscle shortening is an early feature of radiculopathy and may occur in the absence of pain (Gunn 1980). Identification of shortened muscles, therefore, allows for early intervention prior to the perception of pain. Observations such as scoliosis, non-anatomic leg length discrepancies, elevated shoulders or skin creasing will draw the therapist's attention to muscle shortening without the use of expensive imaging tests. The innervation of each indicated muscle directs the clinician to specific spinal levels where further testing may support or refute the observational findings.

Range of motion

The shortening of muscle at rest is easily measured as decreased range of motion. The use of a simple and inexpensive goniometer or tape measurement is the only equipment required to accurately quantify current status and future improvements in most cases.

Palpable bands

Tenderness at motor points was the first clinical feature commented on by Gunn and Milbrandt (1976a). They postulated that partial denervation supersensitivity may lead to increased irritability of muscle and contribute to the muscle shortening seen in neuropathy (Gunn & Milbrandt 1978). On examination, muscle contractures ('taut' or 'ropy bands', 'contraction knots') with exaggerated tenderness (myalgic hyperalgesia) are identified by utilizing a snapping palpation directed perpendicular to the muscle, the presence of which must be notated with attention to the corresponding level of motor innervation.

Autonomic findings

The autonomic portion of peripheral nerves is responsible for controlling many visceral functions. The effects are often un-noted or overlooked as they are thought to be unrelated to the report of pain. Since autonomic patterns of innervation do not always strictly follow dermatomal, myotomal or sclerotomal distributions, their clinical manifestations are less segmentally localizing. Yet attention to this division of the spinal nerve root rounds out the evidence for radiculopathy and was first commented on by Gunn and Milbrandt (1976b). As with the sensory and motor signs, the approximated affected segmental level must be noted for each autonomic sign observed.

Vasomotor disturbances

Vasoconstrictor disturbance secondary to smooth muscle contracture may be observed as mottling of the skin. Additionally, affected areas will be perceptively cooler to palpation, as tested with the back of the examiners hand. In recent times thermographic scans have become more popular, although, for the purpose of this assessment are unnecessary.

Figure 14.3 • L2-3 dermatomal hair loss due to trophic disturbance.

Sudomotor reflex

The pattern of sweating and tendency to sweat is noted. In partial nerve palsies there is an increased sweat response and hyperhidrosis may be noted in affected areas in a characteristic nerve root pattern (Gunn & Milbrandt 1978).

Pilomotor reflex

The pilomotor reflex ('gooseflesh' or 'goosebumps') may be observed when the affected area is undraped for examination. This reflex may also be elicited when palpating or needling muscles of the affected segmental level.

Trophic changes

When the nutritional supply to a tissue is decreased, proper growth may be delayed or absent. A change in nutrition may be observed as alterations in skin, nails, subcutaneous tissues, muscles, bones, and joints (Gunn & Milbrandt 1978). The pattern of hair loss is a common indicator for altered nutritional status. Figure 14.3 shows loss of hair at the L2–3 nerve root level in a hirsute male.

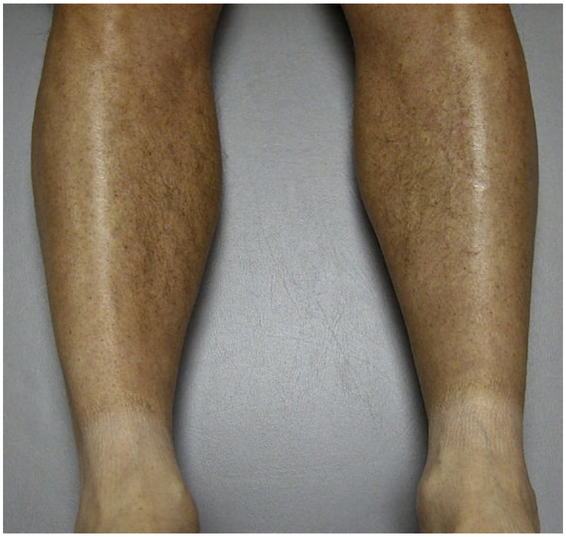

Figure 14.4 • L5 dermatomal hair loss due to trophic disturbance.

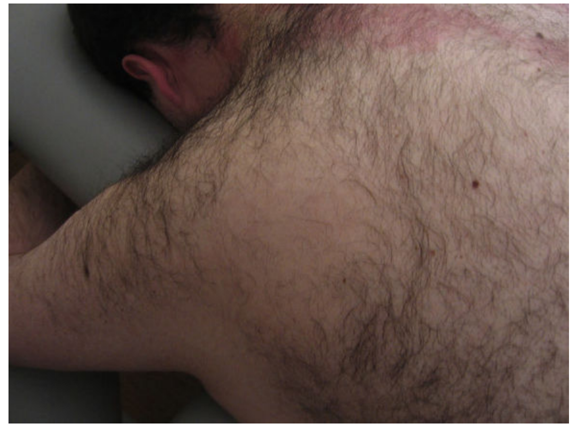

Figure 14.5 • C5 dermatomal hair loss due to trophic disturbance.

Figures 14.4 and 14.5 show additional similar patterns of hair loss at other dermatomal levels (L5, C5). Essential in the Gunn-IMS assessment is the identification and consideration of clinical signs that have often gone unnoticed or were not considered relevant.

Neuropathy may also lead to decreased collagen quality and fewer cross-links with subsequent compromise of the integrity and strength of ligaments, cartilage and bone, and so contributing to a variety of degenerative conditions in weight-bearing and activity-stressed structures. 'These secondary conditions…are probably only the ultimate sequelae of neuropathy. Degenerative disc disease itself may not be a primary condition' (Gunn 1980). Findings may include ligamentous and capsular joint laxity, subluxation or instability.

Trophic edema

When efferent impulses in an autonomic peripheral nerve are partially interrupted, smooth muscle contracture ensues and trophic edema occurs (Haymaker & Woodhall 1953). The matchstick test is another example of the high degree of specificity afforded with this assessment without the need for expensive procedures or imaging (Figure 14.6). Although the matchstick has been replaced by the blunt end of a swab, the test remains the same. The blunt end is firmly pressed into the skin throughout the tested area. A positive test is indicated when the indentation appears deeper, has defined edges and does not resolve for some time (Gunn 1996).

Figure 14.6 • Matchstick test for neurogenic edema.

The presence of a *peau d'orange* effect may also be used to identify trophic changes. Figure 14.7 shows a clinician performing this test by bunching up a section of skin to see if it appears similar in appearance to an orange peel. Neurogenic edema can also manifest as the variable and intermittent swelling around joints, often mistakenly attributed to inflammation despite the absence of evidence of tissue damage.

These sensory, motor and autonomic signs may identify both the presence of neuropathy and the affected spinal segment(s). Treatment should be directed to the segment indicated with re-testing performed in each future session.

Figure 14.7 • *Peau d'orange* ('orange peel') appearance of skin and subcutaneous tissue by skin rolling technique.

Treatment

Evidence based medicine requires clinical practice to rely on the therapists' individual clinical expertise and the best available scientific evidence. Clinical expertise increases with our experience and practice, while evidence increases with advances in the basic sciences and patient centered clinical research. These two aspects are the backbone of our decision-making and must be combined with the patients' predicaments, rights, and preferences (Sackett et al. 1996).

When planning Gunn-IMS treatments, clinicians must keep in mind the history and pathophysiology that supports the radiculopathic model as the science is both growing and unbiased in its support. We must also keep in mind the evidence for the use of Gunn-IMS in this group of clients as accessibility and treatment results often favor Gunn-IMS techniques for RNMP. Clinical research continues to expand our understanding of treatments for neuropathy. By using a needle, the clinician makes use of an ancient technique for stimulating the body. The ancient practice of acupuncture is credited with the discovery of the effects of stimulation on the body, and modern techniques have updated the practice with modern needles. Gunn spoke of the use of needles for treatment in terms of stimulation of motor points in 1976. Lewitt directly compared an injection technique to non-injection stating:

> …in reviewing techniques for therapeutic local anaesthesia of pain spots, it appeared that the common denominator was puncture by the needle and not the anaesthetic employed.
>
> (Lewitt 1979)

The current use of Gunn-IMS follows this rich history of non-pharmaceutical treatment and updates it with modern science and physiology. In clinical practice the treatment must be combined with patient rights and preferences, assisting in the growth of clinical experience.

An interesting series of studies by Ga et al. (2007a, 2007b, 2007c) directly compared different needling techniques for their effect in treating TrPs in myofascial pain. In the first study, acupuncture was compared to lidocaine injection (Ga et al. 2007a). Both groups demonstrated improvement in pain reports and range of motion but were not found to be significantly different. In another study intramuscular and nerve root stimulation was compared to lidocaine injection (Ga et al. 2007b). The intramuscular stimulation technique was found to be superior in reducing pain, increasing range and decreasing depression. The dry needling technique used was described as modified TrP needling as described by Simons with nerve root stimulation as described by Gunn. A final study directly compared dry needling of TrPs with and without paraspinal needling (Ga et al. 2007c). The results were similar to the previously mentioned study with the authors stating, 'TrP and paraspinal dry needling is suggested to be a better method than TrP dry needling only for treating in elderly patients.'

Karakurum et al (2001) published a paper titled 'The "dry-needle technique": intramuscular stimulation in tension-type headache.' They compared treatment with intramuscular stimulation (IMS) with a placebo group that utilized shallow needle insertions. The insertion points used in each group were consistent, differing only in depth of penetration. The study concluded that the treatment (IMS) group was more effective in reducing the tenderness score and increasing neck range of motion. With sufficiently supportive scientific clinical evidence (Gunn et al. 1980, Chu 1995, 1997, 1999, Karakurum et al. 2001, Ga et al. 2007a, 2007b, 2007c), the clinician can be confident that treating paraspinal muscle segments as well as corresponding distal muscles will provide optimal results in this group of patients. With this in mind, the number of treatments, duration of each session and style of needle insertion will be explained.

Number of treatments

It is common for treatment of a non-complex condition to be completed in 6–8 sessions, although more severe cases require a more prolonged course of intervention. Treatments occur once per week, on consecutive weeks. Gunn et al. (1980) found the average number of treatments/condition to be 7.9 sessions in injured workers with chronic low back pain. Other studies reporting successful outcomes with the Gunn-IMS model have used as few as 3 (Ga et al. 2007b, 2007c), or 4 treatments (Karakurum et al. 2001), and as many as 36 or more for patients with long duration symptoms associated with lumbar spinal stenosis, post-laminectomy and fibromyalgia (Chu 1999). These studies did not attempt to identify the number of treatments required for optimal results and, as such, should not be considered for this purpose. The resolution of supersensitivity and reversal of neuropathic signs must be the most important factors used to determine the length of a course of treatments. Detailed re-evaluation after 6 treatments will establish a baseline of initial response and allow for prognosing the likely frequency and length of additional treatment.

Duration of session

It is advised that assessment and treatment be scheduled for 45–60 minutes. A typical treatment time recommended for Gunn-IMS is 30 minutes. This allows time for updating the patient's report of interval responses to treatment, proper testing, explanation, thorough treatment and re-testing with final explanations and advice. The invasive nature of the treatment must also be considered. Permitting sufficient time for the treatment allows the patient to remain calm. If the client feels rushed and nervous, strong autonomic response may accompany treatment and precipitate treatment limiting vasovagal responses.

Needle insertion

Gunn-IMS treatment requires needle stimulation of skeletal muscle. With the choice of muscle being driven by the assessment findings, how does one choose the site of needle insertion? Gunn's initial observation was the tender motor point. Today, palpation of tight bands combined with allodynia and hyperalgesia are the typical findings that finely focus needling practice. The use of a hand-held device commonly called a 'point finder' that measures electrical skin resistance can be useful to more precisely localize the sites likely to provoke the strongest responses but is not routinely necessary. These correspond to the motor endplate regions, where TrP are often found. The amount of stimulation administered is dependent on the patient needs and tolerances and then by the goals of treatment. In the first treatment the number of points and stimulation administered is considerably less than in later treatments. This number will often fall within 12 treatment points, including treatment of up to four spinal segments. The number of points used is considerably less important than the patients' comfort with treatment and the amount of supersensitivity present. Highly supersensitive patients will usually respond favorably to fewer points than those who are moderately or minimally supersensitive. Even patients with a history of prior Gunn-IMS treatment that appear to tolerate points well should only receive a minimal number of points on their initial visit. In later sessions the number of needle insertions may increase as supersensitivity decreases. Audette et al. (2004) demonstrated that 'in subjects with active TrPs, bilateral motor unit activation could be obtained with unilateral needle stimulation of the TrP', suggesting that treatment in the presence of active TrPs and bilateral symptoms does not necessarily require bilateral treatment. The decision regarding the number of points to needle in each session is made using clinical evidence but requires clinician experience. If a smaller number of points are used initially, an increase in points may subsequently be required and tolerated by the patient.

Needle-grasp

Gunn and Milbrandt stated in 1977 that, 'when needle agitation occurs in a partially denervated or neuropathic muscle, the intense local muscular contraction causes the needle-grasp and in extreme cases bending of the needle.' They expand on this phenomenon stating that the exaggerated discharge on needle insertion 'may cause the muscle to fasciculate and relax'. Fasciculation, also called the 'local twitch response', is the term for clinically observable twitching of a group of muscle fibers belonging to a single motor unit. This muscular reaction assists in the identification of muscles that both require treatment and will respond best to Gunn-IMS. The needle-grasp is characterized by resistance to needle removal, reflecting increased reflex muscle contracture-shortening, whereas a local twitch response is characterized by a brief contraction.

