The effectiveness of different types of extracorporeal shock wave therapy in the management of frozen shoulder: a systematic review

La efectividad de diferentes tipos de terapia extracorpórea con ondas de choque en el manejo del hombro congelado: una revisión sistemática

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Abstract

Introduction: Frozen shoulder (FS) is a condition marked by pain and stiffness, which limits daily activities and quality of life. This review evaluates the effectiveness of extracorporeal shock wave therapy (ESWT) in the form of focused (fSWT) and radial (rSWT) modalities for managing FS, aiming to clarify their comparative effectiveness and synthesize current clinical evidence. Evidence Acquisition: A systematic review was conducted according to PRISMA guidelines. Searches were performed across nine databases for randomized controlled trials (RCTs) published between 2010 and 2024 assessing ESWT in FS. Studies were screened using predefined inclusion and exclusion criteria. Extracted data included pain outcomes, shoulder function, and ROM measures.
Methodological quality was assessed using the PEDro scale. Due to study heterogeneity, findings were summarized narratively.
Evidence Synthesis: Nine RCTs met the criteria: four evaluated fSWT and five evaluated rSWT, with intervention and follow-up durations ranging from 6 to 24 weeks.
Findings for fSWT were inconsistent, showing early benefits within the first two months but limited improvement in internal rotation. Outcomes were less reliable in individuals with uncontrolled diabetes. In contrast, rSWT consistently improved pain, ROM, and functional measures, with effects lasting up to 24 weeks. rSWT also demonstrated systemic benefits, including improved HbA1c levels in diabetic patients. Both ESWT types were well tolerated, with only minor, transient adverse effects such as mild discomfort or small hematomas.
Conclusion: Radial SWT shows more consistent and sustained improvements in FS management compared to focused SWT, which demonstrates variable results across studies.

Keywords

Frozen shoulder; adhesive capsulitis; extracorporeal shock wave therapy; focused shock wave therapy; radial shock wave therapy; pain management; shoulder function; randomized control trial; systematic review.

Resumen

Introducción: El hombro congelado (EL) es una condición marcada por dolor y rigidez, que limita las actividades diarias y la calidad de vida. Esta revisión evalúa la efectividad de la terapia de ondas de choque extracorpóreas (ESWT) en forma de modalidades focalizadas (fSWT) y radiales (rSWT) para el manejo de la FS, con el objetivo de aclarar su efectividad comparativa y sintetizar la evidencia clínica actual. Adquisición de evidencia: Se realizó una revisión sistemática de acuerdo con las pautas PRISMA. Se realizaron búsquedas en nueve bases de datos de ensayos controlados aleatorios (ECA) publicados entre 2010 y 2024 que evaluaban la ESWT en FS.
Los estudios se seleccionaron utilizando criterios de inclusión y exclusión predefinidos. Los datos extraídos incluyeron resultados del dolor, función del hombro y medidas de ROM. La calidad metodológica se evaluó mediante la escala PEDro. Debido a la heterogeneidad del estudio, los hallazgos se resumieron narrativamente. Síntesis de la evidencia: Nueve ECA cumplieron los criterios: cuatro evaluaron fSWT y cinco evaluaron rSWT, con duraciones de intervención y seguimiento que oscilaron entre 6 y 24 semanas.
Los hallazgos para fSWT fueron inconsistentes, mostrando beneficios tempranos dentro de los primeros dos meses, pero una mejora limitada en la rotación interna. Los resultados fueron menos confiables en individuos con diabetes no controlada. Por el contrario, la rSWT mejoró consistentemente el dolor, la ROM y las medidas funcionales, con efectos que duraron hasta 24 semanas. La rSWT también demostró beneficios sistémicos, incluida la mejora de los niveles de HbA1c en pacientes diabéticos. Ambos tipos de ESWT fueron bien tolerados, con solo efectos adversos transitorios menores, como molestias leves o pequeños hematomas.
Conclusión: El SWT radial muestra mejoras más consistentes y sostenidas en el manejo del FS en comparación con el SWT enfocado, lo que demuestra resultados variables entre los estudios.

Palabras clave

Hombro congelado; capsulitis adhesiva; terapia extracorpórea con ondas de choque; terapia focalizada con ondas de choque; terapia radial con ondas de choque; manejo del dolor; función del hombro; ensayo aleatorizado de control; revisión sistemática.

