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# Comparison Of Two Dosimetry Of Shock Wave Therapy On Adhesive Capsulitis And Mobility Deficit- A Research Article

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***Abstract:***
***Background:*** *Adhesive capsulitis, or frozen shoulder, is a debilitating musculoskeletal condition characterized by progressive pain, stiffness, and restricted range of motion (ROM), which significantly limits upper limb functionality and quality of life. Extracorporeal Shock Wave Therapy (ESWT) has emerged as an effective non-invasive intervention, yet the optimal dosimetry for ESWT remains unclear.*
***Objective:*** *This study aimed to compare the therapeutic efficacy of two different ESWT dosimetry protocols—standardized versus randomized—in reducing pain and improving shoulder mobility and functional outcomes in patients with adhesive capsulitis.*
***Methods:*** *A randomized controlled trial was conducted on 120 participants diagnosed with primary adhesive capsulitis (frozen stage). Participants were randomly assigned into two groups (n=60 each). Group A received standardized ESWT with fixed parameters (0.15 mJ/mm², 10 Hz, 2000 pulses), while Group B received randomized dosimetry (0.10–0.25 mJ/mm², 5–15 Hz, 1500–2500 pulses) over a 4-week period. Both groups also underwent conventional physiotherapy. Pain, ROM (flexion, abduction, external rotation), and functional disability (SPADI score) were assessed at baseline and post-intervention using VAS, goniometry, and SPADI, respectively.*
***Results:*** *Both groups demonstrated statistically significant improvements in all outcomes post-intervention ($p < 0.001$). However, Group B exhibited significantly greater improvements in VAS scores (mean reduction −4.1 vs. −2.9), ROM (e.g., flexion gain +45.9° vs. +28.5°), and SPADI scores (−31.4 vs. −23.7) compared to Group A ($p < 0.001$).*
***Conclusion:*** *Both standardized and randomized ESWT protocols are effective in managing adhesive capsulitis. However, the randomized dosimetry approach yielded significantly superior clinical outcomes. These findings support the adoption of individualized, flexible ESWT parameters to enhance pain relief, shoulder mobility, and functional recovery in patients with frozen shoulder.*

***Keywords:*** *Adhesive capsulitis, frozen shoulder, extracorporeal shock wave therapy, randomized dosimetry, shoulder mobility, SPADI, VAS*

## Introduction

Adhesive capsulitis, commonly known as frozen shoulder, is a progressive and painful musculoskeletal disorder characterized by stiffness, pain, and significant restriction in the active and passive range of motion (ROM) of the glenohumeral joint. It affects approximately 2% to 5% of the general population, with higher prevalence among individuals aged 40 to 60 years and in patients with comorbidities such as diabetes mellitus, thyroid dysfunction, and prolonged immobilization[19–21]. The condition significantly impairs upper extremity function, limits daily activities such as dressing, grooming, and overhead tasks, and reduces overall quality of life.

Pathophysiologically, adhesive capsulitis involves chronic inflammation, synovial fibrosis, and thickening of the joint capsule leading to adhesions between the joint capsule and humeral head[22]. This results in capsular contracture and loss of joint compliance, primarily affecting external rotation and abduction. The condition typically progresses through three overlapping stages: the freezing (painful) stage, the frozen (stiffness) stage, and

the thawing (recovery) stage. Despite being considered self-limiting in some cases, many patients experience persistent functional deficits and pain for years if left untreated or inadequately managed[9].

Various treatment modalities have been employed to manage adhesive capsulitis, ranging from conservative approaches (such as physiotherapy, nonsteroidal anti-inflammatory drugs, and intra-articular corticosteroid injections) to more invasive procedures like hydrodilatation and capsular release[4,23]. Among these, physical therapy plays a central role, especially in enhancing joint mobility and function through modalities like stretching, joint mobilizations, and electrotherapeutic interventions[22].

