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Current evidence of extracorporeal shock wave therapy (ESWT) in soft tissue disorders

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Abstract: *Objective*. To assess the current evidence of extracorporeal shockwave therapy (ESWT) for patients with soft tissue disorders. This form of treatment involves ballistic shock waves, generated by a piezoelectric, electromagnetic or electrohydraulic source. *Methods*. This was a systematic review designed in accordance with the Preferred Reporting Items for Systematic Reviews. We identified relevant studies by searching multiple electronic databases, relevant publications in English from 2010 to 2024. Two levels of screening were applied. During the first screening, titles and abstracts were reviewed and irrelevant studies were excluded. For the second screening, full-text articles were reviewed using predetermined inclusion and exclusion criteria. *Results*: The electronic database search resulted in 391 articles. After removing duplicates (47), abstract articles (92), articles that did not meet eligibility criteria (154), and those that had poor design or provided inconclusive information for our study (68), we included a total of 30 studies in this review. The results showed that ESWT has a beneficial effect in soft tissue disorders by reducing pain and is recommended when other non-surgical therapies have failed. *Conclusion:* ESWT can play an important role in the treatment of soft tissue conditions, if there are appropriate indications, unitary treatment protocols that are correctly applied and reproducible.

Keywords: systematic review, musculoskeletal disorders, pain relief, non-invasive therapy

1. Introduction

Extracorporeal shock wave therapy (ESWT) is a non-invasive procedure that was used for the first time in 1960 when the idea emerged to generate shock waves extracorporeally and to transmit them into the body to disintegrate kidney stones and gallstones. The first successful stone fragmentation was performed by Professor Christian Chaussy in Munich, in 1980. In the years since, shock waves have been increasingly used for a range of other medical conditions [1].

This form of treatment involves ballistic shock waves, generated by a piezoelectric, electromagnetic or electrohydraulic source [2].

ESWT is characterized by high positive pressures of more than 500 bar, which can be developed in less than 10 nanoseconds (cycle < 10ms), the frequency being between 16 Hz and 20 MHz. The effects of ESWT are multiple and include: stimulation of cellular metabolism and microcirculation, increased cellular permeability, fragmentation and resorption of calcium deposits. Depending on the energy used, ESWT can be: low energy (<0.08 mJ/mm^2), medium (0.08-0.28 mJ/mm^2), and high energy (>0.28 mJ/mm^2), respectively. The pulse duration of the shock wave is extremely short (3 to 5 μs) and is generated at low frequencies, it is minimally absorbed by the tissues and, therefore, no adverse effects were reported [2].

Recently, radial extracorporeal shock wave therapy (rESWT) has been developed, in which the maximum pressure is reached in the first second of the session because the pressure field is divergent. Unlike the classic version of ESWT in which the effect was focused, the device acting in depth, in the case of rESWT, the effect is radial, acting superficially [3, 4].

Several theories on the mechanism of action of ESWT have been described. Some studies show that the emitted pulsations act on the central nervous system, causing changes in the permeability of cell membranes, inhibiting the transmission of painful stimuli, which causes a decrease in pain intensity. Other studies claim that ESWT causes the reactivation of regeneration potential by bombarding soft tissues [5].

Although the main effect of ESWT is pain reduction, the exact mechanisms leading to this effect are not fully understood.

Some studies suggest that ESWT destroys nerve endings. It has also been suggested that it acts on nociceptors, which, by emitting nerve impulses at high frequencies, cause a so-called pain modulation in an inhibitory sense (gate control theory). Another hypothesis is that it alters the chemical environment around nociceptors, disrupting pain transmission. It has also been suggested that a locally generated hyperaemia enhances the degradation of the inflammatory mediators, which reduces the irritation of nerve endings and therefore reduces pain [6].

In the years since, shock waves have been increasingly used for a range of medical conditions. Today, extracorporeally generated shock waves are used as a pain relief modality for various musculoskeletal conditions, including calcifying tendonitis, epicondylitis, frozen shoulder, sacroiliac joint pain, low back pain, knee tendinopathies, Achilles tendinopathy and plantar fasciitis [7-10].

However, ESWT is contraindicated in patients with pacemakers, cochlear implants, defibrillators or growth stimulators, as well as in patients on anticoagulant therapy. It is also contraindicated in patients with respiratory insufficiency, arterial diseases, coagulation disorders, hemophilia or those who are at risk of bleeding. Acute inflammations, pregnancy, varicose veins, neoplasias, deep vein thrombosis are other contraindications to this therapy. Neither ESWT nor rESWT is performed directly on the carotid sinus, vagus nerve, or cervical ganglia.

