Narrative Review

Dry needling: a literature review with implications for clinical practice guidelines[1]

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Background: Wet needling uses hollow-bore needles to deliver corticosteroids, anesthetics, sclerosants, botulinum toxins, or other agents. In contrast, dry needling requires the insertion of thin monofilament needles, as used in the practice of acupuncture, without the use of injectate into muscles, ligaments, tendons, subcutaneous fascia, and scar tissue. Dry needles may also be inserted in the vicinity of peripheral nerves and/or neurovascular bundles in order to manage a variety of neuromusculoskeletal pain syndromes. Nevertheless, some position statements by several US State Boards of Physical Therapy have narrowly defined dry needling as an 'intramuscular' procedure involving the isolated treatment of 'myofascial trigger points' (MTrPs).

Objectives: To operationalize an appropriate definition for dry needling based on the existing literature and to further investigate the optimal frequency, duration, and intensity of dry needling for both spinal and extremity neuromusculoskeletal conditions.

Major findings: According to recent findings in the literature, the needle tip touches, taps, or pricks tiny nerve endings or neural tissue (i.e. 'sensitive loci' or 'nociceptors') when it is inserted into a MTrP. To date, there is a paucity of high-quality evidence to underpin the use of direct dry needling into MTrPs for the purpose of short and long-term pain and disability reduction in patients with musculoskeletal pain syndromes. Furthermore, there is a lack of robust evidence validating the clinical diagnostic criteria for trigger point identification or diagnosis. High-quality studies have also demonstrated that manual examination for the identification and localization of a trigger point is neither valid nor reliable between-examiners.

Conclusions: Several studies have demonstrated immediate or short-term improvements in pain and/or disability by targeting trigger points (TrPs) using in-and-out techniques such as 'pistoning' or 'sparrow pecking'; however, to date, no high-quality, long-term trials supporting in-and-out needling techniques at exclusively muscular TrPs exist, and the practice should therefore be questioned. The insertion of dry needles into asymptomatic body areas proximal and/or distal to the primary source of pain is supported by the myofascial pain syndrome literature. Physical therapists should not ignore the findings of the Western or biomedical 'acupuncture' literature that have used the very same 'dry needles' to treat patients with a variety of neuromusculoskeletal conditions in numerous, large scale randomized controlled trials. Although the optimal frequency, duration, and intensity of dry needling has yet to be determined for many neuromusculoskeletal conditions, the vast majority of dry needling randomized controlled trials have manually stimulated the needles and left them *in situ* for between 10 and 30 minute durations. Position statements and clinical practice guidelines for dry needling should be based on the best available literature, not a single paradigm or school of thought; therefore, physical therapy associations and state boards of physical therapy should consider broadening the definition of dry needling to encompass the stimulation of neural, muscular, and connective tissues, not just 'TrPs'.

Keywords: Dry needling, Literature review, Trigger point, Practice guidelines, Physical therapy

Introduction

Local injection therapies, often referred to as 'wet needling', use hollow-bore needles to deliver corticosteroids, anesthetics, sclerosants, botulinum toxins, or other agents.[1,2] In contrast, 'dry needling' refers to the

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insertion of thin monofilament needles, as used in the practice of acupuncture, without the use of injectate.[3–6] Dry needling is typically used to treat muscles, ligaments, tendons, subcutaneous fascia, scar tissue, peripheral nerves, and neurovascular bundles for the management of a variety of neuromusculoskeletal pain syndromes.[3,6,7] Given the broad base of international literature presently available on the technique, it is particularly concerning that the primary US-based, National Physical Therapy Association[8] and several State Boards of Physical Therapy[9–13] have recently narrowed their definition of dry needling to an 'intramuscular' procedure, i.e. the insertion of needles into nodules within taut bands of muscle, more commonly referred to as 'trigger points' (TrPs) or 'myofascial trigger points' (MTrPs). More specifically, these professional organizations have equated the procedure of dry needling with the term 'intramuscular manual therapy' (IMT) or 'trigger point dry needling' (TDN). Certainly, IMT, or the insertion of needles into TrPs within muscle bellies, is one aspect of dry needling; however, IMT or TDN should not be used synonymously with the term dry needling. In addition to TrPs within muscular tissue, an extensive body of literature, including both peer-reviewed articles and randomized controlled trials, supports the insertion of dry needles throughout the body at non-TrP sites for the purpose of reducing pain and disability in patients with neuromusculoskeletal conditions. Just as the Maitland,[14] Kaltenborn,[15] and McKenzie[16] approaches are each unique brands of manual therapy, 'TDN' and 'IMT' are individual aspects of dry needling. Each describes a single framework, paradigm, or approach that falls under the much larger field of dry needling.[5,6,9,10,17–25]

Dry Needling Targets Neural, Muscular, and Connective Tissues, Not Just TrPs

The first, peer-reviewed journal article on dry needling published by a Western, medical physician[6] did not limit needle insertion to muscular 'TrPs'; rather, the 241-patient study reported that only 2 of the 14 target structures were muscular TrPs.[6] The other structures needled included ligaments, scar tissue, tendons, bones, and teno-osseus insertion sites, all of which are types of connective tissue.[6] In addition, 'a high density of neurovascular structures' has been found at dry needling target sites.[26]