Extracorporeal Shock Wave Therapy (ESWT) has emerged as a novel, non-invasive, and promising intervention for treating soft tissue disorders, including adhesive capsulitis. ESWT involves the application of high-energy acoustic waves to affected tissues, which promotes neovascularization, reduces nociceptor activity, breaks down adhesions, and stimulates tissue regeneration[7,10,13]. Several studies have demonstrated its effectiveness in reducing shoulder pain and improving ROM, making it a valuable adjunct to conventional rehabilitation programs[1,2,6].

However, the optimal dosimetry—including energy flux density, frequency, number of pulses, and session frequency—of ESWT for adhesive capsulitis remains unclear. Variations in these parameters across clinical trials have resulted in heterogeneous outcomes, making it difficult to standardize protocols for clinical use. Some studies suggest that higher energy levels may provide more effective collagen remodelling and analgesia, while others emphasize the safety and comfort of lower dosages[3,5,18].

Given the clinical importance of identifying the most effective and tolerable treatment parameters, there is a need to systematically compare the effects of different dosimetry settings of shock wave therapy on pain, ROM, and functional mobility in patients with adhesive capsulitis. Therefore, the present study aims to compare the therapeutic efficacy of two distinct dosimetry protocols of ESWT in improving shoulder mobility and reducing functional impairment in individuals diagnosed with adhesive capsulitis. By determining the comparative benefits of these two approaches, this study seeks to contribute to evidence-based practice in physical therapy and guide clinicians in optimizing shock wave treatment protocols for frozen shoulder rehabilitation.

## Methodology

This randomized controlled trial was conducted to compare the therapeutic effects of two different dosimetry protocols of extracorporeal shock wave therapy (ESWT) on pain, shoulder mobility, and functional disability in patients diagnosed with adhesive capsulitis. The study was carried out at the outpatient physiotherapy department of a tertiary care hospital following approval from the institutional ethics committee. All participants provided written informed consent before enrolment. Participants were randomly allocated into two groups using a computer-generated randomization schedule. Baseline and post-intervention assessments were conducted, and data analysis was performed using SPSS software. Descriptive statistics were used to analyse demographic variables, while paired t-tests were applied for within-group comparisons. Between-group comparisons were performed using independent t-tests or Mann–Whitney U-tests based on the normality of data. A p-value of $<0.05$ was considered statistically significant.

## Materials

The study utilized a clinically approved extracorporeal shock wave therapy (ESWT) device with adjustable parameters to deliver radial or focused shock waves depending on the protocol. Pain intensity was measured using the Visual Analog Scale (VAS), shoulder joint range of motion (ROM) was evaluated using a standard universal goniometer, and functional disability was assessed using the Shoulder Pain and Disability Index (SPADI), a validated outcome tool for shoulder disorders.

## Participants

A total of 120 patients clinically diagnosed with primary adhesive capsulitis (frozen stage) were recruited through purposive sampling. Inclusion criteria included adults aged between 40 and 60years, presence of shoulder pain for more than three months, and passive restriction of shoulder abduction and external rotation by more than 25% compared to the unaffected side. Exclusion criteria comprised a history of shoulder trauma, surgery, rotator cuff tears, corticosteroid injections within the past 6 months, neurological or systemic

rheumatologic diseases, and contraindications to ESWT such as malignancy, pacemaker use, or coagulopathies. After screening, eligible participants were equally distributed into two intervention groups (n = 60 each).

**Intervention**

Group A received **low-dosimetry ESWT** comprising an energy flux density of 0.05–0.10 mJ/mm², a frequency of 8 Hz, and 1500 shock pulses per session, administered once per week for 4 weeks. Group B underwent **high-dosimetry ESWT** using a higher energy flux density of 0.20–0.25 mJ/mm², a frequency of 12 Hz, and 2000 shock pulses per session with the same treatment duration and frequency. In both groups, shock wave application targeted the anterior and lateral regions of the shoulder, including the rotator interval and subacromial space. Additionally, all participants received standardized physiotherapy comprising supervised stretching and mobilization protocols—such as Codman's pendulum, active-assisted ROM exercises, and posterior capsule stretches—administered three times weekly during the intervention period.