There appears to be current interest in discerning the difference between these graded manifestations of response to the needle. In the Gunn-IMS model this is of interest but not of fundamental importance. The act of properly targeted stimulation is the goal and not all spots elicit a local twitch response or a needle-grasp. In particular, the paraspinal muscles appear to twitch less frequently but are often found to harbor many contractured muscles that are important to treat with needle penetration. The use of snapping palpation is useful in identifying TrPs in distal and more superficial muscles but may be less relevant for identifying deep paraspinal muscles in need of treatment. Systematic examination and treatment of the paraspinal muscles, especially the deeper multifidi, is thus required to probe and feel a tightened band, fibrosis, or even a deep needle-grasp, the 'silent lesion'. As previously discussed, this will often elicit sub-clinical fasciculations that are therapeutic (Chu 1997).

Treatment with needle stimulation is a function of the number of points, the duration of stimulation per point and the style of needle manipulation used. It is not possible to provide a clear single formula to quantify stimulation during treatment, as this has not been adequately tested. The field of treatment using dry needling is still growing and future testing will help to quantify and qualify answers to these questions. Perhaps most importantly, the clinician should consider the effect of stimulation on the patient. If the patient is too sensitive to handle the current application, it must be changed to accommodate both the patients' tolerance and the therapeutic need for stimulation. For example, a quick insertion that elicits a local twitch response may be enough stimulation in a highly sensitive shortened muscle. In this case, the local twitch response can occur immediately, even with a short duration of stimulation. In the event that a local twitch response has not occurred, the clinician may wish to explore the muscle further. Within a short period of time a local twitch response may be found, or in the absence of a twitch or deep ache, the clinician may deem the tissue normal and not in need of treatment. For those muscles where needle-grasp is intense and more sustained than with the LTR, leaving the needle in place for some time allows for more gradual release of contractures and improved patient tolerance. Attempting to prematurely removal the needle leads to the potential of the patient moving or 'jumping', and introduces unnecessary risk. It is therefore advisable to treat additional areas only after the release of muscle contracture and removal of the needle. These examples illustrate that stimulation parameters are often varied for both patient comfort and desired treatment affect. As this field grows, it is expected that more guiding principles on treatment parameters will be developed. In the meantime, we must make use of the experience of the founders of dry needling techniques. Gunn has written:

> Failure to induce needle-grasp signifies that muscle shortening is not the cause of pain and that the condition would probably not respond to this type of treatment. Penetration into almost any part of the muscle can lead to relaxation, but the most rewarding sites are at tender and painful points in muscle bands. These points (which often correspond to traditional acupuncture points) are generally situated beneath muscle motor points, and at musculotendinous junctions.
>
> (Gunn 1996)

Considering these possibilities, one can see that providing the optimal amount of stimulation requires experience. If the therapist elicits a local twitch response by gently penetrating the area, multiple insertions may be tolerated. Alternatively, overly forceful insertions provoking a strong needle grasp and accompanied by premature attempts at needle removal may often result in decreased client tolerance and may unnecessarily risk an adverse reaction such as fainting or non-compliance due to discomfort. When acquiring experience it is advised to remain on the light side of stimulation. By doing so, the shortened muscle and supersensitivity will respond favorably to treatment while respecting patient comfort and tolerance.

Concurrent treatments

From the perspective of treatment goals, it must be remembered that all treatments are forms of stimulation, and in supersensitive patients excessive stimulation can result in poor outcomes. Treatments occurring concurrently should therefore be discouraged by the therapist to avoid potentially negative additive effects. From a safety perspective therefore, it is contraindicated to have joint manipulation immediately after Gunn-IMS. The decrease in protective muscle spasm leaves weakened ligaments and vessels at risk. If Gunn-IMS is being spaced out by 5–7 days and needle insertion is adding the correct amount of stimulation, concurrent treatments could introduce the risk of overstimulating the patient. Thus, by having the patient receive Gunn-IMS alone, the results of treatment can be more accurately evaluated. For similar reasons patients are encouraged to avoid undue physical stress or activity in the days following treatment.

On the second visit, the clinician will assess the efficacy of care and the client's response to treatment. The patient is encouraged to perform gentle functional activities which allow the neuromuscular unit a period of normalized action post treatment. Gunn-IMS must be seen as a method to encourage normal function within the neuromuscular unit rather than a tool that loosens a muscle in order to allow for other mechanical treatments such as manipulation. The effectiveness of this treatment demonstrates that the condition is an electrical problem for which mechanical treatment alone will be insufficient to fully address the signs and symptoms.

Re-assessment

The response to treatment can often be surprisingly quick and deserves re-assessment each session. The start of each treatment session includes questioning the patient to determine the effects of care. A mini-assessment should also be used to re-test appropriate critical assessment findings for evidence of change that correlate to the patients' subjective reports. Choosing outcomes that are a possible consequence and measure of radiculopathy is an important requirement. Their use will remind the therapist of the need for tracking of motor, autonomic and trophic signs that affect both anterior and posterior primary rami of the affected nerve root.

The tools of Gunn-IMS

Although the Gunn-IMS plunger used to hold the needle is often seen as the distinguishing tool of the Gunn-IMS technique, it is given far too much emphasis. The most important tools are the clinical examination and the interpretation of findings. Without these, a needle or plunger will not provide consistently positive outcomes. Having adequately discussed the exam and interpretation of results, the remaining tools to present are the needles, plungers, and required sterilization equipment.

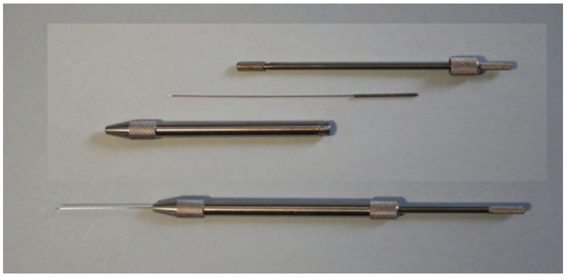

Figure 14.8 • Gunn-IMS plunger with needle.

Needle/sizes

Gunn-IMS uses standard solid filament needles. The most common lengths used vary between 10 mm and 50 mm, the choice of which is entirely dictated by safety and depth required. It is common when treating the cervical paraspinals to limit the needle size to 25 mm. Treatment in the gluteal muscle may often need lengths of 50 mm or 60 mm. Although traditional acupuncture needles are used, needles that are compatible with plungers are also common. These needles do not have the characteristic coiled wire end. Instead they have a small blunt end that fits easily into the locking mechanism of a plunger.

Plunger

The Gunn-IMS plunger is made up of two stainless steel or plated alloy pieces, an outer tube and an inner shaft. The needle handle fits into a locking mechanism on the tip of the shaft. This shaft and needle are inserted into the hollow tube and secured by a tightening screw. The loaded plunger will allow for easy insertion while preventing contamination of the needle from contact with non-sterile or unclean items during treatment. A disposable version of this re-usable medical device has recently become available (Figure 14.8). The disposable plunger is packaged with a needle and guide tube as is typical of any acupuncture style needle (Figure 14.9). An additional shorter guide tube is fit snugly overtop of the standard tube. Upon needle insertion, the longer guide tube is then removed leaving the short tube available for securing the insertion site and preventing over bending of longer needles. This novel device is a useful advance, allowing for easy manipulation of the needle once inserted. It is, however, relatively cumbersome when compared to the Gunn-IMS plunger as re-sheathing the needle and re-setting

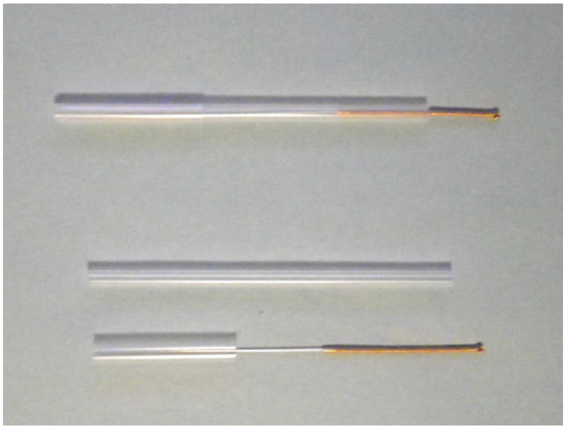

Figure 14.9 • Disposable plunger.

the shorter guide tube requires more time and focus to avoid a needle-stick injury while introducing a risk of contamination resulting from the needle touching non-sterile surfaces.

Cleaning and sterilization

Use of a standard plunger requires specialized equipment and thorough cleaning and sterilization procedures. The policies that dictate these procedures are dependent on the local governing bodies for health care, as well as the clinician's professional licensing body. Typical requirements include a mechanical cleaning followed by sterilization that utilizes steam under intermittent pressure (autoclaving). Clinic policy and procedures should allow for tracking of the use and effectiveness of properly validated sterilization techniques and equipment. It is imperative that national, regional and local requirements be consulted and implemented.

Case study example

Newly certified Gunn-IMS Practitioners may find consistent success by treating a classic case of pseudo-sciatica due to a gluteus medius TrP. The term 'classic' is intended to exclude significant disc injury or nerve root compression. There must be low back dysfunction with radiating leg pain and neuropathic findings indicating a lumbar source. Treatment should be directed at the spinal levels indicated by the assessment as well as to other muscles supplied by the affected nerve root. In this case you may wish to track pain reports (amount, duration, intensity), medicine usage, sleep disturbance and range of motion for the affected joints. Treat the patient once per week for the duration of symptoms using 30 minute appointments. The only additional treatment suggested is the typical client education one would expect for low back care. Avoid the use of other treatments such as mobilization, manipulation and bracing, as long as it is safe and pertinent to do so. In this way you will be able to compare your typical results with that of Gunn-IMS using outcome measures that are of significance to the patient's quality and enjoyment of life. In this patient case, needling of shortened paraspinals as well as distal muscles innervated by the affected myotome distinguishes Gunn-IMS from other dry needling techniques.

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Fu's subcutaneous needling

15

Zhonghua Fu   Li-Wei Chou

CHAPTER CONTENTS

Concept and terminology

Fu's subcutaneous needling (FSN) is a therapeutic approach for musculoskeletal painful disorders that originated from traditional acupuncture. This procedure is performed by inserting a special trocar needle into the subcutaneous layer around the afflicted spot to achieve the desired effect (Figure 15.1).

The name FSN, or *Fu Zhen* (浮针, in simplified Chinese; 浮針, in Traditional Chinese), has some profound implications. 'Fu Zhen' is the Chinese pronunciation for FSN. Fu is the surname of the inventor, who is also the first author of this chapter. In Chinese, 'Fu, 浮' means floating, and it could also mean superficial. 'Zhen' means acupuncture or needling. Therefore, in some English-language papers, FSN is also called Floating Acupuncture (Huang et al. 1998), Fu's Acupuncture (Zhang 2004), Fu Needling (Xia & Huang 2004) and Floating Needling (Fu & Huang 1999). However, neither *floating* nor *superficial* are precise translations; the word ***subcutaneous*** is a better substitute in terms of demonstrating the manipulation features of FSN.

Although FSN originated from classic acupuncture, FSN's manipulation and theory have nothing to do with the concepts of traditional acupuncture, such as meridians, acupoints, Yin-Yang, and *Qi*. Therefore, FSN is not some variety of acupuncture and should not be referred to as acupuncture. Figure 15.2 shows the FSN needle in a subcutaneous layer of a human cadaver.

http://dx.doi.org/10.1016/B978-0-7020-4601-8.00015-3

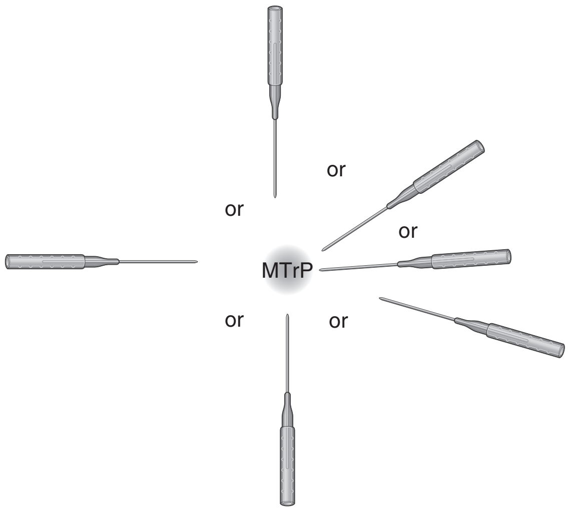

Figure 15.1 • A sketch map of Fu's subcutaneous needling.

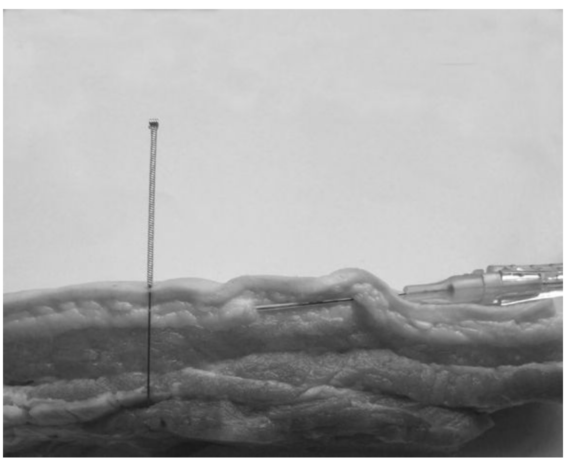

Figure 15.2 • Fu's subcutaneous needling needle locating in subcutaneous layer in a human cadaver

Another approach, called intradermal needle therapy, is easily confused with FSN. The intradermal needle (Figure 15.3) is a type of short needle made of stainless steel wire, especially used for embedding in the skin (Cheng 1987) rather than in the subcutaneous layer.