As early as 1977, Melzack *et al.*[27] stated that 'Trigger points are firmly anchored in the anatomy of the neural and muscular systems… and the stimulation of particular nerves or tissues by needles could bring about an increased input to the central biasing mechanism, which would close the gates to [pain] inputs from selected body areas'.[27] In a more recent commentary titled *'Treatment of Myofascial Pain Syndrome'*, Hong stated that the purpose of 'the fast-in and fast-out needle technique'[26,28–30] in a fan or cone shape is to 'ensure that all or most sensitive loci (i.e. tiny nerve endings) are encountered'.[28] Widely considered one of the world authorities on both dry needling practice and experimental research, Hong further reported that 'high-pressure stimulation by needling'[26,28,31–33] or 'mechanical irritation of the needle'[26,34] to 'multiple sensitive loci or nociceptors within the same MTrP'[26,28,31–34] likely 'elicits a local twitch response that subsequently provides a very strong neural impulse to the MTrP circuit to break the vicious cycle so that MTrP pain is relieved'.[26,28,33,34] Interestingly, 'bilateral or mirror image evoked potentials' or 'local twitch responses'[34] (LTRs) have been recorded in the contralateral trapezius during unilateral dry needling stimulation of active TrPs on the ipsilateral, symptomatic trapezius.[34] Audette *et al.*[34] concluded, 'the LTR is generated by inducing a spinal reflex that involves sensory input to the spinal cord by mechanical irritation of the needle at sensitive loci in the TrP which then results in a motor, efferent response of the alpha motor neuron pool'.[34] The presence of bilateral LTRs during unilateral dry needling 'argues strongly for a central abnormality rather than a purely peripheral [muscular] abnormality in patients with active MTrPs'.[34]

Thus, within the context of myofascial pain syndromes, dry needles likely come in contact with both muscle and connective tissue.[6] It is held by several research teams that needles inserted into MTrPs likely touch, tap, or prick tiny nerve endings or neural tissue for the purpose of pain reduction. Based on the most recent literature,[6,21,26,28–37] the definition of dry needling by the American Physical Therapy Association (APTA) and State Boards of Physical Therapy should therefore clearly articulate that dry needling encompasses stimulation of neural,[26,28–31,33,36,38–54] muscular,[5,17,18,21,26,29,30,33,48,55–69] and connective tissues,[6,48–54,70–72] and not just 'TrPs'.[73,74]

2013 APTA Definition: Dry Needling Targets Both Muscular and Connective Tissues

Page two of the January 2012 Resource Paper[8] titled, *Physical Therapists & the Performance of Dry Needling* defined dry needling as 'an invasive technique used by physical therapists (where allowed by state law) to treat myofascial pain that uses a dry needle, without medication or injection, which is *inserted into areas of the muscle known as trigger points*…'[8] Notably, an updated February 2013 APTA version of this document titled, *Description of Dry Needling in Clinical Practice: an Educational Resource Paper*, defines dry needling as including both muscular and connective tissues, but not neural stimulation.[75] The paper reads, 'dry needling is a

skilled intervention that uses a thin filiform needle to penetrate the skin and stimulate underlying myofascial trigger points, muscular, and connective tissues for the management of neuromusculoskeletal pain and movement impairments'.[75] Interestingly, the 2013 definition implies that only muscle and connective tissue may be targeted by dry needles in the treatment of *neuro*musculoskeletal pain.[26,28,31–34] Yet, nerve endings, referred to as 'sensitive loci' or 'neurovascular bundles' are clearly supported as needle stimulation targets in the existing literature.[26] How can physical therapists treat the 'neuro' in *neuro*musculoskeletal with dry needles without placing needles near, beside, or onto neural tissue (i.e. peri-neural needling)? By adding neural targets to the position statement, the APTA would provide a stronger and more evidence-based framework for state boards to follow.

Narrowly Focused Position Statements by State Boards of Physical Therapy

To date, a number of State Physical Therapy Boards[9–13] continue to have limited definitions of dry needling. As a result, many physical therapists believe that they are only able to treat patients by targeting intramuscular TrPs with dry needles, as their respective State Boards do not authorize them to insert needles into connective tissues (e.g. ligaments, tendons, teno-osseus junctions, musculotendinous junctions, scar tissue) or to perform peri-neural or peri-neurovascular needling. Several State Boards of Physical Therapy have issued narrowly focused position statements on dry needling:

- *Mississippi (Effective: 10 September 2012):* The Mississippi State Board of Physical Therapy updated its regulations to read, 'Intramuscular manual therapy is a physical intervention that uses a filiform needle no larger than a 25-gauge needle to stimulate trigger points, diagnose and treat neuromuscular pain and functional movement deficits; is based upon Western medical concepts; requires an examination and diagnosis, and treats specific anatomic entities selected according to physical signs'.[10]
- *North Carolina (Effective: 14 June 2012):* The North Carolina Board of Physical Therapy Examiners revised its definition of dry needling to read, 'Intramuscular Manual Therapy (IMT), which is generally referred to as dry needling, is defined as a technique to treat myofascial pain using a dry needle (without medication) that is inserted into a trigger point with the goal of releasing/inactivating the trigger points and relieving pain'.[9]
- *Louisiana (Effective: 20 October 2011):* Rule 311 of the Louisiana Physical Therapy State Board uses the terms 'dry needling' and 'intramuscular dry needling' interchangeably, and as a result, requires a physical therapist to 'successfully complete…no fewer than 50 hours of face-to-face instruction in intramuscular dry needling treatment and safety'.[11]
- *Nebraska (Effective: 20 June 2011):* The Nebraska State Board of Physical Therapy opined, 'Dry needling is a mechanical modality technique used to treat myofascial pain that uses a dry needle, without medication, that is inserted into a trigger point with the goal of releasing/inactivating the trigger points'.[12]
- *Colorado (Effective: 30 June 2012):* The Colorado State Physical Therapy Board opined, 'Dry needling (also known as Trigger Point Dry Needling) is a physical intervention that uses a filiform needle to stimulate trigger points, diagnose and treat neuromuscular pain and functional movement deficits; is based upon Western medical concepts; requires an examination and diagnosis, and treats specific anatomic entities selected according to physical signs. Dry needling does not include the stimulation of auricular or distal points'.[13]

