Review Study: The Effects of Ultrasound-guided Dry Needling on Patients With Myofascial Pain Syndrome

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Citation: Ebrahimi Takamjani I, Ezzati K, Khani S, Sarrafzadeh J, Tabatabaei A. The Effects of Ultrasound-guided Dry Needling on Patients With Myofascial Pain Syndrome. Iranian Rehabilitation Journal. 2020; 18(4):369-376. http://dx.doi.org/10.32598/irj.18.4.133.3

http://dx.doi.org/10.32598/irj.18.4.133.3

Article info:
Received: 19 Jun 2020
Accepted: 10 Nov 2020
Available Online: 01 Dec 2020

Keywords:
Ultrasound-guided, Ultrasonography, Dry needling, Trigger points, Musculoskeletal pain, Myofascial pain syndrome

ABSTRACT

Objectives: Dry Needling (DN) is a novel and effective intervention for patients with Myofascial Pain Syndrome (MPS). Some characteristics, such as needle penetration depth, needle insertion into the target muscle, and trigger points must be identified in this intervention. The Ultrasound (US)-guided DN is a technique that involves needle insertion at the site of injury and the simulation of tissue injury and inflammation under US guidance; it indicates the needle insertion site to ensure that it does not penetrate the adjacent tissues. The current study aimed to review previous studies regarding the effects of US-guided DN on MPS.

Methods: A search was performed in PubMed, Scopus, Cochrane, Google Scholar, Springer, and Science Direct databases to retrieve studies published from 2010 to March 2020. We included investigations regarding the effects of US-guided DN on the treatment of MPS. The following keywords and MeSH terms were used in the search process: "ultrasound-guided, musculoskeletal ultrasonography, myofascial pain syndrome, trigger points, and dry needling."

Results: A total of 47 relevant articles were retrieved. However, based on the inclusion and exclusion criteria of the review, 11 articles were finally selected. All studies reported significant pain relief following the use of US-guided DN in patients with MPS.

Discussion: Considering the precise visualization of the site of muscle involvement, precise needle insertion, and reduction of the risk of further injury in US-guided DN may be a useful approach for MPS management in short-term and long-term studies.

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Highlights

- US-guided DN may be an effective alternative intervention for patients with MPS, especially those with pain in deep structures.

- The safety of DN, the visualization of trigger points and local twitch response, as well as the insertion of the needle tip into the trigger points of deep muscles, are the main reasons for applying US-guided DN in patients with MPS.

- There is a need for further clinical trials with long-term follow-ups and comparative groups to apply US-guided DN as a common intervention for patients with MPS.

Plain Language Summary

MPS is a common cause of musculoskeletal disorders. There are many interventions to decrease pain and stiffness in patients with MPS. US-guided DN, in which a needle is inserted under US guidance, can be used as a novel method for treating these patients. The results of this review suggested that US-guided DN may improve therapeutic outcomes in patients with MPS.

1. Introduction

Musculoskeletal pain affects up to 86% of the total population and may be acute or chronic. Approximately 95% of patients with chronic pain encounter Myofascial Pain Syndrome (MPS), which affects millions of individuals. It also imposes a heavy financial burden on the affected individual and society [1, 2]. Approximately 54% of females and 45% of males are affected by MPS, especially due to a sedentary lifestyle and low physical activity [3]. Evidence suggests that MPS is more prevalent in the age group of 27-50 years. MPS has been studied for more than a century; however, its diagnostic, clinical, and therapeutic aspects remain unclear [2, 3].

MPS is a common, non-articular, and musculoskeletal disorder, characterized by myofascial trigger points [4]. MPS symptoms include diffuse pain, Local Twitch Response (LTR) to pressure, decreased Range of Motion (ROM), and autonomic nervous system-induced symptoms [2, 4]. Trigger points include hyperirritable spots along the taut bands of muscle fibers; they become painful upon pressure or stretching and can spread with a specific pattern [3, 4]. Evidence suggests that these trigger points may be either active or latent. Active trigger points, as the primary cause of MPS, are spontaneous. Consequently, they cause familiar symptoms in patients on palpation [2, 3]. In contrast, latent trigger points do not elicit spontaneous or familiar pain on palpation. The formation of trigger points is multifactorial, depending on factors, such as inappropriate posture, poor biomechanics, overuse, direct trauma, and stress [5].

