

# Description of Dry Needling in Clinical Practice:

*An Educational Resource Paper*



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## Forward

The American Physical Therapy Association (APTA) created this document to provide background information on the performance of dry needling in clinical practice for members and components. APTA is the national professional association representing more than 80,000 physical therapists, physical therapist assistants, and students nationwide.

## Description of Dry Needling

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. Dry needling (DN) is a technique used to treat dysfunctions in skeletal muscle, fascia, and connective tissue, and, diminish persistent peripheral nociceptive input, and reduce or restore impairments of body structure and function leading to improved activity and participation.

The physiological basis for DN depends upon the targeted tissue and treatment objectives. The treatment of myofascial trigger points (referred to as TrPs) has a different physiological basis than treatment of excessive muscle tension, scar tissue, fascia, and connective tissues. TrPs are hyperirritable spots within a taut band of contracted skeletal muscle fibers that produce local and/or referred pain when stimulated. TrPs are divided into active and latent TrPs dependent upon the degree of irritability. Active TrPs are spontaneously painful, while latent TrPs are only painful when stimulated, for example, with digital pressure. TrPs can be visualized by magnetic resonance imaging and sonography elastography,<sup>1-5</sup> which has shown that active TrPs are larger than latent TrPs and feature a reduction in circulation.<sup>2</sup> TrPs are physiological contractures,<sup>6</sup> characterized by local ischemia and hypoxia,<sup>2,7</sup> a significantly lowered pH (active TRPs only),<sup>8-10</sup> a chemically altered milieu (active TRPs only),<sup>8-10</sup> local and referred pain,<sup>11-13</sup> and altered muscle activation patterns.<sup>14,15</sup> Although latent TrPs are not spontaneously painful, recent research has shown that they do contribute to nociception, therefore they need to be included in the treatment plan. TrPs are associated with dysfunctional motor endplates,<sup>16,17</sup> endplate noise,<sup>18</sup> and an increased release of acetylcholine.<sup>19-23</sup> TrPs activate muscle nociceptors and are

peripheral sources of persistent nociceptive input, thus contributing to the development of peripheral and central sensitization.<sup>24-27</sup> Stimulation of TrPs activates the periaqueductal grey and anterior cingulate cortex in the brain,<sup>28-30</sup> and enkephalinergic, serotonergic, and noradrenergic inhibitory systems associated with A- $\delta$  (A delta) fibers through segmental inhibition.<sup>31,32</sup>

DN can be divided into deep and superficial DN. Deep DN has been shown to inactivate TrPs by eliciting local twitch responses (LTR),<sup>33,34</sup> which are modulated by the central nervous system.<sup>35,36</sup> A LTR is a spinal cord reflex that is characterized by an involuntary contraction of the contracted taut band,<sup>36,37</sup> which can be elicited by a snapping palpation or penetration with a needle.<sup>38-40</sup> The LTR has been shown to be associated with alleviation and mitigation of spontaneous electrical activity or motor endplate noise,<sup>17,18,41,42</sup> a reduction of the concentration of numerous nociceptive, inflammatory, and immune system related chemicals,<sup>9,10,43</sup> and relaxation of the taut band.<sup>44</sup> Deep DN of TrPs is associated with reduced local and referred pain,<sup>45,46</sup> improved range of motion,<sup>14,15</sup> and decreased TrP irritability both locally<sup>18,47</sup> and more remotely.<sup>42,48</sup> DN normalizes the chemical milieu and pH of skeletal muscle<sup>8-10</sup> and restores the local circulation.<sup>49</sup> Superficial DN is thought to activate mechanoreceptors coupled to slow conducting unmyelinated C fiber afferents, and indirectly, stimulate the anterior cingulate cortex.<sup>50</sup> Superficial DN may also be mediated through stimulation of A- $\delta$  fibers,<sup>51</sup> or via stretching of fibroblasts in connective tissue.<sup>32</sup> Superficial DN is associated with reduced local and referred pain and improved range of motion,<sup>52,53</sup> but it is not known at this time whether superficial DN has any impact on normalizing the chemical environment of active TrPs or reducing motor endplate noise associated with TrPs in general.

The physiological basis for DN treatment of excessive muscle tension, scar tissue, fascia, and connective tissues is not as well described in the literature, but the available research shows that there may be several benefits. Muscle tension is determined by a combination of the basic viscoelastic properties of a muscle and its surrounding fascia, and the degree of activation of the contractile apparatus of the muscle.<sup>54</sup> There is some evidence that excessive muscle tension, as seen for example in spasticity, can be alleviated with DN.<sup>55,56</sup> Scar tissue has been linked to myofascial pain<sup>57</sup> and fibroblasts.<sup>58,59</sup> Fibroblasts are specialized contractile cells within the fascia that are of particular interest, as they synthesize, organize, and remodel collagen, dependent upon the tension between the extracellular matrix and the cell.<sup>60,61</sup> DN, especially when used in combination with rotation of the needle, can place fibroblasts in a high tension matrix, at which point the fibroblast changes shape and assumes a lamellar shape, and

increases its collagen synthesis and cell proliferation.<sup>62,63</sup> DN has been shown to directly activate fibroblasts through mechanical manipulation of the needle,<sup>31,64,65</sup> which in turn activates the release of cytokines and other pro-inflammatory mediators.<sup>66-70</sup> DN can play a substantial role in the process of *mechanotransduction*, which is described as the process by which the body converts mechanical loading into cellular responses.<sup>20,71-76</sup> Fibroblast activation with a solid filament has been shown to result in pain neuromodulation.<sup>32,66</sup>

