Use of Radial Extracorporeal Shock-Wave Therapy for Musculoskeletal Pain for daily practice: 1,580 Cases

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Abstract

Background: Musculoskeletal pain is a quite common, benign, nonfatal condition that is the second leading cause of years lived with a disability worldwide. Despite all efforts, it continues to be a challenging public health problem, because the solutions currently available are complex or are of limited effectiveness, which makes them difficult to adopt. That situation perpetuates suffering and treatment seeking, as well as increasing the health care costs and burden associated with such pain.

Therefore, new treatment options need to be tested and the interest in shock waves is growing, especially in places with few resources, with difficult access to medications and in countries where there is a need for new therapeutic options due to the opioid crisis.

Methods: This was a retrospective observational study of 1,580 patients with musculoskeletal pain who underwent two weekly sessions of radial extracorporeal shock-wave therapy.

Results: We found that the therapy tested decreased pain by 62.50% ($P < 0.0001$), with a high (91.59%) success rate and a low (2.1%) rate of pain worsening (2.1%). The effect was greatest for myofascial pain in the hip or shoulder ($P < 0.05$). Intense pain, myofascial pain (visual analogue scale score ≥ 70 mm), and high shock-wave frequency (≥ 15 Hz) correlated with best response.

Conclusions: It is possible to implement a radial shockwave service that, with just two doses, promotes rapid and effective analgesia for up to 7 days after the last dose, with a high success rate and a low rate of abandonment of treatment. Representing a response to the management of service overload and a non-drug alternative in the era of the opioid crisis.

Study registration: CAAE 51289115.2.0000.5463. Registered 7th October 2015 (prospectively registered).

Background

Musculoskeletal pain (MSP) is related to diseases that directly affect soft tissues [1]. It is limited to nociceptive aspects and excludes pain that is perceived in the musculoskeletal system but does not originate in it, such as the pain caused by nerve compression, as well as that resulting from organ dysfunction, metabolic diseases, immunological disorders, or infections [2]. There are approximately 200 well-recognized conditions that provoke MSP, including bursitis, tendinitis, osteoarthritis, and myofascial pain syndrome [3].

Because MSP rarely causes death and is often associated with aging, it has long been neglected [4]. It has become a major cause of years lived with disability and prolonged sick leave, thus overloading health care services [5]; it is estimated that the prevalence of MSP has increased in parallel with the aging of the population, as well as with the increasing rates of obesity and physical inactivity [6–9]. Despite various guidelines, there are few practical solutions to this serious public health problem [10], because the treatment strategies proposed have flaws and have been implemented inappropriately [11, 12]. Among

the many innovations emerging to meet this challenge, one that shows promise is radial extracorporeal shock-wave therapy (rESWT), which has been shown to control pain and facilitate tissue healing [13–15]. Shock waves are safe and fasten to relieving pain without the participation of the patient in a non-pharmacological way [16–19].

A therapeutic shock wave is a very intense, short-lived mechanical pulse (pressure) with an initial positive phase followed by a negative phase [20–23]. Such waves propagate in the form of three-dimensional concentric hemispheres, following the laws of acoustics [24], by changing the properties of the medium it reaches, in cycles of compression (positive phase) and decompression (negative phase) [25]. It generates pressure forces concentrated at the tissue interfaces (skin, subcutaneous, fascia, muscle, and bone) and more intensely in areas of greater structural density (trigger point, motor end plate, areas of inflammation, or calcifications) [26–29].

The shock wave propagates to a maximum depth of 4 cm and reflects as it hits solid obstacles [27]. The reflected wave collides with the next wave emitted, thus generating a wave with a flattened aspect near the shock-wave source, being known as a secondary wave [30]. By the laws of physics, these secondary reflected waves form bubbles [31], which collide and burst asymmetrically [32], creating jet streams that generate shear forces capable of activating the inflammatory system [19, 33]. The alternation between the compression and decompression cycles triggers biological processes of destruction and synthesis, which result in neovascularization and inflammation-induced repair [34–36].

