ORIGINAL ARTICLE

Comparison of High-Power Pain Threshold Ultrasound Therapy With Local Injection in the Treatment of Active Myofascial Trigger Points of the Upper Trapezius Muscle

Halil Unalan, MD, Javid Majlesi, MD, Filiz Yildiz Aydin, MD, Deniz Palamar, MD

ABSTRACT. Unalan H, Majlesi J, Aydin FY, Palamar D. Comparison of high-power pain threshold ultrasound therapy with local ınjection in the treatment of active myofascial trigger points of the upper trapezius muscle. Arch Phys Med Rehabil 2011;92:657-62.

Objective: To compare the effects of high-power pain threshold ultrasound (HPPTUS) therapy and local anesthetic injection on pain and active cervical lateral bending in patients with active myofascial trigger points (MTrPs) of the upper trapezius muscle.

Design: Randomized single-blinded controlled trial.

Setting: Physical medicine and rehabilitation department of university hospital.

Participants: Subjects (N=49) who had active MTrPs of the upper trapezius muscle.

Interventions: HPPTUS or trigger point injection (TrP).

Main Outcome Measures: Visual analog scale, range of motion (ROM) of the cervical spine, and total length of treatments.

Results: All patients in both groups improved significantly in terms of pain and ROM, but there was no statistically significant difference between groups. Mean numbers of therapy sessions were 1 and 1.5 in the local injection and HPPTUS groups, respectively.

Conclusions: We failed to show differences between the HPPTUS technique and TrP injection in the treatment of active MTrPs of the upper trapezius muscle. The HPPTUS technique can be used as an effective alternative to TrP injection in the treatment of myofascial pain syndrome.

Key Words: Myofascial pain syndrome; Rehabilitation; Trigger points; Ultrasonic therapy.

PAINFUL CONDITIONS of the musculoskeletal system, including MPS, constitute some of the most important chronic problems encountered in a clinical practice.[1] MPS is 1 of the disorders most commonly encountered by physiatrists and other health professionals. MPS commonly is seen when evaluating and treating patients for acute and chronic pain.[2] This syndrome exists as a primary condition and also as a secondary condition in conjunction with musculoskeletal injuries, arthritis, nerve injuries, and visceral diseases.[3] As in most other acute or chronic painful disorders, there are limited data from national epidemiologic studies in the United States about the incidence and prevalence of MPS. Prevalence has been reported to be as high as 30% in patients presenting to a university primary care internal medicine practice.[3,4]

MPS is characterized by the presence of TrPs and characteristic referred pain areas. These are spots in the taut bands of the relevant fibers of muscles. The syndrome is associated with spontaneous pain and pain with tenderness in the muscle by applying pressure, characteristic referred pain, muscle tension, and restriction of motion.

MPS can be acute or chronic and primary or secondary. Secondary MPS may develop in the presence of acquired and congenital abnormalities and skeletal characteristics, such as scoliosis and limb-length discrepancies that would be perpetuating factors and lead to asymmetrical and disproportionate loading. Examples of coincidental pathologic states would be radiculopathies, nerve entrapments, bone or joint in the stage of healing, and congenital musculoskeletal abnormalities, metabolic disorders, nutritional imbalances, and regional biomechanical imbalances.[5] Psychosocial factors can contribute to chronicity, along with metabolic disorders, nutritional imbalances, and regional biomechanical imbalances.[6] Patients with MPS have higher scores for anxiety and depression.[1] Referred pain from MTrPs can mimic visceral pain syndromes, visceral pain syndromes can induce TrP development and MPS, and referred pain syndrome can outlast the initial event, making diagnosis difficult.[7]

The pathogenesis of an MTrP appears to be related to integrative mechanisms in the spinal cord in response to sensitized nerve fibers associated with abnormal endplates.[8] The integrated TrP hypothesis is the result of efforts to explain the pathophysiologic process of TrPs.[9-11] A key element is the energy crisis hypothesis regarding the pathophysiologic pro-