This systematic review aimed to reveal the current clinical applications of ESWT and its mechanisms of action in different musculoskeletal disorders.

2. Materials and Methods

The research was conducted based on the PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) [11].

2.1. Search Strategy

A literature search was carried out, using PubMed, Scopus, Web of Science, and Google Scholar databases from 2010-2024.

A first search addressed the key terms ”shock wave therapy”, ”shockwave”, ”extracorporeal shock wave therapy”, soft tissue condition and soft tissue disorders,

Based on the outcome of the first search, a second search was performed on the key terms ”plantar fasciitis”, ”lateral epicondylitis”, ”frozen shoulder” and ”Achilles tendinopathies”.

2.2. Eligibility Criteria

In this review, we considered several eligibility criteria that influenced its robustness and applicability.

Studies were selected based on the following *inclusion criteria*: (1) the article was available in English (title, abstract, and full text); (2) study design: randomized controlled trial, clinical trials, patients: patients diagnosed with soft tissue disorders (fasciitis, epicondylitis, tendinitis, tendinopathies), (4) intervention: extracorporeal shock wave therapy alone or in combination with other procedures;

Exclusion criteria were as follows: (1) if they discussed topics not related to our search terms; (2) case series, case reports, protocols, poster presentations, conference abstracts, editorials, reviews, meta-analyses, and animal or experimental research; (3) studies failed to meet the inclusion criteria; and (4) studies without usable data

2.3. Study Selection and Data Extraction

All the titles and abstracts of the articles were collected from the four databases. After filtering the articles by titles and abstracts, the full texts of the articles that met the inclusion criteria were reviewed.

After a full reading of the texts, the articles that did not meet the inclusion criteria were removed, as it can be seen in Figure 1. After selecting the most relevant studies for this review, the following data were extracted from each article: article authors, sample (n, sex, age), research design, condition, intervention, outcome, pulses and energy (density/pressure). After having collected all the information from each study included in this review, the studies were classified according to the findings they presented into four findings: plantar fasciitis, lateral epicondylitis, frozen shoulder or calcifying tendinitis of the shoulder and Achilles tendinopathies.

The assessment of the studies was done independently by two blinded reviewers. Two levels of screening were applied. During the first screening, titles and abstracts were reviewed and irrelevant studies were excluded. For the second screening, full-text articles were reviewed using predetermined inclusion and exclusion criteria.

Disagreements between them were resolved by the team's discussions with the corresponding author.

The selection method of the articles included in our study is shown in Figure 1.