The term 'Fu's subcutaneous needling' was first mentioned in a 2005 article by Fu and Xu, in which they described the treatment method

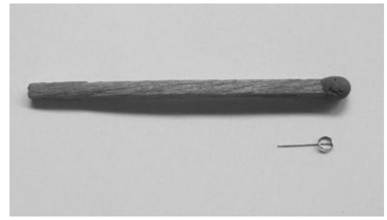

Figure 15.3 • The intradermal needle.

(Fu & Xu 2005), followed by several other research papers (Fu et al. 2006; Fu et al. 2007). FSN should be clearly distinguished dry needling, which involves the insertion of a fine single-use sterile needle into a trigger point (TrP) for the treatment of myofascial pain. Dry needling has been in use since the 1970s and differs from the use of needling from an Oriental paradigm (Baldry 1995, 2000, 2002, Chu 1995, Hsieh et al. 2007, Hong 2000, 2002, 2004, 2006, Simons 2004, 2008). TrP dry needling is based on a Western anatomical and neurophysiological paradigm and has been increasingly utilized in the Western world, especially in the US, UK, The Netherlands, Canada, Belgium, Norway, Australia, Switzerland, Ireland, Brazil, South Africa and Spain, among others (Dommerholt 2006). Unlike traditional acupuncture, dry needling does not consider ancient Chinese philosophy and traditional ideas. Traditional acupuncture is based on pre-scientific ideas, such as meridians, *Qi* (a kind of invisible energy) and Yin-Yang (Ellis et al. 1991, White & Ernst 2001, Kim 2004), whereas dry needling is entirely based on the recent understanding of scientific neurophysiology, anatomy, and pain sciences (Ghia et al. 1976, Melzack et al. 1977, Melzack 1981). The manipulation method used in acupuncture differs from that used in dry needling and is based on different theoretical foundations and principles.

Contemporary research and the emergence of dry needling have reduced the sense of mystique surrounding non-injection therapies for pain (Amaro 2008). Although acupuncture and dry needling have different theoretical bases, they are similar in some aspects:

1. Nothing is injected into the body;
2. Needles may target the same points known as either a trigger point in dry needling or an Ah-shi point in Chinese medicine; and

3. Many of the pain indications overlap.

Further, in trigger point dry needling the importance of the local twitch response is emphasized, which is a reaction during needling with some resemblance to the 'De-Qi' effect in acupuncture (Hong 1994). Chou et al. (2008, 2009) have modified the technique used in acupuncture into a procedure similar to Hong's dry needling technique. Therefore, in a 'broad sense' acupuncture can be considered as one type of dry needling.

FSN borrowed some ideas from traditional acupuncture, but its essential features are different from those of traditional acupuncture. Acupuncture and FSN are based on different theories and different techniques and manipulations are employed with entirely different kinds of needles. Traditional acupuncture theory is mystical, even to Chinese doctors. FSN is a much easier approach, which does not consider the traditional theories. Compared with the current practice of dry needling, FSN has several unique features. There are at least two differences between FSN and dry needling. FSN needles are inserted into non-diseased areas and FSN is confined to subcutaneous layers, whereas dry needling inserts the needles into TrPs and often deep into the muscles.

FSN is considered a particular type of dry needling. FSN shares the same scientific neurophysiological and anatomical foundation as TrP dry needling.

Origin of Fu's subcutaneous needling

The following three sources led to FSN's evolution from traditional acupuncture.

Contemplation of *De-Qi*

De-Qi or *Qi* (Cheng 1987) is an acupuncture phenomenon that occurs during needle manipulation, experienced by the patient as a particular sensation, e.g. soreness, aching, numbness, or 'needle grasp,' or by the acupuncturist as a pulling sensation (Li, 199, Langevin et al. 2006, White et al. 2008). Traditionally, *De-Qi* must be achieved in the process of acupuncture regardless of the manipulation used; otherwise, the therapeutic results are poor (Cheng 1987). In every textbook on acupuncture in Chinese, the importance of *De*-Qi is always emphasized and reiterated and acupuncturists repeatedly highlight *De-Qi*. As a result, most Chinese patients believe in the adage, 'no *De-Qi*, no effect.' Sometimes, patients will be disappointed in the acupuncturist if they fail to acquire *De-Qi*, even though it may cause discomfort to the patient.

Acupuncturists and patients are not the only ones who consider *De*-Qi to be pivotal. Some scientists also believe that *De*-Qi plays an important role in acupuncture analgesia (Cao 2002, Park et al. 2002). Acupuncture needling may activate afferent fibers of peripheral nerves to elicit *De-Qi*, the signal of which ascends to the brain, activates the anti-nociceptive system, including certain brain nuclei, modulators (opioid peptides) and neurotransmitters, and through the descending inhibitory pathway results in analgesia (Cao 2002).

However, occasionally acupuncture does work without *De-Qi* and could fail even when the patients achieve strong *De-Qi*. Furthermore, many acupuncture substitutes, such as cupping, moxibustion, transcutaneous electrical nerve stimulation (TENS), and so on, do not elicit *De-Qi*, but they appear to be effective nevertheless (Chen & Yu 2003).

Therefore, *De*-Qi may be not as relevant as traditionally is often suggested. To prove the insignificance of *De-Qi*, the best method is to stimulate the tissue without obvious direction and then observe what will happen. The elicitation of *De-Qi* is related to the needling depth (Lin 1997). There are few free nerve endings and proprioceptive receptors in the subcutaneous layer, whereas free nerve endings are abundant in the epidermis and dermis. Proprioceptive receptors do exist in the muscular layer (Tortora 1989). Therefore, there should be no occurrence of *De-Qi* even if the subcutaneous layer is stimulated. Under such a condition, does the needling effect still exist? For an acupuncturist, it is easy to verify the existence of the needling effect, and this simple trial was one of several factors resulting in the discovery and development of FSN. One example of a form of acupuncture where achieving De-Qi has been shown to not be critical is wrist-ankle acupuncture.

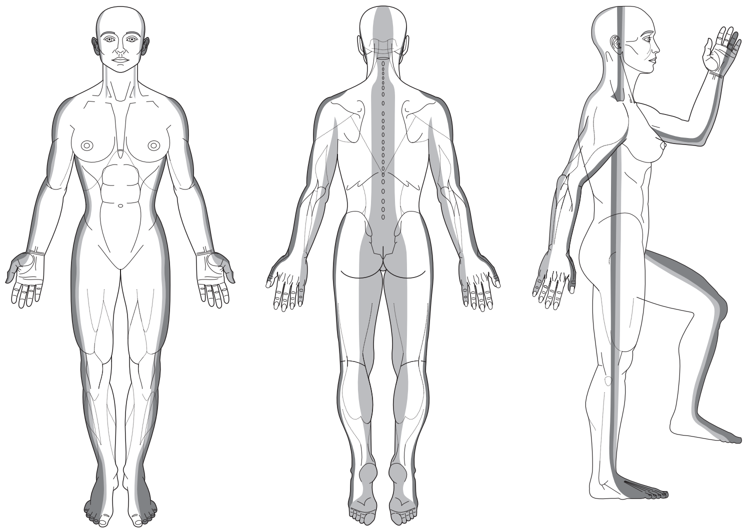

Figure 15.4 • 12 longitudinal regions according to wrist–ankle acupuncture.

Clinical application of wrist-ankle acupuncture

Wrist-ankle acupuncture (WAA) (Jiang et al. 2006) is also called wrist-ankle needling (Song & Wang 1985). Dr Xinshu Zhang, a neurologist who has worked at the Second Military Medical University in Shanghai, developed WAA in 1972. WAA divides the whole body into 12 longitudinal regions, six for each half of the body (Figure 15.4).

There are 6 points 2 *cun* (about 50 mm) above the wrist joint corresponding to the 6 regions above the diaphragm, and there are 6 points 3 *cun* (about 75 mm) above the ankle joint corresponding to the other 6 regions (Figure 15.5). A *cun* is a measure of distance relative to a person's body dimensions commonly used in traditional Chinese medicine. If a disorder occurs in one of the regions, the corresponding point should be chosen. Unlike conventional acupuncture, WAA inserts an acupuncture needle only superficially in the subcutaneous layer; some authors claim that WAA is effective in the treatment of pain with various origins (Zhu & Wang 1998). Needling superficially in WAA wrist or ankle points to treat distant disorders often has a good effect (Song & Wang 1985, Chu & Bai 1997) leading to the idea that needling close to the afflicted area could be at least as effective as needling in an area remote from that which is afflicted, and that needling closer may be preferable. These thoughts motivated the principle author to seek answers through clinical trials.

Figure 15.5 • Insertion style of wrist–ankle acupuncture.

Ancient techniques

The Medical Classic of the Yellow Emperor (also known as The Yellow Emperor's Canon on Internal Medicine or The Yellow Emperor's Inner Classic), written thousands of years ago, is a fundamental book of Traditional Chinese Medicine. The book states that needling superficially and needling nearby are two characteristics of the ancient techniques for the treatment of painful problems. The principle author of this chapter learned from and was inspired by these techniques in the process of developing FSN. In The Medical Classic of the Yellow Emperor, there is a chapter entitled 'Guanzhen,' which records 26 special techniques. The 26 techniques are classified into three groups: a 9-technique group, a 12-technique group, and a 5-technique group.

The characteristic of superficial needling refers to quite a few techniques, such as *MAO Ci* in the 9-technique group, *Zhizhen Ci* and *FU Ci* in the 12-technique group, and *Ban Ci* in the 5-technique group. Among them, especially *Zhizhen Ci* resembles FSN. Hold up the skin with the thumb and index fingers of the left hand; insert the filiform needle into the skin; and then go forward toward the painful spot obliquely. *Zhizhen Ci* can be said to be a precursor to FSN without FSN needling and its swaying movement.

Needling nearby is often seen in the 26 techniques, such as *Fen Ci* in the 9-technique group, *Hui Ci*, *Qi Ci*, *Yang Ci*, *Duan Ci*, and *Pangzhen Ci* in the 12-technique group, and *Baowen Ci*, *Guan Ci*, and *Hegu Ci* in the 5-technique group.

Aside from the practicable techniques mentioned above, *The Medical Classic of the Yellow Emperor* also describes many systemic theories, such as meridians, acupoints, and Yin–Yang. Nevertheless, from then on, most ancient acupuncture texts adopted meridians, acupoints and other theories instead of practicable techniques as their main interests. The long-term neglect of more practicable techniques resulted in today's acupuncturists having little knowledge about this valuable ancient technique, which really is a precursor to FSN.

Based on the above ideas and thoughts, Fu devoted himself to seeking a new and effective treatment strategy and finally developed FSN in 1996, while he worked at the First Military Medical University in Guangzhou, China. The university ran a TCM Clinic in Zengcheng, a city near Guangzhou. In the clinic, patients who were in significant pain were more numerous than the author could deal with, which encouraged him to find ways to relieve the painful problems much more efficiently and quicker.

Fu attempted to treat a patient with tennis elbow or lateral epicondylitis by needling the patient near the painful spot, which caused a positive response, and as such became the first successful case of FSN. From then on, a series of clinical trials were completed and positive results were commonly achieved. In the same year, Fu wrote a brief introduction to FSN, which was published in a Chinese health newspaper (Fu 1996).The following year Fu published his first research paper in Chinese in the *Journal of Clinical Acupuncture and Moxibustion* (Fu 1997).

Development of FSN

Fu continued using FSN in his clinics and accumulated more and more evidence, which improved the technique and clinical efficacy of FSN. The initial focus was on developing the FSN needle and on increasing the indications of FSN.

Innovation of the FSN needle

In physics, scientific theories usually precede technologies. However, in traditional medicine, technologies or therapies often precede theories. Without any past experience to draw from or previous theories to follow, Fu had to develop FSN by trial and error. During FSN's early months, he used a filiform acupuncture needle, but over time several factors changed his thinking:

- When the range of the lesion was large or deep, FSN did not work well with filiform needles even when using many needles simultaneously.
- FSN needs a period of retention, and the patients could not stay in any settled position for extended periods of time. The patients should be able to move their bodies and limbs during needle retention. With a stainless-steel filiform needle patients easily can get hurt.
- In spite of the absence of discomfort or pain, patients often worried about the steel needle.
- FSN requires the needle to sway from side to side. The filiform needle is too elastic to allow for the swaying movement.

Fu realized that certain changes had to be made to the FSN needle; however, the challenge he faced was how to determine what kind of needle would

Figure 15.6 • Chinese patent certification of Fu's subcutaneous needling needle.

go through the skin quickly and stay beneath the skin safely.

Initially, a physical method was developed: a needle was invented using a new material. The material was solid at low temperatures, and became soft at high temperature. When not in use, the needle was stored in a refrigerator to keep it solid. When FSN was used, the needle would become soft after insertion due to the patient's body temperature. The concept was acceptable, but the material used for the needle and the refrigerators were too expensive for most acupuncturists.

Next, a chemical method was considered. Fu tried to produce a biological hard needle made of a high-polymer material, such as absorbable catgut, which would dissolve subsequently by tissue fluids. A large amount of time and energy were devoted to finding such a material, but none was found.

Finally, Fu invented a trocar needle, which is still used at this time. The FSN needle consists of two parts: a solid stainless-steel needle and its soft casing tube. The former is hard enough to break through the skin quickly and to ensure that the FSN needle can be easily controlled; the latter is soft enough to remain beneath the skin without continuously sticking the patient.

A patent application for the FSN needle was filed in December 1997. A Chinese invention patent was granted in August 2002 (Figure 15.6).

Increase of FSN indications

To determine whether a particular disorder would be a suitable indication for FSN, an immediate effect would need to occur with FSN, which was later referred to as 'the golden criterion'. Disorders or symptoms for which FSN did not get immediate results were not included into the indications for FSN. After the first successful case, Fu continued searching for other FSN indications, a process which occurred in roughly four stages.

