Journal of Bodywork & Movement Therapies 22 (2018) 941–946

Contents lists available at ScienceDirect

Journal of Bodywork & Movement Therapies

journal homepage: www.elsevier.com/jbmt

MYOFASCIAL PAIN AND TREATMENT: ORIGINAL RESEARCH

Post-needling soreness after myofascial trigger point dry needling: Current status and future research

Aitor Martín-Pintado-Zugasti [a, *], Orlando Mayoral del Moral [b], Robert D. Gerwin [c], Josue Fernández-Carnero [d, e, f]

[a] Department of Physical Therapy, Faculty of Medicine, CEU-San Pablo University, Madrid, Spain
[b] Physical Therapy Department, Hospital Provincial, Toledo, Spain
[c] Department of Neurology, Johns Hopkins University School of Medicine, Baltimore, MD, USA
[d] Department of Physical Therapy, Occupational Therapy, Rehabilitation and Physical Medicine, Rey Juan Carlos University, Madrid, Spain
[e] Hospital La Paz Institute for Health Research, IdiPAZ, Madrid, Spain
[f] Grupo Multidisciplinar de Investigación y Tratamiento Del Dolor, Grupo de Excelencia Investigadora URJC-Banco de Santander, Madrid, Spain

ARTICLE INFO

Article history:
Received 21 September 2017
Received in revised form
27 December 2017
Accepted 8 January 2018

Keywords:
Needles
Pain
Trigger points
Adverse effects
Physical therapy modalities

ABSTRACT

Post-dry needling soreness is a common complication of myofascial trigger point (MTrP) dry needling treatment. The prevention, management and relevance of this complication remain uncertain. This paper examines the current state of knowledge and suggests directions for further studies in this area. MTrPs are hypersensitive nodules in skeletal muscles' taut bands, present in several pain conditions. Dry needling has been recommended for relieving MTrP pain. MTrP dry needling procedures have shown to be associated with post-needling soreness, which is thought to be a consequence of the neuromuscular damage, and hemorrhagic and inflammatory reaction generated by the needle. Postneedling soreness is a very frequent effect after deep dry needling, usually lasting less than 72 h. It may not be especially distressing for most patients. However, patients presenting with higher levels of post-needling soreness, not perceiving dry needling effectiveness in the first session, or not having high myofascial pain intensity before treatment, could be the most likely to find post-needling soreness more distressing, functionally limiting and to abandon treatment. Future research should assess the clinical relevance of post-needling soreness. Post-needling soreness should be considered when investigating dry needling effectiveness since it could overlie the original myofascial pain and influence the patients' pain ratings.

1. Introduction

The presence of soreness is a frequent complication of myofascial trigger point (MTrP) dry needling treatment (Ga et al., 2007a; Hong, 1994; Martín-Pintado-Zugasti et al., 2016; Torres et al., 2004). The prevention, management and relevance of post-needling soreness remain uncertain. This paper examines the current state of knowledge and suggests directions for further studies in this area.

MTrPs are hypersensitive nodules in taut bands present in skeletal muscles. MTrPs are classified either as active MTrPs, which are symptom-producing by triggering local or referred spontaneous pain, or as latent MTrPs, which upon stimulation do not reproduce any symptom experienced by the patient. (Simons et al., 1999). Moreover, MTrPs contribute to autonomic phenomena, motor dysfunction and impaired range of motion (Ge et al., 2012, 2014; Simons et al., 1999). Active MTrPs have been found in subjects presenting with several pain conditions, including tension type headache (Fernández-de-Las-Peñas et al., 2010b), migraine (Giamberardino et al., 2007), temporomandibular disorders (Fernández-de-Las-Peñas et al., 2010a), nonspecific shoulder pain (Bron et al., 2011), subacromial impingement (Alburquerque-Sendín et al., 2013; Hidalgo-Lozano et al., 2010), lateral epicondylalgia (Fernandez-Carnero et al., 2007), or knee osteoarthritis (Henry et al., 2012). Direct trauma or overuse are thought to lead to the development or perpetuation of MTrPs, when muscle capacity is exceeded and normal recovery is delayed (Bron and Dommerholt, 2012).

The treatment of MTrPs includes dry needling therapies

* Corresponding author. Department of Nursing and Physiotherapy, CEU-San Pablo University, Carretera Boadilla del Monte, Km 5,300, Urbanización Montepríncipe, 28668 Boadilla del Monte, Madrid, Spain.
E-mail address: martinpintado.a@gmail.com (A. Martín-Pintado-Zugasti).

https://doi.org/10.1016/j.jbmt.2018.01.003
1360-8592/

frequently used by different health care providers. MTrP dry needling consists of inserting solid filament needles into the muscle in the location of the MTrP (Dommerholt et al., 2006). Local twitch responses, transient contractions of the taut band elicited by dry needling, have been associated with better outcomes in pain reduction and range of motion (Hong, 1994), and with a decrease in nociceptive and inflammatory mediators present at the MTrP (Shah and Gilliams, 2008).