Whether these State Boards of Physical Therapy[9–13] will update their position statements and/or practice acts to include both neural and connective tissue as possible target structures for dry needling remains to be seen. However, Arizona has recently provided a reason to be optimistic. In January 2013, the Arizona Physical Therapy Association set the standard by becoming the first US-based, physical therapy association to explicitly recognize neural, muscular, and connective tissue as target sites for dry needling.[76] The definition of dry needling that appears in the Arizona position statement reads,

> *It is the position of the Arizona Physical Therapy Association that dry needling for the management of neuromusculoskeletal conditions is consistent with the scope of practice of licensed physical therapists in Arizona. Dry Needling is a skilled intervention performed by a physical therapist that uses a thin filiform needle to penetrate the skin and stimulate underlying neural, muscular and connective tissues for the evaluation and management of neuromusculoskeletal pain and movement impairments.*[76]

Page two of the January 2012 APTA Resource Paper[8] titled, *'Physical Therapists & the Performance of Dry Needling'*, also states, 'Preliminary research supports that dry needling improves pain control, reduces muscle tension, normalizes biochemical and electrical dysfunction of motor endplates, and facilitates an accelerated return to active rehabilitation'. However, although the reference list of the 141-page resource paper[8] cited four systematic reviews,[17,19,24,56] one clinical review,[21] and one unpublished evidence summary,[77] the 23 randomized controlled trials that were reportedly reviewed and rated by a single expert on a 0–5 scale for quality and level of support for dry needling, were not individually identified or specifically referenced in any way.[8] Moreover, while the 'median quality of the research was 4' and the 'median support for dry needling was 3', the specific studies included in the analysis remains a mystery.[8] This resource paper[8] also failed to describe available

literature on neuromusculoskeletal conditions that supports the use of 'TrP' dry needling.

It is concerning that the APTA[8,75] and several State Boards of Physical Therapy[9–13] continue to omit neural and/or connective tissue as possible target structures when defining dry needling in official position statements. Perhaps position statements that compartmentalize dry needling to 'IMT' – i.e. confine it to muscle bellies, tight knots, or 'myofascial TrPs',[8–11] – fit better with the traditional physical therapy framework. Given that other professions continue to question whether dry needling is within the scope of practice of a physical therapist, declaratory statements by State Boards of Physical Therapy that operationalize dry needling with an 'intramuscular'[9–13] framework may be a more defensible position. Certainly, 'nerve points'[42,43] sound a little 'Eastern' to some, and may, at face value, be confused with traditional Chinese acupuncture; however, dry needling neither attempts to move *qi* along meridians, nor does it rely on diagnoses from traditional Chinese acupuncture or Oriental medicine.[78,79]

TrP Needling is Only One Kind of Dry Needling

In 2009, the APTA recommended 'IMT' as the term to be used by physical therapists to describe the intervention of dry needling.[8] The following excerpt is from page two of the January 2012 Resource Paper titled, *'Physical Therapists & the Performance of Dry Needling'*:

> *Dry needling is an invasive technique used by physical therapists (where allowed by state law) to treat myofascial pain that uses a dry needle, without medication or injection, which is inserted into areas of the muscle known as TrPs. A TrP describes a taught band of skeletal muscle located within a larger muscle group. Trigger points can be tender to the touch and can refer pain to distant parts of the body. Physical therapists utilize dry needling with the goal of releasing/inactivating the TrPs and relieving pain.*[8]

This definition seems to suggest that physical therapists should only insert needles into muscle bellies in an attempt to inactivate TrPs. This recommendation makes sense considering Itoh *et al.*[80] found that 'TrP acupuncture' of the splenius capitis, upper trapezius, levator scapulae, sternocleidomastoid, suboccipitals, scaleni and paravertebrals was more effective in the short-term (i.e. at week 13) at reducing pain and disability than classical or sham acupuncture in patients with chronic, non-radiculopathic neck pain. In contrast, Tough *et al.* concluded in a 2009 systematic review and meta-analysis that 'there is limited evidence deriving that deep needling directly into myofascial trigger points has an overall treatment effect when compared to standardized care'.[24] Moreover, 'the result of the meta-analysis of direct dry needling [for myofascial trigger point pain] compared to placebo control treatment did not attain statistical significance'.[24] There is a paucity of high-quality evidence to underpin the use of direct dry needling into myofascial TrPs for the purpose of short/long-term pain and disability reduction in patients with musculoskeletal pain syndromes.[18,20,23,24,80] Rather, the vast majority of the dry needling literature has demonstrated that targeting TrPs (i.e. muscle tissue) and non-TrP structures (i.e. neural and connective tissues) in combination, or non-TrP structures alone, is effective for the reduction of pain and disability in knee osteoarthritis,[50–51,81–83,85–90,166–168] hip osteoarthritis,[53,91–94] piriformis syndrome,[60] carpal tunnel syndrome,[36,37,40,41,44,45,47] migraine,[95–101] tension type headache,[97,98,102] temporomandibular disorder,[59,67,103–107] shoulder pain,[108–110] neck pain,[23,24,29,35,61,63–65,80,111–114] low back pain,[4,5,19,20,66,69,115–125] and plantar fasciitis.[48,49,54,56,126,127]