List of Abbreviations

CI	confidence interval
HPPTUS	high-power pain threshold ultrasound
ITT	intention to treat
LTR	local twitch response
MPS	myofascial pain syndrome
MTrP	myofascial trigger point
NSAID	nonsteroidal anti-inflammatory drug
PPT	pain pressure threshold
RCT	randomized controlled trial
ROM	range of motion
TENS	transcutaneous electrical nerve stimulation
TrP	trigger point
US	ultrasound
VAS	visual analog scale

From the Department of Physical Medicine and Rehabilitation, Cerrahpasa Medical Faculty, Istanbul University, Istanbul (Unalan, Aydin, Palamar); and the Department of Physical Medicine and Rehabilitation, Medicana International Hospital, Istanbul (Majlesi), Turkey.

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit on the authors or on any organization with which the authors are associated.

Correspondence to Javid Majlesi, Yeşilkoy Istanbul Caddesi, Gül Evleri, 37A/5, 34149, Bakırköy, Istanbul, Türkiye, e-mail: *javidmajlesi@yahoo.co.uk*. Reprints are not available from the author.

0003-9993/11/9204-00951$36.00/0
doi:10.1016/j.apmr.2010.11.030

cess underlying TrPs. It states that under a variety of circumstances in which muscles become overloaded, there is excessive and prolonged release of calcium from the sarcoplasmic reticulum of muscle cells. The influx of calcium stimulates prolonged contractile activity within the cells, increasing metabolic activity within them to such an extent that localized ischemia develops.[9-11]

The ischemia then stimulates the release of vasoactive substances. These have 2 major effects. First, they sensitize the nociceptors in muscles, producing the pain reported by patients with myofascial pain. Second, they precipitate a train of events that aggravates ischemia of the muscle, thereby creating a vicious circle.[9-11] The integrative hypothesis contains multiple postulates and allows for multifactorial causation of the pain reported by patients with myofascial pain. For example, it allows for the possibility that nociceptive input from muscles can produce central nervous system sensitization. The integrated hypothesis proposes that myofascial pain is initiated by events that occur in a muscle (muscle overload), and the primary pathophysiologic process in myofascial pain is a metabolic abnormality within muscles that activates nociceptors in the muscles.[9-11] An LTR evoked by either pressure, needle penetration, or snapping palpation of the TrP is the specific and diagnostic characteristic. Studies showed that the referred pain and LTR evoked by mechanical stimulation of the TrP was linked to the spinal cord mechanisms.[8]

Modalities and techniques that directly target the muscle are able to promptly relieve pain when treating acute TrPs. Additional attention to perpetuating factors may be necessary to manage chronic MTrPs. The treating physician ultimately should aim to maintain independence and restoration of physical activity.[12] This also should take into consideration correction of perpetuating factors to prevent recurrences and the need for compliance of the patient for long-term success.[13,14] The need to match the management program with the complex characteristics of some patients can create difficulty managing MPS.[15,16] Some investigators have advocated the efficacy of combining approaches, such as enhancing central inhibition through pharmacologic and behavioral techniques and simultaneously reducing peripheral inputs through physical therapies, including exercises and TrP-specific therapies, have been defined.[17,18] The clinician has to consider the unique symptoms and lifestyle characteristics of each patient, including psychological characteristics. If a diagnosis of secondary MPS has been made, treating the underlying factors leading to activation of TrPs may be the most important strategy that also prevents the recurrence of TrPs.[8]

