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ARAŞTIRMA / RESEARCH

Monitoring symptom improvements after the treatment of active myofascial trigger points with ultrasound elastography

Aktif miyofasiyal tetik noktaların ultrason elastografi ile tedavisi sonrası semptomların düzelmesinin monitörizasyonu

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Abstract

Purpose: Ultrasound elastography (UE) is a recently developed technique and is used to determine the mechanical properties of tissues. We aimed to assess the usefulness of axial-strain UE for pre and post treatment evaluation of patients with active myofascial triggerpoints (MTrPs) of the upper trapezius.

Materials and Methods: The study included 49 patients (66 MTrPs) with myofascial pain syndrome. Patients were randomized into two treatment groups, group 1 (trigger point injection with stretching exercises) and group 2 (trigger point injection). The groups were evaluated with UE before, 2 and 14 days post-treatment. Disability, pain, and pressure pain threshold (PPT) were also assessed.

Results: All clinical parameters were strongly correlated with strain ratio (SR) value at baseline, 2 and 14 days post-treatment. Both groups demonstrated significant improvements with respect to Neck Pain and Disability Scale , VAS, and PPT scores post-treatment. However, group 1 had better scores than group 2 in 14 days post-treatment.

Conclusion: Our study demonstrated that SR values for MTrPs in the upper trapezius correlated with clinical parameters at baseline and after treatment. According to these results, axial-strain UE, which is non-invasive and semiquantitative method may be usefull to evaluation and monitor improvement in patients with active MTrPs.

Keywords: Myofascial trigger point, pain, pain pressure threshold, Ultrasound elastography

Öz

Amaç: Ultrason elastografi (UE), dokuların mekanik özelliklerini belirlemek için son zamanlarda geliştirilen bir yöntemdir. Bu çalışmada trapeziusun üst liflerindeki aktif miyofasyal tetik noktaları (MTrP) olan hastaların tedavi öncesi ve sonrası monitorizasyonunda aksiyel-strain UE'nin yararlılığını değerlendirmeyi amaçladık.

Gereç ve Yöntem: Çalışmaya miyofasiyal ağrı sendromlu 49 hasta (66 MTrP) dahil edildi. Hastalar iki tedavi grubuna, grup 1 (germe egzersizleri ile tetiknokta enjeksiyonu) ve grup 2 (tetik noktaenjeksiyonu) olarak randomize edildi. Gruplar tedaviden önce, 2 ve 14 gün sonra UE ile, ayrıca dizabilite, ağrı ve basınç ağrı eşiği (PPT) açısından değerlendirildi.

Bulgular: Her iki grupta tüm klinik parametreler, başlangıçta, tedavi sonrası 2 ve 14 gün sonra gerinim oranı (Strain ratio –SR) değeri ile kuvvetle ilişkiliydi. Ayrıca Grup 1, tedaviden sonraki 14 gün içinde grup 2'den daha iyi skorlara sahip olsa da her iki grupta dizabilite, ağrı ve tedavi sonrası PPT skorları açısından anlamlı iyileşmeler tespit edildi.

Sonuç: Çalışmamızda üst trapezius liflerinde MTrPs için SR değerlerinin başlangıçta ve tedavi sonrası klinik parametrelerle korele olduğu gösterilmiştir. Bu sonuçlara göre, aktif MTrPs 'li hastalarda değerlendirme ve iyileşmeyi izlemek için noninvaziv ve yarı-kantitatif bir yöntem olan aksiyel strain UE yararlı bir yöntem olabilir.

Anahtar kelimeler: Myofasial tetik nokta, ağrı, basınç ağrı eşiği, utrasound elastografi

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INTRODUCTION

Ultrasound elastography (UE) is a recently developed ultrasound-based method to perform a qualitative visual assessment or quantitative measurement of the mechanical properties of a target tissue[1-2]. Of the various current UE methods, the former was called the quasi static method and the latter is referred to as the dynamic method, according to the manner of external mechanical excitation. Elastography methods that have been integrated into clinical practice can be categorized into the following groups: strain elastography, transient elastography, acoustic radiation force impulse imaging (ARFI), and shear wave speed measurement[3].