While many of these studies directly use the term 'dry needling',[5,18,21,26,33,56,64,67,104,110] in their methodology, other studies use alternative terminology such as 'deep dry needling',[67] 'superficial dry needling',[55,128] 'TrP acupuncture',[20,80] 'paraspinal needling',[64] 'intramuscular and nerve root needling',[65] 'needle electrical intramuscular stimulation',[129] 'needle release',[113] 'acupuncture needling',[63,113] 'needling therapy',[17] 'acupuncture'[36–38,40,41,47,49–55,61,69,72,81–88,90,92,94–100,105–108,112,115–117,119–123,130–135] and 'electroacupuncture'.[37,46,93,126,127,136–139] Some studies have even chosen to use both 'acupuncture and dry needling'[19,23,24,62,77] in their titles. Importantly, none of the studies used medicine and/or injectate in conjunction with their needling procedure; therefore, all studies fit within the strict definition of dry needling, regardless of terminology. To our knowledge, no published randomized controlled trials, to date, have used the words 'IMT' to describe a dry needling intervention for any condition.

Interestingly, the most common term used to describe dry needling is 'acupuncture'. Physiotherapists and/or medical physicians[114–116,119,171–174] within both government administered national health services and mainstream university health systems[53,90,97–99,114,123,133,134,] in the UK,[49,51,52,84,100,101,131,132] Canada,[114] USA and Germany[53,90,97–99,123,133,134] use the term 'acupuncture' to describe dry needling methodologies. The same is true of articles published in mainstream, highly respected journals, including the *British Medical Journal*,[84,89,100,101,112,124] *European Journal of Pain*,[24,131] *Archives of Physical Medicine & Rehabilitation*,[17,22,60,109,140,141] *Pain*,[6,44,87,111,123,125,133,136,142] *Annals of Internal Medicine*,[4,81,86,88,117,132] *Headache*,[95,96] *Rheumatology*,[35,51,82,85] *Spine*,[5,19,66,114,118,119,121,135] and *Cochrane Database of Systematic Reviews*.[62,108] Even the *Physical Therapy Journal* sponsored by the APTA has used acupuncture and

dry needling interchangeably in a recent publication.[52] It would therefore be a mistake to ignore the findings of high-quality, randomized controlled trials,[37,40,53,54,63,81,84,89,90,92,99,100,107,114,115,119,125,132,143] systematic reviews,[17,19,23,56,83,97,121,144] meta-analyses,[24,85] Cochrane reviews,[62,108,145] the British practice guidelines,[124] the European practice guidelines,[146,147] and the joint clinical practice guidelines from the American College of Physicians and the American Pain Society[117] simply because they used the term 'acupuncture' instead of dry needling in their title and/or methods section. Moreover, ignoring RCTs published by PhD and licensed acupuncturists (LAc) in well-respected, peer-reviewed journals would be shortsighted. By disregarding these studies, physical therapists may limit their ability to support the use of dry needling in clinical practice for treating knee osteoarthritis, shoulder pain, carpal tunnel syndrome, migraine headache, tension type headache, hip pain, low back pain, and neck pain.

Physical Therapists Should Not Ignore the Findings of Western Acupuncture Trials

'Acupuncture' literally translates to '*needle penetration*' (*i.e.* 'acu'=needle; 'puncture'=penetration), and the vast majority of the 'acupuncture' trials are not claiming to move *qi* along meridians or channels. Furthermore, the vast majority of the so-called 'acupuncture' RCTs have used Western medical diagnoses (not traditional Chinese or Oriental medicine[78,79] diagnoses such as *bi* syndrome, *qi*, blood stagnation, and kidney *yang* deficiency[143,148]) such as chronic neck pain,[23,24,29,35,61,63–65,80,111–114] plantar fasciitis,[48,49,54,56,126,127] knee osteoarthritis,[50–52,81–90], and carpal tunnel syndrome.[36,37,40,41,44,45,47] These same 'acupuncture' trials have investigated the efficacy of inserting thin filiform needles (without medicine) into 'Ah-Shi points' (Chinese for 'auwh that's where it hurts' or 'that's it'; synonymous with trigger points[57,58,154]) and/or non-trigger point locations. Thus, while the terminology, theoretical constructs, and philosophies are different, the actual procedure of inserting thin monofilament needles, as used in the practice of acupuncture, without the use of injectate is very similar across professions.[3] The use of McKenzie[16] exercises by a chiropractor does not make him or her a physical therapist; likewise, the use of dry needles by a physical therapist does not make him or her an acupuncturist. Rather, these techniques are shared procedures among a variety of healthcare professions. As an additional comparison, physical therapist researchers do not ignore or exclude studies published by MDs, DOs, and DCs when citing references to support the use of spinal manipulation treatments for a variety of neuromusculoskeletal conditions simply because the authors consider the techniques as 'chiropractic' or 'osteopathic manipulations'. Physical therapists should therefore not ignore the findings of large scale randomized controlled trials available in the Western or biomedical 'acupuncture' literature that use the same 'dry needles' to treat patients with neuromuscular conditions.[49,51–53,84,90,97–101,114,123,131–134]

