RESEARCH PAPER

Stage-Specific Ultrasound-Guided Rehabilitation for Post-Stroke Shoulder Pain: A Quasi-Experimental Study Correlating Structural and Functional Outcomes

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ABSTRACT

Background: Post-stroke shoulder pain (PSSP) is a prevalent complication that considerably hinders functional recovery and diminishes quality of life. Despite numerous therapeutic approaches, the connection between structural pathology and stage-specific rehabilitation continues to be ambiguous. Objectives: To assess the efficacy of an ultrasound-guided, stage-specific physiotherapy protocol in enhancing structural and clinical outcomes in patients with PSSP. Materials & Methods: A quasi-experimental study was carried out involving 260 stroke patients experiencing shoulder pain, who were classified into acute (<6 weeks), subacute (6–12 weeks), chronic (>12 weeks), and control groups. Ultrasonography was employed to evaluate shoulder pathologies and inform tailored treatment protocols over 8 weeks. Outcome measures comprised the Ultrasound Rating Scale (URS), Visual Analogue Scale (VAS), Shoulder Pain and Disability Index (SPADI), Range of Motion (ROM), and Fugl-Meyer Assessment Upper Extremity (FMA-UE). Results: All experimental groups exhibited notable enhancements in URS, VAS, SPADI, ROM, and FMA-UE scores when compared to the control group ($p < 0.05$). Patients in the acute stage demonstrated more pronounced improvements in inflammatory conditions, whereas those in the chronic stage displayed a slower yet notable structural recovery. Ultrasound findings showed a positive correlation with clinical outcomes. Conclusion: Ultrasound-guided stage-specific rehabilitation markedly enhances both structural and functional outcomes in PSSP. This approach supports personalised rehabilitation strategies and enhances recovery in stroke survivors.

Keywords: Post-stroke shoulder pain, ultrasonography, rehabilitation, physiotherapy, stroke, shoulder pathology

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1. INTRODUCTION

Stroke continues to be a primary contributor to long-term disability globally, with a considerable number of survivors facing ongoing complications that hinder rehabilitation success. Post-stroke shoulder pain (PSSP) is a highly prevalent and disabling condition, impacting around 30–65% of individuals who have experienced a stroke. PSSP not only extends the duration of hospital stays but also hinders upper limb recovery, diminishes functional independence, and adversely affects quality of life. [1] The aetiology of PSSP is complex, involving various factors such as biomechanical alterations, spasticity, soft tissue injuries, and mechanisms of central sensitisation. Common structural abnormalities encompass rotator cuff tendinopathy, biceps tendon effusion, subacromial-subdeltoid bursitis, and glenohumeral subluxation. Despite thorough investigation, a consensus on the classification and stage-specific progression of these pathologies remains elusive.

Traditional physiotherapy methods mainly concentrate on managing symptoms, often overlooking the fundamental structural issues. Furthermore, patients frequently encounter difficulties in accurately pinpointing pain, which complicates the implementation of targeted interventions. Imaging modalities like ultrasonography offer a dynamic, non-invasive, and cost-effective approach for assessing soft tissue structures and informing treatment strategies.

While ultrasonography has gained significant traction in diagnosing shoulder pathologies, its incorporation into stage-specific rehabilitation protocols has yet to be thoroughly investigated.[2, 3]

Moreover, there is a scarcity of evidence linking structural findings to functional outcomes at various stages of stroke recovery. Consequently, this study seeks to address this gap by creating and assessing an ultrasound-guided, stage-specific physiotherapy protocol for the management of PSSP. By correlating structural changes with clinical outcomes, this study aims to deliver a more thorough and individualised approach to rehabilitation.

2. METHODS

Study Design and Setting

A quasi-experimental study was conducted at a tertiary care hospital over a period of three years.

Participants

A total of 260 patients diagnosed with post-stroke shoulder pain were included in the study. Participants were categorised into four distinct groups:

• Acute (less than 6 weeks)

• Subacute (6–12 weeks) • Long-term (exceeding 12 weeks) • Control group

Inclusion Criteria

- First-ever stroke (ischemic or hemorrhagic)
- Shoulder pain post-stroke
- Ability to participate in rehabilitation

Exclusion Criteria

- Pre-existing shoulder pathology
- Severe cognitive impairment
- Systemic neuromuscular disorders

Intervention

Experimental groups received an **ultrasound-guided physiotherapy protocol** tailored to stage-specific structural findings, including:

- Positioning and handling techniques
- Kinesio taping
- Neuromuscular electrical stimulation (NMES)
- Low-level laser therapy
- Range of motion and strengthening exercises

The control group received conventional physiotherapy.