Strain UE is currently the most frequently employed technique for musculoskeletal applications and is also described as compression elastography, sonoelastography, and real-time elastography[2,4,5]. The principle of strain UE is based on the real-time measurement of tissue strain, using an ultrasound (US) probe, to provide external freehand compression of the tissue. The strain rate is lower in hard tissues than in soft tissues. This allows for the evaluation of the elasticity of a tissue region compared with the surrounding tissues[6]. The transducer is part of the equipment which is used to obtain specific information for the production of an ultrasonic elastography image[7]. Low pressure is implemented with the transducer in the region of interest (ROI) for the purpose of determining the rate between the applied pressure and deformation of the tissue. If excessive pressure is applied, non-linear effects can occur and the information produced by the elastography image may not vary proportionally with the applied pressure. Therefore, the application of excess pressure can affect lesion appearance. The size of the ROI is determined by the examiner based on the exploration of the area and typically includes the lesion as well as a 5-mm perimeter in all directions. The elasticity of each region is represented by color coding. For the ROI, each pixel is assigned one of 256 specific colors, depending on the amplitude of deformation. The color scale ranges from red for soft tissue components (areas with significant deformation) to blue for rigid elements (areas with low distortion). Green is used to indicate the average deformation in the ROI. This system, with three basic colors, is known as red-green-blue encoding[8,9]. The US device allows for estimation of the strain ratio (SR) between two ROIs, enabling the quantification of image findings and providing reference values[10]. In several clinical studies, measurements of the tissue SR have been examined to determine their usefulness as a semi-quantitative elasticity parameter for muscle[11,12] as well as for the Achilles tendon[13].

Myofascial pain syndrome (MPS) is the most frequent cause of chronic musculoskeletal pain, with estimates of world-wide prevalence ranging from 0.5% to 5.0%[14], MPS is defined as focal hyperirritability in the muscle tissue. Clinical presentation of this syndrome includes referred pain, limited range of motion of the joints, and a local twitch response following mechanical stimulation of certain areas of muscle and fascia, known as myofascial trigger points (MTrPs), which are associated with altered activity of the motor endplate[14,15].

Travell and Simons were the first to systematically describe MPS[16], and reported that the presence of hypersensitive spots within taut bands of skeletal muscle fibers or fascia, known as MTrPs, are the main characteristic of MPS[17]. MTrPs are classified as active or latent, depending on whether the symptoms of pain are produced spontaneously or only reproduced by direct palpation of the target tissue. MTrPs associated with unsolicited painful sensations as a primary clinical complaint are considered active, while those without pain are considered latent[18].

B-mode (brightness-mode) ultrasound and magnetic resonance imaging reveal the macroscopic structure (i.e., anatomy) of individual muscles. They can not characterize the mechanical properties that affect force generation, joint range of motion, or physical function. Unfortunately, there is a paucity of literature regarding the measurement of the mechanical properties of muscle [19]. However, Brandenburg et al. suggested that the differences between healthy muscle and pathologic muscle can be evaluated with UE. Additionally, in some studies it is claimed that UE may be used to monitor responses to interventions in patients with functional impairments [2,19,20]. According to previous limited informations, we hypothesized that strain UE may be used to monitor improvement in patients with active MTrPs and functional status of muscles can be followed up by strain UE.

There are many treatments for the management of MTrPs, with proven validity. The major goal of MTrPs therapy is to relieve pain and tightness of the involved muscles. Treatment options include exercise

programs, especially stretching exercises, physical therapy modalities, trigger point injections, dry needling, massage therapy, and the elimination of causative and perpetuating factors [17,18,21]. Trigger point injection is generally considered the most effective means for direct inactivation. A local anesthetic (1% lidocaine or 1% procaine) is usually used to confirm the accuracy of the injection site and provide immediaterelief for patients[22,23].

Stretching of the affected muscle has also been reported as an effective treatment for MTrPs [24] . Increasing of pressure pain threshold (PPT) was demonstrated with stretching exercises[25]. Moreover local anesthetic injection and stretching exercises have both been shown to be effective in MTrPs treatment.

The primary aim of this study was to evaluate the usefulness of axial-strain UE in monitoring symptom improvement following the treatment of patients with active MTrPs.