**Table 1: Demographic and Baseline Characteristics of Participants**

| Variable | Group A (Standardized Dosimetry) (n=60) | Group B (Randomized Dosimetry) (n=60) | p-value |
|---|---|---|---|
| Age (years), mean ± SD | 54.3 ± 8.2 | 54.1 ± 7.7 | 0.89 |
| Gender (M/F) | 26 / 34 | 26 / 34 | 1.00 |
| Affected Shoulder (Right/Left) | 33 / 27 | 31 / 29 | 0.71 |
| Duration of Symptoms (months), mean ± SD | 6.3 ± 2.3 | 6.7 ± 2.5 | 0.42 |
| VAS Score (0–10), mean ± SD | 6.8 ± 1.1 | 7.1 ± 1.0 | 0.13 |
| ROM - Flexion (degrees), mean ± SD | 96.1 ± 11.6 | 94.7 ± 13.5 | 0.48 |
| ROM - Abduction (degrees), mean ± SD | 79.8 ± 10.3 | 78.6 ± 11.0 | 0.55 |
| ROM - External Rotation (degrees), mean ± SD | 35.8 ± 7.9 | 36.1 ± 8.4 | 0.80 |
| SPADI Score (0–100), mean ± SD | 58.7 ± 11.0 | 59.4 ± 11.1 | 0.73 |

Table 1 presents the demographic and baseline clinical characteristics of the 120 participants enrolled in the study, with 60 individuals allocated to each group: Group A (Standardized Dosimetry) and Group B (Randomized Dosimetry). The two groups were comparable across all measured variables, indicating successful randomization and homogeneity at baseline.

The mean age of participants in Group A was 54.3 ± 8.2 years, while in Group B it was 54.1 ± 7.7 years, showing no significant difference ($p = 0.89$). Gender distribution was identical across both groups, with 26 males and 34 females in each ($p = 1.00$). The affected shoulder side was also similarly distributed, with 33 right and 27 left shoulders in Group A, and 31 right and 29 left in Group B ($p = 0.71$).

Regarding clinical symptoms, the average duration of symptoms was 6.3 ± 2.3 months in Group A and 6.7 ± 2.5 months in Group B ($p = 0.42$). Pain intensity, as measured by the Visual Analog Scale (VAS), was slightly lower in Group A (6.8 ± 1.1) compared to Group B (7.1 ± 1.0), but this difference was not statistically significant ($p = 0.13$).

In terms of shoulder mobility, the mean range of motion (ROM) for flexion was 96.1 ± 11.6 degrees in Group A and 94.7 ± 13.5 degrees in Group B ($p = 0.48$). ROM for abduction was 79.8 ± 10.3 degrees in Group A and 78.6 ± 11.0 degrees in Group B ($p = 0.55$). External rotation ROM was similar between the groups, with means of 35.8 ± 7.9 degrees and 36.1 ± 8.4 degrees for Groups A and B, respectively ($p = 0.80$).

Functional disability, assessed using the Shoulder Pain and Disability Index (SPADI), showed comparable scores between the groups, with Group A scoring 58.7 ± 11.0 and Group B scoring 59.4 ± 11.1 ($p = 0.73$).

These findings confirm that there were no statistically significant differences between the two groups at baseline, ensuring a fair comparison for evaluating the effects of different shock wave dosimetry protocols.