Although the exact mechanism of how radial shock waves work in biological systems has yet to be elucidated [35], various studies (all with samples of fewer than 300 cases) have demonstrated that rESWT is efficacious in the treatment of diseases of the bones and tendons, with acceptable safety and a low incidence of side effects [31, 37–46]. However, there is a lack of large-scale studies on the routine use of this treatment [47].

The objective of this retrospective study was reveal the implementation of this treatment in the day-to-day use, quantifying the analgesic effect within the first week after treatment and identifying the predictors of an analgesic response to treatment.

Methods

Study Design And Participants

This was a retrospective observational analysis of the medical records of patients treated in the Department of Physical and Rehabilitation Medicine of Hospital do Servidor Público Estadual (a private service), in the city of São Paulo, Brazil, between October 2015 and July 2018. We included patients in which conventional rehabilitation treatment (postural training, ergonomic counseling, physical therapy, and stretching exercises) had failed and who had undergone two sessions of rESWT (one session a week for 2 weeks). The study was approved by the Research Ethics Committee of the Hospital (Reference no. 51289115.2.0000.5463).

Two researchers reviewed the medical records in order to identify those in which the patient data met the inclusion criteria: a physiatrist-reviewed diagnosis of MSP; gender; age; details of the diagnosis; duration of symptoms; and the Visual Analogue Scale (VAS) scores obtained before the first session and one week after the second session. Patients for whom the medical records were incomplete were excluded, as were those who had not completed treatment at the time of data collection.

Treatments

Although this was a retrospective study, the treatments were standardized, every rESWT session being performed with the same pneumatic (ballistic) shock-wave generator and the same 15 mm² applicator (Swiss DolorClast; EMS Electro Medical Systems, Nyon Switzerland). All sessions were performed on an outpatient basis and individually, in a closed room, and pain was always measured with the same VAS. The performing physician can select the number, frequency, and intensity of the pulses applied. Every one million pulses, the equipment underwent preventive maintenance, ensuring its durability, reliability, and smooth operation.

Evaluation Of Pain

The sample was stratified into 5 groups by the anatomical site of the pain—shoulder (caused by deactivation of shoulder trigger points, adhesive capsulitis, calcified tendinitis, or rotator cuff syndrome), hand/forearm (caused by de Quervain tenosynovitis, trigger finger, lateral or medial epicondylitis, tendinitis of the hand or forearm, pseudoarthritis, or deactivation of the trigger points in the hand or forearm), hip (caused by trochanteric bursitis, pseudarthrosis, or deactivation of the trigger points in the hip region), knee (caused by pes anserine bursitis, osteoarthritis, deactivation of the trigger points in the knee region, or the treatment for patellar tendinopathy), and foot (caused by plantar fasciitis, Haglund's deformity, Achilles tendinitis, bursitis of the Achilles tendon, tendinitis/enthesitis of the foot, metatarsalgia, or deactivation of the trigger points in the feet)—and into 2 groups by the type of pain—myofascial (related to bursitis, enthesitis, myofascial pain syndrome, or any form of tendonitis) and joint (related to any of the forms of osteoarthritis and pseudarthrosis).

The VAS scores were assessed immediately before the first session (designated the initial VAS scores) and at one week after the second session (designated the final VAS scores). On the basis of the VAS score, the pain was categorized as absent/mild (VAS < 40 mm), moderate (40 mm ≤ VAS < 70 mm), or severe (VAS ≥ 70 mm). A clinically significant (successful) result was defined as a reduction of more than 30% in relation to the initial VAS score, whereas worsening was defined as a final VAS score greater than the initial VAS score and treatment abandonment was defined as failure to attend either of the two rESWT sessions were not performed.

Statistical Analysis

The statistical analysis was performed with Stata software, version 15.0 for Windows (Stata Corp., College Station, TX, USA). Categorical variables are presented as absolute and relative frequencies, whereas continuous variables are presented as median with interquartile range (IQR) or as mean and standard deviation, depending on the results of the Shapiro–Wilk test for normality. The initial and final VAS scores are presented as medians and as means, in order to facilitate comparisons with the results of other studies.