## Indications for Use

DN may be incorporated into a treatment plan when myofascial TrPs are present, which may lead to impairments in body structure, pain, and functional limitations. TrPs are sources of persistent peripheral nociceptive input<sup>24</sup> and their inactivation is consistent with current pain management insights.<sup>77</sup> DN also is indicated with restrictions in range of motion due to contractured muscle fibers or taut bands, or other soft tissue restrictions, such as fascial adhesions or scar tissue. TrPs have been identified in numerous diagnoses, such as radiculopathies,<sup>78</sup> joint dysfunction,<sup>79</sup> disk pathology,<sup>80</sup> tendonitis,<sup>81</sup> craniomandibular dysfunction,<sup>82,83</sup> migraines,<sup>84,85</sup> tension-type headaches,<sup>86,87</sup> carpal tunnel syndrome,<sup>88,89</sup> computer-related disorders,<sup>90,91</sup> whiplash associated disorders,<sup>92-94</sup> spinal dysfunction,<sup>95</sup> pelvic pain and other urologic syndromes,<sup>96-99</sup> post-herpetic neuralgia,<sup>100,101</sup> complex regional pain syndrome,<sup>102,103</sup> nocturnal cramps,<sup>104</sup> phantom pain,<sup>105,106</sup> and other relatively uncommon diagnoses such as Barré Liéou syndrome,<sup>107</sup> or neurogenic pruritus,<sup>108</sup> among others.<sup>109</sup>

## Patient Selection

Safe DN practice includes the knowledge, skills, and attributes to perform the technique, which at a minimum incorporates appropriate patient selection, creation of a safe and comfortable environment, assessment of one's own capacity to provide the treatment (eg time constraints, stress, fatigue), safe handling of needles, handling and positioning of the patient, anatomical knowledge, appropriate needle technique (direction and depth), and appropriate monitoring of the patient both during and following treatment.

Regarding patient selection, DN is appropriate for nearly all patients who present with any of the indications for DN. Physical therapists (PTs) must recognize when patients present with significant needle phobia or other anxiety about being treated with needles. PTs must decide on an individual basis whether a patient with needle phobia or significant anxiety is an appropriate candidate for DN. If DN

treatment is perceived as a threatening input, it is unlikely to be therapeutic.<sup>77</sup> In any case, to be considered for DN, patients must be able to communicate with the PT either directly or via an interpreter and they must be able to consent to the treatment.

Caution is warranted with younger patients. Based on empirical evidence, DN is not recommended for children younger than 12 years of age. When treating children, DN should only be performed with parent and child's consent. Care should be taken assuming a child understands the procedure.

### **Precautions**

There are certain precautions to be considered with the use of DN:

1. Patients with a needle aversion or phobia may object to the physical therapy treatment with DN. With appropriate education, however, these patients may still consider DN.
2. Patients with significant cognitive impairment may have difficulty understanding the treatment parameters and DN intervention.
3. Patients who are unable to communicate directly or via an interpreter may not be appropriate for DN treatments.
4. Patients may not be willing to be treated with DN.
5. Patients need to be able to give consent for the treatment with DN.
6. Local skin lesions must be avoided with DN.
7. Local or systemic infections are generally considered to be contraindicated.
8. Local lymphedema (note: there is no evidence that DN would cause or contribute to increased lymphedema, ie, postmastectomy, and as such is not a contraindication).
9. Severe hyperalgesia or allodynia may interfere with the application of DN, but should not be considered an absolute contraindication.
10. Some patients may be allergic to certain metals in the needle, such as nickel or chromium. This situation can easily be remedied by using silver or gold plated needles.
11. Patients with an abnormal bleeding tendency, ie, patients on anticoagulant therapy or with thrombocytopenia, must be needled with caution. DN of deep muscles, such as the lateral pterygoid or psoas major muscle, that cannot be approached with direct pressure to create hemostasis may need to be avoided to prevent excessive bleeding.

12. Patients with a compromised immune system may be more susceptible to local or systemic infections from DN, even though there is no documented increased risk of infection with DN.<sup>110</sup>
13. DN during the first trimester of pregnancy, during which miscarriage is fairly common, must be approached with caution, even though there is no evidence that DN has any potential abortifacient effects.<sup>111-113</sup>
14. DN should not be used in the presence of vascular disease, including varicose veins.
15. Caution is warranted with DN following surgical procedures where the joint capsule has been opened. Although septic arthritis is a concern, DN can still be performed as long as the needle is not directed toward the joint or implant.

## Procedure

DN techniques should be guided by randomized clinical trials, basic research, systematic reviews, and clinical expertise.<sup>114</sup> Clinician education, training, and clinical experience with DN should be clearly communicated to the patient. PTs should use DN only after obtaining the knowledge, skills, and attributes associated with safe and effective DN techniques. The patient should give verbal consent prior to each treatment with DN. Some jurisdictions do require a written consent for treatments with DN. In clinical practice, DN is performed once the physical therapy examination and evaluation are completed and clear therapeutic goals and objectives are established. The solid filament needle allows the PT to target tissues that are not manually palpable, such as the subscapularis, iliacus, and lateral pterygoid muscles.<sup>115</sup>

As part of the procedural guidelines for DN, physical therapists must practice consistent with the OSHA Blood Borne Pathogens standard<sup>116</sup> ([osha.gov](https://www.osha.gov)), which applies to all occupational exposure to blood or other potentially infectious materials. According to the OSHA Blood Borne Pathogens Standard, “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.”<sup>116</sup> As DN creates “non-intact skin” and recent research has shown that the most common adverse event of dry needling is minor bleeding,<sup>110</sup> it follows that the OSHA Blood Borne Pathogens Standard applies.

