



Original Research Article

INITIAL CLAVICULAR SHORTENING PREDICTS FUNCTIONAL AND RADIOLOGICAL OUTCOMES FOLLOWING CONSERVATIVE MANAGEMENT OF MIDSHAFT CLAVICLE FRACTURES: A PROSPECTIVE OBSERVATIONAL COHORT STUDY

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ABSTRACT

Background: Midshaft clavicle fractures account for nearly 80% of all clavicular fractures and are among the most common injuries involving the shoulder girdle. Although conservative treatment remains the standard management for most closed fractures, considerable debate exists regarding its effectiveness in displaced fractures and in patients with significant clavicular shortening. Identifying radiographic predictors of poor functional outcomes may improve patient selection for surgical intervention. **Objective:** To evaluate the clinical and radiological outcomes following conservative management of closed midshaft clavicle fractures and to determine the relationship between initial clavicular shortening and functional outcome.

Materials and Methods: A prospective observational cohort study was conducted in the tertiary hospital. Adult patients presenting within one week of sustaining a closed midshaft clavicle fracture were managed conservatively using a clavicle brace and arm sling followed by a standardized rehabilitation protocol. Functional outcomes were assessed using the Constant Shoulder Score (CSS), while radiological outcomes were evaluated using serial radiographs. Initial clavicular shortening and distraction were measured and correlated with clinical and radiological outcomes.

Results: A total of 111 patients were enrolled, of whom 87 completed the six-month follow-up. The mean age was 36 years, and most participants were male. The mean Constant Shoulder Score improved progressively from 61.1 at four weeks to 82.3 at six months. Initial clavicular shortening demonstrated a significant association with poorer functional outcomes and higher rates of non-union. Patients with greater than approximately 10–11% shortening exhibited significantly lower Constant Shoulder Scores and an increased incidence of radiological non-union.

Conclusions: Conservative management provided satisfactory functional recovery in the majority of patients with midshaft clavicle fractures. However, increasing initial clavicular shortening was significantly associated with poorer functional outcomes and non-union. Percentage shortening may serve as a clinically useful predictor when selecting patients who may benefit from early surgical intervention.

Keywords: Clavicle fracture; Midshaft clavicle fracture; Conservative management; Constant Shoulder Score; Clavicular shortening; Functional outcome; Non-union.

INTRODUCTION

Clavicle fractures constitute approximately 2.5–4% of all skeletal fractures and nearly 45% of injuries involving the shoulder girdle.^[1] Approximately 80% occur in the middle third of the clavicle because of its unique anatomical configuration and the concentration of biomechanical forces at this location. These injuries predominantly affect young, active individuals and commonly result from road traffic accidents, sports injuries, or falls onto the shoulder or an outstretched hand.^[2]

For several decades, conservative treatment using a clavicle brace, figure-of-eight bandage, or arm sling has been considered the standard management for most midshaft clavicle fractures because of historically reported high union rates and satisfactory functional outcomes.^[3] However, recent evidence has questioned this traditional approach, particularly in displaced and comminuted fractures, where substantially higher rates of malunion, non-union, cosmetic deformity, and persistent shoulder dysfunction have been reported.^[4]

Operative fixation has gained popularity because it offers earlier functional recovery, improved fracture alignment, and reduced non-union rates. Nevertheless, surgery is associated with implant-related complications, infection, neurovascular injury, hardware irritation, and the need for secondary procedures.^[5] Furthermore, long-term functional outcomes reported in contemporary studies remain comparable between operative and non-operative treatment in many patients, making the optimal treatment strategy controversial.

Radiographic parameters such as fracture displacement and clavicular shortening have increasingly been investigated as predictors of clinical outcome. Current surgical indications are frequently based on absolute shortening exceeding 20 mm; however, absolute measurements may not adequately account for inter-individual variation in clavicular length.^[6] Whether percentage shortening provides a more accurate predictor of poor functional outcome remains uncertain and requires further clinical evaluation.

The present prospective observational cohort study was undertaken to evaluate the clinical and radiological outcomes of conservatively managed midshaft clavicle fractures using standardized functional assessment with the Constant Shoulder Score and serial radiographic evaluation. Additionally, the study aimed to investigate the relationship between initial clavicular shortening and subsequent functional recovery, radiological union, and complications following conservative treatment.

MATERIALS AND METHODS

Study Design and Setting: After obtaining institutional ethical clearance we conducted hospital based A prospective observational cohort study in

tertiary hospital between 2020-2022. Written informed consent was obtained from all participants prior to enrolment.

Study Population

Adult patients presenting to the Orthopaedic Emergency Department with acute closed midshaft clavicle fractures were screened for eligibility. Patients were enrolled consecutively using a convenience sampling technique.