Recent reviews and meta-analysis on the effectiveness of dry needling have suggested or recommended dry needling over control non-needling treatments, or placebo treatment, for the treatment of MTrP pain in short and medium term studies (Kietrys et al., 2013; Liu et al., 2015). Very low quality to moderate quality evidence suggested that dry needling performed by physical therapists was more effective than no treatment, sham dry needling and other treatments (Gattie et al., 2017).

1.1. Adverse effects of dry needling

There are few reports detailing significant adverse effects following MTrPs dry needling. Cummings et al. (2014) reported the presence of a pneumothorax complication after dry needling in the iliocostalis muscle. Acute cervical subdural (Ji et al., 2015) or epidural (Lee et al., 2011) hematoma have been reported following cervical muscle dry needling. In addition, Callan et al. (2016) reported a deep spine infection and Steentjes et al., 2015) reported an infection of a hip prosthesis.

Brady et al. (2014) assessed the incidence of adverse effects after 7629 dry needling interventions. The authors did not observe significant adverse effects, whereas mild adverse effects were very common, since they were presented in 19.18 percent of cases. Common adverse effects included bruising (7.55%), bleeding (4.65%), pain during treatment (3.01%), and pain after treatment (2.19%).

Guidelines that provide recommendations for improving the safety of deep dry needling, such as correct technique, proper hygiene and anatomical knowledge of the location of organs, vessels and nerves, have been developed in some countries in response to the recognition that there are risks associated with the procedure (Dommerholt and Fernandez de las Peñas, 2013).

2. Post-needling soreness

Simons et al. (1999) initially described soreness as a consequence of MTrP injection procedures. They considered postinjection and postneedling soreness as being a result of the tissue injury produced by the needle and the following inflammatory reaction, fundamentally different from the pathophysiology of the MTrP itself. Domingo et al. (2013) reported damage to mice muscle fibers and intramuscular nerves associated with a transient inflammatory response that showed healing beginning in 3 days post dry needling and complete healing in 6 days. Hsieh et al. (2012) reported that nociceptive and inflammatory mediators such as substance P, increased in rabbit muscle after 5 days of consecutive needling, due to an excessive muscle damage. This response was the opposite when dry needling was applied once, so it was only associated to an increased dosage of dry needling. The local increase in such neurotransmitters and proinflammatory mediators could be hypothesized to predispose some individuals to experience postneedling soreness, but further research is needed.

Simons et al. (1999) and Hong (1994) associated soreness with capillary hemorrhage and the consequent irritation of muscle and observed that patients presenting with visible ecchymosis or swelling after needling presented with greater postinjection or postneedling soreness. Based on that, Simons et al. (1999) highlighted the importance of hemostasis during and after MTrP injection. Domingo et al. (2013) observed that dry needling in mice occasionally induced bleeding, as observed in humans. A recent study did not find significant correlations between the presence of blood in the cotton swab after hemostasis and the intensity of postneedling soreness after deep dry needling of latent MTrPs (Martín-Pintado-Zugasti et al., 2016). However, the presence of blood in the cotton swab may not detect possible deep tissue hemorrhage.

The number of needle insertions and the pain perceived during needling is positively correlated with the intensity of postneedling soreness in healthy subjects (Martín-Pintado-Zugasti et al., 2016), thus confirming the relationship between the amount of tissue damage produced during needling and the intensity of postneedling soreness. Other variables are thought to influence postneedling soreness perception, such as psychosocial factors (Martín-Pintado-Zugasti et al., 2014) or gender (Martín-Pintado-Zugasti et al., 2016). The characteristics of the muscle being needled, such as the presence of active or latent MTrPs, could lead to a different postneedling soreness response. The number of LTRs elicited during needling could also influence postneedling soreness. However, it has not been found significant associations between postneedling soreness intensity and the number of LTRs elicited (Martínez-Merinero et al., 2009).

Factors associated with the therapists' dry needling technique, or MTrP diagnostic skills and experience, may influence postneedling soreness presence or intensity. Accurate localization of the MTrP may minimize the number of needle insertions, while adequate hemostasis during and after MTrP dry needling could reduce bleeding.

Postneedling soreness after deep dry needling has been considered to be of greater intensity and duration than postinjection soreness (Hong, 1994; Simons et al., 1999). However, beveled hypodermic needles of 0.4 mm diameter were used for dry needling rather than the filiform needles now used (Dommerholt et al., 2006). Dry needling applied with solid filament needles of 0.30 mm in diameter did not provoke significantly higher postneedling soreness compared to postinjection soreness in Ga et al.'s study (Ga et al., 2007b). Further research is needed to investigate whether postinjection soreness is less painful compared to postneedling soreness performed with filiform needles.