MTrPs can be relieved through noninvasive physical therapy interventions, such as spray and stretch, TENS, and massage. Invasive treatments for MTrPs include injections with local anesthetics, corticosteroids, or botulinum toxin or dry needling.[1] The effectiveness of such treatment options as TrP injections, using local anesthetic agents, dry needling of the TrPs, spray and stretch, and physical modalities, have been reported in the literature.[1,19] However, the low level of interrater reliability and agreement on the presence of MTrPs and lack of uniformity in using the diagnostic criteria in different studies[20-23] showed various modalities and techniques as effective or ineffective. Noninvasive methods of treatment are vapocoolant spray and stretch, manual stretching by TrP pressure, contract-release method, TENS, traditional physical therapy, and massage; invasive methods are dry needling and TrP injection.[6,24,25] Vernon and Schneider,[25] after reviewing 112 articles, concluded that there was strong evidence for laser therapy; moderate evidence for TENS, acupuncture, and magnet therapy; and weak evidence for electrical muscle stimulation, high-voltage galvanic stimulation, interferential current, frequency modulated neural stimulation, and US therapy. Acute MPS responds well to manual and injection therapies, but requires attention to postural, ergonomic, and structural factors and metabolic factors that impair muscle function.[19] Peloso et al[26] reviewed 36 trials from a search of the Cochrane Database regarding the effects of NSAIDs, psychotropic agents, steroid injections, and anesthetic agents. They found a lack of replication of findings and sufficiently large trials to be the major limitations of the studies.[17] NSAIDs, muscle relaxants, and analgesics were found to have limited evidence and unclear benefits.[27]

The HPPTUS technique was cited first by Travell and Simons[9] from a personal communication with Nielson in 1983. The technique was described as "the power of ultrasound is first increased to the threshold pain level (to 1.5 w/cm) and then reduced to one half of that intensity. Over the next 2 to 3 minutes, the intensity is gradually increased with frequent queries as to patient sensations, until the intensity has been increased, but not beyond the original pain threshold level." The output parameters primarily were chosen from Travell & Simons' Trigger Point Manual and applied as stated in the text.[7] From our experience with thousands of patients, we strongly believe that very brief (2–4s) applications of sound waves at intensities that would elicit pain in the TrP with periods of low-intensity output have the counterirritation effect, which leads to inactivation of TrPs. This study compares the effectiveness of HPPTUS and TrP injection in the treatment of MTrPs of the upper trapezius muscle.

METHODS

Design Overview

The study is a randomized single-blinded controlled trial. Patients (N=197) with reports of neck pain were approached. Inclusion criteria were (1) the presence of at least 1 active TrP on 1 side of the upper trapezius muscle, (2) symptom duration of 0 to 4 weeks, (3) age of 18 to 60 years, (4) patients with primary MPS (no pain at any other area than that corresponding to the TrP and referred pain, pain mostly on contralateral bending of the head, negative Spurling test, negative maximal cervical compression test, normal manual muscle testing results, normal sensory examination findings, normal deep tendon reflexes), and (5) laboratory results in the reference range indicating the absence of active infection and inflammation. Exclusion criteria were the presence of previously diagnosed diseases (diabetes mellitus, such hormonal disorders as hypo/hyperthyroidism, hyperparathyroidism, rheumatoid arthritis, fibromyalgia).

Forty-nine patients who had acute MTrPs on 1 side of their upper trapezius muscles were included in the study. The diagnosis of active TrPs was made by the same physiatrist (D.P.), who is experienced (5y) in MPS. Diagnostic criteria[9] were regional pain report, pain report or altered sensation in the expected distribution of referred pain from a TrP, taut band palpable in an accessible muscle, exquisite spot tenderness at 1 point along the length of the taut band, some degree of restricted ROM, and reproduction of clinical pain or altered sensation by pressure on the tender spot.

Setting and Participants

The study was conducted in the Department of Physical Medicine and Rehabilitation, Cerrahpasa Medical Faculty, Istanbul University. All patients were informed about the procedure and all signed consent forms. The study protocol was

approved by the ethical committee of the institution. The HPPTUS group consisted of 20 patients (17 women, 3 men). The local injection group consisted of 22 patients (20 women, 2 men). There was no statistically significant difference between groups in terms of age ($P=.614$). Average age of the HPPTUS group was 41.0±12.4 years, and average age of the local injection group was 42.6±13.8 years. There was no statistically significant difference between groups in terms of sex ($P=.716$).

