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Original Article

Combined effectiveness of extracorporeal radial shockwave therapy and ultrasound-guided trigger point injection of lidocaine in upper trapezius myofascial pain syndrome

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Abstract: Objective: Myofascial pain syndrome (MPS) is a major musculoskeletal problem and a leading cause of disability worldwide. Extracorporeal shockwave therapy (ESWT) and trigger point injection (TPI) have shown positive results for MPS but no previous study has investigated the combined effects of radial shockwave and trigger point injection of lidocaine for upper trapezius myofascial pain syndrome. Method: For this purpose, forty-five participants were randomly divided into shockwave (n = 15), shockwave with ultrasound-guided trigger point injection (combined; n = 15), and control (standard care; n = 15) groups. Participants were assessed at baseline, one week and four weeks by using the visual analog scale, neck disability index, electromyography, infrared thermography, and sonoelastography. Results: Compared with control group, both shockwave and combined groups showed a statistically significant reduction in pain ($P<0.01$), functional disability ($P<0.01$), skin temperature ($P<0.01$), and elastic stiffness, with greater reduction in the combined group ($P<0.01$) than shockwave group ($P<0.05$) at four weeks. However, no significant difference was found in electrical activity between the groups ($P>0.05$). The combined group also showed significant differences in pain ($P<0.05$) and elastic stiffness ($P<0.01$) compared with shockwave group at four weeks. Conclusion: Our study revealed that extracorporeal radial shockwave therapy combined with trigger point injection of lidocaine was more effective for decreasing pain and elastic stiffness in upper trapezius myofascial pain syndrome at four weeks.

Keywords: Shockwave therapy, upper trapezius myofascial pain, sonoelastography, ultrasound, trigger point injection

Introduction

Neck pain is a major musculoskeletal problem with a prevalence rate of 22-70% [1]. Due to the changes in social life, working modes, and the application of a large number of electronic components and devices, an increasing number of people suffer from non-specific neck pain that affects their physical, social, and psychological health [2]. Activities such as driving, office work, and poor sleeping posture, are associated with upper neck stiffness and pain [3].

Myofascial pain syndrome (MPS) is the main cause of nonspecific neck pain and is defined as the formation of hyperirritable nodules in the tight muscle bands, resulting in pain, functional disability, and decreased range of motion. A myofascial trigger point (MTrP) has an increased prevalence in upper limb postural muscles and most commonly in the trapezius muscle due to its main role in neck mobility and stability. Trigger points in the upper trapezius result in pain and functional loss and develop vascular, electromyographic, and metabolic muscle changes; therefore, proper diagnosis and treatment are essential [4, 5]. The treatment for MPS mainly focuses on disrupting the vicious cycle of pain by eliminating the trigger points. Several conventional treatments are considered helpful in managing myofascial pain

including non-invasive treatments, such as laser, ultrasound, heat therapy, massage, shockwave, and exercise, and invasive therapies, such as trigger point injection (TPI), dry needle therapy, and acupuncture. The exact mechanism for the formation of MTrP remains unknown; therefore, the most effective treatment for MPS is still debatable [6]. However, studies have shown that a single treatment for MPS is not effective or long-lasting. In contrast, combination therapy has attracted the attention of scholars; thus, the combination of two or more treatments has become an important recommendation [7]. Among single treatments, non-invasive shockwave and invasive injection therapy are considered most useful.

Trigger point injection (TPI) is a widely used method of injecting local anesthetics at trigger points to release muscle tension and relieve myofascial pain. At present, TPI therapy has been widely used for MPS in clinical practice due to its rapid analgesic effect and easy application. Studies have shown that TPI improved quality of life (QOL) in patients with MPS [8]. Recently, extracorporeal shockwave therapy (ESWT) has emerged as an advanced treatment for MPS. ESWT is a sequence of pulses transmitted by an appropriate generator to a specific location targeted for treatment [9-11]. Numerous studies have demonstrated the effectiveness of TPI and ESWT for upper trapezius myofascial pain due to its analgesic properties and the stimulation of soft tissue repair and growth [12, 13]. Given existing literature, a comparison of the single shockwave and needling therapies in MPS has shown effective results in relieving pain and improving clinical symptoms and very few studies showed the combined effectiveness of extracorporeal shockwave and blind injection therapy by using corticosteroids [5, 14, 15]. However, no study to date has shown that a combination of radial shockwave and ultrasound guided trigger point injection of lidocaine can quickly relieve pain and cause functional improvement in patients with non-specific upper trapezius myofascial pain.

In addition, due to the lack of objective outcome measure tools, there is a barrier to the critical evaluation of the effectiveness of therapeutic techniques. The current diagnostic protocol for MPS is based upon palpation to locate trigger points [16, 17]. Therefore, reliable objective tools are needed for the accurate identification of trigger points. Such tools could be useful to understand the proper diagnosis and natural history of trigger points and to determine the underlying mechanism of MPS. In our research, we have designed quantitative imaging methods to address these limitations.

This is a novel study that implies extracorporeal (radial) shockwave combined with ultrasound-guided trigger point injection of lidocaine in upper trapezius MPS along with objective outcome measures to explain their effectiveness in multiple dimensions. The results of this study are expected to provide a new theoretical and therapeutic basis for the treatment and prevention of myofascial pain syndrome.

Material and method

Study design

This is a single-blind, prospective randomized clinical trial to compare the combined effects of extracorporeal (radial) shockwave and ultrasound-guided trigger point injection of lidocaine in upper trapezius myofascial pain syndrome.

Participants

A randomized clinical trial (RCT) was conducted from April 2020 to May 2021 at the Department of Rehabilitation Medicine, Second Affiliated Hospital, China. All participants were given detailed information regarding objectives and study procedures and signed a written consent form. Patients referred to the outpatient clinic were enrolled in the study if they met the following criteria: 20-65 years old, neck pain for more than three months, presence of one or two trigger points on both sides in the trapezius muscle upon palpation, and VAS $\geq$3.

Patients with acute neck pain (< three months), patients who exhibit cervical spine imaging with any radiculopathy, nerve root lesions and other spine-related conditions (arthritis, spondylolisthesis, rheumatic diseases, tumors, fractures), patients with intervertebral disc or facet joint pathology, patients receiving any other treatment in forms of physical therapy and medication and undergoing spinal surgical interventions were excluded from the study [18].

Ethical consideration

This study confirms the entire consort reporting guidelines. The study was conducted according to the Declaration of Helsinki, approved by the Ethics Committee of the Science Second Affiliated Hospital (2020)008 and registered to Chinese Clinical Trial Registry.