Poor Inter-Examiner Reliability for TrP Location

Barbero *et al.*[150] reported 'moderate to high' intra-rater reliability of an experienced physiotherapist for determining the location of MTrPs within the upper trapezius muscle. However, in a recent systematic review on the reliability of physical examination for the diagnosis of myofascial TrPs, Lucas *et al.*[144] concluded, 'There is no accepted reference standard for the diagnosis of trigger points, and data on the reliability of physical examination for trigger points is conflicting'. In addition, a predictable pattern of pain referral and the local twitch response are each no longer considered to be sufficient or necessary for the diagnosis of a TrP.[22,25,144] After reviewing nine studies on reliability, Lucas *et al.*[144] further concluded:

> *None of the nine studies in this systematic literature review specifically reported inter-rater reliability estimates for the identification of the location of active trigger points in symptomatic participants…. At present, there is no data on the reliability of pinpointing the exact location of active trigger points…. The existing data on reliability pertain only to agreeing if a muscle has the signs of a trigger point and not the exact location of the taut band or the nodule within the taut band.*[144]

Lew *et al.*[151] reported that the inter-examiner agreement was only 21%, and Sciotti *et al.*[142] reported error rates of 3.3–6.6 cm among examiners attempting to identify the specific location of TrPs in the upper trapezius muscle. In another recent literature review, Myburgh *et al.*[22] found poor inter-examiner reliability of manual palpation of TrPs in various muscle groups. Only 'tenderness' of the upper trapezius, not the actual location of the TrP, was found to be moderately reliable. In 2011, Myburgh *et al.*[152] similarly reported 'good agreement between experienced practitioners' for the 'presence or absence' of a clinically relevant TrP in the upper trapezius muscle. However, this study, like the many others,[153–157] failed to investigate the inter-rater reliability for determining the specific location of the TrP within the target muscle. If clinicians are not able to reliably identify TrPs, they may not be able to consistently activate/deactivate them by penetrating the nodule within the taught band, as is commonly taught by Travell and Simons.[73,74] In fact, in a recent systematic review, Tough *et al.*[25] concluded, 'There is a lack of robust

empirical evidence validating the clinical diagnostic criteria [for TrP identification or diagnosis] proposed by both Travell and Simons (1999) and Fischer (1997)'.

High-quality evidence suggests that manual examination for the identification of the specific location of the 'TrP' is not a valid[22,25,152] or reliable[22,142,144,151] process between-examiners. Poor reliability of TrP identification also makes it rather challenging, if not impossible, for Physical Therapists to be in compliance with the APTA[8] and several State Physical Therapy Boards.[9,10,11,12,13] As Lucas *et al.*[144] summarizes, 'It is not yet evident that examiners can agree on the precise location of an active TrP; hence, they cannot be relied upon to accurately insert the needle into the nodule of the taut band'. Perhaps 'TrP dry needling', or 'IMT',[8–13] as performed by physical therapists, does not meet the criteria of evidence-based practice (i.e. a valid and reliable diagnostic and therapeutic intervention).

Ah-Shi Acupuncture Points and TrPs: Different Theories, Similar Locations

Although 'IMT' or 'TrP needling' involves insertion of needles into muscle bellies, Melzack *et al.*[27] reported:

> *a high degree (71%) of correspondence between MTrPs and acupuncture points, and it is very likely that all MTrPs are* Ah-Shi *acupuncture points… [however], trigger points are firmly anchored in the anatomy of the neural and muscular systems, while acupuncture points are associated with an ancient conceptual but anatomically non-existent system of meridians, which carry Yin (spirits) and Yang (blood).*[27]

Melzack *et al.*[27] further concluded, 'trigger points and acupuncture points for pain, though discovered independently, and labeled differently, represent the same phenomenon and can be explained in terms of the same underlying neural mechanisms'. More recently, Dorsher and Fleckenstein,[57] both medical physicians, found that 238 (93.3%) of 255 common MTrPs anatomically corresponded with classical acupoints. Furthermore, 'the marked correspondences of the pain indications (up to 97%) and somatovisceral indications (up to 93%) of anatomically corresponding common MTrP-classical acupoint pairs provide a second, clinical line of evidence that trigger points and acupuncture points likely describe the same physiologic phenomena'.[58] Dorsher further demonstrated a strong correspondence between the distributions of the myofascial referred-pain patterns[73,74] and acupuncture meridians[78,79] of anatomically corresponding common MTrP-classical acupoint pairs.