Introduction

Frozen shoulder (FS), also known as adhesive capsulitis, is a painful and disabling condition characterized by progressive stiffness and limited range of motion in the shoulder joint (Ramirez, 2019). This condition commonly affects middle-aged individuals and significantly impairs daily functioning and quality of life (Lewis, 2015).

FS progresses through three stages—freezing, frozen, and thawing; each stage presents different clinical challenges (Konarski et al., 2020). The freezing stage is characterized by severe pain and progressive loss of mobility, while the frozen stage involves constant stiffness, and the thawing phase reflects gradual recovery (Schröder et al., 2017). Despite the availability of different conservative and surgical treatments, the optimal management approach is an ongoing topic of debate (Ramirez, 2019).

ESWT has been increasingly used in the management of musculoskeletal disorders, including FS. This non-invasive technique involves delivering acoustic waves to the affected tissue, which promotes biological responses that reduce pain, facilitate healing, and restore function. There are two forms of ESWT: fSWT, which delivers high-energy waves to specific, deep targets, and rSWT, which distributes lower-energy waves over a wider, superficial area (Balzer et al., 1986; Wang, 2012; Speed, 2014). These different mechanisms suggest possible differences in their clinical effectiveness depending on the stage and pathology of the FS.

Despite the growing popularity of ESWT, no systematic review has explicitly compared the outcomes of focused and radial ESWT in FS patients. As clinicians presently rely on anecdotal evidence or generalized research to determine which modality to use, a comparative analysis of these two modalities is essential to enable the provision of evidence-based recommendations, Additionally, understanding how the stage of frozen shoulder impacts the effectiveness of ESWT can inform treatment strategy decisions and improve outcomes (Vahdatpour et al., 2014; Zhang et al., 2022).

Conventional therapies for FS include physical therapy, corticosteroid injections, and surgical interventions. However, non-invasive approaches like ESWT have earned attention due to their capability to promote tissue repair and relieve pain safely (Zhang et al., 2022). The therapy works through mechanotransduction where mechanical energy from shockwaves is converted into biochemical signals, triggering cellular and molecular responses. ESWT alleviates pain by degenerating small nerve fibers, reducing pro-inflammatory mediators, and activating the descending inhibitory system, which releases endorphins. It also stimulates tissue regeneration, promoting neovascularization, collagen synthesis, and cell proliferation. ESWT also has anti-inflammatory effects, prompting macrophage phenotypes to shift from pro-inflammatory (M1) to anti-inflammatory (M2), thereby reducing inflammation and promoting healing. Furthermore, ESWT can disintegrate calcium deposits in tissues (Simplicio et al., 2020).

Research suggests that ESWT may be a suitable adjunctive therapy for managing pain and stiffness in FS patients, especially those unresponsive to standard treatment (Zhang et al., 2022). Due to the frequent overlap of the three phases of frozen shoulder and the intricate symptoms experienced by patients, adjuvant therapy is usually required during the entire course of treatment (Dias et al., 2005). Zhang et al. (2022) reported that the benefits of physical therapy shows were more pronounced during the adhesive phase than to the freezing phase.

Therefore, this SR aims to address a gap in the literature by evaluating the clinical effectiveness of fESWT and rESWT for relieving pain, improving ROM, and enhancing shoulder function in patients with FS.

Method

Search Strategy

This research conducted a comprehensive digital search of physiotherapy, rehabilitation and orthopedic journals accessed through the following databases: CINAHL, CENTRAL, Medline, Ovid PubMed. Science Direct Database and Google Scholar. The search strategy followed the PICO search framework. The

search was restricted to RCTs of shockwave therapy to frozen shoulder, published between 2010 and 2024.

Inclusion Criteria

This systematic review included studies that met the following criteria: (1) adults diagnosed with frozen shoulder. (2) The intervention group received either fESWT or rESWT. (3) Only RCTs published in English were included. (4) There were no restrictions on the duration of treatment, or severity of symptoms; the intensity of shockwave energy was dependent on the tolerance of the patient. (5) There were no limits as to whether the RCT adopted a blinded method. 6) At least one of the following outcome indices were used to determine efficacy: VAS, CMS, DASH, SPADI and ROM. (6) Studies with control groups receiving conventional therapy or steroid injections were considered eligible.

Exclusion criteria

Studies were excluded if they involved participants younger than 18 years, included patients with diagnoses other than FS, or failed to differentiate between focused and radial ESWT in their analysis. Additionally, studies that did not report validated outcome measures, used non-RCT designs, or involved patients with rheumatoid arthritis, traumatic injuries or surgery in shoulder joints were excluded.