An explanation of the procedure to the patient should be performed prior to the application of DN. The patient should be educated on DN rationale and theory, what to expect during and after the treatment,

the type of needle used, precautions, possible side effects, and expected outcomes. Possible fear of needling and pain associated with DN must be addressed. Research has shown that by activating patients' conditioned pain modulation system, patients are able to differentiate and even appreciate the inhibition of their pain by a second noxious stimulus, ie, the pain associated with DN.<sup>117</sup> This realization can activate an endogenous pain inhibitory mechanism, which inhibits early nociceptive processing. By placing DN in this broader context, patients can usually tolerate the discomfort associated with DN without risking further sensitization or windup.<sup>118</sup>

When using DN techniques for the treatment of TrPs, the PT should palpate the target muscle for a taut band and identify a hyperirritable spot within the taut band confirming TrPs to be treated. DN is usually performed with a solid filiform needle in a tube. The filiform needle in its tube is fixed with the non-needling hand against the suspected area by using a pincer grip or flat palpation depending on the muscle orientation, location, and direction of needle penetration. With the needling hand, the needle is gently loosened from the tube. The top of the needle is tapped or flicked allowing the needle to penetrate the skin. With deep DN, the needle is guided toward the TrP until resistance is felt and a LTR is elicited. The elicitation of a LTR is considered essential in obtaining a desirable therapeutic effect.<sup>33,34</sup> The needle is then focused in this area or other neighboring areas by drawing the needle back toward the subcutaneous tissue without taking it out of the skin, and then redirecting the needle toward the remaining TrPs.<sup>119</sup> Generally, numerous LTRs can be elicited. Cessation of a given DN procedure may occur as a result of notable decreased frequency or eradication of LTRs, decreased resistance to palpation of the underlying tissue, or patient intolerance of continued needling at that particular site. Once the needle has been withdrawn completely from the skin, pressure (hemostasis) can be applied directly to the skin over the needle insertion site to aid in the prevention of possible swelling or post needling soreness. The muscle is then palpated again to reassess for taut bands and TrPs. Further needling can be performed for the same muscle or for other clinically relevant musculature within the same treatment session. With superficial needling, the needle is just slightly into a muscle in the vicinity of a TrP, but LTRs are not elicited. The needle is kept in place for approximately 30 seconds. At that time, the needle is withdrawn to the subcutaneous tissue. The therapist assesses whether the sensitivity of the TrP has decreased. If so, the DN needling can be discontinued. If the TrP is still sensitive, the needle is guided again into the muscle in the vicinity of the TrP and left in place for approximately 2 minutes.<sup>51</sup> The superficial DN procedure is usually repeated over several TrPs in a given region. LTRs are not elicited with superficial needling techniques. Superficial DN techniques may be used when patients do not

tolerate deep DN, or when excessive cramping or stiffness of the underlying tissue occurs while needling.

DN can be combined with electrical stimulation in which the needles become the electrodes. To use electrical stimulation combined with DN, a minimum of 2 needles is required per channel, but multiple channels can be used simultaneously. The best results are reached when the needles are placed within the dermatomes corresponding to the region of dysfunction.<sup>119</sup> Frequencies between 2 and 4 Hz with high intensity are commonly used in nociceptive pain conditions and may result in the release of endorphins and enkephalins. For neuropathic pain, frequencies between 80 and 100 Hz are recommended, which are thought to affect the release of dynorphin, gamma-aminobutyric acid, and galanin.<sup>120</sup> The needles can be placed directly in or at either side of a TrP.<sup>121,122</sup>

The DN treatment of fascia and connective tissues, including scar tissue, is similar to the approach for TrPs. The PT should palpate the tissues for adhesions and movement restrictions. The needle is inserted in the same manner as for TrPs, but after insertion, the needle is directed more superficially toward the adhesion or restriction. Rotating the needle facilitates mechanotransduction and eventually will lead to tissue relaxation. The needle is left in place until tissue relaxation has been achieved, at which point the needle can easily be removed. DN of fascia usually is a superficial DN technique.

After DN, functional reassessment should be performed to determine if the established outcome has been achieved. Standardized outcome tools such as the modified Oswestry Disability Index, Disability of the Arm Shoulder Hand, Patient Specific Functional Scale or Lower extremity function scale as examples should be utilized to monitor progress. The patient is monitored during the procedure for tolerance and for possible reproduction of local or referred pain sensations. It should be made clear to the patient that the treatment would cease at any time upon his or her request or if he or she was clearly not tolerating the procedure. Tolerance to the treatment should be evaluated during every session.

Manual soft tissue mobilization, therapeutic exercise, neuromuscular re-education, and functional retraining should be used in combination with DN interventions. The patient should be educated in appropriate self-care techniques post DN treatment, which may include specific stretches of the involved muscles, thermo applications, or gentle TrP pressure.