Randomization

Patients who met the inclusion criteria were consecutively assigned to 1 of the 2 treatment groups.

Interventions

Patients in the study group (n=25) received the high-power pain threshold static US technique. Patients in the study group were assessed on day 2 by using a VAS and cervical ROM to determine the need for a second therapy session. If necessary, the second session was carried out on day 2. Patients in the control group (n=24) were treated with 1 session of injection of 1 mL of 0.5% local anesthetic (lidocaine). In both groups, all assessments were performed before treatment and at the termination of each session. The evaluating physician made the decision to terminate any therapy if perceived pain on the VAS reached the 0 or 1 level. The study protocol necessitated termination of the therapy session by 1 of the 2 physicians or the physiotherapist if any side effects occurred during the treatment.

No patient was given stretching exercises. No patient was blinded to treatment applications or assessments. The physiatrist (F.Y.A.) who assigned patients to the groups was not blinded to the investigation. The physiatrist (D.P.) who administered the VAS and performed goniometric measurements was blinded to the rest of the process.

Local injections were performed according to the technique previously described by Travell and Simons.[9] When a TrP was located and the overlying skin was cleansed with alcohol, the point was isolated with a pinch between the thumb and index finger. Using sterile technique, the needle then was inserted 1 to 2cm away from the TrP so that the needle could be advanced into the TrP at an acute angle of 30° to the skin. To ensure that the needle was not within a blood vessel, the plunger was withdrawn before injection. A small amount (0.2mL) of anesthetic was injected when the needle encountered a tiny sensitive locus when an LTR response was elicited. The needle then was withdrawn to the level of the subcutaneous tissue and redirected superiorly, inferiorly, laterally, and medially, repeating the needling and injection process in each direction until the LTR was no longer elicited or resisting muscle tautness was no longer perceived.[9]

All injections were performed by another physiatrist (F.Y.A.) who is experienced (10y) in the technique. All HPPTUS treatments were applied by a physiotherapist who is experienced (10y) in application of the technique.

HPPTUS was applied in continuous mode, with the probe placed directly on the TrP and held motionless. To elicit threshold pain, the US probe was kept static on the TrP. Intensity gradually was increased to the level of maximum pain the patient could bear. It was kept at that level for 3 to 4 seconds, then reduced to the half-intensity level for another 15 seconds. This procedure was repeated 3 times. Therefore, the intensity of US was dependent on the patient's level of pain. Considering all patients, intensity was applied in the range of 0.5 to 2.0 Watt per/cm^2. Patients continually reported their pain level and its localization and nature.

The US device used in this study was Enraf Nonius[a] (1–3MHz) with a transducer diameter of 5cm^2. The device had been calibrated on July 8, 2010.

Outcomes and Follow-up

Main outcome measures were (1) pain assessment on the VAS, (2) goniometric measurement of active lateral bending of the neck, (3) number of therapy sessions, and (4) presence of any side effects in both groups during and at 1 and 4 weeks after treatment.

The procedure for goniometric measurement was to place the fulcrum of the goniometer on the spinous process of the first thoracic spine and the center of the goniometer arm on the occipital protuberance at right angles. After the device's horizontal arm was manually stabilized, its vertical arm was moved according to the movement of the patient's head and placed on the occipital protuberance to the determine lateral bending angle. Anchor points of the VAS in the present study were 0 (no pain) and 10 (worst pain imaginable).

Diagnosis of active MTrPs, rating of subjective pain, and cervical ROM measurements were performed by the same physiatrist (D.P.), who was blinded to the treatment groups. Assigning patients to groups was performed by the other physiatrist (F.Y.A.) after she made the diagnosis and performed the initial measurements. After each therapy session (whether HPPTUS or local injection), the physiatrist (F.Y.A.) informed each patient that he/she was to meet another physician (D.P.) for the evaluation. She accompanied all patients during the evaluations to ensure that no communication took place except for the minimum necessary dialogue for the evaluation procedure.