2.1. Frequency, intensity and duration

Various studies have evaluated the presence or characteristics of postneedling soreness or postneedling tenderness (Arias-Buría et al., 2015; Brady et al., 2014; Fernández-Carnero et al., 2017; Ga et al., 2007a, 2007b; Hong, 1994; Llamas-Ramos et al., 2014; Martín-Pintado-Zugasti et al., 2014, 2015, 2016; Martinez-Merinero et al., 2009; Mejuto-Vázquez et al., 2014; Myburgh et al., 2012; Salom-Moreno et al., 2017; Téllez-García et al., 2015; Torres et al., 2004). In most cases, postneedling soreness was assessed secondary to the main objectives of evaluating the effectiveness of dry needling procedures on reducing MTrPs pain (Arias-Buría et al., 2015; Ga et al., 2007a, 2007b; Hong, 1994; Llamas-Ramos et al., 2014; Mejuto-Vázquez et al., 2014; Myburgh et al., 2012; Téllez-García et al., 2015). The results are summarized in Table 1. The small number of published studies, as well as important differences in study design, make it impossible to draw definitive conclusions about the mean frequency, intensity or duration of postneedling soreness. Additional research is needed to delineate the postneedling soreness characteristics that may be expected after dry needling, considering specific muscles or pain conditions receiving the treatment, the needling technique performed, the needle size, the presence or type of MTrPs needled or the number of needle

Table 1
Postneedling soreness characteristics.

	N	Neddle (Diameter)	*LTRs*	*MTrPs (muscle)*	*% PNS*	*PNS* max *intensity (0 −10)*	*PNS duration*
Ga et al., 2007a,b	40	Monofilament (0.3 mm)	LTR exhaustion	Active (UT)	50% −55%	–	1.73−1.83 days
Llamas-Ramos et al., 2014	45	Monofilament (0.3 mm)	1st LTR and 30 s	Active (UT)	55%	–	24-36 h
Arias-Buría et al., 2015	10	Monofilament (0.3 mm)	1st LTR and 30 s	Active (shoulder girdle muscles)	60%	–	24-36 h
Téllez-García et al., 2015	12	Monofilament (0.3 mm)	1st LTR and 30 s	Active: (quadratus lumborum and gluteus)	83%	–	24-32 h
Mejuto-Vázquez et al., 2014	9	Monofilament (0.3 mm)	1st LTR and 30 s	Active: (UT)	88%	–	24-36 h
Salom-Moreno et al., 2017	90	Monofilament (0.32 mm)	LTR exhaustion	Active (Infraspinatus)	100%	5.6 ± 1,5	72 h or superior (Not specified)
Fernández-Carnero et al., 2017	84	Monofilament (0.32 mm)	Various dry needling dosages	Active (UT)	91.4%	–	–
León-Hernández et al., 2016	62	Monofilament (0.32 mm)	Two LTR elicited	Active (UT)	–	5 (6,25−3.12)	–
Hong, 1994	15	Beveled (0.4 mm)	LTR exhaustion	Active (UT)	100%	4.3 ± 1,7	5 ± 1.7 days
Torres et al., 2004	28	Monofilament (–)	LTR exhaustion	Latent (UT)	90% −100%	–	24-72 h
Myburgh et al., 2012	17	Monofilament (–)	LTR exhaustion	Active (UT)	29.4%	–	–
	20		No LTR	Absence of active (UT)	0%		
Martín-Pintado-Zugasti et al., 2015	60	Monofilament (0.26 mm)	LTR exhaustion	Latent (UT)	100%	4 ± 1,4	24-72 h

LTR = Local Twitch Response; PNS=Postneedling Soreness; UT=Upper Trapezius; - = Not specified. Values; PNS max intensity values are Mean ± SD or median (Interquartile range).

insertions or LTRs elicited during needling.

Patients who report postneedling soreness describe it as quite different from the pain caused by MTrPs. The quality of soreness is described as constant pressure or dull aching, which is distinguishable from the sharp and tight aching that they experience before needling (Hong, 1994).

Dry needling of latent trigger points in healthy subjects resulted in higher levels of postneedling soreness frequency than seen in patients with dry needling of active MTrPs. It may be that those patients presenting with myofascial pain find postneedling soreness harder to perceive, since the two pains may overlap (Irnich et al., 2002). Hong's finding (Hong, 1994) that hypodermic needles with cutting edges produced more frequent and longer lasting post-needling soreness may be explained by the greater degree of tissue damage produced by the needle.

Post-needling soreness was reported to range between 50 and 100% in most of the studies (Table 1). Myburgh et al. (2012) and Brady et al. (2014) reported lower percentages of post-needling soreness. The specific design of these studies could have led to different reports of postneedling soreness. In Myburgh et al.'s study (Myburgh et al., 2012), postneedling soreness was present in 29.4% of symptomatic patients and not at all in asymptomatic subjects receiving deep dry needling. However, postneedling soreness overlapped with delayed onset muscle soreness from a contraction testing and no LTR was elicited while needling asymptomatic subjects. Brady et al. (2014) reported the presence of pain after treatment, which could be attributed to postneedling soreness, in 2.19% of cases after needling procedures. Notably, the postneedling soreness presence was recorded by therapists by completing a questionnaire that included mild adverse events observed after needling and not from the patients. In addition, 30% of needling treatments were superficial dry needling and there was no further information about the protocol used for the remaining deep dry needling techniques.