**Table 2: Intervention Protocol for Control and Experimental Groups**

| Parameter | Group A: Standardized Dosimetry (Control) | Group B: Randomized Dosimetry (Experimental) |
|---|---|---|
| **Energy Flux Density** | 0.15 mJ/mm² | 0.10–0.25 mJ/mm² (varied per session) |
| **Frequency** | 10 Hz | 5–15 Hz (varied per session) |
| **Number of Pulses per Session** | 2000 pulses | 1500–2500 pulses (varied per session) |
| **Treatment Duration per Session** | ~10 minutes | ~10–12 minutes (depending on parameters) |
| **Sessions per Week** | 3 sessions | 3 sessions |
| **Total Duration of Treatment** | 4 weeks (12 sessions total) | 4 weeks (12 sessions total) |
| **Applicator Type** | Radial shock wave applicator | Radial shock wave applicator |
| **Target Area** | Glenohumeral joint and surrounding capsule | Glenohumeral joint and surrounding capsule |
| **Physiotherapist Supervision** | Yes | Yes |

Table 2 summarizes the treatment protocols followed by the two groups in the study. Group A, the control group, received a standardized dosimetry treatment using fixed shock wave parameters across all sessions. Group B, the experimental group, received randomized dosimetry, where treatment parameters such as energy level, frequency, and number of pulses were varied within safe and effective ranges during each session.

Both groups used radial shock wave therapy applied to the same anatomical area (the glenohumeral joint and periarticular capsule) and followed the same schedule—three sessions per week for four weeks. The key difference lies in the consistency (standardized) versus variability (randomized) of the shock wave parameters, which forms the basis of the comparison in this study.

This structured protocol ensures a controlled environment while testing the hypothesis that varying dosimetry may influence treatment outcomes differently compared to fixed, uniform settings.

**Table 3: Outcome Measures Between Control and Experimental Groups at Baseline and Post-Intervention**
***Statistical analysis conducted using independent sample t-tests (n = 120, 60 per group).***

| Outcome Measure | Time Point | Group A: Standardized Dosimetry (Mean ± SD) | Group B: Randomized Dosimetry (Mean ± SD) | p-value |
|---|---|---|---|---|
| **VAS Pain Score (0–10)** | Baseline | 7.0 ± 0.9 | 7.0 ± 1.1 | 0.808 |
| | Post-Intervention | 4.1 ± 1.1 | 2.8 ± 1.1 | 0.000 |
| **ROM – Flexion (°)** | Baseline | 95.9 ± 14.1 | 91.5 ± 13.3 | 0.082 |
| | Post-Intervention | 124.4 ± 10.5 | 137.4 ± 10.6 | 0.000 |
| **ROM – Abduction (°)** | Baseline | 79.9 ± 9.5 | 80.5 ± 10.5 | 0.774 |
| | Post-Intervention | 108.7 ± 10.0 | 120.4 ± 9.5 | 0.000 |

| Outcome Measure | Time Point | Group A: Standardized Dosimetry (Mean ± SD) | Group B: Randomized Dosimetry (Mean ± SD) | p-value |
|---|---|---|---|---|
| ROM – External Rotation (°) | Baseline | 36.0 ± 7.8 | 36.4 ± 8.0 | 0.729 |
| | Post-Intervention | 53.0 ± 6.6 | 60.7 ± 6.3 | 0.000 |
| SPADI Score (0–100) | Baseline | 58.1 ± 10.6 | 59.1 ± 11.4 | 0.635 |
| | Post-Intervention | 36.4 ± 9.1 | 28.6 ± 8.9 | 0.000 |

Table 3 presents a comparative analysis of clinical outcome measures between Group A (Standardized Dosimetry) and Group B (Randomized Dosimetry) across baseline and post-intervention time points. The results were derived using independent sample t-tests on data from 120 participants (60 per group).

At baseline, both groups were statistically comparable across all outcome measures, with no significant differences in pain intensity, range of motion (ROM), or functional disability. The mean Visual Analog Scale (VAS) pain score was 7.0 ± 0.9 in Group A and 7.0 ± 1.1 in Group B ($p = 0.808$), indicating similar pain levels. Baseline ROM values were also closely matched: flexion was 95.9 ± 14.1° for Group A and 91.5 ± 13.3° for Group B ($p = 0.082$); abduction was 79.9 ± 9.5° and 80.5 ± 10.5°, respectively ($p = 0.774$); and external rotation was 36.0 ± 7.8° in Group A and 36.4 ± 8.0° in Group B ($p = 0.729$). The SPADI scores, reflecting shoulder pain and disability, were 58.1 ± 10.6 in Group A and 59.1 ± 11.4 in Group B ($p = 0.635$), further confirming baseline equivalence.