Randomization

Forty-five eligible patients were randomly divided into three groups by using computer-generated randomization allocation software. All group allocations were arranged and given serial numbers in a sealed packet. A statistician blinded with the randomization performed the procedure for random allocation. Packets were consecutively opened and all eligible participants were randomly divided into radial shockwave (n = 15), radial shockwave with ultrasound-guided trigger point injection of lidocaine (combined; n = 15), and control (standard care; n = 15) groups. The allocation procedure of the participants is presented in **Figure 1**.

Baseline assessment included demographic properties of patient age, gender, height, weight, and body mass index (BMI). Patient weight was measured on a standard digital weight scale, and height was recorded using standard measurement tape. BMI was calculated by dividing the weight by height and expressed as kg/m^2 [19]. Before the interventions, the therapist used a combination of physical examination and US examination to locate and mark the MTrPs of the upper trapezius muscle (**Figure 2**). Objective assessment was performed at the baseline before the intervention and was repeated at one week and four weeks.

Outcome measures

VAS scale: Visual Analog Scale (VAS) was used as a primary indicator to measure general pain intensity. It is a sensitive and comparable method used to identify the general intensity of pain. It is a 10 cm scale which consists of 10 points that assess the patient's pain intensity level ranging from 0 to 10 (0 = none and 10 = unbearable). This rating has sufficient psychometric power for investigating chronic pain conditions and is considered more suitable for maximal reliability [5, 14].

NDI scale: Neck Disability Index (NDI) was used to evaluate cervical spine dysfunction. It is a 10-item scale based on questions of daily activities of living (pain intensity, personal care, sleeping, concentration, work, lifting, reading, recreation, driving, and headache) to measure the neck functional disability level. Every item consists of 5 questions with zero for no disability and five for complete disability. A final score ranging between 5 and 14 was considered as a mild disability, 15-24 as moderate, and ≥25 as severe disability [5].

sEMG: Surface electromyography (sEMG) analysis was performed using Myo Move-EOW (Shanghai Nuocheng Electric Co., LTD) on the upper trapezius muscle bilaterally following the methodology mentioned in previous studies [20-22]. The time base for recording was 1000 ms, the scanning speed was 3 s/D with amplification 80 μV/D during maximal muscle contraction [21]. The assessment was performed in a room with the temperature kept at 26°C. The skin over the trapezius muscle was cleaned with 30% ethylene alcohol. Pair of standard bipolar electrodes was placed over the skin surface of the muscle belly. EMG recordings were obtained during maximal voluntary contraction of the muscle for 5 sec and were repeated thrice to measure the amplitude and the final results were averaged.

Musculoskeletal ultrasound: A Sonosite M-Turbo US system (FUJIFILM Sonosite Inc., Bothell, WA, USA) with a transducer cover and sterile coupling gel was used to locate the upper trapezius trigger points. The scanning was performed using a 13-6 MHz linear transducer. Normally, there are some grayscale degree and pattern changes in areas with MTrPs that appear as focal hypoechoic and heterogeneous echotexture regions [23]. Therefore, we used the musculoskeletal US to locate, guide, and administer TPI for MPS and evaluated the effect of myofascial structural changes before and after the treatment.

SWE: Shear wave sonoelastography (SWE) examination was performed using an ultrasound system (Supersonic Imagine Aixplorer, France) with an SL15-4 linear transducer at 15-4 MHz frequency [24]. To determine the stiffer area in the upper trapezius muscle, patients were asked to sit in a straight upright position.

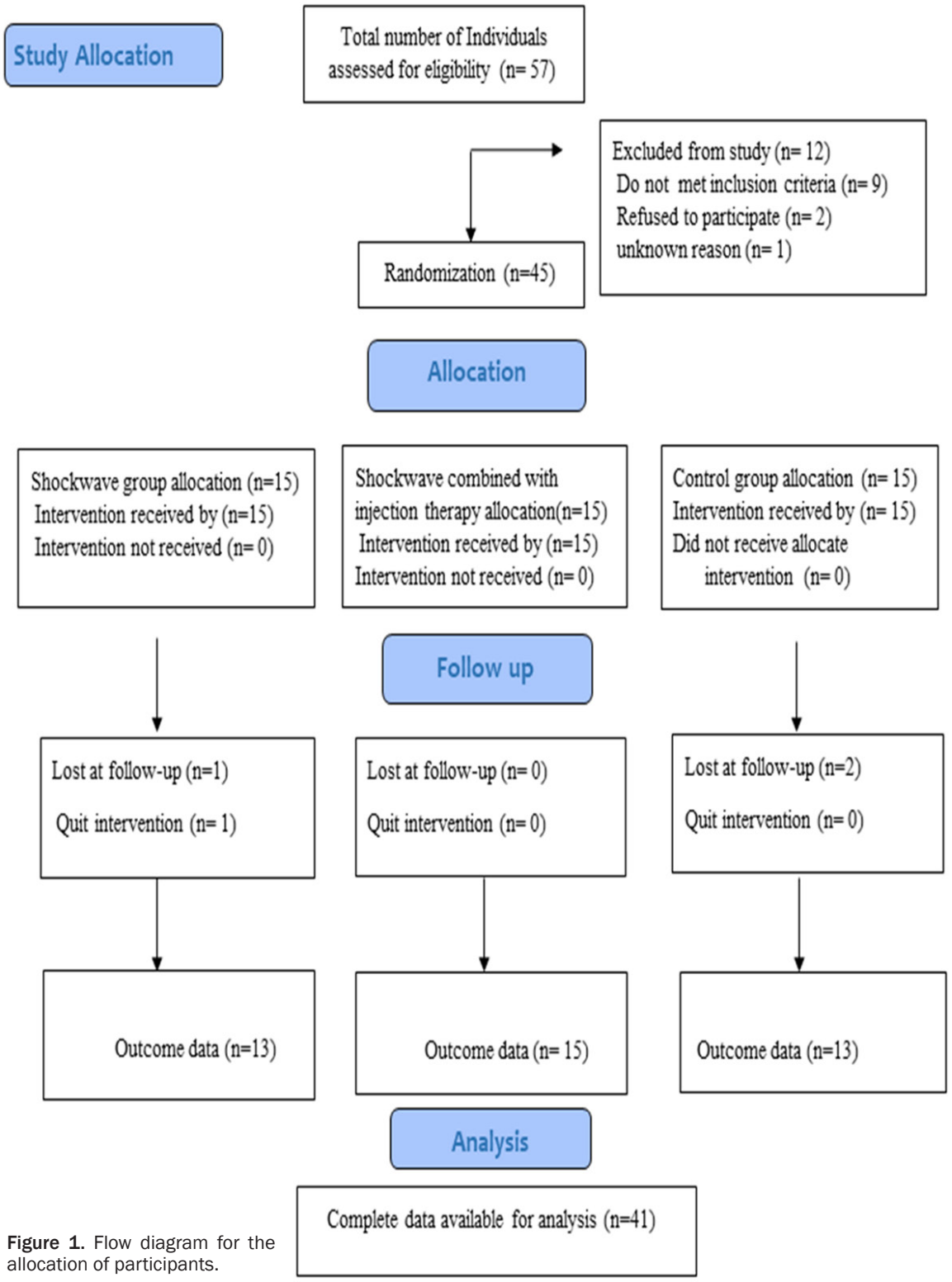

Figure 1. Flow diagram for the allocation of participants.