Stage 1: FSN was mainly used to treat patients with soft tissue injuries of the extremities

In the early months, FSN was used mainly for the treatment of patients with painful problems in the extremities, such as epicondylitis, stenosing tenosynovitis of the styloid process of the radius, snapping finger, osteoarthritis of the knee, sprain and strain of ankle, among others. Due to limited experience with FSN in those early days, the success rate of the treatment of painful problems of the extremities was only about 40%. Therefore, FSN was not considered for the treatment of complex diseases or diagnoses of the trunk.

Stage 2: FSN was used to treat patients with non-visceral diseases in the trunk

In the autumn of 1998, the primary author saw a patient who was suffering from severe neck pain and who had been treated unsuccessfully in the university hospital for nearly 1 month. A friend of the author requested his assistance and pleaded whether something could be done for the patient, who happened to be her father-in-law, before leaving in a couple of days. The author had no better option for treatment than FSN. Surprisingly, the neck pain was immediately relieved, after which the author started using FSN to treat patients with non-visceral painful diseases in the trunk, such as low back pain with or without sciatica, cervical syndrome, and mild ankylosing spondylitis.

Stage 3: FSN was used to treat patients with benign painful visceral problems

FSN is performed superficially; hence, superficial illnesses such as soft tissue injuries were regarded as primary FSN indications. FSN was never expected to be used for the treatment of persons with visceral diseases, until an 80-year-old Chinese acupuncturist wrote the author that he had treated a patient with appendicitis using FSN. Although FSN may not always be suitable for the treatment of appendicitis for a variety of reasons, the letter implied that FSN may in fact be used in the treatment of persons with visceral diseases. From then on, FSN was used to treat individual with acute and chronic gastritis, cholecystitis, pain due to urinary calculus and painful menstruation, among others.

Stage 4: FSN was used to handle painful problems in the head and face and non-painful diseases

After the successful treatments of patients with visceral diseases, more confidence in FSN was gained. The primary author moved on to treat patients with painful head and face problems. The experiences convincingly showed that FSN is effective for the treatment of localized headaches and for painful problems of the face caused by temporomandibular pain and dysfunction and accessory sinusitis. FSN was mainly used to deal with painful problems where an immediate response could always be achieved. The question was raised whether FSN could effectively manage non-painful diseases. After many years of practice, it was found that FSN can also deal with non-painful problems. At present, several non-painful indications have been treated successfully, including chronic cough without sputum, onset of chronic asthma and localized numbness.

FSN manipulations

Although FSN originated from traditional acupuncture, the technique of FSN is quite different, especially in the way the needle is manipulated.

Structure of the FSN needle

FSN needles, individually packaged and presterilized with ethylene oxide gas, are designed for single use. The FSN needle is made up of three parts (Figure 15.7): a solid steel needle core (bottom), a soft casing tube (middle), and a protecting sheath (top).

The needle core consists of a needle and the needle-core handle. The needle is made of stainless steel with a beveled tip. When the needle enters the skin, the bevel of the tip should face upward. The handle is made of plastic and is square-shaped and one of the four sides has 10 protuberances. The protuberances are on the same side as the bevel of the tip. If the protuberances face upward, the bevel will also face upward. The needle core allows the FSN needle to have sufficient rigidity to quickly go through the skin, go forward along the superficial layer, and smoothly sway from side to side. A soft casing tube encases the FSN needle.

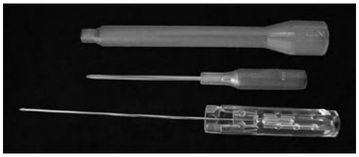

Figure 15.7 • Three parts of Fu's subcutaneous needling needle

The soft casing tube consists of two parts, namely a fluoroplastic body and the tube's hub, which is made of regular plastic. The two parts are connected to each other by a metal wedge. The tip of the casing tube is about 3 mm beyond the tip of the needle core when the needle core is embedded inside the casing tube. The casing tube has two functions. It covers the tip of the needle until the needle is pulled back by 3 mm; thus, the tip of needle stick will not damage surrounding organs or tissues during the swaying movement. The casing tube can substitute for the steel needle core beneath the skin and reduce the patient's pain during retention.

The protective sheath covers the needle core and the casing tube and keeps the FSN needle sterile.

Preparation prior to treatment

Select a treatment posture

The FSN needle is thicker than an acupuncture needle and the FSN manipulation lasts longer than an acupuncture or dry needling treatment. Therefore, selecting a suitable treatment posture is crucial for FSN manipulation. The following postures are commonly used with FSN.

- *Sitting position:* Appropriate for manipulating locations in the head, face, neck, shoulder, upper back and upper extremities (Figure 15.8)
- *Supine position:* Appropriate for manipulating in the abdomen (Figure 15.9)
- *Prone or side-lying:* An appropriate posture when treating diseases of the back and the posterior side of the lower extremities (Figure 15.10).

Figure 15.8 • Sitting position.

Figure 15.9 • Supine position.

The treatment postures may need to be modified dependent upon the patient's condition. More accurately, we should change the patient's postures, especially when there is no immediate effect after several minutes of the FSN swaying movement. For example, although the sitting posture is the first choice for the treatment of neck and upper back pain, if there is no relief of symptoms changing to the prone position may be a better option. When a particular posture

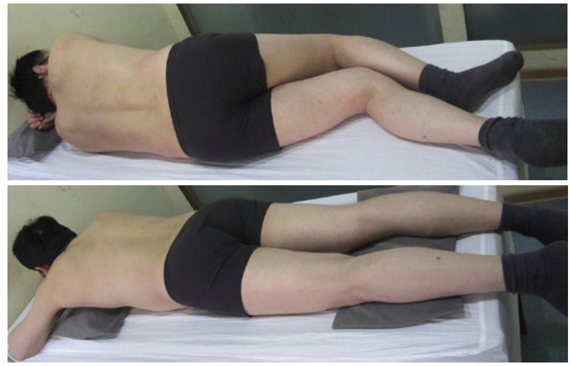

Figure 15.10 • Prone or side-lying position.

Figure 15.11 • Swaying movement during standing position.

causes too much pain, a different treatment posture would be indicated. For example, if back pain is felt only during standing, the FSN needle could be inserted while the patient is in the prone position. Before performing the swaying movement, the patient would be asked to stand up (Figure 15.11).

Palpate the trigger point

In most cases, TrPs are the cause of painful musculoskeletal problems and are also the main targets of the FSN needle.

Figure 15.12 • Flashlight effect.

Table 15.1 Insertion areas corresponding to the dysfunctional regions

Dysfunctional region	Insertion area
Head, face, upper back	Thumb side of forearm, outside of upper arm
Chest, epigastric zone	Inner side of forearm and upper arm
Lower abdomen	Middle part of inner side of leg, anteromedial part of thigh
Lower back	Rear or outside part of leg, outside of thigh
Genital organ, anus	Middle part of inner side of lower limb

Locate the insertion area

Unlike traditional acupuncture, FSN does not require the insertion of needles into acupoints or Ah-shi points. The needles are inserted into the area surrounding TrPs. After identifying clinically relevant TrPs, the needles can be inserted anywhere within the direct vicinity of the TrPs. Several principles are employed to select the proximity of the needle insertion to the TrPs:

- *Principle A:* For a single small-sized nodule, the insertion area should be close to the TrP. For a large-sized taut band or for nodules clustered in one area, the insertion points should be farther removed. For example, the insertion points should be close to the TrP with a tennis elbow and farther away with more generalized upper extremity pain. The farther the tip, the less the intensity of FSN, although its coverage area may be enlarged. This phenomenon is called the *flashlight effect* (Figure 15.12). The illumination of a flashlight becomes weaker, but covers a wider area when the light is used from a greater distance.
- *Principle B:* The FSN needle should not be inserted into scars or into hollow or prominent regions, such as the tip of the elbow, patella, styloid processes of the radius and ulna, malleolus lateralis, or malleolus medialis between the treated TrP and the FSN needle insertion point.
- *Principle* C*:* For different types of diseases, the FSN needle insertion site should follow the guidelines listed in Table 15.1 if the needle insertion area would be far from the lesion site.
- *Principle D:* To reduce pain during needle insertion, surface blood vessels, most of which are veins, should be avoided.

Sterilize

Disinfection is necessary and essential before FSN insertion. All persons administering treatments should be aware of current methods of infection prevention, subject to their local skin-penetration regulations (see Ch. 4). To protect both clinicians and patients from needle stick injuries and contamination from blood-borne infections, the skin at the insertion point and the practitioner's fingers should be disinfected and sharps disposed of in appropriate bio-hazard containers.

Needling method

In this section, the needling procedure for FSN is described, including needle insertion, needle swaying, needle direction, and needle retention.

Needle insertion

We provide an example for a right-handed individual to illustrate the procedure of needle insertion. First, the protective sheath is gently taken off. The FSN needle should be held using the right thumb, index, and middle fingers. The thumb presses the side of the needle-core handle that has the protuberances; the index and middle fingers press the needle-core handle and the tube hub, respectively

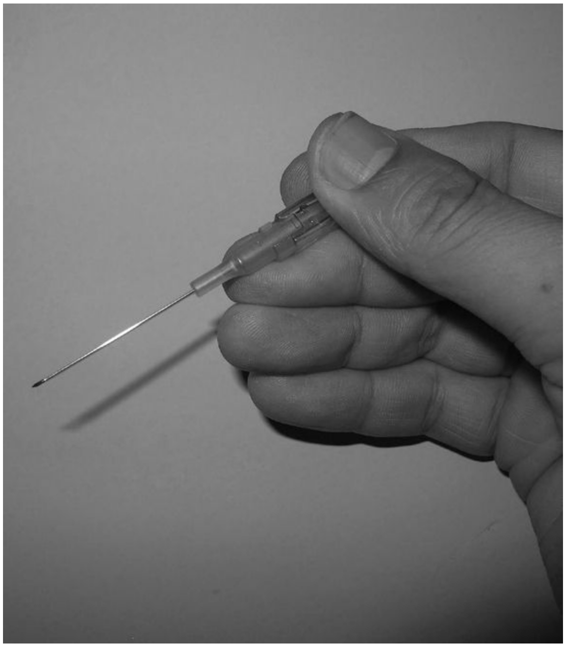

Figure 15.13 • Holding position of Fu's subcutaneous needling needle

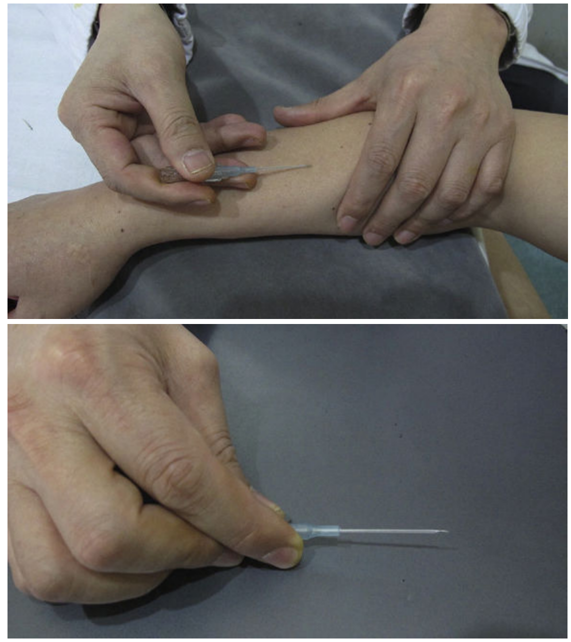

Figure 15.14 • Adjusting the way to hold the needle before taking back

(Figure 15.13). The end of the needle-core handle should not protrude from the index finger to prevent the FSN needle from slipping during insertion. The index and middle fingers should be close to each other for greater force. Care should be taken to avoid touching the casing tube in any way with the fingers.

The posture of the patient is adjusted to ensure that the skin on the inserting point is neither tight nor loose. If the skin is too tight, relevant blood vessels dilate, and the FSN needle is more prone to inducing a pricking sensation; on the other hand, if the skin is too loose, it is harder to penetrate. During the whole process, the needle tip should always be directed toward the TrP.

Next, using the force of the wrist joint (not the elbow joint or shoulder joint), the skin is obliquely penetrated as quickly as possible with the tip of the needle at an angle of about 15°–25° until the tip of FSN needle reaches the muscular layer. As mentioned, FSN focuses on the subcutaneous layer; hence, the needle should be taken back slightly.

Before taking the FSN needle back, the way of holding the needle should be adjusted: the needle should be loosened first and grasped upward (Figure 15.14). While slowly moving the needle backwards, the clinician will feel a sudden loosening, which indicates that the needle tip has entered the subcutaneous layer, and at the same time, a skin hunch appears at the insertion point.

Afterward, the needle should be laid flat and then carefully moved forward. While being pushed forward, the needle tip should be slightly higher to be able to observe if the skin hunch is moving with the needle tip. At this point, the therapist right hand feels loose and has no resistance. The patient feels something moving under the skin, but there is no feeling of *De-Qi*.

After the casing tube is totally embedded beneath the skin, the needle-core handle should be withdrawn by about 3 mm and turned 90° to the left; this way, an embossment in the tube hub goes into a groove in the needle-core handle. The swaying movement can be done. Once the swaying movement is finished, the needle-core handle is turned right by 90° out of the groove, and then the steel needle core is withdrawn. The steel needle core is placed into the protective sheath for safety and to meet hygiene requirements.