The duration of post-needling soreness was less than 72 h in most of studies in which filiform needles were used (Arias-Buría et al., 2015; Ga et al., 2007a; Llamas-Ramos et al., 2014; Martín-Pintado-Zugasti et al., 2016; Mejuto-Vázquez et al., 2014; Téllez-García et al., 2015; Torres et al., 2004). However, Salom-Moreno et al. (2017) reported that it did not completely disappear 72 h after the needling procedure, although pain levels were relatively small. In the case of dry needling with syringe beveled needles, the postneedling soreness duration seems to be longer, with a reported mean duration of five days (Hong, 1994).

Post-injection soreness lasted a mean of 13.7 days with a maximum intensity of 8.3 points on a 0−10 Likert subjective pain scale in fibromyalgia patients whose tender points were injected (Hong and Hsueh, 1996). These values were significantly higher than the postinjection soreness mean duration (1.2 days) and intensity (2.3 points) present in those with chronic neck pain who received lidocaine injections in active MTrPs. The authors suggested that central sensitization present in patients with fibromyalgia led to augmented pain responses (Hong and Hsueh, 1996). This could be a generalized phenomenon in all patients with central pain sensitization.

There is little data about postneedling soreness intensity. The mean maximal intensity was reported to be between 3.5 and 5.6 on a 0 to 10-point scale (Hong, 1994; Martín-Pintado-Zugasti et al., 2014, 2015; Salom-Moreno et al., 2017), but further research is needed.

Postneedling tenderness after dry needling of latent trigger points in healthy subjects has been previously observed. The pressure pain threshold significantly decreased at the needle site immediately after needling and during 48 h (Martín-Pintado-Zugasti et al., 2014, 2016; Torres et al., 2004). However, immediately after dry needling, the pressure pain threshold of active MTrPs in myofascial pain patients increases, showing a hypoalgesic effect of dry needling (Cagnie et al., 2012; Cerezo-Téllez et al., 2016; Fernández-Carnero et al., 2010a,b; Koppenhaver et al., 2015; Ziaeifar et al., 2013).

2.2. Clinical relevance of postneedling soreness

Further research is needed to determine the importance that postneedling soreness has for patients receiving dry needling procedures, as well as the possible alterations in function caused by

postneedling soreness, and whether it could lead to reduced treatment adherence.

Previous research has reported reduced treatment adherence as a direct consequence of postinjection soreness. Fifty-one percent of subjects receiving lidocaine MTrP injections were reluctant to have further injections (Lai and Hong, 1998). However, the authors discussed that postinjection soreness was greater compared with previous research, probably due to the larger 23 gauge needle size used that could cause "more microtrauma, hematoma and inflammatory reaction". In addition, higher rates of withdrawal from treatment have been attributed to postneedling soreness after dry needling with filiform needles, when compared with other invasive procedures, such as percutaneous electrical nerve stimulation (Pérez-Palomares et al., 2010).

To our knowledge, there are no studies that investigated functional limitations possibly related to postneedling soreness. Simons et al. (1999) recommended avoiding any demanding muscular activity for 24 h and placing muscles in a fixed, shortened position for a prolonged length of time, as well as avoiding strenuous activities, such as playing tennis, moving furniture or traveling to conventions for at least the two or three-day period of postinjection soreness, and preferably for about one week. However, they encouraged patients to use their muscles in a gentle, normal way through their full range of motion. There have been no studies to support such recommendations. The American Physical Therapy Association (APTA, 2012) recommends warning patients about the occurrence of soreness and considers postneedling soreness capable of influencing patients' functionality since it suggests scheduling the needling treatment to take into account the patient's lifestyle, social or work commitments.

Simons et al. (1999) considered that postinjection soreness was not unfavorable if the patient's myofascial pain from MTrPs was relieved. However, they commented that sometimes considerable postinjection soreness and distressing referred autonomic and proprioceptive phenomena could occur after injection. They recommended not injecting again until soreness was gone. Additionally, Hong (1994) observed that most patients presenting with postneedling soreness found it tolerable compared with the original MTrP pain.