Sonoelastography was performed using an approximately 80 Hz external vibrating source. The shear wave elastic modulus was measured in kPa (kiloPascals) within the diameter 4 mm and depth 0.5-2 cm. A handheld vibrating massager was applied from a distance of 2-3 cm

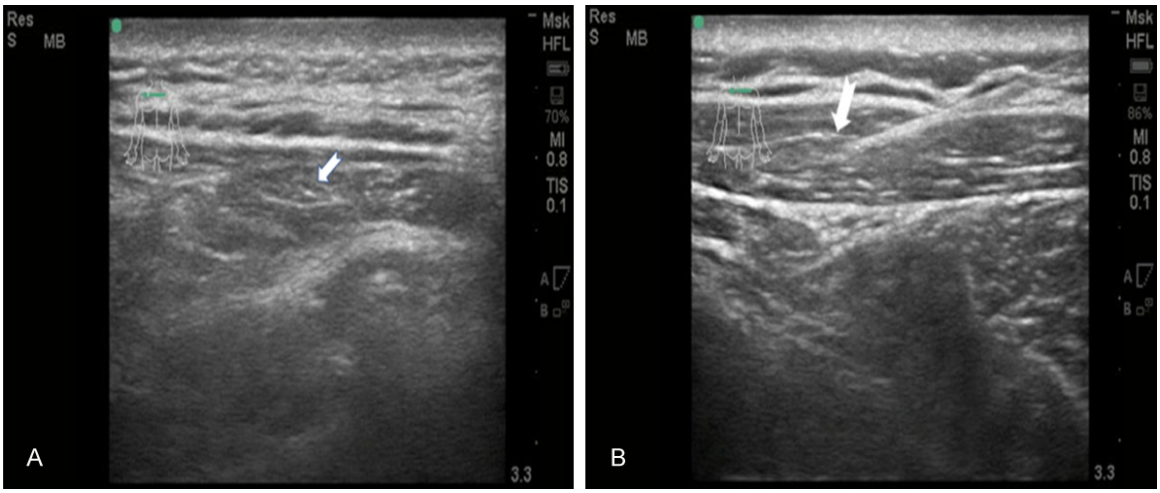

Figure 2. Baseline ultrasound examination of a representative patient. Male, 51 years old, with repeated neck and shoulder pain for more than 10 years, a typical trigger point can be observed at the left side of the neck and shoulder of the patient, as shown by the arrow mark. A white capsule can be seen around, and the ultrasound examination shows a mixed echo area.

from the imaging site. Propagation of waves through MTrPs was recorded by color variance mode [25]. Three images were obtained from each patient and measurement point to improve the accuracy of the measurements.

IRT: Infrared thermography (IRT) (TMT-9000P, Hangzhou Xinhan Photoelectric Technology Co., LTD.) was used to measure skin temperature over the upper trapezius muscle. The participants were held in an empty room for 15 minutes with the temperature kept at 23°C without any other heat-generating equipment [26, 27]. The Infrared images were taken three times in a standing upright position at 100 cm distance from the participant and mean temperature readings were analyzed by the software, and the difference in body surface temperature was distinguished by the difference in color scale.

Interventions

Shockwave group: In the shockwave group, individuals were asked to sit in a straight upright position. One physiatrist had localized and marked the trigger points in the upper trapezius and applied the extracorporeal radial shockwave therapy (Power Shocker LGT-2500 series) with 1000 shots on each point at 5 Hz frequency and 1.2 bar intensity which was applied on each trigger point present either unilateral or bilateral in the upper trapezius muscle. Each patient received three treatments of shockwave (one per week) and guided home-based exercises and postural correction. This protocol was followed as reported in a previous study by Rahbar et al. [18].

Combined group: Participants in this group were given trigger point injection of lidocaine followed by radial shockwave using the same protocol as described previously. To apply trigger point injection therapy, patients were asked to sit in a straight upright position. The MTrPs in the upper trapezius were marked, and skin over the muscle was cleaned with local antiseptic. The injection was applied with 3 ml of 0.5% lidocaine and 0.5% normal saline by using a 1.25-inch long needle under ultrasound guidance [28]. Trigger point injection was applied on each trigger point present either unilateral or bilateral in the upper trapezius muscle. Both interventions were applied on the same day without any gap between the treatments. Patients were given three sessions of shockwave and trigger point injection (one per week) and were guided for home-based exercises and posture correction.

Control group: Participants in the control group were given a conventional physical therapy treatment (heat therapy and exercise) under the supervision of a trained physiotherapist. Each exercise was repeated 10 times with a 5-10 sec hold. The therapy was repeated on

Table 1. Demographic characteristics of the participants

Variables	Control group (n = 13)	Shockwave group (n = 13)	Combined group (n = 15)	*p*-value
Age	41.0 ± 11.6	43.3 ± 9.5	38.3 ± 10.0	P = 0.459
Gender	1.67 ± 0.4	1.54 ± 0.5	1.73 ± 0.2	P = 0.716
Height (cm)	159.7 ± 6.9	162.6 ± 11.4	160.4 ± 6.7	P = 0.753
Weight (kg)	55.9 ± 9.6	62.4 ± 14.7	55.7 ± 8.8	P = 0.353
BMI (kg/m^2)	21.9 ± 3.7	23.4 ± 3.6	21.5 ± 2.3	P = 0.295

Basic demographic characteristics in control group, shockwave group and combined group. BMI indicates body mass index; cm: height in centimeter; kg: weight in kilograms; kg/m^2: kilograms per meter square.

alternate days for a total duration of two weeks. Participants were also guided for self-stretching exercises and posture correction and were instructed to follow the exercise sequence pattern as described by Pesco [29].