The casing tube is then embedded beneath the skin using an adhesive tape water-proof dressing . After 1–2 hours of retention, the adhesive tape is removed and the tube is pulled out. At the same time, the insertion point should be pressed using a

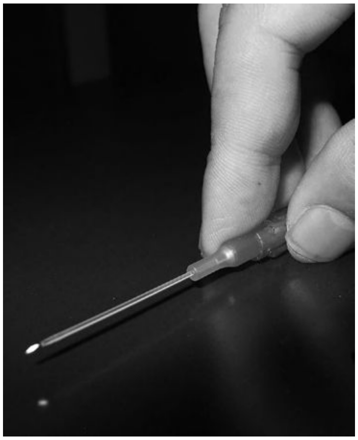

Figure 15.15 • The fulcrum of swaying movement.

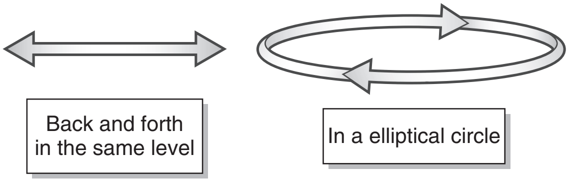

Figure 15.16 • Two different ways of the swaying movement.

sterilized cotton ball for at least one minute to prevent bleeding.

Swaying movement

The swaying movement, a key procedure for FSN, is a smooth, soft, fan-style waggle using the thumb as its fulcrum. The index, middle, and ring fingers stay in a line. The middle finger and thumb affix the needle in a face-to-face way, while the index finger and ring finger alternately move back and forth (Figure 15.15).

The frequency of the swaying movement is about 100 times a minute. The duration of the swaying movement for one insertion point is often less than 2 minutes. After 50 repetitions of the swaying movement (about half a minute), the clinician can palpate the TrP or ask the patient about the condition of the problems. If the TrP has been deactivated or the patient says the problem is gone, the swaying movement should be stopped; otherwise, it should be continued. If the problem persists, the entire needle should be pulled out and the insertion point should be adjusted. In addition, during the swaying movement, the needle tip could be moved back and forth in a line or moved in an elliptical circle (Figure 15.16).

Together with the work of the right hand, the clinicians' left hand or leg should keep on rocking to relax the relevant muscles or joints. Figure 15.17 shows successive photos taken while manipulating the needle in a patient with upper extremity pain. Note the lifting of the sleeve by the practitioner's left hand and the movement of the left thigh. The rocking of the relevant muscles or joints is one of the methods referred to as the ***reperfusion technique***.

Reperfusion technique

Chinese acupuncturists often use a particular kind of technique for the treatment of acute painful problems, which is implemented by patients. The patients move their afflicted body part while acupuncturists insert the needles in an area other than the afflicted region. For example, when Chinese acupuncturists treat an acute sprain in a patient with low back pain, they will ask the patient to stand up and rock his back during needling at the acupoint *Renzhong* (DU26). Although widely used, this practical rocking technique has seldom been introduced in textbooks. At present, this technique has no specific name; sometimes, it is called *Yundong needling* (kinetic needling; Liu et al. 2010), other times, *Dong-qi* (meaning moving the energy) therapy and movement therapy (Luo & Han 2010). In the Western world, there are also some similar techniques, such as stretching (Edwards & Knowles 2003).

Inspired by these techniques, Fu applied them to the practice of FSN. To his surprise and delight, these techniques immediately enhanced FSN in many patients, especially those with stubborn pain. To say that these techniques are a much better fit for FSN than acupuncture is no exaggeration. The insertion point of acupuncture should be far from the afflicted area when these techniques are applied, but there is no such restriction in FSN, because FSN needles are not inserted deep into the muscles. Thus, these techniques could be done easily during FSN manipulation, regardless of whether the FSN insertion point is far from or near the afflicted area.

Fu wondered about the mechanism of these techniques, and his search for relevant studies was disappointing as there are only a few studies on these techniques both in Chinese and English.

Figure 15.17 • Successive photos while manipulating with upper extremity pain.

Figure 15.18 • This state of flux and reflux when the fist clenched and loosened.

The limited number of studies can probably be blamed on the shortage of appropriate techniques, such as ischemic compressions, that can be done while exercising. These techniques are known to increase the effectiveness of FSN. Why do they work this way?

In the energy crisis theory (Hong & Simons 1998, Hong 1999, 2002, 2006), the contraction of a muscle segment creates a demand for energy and may restrict the local circulation. Thus, improving the local circulation is crucial. FSN can relieve contractures and then improve the local circulation, but this consumes both time and the practitioner's energy. FSN can be better utilized with the help of other methods that can improve the circulation. Can these reperfusion techniques help in improving the circulation? The answer can be illustrated using the change in the hand's skin color when the fist is clenched and loosened alternately. Figure 15.18 shows that as soon as the clenched fist loosens, the palm color resembles a rising tide. After a few minutes, the tide ebbs. This state of flux and reflux is useful for improving circulation.

Fu named the series of techniques the ***reperfusion approach (RA)***. RA refers to the mechanical methods that can cause recirculation in non-inflamed ischemic tissues, and includes the repetitive actions applied to relevant soft tissues. *Reperfusion* is a word found in the phrase

Figure 15.19 • Some reperfusion approaches for the neck area.

reperfusion injury, which refers to tissue damage caused when blood supply returns to the tissue after a period of ischemia. Reperfusion injury is often involved in cerebral vascular accidents, brain trauma, and sometimes also in muscular trauma. Could RA lead to reperfusion injury in ischemic tissues? This is very unlikely, because: (1) ischemia is a chronic state; and (2) the approach calls for the performance of actions in a successive and repetitive way, which can only improve the circulation.

Fu distinguishes active and passive RA. Active RA means that the actions are carried out by the patient's involved joints or organs. Passive RA means that the actions are implemented by the practitioner or the patient's healthy limbs. The application range of active RA is broader than that of passive RA. Active RA can be used in most conditions. Passive RA is more applicable in the following conditions: (1) the patient does not know how to perform the RA; (2) the patient has no idea how to control the amplitude and frequency; and (3) the TrP is located in a body part that the patient finds hard to move, such as the scalp.

Active RA and passive RA could be used alternatively. Passive RA in small joints can often be implemented by the practitioner, whereas passive RA in large joints can be carried out by either the practitioner or the patient. For different body parts afflicted with musculoskeletal disease, practitioners should use different methods of RA during FSN. The following illustrates some common RAs.

RAs for the neck area

In the neck area, passive RAs are applied more commonly than active RAs, because the latter easily cause dizziness in nervous or anxious patients. The RAs for the neck should be conducted gently. When the patient is seated, passive RAs can be conducted using several methods. Figure 15.19 shows the most common types of passive RAs for the neck. When the patient feels uncomfortable with moving the head from side to side, the practitioner could move the patient's head from side to side during FSN (Figure 15. 19A). Figures 15.19B and C show examples of techniques for patients, who find it difficult or who feel a traction force when moving their neck back and forth, or when slowly rotating their head. Active RAs for the neck can be performed in a similar way as is depicted in Figure 15.19, but the speed should be slow.

RAs for the shoulder

When using FSN treatment for painful shoulder problems, the patient is usually seated. RAs in the shoulder can be either passive or active, with the former being used more. Figure 15.20 shows examples of both passive and active RAs when the patients' upper limbs are difficult to stretch backwards and when patients feel pain while they are stretching their upper limbs. When patients have difficulty raising their arms or they experience pain when they raise the arms, both passive and active RAs are applicable (Figure 15.21).

Usual RAs for back pain

For back pain, applicable RAs are summarized in Figure 15.22. For stubborn painful problems, the patient should assume a kneeling position. In this position, active RAs in the back can often be performed as shown in Figure 15.23.

Usual RAs for knee pain

For knee pain, the patient could assume either a sitting position (Figure 15.24) or a decubitus position (Figure 15.25).

Figure 15.20 • Passive and active reperfusion approaches when the patients' upper limbs are difficult to stretch backwards.

Figure 15.21 • Passive and active reperfusion approaches when the patients' upper limbs are hard to rise.

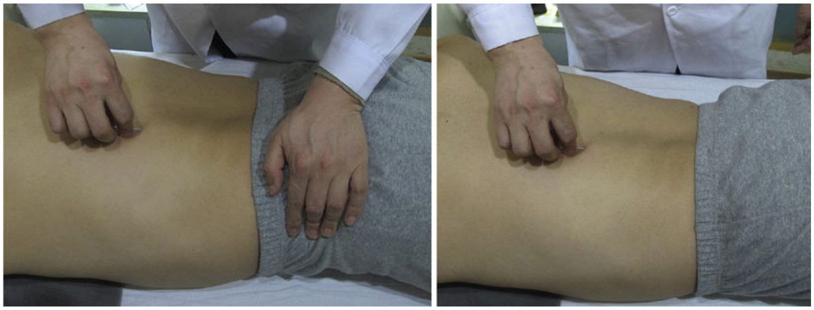

Figure 15.22 • Usual reperfusion approaches for back pain.

Figure 15.23 • Active reperfusion approach while in a kneeling position for back pain.

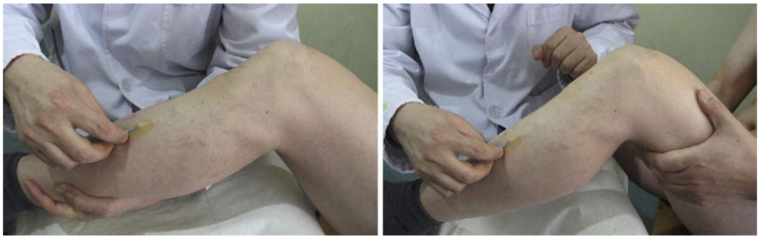

Figure 15.24 • Usual reperfusion approaches with a sitting position.

Figure 15.25 • Usual reperfusion approaches with a decubitus position.

Retention

After the swaying movement and RA, the solid steel needle core should be removed (Figure 15.26), whilst the soft casing tube is retained beneath the skin. Once the patient experiences relief of their symptoms, retention is necessary to maintain the immediate effects of the treatment. If a patient has no immediate relief another needle insertion point or a different posture should be used until relief is obtained.

The sterile adhesive dressing that is used for retention should be big enough to cover the tube

Figure 15.26 • Pulling out the needle core from the casing tube.

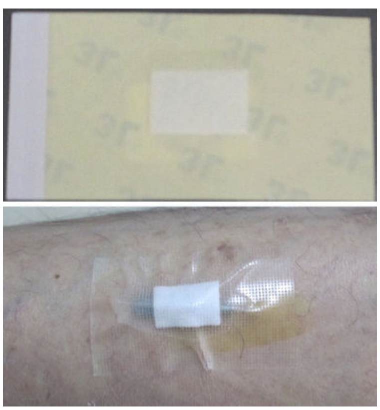

Figure 15.27 • Rubberized fabric and the way to cover the casing tube.

hub and insertion point (Figure 15.27). Sometimes, adhesive dressings can cause local itching and swelling due to allergy. In this case, the rubberized dressing should be changed.

How long should the retention be maintained? Based on clinical observations, the effect of 24-hour retention is a slightly better than that of 8-hour and 12-hour retention, whereas there are no differences between the effects of 24, 48, or 72-hour retention. Considering safety issues, retention time should be at least for 1–2 hours. In addition, during the retention the patient should be instructed: (1) not to wet the rubberized area of the fabric; (2) not to work or exercise too much and avoid contracting the muscles surrounding the needling site; (3) not to sweat too much as excessive perspiration may have a negative effect; (4) to pull out the casing tube immediately if the tube moves and causes a stabbing pain; and, (5) not to worry about bleeding when the tube is withdrawn. Simply press the insertion point and the area 2 cm around the insertion point with a sterilized cotton ball for 1–2 minutes, and cover with a small adhesive dressing.

In order to gain better effect and to be safer, some practitioners divide one session into two halves, with a retention break for 1 hour. During the break, the patients walk around to see if the painful condition subsides. If the pain disappears completely, there is no need to continue the treatment. If the pain persists, the treatment continues. After completion of the second half of the treatment, the practitioner removes the FSN needle without follow-up retention.

Precautions, contraindications, and management of side-effects

Traditional acupuncture and dry needling have an extremely good safety record, but nevertheless, FSN is safer than these methods as the needles are inserted only subcutaneously. However, no form of therapy is absolutely safe. When using FSN, close attention should be given to the following to gain satisfactory effects and to avoid causing patients discomfort:

- FSN treatment should be delayed for those patients who are famished or who have overeaten, and also for patients who are intoxicated, over-fatigued or very weak, because these conditions can easily lead to fainting.
- The insertion of an FSN needle into the lower abdomen of pregnant women is contraindicated.
- During needling, blood vessels should be avoided to prevent bleeding, especially in the region of the superficial temporal artery, posterior auricular artery and radial artery. When a patient suffers from spontaneous hemorrhage, or is taking anti-coagulant medications, FSN treatment are not indicated.
- FSN patients are more susceptible to infection compared to patients of traditional acupuncture

due to the long duration of needle retention. The FSN needle can only be used once. For patients at increased risk of infection, such as patients with diabetes or HIV, more intensive sterilization should be done.

