International Journal of Surgery 24 (2015) 201–206

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Review

Update on the efficacy of extracorporeal shockwave treatment for myofascial pain syndrome and fibromyalgia

Silvia Ramon [a,*], Markus Gleitz [b], Leonor Hernandez [c], Luis David Romero [c]

[a] Hospital Quiron Barcelona, School of Medicine and Health Sciences, Universitat Internacional de Catalunya. Garcia Cugat Foundation, CEU – UCH Chair of Medicine and Regenerative Surgery, Spain
[b] Orthopaedic Practice, Luxembourg
[c] Physical Medicine and Rehabilitation Department, Hospital Quiron Barcelona, Spain

HIGHLIGHTS

- We present the current knowledge on shockwave treatments for myofascial pain syndrome.
- ESWT is an efficient tool for the treatment of myofascial pain síndrome.
- The clinical efficacy of ESWT in fibromyalgia is controversial.
- Promising results have been reported on myofascial pain syndrome.

ARTICLE INFO

Article history:
Received 13 June 2015
Received in revised form
31 July 2015
Accepted 6 August 2015
Available online 10 September 2015

Keywords:
Myofascial pain
Trigger point
Tender point
Fibromyalgia
Shockwave
Efficacy

ABSTRACT

Chronic muscle pain syndrome is one of the main causes of musculoskeletal pathologies requiring treatment. Many terms have been used in the past to describe painful muscular syndromes in the absence of evident local nociception such as myogelosis, muscle hardening, myalgia, muscular rheumatism, fibrositis or myofascial trigger point with or without referred pain. If it persists over six months or more, it often becomes therapy resistant and frequently results in chronic generalized pain, characterized by a high degree of subjective suffering.

Myofascial pain syndrome (MPS) is defined as a series of sensory, motor, and autonomic symptoms caused by a stiffness of the muscle, caused by hyperirritable nodules in musculoskeletal fibers, known as myofascial trigger points (MTP), and fascial constrictions.

Fibromyalgia (FM) is a chronic condition that involves both central and peripheral sensitization and for which no curative treatment is available at the present time. Fibromyalgia shares some of the features of MPS, such as hyperirritability.

Many treatments options have been described for muscle pain syndrome, with differing evidence of efficacy. Extracorporeal Shockwave Treatment (ESWT) offers a new and promising treatment for muscular disorders.

We will review the existing bibliography on the evidence of the efficacy of ESWT for MPS, paying particular attention to MTP (Myofascial Trigger Point) and Fibromyalgia (FM).

1. Extracorporeal shockwave treatment and myofascial pain syndrome

Myofascial Pain Syndrome (MPS) is a musculoskeletal disorder with local pain and stiffness, characterized by the presence of hyperirritable palpable nodules in the skeletal muscle fibers, known as myofascial trigger points (MTP) [1–6]. (Fig. 1). MTP produce pain with any activating stimulus (direct or indirect trauma), causing local and referred pain, tenderness, motor dysfunction, autonomic phenomena and hyperexcitability of the central nervous system [7–9]. Recent research argues that MPS offers a simplistic explanatory model, which posits a local (muscular) origin of nociception within the trigger points (TP) and advocates local treatment.

MPS is a common disorder (12% in general population) [10]. Some studies observed an incidence of 30% MTPs in internal

* Corresponding author.
E-mail address: sramon@comb.cat (S. Ramon).

http://dx.doi.org/10.1016/j.ijsu.2015.08.083
1743-9191/

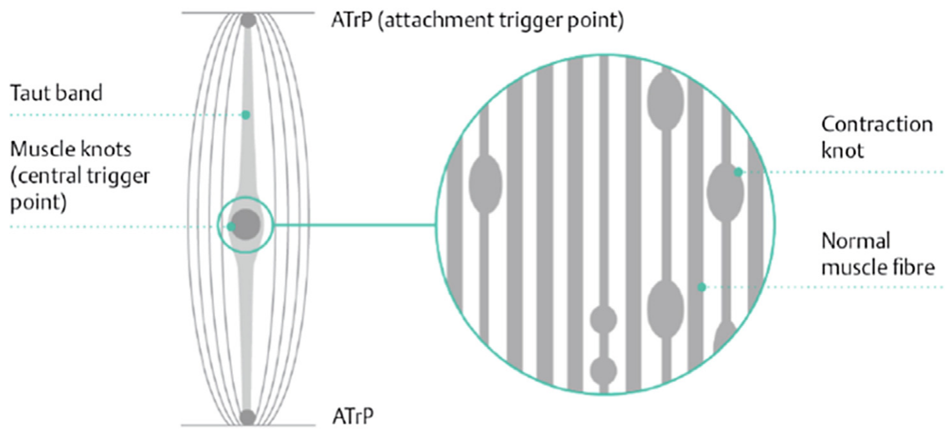

Fig. 1. Myofascial Trigger Point complex: Muscle knot (central trigger point) with taut band and attachment TP [1,2].

medicine practice [11], with a prevalence of 54% in women and 45% in men [2,5,12], although some publications do not report significant differences between the two genders [2,7]. The most common age bracket at onset is 27–50 [8,9].

