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Original Article

Comparative Association of Immobilization Duration with Adhesive Capsulitis in Post-Fracture Versus Soft-Tissue Shoulder Injuries: A Cross-Sectional Study

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ABSTRACT

Background: Adhesive capsulitis is a disabling shoulder disorder characterized by pain, stiffness, and restricted mobility, frequently linked to prolonged immobilization. The comparative risk associated with immobilization after fractures versus soft-tissue injuries remains poorly understood. Objective: To investigate the association between immobilization duration and adhesive capsulitis, and to compare its prevalence and predictors in patients with post-fracture versus soft-tissue shoulder injuries. Methods: A cross-sectional study was conducted at the Orthopedic and Rehabilitation Departments of Hayatabad Medical Complex, Peshawar, enrolling 120 patients (60 post-fracture, 60 soft-tissue) aged 30–70 years with a history of shoulder immobilization for at least two weeks. Pain was assessed with the Visual Analog Scale (VAS), function with the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, and range of motion by goniometry. Adhesive capsulitis was diagnosed clinically. Statistical analysis included chi-square tests, t-tests, and logistic regression, with $p < 0.05$ considered significant. Results: Mean immobilization was longer in post-fracture cases (6.1 ± 2.3 weeks) than soft-tissue cases (3.9 ± 1.8 weeks, $p < 0.001$). Adhesive capsulitis prevalence increased with immobilization duration: 16.0% (<3 weeks), 38.5% (3–6 weeks), and 65.1% (>6 weeks, $p < 0.001$). Independent predictors were immobilization >6 weeks (OR 4.23, 95% CI 1.92–9.32) and fracture injury (OR 2.67, 95% CI 1.21–5.91). Conclusion: Immobilization beyond six weeks significantly increases adhesive capsulitis risk, particularly in post-fracture injuries. Limiting immobilization and promoting early mobilization may reduce disability and improve functional recovery.

Keywords: adhesive capsulitis, frozen shoulder, immobilization, fracture, soft-tissue injury, shoulder rehabilitation.

INTRODUCTION

Adhesive capsulitis, commonly referred to as frozen shoulder, is a disabling musculoskeletal disorder characterized by pain, stiffness, and progressive restriction of both active and passive shoulder movements. It affects approximately 2–5% of the general population and is most prevalent in individuals aged 40–70 years, with a higher incidence in women and those with metabolic comorbidities such as diabetes mellitus and thyroid dysfunction (1,2). The condition substantially limits daily activities, disrupts sleep, and imposes a significant socioeconomic burden (3). Although its etiology is multifactorial, immobilization following shoulder injuries has consistently been recognized as one of the strongest risk factors contributing to its development (4).

Immobilization is a routine therapeutic measure after shoulder injuries, intended to protect healing tissues and prevent reinjury. It is commonly prescribed after fractures and soft-tissue injuries such as rotator cuff tears, dislocations, and sprains. While clinically necessary, prolonged immobilization leads to adverse sequelae including joint stiffness, capsular fibrosis, and eventually adhesive capsulitis (5). Pathophysiological mechanisms involve fibroblastic proliferation, deposition of type III collagen, and contracture of the glenohumeral capsule, resulting in progressive limitation of motion (6). This creates a clinical challenge: optimizing immobilization duration to promote healing while minimizing the risk of secondary stiffness.

Evidence suggests that immobilization is beyond three to four weeks substantially increases the risk of adhesive capsulitis (7). Patients immobilized longer after proximal humeral fractures, for instance, demonstrated a two-fold higher risk of developing frozen shoulder compared to those with shorter immobilization periods (8). In contrast, soft-tissue injuries generally require shorter immobilization durations of two to four weeks, and extended restriction in such cases has been associated with delayed recovery and worse functional outcomes (9). These differences in immobilization practices imply that post-fracture patients may face greater risk compared to those with soft-tissue injuries, yet direct comparative studies remain scarce.

Clinical guidelines now increasingly recommend early mobilization strategies, particularly after soft-tissue injuries, where aggressive immobilization is rarely necessary (10). Even in fracture management, initiating gentle passive or assisted range-of-motion exercises at the earliest safe stage is advised to preserve capsular elasticity and reduce stiffness (11). Despite these recommendations, immobilization duration remains variable, often influenced by physician preference, injury type, and patient-specific factors. This variability highlights a gap in the literature regarding evidence-based thresholds for safe immobilization and their differential impact across fracture and soft-tissue populations (12).