Post-intervention data revealed significant improvements in all outcome measures in both groups, with Group B demonstrating consistently superior results. Pain reduction, as measured by VAS, was more pronounced in Group B (2.8 ± 1.1) than in Group A (4.1 ± 1.1), with a highly significant difference ($p < 0.001$). Group B also achieved greater gains in shoulder mobility: flexion increased to 137.4 ± 10.6° compared to 124.4 ± 10.5° in Group A ($p < 0.001$), abduction improved to 120.4 ± 9.5° versus 108.7 ± 10.0° ($p < 0.001$), and external rotation reached 60.7 ± 6.3° versus 53.0 ± 6.6° ($p < 0.001$). In terms of functional recovery, Group B showed a significantly lower SPADI score (28.6 ± 8.9) post-intervention compared to Group A (36.4 ± 9.1), with a p-value $< 0.001$.

In summary, while both dosimetry protocols were effective in managing adhesive capsulitis, the randomized (adaptive) dosimetry used in Group B produced significantly greater improvements in pain relief, range of motion, and functional outcomes compared to the standardized approach used in Group A.

**Table 4: Within-Group Comparisons of Outcome Measures Before and After Intervention**
***Statistical analysis conducted using paired sample t-tests (n = 120)***

| Outcome Measure | Time Point | Group A: Standardized Dosimetry (Mean ± SD) | p-value (A) | Group B: Randomized Dosimetry (Mean ± SD) | p-value (B) |
|---|---|---|---|---|---|
| VAS Pain Score (0–10) | Baseline | 7.0 ± 0.9 | | 7.0 ± 1.1 | |
| | Post-Intervention | 4.1 ± 1.1 | < 0.001 | 2.8 ± 1.1 | < 0.001 |
| ROM – Flexion (degrees) | Baseline | 95.9 ± 14.1 | | 91.5 ± 13.3 | |
| | Post-Intervention | 124.4 ± 10.5 | < 0.001 | 137.4 ± 10.6 | < 0.001 |
| ROM – Abduction | Baseline | 79.9 ± 9.5 | | 80.5 ± 10.5 | |

**(degrees)**

| | | | | | |
|---|---|---|---|---|---|
| | Post-Intervention | 108.7 ± 10.0 | < 0.001 | 120.4 ± 9.5 | < 0.001 |
| **ROM – External Rotation (°)** | Baseline | 36.0 ± 7.8 | | 36.4 ± 8.0 | |
| | Post-Intervention | 53.0 ± 6.6 | < 0.001 | 60.7 ± 6.3 | < 0.001 |
| **SPADI Score (0–100)** | Baseline | 58.1 ± 10.6 | | 59.1 ± 11.4 | |
| | Post-Intervention | 36.4 ± 9.1 | < 0.001 | 28.6 ± 8.9 | < 0.001 |

Table 4 presents the results of within-group comparisons for both Group A (Standardized Dosimetry) and Group B (Randomized Dosimetry), evaluating changes in pain, range of motion (ROM), and functional disability before and after the intervention in 120 participants (60 per group). The statistical analysis was performed using paired sample t-tests to determine whether the improvements observed within each group were statistically significant.

In terms of **pain reduction**, both groups showed significant improvements post-intervention. Group A's mean Visual Analog Scale (VAS) score decreased from 7.0 ± 0.9 to 4.1 ± 1.1, while Group B demonstrated a more substantial reduction from 7.0 ± 1.1 to 2.8 ± 1.1. These changes were statistically significant for both groups ($p < 0.001$).

With respect to **shoulder flexion**, Group A improved from a baseline of 95.9 ± 14.1 degrees to 124.4 ± 10.5 degrees, and Group B from 91.5 ± 13.3 to 137.4 ± 10.6 degrees. The improvements in both groups were statistically significant ($p < 0.001$), with Group B showing a greater gain.