Data analysis

The total sample size was determined as 45 (15 per group) using G-POWER 3.1.9.2 software by assuming a two-sided α = 0.05 and a statistical power of 0.8, with an effect size of 0.4 and 0.95 confidence level. The protocol followed the study by Rahbar et al. [18]. All statistical analyses were performed with SPSS (version 23, IBM Corp., Armonk, NY, USA) and Graph Pad-Prism.v.6.0. The descriptive statistics are presented as mean ± SD (95% CI). Repeated measures analysis of variance (ANOVA) and one way ANOVA followed by Dunnett's multiple comparison tests were used for the analysis of data. All tests of statistical significance were interpreted with a criterion of P<0.05.

Results

Total of 57 individuals were evaluated at baseline, and 45 of them who met the eligibility criteria were randomly allocated into groups. Out of 45, a total of 41 participants completed the study and were analyzed for the results. The baseline clinical findings and demographic characteristics are presented in **Table 1**. The study was completely harmless, and no adverse effects or complications were seen in any group throughout the study.

VAS changes in pain

In VAS scale analysis, there was no significant difference between the groups at baseline (P>0.05) (**Figure 3A**). At one week, there was only a significant reduction in pain in the combined group compared to the control group (P<0.01) and shockwave group (P< 0.01) (**Figure 3B**). At four weeks, the shockwave group showed pain reduction compared to the control group (P<0.01) and there was also a significant reduction in pain in the combined group compared with the control group (P<0.01) and shockwave group (P<0.05) (**Figure 3C**). In intragroup comparisons, there was a significant reduction in pain within the control group (P<0.01) (**Figure 3D**), shockwave group (P<0.01) (**Figure 3E**), and the combined group (P<0.01) (**Figure 3F**) at one week and four weeks compared to before. The shockwave group also showed significant difference in pain between one week and four weeks (P<0.01) (**Figure 3E**).

NDI changes in functional disability

Significant decrease in the neck functional disability (NDI) was observed for the intergroup comparison; both shockwave and combined groups showed significant reduction in functional disability compared with the control group at the one-week and four-weeks (P<0.01) (**Figure 4A-C**). In intragroup analysis, there were significant decreases in functional disability within the control group (P<0.01) (**Figure 4D**), shockwave group (P<0.01) (**Figure 4E**), and the combined group (P<0.01) (**Figure 4F**) at one-week and four-weeks. Only the combined group showed significant change at four weeks compared to one week (P<0.01) (**Figure 4F**).

EMG changes in electrical activity

Electrical muscle activity (mv) measured by surface electromyography (sEMG) over the upper trapezius muscle did not show any significant difference between the shockwave, combined and control groups (P>0.05) (**Figure 5A-C**) and within the groups at baseline, one week or four weeks (**Figure 5D-F**).

SWE changes in elastic stiffness over the upper trapezius

For shear wave sonoelastography (SWE) results, at the one-week, elastic stiffness (kPa) in the combined group was significantly reduced compared with the control group (P<0.01) and

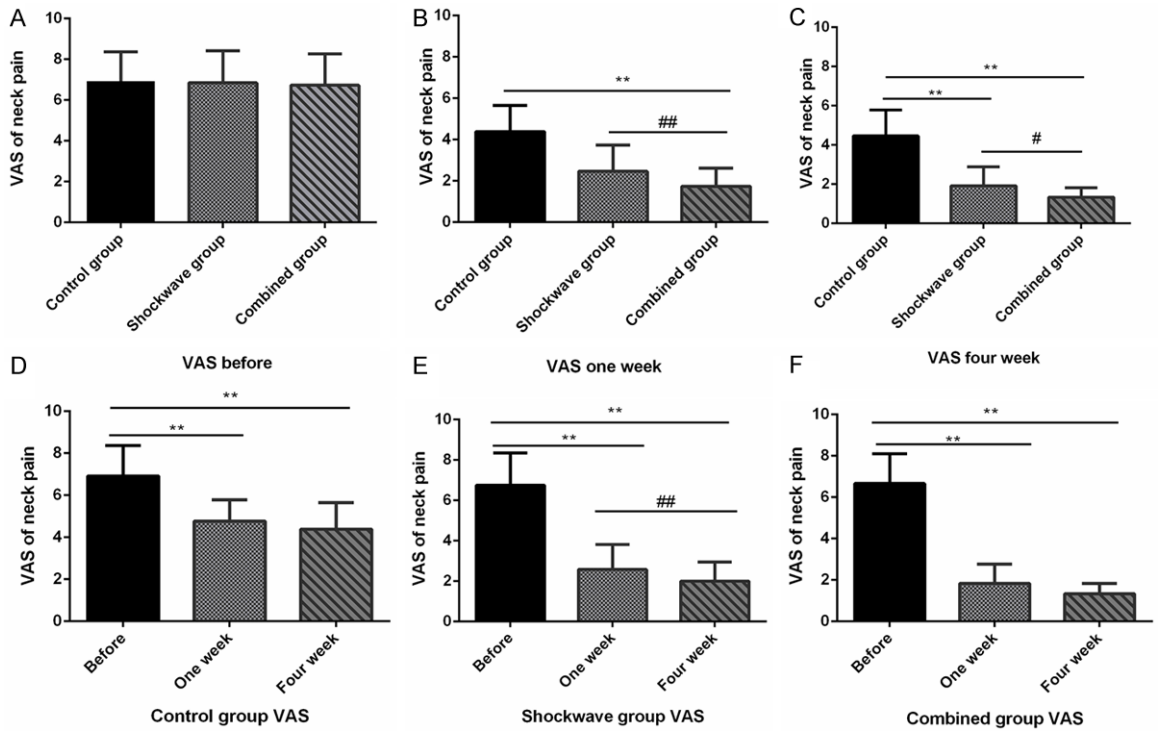

Figure 3. VAS of neck pain between groups with mean ± SD (95% CI) before (A), at one week (B), and four weeks (C). **indicates P<0.01 vs. control group, #indicates P<0.05 and ##P<0.01 vs. shockwave group via repeated measures analysis of variance (ANOVA). VAS of neck pain within each group: control group (D), shockwave group (E) and combined group (F), with mean ± SD (95% CI). **indicates P<0.01 vs. before, ##indicates P<0.01 vs. one week via one-way ANOVA followed by Dunnett's multiple comparison test. VAS = visual analog scale; CD = confidence interval.