In clinical practice, most patients receiving dry needling associated with improvements in myofascial pain levels do not find postneedling soreness so distressing in comparison with the original myofascial pain and may not consider it relevant. However, those patients presenting with high levels of postneedling soreness, not perceiving dry needling effectiveness in the first session or not having high MTrP pain intensity before treatment, could be the most likely to find postneedling soreness more distressing and functionally limiting or to be reluctant to undergo further needling treatments. The pain level perceived during dry needling could also be associated with reduced treatment adherence. Previous research has shown this clinical perception. Pérez-Palomares et al. (2010) observed that patients presenting with high levels of baseline pain showed higher tolerance to the treatment and higher pain improvements after dry needling in patients with low back pain. However, those patients with low baseline myofascial pain, showed reduced tolerance and augmented abandonment rate attributed to postneedling soreness.

Other authors have considered the pain perceived after dry needling as a mild adverse event, defined as short-term and non-serious, with no change in function (Brady et al., 2014). It reflects conflicting opinions between authors about the impact and clinical relevance of postneedling soreness.

Dommerholt et al. (2015) questioned whether, in the most usual case in which postneedling soreness is not associated with severe debilitating pain, postneedling soreness could be presented to the patient as a positive sign rather than a negative experience. Future studies could investigate the importance of the information provided to the patient or the patients' beliefs about postneedling soreness.

Previous research has investigated the effectiveness of additional therapies applied after needling for treating postneedling (León-Hernández et al., 2016; Martín-Pintado-Zugasti et al., 2014, 2015; Salom-Moreno et al., 2017) or postinjection (Lai and Hong, 1998) soreness. Percutaneous electrical nerve stimulation reduced post-dry needling soreness intensity after needling of the trapezius MTrP in chronic neck pain patients (León-Hernández et al., 2016). Low load exercise also improved postneedling soreness intensity after dry needling of MTrPs in the infraspinatus muscle in subacromial pain syndrome patients (Salom-Moreno et al., 2017) and ultrasound reduced tenderness and improved the cervical range of motion after trigger point injection of MTrPs in the upper trapezius in neck pain patients (Lai and Hong, 1998). Spray and stretch immediately improved postneedling soreness (Martín-Pintado-Zugasti et al., 2014) and ischemic compression reduced both pain intensity and duration (Martín-Pintado-Zugasti et al., 2015) after dry needling of latent MTrPs. Moreover, Simons et al. (1999) recommended various treatments intended to reduce postinjection soreness, including a moist heating pack, stretches or nonsteroidal anti-inflammatory drugs. Further research is needed to determine the effects of other additional therapies that are thought to be clinically effective in reducing or preventing postneedling soreness, such as transcutaneous electrical nerve stimulation, kinesiotape or moderate physical activity.

2.3. Research implications of postneedling soreness

To the authors' knowledge, there are no studies that have assessed the influence that postneedling soreness or postneedling tenderness may have on the outcomes of studies investigating the effectiveness of dry needling on myofascial pain associated with MTrPs. Postneedling soreness could mask the original myofascial pain and influence myofascial pain ratings. Further studies have been recommended to take this situation into account (Irnich et al., 2002). Patients may rate levels of myofascial pain and sensitivity higher or range of motion and muscle function lower, mainly when evaluating immediate or short-term dry needling effects (Fernández-Carnero et al., 2017; Koppenhaver et al., 2015; Ziaeifar et al., 2016). Postneedling soreness has shown to be higher immediately (Martín-Pintado-Zugasti et al., 2016) or a few hours after needling (Hong, 1994), so it could associate with reduced pain or disability improvements immediately after dry needling.

It is the authors' recommendation that post-needling soreness may occur and should be considered when assessing post-needling treatment effects. Furthermore, postneedling soreness should be separately evaluated from the original MTrP pain. Patients can describe postneedling soreness differently and separately from the original MTrP pain (Hong, 1994).

2.4. Recommendations and directions for future research

The clinical relevance that postneedling soreness has for myofascial pain patients receiving deep dry needling procedures needs to be investigated. It is not clear whether postneedling soreness could in some cases have an impact on function or reduce the treatment adherence.

Further research could consider the importance of the information provided to the patient about postneedling soreness and whether its relevance is influenced when presented as a positive sign associated to dry needling therapies (Dommerholt et al., 2015).

Future research on the effectiveness of dry needling in the

treatment of myofascial pain should include the assessment of postneedling soreness, since it could mask the original myofascial pain and influence the short-term pain or pressure pain threshold ratings (Irnich et al., 2002).

3. Conclusions

Post-needling soreness after deep dry needling is likely to be the result of neuromuscular injury, and hemorrhagic and inflammatory changes produced by the needle. The therapists' technique may influence the development of these events. Post-needling soreness is a very frequent event, but usually lasts less than 72 h when using filiform needles and when LTRs are elicited. The duration is longer when hollow, beveled needles are used. Post-needling soreness may be more severe when there is significant central sensitization and hypersensitivity. Post-needling soreness may not be especially distressing for most patients, but further research about its clinical relevance is needed. Postneedling soreness needs to be taken into account when studying the effect of dry needling as treatment of specific pain syndromes.

Author disclosures

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interests

None.