Aguilar et al. reported that 60% of costs related to physical treatment for chronic pain cannot be justified [6]. Therefore, evidence-based interventions are emphasized in pain management, especially MPS [7]. Several therapeutic approaches are implemented to treat MPS. Deep Dry Needling (DN) has recently attracted the attention of medical researchers [8]. DN is a frequent therapeutic technique, in which a solid, filiform, and stainless steel needle is inserted through the skin [7]. Inserting needles into the target soft tissues causes mechanical hyperstimulation and manipulation [9]. Bruises, bleeding, and soreness are the three most frequent adverse effects of DN. Besides, these adverse effects are associated with DN techniques, like the number of needle insertions into the trigger points [10].

There are controversies regarding the efficacy, safe application, neuromuscular complications, and needle insertion effects (e.g. LTR) of DN. Moreover, the evaluation of treatment outcomes is a major concern following DN [7-11]. In this regard, Baraja-Vegas et al. indicated that DN may elicit intramuscular edema and alternations in the contractile properties of muscles [11]. The need for information, such as the needle penetration depth, needle insertion into the target muscle and trigger points, as well as the prevention of needle penetration into the adjacent structures (e.g. nerves) has led researchers to employ diagnostic Ultrasound (US) along with DN [7, 9].

US is an essential tool in diagnosing and treating injuries to soft tissues, including the muscles, tendons, and nerves [2, 12]. B-mode and linear probe US interventions are used to monitor the condition of musculoskel-

etal tissues [13]. US can visualize various structures of the musculoskeletal tissue with particular characteristics. For instance, the muscle and the surrounding fascia are observed to be hypoechoic in US, whereas the skin is a hyperechoic structure [12, 13]. US-guided interventions include surgical and conservative treatment approaches. The US-guided DN is a technique, involving needle insertion at the site of injury, the simulation of tissue injury, and inflammation under US guidance. Such a process indicates the needle insertion site to ensure that it does not penetrate the adjacent tissue [13]. Other treatment methods, including injection, cryotherapy, prolotherapy, and electrocoagulation are also US-guided interventions [13]. Thus, the current study aimed to review previous research regarding the effects of US-guided DN on MPS.

2. Methods

A search was conducted in PubMed, Scopus, Google Scholar, CINAHL, Ovid, Cochrane, ProQuest, and Science Direct databases to retrieve articles published from 2010 to March 2020. We included data regarding the effects of US-guided DN on the treatment of MPS. The following keywords and MeSH terms were used in the present search: "Ultrasound-guided, musculoskeletal ultrasonography, dry needling, trigger points, musculoskeletal pain, and myofascial pain syndrome". A total of 47 relevant articles were retrieved by searching the above-mentioned databases.

The inclusion criteria of the present review were as follows: retrospective and prospective, experimental, quasi-experimental, and observational studies; English articles on the effects of US-guided DN on MPS, and relevant articles published from 2010 to March 2020. Based on the inclusion and exclusion criteria (using US-guided DN as the main inclusion criterion), a total of 11 articles were finally reviewed [14-24]. Three of these studies were randomized clinical trials, comparing US-guided DN with other treatment methods [15, 18, 22]; 5 were case reports and case-series [14, 17, 19, 21, 24]; two were retrospective analyses of the effect of US-guided DN on the treatment of MPS [16, 23], and one was a single-group, pretest, post-test study [20].

All studies on the effect of US-guided DN were reviewed, regardless of the trigger points. The selected articles defined and evaluated the outcomes, using the following tools: the Visual Analog Scale (VAS) and the Numeric Pain Rating Scale (NPRS) for pain analysis [25, 26]; a goniometer for ROM [27]; as well as the Neck Disability Index (NDI) and Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire for disability [28, 29].