Biomechanical, Chemical, Endocrinological, and Vascular Effects of Dry Needling

The biomechanical,[70–72,158] chemical,[141,159] and vascular[129,138,140,160–162] effects of needling either superficial[55] subcutaneous tissue (non-muscular) or deep[23,24,73,74] intramuscular tissue without injectate have been well documented. Improved microcirculation around the knee joint has been demonstrated following 'dry' needling into non-TrP locations,[138] and improved muscle blood flow has been found following 'manual acupuncture' in the lower extremities.[163,164] Following needle electrical intramuscular stimulation targeting MTrPs in patients with shoulder and cervical myofascial pain syndrome, microcirculation above the area of the MTrPs was found to have increased from 127.3 to 310.2 BPUs per Laser Doppler Flowmetry, a greater than two-fold increase. Furthermore, low blood flow seemed to correlate with pain intensity,[129] suggesting that reduced microcirculation plays a role in the pathophysiology of myofascial pain syndrome.[162,165] Electrical dry needling in patients with knee osteoarthritis has also resulted in endocrinological changes, including increases in beta-endorphins and decreases in cortisol.[136]

Non-Trigger Point Dry Needling in Knee Osteoarthritis and Carpal Tunnel Syndrome: Highly Effective

Multiple studies have used dry needling of the knee joint without targeting specific trigger points to treat pain and disability in patients with knee osteoarthritis.[50–52,81–85,89,90,131] Recent systematic reviews and meta-analyses provide strong and overwhelming evidence for the effectiveness of acupuncture in the treatment of knee osteoarthritis.[166–168] According to the Cochrane Database systematic review on acupuncture for peripheral joint osteoarthritis, Manheimer *et al.*[167] found acupuncture to be associated with a statistically significant and clinically meaningful short term improvement in OA pain when compared to a wait list control. Additionally, this systematic review,[167] which included 12 RCTs of patients with knee OA and 4 trials of patients with either knee or hip OA, reported statistically significant reductions in pain following acupuncture in patients with knee OA at 6 months when compared with sham acupuncture. Moreover, in an individual patient data meta-analysis of 9 RCTs comparing real, sham and no acupuncture for chronic pain conditions, Vickers *et al.*[168] reported superior outcomes using real acupuncture in the treatment of knee OA. Additionally, a very recent meta-analysis[166] of 11 high-quality RCTs concluded that real acupuncture provides a significant reduction in pain immediately following treatment compared to other physical treatment methods, including sham acupuncture. In contrast to the findings of the Cochrane Database

systematic review[167] and two recent meta-analyses,[166,168] it is noteworthy that an earlier trial[84] found the addition of real acupuncture to a course of advice and exercise for the treatment of knee OA provided no additional improvement in the WOMAC pain subscale at 6 months when compared to sham acupuncture. The data from Foster *et al.*[84] also failed to demonstrate a significant relationship between patient treatment preferences and clinical outcomes or patient expectations and pain at 6 and 12 months. However, the results of Foster *et al.*[84] should be viewed cautiously due to the limited number of treatment sessions in the acupuncture protocol compared to other studies,[53,81,88,90] which may have rendered the true acupuncture intervention suboptimal, a concession that the authors independently made. More importantly, unlike other trials,[81,82,87–90] the subjects in the Foster *et al.*[84] trial did not have radiographically confirmed knee osteoarthritis. Nevertheless, despite the methodologic differences of the Foster *et al.*[84] trial, a cost-utility analysis of the Foster *et al.*[84] data by Whitehurst *et al.*[52] concluded that advice and exercise plus real acupuncture delivered by physical therapists still provided a cost effective use of health care resources.

Likewise, there is robust evidence that peri-neural needling of non-trigger point structures helps reduce pain and disability while improving sensory and motor nerve conduction velocities.[36,37,40,41,47] Peri-neural needling has also been shown to stimulate microcirculation in patients with mild to moderate carpal tunnel syndrome.[36,37,40,41,47] Such findings suggest that organizations that teach physical therapists a TrP 'search and destroy' method of dry needling may not be evidence based. Rather, therapists may be much more effective treating conditions such as osteoarthritis and carpal tunnel syndrome by focusing on non-TrP locations such as neural, connective, and muscle tissue.

Dry Needling for Tendinopathy, Not Just TrPs

Several recent studies[7,158,161,164,169–171] support the use of dry needling in the management of tendinopathy; more specifically, dry needling has been shown to positively influence tendon healing by increasing blood flow via local vasodilation[161,163,164,169] and collagen proliferation.[158,170] It is theorized that the lack of blood flow and subsequent hypoxic environment contributes to 'tendon dysrepair'[172] and leads to the pain and disability associated with chronic tendinopathy.[7] In comparison to a superficial heating modality, and following dry needling using 'vertical pecking' between the tendon and its sheath, Kubo *et al.*[161] found statistically significant increases in blood flow and oxygen saturation levels around the Achilles tendon. Following dry needling to burn-injured mice, and when compared with conventional dressing, Lee *et al.*[170] found significantly greater basic fibroblastic growth factor and accelerated tissue healing rates. Likewise, Langevin *et al.*[158] reported significantly greater fibroblastic activity following rotational needle manipulation in a mouse model. Clearly, dry needling both superficial and deep non-TrP locations results in significant mechanical,[70–72,158] chemical,[141,159] endocrinological,[136] microvascular,[138,161,163,164,170] neural,[36,41,47] and central effects [38,39,44,46,130,137,160] (i.e. activation of the descending pain inhibitory systems, cortex, hypothalamus, and inactivation of the limbic system per recent fMRI, and PET studies). As such, the physical therapy profession must re-evaluate whether it is truly 'best practice' to limit dry needling to muscle TrPs.