Data extraction

Two reviewers (MI, TA) independently screened the titles and abstracts according to the inclusion and exclusion criteria and read the full texts of relevant literature. Studies that met the predefined criteria were included. In the case of a disagreement, a third reviewer (HA) was consulted to assist in the assessment. Three reviewers (S.A.,A.A,S.J) independently extracted the following data: first author, publication year, sample size, intervention details, follow-up, measurement time, and outcome measures.

Bias assessment and quality classification

This SR used the PEDro scale to assess the methodological quality of the included studies. This evaluation was conducted by two blinded authors (MI and HA). The PEDro scale is a valid and reliable tool to assess the methodological quality of RCTs in the field of physiotherapy (de Morton, 2009). It uses a simple strategy of answering questions with a "yes/no" response, then tallying the scores. It is quick to complete and minimizes the chance of individual error when assessing the quality of a study. The studies that score 9 or 10 are considered to be of "excellent" methodological quality. Those scoring between 6-8 are good, 4 or 5 are regarded to be "fair" and those below 4 are considered "poor" (Foley et al., 2003).

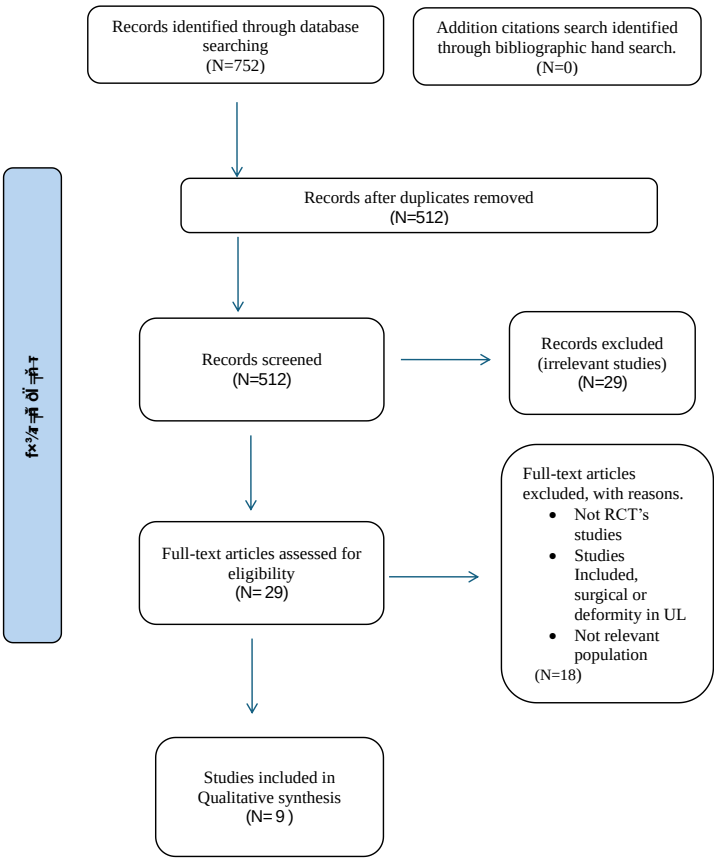
Description of the selected studies

A total of 752 studies were identified during the initial search. After removing duplicates, 512 studies remained. After screening the titles and abstracts, 483 studies were excluded, leaving 29 articles for full-text review. Of these, 18 studies were eliminated from the review due to insufficient information on clinical outcomes or for failing to meet the inclusion criteria. Finally, nine studies were included in this systematic review. The flow diagram of the selection process is shown in Figure 1. The characteristics and findings of the included studies, encompassing a total of 558 participants, have been summarized. The data extraction focused on evaluating pain reduction, functional outcomes, and the effectiveness of focused and radial ESWT compared with conventional therapy, oral steroid and steroid injections. The studies' characteristics are shown in Tables 1 and 2.

Data synthesis

In SR, it is common to use a narrative synthesis method to synthesize research in the context of these types of studies. In this method, no statistical techniques are used. If the statistical techniques are involved, then the study is called meta-analysis, or they could be combined. The literature provides guidance that enables the narrative synthesis to be conducted using a more systematic and transparent method, whilst focusing on synthesis of evidence on efficacy of specific interventions in addition to elements determining the implementation of those interventions (Popay et al., 2006). However, the narrative synthesis method has some limitations. For instance, it depends on subjective judgment, preference and biases of the reviewer (Wolf, 1986). In this SR, rigorous criteria were used to select the best available evidence. The methodological quality of each study will be assessed using a valid scale (PEDro Scale).