Outcome Measures

- Ultrasound Rating Scale (URS)
- Visual Analog Scale (VAS)
- Range of Motion (ROM)
- Shoulder Pain and Disability Index (SPADI)
- Fugl-Meyer Assessment Upper Extremity (FMA-UE)

Statistical Analysis

Pre- and post-intervention comparisons were analysed using appropriate statistical tests, with significance set at $p < 0.05$.

3. RESULTS

3.1 Participant Characteristics

A total of 260 participants were included and completed the study. The study population was divided into four groups: acute (n = 72), subacute (n = 63), chronic (n = 60), and control (n = 65). The overall gender distribution indicated a higher representation of males at 55%, in contrast to females at 45%. The distribution by group was as follows:

Table 1: Gender distribution among study groups

Study Group	Male, n (%)	Female, n (%)	Total, n (%)
Acute	42 (58.3)	30 (41.7)	72 (27.8)
Subacute	32 (50.8)	31 (49.2)	63 (24.3)
Chronic	28 (46.7)	32 (53.3)	60 (23.2)
Control	37 (56.9)	28 (43.1)	65 (25.1)
Total	**139 (53.7)**	**121 (46.3)**	**260 (100)**

3.2 Sonographic Findings

Ultrasound evaluation identified several structural abnormalities across the groups. The predominant pathology identified was biceps tendon involvement (effusion/tenosynovitis/tendinitis), noted in 68 participants, followed by:

- Supraspinatus pathology: 48 participants
- Subscapularis tear: 46 participants
- Subacromial-subdeltoid (SA-SD) bursitis: 34 participants
- Glenohumeral subluxation: 15 participants

Notably, 49 participants exhibited no significant sonographic abnormalities, primarily within the control group. Biceps pathology was most common in the acute stage (n = 22), followed by the subacute stage (n = 19) and the chronic stage (n = 17), suggesting a greater inflammatory component in the early stages.

3.3 Within-Group Comparisons (Pre vs Post Intervention)

Table 2: Summary of Changes in Clinical Outcome Measures Across Study Groups

Outcome Measure	Acute Group	Subacute Group	Chronic Group	Control Group
Pain (VAS)	↓ 3.50 ± 0.50 to 1.48 ± 0.76 ($p < 0.0001$)	↓ 4.13 ± 0.78 to 1.70 ± 1.54 ($p < 0.001$)	↓ 2.88 ± 0.51 to 0.81 ± 0.74 ($p < 0.00001$)	No significant change ($p > 0.05$)
FMA-UE	↑ 27.60 ± 15.33 to 45.62 ± 13.81 ($p < 0.00001$)	↑ 26.32 ± 12.25 to 46.61 ± 10.17 ($p < 0.001$)	↑ 21.30 ± 9.68 to 39.94 ± 17.23 ($p < 0.00001$)	Significant improvement ($p < 0.00001$)
SPADI	↓ 60.05 ± 7.90 to 39.20 ± 9.84 ($p < 0.00001$)	Significant improvement ($p < 0.00001$)	↓ 79.98 ± 4.79 to 64.27 ± 5.94 ($p < 0.00001$)	No significant change ($p > 0.05$)
Ultrasound Rating Score (URS)	Significant improvement ($p = 0.0001$)	Significant improvement ($p = 0.03$)	Significant improvement ($p < 0.00001$)	No significant improvement ($p = 0.23$)
Shoulder ROM	Significant improvement in all movements ($p < 0.00001$)	Significant improvement in extension and external rotation; other movements improved clinically but were not statistically significant	Significant improvement in all ROM parameters ($p < 0.05$)	Significant improvement in ROM ($p < 0.00001$)

The acute group exhibited notable enhancements in all clinical and functional outcome measures, encompassing pain, upper limb function, disability, ultrasound findings, and shoulder range of motion. The subacute group demonstrated notable reductions in pain along with enhancements in function, disability, and ultrasound scores, achieving statistically significant improvements in shoulder extension and external rotation. The chronic group demonstrated notable enhancements across all evaluated parameters, encompassing pain, functional ability, disability, ultrasound score, and all shoulder range of motion measures. In contrast, the control group demonstrated notable enhancements solely in upper limb function and range of motion, whereas alterations in pain, disability, and ultrasound findings did not reach statistical significance.