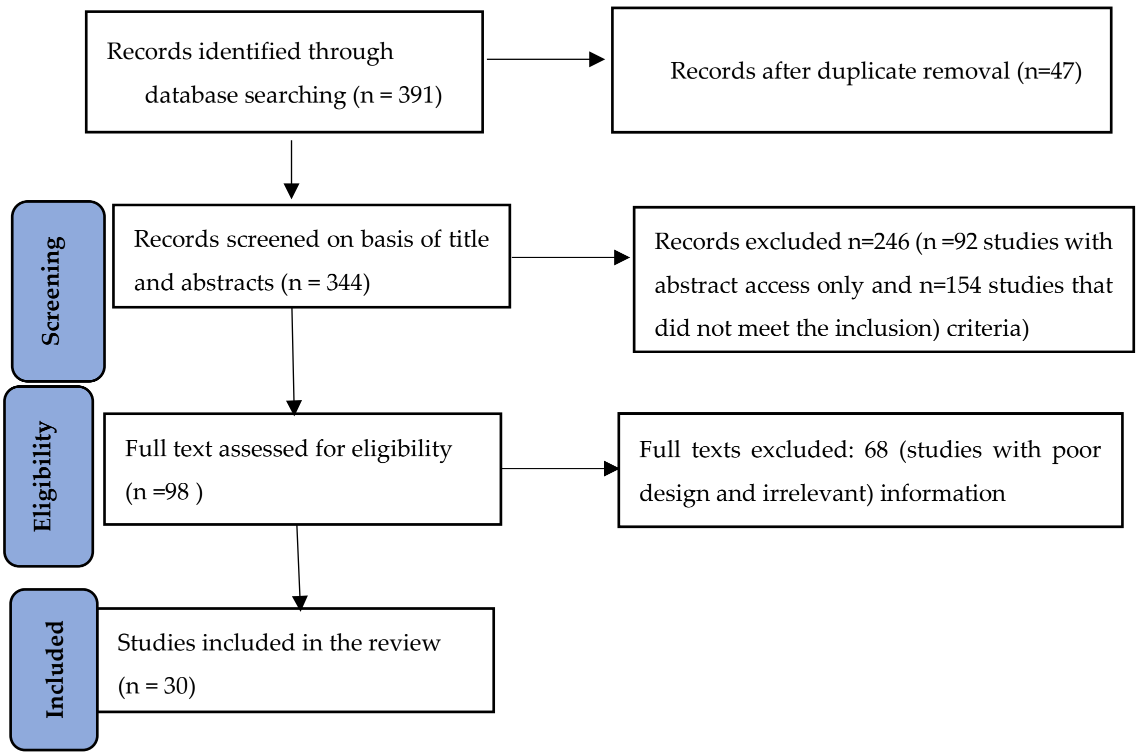

Figure 1. PRISMA article selection scheme

3. Results

The search of the above mentioned electronic databases resulted in 384 articles. After having removed the duplicates, 357 titles and abstracts were assessed for eligibility criteria. Among them, only 78 studies did meet the inclusion and exclusion criteria (Figure 1). After having readthe full text of the remaining articles, 57 were excluded and a total of 21 studies were included in this review.

4. Discussions

Clinical Applications

4.1. Plantar Fasciitis

The treatment of plantar fasciitis involves a series of procedures such as: exercise, stretching, ice massage, drug treatment (NSAIDS, steroids), and surgery. However, the beneficial effect of ESWT in pain reduction has also been found [10].

There are data in the literature that support the use of ESWT in plantar fasciitis, and there are a number of benefits compared to surgery, namely: good effectiveness, shortening of the convalescence period, with subsequent resumption of activity, being a non-invasive method of treatment (with beneficial effects in the case of athletes). The use of this method is recommended when non-surgical therapy has failed [12, 13].

Thus, Noktehsanj R. et al (2020) investigated the effectiveness of this method, in case of its association with the NSAIDS treatment, in plantar fasciitis, showing a reduction in pain, with a significant reduction in VAS (Visual Analogue Scale) values after 8 weeks of treatment. In this case, ESWT consisted of 5 sessions, at an interval of 72 hours, with a pressure of 2 bar, with 2000 SW[14].

Also, the use of low ESWT in combination with stretching exercises has improved the symptoms of patients with plantar fasciitis, as shown by Rompe J.D. et al.[15].

On the other hand, in a 2024 pilot study, Kallani F.A.L. et al. highlighted the reduction of pain level and function improvement in patients with plantar fasciitis treated with ESWT with a high frequency of 15 Hz (intensity 3, 1800 pulses), and with a frequency of 14 Hz (intensity 4, 1800 pulses), the results being better in the group of patients treated with ESWT with increased frequency and low intensity. The ESWT treatment was combined with stretching exercises for the plantar fascia, and the gastrocnemius and soleus muscles, done at home, which continued even after the end of the treatment, to consolidate the results obtained.[16]

Regarding the density and number of ESWT sessions needed to treat pain, fatigue, disability, and physical function, and to improve the quality of life of patients with plantar fasciitis, a recent study revealed an increased effectiveness of a greater number of ESWT high-energy density treatment sessions on pain, disability, and functional status of these patients. It was also highlighted that high-energy ESWT has a more important role than the number of ESWT sessions in treating these patients, without observing any local effect. [17]

Effective use of ESWT is in amateur runners with plantar fasciitis. ESWT (1000 beats/min, power density of 0.25 mJ/mm^2) reduces the intensity and frequency of pain at rest while walking, and during recreational activities, improving the daily and recreational activity of these athletes. However, better results were obtained in runners who previously received other treatment procedures, the effect being visible later than in runners who did not previously receive any treatment.[18]

The effect of ESWT appears to be due to the destruction of non-myelinated sensory nerve fibers, neovascularization, and collagen synthesis in affected tissues [10, 14]. At the same time, ESWT-induced functional proteins cause anti-inflammatory, chondroprotective, anti-apoptotic, and regenerating effects of the damaged tissues, along with stimulating the formation of new capillaries [19].