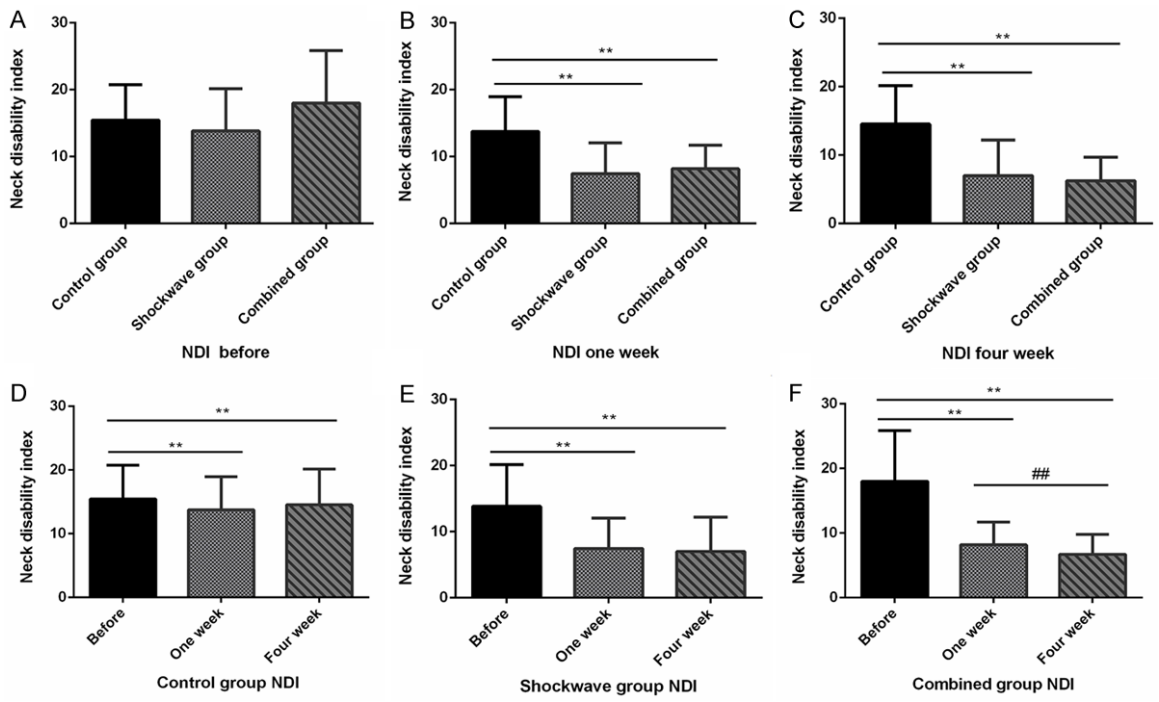

Figure 4. NDI = neck disability index between groups with mean ± SD (95% CI) before (A), at one week (B), and four weeks (C). **indicates P<0.01 vs. control group via repeated measures analysis of variance (ANOVA). NDI within each group: control group (D), shockwave group (E) and combined group (F), with mean ± SD (95% CI). **indicates P<0.01 vs. before, ##indicates P<0.01 vs. one week via one-way ANOVA followed by Dunnett's multiple comparison test.

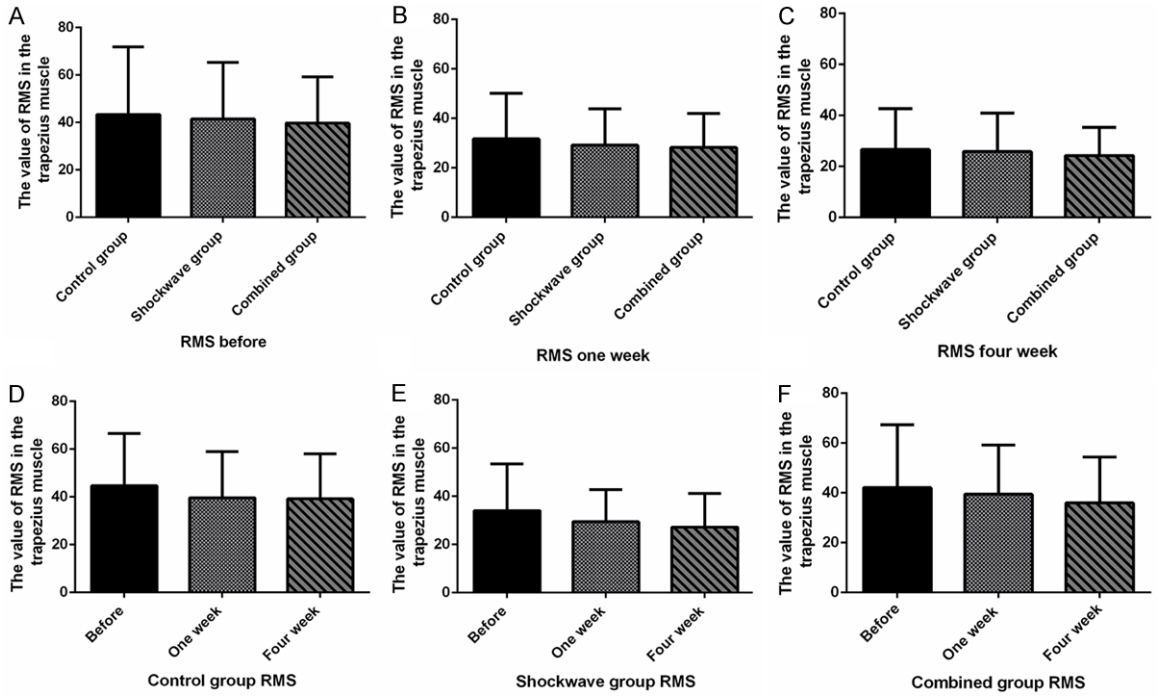

Figure 5. RMS (root mean square) in trapezius muscle between groups with mean ± SD (95% CI) before (A), at one week (B), and four weeks (C), and within each group: control group (D), shockwave group (E) and combined group (F). No significant differences at P>0.05.

shockwave group (P<0.01) (**Figure 6B**); however no change in the elastic stiffness was found in shockwave group compared with the control group (P>0.05) (**Figure 6B**). At four weeks, there was a significant reduction in elastic stiffness in the shockwave group compared with the control group (P<0.05) (**Figure 6C**); however, the reduction was more significant in the combined group compared with the control (P<0.01) and the shockwave group (P<0.01) (**Figure 6C**). In an intragroup comparison, there was no significant change within the control group (P>0.05) (**Figure 6D**). At one-week, elastic stiffness within the shockwave group was significantly reduced compared with before (P<0.05), however no change in the elastic stiffness was found at four weeks (P>0.05) (**Figure 6E**). The combined group showed a greater reduction in the elastic stiffness at one week and four weeks compared with before, and for the comparison between four weeks and one week (P<0.01) (**Figure 6F**).

