Functional outcomes of conservative versus operative management of displaced midshaft clavicular fracture: a comparative study

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Purpose
Management of displaced midthird clavicle fractures is still controversial. Recent studies have shown a high incidence of symptomatic malunion and nonunion following nonoperative treatment of displaced midshaft clavicular fractures, with other studies showing no much improvement in shoulder function following operative treatment. The aim of this study is to compare patient-oriented and surgeon-based outcomes after nonoperative treatment with results following operative treatment of acute completely displaced midshaft clavicular fractures.

Patients and methods
This retrospective study was carried out on 91 patients with a displaced midshaft fracture of the clavicle distributed into two groups, with the first group managed conservatively and the second group with open reduction and internal fixation. Outcome analysis included standard clinical follow-up and the Constant shoulder score, the disability of the arm, shoulder and hand score, as well as radiological evaluation. Deformity evaluation included measurement of displacement, shortening, and angulation in both immediate posttrauma radiograph and final radiographs.

Results
Mean follow-up duration was 28.7±13.3 months in the nonoperative group and 20.4 ±5 months in the operative group. The mean time to radiographic union was 16.4 ±3.3 weeks in the nonoperative group compared with 15.6±3 weeks in the operative group (P=0.00).
All fractures in the operative group united compared with six nonunions (12.5%) in the nonoperative group, and 12 symptomatic malunions (25%) occurred in the nonoperative group. Constant shoulder scores were significantly better for the operative group at all follow-ups (P=0.00). The disability of the arm, shoulder and hand score showed also significant improvement within the operative group (P=0.00).

Conclusion
In this study, primary open reduction and internal plate fixation of acute displaced midshaft clavicular fractures resulted in improved outcomes – including both patient-oriented outcome and surgeon-based outcome – and a decreased rate of nonunion and symptomatic malunion compared with nonoperative treatment. Shorting and displacement were found significantly related to decreased shoulder function.

Keywords:
clavicle, conservative treatment, fracture, internal fixation, midshaft

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Introduction

Clavicular fractures are common injuries, accounting for 2.6% of all fractures [1,2], and occur most commonly in young active individuals. Fractures of the middle third account for ~80% of all clavicular fractures [3], and they were managed for long time with nonoperative measures, even when substantially displaced [4]. Although there is uniform consensus regarding nonoperative treatment of undisplaced midshaft clavicle fractures, the optimal treatment option for isolated acute displaced midshaft clavicle fractures remains controversial. For nonoperatively managed displaced fractures, variable degrees of nonunion and malunion are expected including shortening and deformity. Early reports on midshaft clavicular fractures suggested that nonunion was extremely rare: four nonunions in 566 patients in one series and three in 2235 patients in another [5,6]. Clavicular malunion was formerly described as

being of radiographic interest only, with no clinical importance [5–8]; however, more recent studies of displaced midshaft clavicular fractures have shown a higher nonunion rate of 15% (eight of 52 patients) in one series as well as a rate of unsatisfactory patient-oriented outcomes of 31% in other studies, which are much higher rates than previously reported [4,9,10]. Additionally, clavicular malunion has recently been described by several authors as a distinct clinical entity with characteristic clinical and radiographic features [11–15].

While it is becoming widely accepted that the results of closed treatment are much inferior to those described in early reports, primary operative intervention has not been shown to be superior. Numerous recent studies have examined the safety and efficacy of primary open reduction and internal fixation for completely displaced midshaft clavicular fractures and have noted a high union rate with a low complication rate but with no much improvement on shoulder function [16–18]. There is a rising need to determine the effect of various deformities on final outcome and the value of primary operative treatment when evaluated with patient-oriented outcomes.

The purpose of the present retrospective, clinical trial is to compare patient-oriented and surgeon-based outcomes after nonoperative treatment with those after internal fixation of acute completely displaced midshaft clavicular fractures and to determine the effect of variable deformities on final outcome.