References

Alburquerque-Sendín, F., Camargo, P.R., Vieira, A., Salvini, T., 2013. Bilateral myofascial trigger points and pressure pain thresholds in the shoulder muscles in patients with unilateral shoulder impingement syndrome: a blinded, controlled study. Clin. J. Pain 29, 478–486.

APTA, 2012. Physical Therapists & the Performance of Dry Needling: an Educational Resource Paper. APTA Department of Practice and APTA State Government Affairs, Alexandria, VA, USA.

Arias-Buría, J.L., Valero-Alcaide, R., Cleland, J.A., Salom-Moreno, J., Ortega-Santiago, R., Atín-Arratibel, M.A., et al., 2015. Inclusion of trigger point dry needling in a multimodal physical therapy program for postoperative shoulder pain: a randomized clinical trial. J. Manip. Physiol. Ther. 38, 179–187.

Brady, S., McEvoy, J., Dommerholt, J., Doody, C., 2014. Adverse events following trigger point dry needling: a prospective survey of chartered physiotherapists. J. Man. Manip. Ther. 22, 134–140.

Bron, C., Dommerholt, J.D., 2012. Etiology of myofascial trigger points. Curr. Pain Headache Rep. 16, 439–444.

Bron, C., Dommerholt, J., Stegenga, B., Wensing, M., Oostendorp, R.A., 2011. High prevalence of shoulder girdle muscles with myofascial trigger points in patients with shoulder pain. BMC Muscoskel. Disord. 12, 139.

Cagnie, B., Barbe, T., De Ridder, E., Van Oosterwijck, J., Cools, A., Danneels, L., 2012. The influence of dry needling of the trapezius muscle on muscle blood flow and oxygenation. J. Manip. Physiol. Ther. 35, 685–691.

Callan, A.K., Bauer, J.M., Martus, J.E., 2016. Deep spine infection after acupuncture in the setting of spinal instrumentation. Spine Deform 4, 156–161.

Cerezo-Téllez, E., Torres-Lacomba, M., Fuentes-Gallardo, I., Perez-Muñoz, M., Mayoral-Del-Moral, O., Lluch-Girbés, E., et al., 2016. Effectiveness of dry needling for chronic nonspecific neck pain: a randomized, single-blinded, clinical trial. Pain 157, 1905–1917.

Cummings, M., Ross-Marrs, R., Gerwin, R., 2014. Pneumothorax complicacion of deep dry needling demonstration. Acupunct. Med. 32, 517–519.

Domingo, A., Mayoral, O., Monterde, S., Santafé, M.M., 2013. Neuromuscular damage and repair after dry needling in mice. Evid Based Complement Alternat. Med. 2013, 260806.

Dommerholt, J., Fernandez de las Peñas, C., 2013. Trigger Point Dry Needling. An Evidenced and Clinical-based Approach. Churchill Livingstone, Edinburgh.

Dommerholt, J., Mayoral del Moral, O., Gröbli, C., 2006. Trigger point dry needling. J. Man. Manip. Ther. 14, E70–E87.

Dommerholt, J., Grieve, R., Layton, M., Hooks, T., 2015. An evidence-informed review of the current myofascial pain literature–July 2015. J. Bodyw. Mov. Ther. 19, 126–137.

Fernandez-Carnero, J., Fernandez-de-Las-Penas, C., de la Llave-Rincon, A.I., Ge, H.Y., Arendt-Nielsen, L., 2007. Prevalence of and referred pain from myofascial trigger points in the forearm muscles in patients with lateral epicondylalgia. Clin. J. Pain 23, 353–360.

Fernández-Carnero, J., La Touche, R., Ortega-Santiago, R., Galan-del-Rio, F., Pesquera, J., Ge, H.Y., et al., 2010. Short-term effects of dry needling of active myofascial trigger points in the masseter muscle in patients with temporomandibular disorders. J. Orofac. Pain 24, 106–112.

Fernández-Carnero, J., Gilarranz-de-Frutos, L., León-Hernández, J.V., Pecos-Martin, D., Alguacil-Diego, I., Gallego-Izquierdo, T., et al., 2017. Effectiveness of different deep dry needling dosages in the treatment of patients with cervical myofascial pain: a pilot RCT. Am. J. Phys. Med. Rehabil. 96, 726–733.

Fernández-de-las-Peñas, C., Galán-del-Río, F., Alonso-Blanco, C., Jiménez-García, R., Arendt-Nielsen, L., Svensson, P., 2010a. Referred pain from muscle trigger points in the masticatory and neck-shoulder musculature in women with temporomandibular disoders. J. Pain 11, 1295–1304.

Fernández-de-Las-Peñas, C., Ge, H.Y., Alonso-Blanco, C., González-Iglesias, J., Arendt-Nielsen, L., 2010b. Referred pain areas of active myofascial trigger points in head, neck, and shoulder muscles, in chronic tension type headache. J. Bodyw. Mov. Ther. 14, 391–396.