The comparison between two quantitative variables (before and after treatment) was made by two-tailed Wilcoxon test, with a type II error of 0.05. For the analysis of the groups stratified by the site of the MSP, the Kruskal-Wallis test with Dunn's post-test was performed. Odds ratios were calculated, together with the respective 95% confidence intervals, after which we conducted Fisher's exact tests or chi-square tests, depending on the magnitude of the reduction in pain, to reveal the influence of each variable on treatment success. Clinical, demographic, and dosimetric variables were tested by stepwise multiple linear regression to identify the predictors of a response to treatment.

Results

We analyzed 1,800 medical records, 220 of which were excluded due to insufficient data. Therefore, the final sample comprised 1,580 medical records, and, consequently, data from 3,160 rESWT sessions were analyzed. Of those 1,580 medical records, 1,270 (80.33%) were for women and 310 (19.67%) were for men. As shown in Table 1, the median age was 60 years (IQR, 51–69 years) and the median duration of symptoms was 12 months (IQR, 6–30 months). The mean number of pulses applied in the rESWT sessions was 1983.0 ± 406.5 , at a mean frequency of 14.00 ± 2.05 Hz and a mean pressure of 2.5 ± 0.5 bar.

Table 1
Clinical Data and Type of Musculoskeletal Pain

Variable	(<i>N</i> = 1,580)
Age (years), median (IQR)	60 (51–69)
Female, median (IQR)	1,270 (80–33)
Male, median (IQR)	310 (19–67)
Duration of symptoms (months), median (IQR)	12 (6–30)
Initial VAS score (mm), median (IQR); mean $\pm$ SD	80.00 (60–90); 76.30 $\pm$ 23.50
Final VAS score (mm), median (IQR); mean $\pm$ SD	30.00 (0–50); 33.33 $\pm$ 26.66
Myofascial diseases	1,342 (84.9)
Joint diseases	239 (15.1)
Diseases of the shoulder*	330 (20.87)
Rotator cuff syndrome	141 (42.72)
Impingement syndrome	160 (48.48)
Diseases of the hand and forearm*	198 (12.52)
Trigger finger	28 (14.14)
Epicondylitis	108 (54.54)
Carpal tunnel syndrome	21 (10.60)
Diseases of the hip*	228 (14.42)
Trochanteric bursitis	82 (35.96)
Gluteal trigger point	88 (38.59)
Osteoarthritis of the hip	16 (7.01)
Diseases of the knee*	322 (20.37)
Osteoarthritis	116 (36.02)
Pes anserine bursitis	151 (46.89)
Patellofemoral pain syndrome	25 (7.76)

N, number of observations; SD standard deviation; IQR, interquartile range; VAS, visual analogue scale.

*Only the predominant diseases are listed.

Values are *n* (%) unless otherwise indicated.

Variable	(<i>N</i> = 1,580)
Diseases of the foot*	503 (31.82)
Plantar fasciitis	291 (57.85)
Achilles tendinitis	158 (31.41)
N, number of observations; SD standard deviation; IQR, interquartile range; VAS, visual analogue scale.	
*Only the predominant diseases are listed.	
Values are <i>n</i> (%) unless otherwise indicated.	

The median initial VAS score was 80 mm (IQR, 60–90 mm), and the median final VAS score was 30 mm (IQR, 0–50 mm), corresponding to a post-treatment reduction of 50 mm, which translates to a 62.5% reduction in relation to the initial pain score, a statistically significant difference according to the Wilcoxon test ($P < 0.0001$), as shown in Fig. 1. Analgesia was successfully achieved in 1,448 (91.59%) of the 1,580 cases. The rate of treatment abandonment was 5.02% (79 patients), and the MSP worsened in 33 (2.1%) of the cases in the sample. For all five of the strata by site (shoulder, hand/forearm, hip, knee, and foot), the Wilcoxon test showed a statistically significant reduction in MSP ($P < 0.0001$ for all), as shown in Table 2.