DN is rarely a stand-alone procedure and should be part of a broader physical therapy approach.<sup>119</sup> DN should result in a more efficient progression to corrective exercises to improve activity limitations and participation restrictions.

### Other considerations

Physical therapist need to cognizant of any legal or regulatory requirements or restrictions on the performance of dry needling in their state. Information on dry needling scope of practice considerations can be found in the January 2012 APTA Education Resource Paper *Physical Therapists and the Performance of Dry Needling*, available online at [www.apta.org/stateissues](http://www.apta.org/stateissues). In addition, PTs should check with the insurance payor to see if it has issued any specific policies regarding billing of dry needling. As with any physical therapy service, PTs are responsible for providing complete and accurate documentation; resources on documentation are available online at [www.apta.org/documentation](http://www.apta.org/documentation)

### Note

APTA will revise this document as new information and data becomes available and updates occur. For questions or comments regarding this document, please contact APTA Public Policy, Practice, and Professional Affairs Unit at [advocacy@apta.org](mailto:advocacy@apta.org)

### References

1. Ballyns JJ, Turo D, Otto P, et al. Office-based elastographic technique for quantifying mechanical properties of skeletal muscle. *J. Ultrasound Med.* Aug 2012;31(8):1209-1219.
2. Ballyns JJ, Shah JP, Hammond J, Gebreab T, Gerber LH, Sikdar S. Objective sonographic measures for characterizing myofascial trigger points associated with cervical pain. *J Ultrasound Med.* Oct 2011;30(10):1331-1340.
3. Chen Q, Bensamoun S, Basford JR, Thompson JM, An KN. Identification and quantification of myofascial taut bands with magnetic resonance elastography. *Arch Phys Med Rehabil.* 2007;88(12):1658-1661.
4. Chen Q, Basford J, An KN. Ability of magnetic resonance elastography to assess taut bands. *Clin Biomech (Bristol, Avon).* 2008;23(5):623-629.
5. Sikdar S, Shah JP, Gebreab T, et al. Novel applications of ultrasound technology to visualize and characterize myofascial trigger points and surrounding soft tissue. *Arch Phys Med Rehabil.* Nov 2009;90(11):1829-1838.
6. Mense S. Morphology of myofascial trigger points: what does a trigger point look like? In: Mense S, Gerwin R, D., eds. *Muscle pain; diagnosis and treatment*. Heidelberg: Springer; 2010:85-102.
7. Brückle W, Sückfull M, Fleckenstein W, Weiss C, Müller W. Gewebe-pO<sub>2</sub>-Messung in der verspannten Rückenmuskulatur (m. erector spinae). *Z. Rheumatol.* 1990;49:208-216.

8. Shah JP, Gilliams EA. Uncovering the biochemical milieu of myofascial trigger points using in vivo microdialysis: an application of muscle pain concepts to myofascial pain syndrome. *J Bodyw Mov Ther.* Oct 2008;12(4):371-384.
9. Shah J, Phillips T, Danoff JV, Gerber LH. A novel microanalytical technique for assaying soft tissue demonstrates significant quantitative biomechanical differences in 3 clinically distinct groups: normal, latent and active. *Arch Phys Med Rehabil.* 2003;84:A4.
10. Shah JP, Danoff JV, Desai MJ, et al. Biochemicals associated with pain and inflammation are elevated in sites near to and remote from active myofascial trigger points. *Arch Phys Med Rehabil.* Jan 2008;89(1):16-23.
11. Fernández-de-las-Peñas C, Ge HY, Alonso-Blanco C, González-Iglesias J, Arendt-Nielsen L. Referred pain areas of active myofascial trigger points in head, neck, and shoulder muscles, in chronic tension type headache. *J Bodyw Mov Ther.* Oct 2010;14(4):391-396.
12. Fernández-Carnero J, Fernández de las Peñas CF, de la Llave-Rincón AI, Ge HY, Arendt-Nielsen L. Prevalence of and referred pain from myofascial trigger points in the forearm muscles in patients with lateral epicondylalgia. *Clin J Pain.* May 2007;23(4):353-360.
13. Fernández de las Peñas C, Ge HY, Arendt-Nielsen L, Cuadrado ML, Pareja JA. The local and referred pain from myofascial trigger points in the temporalis muscle contributes to pain profile in chronic tension-type headache. *Clin J Pain.* Nov-Dec 2007;23(9):786-792.
14. Lucas KR, Rich PA, Polus BI. Muscle activation patterns in the scapular positioning muscles during loaded scapular plane elevation: the effects of latent myofascial trigger points. *Clin Biomechanics.* 2010;25(8):765-770.
15. Lucas KR, Polus BI, Rich PS. Latent myofascial trigger points: their effects on muscle activation and movement efficiency. *J Bodyw Mov Ther.* 2004;8:160-166.
16. Simons DG, Hong C-Z, Simons LS. Endplate potentials are common to midfiber myofascial trigger points. *Am J Phys Med Rehabil.* 2002;81(3):212-222.
17. Simons DG. Review of enigmatic MTrPs as a common cause of enigmatic musculoskeletal pain and dysfunction. *J Electromyogr Kinesiol.* 2004;14:95-107.
18. Kuan TS, Hsieh YL, Chen SM, Chen JT, Yen WC, Hong CZ. The myofascial trigger point region: correlation between the degree of irritability and the prevalence of endplate noise. *Am J Phys Med Rehabil.* 2007;86(3):183-189.
19. Gerwin RD, Dommerholt J, Shah JP. An expansion of Simons' integrated hypothesis of trigger point formation. *Curr Pain Headache Rep.* Dec 2004;8(6):468-475.
20. McPartland JM, Simons DG. Myofascial trigger points: translating molecular theory into manual therapy. *J Man Manipulative Ther.* 2006;14(4):232-239.
21. Hong CZ, Simons DG. Pathophysiologic and electrophysiologic mechanisms of myofascial trigger points. *Arch Phys Med Rehabil.* 1998;79(7):863-872.
22. Bukharaeva EA, Salakhutdinov RI, Vyskocil F, Nikolsky EE. Spontaneous quantal and non-quantal release of acetylcholine at mouse endplate during onset of hypoxia. *Physiol Res.* 2005;54(2):251-255.
23. Simons DG. New views of myofascial trigger points: etiology and diagnosis. *Arch Phys Med Rehabil* Jan 2008;89(1):157-159.
24. Dommerholt J. Dry needling — peripheral and central considerations. *J Manual Manipul Ther.* 2011;19(4):223-237.
25. Mense S. How do muscle lesions such as latent and active trigger points influence central nociceptive neurons? *J Musculoskelet Pain.* 2010;18(4):348-353.
26. Fernández de las Peñas C, Cuadrado M, Arendt-Nielsen L, Simons D, Pareja J. Myofascial trigger points and sensitization: an updated pain model for tension-type headache. *Cephalalgia.* 2007;27(5):383-393.