Figure 1. Study Flow Diagram. ESWT, Extracorporeal Shockwave Therapy; RCT, Randomized Controlled Trial



Quality assessment of included studies

All clinical trials were evaluated and analyzed using the PEDro scale. The scores of the included studies ranged from 5 to 9 (scored out of 10), with the average score being 7. The ten criteria for the PEDro scale and the assessment of all the included studies are presented in Table 3.

Discussion

Recently, many studies have used rSWT as a non-invasive intervention for managing adhesive capsulitis and frozen shoulder. The modality demonstrates notable improvements in pain relief, functional outcomes, ROM, and quality of life.

The findings of many studies show consistency in the results produced by rSWT on adhesive capsulitis or frozen shoulder, reflecting significant short-term effectiveness. Furthermore, other studies that investigated the long-term effects of rSWT on AC or frozen shoulder found sustained improvements across key clinical parameters. For instance, one randomized controlled trial compared rSWT with intra-articular corticosteroid injections and demonstrated a long-term reduction in pain and enduring functional improvements, while avoiding adverse metabolic effect (Elerian et al., 2021).

This point is especially important for patients with comorbidities such as diabetes. Moreover, when compared with oral steroid therapy, rSWT demonstrated higher patient satisfaction rates and superior functional outcomes over the 12-week follow-up period (Qiao et al., 2020).

Nine RCT studies met the inclusion criteria and were consistent with the goal of the review. Initially, the reviewers found that the findings of the included studies showed consistent short-term effects, despite differences in the machines used and the sites to which rSWT was applied. However, in terms of the type of SWT, some of the included studies used rSWT, while others used fSWT. This might affect the results and create ambiguity in deciding which type of SWT is the best to use in clinical practice.

Table 1. Summary of rSWT Studies

Authors (Year)	Sample Size (ESWT/Control)	ESWT Group	Parameter/Dose	Control Group	Intervention Duration	Follow-up	Measurement Time	Outcomes Measured	Results
Hussein&Donatelli (2016) [16]	53/53 (40 M,66 F)	rSWT vs. placebo	2000 shocks, 8 HZ, 0.25 mJ/mm², weekly for 6 weeks	Placebo rSWT	6 weeks	24 weeks	Baseline, 6 weeks, 24 weeks	VAS, DASH, ROM	Significant improvement in CSS, OSS, ROM at 24 weeks ($p \leq 0.05$)
El Naggar (2020) [17]	52/51 15/37 M-F	rSWT vs. steroid injection	2000 shocks, 10Hz, 0.2-0.3 mJ/mm², weekly for 4 weeks	Placebo + Lidocaine Injection 9/42 M-F	4 weeks	12 weeks	Baseline, 4 weeks, 12 weeks	VAS, QuickDASH, ROM	Significant improvement in pain, ROM, and quality of life (p=0.001)
Farhat (2021) [18]	25/25 (8/17 M-F)	rSWT + conventional therapy	2000 shocks, 8 HZ, 0.2 mJ/mm², weekly for 4 weeks	Conventional Therapy Alone (9/16 M-F)	4 weeks	24 weeks	Baseline, 4 weeks, 24 weeks	CSS, OSS, ROM	Significant improvement in CSS, OSS, ROM at 24 weeks ($p \leq 0.05$)
Elerian (2021) [19]	25/25	rSWT vs. corticosteroid injection	1800 shocks, 8 HZ, 0.2 mJ/mm², weekly for 4 weeks	Corticosteroid Injection	4 weeks	3 months	Baseline, 4 weeks, 3 months	SPADI, ROM, HbA1c, at 1 month, FBG, PPBG at 3 months	No statistical difference in one month, but Rom improved. Better glycemic control, pain relief, and ROM in rSWT group (p<0.001)
Nambi (2024) [20]	30/30 (14/16 M-F)	rSWT + lidocaine injection	1500 shocks, 8 HZ, 0.25 mJ/mm², weekly for 4 weeks	Placebo + Lidocaine Injection (13/17 M-F)	4 weeks	6 months	Baseline, 4 weeks, 6 months	VAS, ROM, QuickDASH, TSK-AV, HADS, EQ-5D	Significant improvement in pain, ROM, and quality of life (p=0.001)