All patients were followed up at weeks 1 and 4 after completion of the therapies. Patients were seen at week 1 and called by telephone at week 4. Patients were questioned about pain or difficulty during activities of daily living and probable side effect, for example, emergence of pain or symptoms different from the original pain during the treatment sessions. Four patients in the HPPTUS group were lost to follow-up and 1 patient was excluded from follow-up because of a side effect. Two patients in the local injection group were lost to follow-up. Twenty patients in the HPPTUS group and 22 patients in the local injection group completed the study.

Statistical Analysis

Descriptive statistics (mean ± SD, frequency) of the data were computed. Unpaired t test was used to analyze for significant differences in age and ROM between groups. Measured VAS scores before and during treatment were compared by using Wilcoxon test in both groups. Measured values for ROM before and during treatment were compared by using paired t test in both groups. Within- and between-group change scores and associated 95% CIs also were calculated. Dichotomous variables (eg, sex) were compared by using Fisher exact test. Patients who fulfilled the inclusion criteria for MPS, received therapy, and documented at least 1 follow-up observation of the primary outcome were analyzed within the ITT population. Missing values were replaced with a last-value option.

A significance level of .05 was used for all comparisons. All analyses were performed using SPSS for Windows.[b]

RESULTS

There were significant improvements in VAS scores and ROM after treatment in both groups. However, differences in before and after values for the VAS and ROM between groups

Table 1: Clinical Characteristics of the 2 Groups

Test	Variable	Group 1: HPPTUS (n=20)	Group 2: TrP Injection (n=22)	*P*	Mean Difference	95% CI of the Difference	
						Lower	Upper
VAS	Before the treatment	6.68±1.49	7.33±1.59	.211	0.65	−0.26	1.57
	After the treatment	1.44±2.21	0.90±1.13	.860	−0.53	−1.61	0.54
	P	.0001	.0001	NA	NA	NA	NA
	Mean paired difference	5.2	6.4	NA	NA	NA	NA
	95% CI of the difference	4.3 to 6.1	5.6 to 7.2	NA	NA	NA	NA
ROM	Before the treatment	22.08±6.60	21.24±5.60	.887	−0.84	−4.52	2.84
	After the treatment	27.40±6.23	24.90±6.22	.250	−2.49	−6.21	1.22
	P	.001	.001	NA	NA	NA	NA
	Mean paired difference	−5.3	−3.6	NA	NA	NA	NA
	95% CI of the difference	−7.7 to −2.9	−5.2 to −2.0	NA	NA	NA	NA

Abbreviation: NA, not applicable.

were not statistically significant (table 1). The mean number of sessions was lower in group 2 (TrP injection; 1.0±0.0) than group 1 (HPPTUS; 1.5±0.7; mean difference, −0.5; 95% CI, −.81 to −.22).

One patient in the HPPTUS group developed erythema on the TrP during the application and dropped out. The patient did not report pain, the erythema was not painful on compression, and there was no edema or induration. The patient subsequently reported that the erythema had disappeared after 3 days. There were no side effects reported during follow-up.

Statistical significance levels were not changed after ITT analysis.

DISCUSSION

This study compares the effectiveness of HPPTUS with TrP injections using a local anesthetic agent in the treatment of MPS of the upper trapezius muscle. We failed to find differences between HPPTUS and local injections in pain reduction and ROM increase of the cervical spine.

TrP injections using local anesthetic agents and dry needling of the TrPs are effective invasive methods.[1,19] Furthermore, studies showed that injecting local anesthetics was no more effective than needling in the treatment of MPS.[27-31] Local injection using lidocaine was used in the study because it is a classic method of TrP injection. However, the injection procedure has a needling effect during injection of the TrPs. As a result, despite choosing to inject lidocaine, a needling effect also was present. Results may reflect the effects of both lidocaine injection and needling together.