The **mechanism of action** that best explains it is Simons' Integrated Hypothesis of TP Formation (or Energy Crisis Integrated Hypothesis) [1,2]. Fig. 2.

Muscle trauma, strain, repetitive low-intensity muscle overload, or intense muscle contractions may give raise to a vicious circle which ends up damaging the sarcoplasmic reticulum, and leading to an increase of the calcium concentration, a shortening of the actin and myosin filaments, a shortage of adenosine triphosphate and an impaired calcium pump [2,13]. The "energy crisis hypothesis" reflects this vicious circle. This hypothesis has evolved into the "integrated TP hypothesis" [14], which postulates that abnormal depolarization of the post-junctional membrane of the motor endplates causes a localized hypoxic energy crisis, associated with sensory and autonomic reflex arcs that are sustained by complex sensitization mechanisms.

Muscular injury causes a dysfunction of the neuromuscular endplate, which in turn increases the release of Acetylcholine (ACh) in the synaptic gap. This triggers high-frequency miniature endplate potentials, causing permanent depolarization. These endplate potentials can be experimentally revealed as spontaneous electrical activity (SEA) by needle electromyography [2]. The release of ACh in turn increases the release of calcium at the

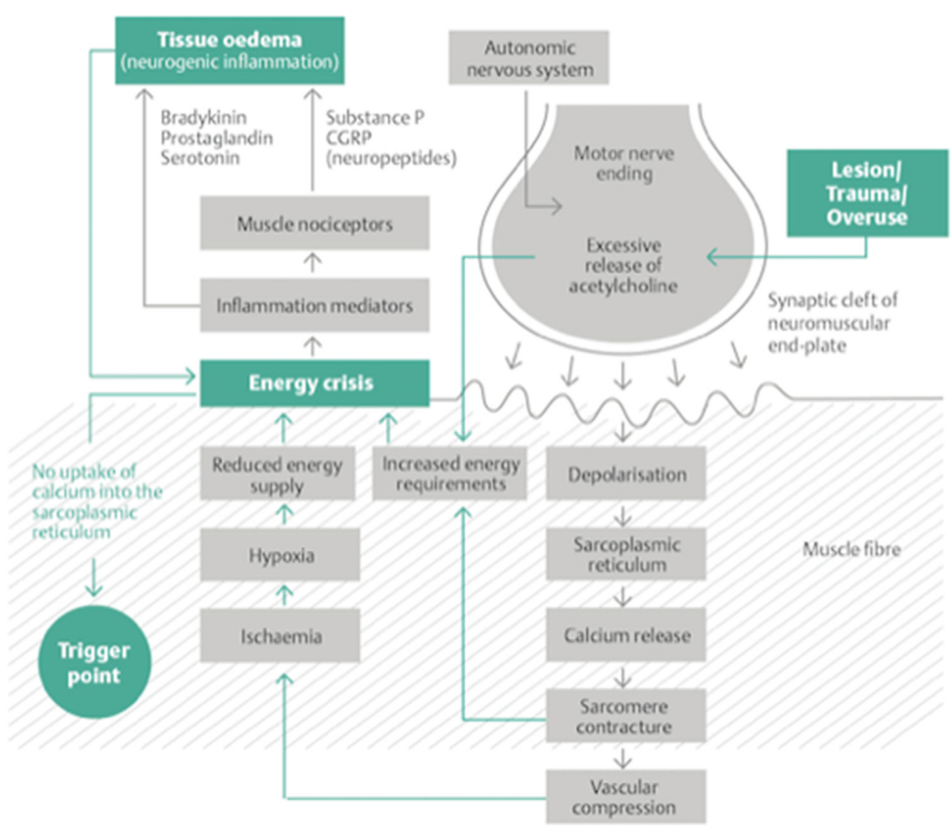

Fig. 2. Integrated myofascial trigger point (MTP) hypothesis [1,2].

sarcoplasmic reticulum, which produces sustained myofascial contraction and forms a knot. The contraction knot thus compresses vascular capillaries causing itself a local ischemia and then local hypoxia. A local energy crisis will ensue due to the loss of energy caused by the ischemia and the increased energy requirement of calcium-pump activation [1,2]. The ischemia sensitizes the nociceptors through the release of known inflammation mediators (such as bradykinin, prostaglandin, serotonin and histamine) and causes local sensitivity to pressure on the MTPs. In addition, ischemia will further damage the already dysfunctional endplate and activate acetylcholinesterase, leading to the release of ACh as part of the aforementioned vicious circle. Recent research in human MTPs has confirmed this theory [15,16].