IRT changes in the skin temperature of upper trapezius

Regarding the results of skin temperature (°C) measured by infrared thermography (IRT), no significant difference was found between the shockwave and combined groups at baseline and one-week compared with the control (P> 0.05) (**Figure 7A**, **7B**), however, at the four-week, a significant decrease in skin temperature was noticed between the shockwave group vs. control and combined group vs. control (P<0.01) (**Figure 7C**). In intragroup analysis, there was no significant change within the control group at one week and four weeks (P>0.05) (**Figure 7D**). There was a significant reduction in the skin temperature within the shockwave group at one week and four weeks vs. before (P<0.01); and four weeks vs. one week (P< 0.01) (**Figure 7E**). A significant reduction in skin temperature was also found within the combined group at one week (P<0.05) (**Figure 7F**), which was significantly greater at four weeks vs. before and four weeks vs. one week (P< 0.01) (**Figure 7F**).

Discussion

MPS is characterized as a complex pain condition comprised of painful trigger points with peripheral and central pathophysiology. If these painful points are not properly addressed, they result in continuous pain by sending pain stimuli to the spinal cord via afferent nerves and cause sensitization of spinal segments [18]. Therefore, the main aim of treatment is desen-

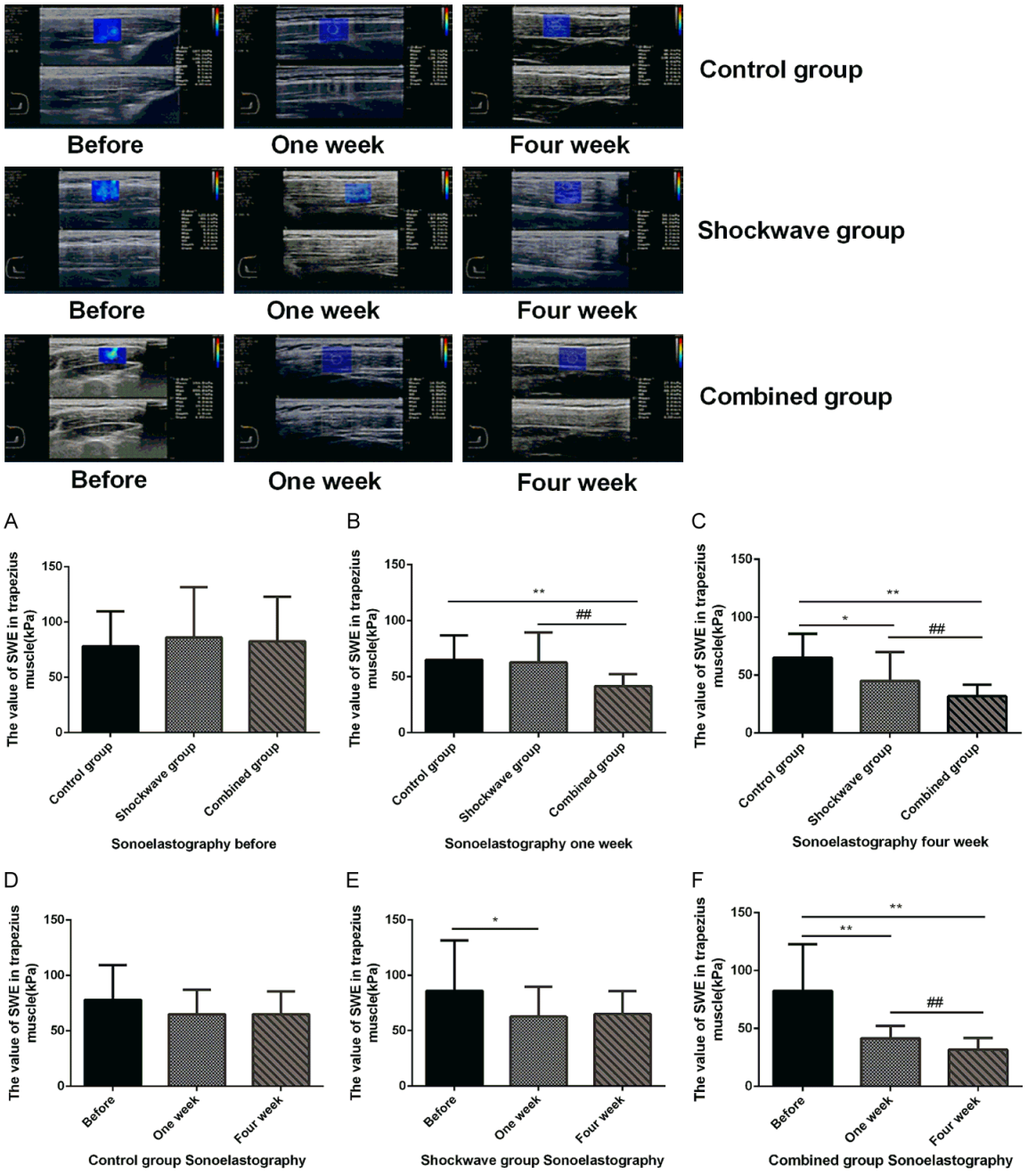

Figure 6. Measurement of SWE value at the trapezius trigger point in patients with cervical and shoulder myofascial pain syndrome in control group (female, 26 years old, with repeated neck pain for more than four years), shockwave group (female, 55 years old, with repeated neck pain for more than four years) and combined group (male, 35 years old, with repeated neck pain for more than two years). SWE = shear wave elastography. The value of SWE in the trapezius muscle (kPa) between groups with mean ± SD (95% CI) before (A), at one week (B) and four weeks (C). *indicates P<0.05 and **indicates P<0.01 vs. control group, ##indicates P<0.01 vs. shockwave group via repeated measures analysis of variance (ANOVA). The value of SWE in the trapezius muscle (kPa) within control group (D), shockwave group (E) and combined group (F) with mean ± SD (95% CI). *indicates P<0.05 and **indicates P<0.01 vs. before, ##indicates P<0.01 vs. one week via one-way ANOVA followed by Dunnett's multiple comparison test.

sitization of these painful points and elimination of root causes by providing a unique and persistent treatment protocol [30]. The results of this study showed that combined treatment