ESWT performs a mechanical stimulation of the tissue, driven by pulse acoustic waves that cause biochemical changes in the target tissue, stimulating its regeneration [8, 20], with the production of proteins, NO and specific growth factors [8].This results in the appearance of neoformation capillaries, the proliferation of leukocytes and fibroblasts and the synthesis of collagen[8, 21, 22]. SW also promotes the regeneration of affected tissue, destruction of calcified deposits and increased permeability of the cell membrane [8, 23]. ESWT can reduce pain by altering nerve transmission of algoreceptors and hyperstimulating nociceptors. [9, 24]. Regarding the effect of ESWT on calcified deposits, there are several hypotheses that explain this, namely the fragmentation of calcified deposits caused by pressure waves, the cavitation effect given by ESWT [9], as well as the inflammatory response and leukocyte chemotaxiswith a role in phagocytizing these calcified deposits [9, 22].

4.2. Lateral epicondylitis (tennis elbow)

Lateral epicondylitis, also called tennis elbow, is a condition located in the elbow that affects the extensor muscles of the hand, which become inflamed and painful because of overuse or trauma. Symptoms can appear at any age, but studies show that the peak is between 45-54 years [25]. The treatment of epicondylitis can be non-surgical in most cases and surgical only exceptionally [26].

Non-surgical treatment varies in approach including: electrotherapy, exercise, ultrasound, phototherapy/laser, shock wave, taping, cryotherapy, corticotherapy, acupuncture, PRP, AIB, etc.

In recent years, radial or focused shockwave therapy is increasingly used to reduce pain and inflammation, but also to regenerate the affected structures [27, 28].

In most of the studies carried out in the last 15 years, the authors used to evaluate the subjects using the Visual analog scale (VAS), Upper extremity functional scale (UEFS)16 and health assessment questionnaire (HAQ)4, Hand grip strength and Roles and Maudsley score, DASH score.

Studies comparing the effectiveness of ESWT with that of conventional physiotherapy (hot packs, US, TENS, physical exercises, immobilization, etc.) have shown that there are no significant differences between the two therapeutic approaches. Altun et al (2018) studied 73 patients with epicondylitis, which they divided into 2 groups: 37 subjects participated in 10 daily conventional therapy sessions and 36 subjects did ESWT on the lateral epicondyle (15 Hz, 1.4–1.6 bar, 1500 shocks) and extensor muscles (21 Hz, 1.8 bar, 2000 shocks) weekly. The only difference observed between the two groups was at 6 weeks in the RMS scale assessment, when the control group patients had a better score [29].

But, combining ESWT with conventional physiotherapy, has superior effects in treating patients with lateral epicondylitis. This was proven by a recent study on a group of 116 patients with medial and lateral epicondylitis. ESWT therapy involved six sessions of 20 minutes, with a frequency of 15 Hz, 2.1 bars, 2000 pulses/session, and conventional physiotherapy involved 15 sessions of 20 minutes of Hotpacks, and 30 minutes of conventional TENS with 200 Hz, 10-30A, 100 pulses/session. The assessment involved pain (assessed using the VAS scale), and hand tightening force (assessed using the PFEQ – Patient Based Forearm Assessment Questionnaire). The results showed that ESWR combined with conventional physiotherapy produced positive clinical effects in patients with epicondylitis.[30]

Conventional therapies such as massage and cryotherapy were also compared with the ESWT intervention by Aldajah et al (2022). The researchers concluded that the use of ESWT, 5 consecutive sessions, with 2000 shock waves of 1.6 bar intensity has positive effects on patients with epicondylitis by decreasing pain, improving the DASH score and grip strength [31]. Another study that discussed the effectiveness of therapies such as US, exercise, local corticoid injections, EWST, was conducted by Gündüz et al 2012. They followed the changes occurring ultrasonically in the injured area. It appears that there are no structural changes in the injured tissues although the VAS and Grip Strength scores are improved following the application of the therapies [32].

Another therapy used in the treatment of lateral epicondylitis is Cryoultrasound (Cryo-US), which has the ability to lower temperatures in the treated area and, in this way, vasoconstriction and local hypoxia are produced, which causes a reduction in pain and in inflammation. The comparison of the therapeutic effects of Cryo-US and ESWT in epicondylitis showed a greater effectiveness of ESWT in the long term, 6 to 12 months after treatment [33].