When a muscle is injured a series of substances are released which activate muscle nociceptors and cause pain. It is accompanied by a facilitation of ACh release, inhibition of ACh breakdown and removal from the Ach Receptor (AchR), and an up-regulation of AchR which, in turn, leads to the development of the persistent muscle fiber contractions, typical of MTPs.

MPS may include muscle pain from taut bands with TP and/or tender points. The muscles are in spasm, with increased tension and decreased flexibility. It usually occurs together with regional muscular pain, distributed through one or two quadrants of the body [17].

Trigger points (TP) are defined as areas of muscle that are painful to palpation. They present taut bands and generate a referral pattern of pain, characteristic to MPS. TP can be classified as "active" or "latent". An active TP is a spontaneous focus of pain, accentuated with pressure, and which the patient recognizes as familiar. A latent TP is a focus of hyperirritability in a muscle or its fascia that is clinically quiescent in terms of spontaneous pain and is painful only when palpated [18,19].

Tender points are areas of tenderness occurring in muscle, muscle-tendon junctions, bursas, or fat pads. When they are distributed throughout the body they are considered a feature of fibromyalgia. The two forms of painful points may coexist.

Taut bands (TB) are groups of muscle fibers found to be hard and painful on palpation. The detection of TB with the palpation of the muscle is considered an objective finding consistent with myofascial pain. Table 1.

The criteria to establish a **diagnosis** of MPS are: regional pain; palpation of a trigger point elicits a stereotypic zone of referred pain specific to that muscle; identification of a palpable taut band as well as a palpable and exquisitely tender spot along the length of that taut band; and a restricted range of motion of the involved muscle [2]. It has been suggested that certain other, minor, criteria may further aid in the diagnosis of myofascial pain syndrome: palpation of a trigger point should reproduce the clinical pain complaint; a local twitch response may be obtained by transverse snapping or needling of the trigger point, and the alleviation of pain by trigger point inactivation.

The palpable band is considered to be critical to the identification of a trigger point. Three methods have been established for trigger point palpation: flat palpation, pincer palpation, and deep palpation.

The approach to the **treatment of myofascial pain** should be conservative and multidisciplinary, and should include education, pharmacological treatment (analgesics, myorelaxants such as baclofen or tizanidine, nonsteroidal anti-inflammatory drugs); physical therapy (hot packs or ice, massage therapy using myofascial release techniques consisting in gentle fascia manipulation, which may be effective in short-term pain relief; and gentle stretching and exercise, useful for maintaining or recovering a full range of motion and overcoming motor imbalance; stretch and spray, biofeedback, transcutaneous electrical nerve stimulation –TENS-, ultrasound, interferential currents, laser therapy) and lately ESWT [5,10].

Invasively MPS can be treated by **dry needling,** without injecting any substance at all, in order to reach the MTP and destroy it [23]. Tekin (2013) recognized this as the treatment of choice. A systematic review concluded that dry needling for the treatment of MPS in the lower back appeared to be a useful adjunct to standard therapies, but this is currently under investigation [24]. Furthermore, Gerber (2015) demonstrated that dry needling reduces pain from the TP, and is associated with improved mood, function, and a lessening of disability [25].

In a recent systematic review and meta-analysis, Tough (2009) compare dry needling with acupuncture for the management of MTPs and find that the available evidence is inconclusive [26].

Liu (2015) published a systematic review and meta-analysis about the effectiveness of dry needling for myofascial trigger points associated with neck and shoulder pain. He concluded that trigger point dry needling can be recommended for relieving myofascial pain in the short and medium term, but wet needling is found to be more effective than dry needling in the medium term [27].

TP injections using local anesthetics, such as lidocaine, is a controversial treatment, either when injected on their own [28], or together with corticosteroids [29]. There is insufficient evidence available regarding the treatment of MPS with botulinum injections [13].

A novel therapy for the treatment of muscular pain is **Extracorporeal Shockwave Treatment** (ESWT), as an empirically extended indication for regenerative shockwave therapy.