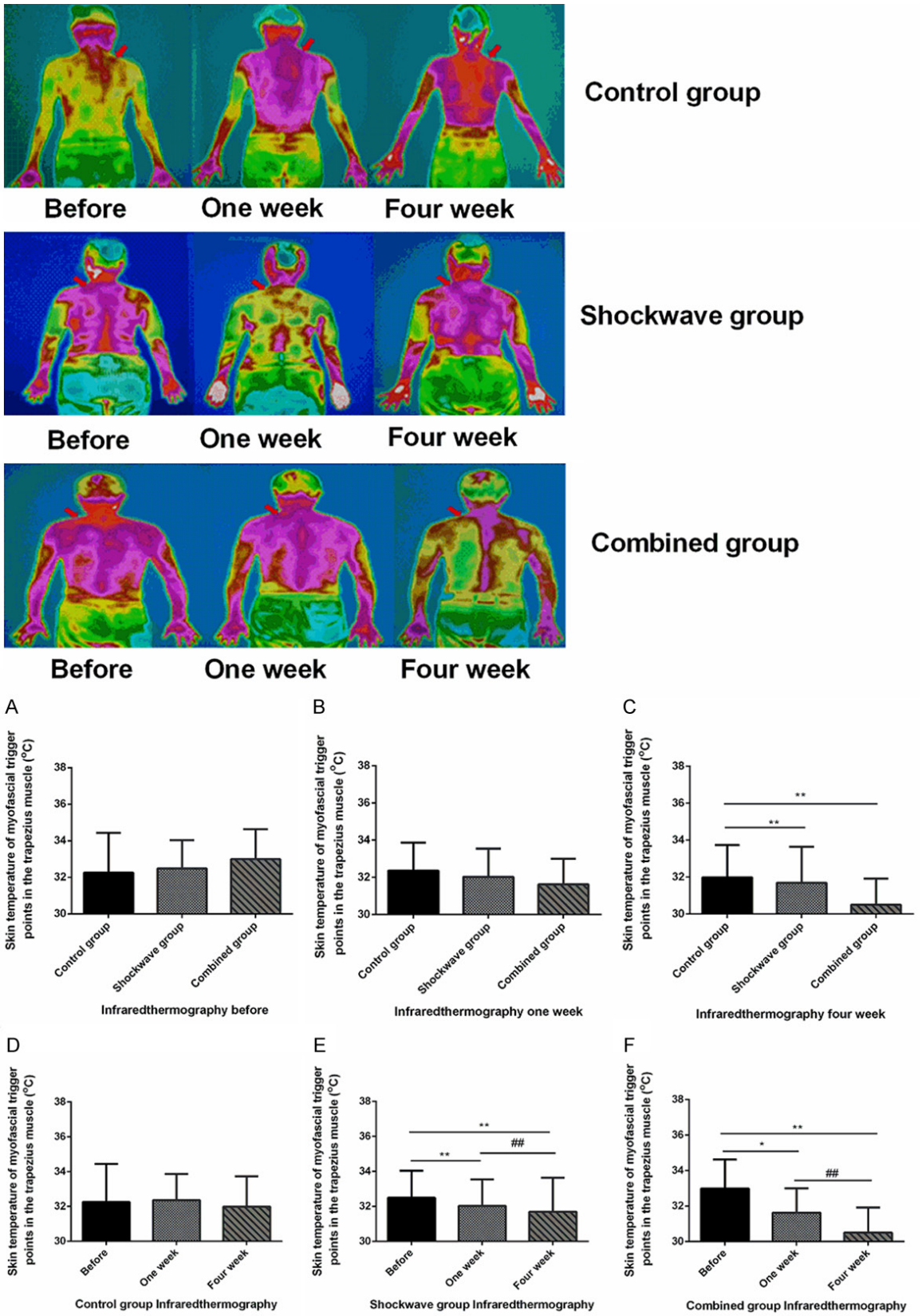

Figure 7. Measurement of infrared thermography at the trapezius trigger point, as shown by the arrow mark, in patients with cervical and shoulder myofascial pain syndrome in the control group (female, 24 years old, with repeated neck pain for more than five years), shockwave group (female, 55 years old, with repeated neck pain for more than

four years) and combined group (male, 56 years old, with repeated neck pain for more than six years). Skin temperature of myofascial trigger points in the trapezius muscle (0°C) between groups with mean ± SD (95% CI) before (A), at one week (B) and four weeks (C). **indicates P<0.01 vs. control group, ##indicates P<0.01 vs. shockwave group via repeated measures analysis of variance (ANOVA). Skin temperature of myofascial trigger points in the trapezius muscle (0°C) within control group (D), shockwave group (E) and combined group (F) with mean ± SD (95% CI). *indicates P<0.05 and **indicates P<0.01 vs. before, ##indicates P<0.01 vs. one week via one-way ANOVA followed by Dunnett's multiple comparison test.

(ESWT+TPI) was more effective in reducing pain and elastic stiffness than single treatment after four weeks. Previous studies have demonstrated the effectiveness of ESWT and TPI either alone or in combination with other treatments in MPS. Rahbar et al. conducted a study on the effects of ESWT compared with standard care in twenty-four participants with myofascial pain and found that shockwave was more effective than ultrasound in alleviating pain after four weeks [31]. Jeon et al. compared shockwave and TPI combined with transcutaneous electrical nerve stimulation (TENS) in thirty patients with MPS and found that ESWT was equally as effective as injection combined with TENS for improving pain and functional disability [5, 9]. Lee et al. investigated the effectiveness of proprioceptive neuromuscular facilitation (PNF), TPI, and ESWT in MPS and compared the treatment outcomes for pain and functional activity and concluded that ESWT and injection therapy effectively reduced pain but demonstrated limited effects in improving range of motion [32]. Cho et al. compared two non-invasive methods (ESWT and stability exercises) with ESWT and stability exercises alone in MPS to formulate a standard treatment for pain and function and found that the combined treatment was more effective for pain reduction compared with exercise or ESWT alone after four weeks [13]. The results of the present study also suggested that shockwave therapy is better than standard care treatment in improving pain intensity, but combined therapy (extracorporeal radial shockwave and trigger point injection of lidocaine) offers greater clinical improvement in pain symptoms and functional disability compared with shockwave therapy alone. The current study combined the two effective treatment approaches for myofascial pain, and injection therapy was given under ultrasound guidance to ensure exact localization of the targeted trigger point, hence, providing better outcome effects. Kang et al. investigated the feasibility of ultrasound-guided TPI with blind injection method and shear wave elastography for measuring stiffness at MTrP and found that US-guided MTrP injection was a more useful method than blind injection in patients with myofascial pain [33]. Our study also used ultrasound-guided TPI for better accuracy and to avoid potential complications. The study results also support the use of shear wave elastography as it significantly reduced elastic stiffness in upper trapezius muscle in the combined group compared with the shockwave group alone after four weeks.