Two reviewers (KE & SK) independently evaluated the titles and abstracts of studies on US-guided DN for patients with MPS. Besides, the reviewers independently screened the full-text articles. Moreover, the two raters evaluated the methodological quality of the selected articles.

There exist no standard criteria to evaluate the methodological quality of single-case studies [30]. Tate et al. developed a Single-Case Experimental Design (SCED) scale for this purpose. The SCED is an 11-item rating scale, with 10 items on the methodological quality and statistical analysis [30]. Moreover, the quality of Randomized Controlled Trials (RCTs) was assessed, using the 11-point Physiotherapy Evidence Database (PEDro) scale, i.e. a reliable and valid instrument. A PEDro score of ≥7 represents a high methodological quality, whereas a PEDro score of ≤5 represents a low methodological quality [31].

3. Results

Initially, we retrieved 47 relevant articles in this review research. However, 18 studies were excluded based on the title and abstract. The full-texts of 29 remaining articles were screened. Furthermore, 18 articles were excluded due to inappropriate study designs, non-English writing, and reporting other diseases rather than myofascial pain. Finally, 11 articles were included for further analysis and methodological quality assessment (Table 1). All studies were of moderate [24] to high [14, 15, 17-19, 21, 22] quality (PEDro score: ≥5), except for 3 retrospective investigations [16, 20, 23]. All studies were of moderate to high quality (PEDro score: ≥5). Approximately 91% of the included articles (n=10) reported the positive effects of US-guided DN on the outcome measures, like pain. Almost all studies reported pain reduction and improvement of outcomes following the use of US-guided DN. In this regard, Zheng et al. compared US-guided DN with US-guided mini scalpel needle release technique in patients with chronic neck pain. The relevant results indicated the efficacy of both treatments and the superiority of mini scalpel needle release over DN [15]. Moreover, the disability index was assessed in 44 patients with complex regional pain syndrome. The related results demonstrated that US-guided DN significantly improved outcomes at 15 and 45 days after treatment [16]. Fusco et al. explored the effects of US-guided DN on three patients with piriformis syndrome. Accordingly, they reported positive outcomes one day after the intervention and in the 6-month follow-up [21].

Vas and Pai reported improvements in the symptoms after one session of US-guided plane block and 3 sessions of US-guided DN. Furthermore, significant pain

Table 1. The general information and methodological quality of the included studies

Authors (y)	Disease, Sample Size	Type of Article (Main Inclusion Criteria)	Methods	Measurement	Follow-up	Results
Bubnov et al. (2013) [14] SCED: 7	Trigger points, 133	Case series	Group A: US-guided DN Group B: DN	Pain (VAS)	24 hours after the intervention	Group A (MD=6.1) Group B (MD=4.5)
Zheng et al. (2014) [15] PEDro score: 9	Chronic neck pain, 60	RCT	Group A: US-guided miniscalpel DN Group B: US-guided DN	Pain (VAS), neck disability, and SF-36 health survey	3 and 6 months after the intervention	the superiority of US-guided mini scalpel DN over US-guided DN
Vas et al. (2016) [16]	Complex regional pain syndrome type 1, 44	Retrospective (pre-test, post-test design)	Treatment with medications plus US-guided DN for neck and upper extremity muscles	Pain (VAS), ROM, and DASH score	15 and 45 days after the intervention	The lack of pain, pain-free full ROM, and improved DASH scores due to treatment
Vas et al. (2016) [17] SCED score: 6	Pancreatic cancer pain, 5	Case series	The US-guided DN of abdominal and back muscles plus neurolytic coeliac plexus block or splanchnic nerve radiofrequency ablation	Pain (NRS)	3 and 15 days after the intervention	Significant pain relief
Sánchez-Mila et al. (2018) [18] PEDro score: 7	Stroke, 26	RCT	Group A: Bobath only Group B: Bobath plus DN	Modified Ashworth Scale, Fugl-Meyer motor scale, and computerized dynamic posturography	10 minutes after treatment	Improved spasticity, function, and postural control
Pai and Vas (2018) [19] SCED score: 7	Complex regional pain syndrome type 1, 1	Case study	US-guided DN plus medications and stellate ganglion block	DASH score, painDETECT questionnaire, and patient health questionnaire-9	1 year	Functional improvement
Bubnov and Kalika (2018) [20]	Low back pain, 23	Pre-test, post-test	US-guided DN	Pain scale (VAS) and Leeds Assessment of Neuropathic Symptoms and Signs	Before, immediately after, 24 hours after, and 7 days after the intervention	Improved pain, nerve structure, motility, and contractility
Fusco et al. (2018) [21] SCED score: 6	Piriformis syndrome, 3	Case series	US-guided DN for the piriformis and gluteal muscles	Pain (NRS)	6 months after treatment	Complete pain relief
Tabatabaei et al. (2019) [22] PEDro score: 8	Piriformis syndrome, 32	RCT	Group A: US-guided DN plus home recommendations Group B: Home recommendations	Pain (VAS), Oswestry disability index, pressure pain threshold, and hip joint ROM	24 hours, 72 hours, and 1 week after the intervention	The superiority of the intervention with various effect sizes
Vas and Pai (2019) [23]	Postmastectomy pain syndrome, 20	Retrospective (pre-test, post-test)	Group A: US-guided DN plus neural interventions Group B: US-guided DN	DASH score, painDETECT score, Patient Health Questionnaire-9, and opioid use scale	-	Reduction of pain, disability, and opioid use
Kurosawa et al. (2019) [24] SCED score: 5	Shoulder pain, 1	Case study	US-guided DN	Pain (NRS) and ROM	2 weeks after the intervention	Pain reduction and improved ROM

