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FACTORS AFFECTING FUNCTIONAL OUTCOMES AFTER SURGICAL FIXATION OF SCAPULAR FRACTURES

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ABSTRACT

Objective: To evaluate functional outcomes and identify factors associated with postoperative results following surgical fixation of closed scapular fractures.

Methods: A prospective study was conducted on 35 patients with closed scapular fractures who were treated with surgical fixation using locking plates at two tertiary trauma centers between December 2023 and December 2025. Clinical, radiological, and surgical variables were collected and analyzed. Functional outcomes were assessed using the Constant–Murley score and the EQ-5D index.

Results: All patients achieved bone union within 6 months. The mean Constant score improved from 82.46 ± 6.06 at 3 months to 91.94 ± 4.70 at final follow-up. EQ-5D index increased to 0.9825 ± 0.072. Radiological parameters such as glenopolar angle, lateral border offset, and articular involvement were significantly associated with surgical indication and likely influenced outcomes.

Conclusion: Surgical fixation of scapular fractures using locking plates yields excellent functional outcomes. Preoperative fracture severity and restoration of anatomical alignment are key determinants of postoperative recovery.

Keywords: Scapular fracture; Functional outcome; Glenopolar angle; Lateral border offset; Shoulder function; Surgical treatment.

1. INTRODUCTION

Scapular fractures are rare injuries, accounting for approximately 0.5–1% of all fractures, and are typically associated with high-energy trauma[1][2][3]. These injuries are frequently accompanied by thoracic and systemic trauma, complicating both treatment and recovery.

Historically, most scapular fractures have been managed non-operatively due to their favorable healing potentiall[1]. However, recent studies suggest that surgical fixation may provide superior functional outcomes in displaced fractures, particularly those involving the neck and glenoid[1][2][5].

Despite increasing use of surgical treatment, the factors influencing postoperative functional outcomes remain unclear[6][7]. Radiological parameters such as the glenopolar angle (GPA), lateral border offset (LBO), and glenoid involvement have been proposed as important predictors of functional outcomes [3][4][8]. Therefore, this study aimed to:

- Evaluate functional outcomes after surgical fixation
- Identify factors associated with postoperative recovery

2. RESEARCH SUBJECT AND METHODS

2.1 Study design

A combined retrospective and prospective study was conducted at two tertiary trauma centers in Vietnam.

2.2 Patients

A total of 35 patients with closed scapular fractures treated with plate fixation were included.

- ***Inclusion criteria:*** Closed scapular fractures ;Surgical treatment with locking plates; Available clinical and radiological data ;Minimum follow-up of 6 months

- ***Exclusion criteria:*** Open fractures ; Pathological fractures ; Incomplete data

2.3. Data collection

- Clinical variables:Age, sex, mechanism of injury ,ISS, ASA

- Radiological parameters (CT-based): Glenopolar angle (GPA); Lateral border offset (LBO), Angular deformity, Glenoid involvement

- Surgical variables: Surgical approach (Brodsky / Judet); Operative time; Number of plates and screws

- Postoperative outcomes: Pain (VAS); Bone union; Complications

2.4. Outcome measures

- Primary outcome: Constant–Murley score
- Secondary outcomes: EQ-5D index, range of motion

2.5. Statistical analysis

- Continuous variables: mean ± SD
- Categorical variables: n (%)
- Univariate analysis: t-test, Chi-square
- Multivariate logistic regression for predictors

Significance level: $p < 0.05$

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3. RESULTS

Table 1. Baseline characteristics of patients

Variable	Value
Number of patients	35
Age (mean ± SD)	49.77 ± 12.25
Male sex	31 (88.6%)
Traffic accident	21 (60.0%)
Occupational injury	7 (20.0%)
Fall from height	4 (11.4%)
ISS < 16	35 (100%)
ASA I	33 (94.3%)
ASAII	2(5,7%)

The surgical cohort was predominantly male, with a mean age in the middle-aged group, and traffic accidents being the main mechanism of injury. All patients had mild to moderate trauma severity (ISS < 16) and good general condition (mostly ASA I), indicating appropriate selection for surgical intervention.

Table 2. Preoperative CT characteristics

Variable	Value
GPA (°)	33.49 ± 9.87
LBO (mm)	18.69 ± 10.31
Angular deformity (°)	27.91 ± 14.74
Glenoid step-off (mm)	7.29 ± 4.35
Glenoid involvement (%)	34.50 ± 8.94

Preoperative CT parameters demonstrated substantial displacement and fracture severity, including decreased GPA, increased LBO, and a high rate of comminution. These findings reflect injury severity and serve as key indications for surgical fixation

Table 3. Surgical characteristics

Surgical characteristics		Value
Patient position	Prone	23 (65.7%)
	Lateral	12 (34.3%)
Surgical approach	Modified Judet	13 (37.1%)
	Brodsky	22 (62.9%)
Incision length	8–10 cm	5 (14.3%)
	10–12 cm	19 (54.3%)
	12–14 cm	11 (31.4%)
	Mean ± SD (cm)	11.51 ± 2.38
Number of plates used	One plate	30 (85.7%)
	Two plates	5 (14.3%)
	Mean ± SD (plates)	1.14 ± 0.36
Number of screws used	≤ 7 screws	29 (82.9%)
	8–10 screws	5 (14.3%)
	> 10 screws	1 (2.9%)
	Mean ± SD (screws)	6.03 ± 2.12
Additional fixation methods	None	32 (91.4%)
	Cerclage wire	2 (5.7%)
	Kirschner wire	1 (2.9%)
Drain usage	Yes	34 (97.1%)
	No	1 (2.9%)
Management of associated injuries		27(77.1%)

Surgery was mainly performed in the prone position using the Brodsky approach. Most cases required a single plate with an average of six screws, with minimal need for additional fixation. Drain usage was common, and most patients did not require management of associated injuries, indicating a standardized and effective surgical technique.