The therapeutic intervention with PBMT (Photobiomodulation) and ESWT was studied and compared. Both therapies aim to reduce pain and inflammation as well as to accelerate healing, Research results show that the VAS scale, Handgrip strength, DASH, MEPS (Mayo Elbow Performance Score, 12-Item Short Form (SF-12)) are improved without finding a difference between the results, but PBMT is a cheaper and more easily accepted therapy by patients [34]. However, when the specific assessment test for chronic epicondylitis (PRTEE test) was used, it showed that ESWT was more effective in chronic epicondylitis for reducing pain and improving function than using low-intensity laser [35].

Another therapeutic approach is to use of the local PRP injection. The study published in 2018 after a research carried out for 2 years (63 subjects) concluded that both US-guided autologous PRP injections and US-guided focal ESWT are two safe and effective methods in the case of chronic epicondylitis. However, PRP injection has a faster effectiveness in reducing pain [36].

Although ESWT therapy has favorable results in treating lateral epicondylitis, when compared with ozone therapy, the effects are less favorable. Thus, in a recent study, the effects of ESWT and injectable ozone therapy in reducing pain associated with chronic lateral epicondylitis were investigated in a group of 89 patients. The pain was assessed before and after treatments and at one, three, six, and nine months later, using Verhaar scores. ESWT was performed as a two-stage procedure (in the first stage, energy density was 0.348 mJ/cm^2, 5 Hz frequency, at 300 pulses, and in the second stage, 0.372 mJ/cm^2, 3.5 Hzand 1200 pulses), and ozone therapy involved a total of eight sessions at three-day intervals with subcutaneous doses of 5-20 μg. The results showed that although both ESWT and ozone therapy had pain-reducing effects from chronic lateral epicondylitis, ozone therapy resulted in significantly greater pain reduction at three and nine months post-treatment.[37]

ESWT therapy has also been compared with neural therapy in treating patients with lateral epicondylitis, both showing similar effects in reducing pain and improving hand function in these patients. Thus, in the study carried out by Atalay, S.G. and Gezginaslan Ő., which compared the effect of ESWT (three sessions at one-week intervals, with 2000 pulses, 1.9 bars, 10 Hz frequency, power between 00.08 to 0.28 mJ/mm^2) with neural therapy (injections with 0.5 mL Lidocaine HCL, intracutaneous, with a total of 16 mL), one session per week, for three weeks, in the treatment of patients with lateral epicondylitis. Both pain severity (assessed by the VAS scale) and functional disability (assessed by the DHI – Duruoz Hand Index) were reduced/respectively improved following the ESWT treatment and neural therapy, without significant differences between them.[38]

Since Kinesio taping (KT) has been increasingly used in recovery in recent years, it is appropriate to discuss this treatment option as well. Özmen et al in 2021 analyzed, clinically and sonographically, 40 subjects who completed 2 weeks of treatment. The subjects were divided into 3 groups: the first group had as treatment hotpack, TESN and US, for group two was applied hotpack, TENS and ESWT sessions (3 sessions), and the third group had hotpack, TENS and kinesio taping treatment (every 2 days) for fascial and muscle correction. In the case of all subjects, both at the end of the 2 weeks of treatment and at a distance of 6 weeks, a significant reduction in pain was observed, but in the group where kinesio taping was also applied, an improvement was also obtained in grip strength [39]. The superiority of treatment using kinesio tape over ESWT was also demonstrated by Guler and Yldirim (2020) in the case of acute/subacute lateral epicondylitis. Patients with kinesio tape treatment had better results on VAS, hand grip strength (HGS), RMS and Q-Dash, after 4 and 8 weeks [40].

There are also studies comparing ESWT with wrist splint immobilization. The evaluations made with the VAS and HGS scale both at rest and during daily life movements did not highlight the superiority of one method over the other [41]. However, the cost-effectiveness ratio is in favor of immobilization.

Surgery is also a treatment option for subjects with lateral epicondylitis when the symptoms persist after 6 months. There are several types of approaches, arthroscopic, percutaneous or open. The arthroscopic intervention allows a better visualization of the entire affected area and it is often preferred by orthopedists. Defoort et al in 2021 conducted a comparative study between the use of ESWT and surgery in lateral epicondylitis trying to track the rank of patient satisfaction and pain reduction. The authors did not find statistically significant differences between the two types of approaches, but believe that ESWT, being a noninvasive procedure, would still be preferred by patients [26].

4.3. Frozen Shoulder, Calcifying Tendinitis of the Shoulder

A number of data in the literature support the use of low or medium energy ESWTs to treat tendon disorders, and high energy ESWTs to treat tendon calcifications and various bone pathologies [42].