3.4 Between-Group Comparisons

Table 3: Baseline, Post-Intervention, and Between-Group Comparison of Clinical Outcome Measures

Comparison	Outcome Measure	Findings	*P* Value	Interpretation
Baseline (Pre-test)	VAS	Significant difference among groups	<0.001	Significant
	FMA-UE	Significant difference among groups	0.001	Significant
	SPADI	Significant difference among groups	<0.001	Significant
	URS	Significant difference among groups	<0.05	Significant
	ROM (Abduction & Adduction)	Comparable among groups	>0.05	Not Significant
Post-test	VAS	Significant difference (F = 8.57)	<0.001	Significant
	SPADI	Significant difference (F = 56.48)	<0.001	Significant
	FMA-UE	Significant difference	0.041	Significant
	URS	Significant difference	0.0001	Significant
	ROM	Significant improvement in flexion, abduction, internal & external rotation	<0.05	Significant
	Overall Outcome	Acute group showed the greatest improvement, followed by subacute and chronic groups	—	—
Acute vs Control	VAS	Significant reduction	<0.00001	Significant
	SPADI	Significant improvement	<0.00001	Significant
	ROM	Significant improvement in all parameters	<0.001	Significant
	FMA-UE	Comparable between groups	0.27	Not Significant
Subacute vs Control	VAS	Significant reduction	<0.00001	Significant
	SPADI	Significant improvement	<0.001	Significant
	ROM	Significant improvement in flexion, abduction & internal rotation	<0.05	Significant
	URS & Other ROM	Comparable with control	>0.05	Not Significant
Chronic vs Control	VAS	Significant reduction	<0.00001	Significant

	SPADI	Significant improvement	<0.00001	Significant
	ROM	Significant improvement in selected parameters	<0.05	Significant
	FMA-UE & Some ROM	Comparable with control	>0.05	Not Significant

Baseline analysis revealed notable differences among the study groups regarding pain (VAS), upper extremity motor function (FMA-UE), shoulder disability (SPADI), and ultrasound rating score (URS), while shoulder abduction and adduction showed comparable results. Following the intervention, notable enhancements were recorded in VAS, SPADI, FMA-UE, URS, and the majority of range of motion (ROM) parameters, with the acute group demonstrating the most substantial improvement, followed by the subacute and chronic groups. In comparison to the control group, the acute, subacute, and chronic groups demonstrated significantly greater reductions in pain and disability. However, improvements in FMA-UE and specific ROM measures did not show statistically significant differences in the subacute and chronic groups.

3.5 Overall Group Comparison (ANOVA)

Table 4: Summary of One-way ANOVA

Outcome Measure	ANOVA *P* Value	Statistical Significance
Visual Analogue Scale (VAS)	<0.05	Significant
Fugl-Meyer Assessment for Upper Extremity (FMA-UE)	<0.05	Significant
Shoulder Pain and Disability Index (SPADI)	<0.05	Significant
Ultrasound Rating Score (URS)	<0.05	Significant
Shoulder Flexion (ROM)	<0.05	Significant
Shoulder Extension (ROM)	<0.05	Significant
Shoulder Internal Rotation (ROM)	<0.05	Significant
Shoulder External Rotation (ROM)	<0.05	Significant
Shoulder Abduction (Pre-test)	>0.05	Not Significant
Shoulder Abduction (Post-test)	>0.05	Not Significant
Shoulder Adduction (Pre-test)	>0.05	Not Significant
Shoulder Adduction (Post-test)	<0.05	Significant

ANOVA analysis demonstrated statistically significant differences among groups for most parameters:

- VAS, SPADI, FMA-UE, URS: **$p < 0.05$**
- Most ROM parameters: **$p < 0.05$**

However, no significant differences were observed in:

- Shoulder abduction (pre and post)
- Shoulder adduction (pre-test)

Overall, the **acute group showed the greatest improvement**, followed by subacute and chronic groups, confirming the effectiveness of stage-specific intervention.

4. DISCUSSION

The current study assessed the efficacy of a stage-specific physiotherapy protocol guided by ultrasound in addressing post-stroke shoulder pain (PSSP), emphasizing the correlation between structural and functional outcomes. The findings indicate notable advancements in pain, disability, motor recovery, range of motion (ROM), and sonographic parameters, especially during the acute and subacute stages, thereby reinforcing the importance of early, targeted intervention.

4.1 Analysis of Principal Insights

One of the key findings of this study is that all experimental groups exhibited statistically significant improvements, while the control group showed limited or non-significant changes in pain (VAS), disability (SPADI), and structural outcomes (URS). This clearly indicates that traditional physiotherapy alone may not sufficiently address the complex nature of PSSP, especially when structural pathology is not specifically targeted. The acute group demonstrated the most significant enhancement in nearly all outcome measures, encompassing pain reduction, range of motion, and functional recovery. This can be attributed to the prevalence of inflammatory and reversible soft tissue changes in the early stages, including biceps tendon effusion and tendinopathy, which respond favourably to prompt intervention. These findings align with earlier research indicating that early rehabilitation markedly enhances outcomes and mitigates chronic complications.