HPPTUS is a technique that requires application of US waves directly on the TrP in a static and intermittent manner. Intensity gradually is increased to the level of maximum pain perception. As a result, intensity of the US differs from patient to patient and standardization is not possible. Standardization might lead to undertreatment in some patients and overtreatment in others. HPPTUS is a noninvasive technique in the treatment of TrPs. It seems to be free of serious complications, such as infection, injection intravascularly, nerve damage, and even cardiac and pulmonary arrest that would emerge after or during injections.[32] However, the technique requires some additional experience of the therapist and communication and concentration of both patient and therapist. The procedure may be as painful as TrP injections.

During HPPTUS, sound waves encountering sensitive loci can lead to intense pain. The elicited pain can arise in low intensities of sound waves and in the absence of a heating effect or sensation that the patient could report. This counter-irritation effect may create hyperstimulation analgesia derived from firing alterations in the spinal internuncial neurons. This mechanism underlies the similar treatment effect obtained from injection or needling.[10,11,33,34]

Few studies have investigated the effectiveness of the HPPTUS technique. In a previous study, we compared the effectiveness of this technique with conventional US and found it to be far superior.[35] In a more recent study of patients with chronic myofascial pain, Esenyel et al[36] found lidocaine and botulinum toxin-A TrP injections to be more effective than conventional US and HPPTUS therapies; conventional and HPPTUS techniques were equally effective in this study. However, patients with a diagnosis of chronic (pain duration >6mo) MTrPs were included in this study. In an RCT, Gam et al[37] found no difference between groups given conventional or sham US techniques in the treatment of MTrPs in the neck and shoulder. In another RCT, Esenyel et al[38] reported that combined with neck stretching exercises, conventional US treatment and TrP injections were equally effective in the treatment of MTrPs of the upper trapezius muscle. In their RCT, Srbely and Dickey[39] reported that therapeutic exposures to US decrease short-term TrP sensitivity. In a recent randomized controlled study, Srbely et al[40] showed that low-dose US evoked short-term segmental antinociceptive effects on TrPs that may have applications in the management of musculoskeletal pain.

A few points of this study merit consideration. Only patients with a diagnosis of acute primary MPS were included in the study. Our experiences with the HPPTUS technique have led us to believe that the technique is more effective in patients with acute active TrPs. Furthermore, we strongly believe that additional characteristics of the patient, such as lifestyle, psychosocial, and biomechanical factors, should be considered in the treatment plan for chronic MPS.[7,8,19] As a result, the HPPTUS technique may not be as effective in the treatment of patients with chronic MPS.

Despite the potential life-threatening yet seldom occurring side effects of injection, both techniques were equally free of serious side effects.

The average number of therapy sessions in the US group was 1.5 compared with 1 in the injection group. Statistically, there was a significant difference between the 2 groups in this regard. However, the number of sessions for the US group was very low and shows the effectiveness and economy of the treatment.

HPPTUS is a technique that requires basic knowledge of MPS and localization of the TrPs. The HPPTUS technique is not invasive and was free of serious adverse effects if applied after an accurate diagnosis was made and with knowledge of

regional anatomy. It is free from serious yet rare complications that might accompany injection of TrPs.[11] However, HPPTUS should not be applied on TrPs adjacent to the bones and nerves to avoid inflicting probable injury to these tissues. Care also must be taken to distinguish pain originating from a TrP from pain originating from excessive heating, such as if US has been applied for more than 3 seconds.

We believe that mastering the HPPTUS technique requires at least 5 applications under supervision to prevent excessive pain. Lack of experience also would lead to patient noncompliance stemming from his/her misunderstanding of the technique and/or the expected level and nature of the pain to be elicited. It also requires good communication and concentration for both therapist and patient. The procedure could be as painful as TrP injection, yet the intensity of the pain can be controlled immediately by the therapist. Similar to injection techniques, the procedure can be terminated or interrupted when necessary.[8]

Study Limitations

Inclusion of a PPT would enhance results of the study because it is a valid measure of TrP sensitivity. Inclusion of a placebo control group would enhance results of the study. The reliability and validity of the goniometric measurement method we used in the study have not been studied. However, the method has been used in other studies by the authors. Cointervention and contamination during the study were not monitored.