Several studies have highlighted that ultrasound, sonoelastography and electromyography could be applicable in the assessment of MPS [25, 34, 35]. To date, this is the first study to use multiple objective outcome measure tools to determine the changes in upper trapezius muscle in multiple dimensions. Sikdar et al. used 2D grayscale ultrasound imaging and vibration elastography to visualize upper trapezius MTrPs to differentiate soft tissue characteristics from surrounding muscles and found that the trigger point areas were harder and stiffer than the surrounding tissues [36]. None of the previous studies have measured the elastic stiffness of the trapezius muscle in combined treatment using invasive and non-invasive methods. The present study combined the two effective treatments and applied injection therapy of lidocaine under ultrasound guidance to facilitate the exact localization of trigger points to obtain better efficacy results. Farmani et al. compared the effects of lidocaine patches (5%) with placebo for pain and electromyographic activity in active MTrPs of the upper trapezius muscle and found that lidocaine patches effectively reduced pain and increased EMG activity during maximum voluntary muscle contraction after treatment [37]. Wytrazek et al. investigated motor unit electrical activity in the upper trapezius muscle in patients with MPS and found a spontaneous increase in motor unit activity in patients with upper trapezius trigger points [38]. Kostopoulo et al. compared passive stretching and compression techniques in combination versus alone to determine a reduction in spontaneous

electrical activity and pain in upper trapezius trigger points and reported a significant decrease in spontaneous electrical activity and pain in the combination group [39]. The present study results showed no change in electrical activity over the trapezius muscle after treatment as we used surface electromyography while the previous literature supports the use of needle electromyography to measure electrical changes in the muscle. Girasol et al. investigated the association between skin temperature of upper trapezius MTrPs and pain, cervical ROM, and EMG activity in patients with chronic neck pain. The results suggested reduced skin temperature at trapezius trigger points, which was directly related to the decreased cervical range of motion [5]. Dibai-Filho et al. investigated temperature changes in the center of the upper trapezius muscle in participants with or without pain and found no changes in skin temperature compared with the control group [40]. The present study found that the skin temperature over MTrPs of the upper trapezius in the combined group and shockwave group was significantly decreased which was linked with muscle relaxation and improved blood circulation by removal of local chemical stimulants that cause painful trigger points in the muscle.

Extracorporeal shockwave represents an alternative treatment approach for MPS. Despite the high cost, it has more advantages than other noninvasive treatments given its insignificant adverse effects, with easily adjustable probe positions, and frequencies and impulses defined according to patient tolerance and need. Possible side effects include headache, pain, redness over the skin surface, or small hematomas [18]. Trigger point injection (TPI) with lidocaine is a more practical, rapid, cost-effective, minimally invasive approach with low infection risk, so it appears to be the treatment of choice compared with other invasive methods. Local pain, dizziness, erythema, and syncope are possible side effects after TPI [28]. Some patients experienced mild redness and soreness after injection therapy, but none of the patients suffered from any serious side effects during or after either intervention.

The proposed mechanisms of radial shockwave ESWT for pain relief, and tissue repair and growth, include tissue calcification, rich vascularization, high blood flow, and pain gate pathway blockage. It is also effective for desensitization, and it has mechanotransduction effects in MPS, including angiogenesis, pain signal alterations in ischemic tissues via calcium influx, and nerve excitability dysfunction via acetylcholine degeneration at the neuromuscular junction. The proposed mechanism of injection therapy is based on the blockade of acetylcholine release from motor nerve endings, the disruption of trigger points by chemical and mechanical effects of needling and the subsequent muscle fiber relaxation, improved blood circulation, and local tissue repair by the removal of accumulated nociceptive substances [41].

The uniqueness of the present study involves the use of multiple objective outcome tools for accurate assessment, diagnosis, and treatment. Sikdar et al. showed that ultrasound and sonoelastography are objective and reliable tools for localizing MTrP [6]. Although the etiology of trigger points remains unclear, a proposed mechanism suggests that the overuse of muscles causes inflammation resulting in histological changes within the muscle in response to pain that promotes changes in the mechanical properties of muscle. SWE assesses the mechanical properties of soft tissues and measures the shear elastic modulus in muscles. We used this method to compare the quantitative effectiveness of shockwave and injection therapy for reducing elastic stiffness in trapezius muscle and found promising results. On the other hand, ultrasound diagnostic methods help to differentiate MTrPs and their adjacent structures from normal tissues and provide a quantified description of underlying structural abnormalities related to trigger points, which can be useful for determining the pathogenesis and pathophysiology of painful MTrPs [42, 43]. Infrared thermography provides an image of the body skin temperature distribution associated with microcirculatory functions [44]. MTrPs cause autonomic and metabolic muscle activities and IRT provides the possibility of assessing MTrP metabolic changes. AlmirVieira Dibai-Filho reviewed the literature on the use of infrared thermography to assess MTrPs and found no impact of skin temperature changes on the presence of trigger points [40]. The present study results showed a significant reduction in skin temperature over the trapezius muscle, hence supporting the use of this

tool. Surface electromyography is a precise diagnostic tool used to measure activity changes in motor units in individuals with myofascial pain [45]. Active MTrP shows increased tension in muscles and local areas by measuring spontaneous electrical activity in both surface and needle EMG machines [46]. The mechanism of electromyography suggests that muscle fiber contraction or increased muscle potential within the taut band at the extrafusal motor endplate causes spontaneous electrical activity at MTrPs, resulting in pain if sustained for a long time, enhanced central sensitization, and dysfunctional motor control [47]. Although various studies have reported spontaneous electrical activity changes in muscle trigger points, our study did not show any significant changes in the electrical activity of the upper trapezius muscle, which might be due to the use of surface electromyography instead of needle EMG and the small sample size.

To the best of our knowledge, this is the first study to use ultrasound-guided trigger point injection of lidocaine combined with extracorporeal radial shockwave using multiple objective outcome tools to measure pain intensity, functional disability, electrical activity, elastic stiffness, and temperature change in upper trapezius MPS, demonstrating promising results in favor of the combination treatment concerning the efficacy, safety, and a quick recovery response along with the accuracy and authenticity of objective measurement outcomes. However, this study has some limitations. The sample size was small as few participants participated in the study and the investigation time for neck pain was short. Follow up time could be 3 or 6 months for better findings. Present study did not include single trigger point injection group or sham injection treatment as control. Moreover no significant change in electrical activity was noted over the upper trapezius muscle as we used surface EMG while previous literature reported with needle EMG analysis. We are expected to address these limitations in our future study to achieve better outcomes.

Conclusion

Extracorporeal (radial) shockwave therapy combined with ultrasound guided trigger point injection of lidocaine was more effective for decreasing pain and elastic stiffness in patients with upper trapezius myofascial pain syndrome at four weeks of follow-up.

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Disclosure of conflict of interest

None.

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