27. Xu YM, Ge HY, Arendt-Nielsen L. Sustained nociceptive mechanical stimulation of latent myofascial trigger point induces central sensitization in healthy subjects. *J Pain*. 2010;11(12):1348-1355.
28. Niddam DM, Chan RC, Lee SH, Yeh TC, Hsieh JC. Central representation of hyperalgesia from myofascial trigger point. *Neuroimage*. Feb 1 2008;39(3):1299-1306.
29. Niddam DM, Chan RC, Lee SH, Yeh TC, Hsieh JC. Central modulation of pain evoked from myofascial trigger point. *Clin J Pain*. Jun 2007;23(5):440-448.
30. Svensson P, Minoshima S, Beydoun A, Morrow TJ, Casey KL. Cerebral processing of acute skin and muscle pain in humans. *J Neurophysiol*. Jul 1997;78(1):450-460.
31. Langevin HM, Bouffard NA, Badger GJ, Churchill DL, Howe AK. Subcutaneous tissue fibroblast cytoskeletal remodeling induced by acupuncture: Evidence for a mechanotransduction-based mechanism. *J Cell Physiol*. May 2006;207(3):767-774.
32. Langevin HM, Bouffard NA, Badger GJ, Iatridis JC, Howe AK. Dynamic fibroblast cytoskeletal response to subcutaneous tissue stretch ex vivo and in vivo. *Am J Physiol Cell Physiol*. Mar 2005;288(3):C747-756.
33. Hong CZ. Lidocaine injection versus dry needling to myofascial trigger point. The importance of the local twitch response. *Am J Phys Med Rehabil*. 1994;73(4):256-263.
34. Tekin L, Akarsu S, Durmus O, Cakar E, Dincer U, Kiralp MZ. The effect of dry needling in the treatment of myofascial pain syndrome: a randomized double-blinded placebo-controlled trial. *Clin Rheumatol*. Nov 9 2012.
35. Hong C-Z, Yu J. Spontaneous electrical activity of rabbit trigger spot after transection of spinal cord and peripheral nerve. *J Musculoskelet Pain*. 1998;6(4):45-58.
36. Hong CZ, Torigoe Y, Yu J. The localized twitch responses in responsive bands of rabbit skeletal muscle are related to the reflexes at spinal cord level. *J Musculoskel Pain*. 1995;3:15-33.
37. Hong CZ. Persistence of local twitch response with loss of conduction to and from the spinal cord. *Arch Phys Med Rehabil*. Jan 1994;75(1):12-16.
38. Rha DW, Shin JC, Kim YK, Jung JH, Kim YU, Lee SC. Detecting local twitch responses of myofascial trigger points in the lower-back muscles using ultrasonography. *Arch Phys Med Rehabil*. Oct 2011;92(10):1576-1580 e1571.
39. Hong CZ, Kuan TS, Chen JT, Chen SM. Referred pain elicited by palpation and by needling of myofascial trigger points: a comparison. *Arch Phys Med Rehabil*. 1997;78(9):957-960.
40. Simons DG, Dexter JR. Comparison of local twitch responses elicited by palpation and needling of myofascial trigger points. *J Musculoskeletal Pain*. 1995;3:49-61.
41. Ge HY, Fernandez-de-Las-Penas C, Yue SW. Myofascial trigger points: spontaneous electrical activity and its consequences for pain induction and propagation. *Chinese Medicine*. 2011;6:13.
42. Hsieh YL, Chou LW, Joe YS, Hong CZ. Spinal cord mechanism involving the remote effects of dry needling on the irritability of myofascial trigger spots in rabbit skeletal muscle. *Arch Phys Med Rehabil*. Jul 2011;92(7):1098-1105.
43. Shah JP, Phillips TM, Danoff JV, Gerber LH. An in-vivo microanalytical technique for measuring the local biochemical milieu of human skeletal muscle. *J Appl Physiol*. 2005;99:1977-1984.
44. Majlesi J, Unalan H. Effect of treatment on trigger points. *Curr Pain Headache Rep*. Oct 2010;14(5):353-360.
45. Affaitati G, Costantini R, Fabrizio A, Lapenna D, Tafuri E, Giamberardino MA. Effects of treatment of peripheral pain generators in fibromyalgia patients. *Eur J Pain*. Jan 2011;15(1):61-69.
46. Srbely JZ, Dickey JP, Lee D, Lowerison M. Dry needle stimulation of myofascial trigger points evokes segmental anti-nociceptive effects. *J Rehabil Med*. 2010;42(5):463-468.