Frozen shoulder is a disabling condition that causes pain, limited function of the scapulohumeral joint affecting both the active and the passive movement of the shoulder. Shoulder pain and stiffness can interfere in everyday activities such as: eating, dressing, grooming, bathing, and personal hygiene.

In order to improve the quality of life in patients with frozen shoulder, an increasing number of studies have investigated the efficiency of certain therapeutic regimens. Among them, ESWT may induce an analgesic effect by reducing the excitability of the axon and destroying unmyelinated sensory fibers.

Vahdatpour B., et al. compared the results of shockwave therapy in 20 patients with frozen shoulder with a control group of 20 patients. The patients in the intervention group received 1200 shocks from anterior and posterior directions, with energy between 0.1 and 0.3 mJ/mm^2, once a week, for 4 weeks. The control group received sham shockwave therapy once a week, for 4 weeks, with a nonfunctional device. All patients were followed for 5 months [43].

The statistical analysis revealed a significant difference in the mean pain, disability score (SPADI questionnaire), and range of motion of the involved shoulder between the two groups ($p < 0.05$). Although, the improvement in the range of motion was more significant in the intervention group, the mean internal rotation did not differ significantly between the two groups ($p > 0.05$).

Another study compared the results of ESWT in 15 patients with frozen shoulder with a control group of 15 patients who underwent a conservative physical therapy. Patients from the interventional group received 1000 shocks at 2.5 Hz, with the energy adjusted from 0.01–0.16 mJ/mm^2., two times per week, for six weeks. After the treatment, the intervention group showed significant decreases in terms of pain and functions compared to the control group [44].

In the treatment of frozen shoulder, the combination of ESWT with intra-articular corticosteroid injections is more effective in reducing pain, functional disability, and joint range of motion.

This is also supported by a recent work that studied the effects of combining ESWT (3.5 bar, 2000 pulses with an energy flux density of ¼ 0.16 mJ/mm^2, three sessions per week, for four weeks), with intra-articular corticosteroid injections (Lidocaine 1% and 2 cc methylprednisolone acetate), on a group of 60 people with frozen shoulder. Study results support an improvement in pain, functional disability, joint range of motion, as well as kinesiophobia, depression status, and quality of life, when compared to placebo, in patients with frozen shoulder who also performed progressive resistance exercises for the shoulder muscles [45].

A meta-analysis study showed that there is a correlation between diabetes mellitus (DM) and frozen shoulder, and the prevalence of DM in FS was found in 30% of cases [46, 47].

In a study conducted by Seyam MK, thirty patients with diabetic FS were divided into two groups. Group A consisted of 15 patients treated with ESWT (1200 shocks, at intensity 0.2 mJ/mm^2) and therapeutic exercises for five weeks. Patients from group B were treated with traditional physical therapy (ultrasonic therapy, infrared and therapeutic exercise) with two sessions per week, for five weeks. Although, both groups showed significant improvement in the studied outcomes, the intervention group recorded a better Improvement Ratio (IR = 91.26%) in pain, functional activities and range of shoulder joint movements compared to the control group (IR = 81.81%) [48].

Similarly, in the study conducted by Muthukrishnan R. et al., diabetic patients with FS who received ESWT, registered significant pain reduction, reduced number of therapy sessions and costs of treatment compared to the control group [49].

Regarding the beneficial effect of ESWT on diabetic frozen shoulder patients, it was found that both medium-energy and high-energy radial ESWT have effects of reducing pain and significantly improving joint function, this being an effective short-term therapeutic intervention. Thus, Saldiran, T.Ç., et al. compared therapy medium energy radial ESWT (energy flux density 0.12 mJ/mm^2, 8 Hz frequency) with high energy radial ESWT (energy flux density 0.25 mJ/mm^2, 8 Hz frequency) and with placebo ESWT (simulated ESWT, 0 mJ/mm^2, 8 Hz frequency) in frozen shoulder diabetic patients. Of the two forms of radial ESWT, the medium-energy one appears to be more effective in reducing pain and improving the mechanical properties of the deltoid muscle, and the high-energy one in improving the mechanical properties of the trapezius upper muscle and internal and external rotation shoulder range of motion[50]

When comparing ESWT with intra-articular corticosteroid injections in the management of diabetic frozen shoulder patients, although both methods have positive results in reducing pain, improving disability, and increasing range of motion, however, ESWT showed more significant improvements. (Elerian, A.E., 2021)