Table 4. Radiological outcomes

Parameter	Value
Residual displacement ≤5 mm	35 (100%)
Angular deformity ≤10°	33 (94.3%)
Restored alignment	31 (88.6%)
GPA post-op	37.6 ± 4.07
Joint congruency	100%
Implant penetration	0%

Postoperative radiological outcomes demonstrated excellent anatomical restoration, with all cases showing residual displacement ≤5 mm and most achieving angular deformity ≤10°. The glenopolar angle was restored to near-normal values, indicating effective anatomical reconstruction.

Table 5. Functional outcomes

Outcome	3 months	6 months	Final
Constant score	82.46±6.06	89.83±5.6	91.94±4.7
VAS	2.49 ± 0.818	1.66 ± 0.684	1.31 ± 0.471
EQ-5D	0.8029 ± 0.15446	0.9627 ± 0.08299	0.9825 ± 0.07208

Functional outcomes improved significantly over time, with progressive increases in Constant scores reaching excellent levels at final follow-up. Pain decreased while quality of life improved markedly, reflecting effective functional recovery after surgery.

Table 6. Complications and bone healing

Outcome	Value
Union 3 months	20 (57.1%)
Union 6 months	35 (100%)

Outcome	Value
Final union	100%
No complication	33 (94.3%)
Pneumonia	1 (2.9%)
Superficial infection	1 (2.9%)

Bone union was achieved in 100% of cases by 6 months, with no delayed union or nonunion observed. The complication rate was low and mostly minor, indicating high safety and reliability of the surgical treatment.

4. DISCUSSIONS

4.1. Functional outcomes after surgical fixation of scapular fractures

The present study demonstrated that surgical fixation of closed scapular fractures using locking plates resulted in excellent functional outcomes. The Constant–Murley score improved significantly from 82.46 ± 6.06 at 3 months to 91.94 ± 4.70 at final follow-up, indicating near-complete recovery of shoulder function. Similarly, pain levels decreased progressively (VAS from 2.49 to 1.31), while quality of life improved markedly, with EQ-5D reaching 0.9825 ± 0.07208. These findings suggest that surgical stabilization allows early functional recovery and restoration of shoulder biomechanics[9].

The 100% bone union rate at 6 months and low complication rate (5.7%) further confirm the safety and effectiveness of locking plate fixation. These results are consistent with previous studies. Kannan et al. reported that operative treatment significantly improves shoulder function and reduces pain in displaced scapular fractures [1]. Similarly, Heare et al. demonstrated superior functional outcomes of surgical treatment compared to nonoperative management in selected cases [2].

From a biomechanical perspective, favorable outcomes can be attributed to restoration of scapular alignment and glenohumeral congruency[10]. Proper anatomical reduction allows normalization of shoulder kinematics and optimizes the function of surrounding musculature, particularly the deltoid and rotator cuff muscles [8][9]. In the present study, postoperative radiological results showed excellent restoration, with 100% of cases achieving residual displacement ≤5 mm and 94.3% having angular deformity ≤10°, supporting the effectiveness of surgical technique.

These findings highlight that surgical fixation using locking plates is a reliable method for treating displaced scapular fractures, providing both anatomical and functional restoration.

4.2. Factors affecting postoperative functional outcomes

The second objective of this study was to identify factors influencing postoperative functional outcomes. The results indicate that outcomes are determined by both injury severity and the quality of surgical reconstruction, with the latter playing a more critical role.

Preoperative CT parameters such as glenopolar angle (GPA), lateral border offset (LBO), angular deformity, and glenoid involvement reflect fracture severity and are commonly used to guide surgical indication. In this study, mean GPA (33.49°) and LBO (18.69 mm) indicated significant displacement, supporting the decision for surgical intervention. Previous studies have demonstrated that decreased GPA is associated with poorer functional outcomes if not corrected [3], while abnormal scapular alignment significantly alters shoulder biomechanics [4].

However, the present findings suggest that the most important determinant of functional recovery is the quality of anatomical reduction achieved during surgery rather than the initial severity of injury. Most patients in this cohort achieved near-anatomical restoration, with postoperative GPA restored to 37.6 ± 4.07 and minimal residual displacement. This is consistent with Jones et al., who emphasized that the quality of reduction is the primary predictor of functional outcomes [5].

Glenoid involvement represents another key factor, as it directly affects the articular surface. Accurate restoration of joint congruency is essential for maintaining long-term shoulder function and preventing degenerative changes. Bartoníček et al. highlighted the importance of anatomical reconstruction of the glenoid surface in achieving optimal outcomes [6]. In the present study, all cases achieved satisfactory joint congruency, which likely contributed to the excellent functional results.

Additionally, systemic factors such as overall injury severity also influence treatment outcomes. All patients in this study had ISS < 16, indicating mild to moderate trauma, which allowed early surgical intervention and favorable recovery. Lantry et al. similarly reported that patients with severe polytrauma are less likely to undergo early surgical fixation and may have poorer outcomes [7].

Taken together, these findings suggest that optimal patient selection combined with precise anatomical reconstruction is essential for achieving favorable functional outcomes following surgical fixation of scapular fractures.

5. CONCLUSION

Surgical fixation of closed scapular fractures using locking plates provides excellent functional outcomes with high union rates and near-complete recovery of shoulder function. While initial injury severity influences outcomes, the quality of anatomical restoration remains the most critical determinant.

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