47. Chen JT, Chung KC, Hou CR, Kuan TS, Chen SM, Hong CZ. Inhibitory effect of dry needling on the spontaneous electrical activity recorded from myofascial trigger spots of rabbit skeletal muscle. *Am J Phys Med Rehabil.* Oct 2001;80(10):729-735.
48. Tsai C-T, Hsieh L-F, Kuan T-S, Kao M-J, Chou L-W, Hong C-Z. Remote effects of dry needling on the irritability of the myofascial trigger point in the upper trapezius muscle. *Am J Phys Med Rehabil.* 2010;89(2):133-140.
49. Simons DG. Understanding effective treatments of myofascial trigger points. *J Bodyw Mov Ther.* 2002;6(2):81-88.
50. Olausson H, Lamarre Y, Backlund H, et al. Unmyelinated tactile afferents signal touch and project to insular cortex. *Nat Neurosci* Sep 2002;5(9):900-904.
51. Baldry PE. *Acupuncture, Trigger Points and Musculoskeletal Pain.* Edinburgh: Churchill Livingstone; 2005.
52. Ceccherelli F, Rigoni MT, Gagliardi G, Ruzzante L. Comparison between superficial and deep acupuncture in the treatment of lumbar myofascial pain: a double-blind randomized controlled study. *Clin J Pain.* 2002;18:149-153.
53. Edwards J, Knowles N. Superficial dry needling and active stretching in the treatment of myofascial pain--a randomised controlled trial. *Acupunct Med.* 2003/9 2003;21(3 SU):80-86.
54. Simons DG, Mense S. Understanding and measurement of muscle tone as related to clinical muscle pain. *Pain.* 1998;75(1):1-17.
55. Whisler SL, Lang DM, Armstrong M, Vickers J, Qualls C, Feldman JS. Effects of myofascial release and other advanced myofascial therapies on children with cerebral palsy: six case reports. *Explore.* May-Jun 2012;8(3):199-205.
56. Dilorenzo L, Traballese M, Morelli D, et al. Hemiparetic shoulder pain syndrome treated with deep dry needling during early rehabilitation: a prospective, open-label, randomized investigation. *J Musculoskeletal Pain.* 2004;12(2):25-34.
57. Lewit K, Olsanska S. Clinical importance of active scars: abnormal scars as a cause of myofascial pain. *J Manipulative Physiol Ther.* 2004;27(6):399-402.
58. Iqbal SA, Sidgwick GP, Bayat A. Identification of fibrocytes from mesenchymal stem cells in keloid tissue: a potential source of abnormal fibroblasts in keloid scarring. *Arch. Dermatol Res.* Oct 2012;304(8):665-671.
59. Eto H, Suga H, Aoi N, et al. Therapeutic potential of fibroblast growth factor-2 for hypertrophic scars: upregulation of MMP-1 and HGF expression. *Lab Invest.* Feb 2012;92(2):214-223.
60. Findley TW. Fascia Research from a Clinician/Scientist's Perspective. *Int J Ther Massage Bodywork.* 2011;4(4):1-6.
61. Grinnell F. Fibroblast biology in three-dimensional collagen matrices. *Trends Cell Biol.* May 2003;13(5):264-269.
62. Hicks MR, Cao TV, Campbell DH, Standley PR. Mechanical strain applied to human fibroblasts differentially regulates skeletal myoblast differentiation. *J Appl Physiol.* Aug 2012;113(3):465-472.
63. Langevin HM, Bouffard NA, Fox JR, et al. Fibroblast cytoskeletal remodeling contributes to connective tissue tension. *J Cell Physiol.* May 2011;226(5):1166-1175.
64. Fu ZH, Wang JH, Sun JH, Chen XY, Xu JG. Fu's subcutaneous needling: possible clinical evidence of the subcutaneous connective tissue in acupuncture. *J Altern Complement Med.* Jan-Feb 2007;13(1):47-51.
65. Fu ZH, Chen XY, Lu LJ, Lin J, Xu JG. Immediate effect of Fu's subcutaneous needling for low back pain. *Chin Med J. (Engl).* Jun 5 2006;119(11):953-956.
66. Chiquet M, Renedo AS, Huber F, Fluck M. How do fibroblasts translate mechanical signals into changes in extracellular matrix production? *Matrix Biol.* Mar 2003;22(1):73-80.