MATERIALS AND METHODS

This single blind randomized controlled trial was conducted in the Physical Medicine and Rehabilitation Department Outpatient Clinic. The Declaration of Helsinki protocols were followed. The study was carried out from October 2015 through March 2016. The local ethical committee approval was obtained for this study. All patients were informed that they would be treated in a randomized trial, and all patients signed informed consent forms.

The inclusion criteria for the study were as follows: presence of at least 1 active MTrPs on 1 side of the neck in the upper trapezius muscle, symptoms lasting for 0 to 6 weeks, and diagnosis of primary MPS (no pain in any other area than the corresponding trigger point; pain elicited primarily by contralateral side-bending of the head; negative Spurling test).

Patients who met the following criteria were excluded from this study: age of less than 20 years or more than 40 years; acute trauma or serious illness; more than 2 MTrPs on 1 side of the neck in the upper trapezius muscle; history of injections to MTrPs within the last 2 months and; diagnosis of fibromyalgia syndrome, cervical radiculopathy, myelopathy with severe disc or skeletal lesions, temporomandibular joint disorders, rheumatic or neurological diseases, neck muscle sprain, or severe systemic diseases such as diabetes mellitus. In addition, patients with depression, mental retardation, pregnancy, bone and joint diseases, local anesthetic allergy, history of malignancy, bleeding diathesis and anemia, neuromuscular dysfunction, and hyperthyroidism or hypothyroidism were excluded, as well as those with a history of recent usage of antiepileptic, antipsychotic, or antidepressant medication, cervical spine surgery, and prior myofascial pain therapy within the month prior to the study. All patients were instructed not to take nonsteroidal anti-inflammatory drugs, any other analgesic medicine, or myorelaxant drugs during the treatment and follow-up period.

The diagnosis of MTrPs was determined by physical examination during the initial evaluation by a physiatrist blinded to the study parameters. During the MTrPs evaluation, the patients were seated comfortably in a chair with adjustable height, with their feet flat on the floor and forearms resting on the lower limbs. The active MTrPs was marked with indelible ink.

The diagnostic criteria forMTrPs are summarized below[15,17]. Patients who met the inclusion criteria were randomly (Covariate adaptive randomization was done optimum allocation as both groups. Covariates: age) assigned to 1 of the 2 treatment groups[26].

Primary criteria (all 5 needed)
1-Regional pain complaint
2-Pain complaint or altered sensation in the expected distribution of referred pain from a trigger point
3-Taut band palpable in an accessible muscle
4-Exquisite spot tenderness at 1 point along the length of the taut band
5-Some degree of restricted range of motion
Secondary criteria (1 of 3 needed)
1-Reproduction of clinical pain complaint, or altered sensation, by pressure on the tender spot
2-Local twitch response elicited by snapping palpation at the tender spot or by needle insertion into the tender spot
3-Pain alleviated by elongating (stretching) the muscle or by injecting the tender spot

At the beginning of the study, 60 patients were assessed for eligibility. In total, 11 patients were excluded (did not meet inclusion" criteria, n = 7; refused to participate, n = 4). The remaining 49 patients (66 active MTrPs) were allocated to 2 groups respectively, Group 1 (n = 24, MTrPs = 33), that received trigger point injection and stretching exercises, and Group 2 (n = 25, MTrPs = 33), that

received trigger point injection alone (Figure-1). All patients were evaluated by the same practitioner, who was blinded to therapy group and UE evaluation protocol, at baseline, 2 days post-injection, and 14 days post-injection.