Muscular shockwave therapy has come to be referred to as "trigger point shockwave therapy" because shockwaves are able to trigger the referred pain that is characteristic of TP and treat the clinical symptoms associated with these TP [30].

ESWT uses biphasic acoustic energy that goes from positive high peak pressures (10–100 MPa megapascals–MPa-for Focused F-ESWT; 0.1–1 MPa for Radial R-ESWT) to negative phase (−10 MPa); short rise times (10–100 ns for F-ESWT; 0.5–1 ms for R-ESWT), short duration (0.2–0.5 μs for F-ESWT; 0.2–0.5 ms for R-ESWT) (Fig. 3). Focused and radial shockwaves are generated in different ways. Focused shockwaves are generated electrically, either within the applicator (electrohydraulic technique), or externally to it in the focal zone (electromagnetic or piezoelectric techniques), and then

Table 1
Differences between trigger points and tender points [20,21].

Trigger points	Tender points
Local tenderness, taut band, local twitch response, jump sign	Local tenderness
Singular or multiple	Multiple points
May occur in any skeletal muscle and are mostly located in the muscle belly	Occur in specific locations that are symmetrically located
May cause a specific referred pain pattern	Do not cause referred pain, but often cause increase in pain sensitivity over the whole body
The point itself may or may not be tender	The specific point itself is tender
Trigger points refer pain to other areas	Tender points do not cause referred pain

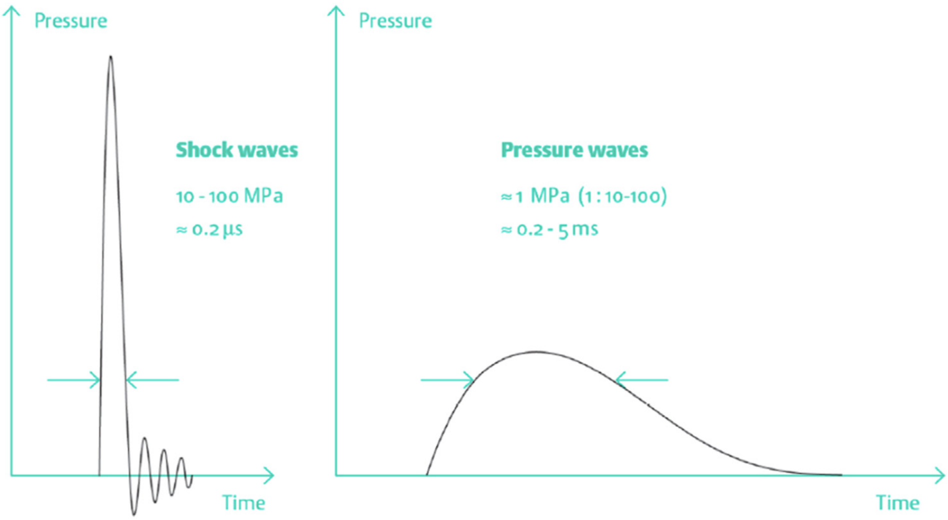

Fig. 3. Typical parameters of focused shockwaves and radial shockwaves [1,2].

propagate to a designated focal point in order to treat it. Radial shockwaves are ballistic pressure waves generated at lower pressures over a longer time and propagate divergently within the tissue [30]. The induced energy is propagating in the tissue and converges into a focal or radial area, depending on the equipment used and the settings selected for intensity, angle and other parameters. The effect varies, depending on the tissue through which the wave passes and how it absorbs, reflects, refracts or transmits the energy, depending on the specific impedance [31].

There have been several publications on ESWT for MTP since 1999, using Focused low-energy ESWT [32].

Most research in shockwave therapy has focused on understanding the mechanism which results in the establishment of a mechano-sensitive feedback loop between the acoustic impulse and the stimulated cells, and involves specific transduction pathways and gene expression [31].

How do shockwaves affect myofascial pain? While today we have certain hypotheses regarding how MTP are formed, it remains unclear how ESWT may affect them. Taking as valid the Energy Crisis Hypothesis, and considering the mechanotransduction effect of ESWT in other diseases [16,33,34], it could be posited that ESWT in MPS may increase perfusion, promote angiogenesis and alter the pain signaling in ischaemic tissues caused by the influx of calcium.

On the other hand, recent articles have demonstrated that free nerve endings degenerate after the application of ESWT, and that ESWT produces a transient dysfunction of nerve excitability at the neuromuscular junction [35], by bringing about the degeneration of AChR. Although this test was performed on spastic muscles, it could also be extrapolated to MTP and to the Energy Crisis Hypothesis.