Inclusion Criteria

- Age ≥ 18 years.
- Closed fracture involving the middle one-third of the clavicle.
- Presentation within one week of injury.
- Robinson (Edinburgh) Type 2 clavicle fractures.

Exclusion Criteria

Patients were excluded if they had:

- Bilateral clavicle fractures.
- Segmental clavicle fractures.
- Previous fracture of the same clavicle.
- Open clavicle fractures.
- Associated fractures involving the ipsilateral upper limb.
- Floating shoulder.
- Neurovascular injury associated with the clavicle fracture.

Sample Size

The required sample size was calculated using a Pearson correlation coefficient of 0.31 with 90% statistical power, yielding a minimum sample size of 112 participants. Ultimately, 111 eligible patients were recruited during the study period.

Baseline Clinical Assessment

At enrolment, demographic variables including age, sex, occupation, residence, socioeconomic status, smoking status, alcohol consumption, and relevant comorbidities were recorded. A detailed history regarding the mechanism of injury and associated trauma was obtained. Clinical examination included assessment for deformity, tenderness, neurovascular status, and associated injuries.

Radiographic Evaluation

Standard anteroposterior radiographs of the clavicle and shoulder were obtained at presentation. Fractures were classified according to the Robinson (Edinburgh) classification system.

The lengths of both the injured and contralateral clavicles were measured on the initial radiographs. Absolute shortening (mm), percentage shortening relative to the uninjured clavicle, and distraction were calculated. These radiographic parameters were analysed as potential predictors of functional and radiological outcomes.

Treatment Protocol

All enrolled patients underwent conservative treatment consisting of:

- Immobilisation using a clavicle brace and arm sling for four weeks.
- Oral analgesics as required.
- Pendulum exercises during the immobilisation period as tolerated.

- Commencement of active and passive range-of-motion exercises after removal of the brace at four weeks.
- Progressive shoulder mobilisation and functional rehabilitation over the following two weeks.

Patients were followed regularly through outpatient visits and telephone reminders to maximise follow-up compliance.

Follow-up and Outcome Assessment

Participants were evaluated at 1 week, 4 weeks, 6 weeks, and 6 months after injury.

Clinical Assessment

Clinical evaluation included assessment of:

- Pain.
- Shoulder stiffness.
- Range of motion.
- Activities of daily living.
- Muscle strength.
- Functional outcome using the Constant Shoulder Score (CSS).

The Constant Shoulder Score served as the primary functional outcome measure.

Radiological Assessment

Serial radiographs were obtained to evaluate fracture healing.

Radiological union was defined as disappearance of the fracture line with bridging callus formation on standard anteroposterior radiographs.

Patients were categorised as having:

- Radiological union.
- Malunion.
- Non-union.

Complications including persistent pain, visible deformity, loss of shoulder function, and symptomatic non-union were also documented.

Outcome Measures

Primary Outcome

- Functional outcome measured using the Constant Shoulder Score at six months.

Secondary Outcomes

- Radiological union.
- Malunion.
- Non-union.
- Association between initial clavicular shortening and Constant Shoulder Score.
- Association between clavicular shortening and radiological outcome.

Incidence of treatment-related complications.

RESULTS

Study Population

A total of 111 patients with acute closed midshaft clavicle fractures were enrolled during the study period. Fourteen patients were lost to follow-up, and ten patients subsequently underwent operative fixation at other institutions because they were dissatisfied with conservative management. Consequently, 87 patients completed the six-month follow-up and were included in the final analysis.

Baseline Characteristics

The mean age of the study population was **36.0 ± 13.6 years**. Most patients were between 20 and 40 years of age. Eighty-one patients (93.1%) were male and six (6.9%) were female. The left clavicle was involved in 57.5% of cases. Road traffic accidents were the predominant mechanism of injury (71.3%), followed by falls on an outstretched hand (27.6%) and falls from height (1.1%).

Table 1: Baseline Demographic and Injury Characteristics

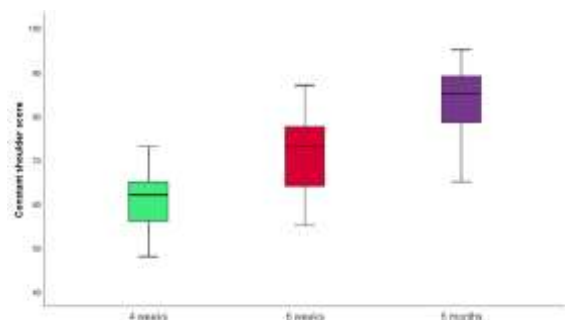
Mean age (years)	36.0 ± 13.6
Male sex	81 (93.1%)
Female sex	6 (6.9%)
Left-sided fracture	50 (57.5%)
Right-sided fracture	37 (42.5%)
Road traffic accident	62 (71.3%)
Fall on outstretched hand	24 (27.6%)
Fall from height	1 (1.1%)