Table 2. Summary of fSWT Studies

Author(s) (Year)	Sample Size (ESWT/Control)	ESWT Group	Parameter/Dose	Control Group	Intervention Time	Follow-up	Measurement Time	Outcomes Measured	Results
Chen (2014) [21]	19/17	fSWT vs oral steroid therapy	1,350–1,500 shocks, 0.6 mJ/mm², 1.25 Hz, 3 sessions	Oral steroid therapy	4 weeks	12 weeks	Baseline, 4 weeks, 6 weeks, 12 weeks	CSS, OSS, ROM	Significant improvement in pain (p<0.05), ADL (p=0.045), ROM (p=0.001).
Vahdaptour (2014) [22]	19/17	fSWT vs sham therapy	1200 shocks, 0.1–0.3 mJ/mm², weekly for 4 weeks	Sham therapy	4 weeks	5 months	Baseline, 2 months, 5 months	SPADI, ROM (Flexion, Abduction, Extension, Rotation)	Significant improvement in SPADI, ROM (except internal rotation).
muthukRishnan (2019) [23]	10/10	fSWT vs ultrasound therapy	2000 shocks, 3 Hz, once per week for 4 weeks	Ultrasound therapy + mobilization	4 weeks	12 weeks	Baseline, weekly for 4 weeks	VAS, DASH, ROM, GROC	Significant reduction in pain (p<0.05), improved ROM (p<0.05).
Suwalak (2021) [24]	14/12	fSWT + home exercise vs sham therapy	1500 shocks, 0.1–0.3 mJ/mm², weekly for 6 weeks	Sham fSWT + home exercise	6 weeks	10 weeks	Baseline, 2 weeks, 4 weeks, 6 weeks, 10 weeks	SPADI, ROM, numeric pain scale	Improvement in ROM and SPADI, no significant difference from sham (p>0.05).

Table 3. PEDro quality assessment criteria and results

PEDro Criteria	Chen et al. (2014) [21]	Vahdatpour et al. (2014)[22]	Hussein & Donatelli (2016)[16]	Muthukrishnan et al. (2019) [23]	El Naggar et al. (2020) [17]	Suwalak et al. (2021) [24]	Farhat et al. (2021) [18]	Elerian et al. ((2021) 19	Nambi et al. (2024) [20]
Eligibility criteria were specified (non account to total score)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Random allocation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Allocation was concealed	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Similarity between group at baseline	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Blinding of subjects	Yes	Yes	Yes	No	No	Yes	No	No	No
Blinding of therapists	No	No	No	No	No	No	No	Yes	Yes
Blinding of assessors	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Measure at least one key outcome were obtained from more than 85%of the subjects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intention to treat analysis	No	No	Yes	No	No	Yes	No	Yes	No
Between group statistical comparisons reported for at least one key outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Point and variable measures for at least one key outcome measure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total score (out of 10)	7	7	9	5	7	9	7	9	7

Five out of the nine included studies compared rSWT to placebo, corticosteroid injection, or conventional therapy in patients with adhesive capsulitis. Three of the five studies achieved a high score on the PEDro scale, reaching 9 out of 10 (Hussein, A. Z., & Donatelli, 2016; Farhat et al., 2021; Nambi et al., 2024). Meanwhile, the PEDro score of the two other studies was 7 out of 10 (El Naggar et al., 2020; Elerian et al., 2021). However, there was considerable diversity in the rSWT parameters used in these five studies in terms of the number of shocks, frequency (Hz), targeted site, and number of treatment sessions administered. These differences can account for variations in the outcomes. Three of the five studies used 2000 shocks at 10 or 8 Hz for 4 weeks, which was reported to yield a significant effect in reducing pain and improving functionality. The rSWT parameters in two studies were 1800 shocks and 1500 shocks at 8 Hz, respectively (Elerian et al., 2021; Nambi et al., 2024).

However, there is inconsistency in the results of these studies. One trial reported no significant short-term benefit (Elerian et al., 2021) while another showed a significant short-term reduction in pain and improvement in ROM (Nambi et al., 2024). These observations might not fully reflect the effect of rSWT, as the authors used corticosteroid and lidocaine as adjunctive therapies, which might have influenced the treatment outcome. It is well established that several factors influence the degree of improvement achieved with rSWT, such as treatment parameters (e.g., energy flux density, frequency, number of sessions) and patient adherence to rehabilitation exercises. Studies that used optimized energy levels (e.g., 0.2–0.3 mJ/mm^2) and multiple treatment sessions reported superior outcomes compared with those using suboptimal dosing or shorter treatment durations. Therefore, clinical practitioners should consider the effect of concurrent medication and determine the optimal treatment duration and protocol parameters for the implementation of rSWT in their patients.