SCED: Single-Case Experimental Design; US: Ultrasound; DN: Dry Needling; VAS: Visual Analog Scale; MD: Mean Difference; RCT: Randomized Controlled Trial; DASH: Disabilities of the Arm, Shoulder, and Hand Index; NRS: Numerical Rating Scale; ROM: Range of Motion.

Table 2. The purposes and assessment time of US-guided DN in patients with MPS (n=11)

US-guided DN	
Goals	**Assessment**
Guidance (100%)	Immediately after the intervention (45%)
LTR (54%)	Short-term follow-up (54%)
Trigger point visualization (36%)	Long-term follow-up (27%)
Visualization of deep structures (100%)	-

US: Ultrasound; DN: Dry Needling; LTR: Local Twitch Response.

relief was observed at a 4-month follow-up assessment [23]. Tabatabaei et al. investigated the effects of US-guided DN on piriformis syndrome. Thirty-two patients with piriformis syndrome were divided into two groups. One group received US-guided DN and home recommendations, while the other group only received home recommendations. The explored patients were evaluated at 24 and 72 hours, as well as one week after the intervention concerning pain, hip external and internal rotations, disability, and pressure pain tolerance. The results of the study by Tabatabaei et al. signified that the group receiving US-guided DN presented significantly better outcomes than the controls in terms of pain relief and internal ROM with a great effect size. However, there was no significant difference between the study groups regarding the increased pressure pain tolerance (with a moderate effect size) and disability (with a small effect size) [22]. The details of the reviewed articles on using US-guided DN, including the author's name, sample size, article type, the number of interventions, study duration, studied variables, and relevant results are listed in Table 1.

According to Table 2, the main applications of US-guided DN included guidance (100%), the evaluation of deep structures (100%), LTR visualization (54%) [14, 16, 18, 19, 21, 22], and trigger point visualization (36%) [14, 20, 24], respectively. Additionally, nearly 54% of the included studies on US-guided DN evaluated the outcomes in short-term follow-ups [15-20, 22-24]; whereas long-term follow-ups were only performed in 27% of the studies [15, 21] (Table 2).

Moreover, in 63% of the reviewed studies, the number of US-guided DN sessions was less than 3 [14-18, 20, 22]. Only about 10% of the studies reported the adverse effects of US-guided DN [15]. Eventually, the validity and repeatability of the methods of the included studies were not reported.