When performed correctly, FSN is free from any adverse and addictive side-effects. However, there are some temporary side-effects:

- *Hematoma:* There are many small blood vessels, mostly veins, in the subcutaneous layer. During FSN manipulation, care should be taken to avoid the veins. However, some conditions make it impossible to avoid all blood vessels; hence, bruising under the skin sometimes occurs. A bruise appears where small blood vessels are broken, leaking blood under the skin. Bruises often feel tender or swollen in the first few days. If the congestion is severe and causes pain or affects local function, the casing tube should be removed immediately, and a cold compress applied to the local area.
- *Fainting:* Occasionally patients feel faint while undergoing FSN, especially at the start of the first treatment. When patients are faint, they may feel tired, dizzy, or nauseous, and their face may turn pale. Sometimes, patients exhibit profuse sweating, flushing, and coldness of the extremities, or even go into syncope or fall to the ground. The prevention of fainting is more important than its treatment. When a patient undergoes FSN treatment for the first time and feels nervous or is in a weak condition, the clinician should explain the FSN procedure and help the patient relax by selecting the most suitable posture. During manipulation, the patient's expressions should be observed; if any sign of faintness is seen, stop the FSN and let the patient lie down. In most cases, the patient will recover within 3–5 minutes. Drinking a glass of water may help.

Factors that influence FSN effects

Many factors influence the effects of FSN, but some of them, such as smoking, have not been proven. However, there is some clinical evidence for some of the factors.

Main factors that influence short-term effects

- *Edema:* Stopping FSN treatment is advisable when a patient is suffering from general edema, i.e. if a patient with lupus or rheumatoid arthritis and a painful problem received steroid treatments, FSN will have no effect on the painful problem.
- *Fever:* Regardless of the cause of fever, the effects of FSN are not as good and FSN should be discontinued until the fever is controlled.
- *Other previous treatments:* Some previous treatments, such as local steroid injections, heavy cupping, herbal plaster medicine, local ointment medicine, and local application of the coupling medium for an ultrasound check, will influence the effects of FSN.
- *Poor manipulation:* If any step of FSN manipulation, especially the swaying movement, has not been performed well, the short-term effect will be negatively impacted.
- *Wrong diagnosis:* FSN is good for non-traumatic soft tissue lesions, but not for traumatic lesions, such as an acute ankle sprain or pain caused by a hairline fracture. If unsure the patient should be referred for an X-ray or sonography before proceeding.

Factors that influence long-term effects

- *Short-term effectiveness:* When there is a good short-term effect, it is likely that there will be a good long-term effect. If the short-term effect is not easily achieved, the long-term effect will probably not be as favorable.
- *Chronicity of the lesion:* When the non-traumatic soft tissue lesion has been present for a long time, the long-term effect will not be as good as when the lesion has only been present for a short time.
- *Completeness of FSN treatment for TrPs:* Beginners of FSN can easily deactivate active TrPs, but often ignore the palpation and the treatment of latent TrPs, which frequently get activated, especially when patients are over-fatigued or with changes in the weather.

- *Personal habit:* Some routine habits or customs diminish FSN's long-term effects. These routine habits include watching TV in the bedroom, poor posture, repetitive movements at work or leisure activities, using an electric fan while sleeping, prolonged walking or standing, and sleep deprivation. For most chronic conditions, even if the painful problems have gone away after FSN treatment, the involved tissues need time and energy to recover. Under these situations, the effected tissues are over fatigued and the pain will often come back.
- *Health condition:* If the patient suffers from other concurrent diseases such as immunological diseases, chronic infections, hypothyroidism, diabetes, hyperuricemia, or malignancy, the treatment effects may be poor.

FSN features

As mentioned before, the way the needle is manipulated distinguishes FSN from traditional acupuncture and other needling approaches. In addition, the FSN is quicker and more effective than traditional acupuncture.

Manipulation features

FSN differs from acupuncture in terms of manipulation of the needle in the following aspects:

The selection of the FSN insertion area is based on the nature of TrPs or other focal disorders

FSN abandoned traditional acupuncture theories, such as meridians and acupoints. Where the FSN needles are inserted depends on where the TrPs or other focal disorders are located. The insertion points are always in the vicinity of TrPs and other focal disorders, although the distances between the insertion points and the local disorder are variable, because of different characters of the disorders.

The FSN needle is inserted into non-diseased areas

Common techniques used in traditional acupuncture include the application of medicated plaster, which is somewhat similar to the use of medicated patches in Western medicine, i.e. lidocaine or fentanyl patches. Another acupuncture technique is known as cupping, whereby local cutaneous suction is created to promote healing. These interventions are commonly applied directly to the afflicted or painful area. In other words, a medicated plaster or a cupping technique is applied where the patient complaints of pain. A solid filament needle used in dry needling is commonly inserted directly into a local TrP.

Figure 15.28 • Different layer of Fu's subcutaneous needling and traditional acupuncture.

Based on the principles of traditional acupuncture, Tseng et al. (2008), Tsai et al. (2010) and Chou et al. (2009) have demonstrated an effective way to inactivate severely hyperirritable TrPs by needling other TrPs remote to these TrPs. Similarly, FSN acts on non-afflicted areas. The tip of the FSN needle usually does not reach the actual lesion. The FSN needle stimulates a non-afflicted area to heal the afflicted area. If the patient has edema, broken skin or swelling in the chosen insertion site, FSN needles should not be inserted and an alternative area must be used or the treatment should be suspended or cancelled. For example, if the surrounding area of the painful spot is swollen, the FSN needle should not be inserted into the swollen part.

The insertion of FSN needle is restricted to the subcutaneous tissue

The needle used in dry needling goes through the skin, into the subcutaneous layer, and then enters deeply into muscles, whereas the FSN needle stops at the subcutaneous layer (Figure 15.28).

De Qi is not required during FSN treatment

In traditional acupuncture, *De Qi* is considered an indication of its curative effect (Park et al. 2005, White et al. 2008), which is why most acupuncturists try to induce *De Qi*. However, FSN aims to avoid sensations of soreness, swelling, or numbness for the patient, while the clinician does not look for mild resistance or 'needle grasp'.

The FSN needle is retained in the subcutaneous tissues for a prolonged period of time

Retention of needles is seldom mentioned in ancient acupuncture. In modern acupuncture, however, retention is widely used, and the retention often lasts for 15 or 20 minutes, but never goes over 60 minutes. FSN needs a longer retention time, often lasting more than 1 hour. The patient should be allowed to keep on moving even with the FSN needles retained in the subcutaneous region.

The tip of FSN needle is directed to the painful region

The acupuncture needle is often inserted perpendicularly or obliquely, whereas the FSN needle is inserted horizontally and directed toward the TrP or other focal disorder.

The FSN needle is swayed from side to side

The FSN applies a special technique referred to as 'the swaying movement'. The swaying movement is essential to FSN treatment and provides a curative effect, especially when dealing with chronic disorders. In most circumstances, FSN does not work well without the swaying movement.

The involved muscles and joints can move easily during FSN treatment

Moving afflicted joints and muscles can effectively speed up the recovery from soft tissue injury. As mentioned, the FSN needle is manipulated above the muscular layer, which makes it easy for the medical staff or the patients themselves to move the afflicted joints or muscles even during FSN's swaying movement (Figure 15.29).

Figure 15.29 • The moving of afflicted muscles during the swaying movement of Fu's subcutaneous needling.

Characteristics of effectiveness

After 15 years of clinical observations, the principle author defined the following characteristics of FSN:

- FSN focuses on treating painful problems, although FSN can also have positive effects on some non-painful disorders, such as numbness, chronic cough without sputum, and acute onset of asthma.
- FSN can provide relief under most conditions. After the swaying movement, the pain is reduced or completely absent.
- Retention of the FNS needle is usually necessary when symptoms recur frequently, although they are often suppressed after therapy.
- Generally, acupuncture has fewer side effects than many medications, but there are still several adverse effects such as hemorrhage, hematoma, dizziness, fainting, nausea, pneumothorax, prolonged *De-Qi* effect (paraesthesia), and increased pain (Ernst et al. 2003). However, FSN is safer than acupuncture, because the needles do not penetrate deeply and fewer needles are required for each treatment. So far, there have been no cases of nausea, pneumothorax, or a prolonged *De-Qi* effect.
- FSN has short-term and long-term effectiveness in the treatment of a majority of non-traumatic soft tissue lesions if the afflicted joints and muscles can have enough recovery time. However, for painful problems caused by malignant tumors, trigeminal neuralgia, and post-herpetic neuralgia, FSN only has short-term effects.
- Empirically, FSN treatment appears to achieve an equal or better effect with fewer treatments compared to other manual techniques in current practice, saving time and resources. There is also a complete absence of 'post-treatment tissue soreness' often experienced by patients following other manual therapy interventions. In addition, because it can often relieve

painful problems, such as lower back pain with sciatica, patients may avoid invasive surgical procedures.
- FSN provides immediate feedback and occasionally FSN can modify the diagnosis based on whether the patient's symptoms are not relieved or reduced immediately. For example, FSN could be used in the neck region in an effort to treat dizziness without an obvious diagnosis. If there is immediate improvement, the diagnosis may be modified to a neck problem causing dizziness.

In the authors' experience, FSN is superior to traditional approaches, but there are also certain disadvantages. For example, FSN is more time-consuming and clinicians need to expend more energy on each patient. FSN can be easily misunderstood by patients and other healthcare providers, because the FSN rationale may be too unconventional. Chinese physicians often doubt the results and effects of FSN, probably because FSN does not obey the rules of traditional Chinese medicine. Furthermore, Chinese patients who are not familiar with FSN often think that their physicians have discreetly injected an anesthetic or steroid. Future studies confirming the authors' clinical assumptions and experiences are imperative to further determine the effectiveness of FSN versus acupuncture.

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Trigger Point Dry Needling

An Evidenced and Clinical-Based Approach

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Preface

Janet Travell, who was President Kennedy and Johnson's White House physician, re-discovered trigger points (TrPs) during the early 1940ies. She developed the notion of TrP injections. Already in 1944, the idea was born that the actual needle could be responsible for at least part of the therapeutic effect of TrP injections (Steinbrocker 1944). It was not until 1979, however, that the first article about TrP dry needling appeared in the medical literature (Lewit 1979). At first there seemed to be little interest in pursuing dry needling much beyond a few individuals, who were intrigued by Lewit's report that dry needling provided immediate anesthesia without hypesthesia in over 86% of cases (Baldry 2005, Lewit 1979). Of course, pressure-sensitive and pain-producing points in the body have been the target of therapeutic interventions for many centuries within the context of various underlying philosophies, e.g. Traditional Chinese Medicine or Ayurvedic Medicine (Simons 1975, Unschuld 1987, Janz & Adams 2011). Initially, the management of patients with myofascial pain and TrPs with invasive techniques was reserved for physicians and a few acupuncturists. Many physicians seem to prefer TrP injections over dry needling (Peng & Castano 2005), while the interest of acupuncturists in TrP concepts did not really develop until the 1980ies, when Seem and other acupuncture pioneers became aware of the work by Travell and Simons (Seem 2007). During that same time period, physical therapists, who studied with Dr. Janet Travell, developed an interest in dry needling. In 1984, the Maryland Board of Physical Therapy Examiners was the first state board in the US to approve dry needling to be within the scope of physical therapy practice (Dommerholt et al. 2006). Currently dry needling is in the scope of physical therapy practice in the majority of US states and in many countries around the world. Recently, the chiropractic profession in the US has also taken an interest in expanding its scope of practice by including dry needling in its scope.

To the best of our knowledge, this book is the first textbook exclusively devoted to the topic of TrP dry needling. The book is divided into three sections. The first section provides an up-to-date overview of the basic concepts and understanding of TrPs. Chapter 1 provides information about muscle referred pain, TrPs and sensitization, and other neuro-physiological aspects of TrPs. Chapter 2 summarizes the proposed mechanisms of TrP dry needling, while chapter 3 considers the effect of needling therapies on fascia. Chapter 4 deals with safety and hygiene issues in the practice of dry needling. Chapter 5 gives a review of professional controversies surrounding dry needling with an emphasis on the opposition of some acupuncture groups to physical therapists and other non-acupuncture healthcare providers using dry needling techniques in their practices.

The second section of the book provides detailed descriptions of dry needling techniques in muscles of the head and neck (Chapter 6), shoulder (Chapter 7), arm and hand (Chapter 8), trunk (Chapter 9), hip and pelvis (Chapter 10), and leg and foot (Chapter 11). The focus of the second section is on so-called deep dry needling. We are aware that there are many variations on a theme, which is why we invited several representatives of different needling approaches to share their concepts and perspectives in the third section of the book. Superficial dry needling is discussed in Chapter 12. Chapter 13 summarizes dry needling from a Western medical acupuncture perspective. Intramuscular stimulation developed by Dr. Chan Gunn is reviewed in chapter 14, while Fu's subcutaneous needling is discussed in the final chapter of the book.

We anticipate that this book will become the standard in TrP dry needling and we hope that this book will bridge apparent differences in opinion. We aim to unite different disciplines involved with different varieties of needling techniques. In the end, the welfare of our patients needs to be the guiding principle. We hope that this book will ultimately benefit many patients worldwide.

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Foreword by Leon Chaitow ND, DO

A number of potentially contentious issues come together in this carefully constructed book - particularly the key topics of myofascial trigger points (TrPs), and dry needling. By directly confronting and debating the controversies surrounding these themes the editors and their contributing authors perform an intellectually and clinically useful service.

Despite a steady stream of pain research, as well as clinical studies, that confirm the presence, in the soft tissues of most adults, of local areas of hyperirritability, lying in taut muscle bands capable of generating pain locally as well as in distant tissues (Simons et al., 1999; Mense & Gerwin, 2010), there remain a hard-core of TrP deniers (Quintner & Cohen, 1994).

While the aetiology of these noxious points remains to be precisely determined, researchers such as Shah and Gilliams (2008) have shown that:

- Objective biochemical data confirms the clinical distinction observed by digital palpation - using the criteria of Simons et al (1999), that discriminates active TrPs from latent TrPs, and uninvolved muscle.
- Active TrPs have a unique biochemical milieu of substances known to be associated with pain, inflammation and intercellular signaling.
- Ultrasound imaging can be used to visualize TrPs, and for objective clinical assessment in conjunction with digital palpation, TrPs are stiffer than surrounding tissue.
- Active TrPs have a larger surface area than latent TrPs and can be distinguished from latent TrPs by their blood flow waveform characteristics using sonoelastography imaging (Ballyns et al. 2011).