In contrast, while the chronic group demonstrated statistically significant improvements, the extent of recovery was relatively lower, especially in functional measures such as FMA-UE and SPADI. This may be attributed to the presence of fibrotic changes, muscle stiffness, and prolonged disuse, which tend to be less responsive to short-term rehabilitation. Similar observations have been noted in chronic stroke populations, where structural changes and maladaptive motor patterns restrict recovery potential [4].

4.2 The Role of Ultrasound in Identifying Structural Pathology: The sonographic findings in this study indicated that biceps tendon pathology was the predominant abnormality, followed by involvement of the supraspinatus and subscapularis. This is consistent with earlier studies showing that lesions of the rotator cuff and biceps tendon are common in PSSP [5,6]. It is noteworthy that the distribution of pathologies exhibited variation across different stages, with acute cases showing a higher prevalence of inflammatory findings and chronic cases displaying more degenerative features. This observation reinforces the concept of stage-wise progression of PSSP. Ultrasonography allowed for the immediate identification of these abnormalities, supporting focused and personalised intervention. In contrast to MRI, ultrasonography presents several advantages, including cost-effectiveness, accessibility, and the ability to conduct dynamic assessments, which render it especially appropriate for regular clinical application in rehabilitation environments [7]. The notable enhancement in URS scores identified in this study reinforces the efficacy of ultrasound-guided intervention in tackling underlying structural pathology.

4.3 Relationship Between Structural and Functional Recovery

A significant strength of this study is the evidence of concurrent enhancement in structural (URS) and clinical outcomes (VAS, SPADI, ROM, FMA-UE). This indicates that tackling structural abnormalities plays a crucial role in achieving functional recovery, rather than simply reducing symptoms. Previous studies have frequently analysed clinical outcomes without establishing a correlation with imaging findings. Emerging evidence indicates that persistent structural lesions are linked to ongoing pain and functional impairment [8]. The current study supports this relationship by demonstrating that enhancements in sonographic findings were associated with notable clinical advancements.

4.4 Effectiveness of Stage-Specific Rehabilitation

The ANOVA analysis results indicated statistically significant differences among the groups, with the acute group exhibiting superior outcomes, followed by the subacute and chronic groups. This underscores the significance of intervention strategies tailored to specific stages.

During the acute stage, interventions should concentrate on: Management of discomfort; Reduction of inflammation; Proper positioning is essential for preventing secondary complications such as subluxation and contracture.

During the subacute stage, the focus transitions to: Gradual mobilisation Activation of muscles; Functional training

In the chronic stage, rehabilitation necessitates: Focused stretching Enhancing Motor relearning. This structured methodology is consistent with the principles of neurorehabilitation and is backed by previous research highlighting the importance of timely and phase-specific interventions for achieving optimal recovery [9].

4.5 Analysis in Relation to Existing Literature

Although numerous studies have explored PSSP, the majority have concentrated on clinical outcomes or imaging findings in isolation. For example, Ada Tang and colleagues documented enhancements in upper limb function through structured rehabilitation; however, they did not utilise imaging guidance [10]. Studies conducted by Hsieh Yu-Chen et al. similarly emphasised the prevalence of shoulder pathologies identified through ultrasonography; however, they did not establish interventional correlation [11]. The current study distinguishes itself by incorporating ultrasound assessment alongside stage-specific physiotherapy and longitudinal outcome evaluation, thus providing a more thorough model for the management of PSSP.

4.6 Clinical Implications

The results of this study carry significant clinical implications: Ultrasound may serve as a standard screening instrument in PSSP. Rehabilitation can be tailored according to structural findings. Early intervention greatly enhances results. Stage-specific protocols improve the efficiency of treatment. This approach has the potential to enhance patient outcomes while minimising long-term disability and healthcare expenses.

4.7 Limitations: While this study presents several strengths, it is important to acknowledge its limitations: The quasi-experimental design restricts the ability to draw causal inferences. Operator dependency in ultrasonography can lead to variability. Long-term follow-up was not conducted. The absence of randomisation could lead to the introduction of selection bias. Future research should prioritise randomised controlled trials with extended follow-up to confirm these findings.

4.8 Future Directions

Additional investigation is required to: Develop standardised classification systems based on ultrasound; Assess the enduring viability of results; Analyse the differences between ultrasound-guided therapy and advanced imaging-guided interventions. Investigate the incorporation of technology in rehabilitation practices

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