And finally, following a pure mechanistic approach, shockwaves might be able to break-up the Actin–Myosin links, as they are propagating perpendicularly to the sarcomere contractions.

Table 2 shows evidence of the efficacy of Extracorporeal Shockwave Treatment on Myofascial Pain Syndrome.

Müller-Ehrenberg (2005) demonstrated the efficacy of focused ESWT on MTPs (Piezoelectric device: Piezo Son100), alleviating pain in 95% of the 30 patients in his group at 3 months, (800 impulses of energy level: 0.04–0.26 mJ/mm^2; 6 Hz; average 7 treatments, 2 sessions per week) [36].

In a study on 30 patients with MPS in trapezius muscle, Jeon demonstrated that 3 sessions of 1500 pulses of low energy (0.10 mJ/mm^2) with focused ESWT (Electrohydraulic: Evotron RFL0300) weekly is as effective as TENS and TP injection, measuring the results in terms of pain (visual analog scale – VAS – and McGill Pain Questionnaire), as well as on the Roles and Maudsley scale [37].

Ji used an electromagnetic device (Dornier AR2) to demonstrate the same results on MPS of upper Trapezius compared to placebo. In this study they separated treatment of the taut band (700 impulses) and of the surrounding area (300 impulses) at energy levels of 0.056 mJ/mm^2, with 2 sessions per week for 2 weeks [38].

Multimodal therapy has been studied for myofascial pain, combining ESWT with shoulder exercises, demonstrating pain reduction and functional recovery in the combined therapy group [39].

In 2014, Moghtaderi studied the use of ESWT (Duolith SD1) on the gastroc-soleus MTP for the ESWT treatment of plantar fasciitis. He concluded that using ESWT for both regions (plantar fasciitis and gastroc-soleus) is more effective than treating only the plantar fascia [40].

In a randomized study, Gür (2014) demonstrated that low-energy ESWT (Storz Minilith SL1: 1000 pulses at 0.25 mJ/mm^2) for MPS may be more effective when administered as a three-session treatment regime [41].

2. Extracorporeal shockwave treatment and fibromyalgia

FM is a separate category of muscle pain condition, defined by the American College of Rheumatology as chronic widespread pain and reduced pain thresholds to palpation [22].

The pain is widespread or diffuse, distributed symmetrically above and below the waist. Although MPS and fibromyalgia are separate conditions, they may occur concomitantly. FM patients may develop MPS. FM patients have tender points; some may also have trigger points. Taut band with TP and tender point may appear in the muscles [17].

Treatment of FM includes pharmacological treatment (especially antidepressants) and non-pharmacological approaches (education, therapeutic exercises: strengthening, low-impact physical activity, acupuncture, injections, cognitive behavioral therapy, non-invasive brain stimulation) [22,42].

As yet no literature is available on ESWT and FM. Since ESWT is indicated for myofascial syndrome but not yet for FM, Ramon et al. conducted a randomized clinical trial in an attempt to gather evidence on the treatment of the known myofascial points present in

Table 2
Evidence on extracorporeal shockwave treatment for myofascial pain syndrome.

Author	Study	Application	Dose	Results
Müller-Ehrenberg MOT 2005 [36]	Diagnosis and treatment of MPS with ESWT	Focused: Piezoelectric (PiezoSon100)	800–1000 pulses on MTPs 6 Hz 0.04–0.26 mJ/mm^2 7 sessions	Decrease in VAS score at 3 months
Jeon Ann Rehabil Med 2012 [37]	Compare ESWT and TENS + TP injection for MTP on Upper Trapezius	Focused: Electrohydraulic (Evotron)	1500 pulses on trapezius muscle. 0.10 mJ/mm^2 3 sessions	ESWT as effective as TENS and TP injection in VAS and R&M scores
Ji Ann Rehabil Med 2012 [38]	Compare ESWT with placebo on MTP on Trapezius	Focused: Electromagnetic (Dornier)	1000 pulses on trapezius muscle. 0.056 mJ/mm^2 4 sessions (2 sessions per week, in 2 weeks)	ESWT effective therapy in VAS, pain threshold and R&M scores
Cho J Phys Ther Sci 2012 [39]	Combined ESWT in upper trapezius myofascial pain syndrome and stabilization shoulder Exercise	Radial (Jest 2000 – Joeun medical)	1000 pulses on tender points. 0.12 mJ/mm^2 12 sessions (3 sessions per week in 4 weeks)	Combined therapy obtains better results for both pain and functional scores
Moghtaderi Adv Biomed Res 2014 [40]	ESWT for gastroc-soleus MTP in treatment of plantar fasciitis	Focused: Electromagnetic and Radial (Duolith SD1)	40 patients **Heel:** 3000 pulses 0.2 mJ/mm^2 + Each **MTP:** 400 pulses 0.2 mj/mm^2	Combined therapy obtains better results
Gür Arch Rheumatol 2014 [41]	Compare ESWT: one single session versus 3 sessions on Upper Trapezius MPS	Focused: Electromagnetic (Storz Minilith SL1)	1000 impulses 0.25 mJ/mm^2 3 sessions	Three-session treatment improve pain compared to one session