There is Limited Evidence Supporting the Effectiveness of Deep TDN

Compared to sham or placebo treatments, a recent systematic review and meta-analysis[173] recommended 'dry needling [directly into MTrPs] for decreasing pain in patients with upper quarter myofascial pain syndrome'; however, the data in this meta-analysis was based on three 'immediately after' and two 'at 4-weeks' post-treatment studies. More specifically, although the findings of Kietrys *et al.*[173] support the immediate and short-term effectiveness of dry needling, it does not provide any evidence for the long-term effects of direct TDN on pain or disability in patients with upper quarter myofascial pain syndrome.

There are three trials[20,80,113] that seem to be frequently cited by clinicians in support of deep TDN; however, all three studies have significant methodologic limitations. First, Ma *et al.*[113] used a 'mini-scalpel needle release' surgical procedure instead of monofilament dry needling in an effort

Table 1 Duration needles left *in situ* for neuromusculoskeletal condition.

Neuromusculoskeletal condition	Duration needles left *in situ*
Low back pain	10 minutes,[20] 15 minutes,[68] 20 minutes[116,119,125,177] or 30 minutes.[69,123,139]
Carpal tunnel syndrome	30 minutes,[37,40,41] 40 minutes[47] or 60 minutes.[36]
Plantar fasciitis	5 minutes,[56,178,179] 15 minutes[49] or 20 minutes.[126,127]
Knee osteoarthritis	20 minutes[51,81,82,87,88,136] or 30 minutes.[88–90,138]
Shoulder pain	5 minutes[18] or 10 minutes.[110]
Neck pain	10 minutes,[80] 20 minutes[61,132,174,180] or 30 minutes.[111,112,133,181]
Headaches	20 minutes[95] or 30 minutes.[96,98–101]

to remove or disrupt a TrP within the upper trapezius. As such, the study[113] should not be cited in support of 'sparrow pecking', 'pistoning', 'fast-in fast-out' intramuscular and deep TDN in patients with myofascial pain syndrome. Second, although Itoh *et al.*[20] found that deep (20 mm) TrP acupuncture of myofascial TrPs is more effective than either superficial (3 mm) TrP acupuncture or standard acupuncture, the conclusions should be cautiously considered given the following methodological shortcomings: (1) the sample contained just 35 patients that were further split into three smaller groups, (2) the longest outcome measures for pain and disability were taken just 4 weeks after the final needling session, (3) the improvements in pain seen in the deep TrP acupuncture group was 'reversed' by the end of the 3-week no treatment interval, (4) the between-group differences for pain and disability were not statistically significantly different by week 13. Third, after comparing TrP, standard, and sham acupuncture, Itoh *et al.*[80] concluded that TrP acupuncture is more effective than standard (traditional/classical) acupuncture and non-penetrating sham acupuncture for reducing pain and disability in patients with chronic, non-radiculopathic neck pain. However, the 40-patient sample size was divided among three smaller groups, and outcome measures for pain and disability were taken only 3 weeks post-treatment.

Multiple Needles Should Be Left *In Situ* for 10–30 minutes

Although the optimum dosage[50,51,83,85,124] (frequency of treatment sessions per week or month), duration (length of time the needles should remain *in situ*), and intensity (the number of needles used and degree of manual manipulation or electrical stimulation) has yet to be determined[23,24,50,51,83,85,114,135,174] for many neuromusculoskeletal conditions, the vast majority of 'dry' needling randomized controlled trials attempt to elicit a *deqi* response.[175,176] Deqi has been defined as a dull ache, heaviness, distension, numbness, tingling, cramping, pressure, fullness, spreading, warmth, or coolness.[175,176] In addition, most trials have left multiple needles *in situ* for between 5 and 40-minute durations; moreover, a recent systematic review and meta-analysis[19] within the framework of the Cochrane collaboration concluded, 'for low back pain of any duration, needle retention for about 10 minutes is better than removal immediately after insertion'.[19] Table 1 provides the durations and specific studies that multiple needles were left *in situ* for a variety of neuromusculoskeletal conditions.

Even when 'pistoning', 'sparrow pecking', or 'fast-in-and-out' maneuvers were used with the intent of eliciting an LTR in muscular TrPs, multiple needles were often left in place for ten minutes or longer.[20,80] While several studies[29,35,59,63,64,67,102,104,182,183] have demonstrated immediate and/or short-term improvements in pain and/or disability following 'in-an-out' techniques, to date, there are no high-quality long-term trials[23,24] to support the practice of immediately removing the needles after pricking TrPs or eliciting LTRs; therefore, this practice should be questioned.