Table 2: Association tables between initial shortening, percentage shortening and final shortening between clinical outcome

	INFERENCE OF CSS	Q1	Median	Q3	Kruskal-Wallis H	df	Asymp. Sig.
FINAL SHORTENING (MM)	Excellent	2.50	5.0	9.50	38.488	3	.001
	Good	5.0	8.5	12.25			
	fair	13.25	18.50	22.0			
	Poor	16.00	19.50	24.0			
% SHORTENING (%)	Excellent	1.10	3.35	8.0	15.656	3	.001
	Good	2.80	5.70	7.3			
	fair	6.625	13.05	17.0			
	Poor	7.925	9.30	12.7			
INITIAL SHORTENING (MM)	Excellent	2.75	6.50	11.0	14.768	3	.001
	Good	6.0	8.0	12.0			
	fair	9.50	18.0	21.25			
	Poor	12.0	13.0	17.0			

Table 3: Constant Shoulder Score During Follow-up

	Mean	SD
CSS- 4 week	61.13	6.452
CSS-6 week	71.10	7.716
CSS-6months	82.29	8.884

**Figure 1: Box and Whisker plot of the CMS score at various time intervals**

The Constant Shoulder Score improved progressively throughout follow-up, demonstrating continuous recovery after conservative treatment. The mean score increased from 61.13 ± 6.45 at four weeks to 71.10 ± 7.72 at six weeks and 82.29 ± 8.88 at six months.

At the six-month assessment, 25 patients (28.7%) achieved excellent outcomes, 33 (37.9%) had good outcomes, 13 (14.9%) had fair outcomes, and 16 (18.4%) had poor outcomes according to the Constant Shoulder Score classification.

Table 4: Radiological Outcomes

RADIOLOGICAL OUTCOME	CSS at 6 months Q1 median Q3			Kruskal-Wallis H	df	Asymp. Sig.
UNION	89.00	91.00	93.50	51.341	2	.001
MALUNION	81.00	86.00	88.00			
NONUNION	67.00	68.00	69.00			

Radiological outcomes at 6 months: In our study 13 patients (14.9%) had union, 55 patients (63.2%) had mal-union, 19 patients had non-union (21.8%).

Among the 19 patients with non union had initial 8 patients, (5 patients with head injury and 3 patients with chest injury) were symptomatic with persistent pain at fracture site and restricted ROM of shoulder. Association between CSS and Radiological outcomes.

The median CSS for the patients with union was 91 (89,93.5), with malunion was 86.00(81,88), with non union was 68(66,69). The association was found to

be statistically significant (Kruskal Wallis Test 50.661 p value <0.001)

Complications

Visible deformity at the fracture site was the most frequent complication and occurred in 40 patients (46%). Pain while sleeping on the affected side was reported by 11 patients (12.6%), predominantly among those with symptomatic non-union. Patients with visible deformity had significantly poorer functional outcomes and were more likely to have malunion or non-union (Fisher's exact test, $p = 0.001$).

Table 5: Complications

Complication	n (%)
Visible deformity	40 (46.0)
Pain while sleeping on affected side	11 (12.6)
Malunion	55 (63.2)
Non-union	19 (21.8)

**Figure 2: Clinical images of assessment of constant shoulder score and X-ray of patient with excellent clinical outcome at 6 months following conservative management**



Figure 3: 6 months follow up xray chest AP showing union of clavicle with 6mm shortening



Figure 4a and 4b: 6 months follow up xray chest AP showing malunion at fracture site shortening of 36mm and 12mm shortening respectively

DISCUSSION

The present prospective observational cohort study evaluated the clinico-radiological outcomes of conservative management of closed midshaft clavicle fractures and investigated the relationship between initial clavicular shortening and functional outcome. The principal findings of this study were that conservative treatment resulted in satisfactory functional recovery in the majority of patients, while greater initial clavicular shortening and distraction were associated with poorer functional outcomes and an increased incidence of radiological non-union.

The demographic profile observed in the present study is consistent with the epidemiology of clavicle fractures reported in the literature. The majority of patients were young adult males, and road traffic accidents were the predominant mechanism of injury. This distribution reflects the greater exposure of economically active individuals to high-energy trauma. Similar demographic patterns have been reported in previous studies by Böstman et al,^[7] and Cho et al,^[8] supporting the observation that midshaft clavicle fractures are primarily injuries of young, active adults.

Historically, conservative treatment has remained the standard of care for most midshaft clavicle fractures because of its simplicity, low cost, and satisfactory long-term functional outcomes. In the present study, all patients were managed with a clavicle brace and

arm sling followed by a structured rehabilitation programme. Progressive improvement in Constant Shoulder Score was observed throughout follow-up, indicating gradual restoration of shoulder function with non-operative management. These findings are in agreement with previous reports demonstrating that appropriately selected patients can achieve favourable clinical outcomes with conservative treatment.