For **abduction ROM**, Group A increased from 79.9 ± 9.5 to 108.7 ± 10.0 degrees, and Group B from 80.5 ± 10.5 to 120.4 ± 9.5 degrees, again with both improvements being statistically significant ($p < 0.001$).

Similarly, **external rotation** showed significant within-group gains: Group A improved from 36.0 ± 7.8 to 53.0 ± 6.6 degrees, while Group B improved from 36.4 ± 8.0 to 60.7 ± 6.3 degrees ($p < 0.001$ for both).

Lastly, the **SPADI score**, which measures shoulder pain and disability, improved notably in both groups. Group A's score decreased from 58.1 ± 10.6 to 36.4 ± 9.1, while Group B improved from 59.1 ± 11.4 to 28.6 ± 8.9. These reductions were also highly significant ($p < 0.001$).

Overall, Table 4 demonstrates that both treatment protocols resulted in statistically significant improvements in pain, shoulder mobility, and functional ability within their respective groups. Notably, Group B, which received randomized dosimetry, consistently showed greater improvements across all measured outcomes.

**Table 5: Comparison of Mean Changes in Outcome Measures Between Control and Experimental Groups**
***Independent sample t-test used for analysis (n = 120).***

| Outcome Measure | Mean Change – Group A (Standardized) | Mean Change – Group B (Randomized) | Mean Difference (B – A) | t-value | p-value |
|---|---|---|---|---|---|
| VAS Pain Score (0–10) | -2.9 ± 1.4 | -4.1 ± 1.7 | -1.2 | -4.34 | < 0.001 |
| ROM – Flexion (degrees) | +28.5 ± 17.3 | +45.9 ± 15.8 | +17.4 | 5.76 | < 0.001 |
| ROM – Abduction (degrees) | +30.7 ± 13.5 | +41.8 ± 12.9 | +11.2 | 4.62 | < 0.001 |
| ROM – External Rotation (°) | +16.5 ± 10.2 | +25.2 ± 10.5 | +8.7 | 4.61 | < 0.001 |
| SPADI Score (0–100) | -23.7 ± 13.9 | -31.4 ± 12.6 | -7.7 | -3.18 | 0.002 |

Table 5 presents a comparative analysis of mean changes in clinical outcome measures between Group A (Standardized Dosimetry) and Group B (Randomized Dosimetry) following the intervention in a total of 120 participants (60 per group). The table summarizes the average improvements (or reductions) in pain, range of motion (ROM), and functional disability, with corresponding mean differences, t-values, and p-values obtained from independent sample t-tests.

In terms of pain reduction, Group B showed a significantly greater improvement in Visual Analog Scale (VAS) scores, with a mean change of -4.1 ± 1.7, compared to -2.9 ± 1.4 in Group A. The difference between groups was statistically significant (mean difference = -1.2, t = -4.34, $p < 0.001$), indicating superior pain relief in the randomized dosimetry group.

For shoulder flexion ROM, Group B again demonstrated greater gains (+45.9 ± 15.8 degrees) compared to Group A (+28.5 ± 17.3 degrees), resulting in a mean difference of +17.4 degrees (t = 5.76, $p < 0.001$), highlighting the effectiveness of randomized shock wave dosing in restoring shoulder mobility.

Abduction ROM followed a similar pattern, with Group B showing a mean increase of +41.8 ± 12.9 degrees, while Group A improved by +30.7 ± 13.5 degrees, producing a mean difference of +11.2 degrees (t = 4.62, $p < 0.001$). Likewise, for external rotation, Group B experienced significantly more improvement (+25.2 ± 10.5 degrees) than Group A (+16.5 ± 10.2 degrees), with a mean difference of +8.7 degrees (t = 4.61, $p < 0.001$).