MPS: myofascial pain syndrome; VAS: visual analog scale; ESWT: extracorporeal shockwave treatment; TENS: transcutaneous nerve stimulation; TP: trigger point; R&M: Roles and Maudsley.

FM. A cohort of 24 FM patients was randomly divided into 2 groups, receiving 5 sessions either radial ESWT or placebo. The treatment group received 500 pulses, at 1.5 bar pressure, 15 hz frequency; followed by 1000 pulses, at 2 bar and 8 Hz, and finally 500 pulses at 1.5 bar and 15 hz, thus completing 2000 pulses in each of the 3 most painful points selected. For the placebo application, we used a soft rubber cap and leaving a gap between the cap and the skin, rendering it impossible for the pulses to actually reach the patient. Placebo patients received the same number of pulses at a constant pressure of 1.5 bar. The Radial ESWT patients showed significant improvement in subjective measures (such as local pain according to VAS) and objective measures (algometer, Roles and Maudsley, Fibromyalgia Impact Questionnaire FIQ, pain dimension in SF-36 at 3 months after treatment, without any side effects. We concluded that in a multidisciplinary approach, rESWT appears to be a safe and effective early adjunctive therapy in patients suffering from FM. The long-term benefits of ESWT will be evaluated in order to establish the right moment to repeat treatment and to find a new treatment paradigm for FM [43].

2.1. Suggested protocol for MPS and FM

A) We suggest the following **MPS** Treatment Protocol, based on the area to treat, its depth and surface area. The treatment range should always be kept at low (and medium) energy levels:
   1 Focused ESWT: 1000–2000 pulses (depending on the generator and muscle size); 4 Hz; 0.1 mJ/mm^2 (0.05–0.35 mJ/mm^2) 1–3 sessions
   2 Radial ESWT: 1000 pulses; 1–1.5 bar (for medium-sized muscles); 1.5–2 bar (big muscles); 6–10 Hz; 3–5 sessions
      - Application interval: 1 week
      - Follow-up: 6 weeks; 3, 6, 12 months after treatment

No local anesthesia.

B) In **Fibromyalgia patients**, we suggest the inclusion of radial ESWT for treating the myofascial component of pain with a radial treatment of 1000–1500 pulses on each tender or trigger point, at 2 bar intensity and 10 Hz frequency.

In all the cases, ESWT should be accompanied by a comprehensive supervised exercise program.

In conclusion, muscular pain and especially myofascial pain are new indications for ESWT, since ESWT shows satisfactory results for both conditions. FM can no longer be considered an exclusion criterion for ESWT.

ESWT is a promising new possibility for the management of MPS, but studies with larger series of patients, using the best methodological parameters to improve evidence, are required to confirm these results.

Ethical approval

Not required.

Funding

No funding was received by the authors.

Author contribution

Silvia Ramón: Writing, coordinating.

Conflict of interest

None of the authors have any conflict of interest.
Markus Gleitz: Writing, pictures, revision.
Leonor Hernandez: Writing.
Luis Romero: Final revision.

Guarantor

Silvia Ramon (sramon@comb.cat)

References

[1] M. Gleitz, Shockwave Therapy in Practice: Myofascial Syndrome and Trigger Points, Level 10 Book, first ed., 2011. Germany.

[2] D.G. Simons, J.G. Travell, Travell & Simons' Myofascial Pain and Dysfunction the Trigger Point Manual, second ed., Williams & Wilkins Baltimore, 1999.

[3] E.D. Lavelle, W. Lavelle, H.S. Smith, Myofascial trigger points, Anesthesiol. Clin. 25 (2007) 841–851.

[4] R. Poveda Roda, J.M. Díaz Fernández, S. Hernández Bazan, Y. Jimenez Soriano, M. Margaix, G. Sarrion, A review of temporomandibular joint disease (TMJD). Part II: clinical and radiological semiology. Morbidity processes, Med. Oral Patol. Oral Cir. Bucal 13 (2008) 102–109.