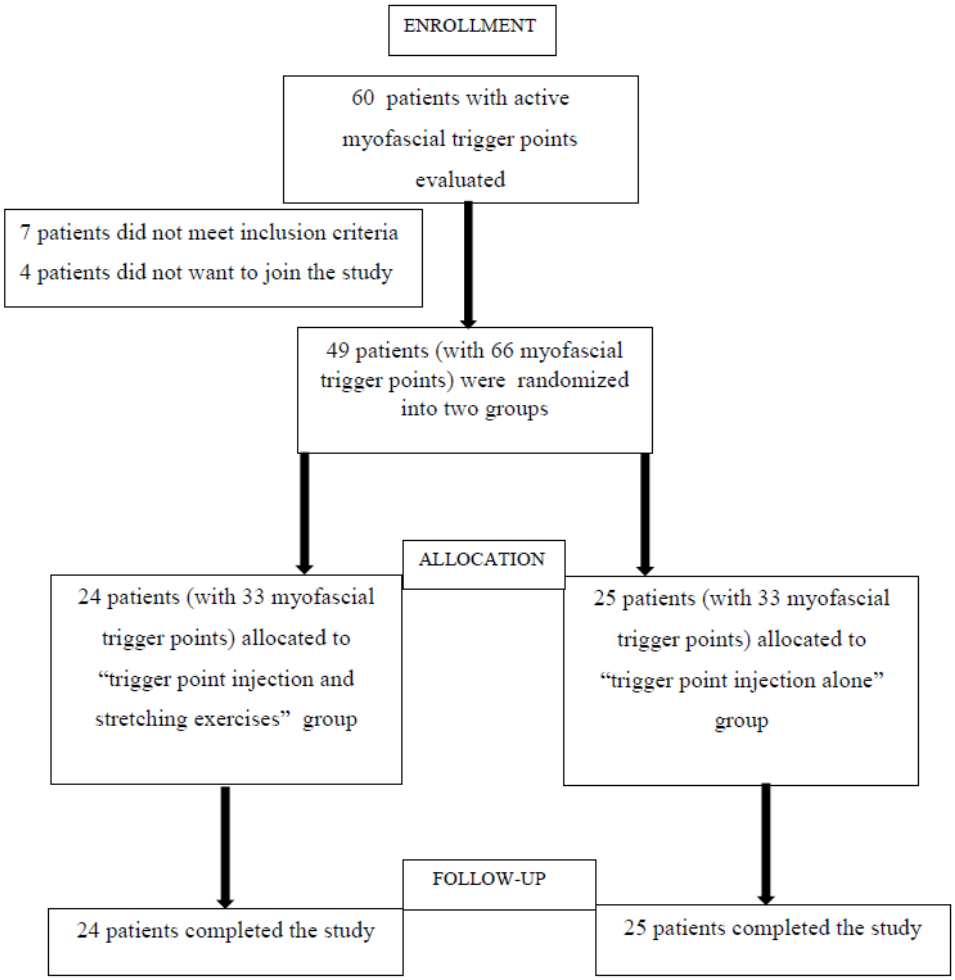

Figure 1. Participant flow through the study

Assessment Parameters

UE and B-mode US

The patient was asked to lie down in a prone position, with their forehead resting on a c pillow and their arms extended to both sides. The first evaluation and control examinations were performed in the same position. Muscle structure and thickness were evaluated in B-mode US (longitudinal).

The second step was to perform the UE (longitudinal) exam. The examiner used methods described previously in other studies[27]. According to the standardization of the technique by tissue compression and decompression sinusoid visualization, after placing the transducer over marked MTrPs, the practitioners made 6 to 10 rhythmic motion of the transducer on the affected muscles. After localization of the best sinusoid compression, two ROIs were selected for the SR measurement, using the mean strain of each ROI. The first point was selected as a reference point in an unaffected and normal region of muscle. The second point included the MTrPs. According to previous

studies, two ROI should be placed at the same tissue depth in order to minimize variability in tissue compression responses due to disparate depth localization. ROI size was the same for all subjects for the reference and pathological sites. The ROI sites were selected based on the greatest possible uniformity of color for both reference (green) and pathological (blue) points(Figure-2)[27].

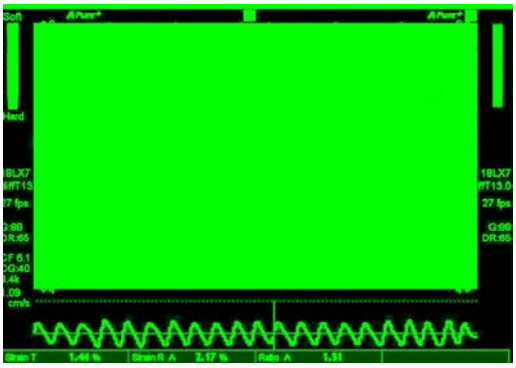

Figure-2. Evaluation of the patients by using B-mode ultrasonography vs ultrason elastography

MTrPs in the upper trapezius were evaluated using US and UE images in the same areas both pre- and post-treatment. The 2D US and UE images and elastograms were acquired using Aplio 500 US (Toshiba Medical Systems Corporation, Tokyo, Japan) equipment with a digital 7.2-14 MHz linear probe (1204bx). All US evaluations were performed by a single radiologist with five years of experience of using UE and 13 years of experience of using B-mode US, who was blinded to therapy group and other evaluation protocols.