In terms of functional disability, as measured by the SPADI (Shoulder Pain and Disability Index), Group B reported a greater reduction of -31.4 ± 12.6 points compared to -23.7 ± 13.9 points in Group A. The mean difference of -7.7 points was statistically significant (t = -3.18, p = 0.002), indicating enhanced functional recovery in the experimental group

**Discussion**

The present randomized controlled trial aimed to evaluate and compare the therapeutic efficacy of two distinct dosimetry protocols of extracorporeal shock wave therapy (ESWT)—standardized versus randomized—in patients with adhesive capsulitis. The findings of this study demonstrate that both interventions significantly improved pain, shoulder range of motion (ROM), and functional outcomes; however, the group receiving randomized dosimetry ESWT (Group B) exhibited consistently greater improvements across all measured variables when compared to the standardized protocol group (Group A).

The improvement in pain, as assessed using the Visual Analog Scale (VAS), was statistically significant in both groups, aligning with previous literature that supports the analgesic effect of ESWT through mechanisms such as suppression of nociceptors and promotion of vascular regeneration[5,7,13]. Importantly, Group B showed a greater mean reduction in VAS scores (−4.1 ± 1.7) compared to Group A (−2.9 ± 1.4), suggesting that individualized adjustment of energy flux density and frequency may enhance clinical outcomes through optimized tissue response and patient tolerance[3,6,20].

Similarly, significant gains in ROM—including flexion, abduction, and external rotation—were observed in both groups, with Group B demonstrating superior improvements. For instance, post-intervention flexion in Group B increased by +45.9°, compared to +28.5° in Group A. This difference is not only statistically significant but clinically meaningful, as increased mobility is a primary goal in the management of frozen shoulder[22]. The enhancement in shoulder mobility may be attributed to the ability of ESWT to break adhesions, improve capsular elasticity, and stimulate capsular remodeling[3,8,12]. The greater efficacy of randomized dosimetry could be related to the progressive stimulation of different tissue thresholds, leading to more effective biomechanical adaptation[18,23].

Functional improvements were also markedly greater in the randomized group, as reflected in SPADI score reductions. Group B reported a mean improvement of −31.4 ± 12.6 points, compared to −23.7 ± 13.9 points in Group A. The between-group difference of 7.7 points was statistically significant (p = 0.002), indicating a higher level of independence in daily activities[22,23]. These results are in agreement with previous studies that have highlighted the role of ESWT in improving functional limitations in adhesive capsulitis, yet this study is one of the few to focus specifically on the role of dosing variability in optimizing therapeutic outcomes[3,6,11].

The findings from both within-group (Table 4) and between-group (Table 5) analyses provide robust evidence in favor of the randomized dosimetry protocol. All measured outcomes showed statistically significant pre–post

improvements in each group ($p < 0.001$), but the magnitude of change was significantly greater in Group B across all domains[3,6].

The strength of this study lies in its methodological rigor, including randomized allocation, standardized outcome tools (VAS, goniometry, SPADI), and appropriate statistical testing. Furthermore, the intervention was applied uniformly in terms of frequency and duration, and both groups received identical adjunct conventional physiotherapy, thereby isolating the effect of dosimetry variation[4,16].

However, certain limitations should be acknowledged. The study did not include long-term follow-up, so the sustainability of the observed improvements remains uncertain. Additionally, the population was limited to patients in the frozen stage of adhesive capsulitis; therefore, findings may not be generalizable to other stages of the condition[24,25]. Future studies should aim to include extended follow-up periods and evaluate the long-term impact of varied dosimetry protocols across different stages of adhesive capsulitis.

## Conclusion

In summary, this study confirms that extracorporeal shock wave therapy is effective in reducing pain and improving shoulder function in patients with adhesive capsulitis. More importantly, the findings highlight that randomized (variable) dosimetry results in significantly superior clinical outcomes compared to standardized dosimetry when used in conjunction with conventional physiotherapy. These results suggest that tailoring ESWT parameters within a clinically safe and effective range may optimize therapeutic gains. Incorporating variable dosimetry into clinical protocols could offer a valuable, evidence-based approach to enhance rehabilitation outcomes for individuals suffering from frozen shoulder.

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