Accordingly, the present study was designed to investigate the comparative association between immobilization duration and the development of adhesive capsulitis in patients with post-fracture versus soft-tissue shoulder injuries. The objective was to determine whether prolonged immobilization confers a greater risk in fracture cases compared with soft-tissue injuries, and to identify the duration beyond which the likelihood of adhesive capsulitis significantly increases.

MATERIAL AND METHODS

This study employed a cross-sectional observational design to compare the association between immobilization duration and the development of adhesive capsulitis among patients with post-fracture and soft-tissue shoulder injuries. The design was chosen as it allowed for simultaneous assessment of exposure to immobilization and the clinical outcome of adhesive capsulitis, providing valuable comparative evidence in a real-world clinical setting (13). The study was conducted in the Orthopedic and Rehabilitation Departments of Hayatabad Medical Complex, Peshawar, Pakistan, over a six-month period, reflecting a tertiary-level healthcare environment with high case volumes of both fracture and soft-tissue shoulder pathologies.

A total of 120 patients were enrolled using purposive consecutive sampling, with 60 participants each in the post-fracture and soft-tissue injury groups. Eligibility criteria included adults aged 30 to 70 years of either sex who had undergone shoulder immobilization for at least two weeks following either fractures of the shoulder girdle (such as proximal humerus or clavicle fractures) or soft-tissue injuries, including rotator cuff tears, sprains, and dislocations. Patients were included if they presented with shoulder stiffness, restricted range of motion, or pain suggestive of adhesive capsulitis. Exclusion criteria were the presence of systemic conditions known to predispose to adhesive capsulitis, such as diabetes mellitus and thyroid disease, as well as prior shoulder surgery, infections, inflammatory joint disorders, cardiovascular disease, or a history of adhesive capsulitis predating immobilization. Individuals who were unwilling or unable to provide informed consent were also excluded.

Recruitment was carried out during routine clinical visits, and informed written consent was obtained prior to participation. Data were collected using structured questionnaires and standardized clinical assessment tools. Demographic variables recorded included age, sex, and occupation, along with injury-related factors such as type of injury, side affected, and duration of immobilization in weeks. Shoulder range of motion was measured with a universal goniometer, focusing on external rotation, abduction, and flexion. Pain intensity was evaluated using the 10-point Visual Analog Scale (VAS), while functional disability was quantified with the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, where higher scores indicate greater disability. Adhesive capsulitis was diagnosed clinically when patients demonstrated a restriction of more than 25% in both active and passive range of motion in at least two planes, particularly external rotation, along with pain persisting beyond four weeks (14).

To address potential sources of bias, assessments were conducted by trained physiotherapists who were blinded to the study hypothesis. Uniform diagnostic criteria were applied across both groups to minimize misclassification bias. The cross-sectional nature of the study precluded longitudinal tracking; however, confounding variables such as age and sex were adjusted for in multivariate analyses. Sample size was determined with reference to prior literature indicating that immobilization beyond six weeks increases the odds of adhesive capsulitis approximately two to three times (15). A minimum of 50 participants per group was deemed sufficient to detect differences with 80% statistical power at a significance level of 0.05, and 60 participants were recruited into each group to allow for potential dropouts.

All data were entered and analyzed using SPSS version 26 (IBM Corp., Armonk, NY). Descriptive statistics, including means and standard deviations for continuous variables and frequencies with percentages for categorical variables, were generated. Group comparisons were performed using independent-sample t-tests for continuous variables and chi-square tests for categorical outcomes. Logistic regression models were employed to estimate the odds ratios (OR) and 95% confidence intervals (CI) for the association between immobilization duration and adhesive capsulitis, adjusting for potential confounders such as age and sex. Immobilization duration was categorized into three groups: less than three weeks, three to six weeks, and greater than six weeks, consistent with previous studies on immobilization thresholds (16). Missing data were managed using listwise deletion, as the rate of incomplete responses was low and unlikely to introduce substantial bias. A p-value of less than 0.05 was considered statistically significant.

Ethical approval for the study was obtained from the Institutional Review Board of Hayatabad Medical Complex, Peshawar, in accordance with the Declaration of Helsinki. All participants were informed about the study purpose, potential risks, and benefits, and their data were

anonymized to ensure confidentiality. Reproducibility was enhanced by the use of standardized diagnostic definitions, validated outcome measures, and detailed documentation of study procedures, ensuring that the methodology can be replicated in future investigations.