Table 2
Evolution of Musculoskeletal Pain, by Site

Site	<i>n</i> (%)	VAS Score		<i>p</i> *
		Initial	Final	
		Median (IQR)	Median (IQR)	
Shoulder	330 (20.87)	80.00 (70.00–97.5)	30.00 (0.00–50.00)	< 0.0001
Hand/forearm	198 (12.52)	72.50 (60.00–80.00)	30.00 (0.00–50.00)	< 0.0001
Hip	228 (14.42)	80.00 (70.00–100.00)	30.00 (0.00–50.00)	< 0.0001
Knee	322 (20.37)	77.18 (70.00–90.00)	30.00 (20.00–60.00)	< 0.0001
Foot	502 (31.82)	80.00 (60.00–90.00)	30.00 (10.00–50.00)	< 0.0001
N, number observations; VAS, visual analogue scale; IQR, interquartile range.				
*Wilcoxon test.				

Our comparison between the initial and final VAS scores showed statistically significant reductions in MSP in the myofascial and joint pain groups ($P < 0.001$ for both). The comparison between the joint and myofascial groups was based on the initial VAS analysis of both groups using the Wilcoxon test, which revealed no statistical difference for pain intensity before treatment ($P = 0.903$); that is, the patients in

both groups started treatment with the same level of pain intensity, as shown in Table 3. One week after the second (last) rESWT session, the final VAS analysis of those two groups showed that there was a statistically significant difference ($P < 0.001$), the reduction in pain being greater in the myofascial group, as can also be seen in Table 3.

Table 3
Comparisons Between the Pre-Treatment and Post-Treatment Periods,
by the Type of Musculoskeletal Pain, in Terms of the Intensity of the
Pain

Variable	Joint Pain	Myofascial Pain	p^*
	Median (IQR)	Median (IQR)	
Initial VAS score	80 (70–90)	80 (65–90)	0.903
Final VAS score	40 (20–60)	30 (10–50)	< 0.001
P^*	< 0.001	< 0.001	
Abbreviations: IQR, interquartile range; VAS, visual analogue scale.			
*Wilcoxon test.			

The analysis of odds ratios, followed by Fisher's exact test, comparing the analgesic success outcome with the variables age, type of MSP, initial VAS score, duration of symptoms, and rESWT dosimetry, as categorized in Table 4, demonstrated that patients with severe initial pain are twice as likely to achieve significant analgesia as are those with lower initial pain levels. In terms of the dosimetry, we found that the patients who received high-frequency rESWT were 1.7 times more likely to improve than were those receiving low-frequency rESWT. In addition, higher pressures (≥ 3 bar) were associated with a 1.5 times greater chance of success compared with lower pressures (< 2 bar). Furthermore, as shown in Table 5, the possibility of achieving statistically significant analgesia was 1.5 times greater in the myofascial pain group than in the joint pain group.

Table 4

Categorization of the Variables Age, Duration of Symptoms, and Dosimetry (Pulse Frequency, Number, and Pressure) used in the Odds Ratio Analysis

Variable	Group	Criteria	Reference Values
Age	Adult	From 5% of the observations up to the 1st quartile (25%)	39–51 years of age
	Elderly	From the 3rd quartile (75%) up to 95% of the observations	69–79 years of age
Duration of symptoms	≤ 6 months	From 5% of the observations up to the 1st quartile (25%)	< 6 months
	> 24 months	From the 3rd quartile (75%) up to 95% of the observations	≥ 24 months
Dosimetry	Frequency (Hz)	High dose: cases above the 3rd quartile (75%)	≥ 15 Hz
		Low dose: cases below the 1st quartile	< 13 Hz
	Pulses per session	High dose: cases above the 3rd quartile (75%)	≥ 2,000 pulses/session
		Low dose: cases below the 1st quartile	< 1,800 pulses/session
	Pressure (bars/session)	High dose: cases above the 3rd quartile (75%)	≥ 3 bar
		Low dose: cases below the 1st quartile	< 2 bar
Categorization of the variables age, duration of symptoms, and dosimetry (pulse frequency, pulses per session, and pressure) used in the odds ratio analysis.			