[5] E. Vázquez Delgado, J. Cascos-Romero, C. Gay-Escoda, Myofascial pain syndrome associated with trigger points: a literature review (I): epidemiology, clinical treatment and etiopathogeny, Med. Oral Patol. Oral Cir. Bucal 14 (2009) 494–498.

[6] H.Y. Ge, C. Fernández-de-Las-Peñas, S.W. Yue, Myofascial trigger points spontaneous electrical activity and its consequences for pain induction and propagation, Chin. Med. 6 (2011) 13.

[7] J.P. Okeson, Management of Temporomandibular Disorders and Occlusion, fourth ed., Mosby, St. Louis, 1998.

[8] T.M. Cummings, A.R. White, Needling therapies in the management of myofascial trigger point pain: a systematic review, Arch. Phys. Med. Rehabil. 82 (2001) 986–992.

[9] R.A. Kruse Jr., J.A. Christiansen, Thermographic imaging of myofascial trigger points: a follow-up study, Arch. Phys. Med. Rehabil. 73 (1992) 819–823.

[10] I. Koca, A. Boyaci, A new insight into the management of myofascial pain syndrome, Gaziantep Med. J. 20 (2014) 107–112.

[11] S.A. Skootsky, B. Jaeger, R.K. Oye, Prevalence of myofascial pain in general internal medicine practice, West J. Med. 151 (1989) 157–160.

[12] A.E. Sola, M.L. Rodenberger, B.B. Gettys, Incidence of hypersensitive areas in posterior shoulder muscles; a survey of two hundred young adults, Am. J. Phys. Med. 34 (1995) 585–590.

[13] R. Gerwin, Botulinum toxin treatment of myofascial pain: a critical review of the literature, Curr. Pain Headache Rep. 16 (2012) 413–422.

[14] D.G. Simons, Review of enigmatic MTrPs as a common cause of enigmatic musculoskeletal pain and dysfunction, J. Electromyogr. Kinesol. 14 (2004) 95–107.

[15] J.P. Shah, T.M. Phillips, J.V. Danoff, L.H. Gerber, An in vivo microanalytical technique for measuring the local biochemical milieu of human skeletal muscle, J. Appl. Physiol. 99 (2005) 1977–1984.

[16] J.P. Shah, J.V. Danoff, M.J. Desai, S. Parikh, L.Y. Nakamura, T.M. Phillips, L.H. Gerber, Biochemicals associated with pain and inflammation are elevated in sites near to and remote from active myofascial trigger points, Arch. Phys. Med. Rehabil. 89 (2008) 16–23.

[17] E.C. Yap, Myofascial pain: an over view, Ann. Acad. Med. Singap. 36 (2007) 43–48.

[18] D.G. Simons, J.G. Travel, Myofascial Pain Dysfunction and Pain, second ed., 2001.

[19] D.G. Simons, New views of myofascial trigger points: etiology and diagnosis, Arch. Phys. Med. Rehabil. 89 (2008) 157–159.

[20] D.J. Alvarez, P.G. Rockwell, Trigger points: diagnosis and management, Am. Fam. Physician 65 (2002) 653–660.

[21] Retrieved, Fibromyalgia Tender Points Identified by The American College of Rheumatology in 1990, May 25, 2008.

[22] M. Imamura, D.A. Cassius, F. Fregni, Fibromyalgia: from treatment to rehabilitation, Eur. J. Pain 3 (2009) 117–122.

[23] J. Dommerholt, O. Mayoral del Moral, C. Grobli, Trigger point dry needling, J. Man. Manip. Ther. 14 (2006) 70–87.

[24] L. Tekin, S. Akarsu, O. Durmus, E. Cakar, U. Dincer, M.Z. Kiralp, The effect of dry needling in the treatment of myofascial pain syndrome: a randomized double-blinded placebo-controlled trial, Clin. Rheumatol. 32 (2013) 309–315.

[25] L.H. Gerber, J. Shah, W. Rosenberger, K. Armstrong, D. Turo, P. Otto, J. Heimur, N. Thaker, S. Sikdar, Dry needling alters trigger points in the upper trapezius muscle and reduces pain in subjects with chronic myofascial pain, PM R 7 (2015) 711–718.

[26] E.A. Tough, A.R. White, T.M. Cummings, S.H. Richards, J.L. Cambell, Acupuncture and dry needling in the management of myofascial trigger point pain: a systematic review and meta-analysis of randomised controlled trials, Eur. J. Pain 13 (2009) 3–10.