4. Discussion

According to the present research results, US-guided DN improves therapeutic outcomes, like pain in patients with MPS [14-24]. DN is an invasive method, i.e. usually implemented for patients with MPS [32]. In Deep DN, the needles may penetrate >4 cm into tissues [3]. Thus, targeting and visualizing tissue using US may influence the patient's treatment outcomes and complications after DN [14]. A review on the effects of DN on chronic low back pain concluded that the clinical superiority of DN and its follow-up efficacy were unclear [33]. Besides, the International Conference on Invasive Physical Therapy (ICIPT) recommended using US during needling. The safety considerations, visualizing deep tissues and LTR, and recording changes and outcomes were mentioned as the main reasons for applying US [9]. However, the main purpose of US-guided DN is to guide fine needles into deep muscles [14-24].

In a previous study, the superiority of US-guided mini scalpel needling over US-guided DN was attributed to differences in needle penetration into the target and the US-guided needling procedure [15]. In US-guided mini scalpel needling, the needle was inserted into the extensor neck muscle, and the trigger point was destructed. However, in US-guided DN, the needle was inserted into the tight neck extensor muscle and not exactly the trigger point [15]; this difference can be a major reason for the superiority of US-guided Miniscalpel needling over US-guided DN [15]. LTR eliciting under US guidance is another essential feature of this method [14, 16, 18-20, 22].

Significant pain relief was reported in another study that used US-guided DN for treating patients with piriformis syndrome, compared to the controls [22]. However, the used technique provided a small effect size for the disability index, compared to the control group. Such data could be attributed to the short-term follow-up, as the patients required adequate time to improve their

abilities following therapy [22]. Regarding the hip ROM index, the piriformis muscle is a short external rotator muscle of the hip joint; therefore, pain relief, induced by US-guided DN, improved the muscle stiffness symptoms and allowed further internal hip rotation. However, no significant superiority over the control group was observed respecting external hip rotation, as a muscle function. Regarding the pressure pain tolerance, due to the micro-trauma caused by DN in the muscle, the pressure pain threshold further increased in the intervention group in less than a week following US-guided DN, with moderate effect size, compared to the controls [22].

There are some controversies regarding the US visualization of trigger points in MPS patients [12]. The least common application of US-guided DN is the visualization of trigger points [14, 20, 24]. Previous studies revealed that US fails to identify the exact echogenicity changes [12]. The mechanism of action of DN in pain relief among patients with MPS remains undiscovered [9]. However, therapists can employ needles with an appropriate length to minimize the micro-trauma caused by muscle stimulation; this is due to the effectiveness of this therapeutic technique, the inadequate availability of all muscles, the risk of damage to vessels entering the muscles and the surrounding nerves, and the odds of monitoring muscles through US [10, 12].

US technique allows us to observe LTR in deep muscles (indicating precise needle insertion into the trigger point of the muscle); thus, applying diagnostic US alongside DN, as a therapeutic modality, can significantly help patients [4, 9, 14-24]. US-guided DN seems to be able to increase pain relief and decrease the number of treatment sessions in MPS patients [14]. According to the present research findings, US-guided DN may be a safe and suitable alternative for the conventional interventions of MPS [21].

The results of the reviewed studies suggested considerable improvements in pain after US-guided DN; however, there were some limitations in these studies. First, in some studies, needle insertion was performed in different muscles [14, 16, 19]. Second, US was used for various purposes, such as needle guidance, LTR visualization, and the visualization of trigger points or deep structures [14-24]. Third, the repeatability of the methods was suspected in numerous studies [14-24]. Four, almost all studies evaluated the immediate or short-term effects of US-guided DN [16, 17]. Finally, the cost of US equipment and educational courses, besides the feasibility of protocols, should be considered in future studies [14].

5. Conclusion

Based on the data reported in the literature, US-guided DN may help treat patients with MPS. However, further RCTs with longer follow-up courses may provide more conclusive results.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles were considered in this article.

Funding

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

Authors' contributions

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Conflict of interest

The authors declared no conflicts of interest.

Acknowledgments

The authors would like to thank the Iran University of Medical Sciences for supporting this research.

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