Table 5
Univariate Analysis of the Probabilities of Success of Radial Extracorporeal Shock-Wave Therapy

Variable	Categorization	OR*	95% CI	<i>p</i> *
Initial pain intensity	Severe vs. moderate/mild	2.00	1.40–2.80	< 0.001
	Moderate vs. mild	1.60	0.70–3.20	0.152
Gender	Male vs. female	1.10	0.70–1.70	0.565
Age group	Elderly vs. Adult	0.60	0.30–1.00	0.038
Duration of symptoms	≤ 6 months vs. > 24 months	1.30	0.80–2.10	0.218
Dosimetry	High vs. low frequency	1.70	1.20–2.50	< 0.001
	High vs. low number of pulses	1.20	0.80–1.80	0.013
	High vs. low pressure	1.50	1.00–2.50	< 0.001
Site of MSP	Shoulder vs. hip	1.30	0.78–2.47	0.227
	Shoulder vs. knee	1.60	0.98–2.75	0.047
	Shoulder vs. foot	1.20	0.74–1.97	0.441
	Hip vs. knee	1.10	0.69–2.13	0.535
	Hip vs. foot	0.80	0.52–1.44	0.541
	Knee vs. foot	0.70	0.47–1.14	0.148
Type of MSP	Myofascial vs. joint	1.5	1.04–2.40	0.04
MSP, musculoskeletal pain; OR, Odds Ratio; *Fisher's exact test.				

As can be seen in Table 6, the stepwise multiple regression analysis showed that the positive predictors of a response to rESWT were a higher initial VAS score and a higher pulse frequency. Having joint pain (as opposed to myofascial pain) was found to be a negative predictor of response.

Table 6

Multiple Regression Analysis of Pre-Treatment Pain Intensity, Pulse Frequency, and Joint Pain as Predictors of a Response to Radial Extracorporeal Shock-Wave Therapy

Variable	Coefficient β	Standard Error	<i>P</i>	95% CI	Result
Initial VAS score	-0.67	0.04	< 0.001	-0.74 to - 0.59	
Pulse frequency	-0.13	0.04	< 0.001	-0.21 to - 0.06	$r^2 = 0.22$
					$r^2 \text{ adj} = 0.22$
					$P^* < 0.001$
Joint MSP	0.71	0.21	0.001	0.31 to 1.12	
CI, confidence interval; VAS, visual analogue scale; MSP, musculoskeletal pain; r^2 , coefficient of determination; adj, adjusted; P^* , model <i>P</i> -value.					

Discussion

In the present study, we identified severe myofascial MSP (VAS score ≥ 70 mm) and the use of high-frequency shock waves as positive predictors of rESWT response. To our knowledge, this is the first study to address the predictors of a response to rESWT. Intense pain limits the use of kinetic therapy, and controlling it quickly is a way of preparing the patient for exercises that will modify the biomechanical factors that cause or amplify pain. This study demonstrates that rESWT is effective in reducing pain in a short time and can be used as the first-line analgesic intervention in musculoskeletal rehabilitation programs.

In a study conducted in 2017, Hong et al. [48] achieved a 48.0 mm reduction in the VAS score with three sessions of focal shock wave therapy in lumbar myofascial pain syndrome and a 29.3 mm reduction in the mean VAS score with trigger point injection. Another study on the treatment of trapezoid myofascial pain with focal shock waves reported a reduction of 26.4 mm in relation to the mean initial VAS score after four sessions [49]. Comparatively, our study demonstrated that rESWT is superior to focal shock wave therapy and trigger point injection, because rESWT, which is noninvasive, reduced the mean VAS score by 43 mm with fewer sessions over a similar period using a more affordable radial ballistic pneumatic device than the focal device used in the two studies cited above. Given that there is still no evidence of any advantages of focal generators over radial generators [48–50], the present study contributes to leading health care facilities to prefer, for reasons of cost and access, pneumatic radial ballistic equipment for analgesia in patients with MSP.