Chapters 1 and 2 cover the basis for TrP dry needling, including the proposed neurophysiology of the method. The potential for TrP deactivation to positively influence central sensitization processes is of particular interest in these discussions. Chapter 3 provides an insightful evaluation of the links between acupuncture (but not necessarily dry needling), loose connective tissue and possible therapeutic effects. The mechanisms described in this brief but intriguing chapter suggest that mechano-transduction resulting from the physical effects of the rotation of acupuncture needles, inserted into loose connective tissue may produce some of the therapeutic effects of acupuncture. The effects of dry needling, which does not as a rule involve needle rotation are, as mentioned, outlined in Chapter 2. Concerns over the safety of dry needling methods receive full and appropriate attention in Chapter 4, while Chapter 13 concerns itself with dry needling from the perspective of Western style acupuncture practice.

Ideal treatment models for the deactivation of TrPs, including dry needling, provide a rich area of controversy and debate, with a clinical tension existing between those who advocate manual TrP release approaches, and those whose preference lies in use of dry needling. Chapter 1 partially deals with this question, in which the efficacy of manual methods is acknowledged, alongside the statement that “empirically dry needling and TrP injections have quicker results than strict manual TrP release techniques.” That speed might not always be the most important determinant of methodological superiority, and that there might be other benefits relating to manual methods of treatment, as compared with needling, is likely to remain an ongoing debate, that should not detract from the undoubted value of dry needling, in appropriate settings, in support of which this book provides extensive and persuasive arguments.

It is important to emphasize that the controversy around the methodology of dry needling does not relate to its efficacy in achieving pain relief - there are too many studies confirming this to leave scope for doubt (over 100 citations in Chapter 2 alone!). However, an intense debate, largely confined to North America, relates to interprofessional concerns. This debate deserves to be aired – as it has been, with careful analysis, in Chapter 5 – in which the current issues relating to the overlap of dry needling with the practice of acupuncture are discussed.

The major portion of the book provides detailed guidance (offered by a variety of experts) in the use of dry needling methods wherever myofascial TrPs are to be found - from the head and neck (Chapter 6), via the shoulder (Chapter 7), to the arm and hand (Chapter 8), the trunk (Chapter 9), the hip and pelvis (Chapter 10) to the leg and foot (Chapter 11).

Alternative needling methods, including Baldry's superficial approach (Chapter 12), Gunn's intramuscular stimulation (Chapter 14) and Fu's subcutaneous needling (Chapter 15) also receive appropriate attention.

This book is justifiably bound to become the definitive resource for those who use, or wish to understand, dry needling in relation to myofascial pain, and the editors and contributors are to be congratulated on the comprehensive nature of its balanced content.

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Part 1: Effects of acupuncture needling on connective tissue

3

Helene M. Langevin

CHAPTER CONTENT

Needles and connective tissue

Acupuncture needles are fine, filiform needles used both in traditional acupuncture as well as in more recently developed 'dry needling' techniques. An important characteristic of acupuncture needles is that their small diameter (typically less than 300 μm) allows a unique form of interaction to occur between the needle and connective tissue (Langevin et al. 2001a). When acupuncture needles are rotated, collagen bundles adhere to the needle and wind around its shaft, creating a small 'whorl' of collagen in the immediate vicinity of the needle, i.e., within a few millimeters (Kimura et al. 1992, Langevin et al. 2002). Winding of collagen, which can occur with as little as half a revolution of the needle, causes connective tissue to follow the rotating needle and then adhere to itself, further increasing the mechanical bond between needle and tissue. Once a needle–tissue bond is established, any further motion of the needle, either rotation or up-and-down, effectively pulls the tissue along the direction of needle motion.

Because needle rotation causes pulling and gathering of connective tissue from the periphery toward the needle, this form of needle manipulation results in a unique form of 'internal' tissue stretching that predominantly involves the 'loose' subcutaneous or inter-muscular connective tissue layers with little stretching of the skin. Furthermore, when acupuncture needles are left in situ after being rotated, the connective tissue whorl does not immediately unwind, which allows the connective tissue stretch to persist for several minutes. Thus, acupuncture needles can be used to create sustained, localized and specific stretching of subcutaneous and deeper connective tissue layers.

In humans, winding of connective tissue is quantified using robotic acupuncture needling as well as ultrasound elastography imaging techniques (Figure 3.1; Langevin et al. 2001b, 2004). Both uni-directional, whereby the needle is rotated continuously in one direction, and bi-directional rotation, with the needle rotated back and forth, cause a measurable increase in the amount of force necessary to pull the needle out of the skin (Langevin et al. 2001b). With *uni-directional rotation*, the torque developing at the needle–tissue interface increases exponentially as the needle rotates. This phenomenon is similar to the exponential increase in friction forces that develops as a cable is wound around a winch drum. With *bi-directional rotation*, needle torque gradually increases over successive rotation cycles. This is likely due to incomplete unwinding of tissue at the end of each cycle, leading to a gradual build-up of torque in the tissue.

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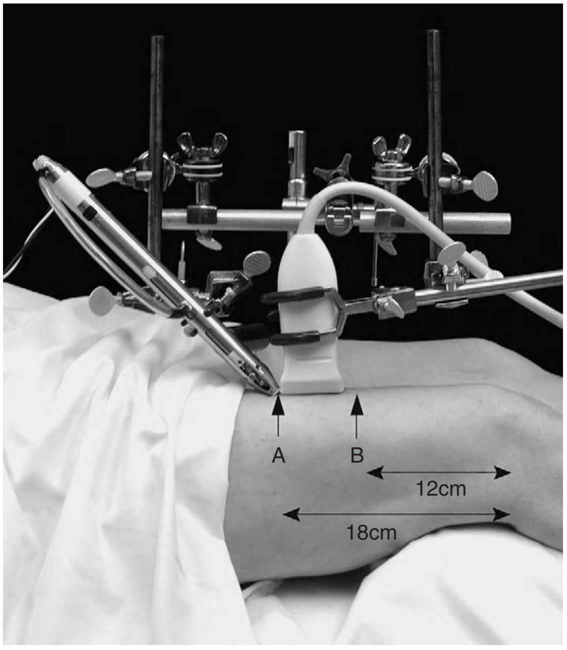

Figure 3.1 • Method used for ultrasound elasticity imaging during robotic acupuncture needling • An acupuncture needle is inserted and manipulated using a robotic acupuncture needling instrument and an ultrasound cine-recording is acquired during the needle manipulation. Reprinted with permission from Langevin HM, Konofagou EE, Badger GJ et al. (2004) Tissue displacements during acupuncture using ultrasound elastography techniques. Ultrasound Med Biol 30: 1173-1183.

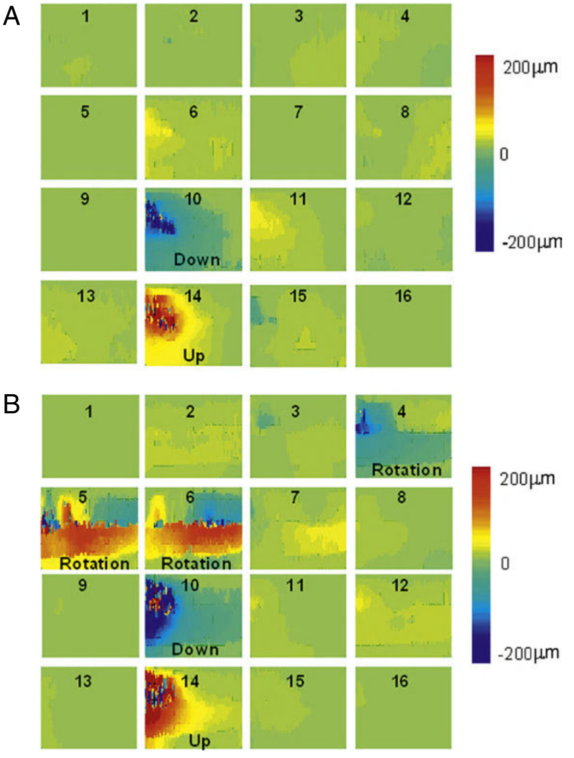

Figure 3.2 • Example of tissue displacement maps obtained by post processing of sequential ultrasound images acquired during acupuncture needle manipulation • Gray scale values indicate upward or downward tissue displacement during (A) downward and upward needle motion and (B) rotation followed by downward and upward needle motion. Reprinted with permission from Langevin HM, Konofagou EE, Badger GJ et al. (2004) Tissue displacements during acupuncture using ultrasound elastography techniques. Ultrasound Med Biol 30: 1173-1183

Thus, both uni-directional and bi-directional needle rotation can cause the tissue to 'grip' the needle. Even small amounts of needle motion can cause measurable tissue displacement up to several centimeters away from the needle (Figure 3.2). Furthermore, increasing the amount of rotation causes a linear increase in the amount of tissue displacement during subsequent axial needle motion (Figure 3.3; Langevin et al. 2004). Acupuncture needles therefore can be used as 'tools' to cause specific mechanical stimulation of connective tissue that can be quantified in vivo in humans and animals.

What are the consequences of mechanical stimulation of connective tissue?

Connective tissues are constantly exposed, and respond to mechanical forces. Under normal circumstances, connective tissues are under a certain amount of tension, or pre-stress, in the body. During normal body movements, a transient mechanical input (either stretching or compression) elicits a visco-elastic response determined by the composition and organization of the extracellular matrix. For example, loose 'areolar' connective tissue is less stiff and deforms more easily than densely organized connective tissues such as dermis and perimuscular fasciae. Sustained stretching of connective tissue slightly beyond its usual range of motion causes visco-elastic relaxation. When such stretching is sustained for several minutes, as occurs during changes in body position, tension

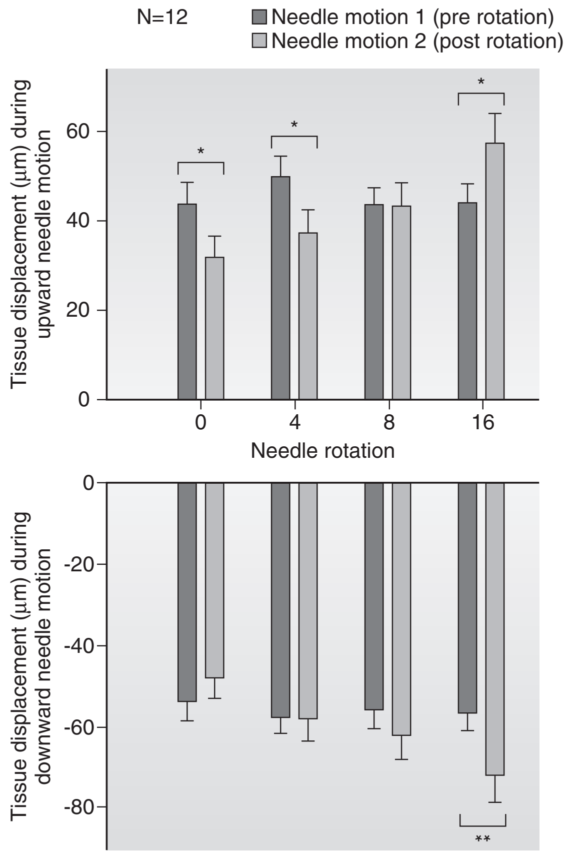

Figure 3.3 • Tissue displacement during upward and downward needle motion before (dark grey bars) and after (light grey bars) increasing amounts of needle rotation • After needle rotation, there was a significant ($p<0.001$) linear increase in tissue displacement as a function of needle rotation for both upward and downward needle motion. Reprinted with permission from Langevin HM, Konofagou EE, Badger GJ et al. (2004) Tissue displacements during acupuncture using ultrasound elastography techniques. Ultrasound Med Biol 30: 1173-1183

within the tissue initially drop; then, settles at an equilibrium level of tension due to molecular reorganization within the collagen matrix.

Further, stretching has also important effects on the cells that inhabit connective tissues. In particular, connective tissue fibroblasts within loose areolar (but not dense) connective tissue respond to sustained static stretch by changing shape, flattening and expanding in the plane of the tissue, with formation of new cytoplasmic extensions termed 'lamellipodia' (Langevin et al. 2005). This pronounced change in fibroblast shape is an active response of the cell that involves remodeling of the cell's cytoskeleton. This active change in cell shape is accompanied by a further drop in tissue tension that is beyond that achieved by simple visco-elastic relaxation (Langevin et al. 2011). This active connective tissue relaxation appears to require static stretching that is sustained for at least 10 minutes and is slightly beyond the usual range of motion, but not sufficient to cause tissue damage.

Remarkably, this is exactly the type of mechanical stimulation produced by acupuncture needle rotation followed by leaving the needle in place for several minutes as is commonly done in acupuncture practice. In fact, recent animal experiments have confirmed that the same type of fibroblast responses induced by sustained tissue stretch also occurs after acupuncture needle rotation (Langevin et al. 2006). In the immediate vicinity of the needle, fibroblasts are caught in the collagen 'whorl' and appear twisted and damaged. However, beginning a few millimeters from the needle, fibroblasts expand, flatten and increase their cross-sectional area up to several centimeters away from the needle.