This emerges from a recent study comparing the two treatment methods (ESWT 12 sessions, one session per week with 2000 shots and flux density ranged from 0.06 to 0.14 mJ/mm^2, 4 bar pressure, 8 Hz frequency and intra-articular corticosteroid injections with 2 mL of Lidocaine 2% and 40 mg/mL methylprednisolone) both groups of patients also performing a traditional physiotherapy protocol, which included manual mobilization technique and a simple exercise program. Although, when the study results were compared, significant improvements were found in shoulder pain, disability, and range of motion in flexion and abduction, however, the ESWT group showed more significant improvements in pain reduction, disability, and flexion and abduction movements, after three months of treatment. At the same time, better results were obtained regarding the glycemic control of these patients [51].

The beneficial effects of ESWT in the patients with calcific tendinitis of the shoulder were reported in several studies. One of those studies is an observational study which evaluates the effectiveness of radial extracorporeal shock-wave therapy (RESWT) compared with high power laser therapy (HPLT) in patients with shoulder calcific tendinitis [3]. From 62 selected patients, 36 were treated only with RESWT (group A) and 26 patients were treated with HPLT (group B). The patients from group B who did not show improvement with HPLT were retreated with RESWT (group C). The results recorded by the patients treated with HPLT showed good clinical outcomes, but the symptoms recurred after 1 month of treatment. In return, RESWT resulted in improvement after 3 months of treatment, in terms of pain and functionality.

It is worth mentioning Verstraelen's study which shows that high-energy shock wave therapy produced better results and resorption of the deposits compared to low-energy therapy [52].

4.4. Achilles Tendinopathies

The clinical disorder known as chronic Achilles tendinopathy (AT) is typified by discomfort, swelling, and reduced function. Chronic degeneration of the Achilles tendon is the result of repeated microtrauma induced by overuse and inadequate repair [53].

Achilles tendinopathy (AT) is the most common manifestation of tendon disease (55-65%). AT can be divided into mid-Achilles tendinopathy (mid-AT) and insertional Achilles tendinopathy (ins-AT). Mid-AT is more common (55-65%) than ins-AT (20-25%) [54] . Alternative treatment approaches for Achilles tendinopathy involve modifying activities, using heel lifts and arch supports, performing stretching exercises, taking non-steroidal anti-inflammatories, and engaging in eccentric loading [55]. Additionally, extracorporeal shock wave therapy (ESWT) has shown promising results in treating soft-tissue disorders, including Achilles tendinopathy, and can significantly enhance the patients' quality of life. Wilson & Stacy's research suggests that ESWT can be a beneficial complement to conservative treatment methods when they prove ineffective [55].

In their study, Vahdatpour et al. (2018) examined the efficacy of a combined shock wave therapy approach, which included both radial and focused shock waves [56]. The results demonstrated a notable reduction in pain and a significant improvement in the American Orthopaedic Foot and Ankle Society score (AOFAS). Patients diagnosed with chronic Achilles tendinopathy underwent four sessions of ESWT, consisting of radial shock wave therapy (SWT) with parameters of 3000 pulses, a frequency of 2.21 Hz, and an energy flux density ranging from 1.8 to 2.6 mJ/mm2, as well as focused shock wave therapy (FSWT) with 1500 pulses, a frequency of 2.3 Hz, and an energy flux density ranging from 0.25 to 0.4 mJ/mm2. Additionally, a physical-supportive treatment was administered for a duration of four weeks. Furthermore, the authors have indicated that the utilization of ESWT in conjunction with an exercise regimen yielded positive outcomes in terms of pain reduction and improved functionality [57-59]. It has been suggested that a weekly administration of ESWT over a span of 3 weeks proves to be more efficacious than eccentric exercises in the treatment of insertional tendinopathy [60].

ESWT is clinically effective in treating insertional and non-insertional Achilles tendinopathy, even in the long term. Thus, Li, H. et al. studied the effect of radial ESWT (2000 impacts, energy density 0.16 mJ/mm^2, 1.5-2.5 pa, 6-8 Hz) on patients with insertional and non-insertional Achilles tendinopathy, proving an improvement of symptoms in both forms of Achilles tendinopathy. Patients with insertional Achilles tendinopathy showed much better clinical improvements (in VAS and VISA-A – Victorian Institute of Sports Assessment – Achilles Questionnaire scores) compared to those with non-insertional Achilles tendinopathy, five years after treatment [61].