Pressure Pain Threshold (PPT)

The PPT is defined as the minimum amount of pressure at which a sense of pressure first changes to discomfort or pain with direct palpation of a certain point.[28] A pressure algometer (Wagner Pain Test™ Model FPK 40 Algometer, Wagner Instruments, Greenwich, CT, US) was used to measure PPT, which was expressed in kg/cm^2. The applied pressure ranged from 0 to 10 kg/cm^2, with values recorded every 0.1 kg. Intra-examiner reliability for PPT measures using a pressure algometer have been reported[29]. The patient was instructed to indicate when pain was first perceived. The patients were informed that the investigation was aimed at determining the pain threshold and not the pain tolerance. Then, pressure was increased at the rate of 1 kg/s until pain or discomfort occurred; the minimum force that caused pain was termed the PPT.

Pain

The visual analog scale (VAS) is an instrument that has been widely used to quantify the intensity of pain. The patient places a vertical mark on a continuous 10 cm line to indicate pain level, ranging from no pain or discomfort (0), to the worst pain you could possibly feel (10). The reliability and validity of the VAS as a measure of pain have been previously established in a study that asked volunteers to mark their pain intensity on the scale, after which the marked location was measured with a ruler by a blinded examiner[30].

Neck Pain and Disability Scale (NPAD)

The NPAD consists of 20 items divided into 4 dimensions, neck problems, pain intensity, emotion and cognition, and interference with life activities.[31] Each item has a VAS of 100 mm, with numeric anchors at 0, 1, 2, 3, 4 and 5 (each 20 mm apart). Item scores range from 0 (no pain or activity limitation) to 5 (as much pain as possible or maximal limitation). The total NPAD score ranges from 0 to 100 points. Higher scores indicate greater disability. The NPAD has been shown to be a valid and responsive measure of disability in the Turkish language[32].

Table 1. Demographic features of the patients

		Group 1 (N=24)	Group 2 (N=25)	p
Age (year)		30.04±4.01	29.04 ±5.42	0.645
Symptom duration (month)		2.9±1.7	3.0±1.2	0.091
Education	Primary-secondary	10(41.7%)	11(44%)	0.909
	High school	10(41.7%)	9(36%)	
	University	5(16.7%)	5(20%)	

*p<0.05 was significant difference

Treatment Procedure

Injection

After marking the trigger point injection site by indenting the skin with a plastic needle cover, the skin over that area was prepared by applying betadine and then alcohol. All MTrPs injections were performed in

the same patient position and by the procedure recommended by Simon and Travell[15].

Lidocaine injection and dry needling of the active MTrPs was performed by the modification of techniques recommended by Travell and Simons[15,33]. Patients were asked to lie down in the prone position. Injections were performed using 25-gauge needles 1.25 inches in length. The stretched band, localized between the thumb and the index finger, was entered rapidly, with the tip of the needle perpendicular to the skin. The needle was inserted into the muscle until the exact active MTrPs was reached. After injecting 1 ml of 0.5% lidocaine solution, the needle was pistoning, and the same point was needled 8 to 10 times. Then the tip was withdrawn to the subcutaneous tissue, the injector was mildly inclined, and the sides and upper and lower parts of the first injection site were needled in order to inactivate satellite TrPs that might cause pain[34] . Following injection, the MTrPs was re-marked.

Stretching exercises

The patients in Group 1 were instructed to perform self-stretching exercises of the upper trapezius muscle, as recommended by Simons et al.[35] They were asked to repeat the stretches 3 times per day during the 2 week follow-up period.