A study comparing rESWT with therapeutic ultrasound showed that four sessions of rESWT at 2,000–3,000 pulses/session, a pressure of 1.60–3.00 bars, and a frequency of 10 Hz reduced the VAS score by 15.3 mm, compared with only 10.7 mm for therapeutic ultrasound [51]. In another study, involving patients with shoulder tendinitis, seven sessions of rESWT, with a mean pressure of 1.70 bar, mean

frequency of 5 Hz, and mean of 2,175 pulses/session, resulted in a 26 mm reduction in the VAS score [52]. The fact that we achieved greater reductions using the same type of generator, with fewer pulses/session, higher pressures, and higher frequencies is likely attributable to the last (the higher frequencies).

The fact that the rESWT device employed in the present study must be serviced every one million pulses is important for the organization of health care facilities. If the dose is the same as that employed in our study (1,800 pulses/session), with a single service protocol, a larger number of patients can be served and the analgesic effect can be greater, thus reducing the direct and indirect costs, as well as increasing access to the treatment.

Although the present study did not involve the use of a placebo or control group, a review of the literature based on articles cited in systematic reviews and meta-analyses showed that, for the pathologies included in this study, placebo effects accounted for a 25–35% reduction in pain, as measured by VAS [53–56]. Despite its design, our study showed that rESWT promoted effective analgesia greater than any placebo effect reported recently in the literature.

Regarding the frequency of rESWT application, our findings are in line with explanations of the mechanical and chemical effects of the treatment. According to the literature, rESWT evokes dose-dependent histological reactions related to mechanotransduction phenomena—the conversion of mechanical stimuli into biochemical and biological signals [32, 36, 37, 57]. Higher frequencies increase the cycles of tissue compression and decompression, forming more cavitation bubbles that are implicated in the signaling that promotes mechanotransduction and the consequent biological effects, providing greater pain reduction [58–61].

One common feature of all pressure waves occurs when the energy displacement encounters an obstacle presenting resistance to its propagation [32]. Every tissue interface (skin, fascia, muscle, or bone) or higher density structure (motor plate, myofascial trigger point, inflammation or calcification) functions as a reflective surface [21]. The shock wave emitted by the equipment propagates towards the focus to be treated and thus undergoes increased reflection in these areas. The encounter between the next emitted wave and the reflected wave generates a secondary wave of greater intensity than the incident wave [19]. Thus, increasing the frequency of pulse firing increases the number of these secondary waves, resulting in a greater number of cavitations [20, 23] and thus a greater therapeutic effect, precisely in the areas related to pain and analgesia, explaining the fact that the higher frequency used in our study increased the magnitude of the analgesic effect in comparison with that obtained with low frequencies by other authors [51, 52].

Radial shock waves present less penetration, and cavitations are therefore concentrated closer to the emitting source, presenting no propagation to act in deep structures [23]. Thus, its analgesic effect in joint diseases, which require greater shock wave penetration, is inadequate, which is consistent with our finding of lower analgesic effect in our joint pain group [23, 25].

Although still speculative, other researchers have concluded that rESWT produces a series of reactions such as increased capillary blood flow at the site of application, decreased muscle tension, reduced substance P [28], and, especially important for our study, direct suppression of pain receptors [26, 62], which explains the fact that higher initial VAS scores correlated with greater treatment success. Greater pain increases the number of active nociceptors that increase local density and act as a reflective surface that generates more cavitations and a greater therapeutic effect. In addition, rESWT mechanically inhibits the nociceptors, generating immediate analgesia and minimizing pain afferents to the central nervous system [59, 63].

Although the mechanism involved in MSP analgesia by rESWT remains uncertain, studies show that the series of events triggered by the energy also promote the process of repair and regeneration of muscle, tendon, and bone in the target area [19, 44, 61, 65]. Regeneration is a challenge for modern medical science, and basic research has provided evidence of the potential of rESWT to stimulate regenerative activity. Studies have shown increased collagen synthesis and maturation, resulting in a more resilient scar [14, 43, 47, 50, 64].

Because rESWT is a physical therapy, the biological responses will be similar, regardless of the pathology or disease being treated, as reported in studies related to the neovascularization induced by this treatment in other conditions such as ischemic cardiomyopathy [66]. The present study, based on the biological effect already demonstrated in other areas of medicine, grouped together a large number of diseases of the musculoskeletal system and showed that rESWT promotes analgesia, regardless of the anatomical site of the pain, patient gender, patient age, the duration of symptoms, the rESWT pressure, or the number of rESWT pulses per session.