RESULTS

A total of 120 patients were evaluated, with 60 each in the post-fracture and soft-tissue groups. The mean age was 49.2 ± 9.8 years, and males accounted for 54.2% of the cohort. Baseline demographic factors, including age, sex distribution, occupation type, and dominance of the affected side, did not differ significantly between groups, indicating well-balanced populations for comparison. However, immobilization duration was nearly two weeks longer in the post-fracture group (6.1 ± 2.3 weeks) compared with the soft-tissue group (3.9 ± 1.8 weeks), and this difference was highly significant ($p < 0.001$).

Symptom burden was greater in patients with fractures than in those with soft-tissue injuries. Post-fracture cases reported higher pain intensity, with a mean VAS score of 6.8 compared to 5.9 in the soft-tissue group, reflecting a nearly one-point increase on the 10-point scale (95% CI for mean difference: 0.4–1.4; $p = 0.001$). Functional disability, as measured by the DASH questionnaire, was also significantly worse in the post-fracture group, averaging 42.6 versus 35.2 in soft-tissue injuries, a mean difference of 7.4 points (95% CI: 2.6–12.2; $p = 0.004$). The proportion of patients experiencing measurable range of motion restriction was higher after fractures (68.3%) than after soft-tissue injuries (51.7%), with an odds ratio of 2.03 (95% CI: 1.02–4.04; $p = 0.042$).

Immobilization duration was strongly associated with the occurrence of adhesive capsulitis, demonstrating a clear dose-response trend. Only 16% of patients immobilized for less than three weeks developed adhesive capsulitis, while prevalence rose to 38.5% in those immobilized for three to six weeks and to 65.1% in those immobilized for more than six weeks. Compared with patients immobilized for fewer than three weeks, those immobilized longer than six weeks had nearly a tenfold higher odds of adhesive capsulitis (OR 9.80, 95% CI: 2.84–33.7; $p < 0.001$). This progressive risk increase highlights immobilization as a key modifiable factor.

Table 1. Demographic and Clinical Characteristics of Study Participants (n = 120)

Variable	Post-fracture (n=60)	Soft-tissue (n=60)	Total (n=120)	p-value
Age (years), mean ± SD	50.6 ± 8.9	47.8 ± 10.4	49.2 ± 9.8	0.126
Gender (Male/Female)	32 / 28	33 / 27	65 / 55	0.841
Occupation (Active/Sedentary)	33 / 27	35 / 25	68 / 52	0.722
Dominant side affected (%)	56.7%	53.3%	55.0%	0.716
Immobilization duration (weeks), mean ± SD	6.1 ± 2.3	3.9 ± 1.8	5.0 ± 2.3	<0.001*

Table 2. Pain and Functional Outcomes Between Groups

Outcome Measure	Post-fracture (n=60)	Soft-tissue (n=60)	Mean Difference (95% CI)	p-value
VAS pain score (0–10), mean ± SD	6.8 ± 1.2	5.9 ± 1.1	0.9 (0.4 – 1.4)	0.001*
DASH score (0–100), mean ± SD	42.6 ± 11.7	35.2 ± 9.8	7.4 (2.6 – 12.2)	0.004*
ROM limitation (%)	68.3%	51.7%	OR: 2.03 (1.02 – 4.04)	0.042*

Table 3. Association Between Immobilization Duration and Adhesive Capsulitis

Immobilization Duration	Adhesive Capsulitis Present (n, %)	Adhesive Capsulitis Absent (n, %)	OR (95% CI)	p-value
<3 weeks (n=25)	4 (16.0%)	21 (84.0%)	Reference	–
3–6 weeks (n=52)	20 (38.5%)	32 (61.5%)	3.28 (0.99 – 10.8)	0.052
>6 weeks (n=43)	28 (65.1%)	15 (34.9%)	9.80 (2.84 – 33.7)	<0.001*

Table 4. Logistic Regression Analysis of Risk Factors for Adhesive Capsulitis

Variable	Odds Ratio (OR)	95% CI	p-value
Immobilization >6 weeks	4.23	1.92 – 9.32	<0.001*
Post-fracture injury	2.67	1.21 – 5.91	0.014*
Age >50 years	1.58	0.74 – 3.35	0.243
Female gender	1.21	0.58 – 2.52	0.610