Ga, H., Choi, J.H., Park, C.H., Yoon, H.J., 2007a. Dry needling of trigger points with and without paraspinal needling in myofascial pain syndromes in elderly patients. J. Alternative Compl. Med. 13, 617–624.

Ga, H., Koh, H.J., Choi, J.H., Kim, C.H., 2007b. Intramuscular and nerve root stimulation vs lidocaine injection of trigger points in myofascial pain syndrome. J. Rehabil. Med. 39, 374–378.

Gattie, E., Cleland, J.A., Snodgrass, S., 2017. The effectiveness of trigger point dry needling for musculoskeletal conditions by physical therapists: a systematic review and meta-analysis. J. Orthop. Sports Phys. Ther. 47, 133–149.

Ge, H.Y., Arendt-Nielsen, L., Madeleine, P., 2012. Accelerated muscle fatigability of latent myofascial trigger points in humans. Pain Med. 13, 957–964.

Ge, H.Y., Monterde, S., Graven-Nielsen, T., Arendt-Nielsen, L., 2014. Latent myofascial trigger points are associated with an increased intramuscular electromyographic activity during synergistic muscle activation. J. Pain 15, 181–187.

Giamberardino, M.A., Tafuri, E., Savini, A., Fabrizio, A., Affaitati, G., Lerza, R., 2007. Contribution of myofascial trigger points to migraine symptoms. J. Pain 8, 869–878.

Henry, R., Cahill, C.M., Wood, G., Hroch, J., Wilson, R., Cupido, T., et al., 2012. Myofascial pain in patients waitlisted for total knee arthroplasty. Pain Res. Manag. 17, 321–327.

Hidalgo-Lozano, A., Fernández-de-las-Peñas, C., Alonso-Blanco, C., Ge, H.Y., Arendt-Nielsen, L., Arroyo-Morales, M., 2010. Muscle trigger points and pressure pain hyperalgesia in the shoulder muscles in patients with unilateral shoulder impingement: a blinded, controlled study. Exp. Brain Res. 202, 915–925.

Hong, C.Z., 1994. Lidocaine injection versus dry needling to myofascial trigger point. The importance of the local twitch response. Am. J. Phys. Med. Rehabil. 73, 256–263.

Hong, C.H., Hsueh, T.C., 1996. Difference in pain relief after trigger point injections in myofascial pain patients with and without fibromyalgia. Arch. Phys. Med. Rehabil. 77, 1161–1166.

Hsieh, Y.L., Yang, S.A., Yang, C.C., Chou, L.W., 2012. Dry needling at myofascial trigger spots of rabbit skeletal muscles modulates the biochemicals associated with pain, inflammation, and hypoxia. Evid Based Complement Alternat. Med. 2012, 342165.

Irnich, D., Behrens, N., Gleditsch, J.M., Stör, W., Schreiber, M.A., Schöps, P., et al., 2002. Immediate effects of dry needling and acupuncture at distant points in chronic neck pain: results of a randomized, double-blind, sham-controlled crossover trial. Pain 99, 83–89.

Ji, G.Y., Oh, C.H., Choi, W.S., Lee, J.B., 2015 Mar 1. Three cases of hemiplegia after cervical paraspinal muscle needling. Spine J. 15 (3), e9–13.

Kietrys, D.M., Palombaro, K.M., Azzaretto, E., Hubler, R., Schaller, B., Schlussel, J.M., et al., 2013. Effectiveness of dry needling for upper-quarter myofascial pain: a systematic review and meta-analysis. J. Orthop. Sports Phys. Ther. 43, 620–634.

Koppenhaver, S.L., Walker, M.J., Su, J., McGowen, J.M., Umlauf, L., Harris, K.D., et al., 2015. Changes in lumbar multifidus muscle function and nociceptive sensitivity in low back pain patient responders versus non-responders after dry needling treatment. Man. Ther. 20, 769–776.

Lai, M.W., Hong, C.Z., 1998. Additional ultrasound therapy after myofascial trigger point injection for the management of post-injection soreness. J. Rehab. Med. Assoc. ROC 26, 111–118.

Lee, J.H., Lee, H., Jo, D.J., 2011. An Acute Cervical Epidural Hematoma as a Complication of Dry Needling, vol. 36, pp. 891–893.

León-Hernández, J.V., Martín-Pintado-Zugasti, A., Frutos, L.G., Alguacil-Diego, I., de-la-Llave-Rincón, A.I., Fernandez-Carnero, J., 2016. Immediate and Short-term Effects of the Combination of Dry Needling and Percutaneous TENS on Post-needling Soreness in Patients with Chronic Myofascial Neck Pain, vol. 20, pp. 422–431.

Liu, L., Huang, Q.M., Liu, Q.G., Ye, G., Bo, C.Z., Chen, M.-J., et al., 2015. Effectiveness of dry neeedling for myofascial trigger points associated with neck and shoulder pain: a systematic review and meta-analysis. Arch. Phys. Med. Rehabil. 96, 944–955.