On the other hand, fSWT has been studied as a treatment for many orthopedic disorders. Nonetheless, in relation to FS, the evidence of efficacy remains contentious. The parameters of fSWT differ from those of rSWT in terms of pressure peak, which is 500 bar, and frequency, which ranges from 16 Hz to 20 MHz. Therefore, the mechanism of the biological effect induced by shock waves is not fully understood. Four studies examined fSWT versus oral steroid, sham therapy, ultrasound, and home exercise (Chen et al., 2014; Vahdatpour et al., 2014; Muthukrishnan et al., 2019; Suwalak et al., 2021). Except for one study that reported no significant difference between fSWT and home exercise (Suwalak et al., 2021) all studies reported significant reductions in pain and improved ROM. The respective PEDro scores for these studies were 7, 5, 7, and 7 (Chen et al., 2014; Vahdatpour et al., 2014; Muthukrishnan et al., 2019; Suwalak et al., 2021). These four studies might have limitations in terms of small sample size and the extent of the therapist's experience in delivering treatment. The total number of participants recruited into the four studies was 62, which is a small sample and could limit the actual effect of fSWT, thereby increasing the risk of bias in the findings. Moreover, more than 75% of participants in one study were female, which

might decrease the internal validity of the study (Vahdatpour et al., 2014). In another study, fSWT was applied by nurses, which might have led to therapist experience bias (Chen et al., 2014). In addition, the authors used different parameters of fSWT with no consensus regarding the settings, which makes it challenging for clinical practitioners to determine the optimal parameters for implementation in practice.

The effectiveness of treatment could be influenced by the frequency and duration of its administration. One study found that using fSWT in conjunction with mobilization for four sessions per month produced similar results to 12 sessions of ultrasound with exercise and mobilization (Muthukrishnan et al., 2019). These findings have implications for patients with heavy workloads and commitments or those unable to make regular, ongoing visits to the hospital. Likewise, another study reported that stimulation in the lateral direction was less effective than stimulation in the anterior–posterior direction and recommended increasing the level of energy while reducing the number of shocks (Vahdatpour et al., 2014).

Study Limitations

This SR included studies that use different types of SWT and different application protocols, which might lead to unclear outcomes. Moreover, the sample sizes of the reviewed studies was small, which limits the generalizability of the study. However, this SR highlighted the most analytical theme for future studies to consider the type of SWT parameters, site of application, and number of sessions for the implementation.

Conclusions

In conclusion, radial shock wave therapy (rSWT) consistently demonstrates efficacy as an intervention for frozen shoulder and adhesive capsulitis, producing benefits to pain relief, sustained improvement in ROM, and enhanced functional capacity. In contrast, evidence collected from the different studies for the efficacy of fSWT to manage FS is conflicted. Further research with standardized protocols for each type of SWT, larger sample sizes, and extended follow-ups that consider adverse events of application is essential to make informed decisions about its optimal application and to maximize clinical utility.

Future Research Directions

To evaluate the sustainability of treatment benefits of both fSWT and rSWT, future research should focus on conducting large-sample size, multi-center RCTs with follow-up durations that exceed 12 months. Standardization of treatment protocols, including energy flux density, session frequency, and duration, is essential to ensure reproducibility and improve clinical outcomes. Head-to-head comparative studies between fSWT and rSWT are needed to identify the most effective modality for specific patient populations. Further investigation into the biochemical and molecular mechanisms underlying the effects of shock wave therapy is crucial to understand its systemic benefits, particularly in diabetic patients.

Authors' Contributions

M.I. conceptualized the study, designed the search strategy and methodology, and wrote the first draft of the manuscript. M.I. and T.A. independently screened the titles and abstracts according to the inclusion and exclusion criteria and read the full texts of relevant literature. In case of disagreement, H.A. was consulted to assist in the assessment. S.A., A.A., and S.J., together with T.A., independently extracted the data including first author, publication year, sample size, intervention details, follow-up, measurement time, and outcome measures. M.I. and H.A. assessed the methodological quality of the included studies using the PEDro scale. All authors contributed to data synthesis, interpretation of findings, and manuscript revision. All authors read and approved the final version of the manuscript.

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