[27] L. Liu, Q.M. Huang, Q.G. Liu, G. Ye, C.Z. Bo, M.J. Chen, P. Li, Effectiveness of dry needling for myofascial trigger points associated with neck and shoulder pain: a systematic review and meta-analysis, Arch. Phys. Med. Rehabil. 96 (2015) 944–955.

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

[29] R. de A. Venancio, F.G. Alencar, C. Zamperini, Different substances and dry-needling injections in patients with myofascial pain and headaches, Cranio 26 (2008) 96–103.

[30] M. Gleitz, K. Hornig, Trigger points-diagnosis and treatment concepts with special reference to extracorporeal shockwaves, Orthopade 41 (2012) 113–125.

[31] P. Romeo, V. Lavanga, D. Pagani, V. Sansone, Extracorporeal shock wave therapy in musculoskeletal disorders: a review, Med. Princ. Pract. 23 (2014) 7–13.

[32] M. Kraus, E. Reinhart, H. Krause, J. Reuther, Low energy of extracorporeal shockwave therapy (ESWT) for treatment of myogelosis of the master muscle, Mund Kiefer Gesichtschir 3 (1999) 20–23.

[33] C. Ottoman, B. Hartmann, J. Tyler, H. Maier, R. Thiele, W. Schaden, A. Stojadinovic, Prospective randomized trial of accelerated re-epithelization of skin graft donor sites using extracorporeal shock wave therapy, J. Am. Coll. Surg. 211 (2010) 361–367.

[34] J.D. Rompe, C. Hope, K. Küllmer, J. Heine, R. Bürger, Anlagesic effect of extracorporeal shock-wave therapy on chronic tennis elbow, J. Bone Jt. Surg. Br. 78 (1996) 233–237.

[35] J. Hausdorf, M.A. Lemmens, K.D. Heck, N. Grolms, H. Korr, S. Kertschanska, H.W. Steinbusch, C. Schmitz, M. Maier, Selective loss of unmyelinated nerve fibers after extracorporeal shockwave application to the musculoskeletal system, Neuroscience 155 (2008) 138–144.

[36] H. Muller-Ehrenberg, G. Licht, Diagnosis and therapy of myofascial pain syndrome with focused shock waves, MOT 5 (2005) 1–5.

[37] J.H. Jeon, Y.J. Jung, J.Y. Lee, J.S. Choi, J.H. Mun, W.Y. Park, C.H. Seo, K.U. Jang, The effect of extracorporeal shock wave therapy on myofascial pain syndrome, Ann. Rehabil. Med. 36 (2012) 665–674.

[38] H.M. Ji, H.J. Kim, S.J. Han, Extracorporeal shock wave therapy on myofascial pain syndrome of upper trapezius, Ann. Rehabil. Med. 36 (2012) 675–680.

[39] Y.S. Cho, S.J. Park, S.H. Jang, Y.C. Choi, J.H. Lee, J.S. Kim, Effects of combined treatment of extracorporeal shock wave therapy (ESWT) and stabilisation exercises on pain and functions of patients with myofascial pain syndrome, J. Phys. Ther. Sci. 24 (2012) 1319–1323.

[40] A. Moghtaderi, S. Khosrawi, F. Dehghan, Extracorporeal shock wave therapy of gastroc-soleus trigger points in patients with plantar fasciitis: a randomised, placebo-controlled trial, Adv. Biomed. Res. 3 (2014) 99.

[41] A. Gür, I. Koca, H. Karagüllü, O. Altindag, E. Madenci, A. Tutoglu, A. Boyaci, M. Isik, Comparison of the effectiveness of two different extracorporeal shock wave therapy regimens in the treatment of patients with myofascial pain syndrome, Arch. Rheumatol. 29 (2014) 186–193.

[42] S.F. Carville, S. Arendt-Nielsen, H. Bliddal, F. Blotman, J.C. Branco, D. Buskila, J.A. Da Silva, B. Danneskiold-samsøe, F. Dincer, C. Henriksson, E. Kosek, K. Longley, G.M. McCarthy, S. Perrot, M. Puszczewicz, P. Sarzi-Puttini, A. Silman, M. Späth, E.H. Choy, EULAR evidence-based recommendations for the management of fibromyalgia syndrome, Ann. Rheum. Dis. 67 (2008) 536–541.

[43] S. Ramón, L. Hernández, A. Gomez-Centeno, O. Ares, M. Garcia-Manrique, E. Morales, F. Vidiella, R. Cugat, Radial extracorporeal shockwave therapy in fibromyalgia, in: 17th International Congress of the International Society for Medical Shockwave Treatment. Milan, 2014.