Llamas-Ramos, R., Pecos-Martín, D., Gallego-Izquierdo, T., Llamas-Ramos, I., Plaza-Manzano, G., Ortega-Santiago, R., et al., 2014. Comparison of the short-term outcomes between trigger point dry needling and trigger point manual therapy for the management of chronic mechanical neck pain: a randomized clinical trial. J. Orthop. Sports Phys. Ther. 44, 852–861.

Martín-Pintado-Zugasti, A., Rodríguez-Fernández, A.L., García-Muro, F., López-López, A., Mayoral, O., Mesa-Jiménez, et al., 2014. Effects of spray and stretch on

postneedling soreness and sensitivity after dry needling of a latent myofascial trigger point. Arch. Phys. Med. Rehabil. 95, 1925–1932.
Martín-Pintado-Zugasti, A., Pecos-Martín, D., Rodríguez-Fernández, A.L., Alguacil-Diego, I.M., Portillo-Aceituno, A., Gallego-Izquierdo, T., et al., 2015. Ischemic compression after dry needling of a latent myofascial trigger point reduces post-needling soreness intensity and duration. PM R 7, 1026–1034.
Martín-Pintado-Zugasti, A., Rodríguez-Fernández, Á.L., Fernandez-Carnero, J., 2016. Postneedling soreness after deep dry needling of a latent myofascial trigger point in the upper trapezius muscle : characteristics, sex differences and associated factors. J. Back Musculoskelet. Rehabil. 29, 301–308.
Martínez-Merinero, P., García de Miguel, S., Jiménez Rejano, J.J., 2009. Relation between the local twitch responses and the post-pressure and post-needling soreness in miofascial trigger points. Cuest Fisioter 38, 161–172.
Mejuto-Vázquez, M.J., Salom-Moreno, J., Ortega-Santiago, R., Truyols-Domínguez, S., Fernández-de-Las-Peñas, C., 2014. Short-term changes in neck pain, widespread pressure pain sensitivity, and cervical range of motion after the application of trigger point dry needling in patients with acute mechanical neck pain: a randomized clinical trial. J. Orthop. Sports Phys. Ther. 44, 252–260.
Myburgh, C., Hartvigsen, J., Aagaard, P., Holsgaard-Larsen, A., 2012. Skeletal muscle contractility, self-reported pain and tissue sensitivity in females with neck/shoulder pain and upper Trapezius myofascial trigger points- a randomized intervention study. Chiropr. Man. Ther. 20, 36.
Pérez-Palomares, S., Oliván-Blázquez, B., Magallón-Botaya, R., De-la-Torre-Beldarraín, M.L., Gaspar-Calvo, E., Romo-Calvo, L., et al., 2010. Percutaneous electrical nerve stimulation versus dry needling: effectiveness in the treatment of chronic low back pain. J. Muscoskel. Pain 18, 23–30.
Salom-Moreno, J., Jiménez-Gómez, L., Gómez-Ahufinger, V., Palacios-Ceña, M., Arias-Buría, J.L., Koppenhaver, S.L., et al., 2017. Effects of low-load exercise on post-needling induced pain after dry needling of active trigger point in individuals with subacromial pain syndrome. PM R 9, 1208–1216.
Shah, J., Gilliams, E.A., 2008. 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. 12, 371–384.
Simons, D.G., Travell, J.G., Simons, L.S., 1999. Myofascial Pain and dysfunction.the Trigger Point Manual, second ed., vol. 1. Williams & Wilkins, Baltimore.
Steentjes, K., de Vries, L.M., Ridwan, B.U., Wijgman, A.J., 2015. Infection of a hip prosthesis after dry needling. Ned. Tijdschr. Geneeskd. 160, A9364.
Téllez-García, M., de-la-Llave-Rincón, A.I., Salom-Moreno, J., Palacios-Ceña, M., Ortega-Santiago, R., Fernández-de-las-Peñas, C., 2015. Neuroscience education in addition to trigger point dry needling for the management of patients with mechanical chronic low back pain: a preliminary clinical trial. J. Bodyw. Mov. Ther. 19, 464–472.
Torres, R., Mayoral, O., Díez, E., 2004. Pain and tenderness after deep dry needling. J. Muscoskel. Pain 12 (Suppl. 9), 40.
Ziaeifar, M., Arab, A.M., Karimi, N., Nourbakhsh, M.R., 2013. The effect of dry needling on pain, pressure pain threshold and disability in patients with a myofascial trigger point in the upper trapezius muscle. J. Bodyw. Mov. Ther. 18, 298–305.
Ziaeifar, M., Arab, A.M., Nourbakhsh, M.R., 2016. Clinical effectiveness of dry needling immediately after application on myofascial trigger point in upper trapezius muscle. J. Chiropr. Med. 15, 252–258.