67. Langevin HM, Storch KN, Snapp RR, et al. Tissue stretch induces nuclear remodeling in connective tissue fibroblasts. *Histochem Cell Biol.* Apr 2010;133(4):405-415.
68. Skuttek M, van Griensven M, Zeichen J, Brauer N, Bosch U. Cyclic mechanical stretching enhances secretion of Interleukin 6 in human tendon fibroblasts. *Knee Surg Sports Traumatol Arthrosc.* Sep 2001;9(5):322-326.
69. Skuttek M, van Griensven M, Zeichen J, Brauer N, Bosch U. Cyclic mechanical stretching modulates secretion pattern of growth factors in human tendon fibroblasts. *Eur J Appl Physiol.* Nov 2001;86(1):48-52.
70. Adair-Kirk TL, Senior RM. Fragments of extracellular matrix as mediators of inflammation. *Int J Biochem Cell Biol.* 2008;40(6-7):1101-1110.
71. McPartland JM. Expression of the endocannabinoid system in fibroblasts and myofascial tissues. *J Bodyw Mov Ther.* Apr 2008;12(2):169-182.
72. Khan KM, Scott A. Mechanotherapy: how physical therapists' prescription of exercise promotes tissue repair. *Br J Sports Med.* Apr 2009;43(4):247-252.
73. Langevin HM, Churchill DL, Cipolla MJ. Mechanical signaling through connective tissue: a mechanism for the therapeutic effect of acupuncture. *FASEB J.* Oct 2001;15(12):2275-2282.
74. Chan MW, Hinz B, McCulloch CA. Mechanical induction of gene expression in connective tissue cells. *Methods Cell Biol.* 2010;98:178-205.
75. Hinz B, Phan SH, Thannickal VJ, et al. Recent developments in myofibroblast biology: paradigms for connective tissue remodeling. *Am J Pathol.* Apr 2012;180(4):1340-1355.
76. Hinz B. The myofibroblast: paradigm for a mechanically active cell. *J Biomech.* Jan 5 2010;43(1):146-155.
77. Moseley GL. A pain neuromatrix approach to patients with chronic pain. *Man Ther.* Sep 2003;8(3):130-140.
78. Rosomoff HL, Fishbain DA, Goldberg N, Rosomoff RS. Myofascial findings with patients with "chronic intractable benign pain: of the back and neck. *Pain Management.* 1989;3:114-118.
79. Bajaj P, Bajaj P, Graven-Nielsen T, Arendt-Nielsen L. Trigger points in patients with lower limb osteoarthritis. *J Musculoskeletal Pain.* 2001;9(3):17-33.
80. Hsueh TC, Yu S, Kuan TS, Hong CZ. Association of active myofascial trigger points and cervical disc lesions. *J Formos Med Assoc.* 1998;97(3):174-180.
81. Wang C-F, Chen M, Lin M-T, Kuan T-S, Hong CZ. Teres minor tendinitis manifested with chronic myofascial pain syndrome in the scapular muscles; a case report. *J Musculoskeletal Pain.* 2006;14(1):39-43.
82. Friction JR. Etiology and management of masticatory myofascial pain. *J Musculoskeletal Pain.* 1999;7(1/2):143-160.
83. Teachey WS. Otolaryngic myofascial pain syndromes. *Curr Pain Headache Rep.* Dec 2004;8(6):457-462.
84. Calandre EP, Hidalgo J, Garcia-Leiva JM, Rico-Villademoros F. Trigger point evaluation in migraine patients: an indication of peripheral sensitization linked to migraine predisposition? *Eur J Neurol.* Mar 2006;13(3):244-249.
85. Giamberardino MA, Tafuri E, Savini A, et al. Contribution of myofascial trigger points to migraine symptoms. *J Pain.* Nov 2007;8(11):869-878.
86. Fernández de las Peñas CF, Cuadrado ML, Gerwin RD, Pareja JA. Referred pain from the trochlear region in tension-type headache: a myofascial trigger point from the superior oblique muscle. *Headache.* Jun 2005;45(6):731-737.
87. Fernández de las Peñas C, Alonso Blanco C, Cuadrado ML, Pareja JA. Myofascial trigger points in the suboccipital muscles in episodic tension-type headache. *Man Ther.* 2006;11:225-230.