Local, Proximal, and Distal Needling

'Regional interdependence' has been defined as 'the concept that seemingly unrelated impairments in a remote anatomical region may contribute to, or be associated with, the patient's primary complaint';[184] that is, the practice of examining and treating muscle, joint or neural impairments that are not local, but are distal or proximal to the patient′s symptoms, has gained widespread acceptance in the orthopedic manual physical therapy community.[184-190] For example, there are several trials that support the use of thrust manipulation to the cervical, cervicothoracic, thoracic, and upper rib articulations in the treatment of patients with the primary complaint of shoulder pain[185-190] or shoulder impingement[191,192]– i.e. treating proximal structures to affect distal symptoms. Likewise, patients with lateral epicondylalgia often seek conservative treatment by a physical therapist. In addition to providing manual therapy to the humero-radial joint and needling the forearm extensor muscles,[183] physical therapists often manipulate the neck and wrist based on supporting evidence in the literature.[193,194] That is, physical therapists commonly deliver manual therapy both proximal[193] and distal[194] to the site of pain. The fact that the Mississippi and Colorado State Boards of Physical Therapy believe that IMT and dry needling, respectively, do not include the stimulation of distal points seems misleading and clinically illogical.[10,13] Based on this line of reasoning, physical therapists in Mississippi[10] and Colorado[13] are not allowed to target TrPs in the adductor magnus muscle in patients with 'generalized internal pelvic pain…or pain shooting up inside the pelvis'[74] because the pain is located 'distal' to the patient's pain complaint. It is worth noting that this clinical reasoning is directly contrary to that recommended by Travell and Simons. According to Travell and Simons, 'deep pain in the ipsilateral sacroiliac joint'[74] may be caused by a TrP in a very 'distal' location, namely the soleus muscle. Interestingly, the most recent literature on myofascial pain syndrome provides clear evidence for needling distal sites, a finding analogous to the acupuncture tradition of treating distal acupoints to influence anatomically remote pain.[149]

More recently,[33] ipsilateral or contralateral dry needling to MTrSs (myofascial trigger spots) in the

distal gastrocnemius muscle (lower leg) was shown to suppress spontaneous electrical activity (i.e. end plate noise) in MTrSs within the more proximal biceps femoris muscle. Furthermore, after either tibial nerve transection or L5-6 spinal cord transection in rabbits, Hsieh *et al.*[33] found that the remote effects in the bicep femoris disappeared. According to Hsieh *et al.*,[33] the physiologic basis for the remote and/or distal effects of dry needling may be related to activation of the diffuse noxious inhibitory control (DNIC) system, as induced by noxious stimulation provided by the needles. Simply put, 'the pathway for the remote effect appears to be a spinal reflex'.[33] Such a finding implies that inserting a needle into the left hand would potentially lead to pain relief in the right hand. The recent findings of Hsieh *et al.*[33] add support to the practice of needling contralateral to the side of pain and/or needling distal to the site of pain in order to reduce end plate noise and suppress activity of more proximal painful TrPs.

In another recent experimental study,[26] dry needling of primary MTrPs in patients with shoulder pain was found to inhibit the activity of satellite or secondary MTrPs situated in the shoulder, elbow, or forearm. That is, the target MTrP was found either proximal or distal to the patient's site of discomfort.[26] It follows then that the APTA[8] and Physical Therapy State Boards[10,13] should consider that the best practice for dry needling may require the placement of needles both 'local and/or distal' to the patient's primary source of pain.

Physical therapists often deliver manual therapy and/or orthotic interventions to the tarso-metatarsal, subtalar, or talocrural joints in order to manage patients with low back pain;[195–199] likewise, the insertion of needles without injectate into bodily areas that are asymptomatic but distal or proximal to the site of pain is supported by the myofascial pain syndrome literature.[149] As Melzack *et al.*[27] points out:

> *The stimulation of particular nerves or tissues by needles…would close the gates to [pain] inputs from selected body areas. The cells of the midbrain reticular formation are known to have large receptive fields…. It is possible, then, that particular [distant] body areas may project especially strongly to some reticular areas, and these, in turn, could bring about a complete block of inputs from particular parts of the body.*[27]

Conclusion

Just as the Maitland,[14] Kaltenborn,[15] and McKenzie[16] approaches are unique brands of manual therapy, so is 'TDN' and 'IMT' to dry needling. They provide a single framework or paradigm within the much broader field of dry needling.[5,17–25] Therefore, the terms 'TDN' or 'IMT' should not be used interchangeably or synonymously with the term 'Dry Needling'. Dry needling encompasses the insertion of needles without injectate[3] into, alongside, or around nerves,[17,28,36,40,42,43,47,55,65,159] muscles,[5,6,20,23,24,65,109] or connective tissues[6,7,48,49,70–72,126,170,172] for the management of pain and dysfunction in neuromusculoskeletal conditions. Dry needling neither attempts to move *qi* along meridians nor does it rely on diagnoses from traditional Chinese or Oriental Medicine.[78,79] Considering the mechanical,[70–72,158] chemical,[141,159] endocrinological,[136] microvascular,[138,161,163,164,170] neural,[36,41,47] and central effects[38,39,44,46,130,137,160] of both superficial and deep dry needling at TrP and non-TrP locations, the position statements by the APTA[8,75] and many State Boards of Physical Therapy[9–13] do not seem to be consistent with the existing literature.

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Conflicts of Interest

Dr. James Dunning is the President of the American Academy of Manipulative Therapy (AAMT). Through Spinal Manipulation Institute (SMI) and Dry Needling Institute (DNI), AAMT provides postgraduate training programs in dry needling and spinal manipulation to licensed physical therapists, osteopaths and medical doctors. Drs. James Dunning, Raymond Butts, Thomas Perreault, and Firas Mourad are senior instructors for SMI and DNI.

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Ethics Approval

N/A.

Contributors

JD participated in the conception, design, initial drafting and revision of the manuscript. FM participated in the design and revision of the manuscript. RB participated in the conception, design, and revision of the manuscript. IY participated in the drafting of the manuscript and revision of the manuscript. SF and TP participated in the revision of the manuscript. All authors read and approved the final manuscript.

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