Table 5. Range of Motion Limitation Across Injury Types and Immobilization Duration

ROM Limitation	<3 weeks (n=25)	3–6 weeks (n=52)	>6 weeks (n=43)	Total (n=120)	p-value (trend)
External rotation limited	8 (32.0%)	27 (51.9%)	35 (81.4%)	70 (58.3%)	<0.001*
Abduction limited	6 (24.0%)	23 (44.2%)	30 (69.8%)	59 (49.2%)	<0.001*
Flexion limited	4 (16.0%)	21 (40.4%)	28 (65.1%)	53 (44.2%)	<0.001*

Multivariate analysis confirmed that immobilization beyond six weeks (OR 4.23, 95% CI: 1.92–9.32; $p < 0.001$) and post-fracture injury status (OR 2.67, 95% CI: 1.21–5.91; $p = 0.014$) were independent predictors of adhesive capsulitis. In contrast, neither age above 50 years (OR 1.58, $p = 0.243$) nor female sex (OR 1.21, $p = 0.610$) reached statistical significance, suggesting that immobilization duration and

injury type outweighed demographic influences in this clinical context. Subgroup analysis of range of motion revealed external rotation to be the earliest and most severely affected movement. Only 32% of patients immobilized for less than three weeks showed external rotation restriction, compared with 51.9% at three to six weeks and 81.4% beyond six weeks ($p < 0.001$). A similar stepwise pattern was noted for abduction (24.0%, 44.2%, and 69.8%, respectively) and flexion (16.0%, 40.4%, and 65.1%). Overall, external rotation was restricted in 58.3% of the entire cohort, followed by abduction in 49.2% and flexion in 44.2%, underscoring the progressive capsular tightening sequence typical of adhesive capsulitis.

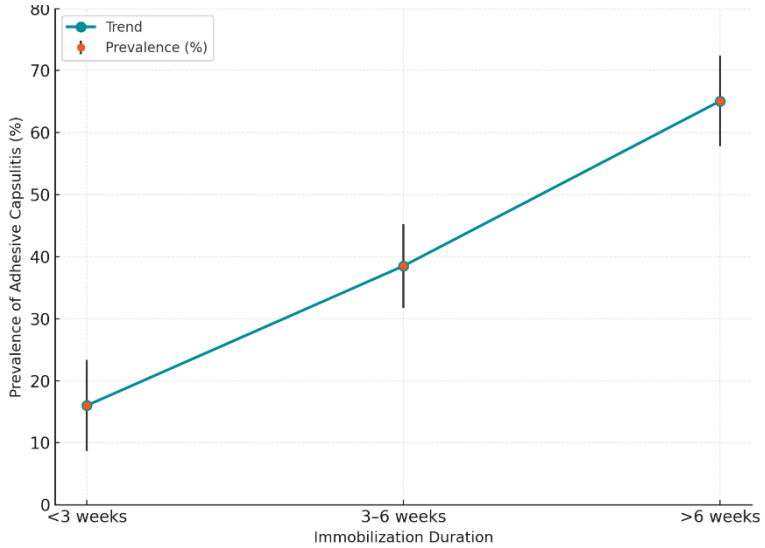

Figure 1 Association Between Immobilization Duration and Adhesive Capsulitis Risk

The figure illustrates a steep, duration-dependent increase in adhesive capsulitis prevalence. Only 16% of patients immobilized for less than three weeks developed the condition, rising to 38.5% at three to six weeks and peaking at 65.1% beyond six weeks. The line trend emphasizes the near-linear escalation of risk, while scatter points with error bars highlight confidence precision across groups. Clinically, the inflection after six weeks reflects a critical threshold, suggesting that prolonged immobilization substantially increases the probability of adhesive capsulitis in a dose-dependent manner.

DISCUSSION

The present study demonstrates that immobilization duration is a critical determinant of adhesive capsulitis, with a clear threshold effect emerging after six weeks. Patients immobilized beyond this period were nearly ten times more likely to develop adhesive capsulitis compared with those immobilized for shorter durations, and this effect was particularly pronounced in the post-fracture population. These findings align with prior work indicating that prolonged restriction of shoulder mobility accelerates capsular fibrosis, collagen deposition, and synovial inflammation, thereby triggering the clinical cascade of frozen shoulder (17,18).