Follow-up included only interviews at weeks 1 and 4 regarding the presence of pain and activity restriction. VAS and ROM measurements are lacking in the follow-up period. Inclusion of these would give information regarding the lasting effect of HPPTUS because studies have shown that the effect of TrP injection may last for 2 weeks. No controlling was done for the dry needling effect. The groups consisted of mainly women. This should be considered during generalization of results of the study.

Avenues for Future Research

This study investigated HPPTUS against only 1 of several commonly used techniques that have been effective in the treatment of MPS. We chose lidocaine injection because it is classic and 1 of the first mentioned techniques. Other known effective techniques also should be compared with HPPTUS in future studies.

CONCLUSIONS

No treatment differences were found between the HPPTUS technique and local injections in the treatment of patients with TrPs in the upper trapezius. Both techniques could be considered equally as treatment options when treating patients with MPS.

References

1. Lavelle ED, Lavelle W, Smith HS. Myofascial trigger points. Med Clin North Am 2007;91:229-39.
2. Walsh NE, Dumitru D, Schoenfeld LS, Ramamurthy S. Treatment of the patient with chronic pain. In: DeLisa JA, editor. Physical medicine and rehabilitation. 4th ed. Philadelphia: Lippincott, Williams & Wilkins; 2005. p 493-529.
3. Sola AE, Bonica JJ. Myofascial pain syndromes. In: Loeser JD, editor. Bonica's management of pain. 3rd ed. Philadelphia: Lippincott, Williams & Wilkins; 2001. p 530-42.
4. Skootsky SA, Jaeger B, Oye RK. Prevalence of myofascial pain general internal medicine. West J Med 1989;151:157-60.
5. Manolopoulos L, Vlastarakos PV, Georgiou L, Giotakis I, Loizos A. Nikolopoulos TP. Myofascial pain syndromes in the maxillofacial area: a common but underdiagnosed cause of head and neck pain. Int J Oral Maxillofac Surg 2008;37:975-84.
6. Gerwin RD. A review of myofascial pain and fibromyalgia—factors that promote their persistence. Acupunct Med 2005;23: 121-34.
7. Bladry P. Superficial versus deep needling. Acupunct Med 2002; 20:78-81.
8. Hong CZ, Simons DG. Pathophysiologic and electrophysiologic mechanisms of myofascial trigger points. Arch Phys Med Rehabil 1998;79:863-72.
9. Simons DG, Travell JG. Apropos of All Muscles. In: Simons DG, Travell JG, Simons LS, editors. Travell & Simons' Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Baltimore: Williams & Wilkins; 1999. p 94-173.
10. Simons DG. New aspects of myofascial trigger points: etiological and clinical. J Musculoskelet Pain 2004;12:15-21.
11. Simons DG. New views of myofascial trigger points: etiology and diagnosis [commentary]. Arch Phys Med Rehabil 2008;89:157-9.
12. Friction JR. Myofascial pain syndrome. Neurol Clin 1989;7: 413-27.
13. Lartigue AM. Patient education and self-advocacy. Myofascial pain syndrome treatments. J Pain Palliat Care Pharmacother 2009; 23:169-70.
14. Sucher BM. Thoracic outlet syndrome—a myofascial variant: part 2. Treatment. J Am Osteopath Assoc 1990;90:810-2, 817-23.
15. Friction JR, Steekinks MH. Diagnosis and treatment of myofascial pain. Ned Tijdschr Tandheelkd 1996;103:249-53.
16. Yap EC. Myofascial pain—an overview. Ann Acad Singapore 2007;36:43-8.
17. Borg-Stein J, Simons DG. Myofascial pain. Arch Phys Med Rehabil 2002;83(Suppl 1):S40-7.
18. Han SC, Harrison P. Myofascial pain syndrome and trigger point management. Reg Anesth 1997;22:89-101.
19. Hong CZ. Treatment of myofascial pain syndrome. Curr Pain Headache Rep 2006;10:345-9.
20. Russell IJ. Reliability of clinical assessment measures for the classification of myofascial pain syndrome. J Musculoskelet Pain 1999;7:309-24.
21. Gerwin RD, Shannon S, Hong CZ, et al. Interrater reliability in myofascial trigger point examination. Pain 1997;69:65-73.
22. Sciotti VM, Mittak VL, DiMarco L, et al. Clinical precision of myofascial approach when other treatment failed. Phys Med Rehabil Clin N Am 1997;8:23-53.
23. Hong C-Z, Chen Y-N, Twehous D, Hong D. Pressure threshold for referred pain by compression on the trigger point and adjacent areas. J Musculoskelet Pain 1996;4:61-79.
24. Lavelle ED, Lavelle W, Smith HS. Myofascial trigger points. Anesthesiol Clin 2007;25:841-51.
25. Vernon H, Schneider M. Chiropractic management of myofascial trigger points and myofascial pain syndrome: a systematic review of the literature. J Manipulative Physiol Ther 2009;32:14-24.
26. Peloso P, Gross A, Haines T, et al. Medicinal and injection therapies for mechanical neck disorders. Cochrane Database Syst Rev 2007;18:CD000319.
27. Criscoulo CM. Interventional approaches to the management of myofascial pain syndrome. Curr Pain Headache Rep 2001;5:407-11.
28. Birch S, Jamison RN. Controlled trial of Japanese acupuncture for chronic myofascial neck pain: assessment specific and nonspecific effects of treatment. Clin J Pain 1998;14:248-55.
29. Chu J. Dry needling (intramuscular stimulation) in myofascial pain related to lumbar radiculopathy. Eur J Phys Med Rehabil 1995;5:106-21.
30. Melzack R. Myofascial trigger points: relation to acupuncture and mechanism of pain. Arch Phys Med Rehabil 1981;62:114-7.