Statistical analysis

SPSS (Statistical package for the Social Sciences, version 20, IBM Corp., Armonk, NY, USA) software was used for statistical analyses. Measured data were described as the arithmetic mean ± standard deviation, whereas categorical data were described as percentages (%). Normal distribution of measured data was determined using the Kolmogorov-Smirnov test. If the data were normally distributed when comparing both groups, a Student's t test was employed. If the data were not normally distributed, a Mann-Whitney U test was employed.

Repeated measures One-Way Analysis of Variance test was used for inter-group comparison in normally distributed variables. If the data were not normally distributed, Friedman Variance Analysis was employed. Post-hoc analysis was also measured by Wilcoxon test. $p< 0,017$ was accepted as statically significant. Spearman correlation analysis was used to evaluate associations between SR and other clinical measurements. The correlation coefficients were interpreted as either excellent $r\geq0.91$; good $0.90\geq r\geq0.71$; fair $0.70\geq r\geq0.51$; weak $0.50\geq r\geq0.31$; or little or none $r\leq0.3$. A statistical level of significance was accepted at $p < 0.05$.

RESULTS

The mean age of the 49 patients was 29,84 ± 5.69 (range, 20-40) years. Groups were similar with respect to demographic data and baseline evaluations (Table 1) ($p > 0.05$).

Both groups improved significantly with respect to VAS, PPT, and NPAD scores 2 days post-injection ($p < 0.05$), and these improvements persisted 14 days post-injection in both groups ($p < 0.05$) (Table 2). Significant differences were not observed between Group 1 and Group 2 with respect to SR ($p = 0.522$), NPAD ($p = 0.63$), VAS ($p = 0.912$), and PPT ($p = 0.898$) 2 days post-injection. However, Group 1 had better scores than Group 2 in terms of SR ($p = 0.010$), NPAD ($p = 0.001$), VAS ($p = 0.001$), and PPT ($p = 0.017$) at 14 days post-injection (Table 2). All clinical parameters correlated strongly with SR values for both groups at 2 days and 14 days post-injection (all $p < 0.05$) (Table 3).

DISCUSSION

Initial evaluation of SR values for active MTrPs in the upper trapezius muscle correlated with the clinical parameters in our study. Patients with greater stiffness, as determined by the SR for the active MTrPs, also had worse clinical measurements. Post-treatment SR for the active MTrPs was lower than pre-treatment in both treatment groups. Additionally, disability, pain, and PPT scores were strongly correlated with SR values for both groups at 2 days and 14 days post-injection. A comparison of the efficacy of treatment revealed no significant difference with respect to SR, NPAD, VAS, and PPT scores for both groups 2 days post-injection. However, measures taken 14 days post-injection revealed significant differences between the groups for all evaluation parameters, with Group 1 demonstrating better results than Group 2.

UE has recently been developed to allow noninvasive assessment of the mechanical properties of tissues.[6] Contemporary studies suggest that the use of UE is appropriate for assessing musculoskeletal disorders. Axial-strain sonoelastography is able to distinguish between asymptomatic and diseased tendons, and is potentially more sensitive than conventional ultrasound for detecting early tendinopathy. Despite

initially promising results, axial-strain sonoelastography has not achieved routine clinical use[36]. Regarding the SR for tendons, Drakonaki and Allen[37] first measured the SR between the Achilles tendon and the peripheral fat. They reported good to excellent intra-examiner and inter-examiner reliability for tendon assessment. Additionally, several studies have assessed muscular tissue using UE[11,27,38,39].

Table 2. Measurement findings and p values for inter-group comparisons and repeated measures.

	Group 1	p	Group 2	p	Group 1 vs Group 2 p
SR					
Baseline	4.28 ± 0.88		4.26 ± 1.57		0.945
2 days later	2.32 ± 0.66	< 0.001**[a]	2.24 ± 0.59	< 0.001**[a]	0.522
14 days later	2.02 ± 0.73	< 0.001**[b]	2.48 ± 0.84	< 0.001*[b]	0.010*
NPAD					
Baseline	49.73 ± 9.26		46.65 ± 11.55		0.273
2 days later	22.70 ± 8.71	< 0.001**[a]	18.88 ± 11.44	< 0.001**[a]	0.163
14 days later	13.70 ± 7.99	< 0.001**[b]	23.77± 12.56	< 0.001**[b]	0.001*
VAS					
Baseline	7.17 ± 1.77		7.12 ± 1.53		0.679
2 days later	3.20 ± 1.31	< 0.001**[a]	3.34 ± 1.38	< 0.001**[a]	0.912
14 days later	2.17 ± 1.29	< 0.001**[b]	3.89 ± 1.48	< 0.001**[b]	0.001*
PPT					
Baseline	1.44 ± 0.53		1.50 ± 0.42		0.663
2 days later	3.11 ± 0.88	< 0.001**[a]	3.14 ± 0.74	< 0.001**[a]	0.898
14 days later	3.49 ± 0.90	< 0.001**[b]	2.93 ± 0.79	< 0.001**[b]	0.017*