This active response of fibroblasts is dependent on the 'dose' of needle rotation: a specific amount of uni-directional or bi-directional rotation cause a maximum response, while more rotation causes fewer changes in fibroblast shape (Langevin et al. 2006, 2007). These non-linear responses are interesting in light of the commonly held notion in acupuncture practice that needles must be manipulated 'just enough' to elicit an effect, but not too much. Indeed, acupuncturists are trained to feel for a slight tug of the tissue on the needle indicating that the proper amount of stimulation has taken place. In addition simultaneously to the 'grasping' of the needle by the tissue, the patient often feels a specific sensation termed 'de qi' which is thought to be due to stimulation of deep sensory afferents within the tissue.

It is important to note that we have little knowledge at present linking the connective tissue responses described above to therapeutic effects. A substantial body of evidence has shown that the manual stimulation of acupuncture needles has effects on the nervous system (Chiang 1974, Hui et al. 2000, Kong et al. 2002, Napadow et al. 2009, Goldman et al. 2010). However, the mechanistic pathway leading from the needle to the nervous system is not well understood. A plausible scenario is that, during acupuncture, winding of collagen is an important mechanism transmitting the mechanical signal delivered by the needle to the sensory nervous system. This is supported by a recent study in rats in which injection of collagenase into the tissue abolished the analgesic effect of acupuncture needle manipulation by breaking down collagen fibers and preventing formation of the needle-tissue bond (Yu et al. 2009). We do not know, however, the significance of the change in fibroblast shape occurring away from the needle. An interesting hypothesis is that active fibroblast responses away from the needle could modulate connective tissue tension or signaling along connective tissue planes, although this has not yet been tested. Ancient acupuncture texts contain a number of references to 'fat, greasy membranes, fasciae and systems of connecting membranes' through which a form of communication or energy exchange termed 'qi' is believed to flow (Matsumoto & Birch 1988). Several authors have suggested that a correspondence may exist between acupuncture meridians and connective tissue (Larson 1990, Oschman 1998, Ho & Knight 1998). A study mapping acupuncture points and meridians on serial cadaver sections suggests a correspondence between acupuncture meridians and inter- or intra-muscular connective tissue planes (Langevin & Yandow 2002). Interestingly, after acupuncture needle rotation, the force necessary to pull the needle out of the skin is slightly greater at acupuncture points than at neighboring control points (Langevin et al. 2001b). This is consistent with the possibility that the needles may have inserted into slightly deeper connective tissue at acupuncture points. It is indeed possible that acupuncture meridian maps were developed over 2000 years ago as guides to insert needles into connective tissue, although of course this will have to remain a speculation.

Conclusion

In summary, the effects of acupuncture needling on connective tissue include winding of collagen, mechanical coupling between needle and tissue, sustained static stretching after needle rotation and active fibroblast cytoskeletal responses extending several centimeters away from the needle. Much remains unknown regarding the therapeutic importance of these responses. Clearly, however, the continued investigation of these phenomena will expand our understanding of normal connective tissue function, which is an essential step toward understanding its role in disease and treatment.

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Part 2: Fascia and dry needling

3

Jan Dommerholt

CHAPTER CONTENT

Introduction

Although Travell coined the term 'myofascial' in relation to trigger points (TrP), the myofascial literature rarely considers the role of fascia in defining the etiology of TrPs and therapy. In the TrP literature, including this publication and Travell and Simons' two-volume *Trigger Point Manual*, muscles are usually presented as individual, stand-alone structures with defined origins and insertions, contractile functions, and referred pain patterns (Travell & Simons 1992, Simons et al. 1999). Viewing muscles independently from fascial structures is quite common in anatomy books, sports medicine, physical therapy and chiropractic publications, yet does not come close to reflecting the actual reality. While this outdated model is still acceptable for teaching the basics of TrP dry needling, current advances in fascial research have shown that the role of fascia can no longer be ignored. In Part I of this chapter, Langevin reported on the effect on needling procedures on connective tissue. In this section, we will explore a theoretical framework for the role of fascia in dry needling. Unfortunately, there is no substantial research into this area, which makes this chapter by default somewhat speculative.

Brief update on fascia

Every time a needle is inserted through the skin towards a TrP, the needle passes through multiple levels of fascia. Fascia is divided into superficial and deep fascia, reflecting their topographical relationships with the skin, and muscle-related fascial layers (Langevin & Huijing 2009, Findley et al. 2012). Superficial fascia consists of subcutaneous 'loose' or non-dense connective tissue, which contains collagen, elastin, and some fat tissue. Deep fascia is comprised of a connective tissue membrane that sheaths muscles, nerves, vessels, and certain organs. Deep fascia has no fat tissue. The deep fascia and muscles are separated by a layer of loose connective tissue rich in hyaluronan, which is thought to facilitate the free sliding of adjacent layers (Stecco et al. 2011). Hyaluronan is a glycosaminoglycan polymer of the extracellular matrix and has also been identified in between various muscle tissues in rats and humans (Laurent et al. 1991, Piehl-Aulin et al. 1991).

Muscle-related layers consist of epimysium, perimysium and endomysium. The epimysium consists of the fascia, which surrounds single muscles, and is directly connected with the perimysium, which surrounds muscle fiber bundles, and the endomysium, which surrounds deeper muscles fibers (Findley et al. 2012). The endomysium covers the full length of myofibrils until the myotendinous junction (Trotter & Purslow 1992, Trotter, 1993) and is the main aspect of the extracellular matrix involved in muscle flexibility (Passerieux et al. 2009).

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The tension of the deep fascia is maintained by many muscular attachments. Muscles distribute a significant part of contractile forces onto fascial structures, which subsequently will increase joint stability and facilitate movement involving several other muscles (Findley 2012). Myofascial force transmission occurs between antagonistic muscles via the endomysium (Huijing 2009a, 2009b, 2009c). Interestingly, Maas Sandercock (2009) demonstrated that although the soleus muscle in a cat does have strong mechanical connections with synergistic muscles, the force transmission from the soleus muscle does not appear to be affected by length changes of its synergists, which means that not all muscles appear to use the same mechanisms for force transmission.

The most common cells found in connective tissue are fibroblasts, which play a significant role in the synthesis of collagen, ground substance, elastin and reticulin (Cantu & Stanborough 2012). Normally, fibroblasts are more or less shielded in the extracellular matrix, but their interactions with the collagen matrices are determined partially by the degree of tension in the matrix. Under high tension, fibroblasts feature stress fibers and focal adhesions, and appear lamellar in shape, while under low stress they are more or less rounded and somewhat dendritic in nature (Grinnell 2003, Langevin et al. 2005, 2010, 2011, Miron-Mendoza et al. 2008). Lamellar fibroblasts have a characteristic high matrix biosynthetic activity and they can differentiate in myofibroblasts, which feature a contractile apparatus of actin microfilaments and non-muscle myosin (Tomasek et al. 2002). Myofibroblasts are involved in wound closure, but are also active during muscle contractions (Yahia et al. 1992,1993) and the formation of Dupuytren's contractures (Satish et al. 2011). Perimysium, especially, has a high density of myofibroblasts and they may play a significant role in muscle contractibility and possibly in the formation of TrPs (Schleip et al. 2005, 2006a, 2006b, 2008). If direct connections are present between TrPs and perimysium, would that suggest that myofascial TrPs are more prevalent in tonic muscles, since they contain more perimysium than phasic muscles (Schleip et al. 2006a)?

Collagen fibers in a particular layer are oriented in the same plane and direction; however, they are at a 78° angle with the fiber direction in adjacent layers (Purslow 2010, Benetazzo et al. 2011). This may have implications for manual TrP therapy. Chaudhry et al. (2007, 2008, 2012) found that a greater fiber angle makes collagen fibers more resistant to longitudinal stretching. Since the muscle fiber direction does not necessarily match the fascia fiber direction, further research should examine whether stretching exercises after manual TrP release or dry needling have evidence-based value and if so, what the optimal stretching methods entails.

Fascia and trigger points (TrPs)

As early as 1944, one effect of TrP injections was attributed to mechanical stimulation (Steinbrocker 1944). Dry needling is similar to injection therapy and generally thought to be equally effective (Cummings & White 200, Ga et al. 2007). Because the needle has to pass through the superficial and deep fascia to reach TrPs, the effects on these structures has to be considered on treatment outcomes, even though there is no research confirming or denying this hypothesis.

In Part I of this chapter, Langevin mentioned that rotation of solid filament needles can cause an 'internal' stretch of the tissues. In a previous paper, Langevin et al. (2001a) suggested that there may be a coupling between the needle and body tissues consisting of surface tension and electrical attraction. The electrical attraction is probably fairly weak, but may be sufficient to cause some initial winding of tissue around the needle and contribute to the mechanical effect of dry needling (Dommerholt 2012). Rotating a needle that has been placed in a taut band or a TrP is advocated in dry needling courses as the most direct method of stretching the taut band or muscle contracture (Gunn & Milbrandt 1977). As every muscle fiber bundle is surrounded by fascial layers, the question emerges whether rotation of the needle actually stretches the taut band and muscle fibers or the deeper connective tissue fibers, or perhaps both muscle and fascia (Langevin et al. 2001a). With needling rat abdominal explants, Langevin et al. observed pulling of the sub-dermal tissue without structural changes in the dermis and muscle (Langevin et al. 2001a). Does DN change the viscoelastic properties or behaviour of fascia? If so, fascial manipulation techniques should probably play a greater role in trigger point therapy as suggested by Stecco and others (Stecco 2004, Gröbli & Dommerholt 1997).

Taking this a step further, it is conceivable that fascial restrictions of the perimysium contribute to taut band formation. Perimysium seems to adapt more to changes in mechanical tension than other intramuscular connective tissues and is capable of increasing muscle stiffness (Passerieux et al. 2007). On the other hand, taut bands are palpated perpendicular to the muscle fiber direction and the direction of fascial fibers does not match the direction of muscle fibers. Stecco et al. (2011) speculated that changes in the density of loose connective tissue of the deep fascia and the hydrodynamics of hyaluronan may contribute to the development of myofascial pain.

Stretching connective tissue with a needle has been shown to stretch and reduce the tissue tension, flatten fibroblasts and remodel the cytoskeleton (Langevin et al. 2011). The mechanical stimulation by a needle may activate mechanotransduction (Langevin et al. 2001a). It is not known whether the instantaneous reduction of local and referred pain following DN or TrP injections is related to stimulation of fibroblasts. Langevin et al. (2001b, 2002, 2006) showed that the effects of acupuncture needling can at least partially be explained by stimulation of fibroblasts. Does stimulation of TrPs involve myofibroblasts and result in similar mechanical signalling and a reduction in nociception (Dommerholt 2012)?

Summary

As mentioned in the introduction of part II of this chapter, the role of fascia in myofascial pain and TrPs is not at all clear. There is virtually no research of the contributions of the various fascial layers to TrP formation, referred pain, peripheral and central sensitization, among others. What about the effects of DN on fascial adhesions, densifications, scar tissue, development of strength and flexibility? Fortunately, many researchers around the globe have zoomed in on fascia and its role in our bodies. Much research is indeed needed to gain a better understanding of the interactions between TrPs, muscles and fascia.

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Dedication

Jan Dommerholt would like to dedicate this book to
Mona for her support and understanding
Taliah for reminding me that the world is here to explore
Aram for swimming very early in the morning, which gives me time to write
Tuli for her unconditioned love and affection
My parents for providing the foundation of everything I have accomplished
My patients for giving me inspiration to educate others

César Fernández-de-las-Peñas would like to dedicate this book to
Cristina for her love and support during her life
Marta for not permitting me to write during the day
Miguel Angel for his love from heaven
My parents for their lives dedicated to the family
My colleagues and friends of the Department of Physical Therapy, Occupational Therapy, Rehabilitation and Physical Medicine for their support during my life
My patients for permitting my personal and professional growth

Foreword by Robert D. Gerwin MD

Myofascial pain is arguably the most common cause of pain to afflict humankind. It is a pervasive musculoskeletal pain that is associated with a wide variety of ills: tension-type and migraine headaches, cervicogenic headache, shoulder pain in frozen shoulder, in rotator cuff injuries, in hemiplegic shoulder dysfunction, in non-specific low back pain, in lumbar and cervical radiculopathy, in pelvic pain syndromes, in repetitive strain injuries, and the list can go on and on. The need to be knowledgeable about this pain condition, and to be competent in treating this condition, becomes obvious when one considers the pervasive nature of myofascial pain. Failure to recognize this condition and treat it effectively is to consign our patients to continuing and unnecessary suffering. Fortunately, two of the most skilled and productive clinicians in this field have combined their talents to produce this remarkable text. César Fernández-de-las-Peñas has been extraordinarily productive in the relatively short time since he earned his PhD with Lars Arendt-Nielsen at Aalborg University in Denmark. He has taken a systematic look at myofascial trigger point pain and the varieties of treatment that are used in addressing this condition. His contributions to the field of myofascial pain have been enormous. Jan Dommerholt is perhaps the most distinguished and accomplished clinician in the field. He is certainly the foremost educator in the field of myofascial pain treatment in the world today. He has been the moving force in the growing acceptance of trigger point dry needling by physical therapists in the United States.

These two have brought their knowledge and enthusiasm to bear on this condition in this extraordinary book. The first part of the book provides the scientific underpinning of the field, laying out clearly the current understanding of the nature of myofascial pain and the trigger point. The second part of the book describes the technique of dry needling muscle by muscle. The third part of the book discusses other needling techniques for treating myofascial pain besides trigger point dry needling.

This is a practical book that presents both the foundation for the diagnosis and treatment of myofascial pain and also its treatment by trigger point dry needling. It belongs not on the shelf of every clinician who examines and treats those with musculoskeletal pain, but in the hand and by the treatment table of every such clinician. This book follows in the great tradition of the texts on myofascial pain by the late Drs Janet Travell and David Simons and David's wife Lois Simons. The authors of this text have done us all a great favor, for which we and our patients should be ever grateful.

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