88. Skubick DL, Clasby R, Donaldson CC, Marshall WM. Carpal tunnel syndrome as an expression of muscular dysfunction in the neck. *J Occupational Rehab.* 1993;3(1):31-43.
89. Qerama E, Kasch H, Fuglsang-Frederiksen A. Occurrence of myofascial pain in patients with possible carpal tunnel syndrome - a single-blinded study. *Eur J Pain.* Jul 2009;13(6):588-591.
90. Treaster D, Marras WS, Burr D, Sheedy JE, Hart D. Myofascial trigger point development from visual and postural stressors during computer work. *J Electromyogr Kinesiol.* Apr 2006;16(2):115-124.
91. Hoyle JA, Marras WS, Sheedy JE, Hart DE. Effects of postural and visual stressors on myofascial trigger point development and motor unit rotation during computer work. *J Electromyogr Kinesiol.* Feb 2011;21(1):41-48.
92. Freeman MD, Nystrom A, Centeno C. Chronic whiplash and central sensitization; an evaluation of the role of a myofascial trigger points in pain modulation. *J Brachial Plex Peripher Nerve Inj.* 2009;4:2.
93. Dommerholt J. Persistent myalgia following whiplash. *Curr Pain Headache Rep.* Oct 2005;9(5):326-330.
94. Ettlin T, Schuster C, Stoffel R, Bruderlin A, Kischka U. A distinct pattern of myofascial findings in patients after whiplash injury. *Arch Phys Med Rehabil.* Jul 2008;89(7):1290-1293.
95. Fruth SJ. Differential diagnosis and treatment in a patient with posterior upper thoracic pain. *Phys Ther* Feb 2006;86(2):254-268.
96. Doggweiler-Wiygul R. Urologic myofascial pain syndromes. *Curr Pain Headache Rep.* Dec 2004;8(6):445-451.
97. Jarrell J. Myofascial dysfunction in the pelvis. *Curr Pain Headache Rep.* Dec 2004;8(6):452-456.
98. Jarrell JF, Vilos GA, Allaire C, et al. Consensus guidelines for the management of chronic pelvic pain. *J Obstet Gynaecol Can.* Sept 2005;27(9 ):869-887.
99. Weiss JM. Pelvic floor myofascial trigger points: manual therapy for interstitial cystitis and the urgency-frequency syndrome. *J Urol.* Dec 2001;166(6):2226-2231.
100. Weiner DK, Schmader KE. Postherpetic pain: more than sensory neuralgia? *Pain Med.* May-Jun 2006;7(3):243-249.
101. Chen SM, Chen JT, Kuan TS, Hong CZ. Myofascial trigger points in intercostal muscles secondary to herpes zoster infection of the intercostal nerve. *Arch Phys Med Rehabil.* 1998;79(3):336-338.
102. Dommerholt J. Complex regional pain syndrome; part 1: history, diagnostic criteria and etiology. *J Bodywork Movement Ther.* 2004;8(3):167-177.
103. Rashiq S, Galer BS. Proximal myofascial dysfunction in complex regional pain syndrome: a retrospective prevalence study. *Clin J Pain.* Jun 1999;15(2):151-153.
104. Prateepavanich P, Kupniratsaikul V, Charoensak T. The relationship between myofascial trigger points of gastrocnemius muscle and nocturnal calf cramps. *J Med Assoc Thailand.* 1999;82:451-459.
105. Kern KU, Martin C, Scheicher S, Muller H. Auslösung von Phantomschmerzen und -sensationen durch muskulare Stumpftriggerpunkte nach Beinamputationen [Referred pain from amputation stump trigger points into the phantom limb]. *Schmerz.* Aug 2006;20(4):300-306.
106. Kern U, Martin C, Scheicher S, Müller H. Does botulinum toxin A make prosthesis use easier for amputees? *J Rehabil Med.* Sep 2004;36(5):238-239.
107. Longbottom J. A case report of postulated 'Barré Liéou syndrome'. *Acupunct Med.* Mar 2005;23(1):34-38.
108. Stellon A. Neurogenic pruritus: an unrecognised problem? A retrospective case series of treatment by acupuncture. *Acupunct Med.* Dec 2002;20(4):186-190.
109. Dommerholt J, Stanborough RW. Muscle pain syndromes. In: Cantu RI, Grodin AJ, Stanborough RW, eds. *Myofascial Manipulation.* Austin: Pro-Ed; 2012:125-180.

110. Brady, S., McEvoy, J., Dommerholt, J., Doody, C.: Adverse events following trigger point dry needling: a prospective survey of chartered physiotherapists. submitted, 2012
111. Betts D, Budd S. 'Forbidden points' in pregnancy: historical wisdom? *Acupunct Med.* 2011; 29:137-139.
112. Cummings M. 'Forbidden points' in pregnancy: no plausible mechanism for risk. *Acupunct Med.* 2011;29:140-142.
113. Guerreiro da Silva AV, Uchiyama Nakamura M, Guerreiro da Silva JB. 'Forbidden points' in pregnancy: do they exist? *Acupunct Med.* 2011;29:135–136.
114. Cicerone KD. Evidence-based practice and the limits of rational rehabilitation. *Arch Phys Med Rehabil.* Jun 2005;86(6):1073-1074.
115. Gerwin RD, Dommerholt J. Treatment of myofascial pain syndromes. In: Boswell MV, Cole BE, eds. *Weiner's pain management; a practical guide for clinicians.* Vol 7. Boca Raton: CRC Press; 2006:477-492.
116. United States Department of Labor OSHA. Occupational Safety and Health Standards, Z, Toxic and Hazardous Substances, 1910.1030. *Bloodborne pathogens.* Washington, DC: United States Department of Labor, Occupational Safety & Health Administration.
117. Bjorkedal E, Flaten MA. Expectations of increased and decreased pain explain the effect of conditioned pain modulation in females. *J Pain Res.* 2012;5:289-300.
118. Legrain V, Iannetti GD, Plaghki L, Mouraux A. The pain matrix reloaded: a salience detection system for the body. *Prog Neurobiol.* Jan 2011;93(1):111-124.
119. White PF, Craig WF, Vakharia AS, Ghoname E, Ahmed HE, Hamza MA. Percutaneous neuromodulation therapy: does the location of electrical stimulation effect the acute analgesic response? *Anesth Analg.* Oct 2000;91(4):949-954.
120. Lundeberg T, Lund I. Is there a role for acupuncture in endometriosis pain, or 'endometrialgia'? *Acupunct Med.* Jun 2008;26(2):94-110.
121. Elorriaga A. The 2-Needle Technique. *Med Acupunct.* 2000;12(1):17-19.
122. Mayoral O, De Felipe JA, Martínez JM. Changes in tenderness and tissue compliance in myofascial trigger points with a new technique of electroacupuncture. Three preliminary cases report. *J Musculoskel Pain.* 2004;12(suppl):33.