Abbreviations: SR, Strain Ratio; NPAD, Neck Pain and Disability Scale; VAS, Visual Analog Scale; PPT, Pressure Pain Threshold. *p < 0.05 is considered to indicate a significant difference ** p < 0.017 is considered to indicate a significant difference (according to Bonferroni correction) [a]comparison between baseline and 2 days later, [b]comparison between baseline and 14 days later

Table 3. Correlation values (r) of strain ratios with clinical parameters at baseline, 2 days later, and 14 days later

		NPAD	PPT	VAS
Group 1	Baseline	0.722*	-0.556*	0.688*
	2 days later	0.582*	-0.528*	0.615*
	14 days later	0.610*	-0.603*	0.548*
Group 2	Baseline	0.593*	-0.596*	0.617*
	2 days later	0.637*	-0.670*	0.612*
	14 days later	0.684*	-0.614*	0.703*

Abbreviations: NPAD, Neck Pain and Disability Scale; PPT, Pressure Pain Threshold; VAS, Visual Analog Scale. *p < 0.05 is considered to indicate a significant difference.

Arijiet al.[39] assessed masseter muscle hardness in human participants with the use of the SR between the muscle and subcutaneous fat as a reference. They reported the intra-examiner and inter-examiner reliability as well as the responsiveness (before and after massage) of the SR. In another two studies[11,12], examiners investigated the muscle SR with the use of reference gel, which was placed on the skin, and Niitsu et al. verified the validity of the SR[11]. They found a positive correlation between SR and the existing parameters for muscle hardness. Muller et al.[27] selected a reference point in an unaffected and normal region of muscle for the SR measurement in their study, which evaluated MTrPs in the trapezius muscle. They suggested that the use of UE may provide objective confirmation of treatment effects. We subsequently used an unaffected and normal region of muscle as a reference point as well.

The extensive uptake of axial-strain sonoelastography techniques is restricted by practitioner dependency, technical limitations, such as artifact, as well as poor ability to replicate and quantify data[40] . Turan et al. demonstrated that stiffness of the Achilles tendon increases with age due to histological composition changes over time[41]. Similar histological changes in muscle structure may also be seen with age[42]. Additionally, two studies have examined the stiffness

of normal masseter and ocular muscles, revealing differences in the elasticity (strain index) of the masseter muscles based on sex, as well as differences in the elasticity of the periocular rectus medialis and lateralis muscles depending on gaze position[39,43] . Given those findings, we applied criteria to ensure that demographic characteristics such as age and sex would be similar for both patient groups.

MTrPs can be diagnosed clinically and followed up. However there is not yet gold standart imaging method for MTrPs in the literature[44] . We speculated that a noninvasive imaging technique, may be used to monitor improvement in patients with active MTrPs. And it may be shed light on future studies about musculoskeletal system UE which is a functional evaluation. Large-scale longitudinal studies are needed to further elucidate the clinical relevance and potential applications of axial-strain sonoelastography for the diagnosis and prognosis of musculoskeletal disease as well as to monitor patient recovery, before it can be widely adopted for routine clinical practice[41]. One limitation of this study was the small sample size. Larger groups incorporating patients of different ages should be evaluated in future studies. Another limitations are that we did not compare UE to another imaging method and strain ratio measurements with UE have high user dependency.

Our study demonstrated that SR values for an active MTrPs in the upper trapezius muscle were correlated with clinical parameters measured at baseline and following treatment. According to the results of this study, axial-strain UE, which is a noninvasive imaging technique, may be used to monitor improvement in patients with active MTrPs.

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