The same beneficial effects, in the short and long term, were also obtained by Abdelkader, N.A. et al. when they associated ESWT (2000 pulses, 3 bar pressure, energy flux density 0.1 mj/mm^2, frequency of 8 pulses/s) with calf eccentric loading and stretching exercises, resulting in a significant improvement in functional and pain scores in patients with non-insertional Achilles tendinopathy. Combining calf eccentric loading with stretching exercises had a significant improvement effect on VAS and VISA-A scores in these patients, but the combination with ESWT therapy led to greater improvements in these scores, both in the short and long term (16 months). [62]

Throughout numerous years, the benefits of laser therapy on soft tissues, including its ability to reduce inflammation and alleviate pain, have been widely acknowledged. In a prospective clinical trial conducted by Notarnicola A. et al., the effectiveness of Cold air flow and High Energy Laser Therapy (CHELT) was compared to Extracorporeal Shockwave Therapy (ESWT) in the treatment of Achilles tendinopathy. To the surprise of the researchers, the results showed that patients who underwent CHELT experienced a significant reduction in pain, improved functionality, and enhanced quality of life after a 2-month follow-up period [63].

Contradictory findings have been reported in various studies concerning the positive impact of ESWT on Achilles tendinopathy. A study conducted by Lynen N. et al. presents evidence that peritendinous HA injections yield superior results in the treatment of midportion tendinopathy in the Achilles tendon, as compared to standard ESWT [64].

According to the available research, ESWT is a safe treatment with very few side effects documented. Additionally, its therapeutic effect can be increased by using it alone or in combination with other physical therapies like static stretching or eccentric strengthening exercises [65].

There are data in the literature that support the use of ESWT in plantar fasciitis, and there are a number of benefits compared to surgery, namely: good effectiveness, shortening of the convalescence period, with subsequent resumption of activity, being a non-invasive method of treatment (with beneficial effects in the case of athletes). The use of this method is recommended when non-surgical therapy has failed .

Defoort et al in 2021 conducted a comparative study between the use of ESWT and surgery in lateral epicondylitis trying to track the rank of patient satisfaction and pain reduction. The authors did not find statistically significant differences between the two types of approaches, but believe that ESWT, being a non-invasive procedure, would still be preferred by patients [26].

ESWT may be a useful therapeutic option for some sports-related injuries when used alone or in conjunction with concurrent exercise therapy and without causing significant side effects. To clarify the function and clinical results of ESWT, further extensive research is required [66]

Based on the evidence gathered in our study, several clinical recommendations emerged regarding the conditions under which ESWT should be used in patients with soft tissue disorders. According to our findings, the most frequent application of ESWT is in the treatment of tendinopathies. Focused and radial shock wave therapy should be used in patients with tennis elbow, rotator cuff pathology (frozen shoulder, calcific and non-calcific tendinopathies), plantar fasciopahty, and Achilles tendinopathies (17, 20,21).

ESWT should not be used in patients with pacemakers, hemophilia, neuropathy or hypersensitivity, in case of clavicle or first rib injury to avoid lung exposure to the ESWT beam, malignancy, pregnancy, infections, and in children with open growth plates. Furthermore, patients must inform before starting this procedure if they have had a steroid injection to the same area in the last three months or if they are taking any anticoagulant or anti-inflammatory medication.

Our review study has a series of **limitations**. First, we aimed to study the musculoskeletal conditions most frequently encountered in current practice and which we face every day, including fasciitis, epicondylitis, frozen shoulder, calcifying tendinitis of the shoulder and Achilles tendinopathies. This made the studies heterogeneous in terms of clinical conditions discussed. Secondly, the studies do not have the same design, the same type of protocol (different intensity and number of sessions), the number of patients being variable within the studies (minimum 10, maximum 54), and notall studies followed the evolution over a longer period of time.

5. Conclusions

Although the results of the ESWT therapy are encouraging, standardization of treatment parameters is needed. Many studies in the literature are of limited value due to poor methodological quality, the small number of cases used, and the high variability of therapeutic protocols.

ESWT can play an important role in the treatment of musculoskeletal disorders, if there are appropriate indications, unitary treatment protocols that are correctly applied and reproducible.

Moreover, ESWT could play an important role in regenerative therapy and in treating other new pathological conditions in which both incisive metabolic stimulation and angiogenesis are required.

However, studies comparing the effectiveness of ESWT with other types of therapy have shown that there are no significant differences between the use of ESWT and conventional therapies. And yet, this form of treatment with various clinical applications has the potential to become a new routine modality used by physical therapists

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