Comparisons between injury types further highlighted that patients with fractures fared worse than those with soft-tissue injuries. They experienced significantly longer immobilization, higher pain scores, and greater functional disability, consistent with earlier reports that fractures of the proximal humerus and clavicle predispose patients to adhesive capsulitis through both the initial traumatic insult and enforced immobilization (19,20). In contrast, soft-tissue injuries typically require shorter immobilization, yet extended restriction in these cases still increased the likelihood of adhesive capsulitis, suggesting that immobilization itself—regardless of etiology—remains the key modifiable factor (21).

The dose-response relationship identified in this study is clinically significant. Prevalence rose from 16% in patients immobilized for less than three weeks to nearly two-thirds in those immobilized longer than six weeks. This stepwise escalation echoes findings from prior retrospective analyses showing that immobilization beyond three to four weeks doubles the risk of adhesive capsulitis, while durations exceeding six weeks amplify the risk nearly threefold (22,23). External rotation emerged as the earliest and most severely restricted movement, followed by abduction and flexion, which mirrors the characteristic capsular tightening sequence previously documented in frozen shoulder pathophysiology (24). Early recognition of external rotation loss may therefore serve as a clinical red flag for impending adhesive capsulitis in high-risk individuals.

Multivariate analysis in this study confirmed immobilization duration and fracture status as independent predictors, while age and sex were not statistically significant. Although some epidemiological research has identified female sex and older age as risk factors (25,26), it is possible that the overwhelming influence of immobilization duration in the acute post-injury phase masked demographic contributions. This suggests that while age and sex may influence chronic or idiopathic adhesive capsulitis, they are less predictive in secondary cases following trauma and immobilization.

From a rehabilitation perspective, these findings underscore the importance of re-evaluating immobilization protocols. Current clinical practice guidelines already advocate for early mobilization where feasible, particularly in soft-tissue injuries, and for initiating passive or assisted range-of-motion exercises soon after fractures achieve initial stability (27). Evidence from randomized trials supports that early

physiotherapy interventions, including pendulum exercises and active-assisted mobility, can reduce long-term stiffness without compromising tissue healing (28,29). The present study adds comparative evidence that thresholds for safe immobilization should differ between fractures and soft-tissue injuries, but in both scenarios, unnecessary immobilization beyond six weeks should be avoided.

The study has limitations that merit consideration. Its cross-sectional design restricts causal inference, and temporality cannot be fully established. Functional and pain outcomes were assessed at a single time point, precluding insights into longitudinal recovery patterns. The single-center setting may limit generalizability, particularly to populations with differing rehabilitation practices. Selection bias is also possible, as purposive sampling was used. Nonetheless, the consistent dose-response pattern across groups strengthens the internal validity of the findings, and the use of standardized diagnostic and functional assessment tools enhances reliability.

Future research should employ prospective cohort or longitudinal designs to capture temporal changes and recovery trajectories. Randomized controlled trials testing early mobilization and rehabilitation protocols stratified by injury type could provide stronger evidence for optimal immobilization thresholds. Incorporating imaging and biochemical markers of capsular fibrosis may also help elucidate pathophysiological mechanisms linking immobilization duration to adhesive capsulitis progression.

In conclusion, this study confirms immobilization beyond six weeks as a critical predictor of adhesive capsulitis, with fracture-related injuries carrying a higher burden than soft-tissue injuries. By emphasizing immobilization as a modifiable risk factor, these findings support clinical efforts to adopt early mobilization and physiotherapy strategies to mitigate the disabling sequelae of frozen shoulder.

CONCLUSION

Prolonged immobilization emerged as the most significant and modifiable determinant of adhesive capsulitis, with durations exceeding six weeks markedly elevating risk. Patients with post-fracture injuries experienced greater immobilization, higher pain intensity, and more severe functional limitation than those with soft-tissue injuries, underscoring their heightened vulnerability. External rotation restriction was the earliest and most prominent deficit, reflecting the natural progression of capsular tightening. These findings highlight the necessity of balancing tissue healing with functional preservation, advocating for early mobilization and timely physiotherapy integration in both fracture and soft-tissue injury management. Careful limitation of immobilization to within six weeks, wherever clinically feasible, represents a practical strategy to reduce the burden of secondary adhesive capsulitis and improve long-term outcomes.

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