This study proved that rESWT provides analgesia that is efficacious for at least one week after the end of treatment, which is important for patient well-being and for the prevention of chronicity (conceptually, all chronic pain was once acute). Although the rate of treatment abandonment was low in our study, it was not possible to identify the cause—whether due to improvement or worsening of symptoms, or to other reasons such as transportation difficulties or the treatment schedule.

Musculoskeletal pain is treated, regardless of cause or location, mainly in overburdened health services, in the same way: patients receive analgesics, anti-inflammatory drugs or opioids for up to 7 days. This work proposes the use of radial shock waves as a technique to promote analgesia quickly, effectively, in a non-invasive way, in which two doses are sufficient to give analgesia to the patient for up to 1 week after the end of treatment. Representing a response to manage the overload of services and the opioid crisis.

Limitations

Our study has some limitations. The most important limitation was the study design. The fact that it was a retrospective analysis without an active control group, placebo, or randomization, as well as with a short follow-up period, significantly reduced its power. Another relevant issue would be the possible placebo effect related to therapy since the study was not randomized and controlled. Studies evaluating

pain of any kind (including cardiac pain), whether related to pharmacological or mechanical therapies, are known to be prone to a placebo effect.⁶⁴ The existence of a control group would require a “placebo” shock wave applicator, which would make this study impossible, as it would be impossible for São Paulo State Hospital for Civil Servants not to employ this device, because it is exclusively a treatment facility.

We recognize that an active control compared with conventional treatment or other therapies could help determine whether the predictors highlighted in this study were present in other treatments or situations.

Another limitation is the lack of information on prior patient pain data, such as previous or current treatments, and the lack of knowledge of medications being used. Although data on previous attempts to treat pain were not systematically collected, one of the prerequisites for rESWT was the failure of conservative or conventional therapies.

Strengths

This was a study on the science of everyday life, which uses retrospective data on the care provided at a rehabilitation facility revealing a potential panorama for improving individual health and management processes. Our findings categorize the nonpharmacological treatment rESWT as effective, providing data that guide its best indication and the dosimetry to be applied. In addition, it demonstrates the role of frequency in therapeutic success, a feature previously linked to patient comfort and tolerance, although we have demonstrated its importance in therapeutic application; that is, it is a button on the equipment that should not be overlooked.

Conclusions

Two rESWT sessions, one week apart, promote pain relief, regardless of the site of the pain, with a high success rate and low rates of treatment abandonment and worsening. The best results are obtained in myofascial MSP patients who report high pain intensity and are treated with high-frequency radial shock waves.

Therefore, the best responders would be patients with severe pre-treatment myofascial MSP (initial VAS score ≥ 70 mm) treated with high-frequency pulses (≥ 15 Hz).

Abbreviations

MSP: Musculoskeletal pain (MSP); rESWT: radial extracorporeal shock-wave therapy; VAS: Visual Analogue Scale; IQR: Interquartile Range; VAS-I: Initial Visual Analogue Scale; VAS-F: Final Visual Analogue Scale; N: number of observations; SD: Standard Deviation; OR: Odds Ratio; CI: Confidence Interval

Declarations

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Authors' contributions

ATS – study concept and design, data collection, analysis, interpretation of data, drafting manuscript and submission; MCL – acquisition of data, data analysis and interpretation of data; MSCMO – acquisition of data and support with the medical records; CDB – data analysis and interpretation of data, drafting manuscript, final approval; The author(s) read and approved the final manuscript.

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Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study was approved by the Research Ethics Committee of the Institute of Medical Assistance to the State Civil Servant of São Paulo – Ref - number CAAE 51289115.2.0000.5463 on October 7, 2015. There was no consent to participate, as this is a retrospective study based on the analysis of medical records, without patient contact.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests

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Figures

Figure 1

Comparative analysis of the initial and final visual analogue scale scores (VAS-I and VAS-F, respectively).

*Wilcoxon test.