31. Chu J, Schwartz I. The muscle twitch in myofascial pain relief: effects of acupuncture and other needling methods. Electromyogr Clin Neurophysiol 2002;42:307-11.
32. Walsh NE, Rogers JN, Patil JJ. Injection procedures. In: DeLisa JA, Gans BM, editors. Rehabilitation medicine. 3rd ed. Philadelphia: Lippincott-Raven; 1998. p 553-610.
33. Hong CZ. Lidocaine injection versus dry needling to myofascial trigger point: the importance of the local twitch response. Am J Phys Med Rehabil 1994;73:256-63.
34. Hong CZ. Consideration and recommendation of myofascial trigger point injection. J Musculoskelet Pain 1994;2:29-59.
35. Majlesi J, Unalan H. High-power pain threshold ultrasound technique in the treatment of active myofascial trigger points: a randomized, double-blind, case-control study. Arch Phys Med Rehabil 2004;85:833-6.
36. Esenyel M, Aldemir T, Gürsoy E, et al. Myofascial pain syndrome: efficacy of different therapies. J Back Musculoskel Rehabil 2007;20:43-7.
37. Gam AN, Warming S, Larsen LH, et al. Treatment of myofascial trigger points with ultrasound combined with massage and exercise: a randomised controlled trial. Pain 1998;77:73-9.
38. Esenyel M, Caglar N, Aldemir T. Treatment of myofascial pain. Am J Phys Med Rehabil 2000;79:48-52.
39. Srbely JZ, Dickey JP. Randomized controlled study of the antinociceptive effect of ultrasound on trigger point sensitivity: novel applications in myofascial therapy? Clin Rehabil 2007; 21:411-7.
40. Srbely JZ, Dickey JP, Lowerison M, Edwards AM, Nolet PS, Wong LL. Stimulation of myofascial trigger points with ultrasound induces segmental antinociceptive effects: a randomized controlled study. Pain 2008;139:260-6.

Suppliers

a. Enraf-Nonius, B.V. Postbus 12080 3004 GB Rotterdam.
b. SPSS for Windows; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.