One of the major objectives of this study was to determine whether clavicular shortening influences functional recovery. The results demonstrated a statistically significant association between initial shortening, percentage shortening, final shortening, and Constant Shoulder Score. Patients with excellent functional outcomes had substantially smaller degrees of shortening, whereas those with fair or poor outcomes exhibited greater shortening. These findings suggest that fracture shortening adversely affects shoulder biomechanics and functional recovery following conservative treatment.

The difference in length of the clavicle: Clavicle length in the fractured side was measured in the standard AP view of chest x-ray for the clavicle at the time of trauma compared with the normal side.(fig3) we found Shortening of the clavicle was found in 59 patients (67.8%) with a mean shortening of 12.5mm with a standard deviation(SD) of 5.945mm, and Distraction was found in 28 patients (32.1%) with a mean distraction of 11.5mm SD of 4.8mm. However, at six months post-injury, all the patients had shortening of the affected side with a mean shortening of 12.21mm with a mean SD of 6.47mm. The median Initial shortening(mm) in patients with Excellent outcome was 6.5mm; (FIG4a&b) Good outcome was 8mm, Fair outcome was 18mm, Poor outcome was 13mm (Kruskal Wallis Test 16.68 and p-value 0.001). In patients with Radiological Union was 7mm, Malunion was 8mm,^[6,12] Non-union was 14mm (Kruskal Wallis Test 8.66 and a p-value of 0.013).

An important observation of the present study is the value of percentage clavicular shortening as a predictor of outcome. Unlike absolute shortening, percentage shortening accounts for normal individual variation in clavicular length and therefore may provide a more patient-specific assessment of deformity. Patients with percentage shortening exceeding approximately 9–11% demonstrated significantly poorer functional outcomes, while greater shortening was associated with an increased incidence of radiological non-union. These findings support the concept that proportional shortening may be clinically more informative than a fixed absolute threshold when considering treatment options.

The association between shortening and poor outcome observed in this study is consistent with previous investigations discussed in the dissertation. Neer and Hill et al,^[9] reported inferior outcomes in patients with greater shortening, whereas Silvana De Giorgi et al,^[10] found that dissatisfied patients had greater mean clavicular shortening following

conservative treatment. Similarly, Postacchini et al,^[1] suggested that percentage shortening may have prognostic value in predicting non-union and functional impairment. The present study adds prospective evidence supporting these observations in an Indian cohort.

Radiological healing demonstrated a strong relationship with functional recovery. Patients who achieved radiological union had the highest Constant Shoulder Scores, whereas patients with non-union experienced persistent pain, restricted shoulder movement, and substantially lower functional scores. These findings emphasise that radiographic healing remains an important determinant of patient-reported functional recovery following conservative management.

Although Robinson Type 2B1 fractures constituted the largest subgroup in this study, fracture subtype was not significantly associated with either clinical or radiological outcome. This observation suggests that fracture morphology alone may be insufficient for predicting prognosis and highlights the importance of incorporating quantitative radiographic parameters such as shortening and displacement into clinical decision-making.

Complications observed after conservative management were predominantly visible deformity, malunion, and non-union. Visible deformity occurred in nearly half of the patients and was significantly associated with poorer functional outcomes. Symptomatic non-union was accompanied by persistent pain, particularly while sleeping on the affected side, and limitation of shoulder movement. These findings underscore the need for careful follow-up of patients with substantial fracture shortening or persistent symptoms during conservative treatment.

Patients with marked shortening or significant distraction may benefit from closer surveillance and early consideration of operative management to minimise the risk of non-union and inferior functional recovery. These observations should, however, be interpreted in conjunction with clinical assessment, patient expectations, fracture displacement, associated injuries, and overall functional demands.

The findings suggest that conservative treatment remains an effective option for many patients with closed midshaft clavicle fractures. However, initial percentage shortening and fracture distraction appear to be useful prognostic indicators of functional recovery and radiological healing. Incorporating these radiographic parameters into routine assessment may improve identification of patients at higher risk of poor outcomes and help guide treatment selection.

CONCLUSION

Strengths

The strengths of this study include its prospective cohort design, standardised conservative treatment protocol, serial clinical and radiological assessments, and the use of the validated Constant Shoulder Score for functional evaluation. In addition, measurement of both absolute and percentage clavicular shortening allowed assessment of radiographic predictors that may assist clinical decision-making.

Limitations

Several limitations should be acknowledged. This was a single-centre observational study without a comparison group undergoing operative fixation. A proportion of enrolled patients was lost to follow-up or underwent surgery elsewhere, which may have introduced attrition bias. The follow-up period was limited to six months, preventing assessment of long-term functional recovery and late complications. Furthermore, multivariable analyses to adjust for potential confounding factors were not performed, and therefore the observed associations should be interpreted cautiously.

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