Patients and methods

After Institutional Review Board approval, patients who sustained closed midshaft clavicle fractures between 2010 and 2015 were identified in our institutional trauma registry. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Mansoura University, Mansoura, Egypt. The medical records were used to collect patient demographics, mechanism of injury, side of the injury, associated injuries, presence of neurologic injury, time till union, time to return to activities, and complications (Table 1). The age range included in this study was 18–70 years old. Middle third shaft fractures with complete displacement of the fragments with or without shortening and angulation were included in the study. Medial and lateral end clavicular fractures were excluded. Patients were also excluded if they had a pathologic fracture, an open fracture, associated neurovascular injury with objective neurologic findings on physical examination, or any associated ipsilateral shoulder injury that would affect the outcome evaluation. Patients were recalled to visit the outpatient clinic for clinical and radiological evaluation. Only 107 patients (61 conservative and 46 in the operative group) accepted to come and participate in the study. Patients were called sequentially from the recent visits to the older ones with no preference to certain cases. From these patients, however, 16 cases were excluded later owing to failure to present to our outpatient clinic.

Patients in the nonoperative group were treated with a simple sling. These patients were offered initially internal fixation owing to excessive displacement of the fracture, but they refused because of variable reasons. Patients in the operative group were treated with locking or nonlocking, compression plating on the anterosuperior surface of the clavicle.

Clinical assessment included range-of-motion measurement using a goniometer for abduction, forward elevation, internal rotation, and external rotation. Constant score [19] was used for clinical evaluation. Disability of the arm, shoulder and hand (DASH) score [20] was used to evaluate patient improvement and function of upper limb. Patient satisfaction was evaluated regarding the overall satisfaction with shoulder function and with the shape of the shoulder by a visual analog scale from 0 to 10, with 0 indicating the patients completely unsatisfied with the results and 10 for fully satisfied patients.

Initial radiographs were collected from hospital registry; additionally, on the last follow-up, two radiographs were obtained for each patient: standard shoulder anteroposterior view and shoulder anteroposterior with 20° cephalic tilt. Angulations, shortening, and displacement were measured on both initial and on final follow-up radiographs, and the worst measurement on both views was recorded as an absolute measure.

Radiographic union was defined as bony bridging on both views and confirmed with clinical examination. Delayed union was defined as no fracture union at 4 months (16 weeks), and nonunion was defined as no fracture union at 6 months (24 weeks). Malunion was defined if one of the following criteria [16,21–23] was present: angulation of more than 15°, shortening, or displacement of more than 1.5 cm. Symptomatic malunion was defined as fracture union with shortening or angulation and asymmetry as compared with the uninvolved shoulder associated with subjective

complaints including pain with overhead use, weakness, fatigability, or neurologic symptoms.

Statistical analysis

Statistical analysis was conducted using SPSS version 20 (SPSS Statistics for Data Analysis and Visualization - Programmer Company: IBM SPSS Statistics, Chicago, Illinois, United States). Percent and means ±SD were used to describe data as appropriate. Matching of similar variables between groups as well as test of significance was conducted using independent *t* test for means and Pearson χ^2 test for frequency distribution of variables. Pearson correlation test was used to test significance of correlation between means of quantitative variables in the same group. *P* value less than or equal to 0.05 was considered significant.

Results

This study included a total of 91 patients recruited from the hospital registry, and cases were divided into two groups, the operative group included 43 (47.3%) patients, and 48 (52.7%) patients in the nonoperative group. Duration of follow up, healing time, Constant score, and DASH score were all assessed and were plotted in Table 2. Associated fractures were found in eight cases including two cases of head injury, two cases of chest trauma, one case of ipsilateral fracture tibia and fibula, one case of contralateral distal radius, one case of contralateral forearm fracture, and one case of Pott's fracture and sacral fracture. The outcome scores are represented in Table 2.

A statistically significant difference was detected between operative and nonoperative group regarding Constant score, DASH score, range of motion, as well as patient satisfaction, with statistically better results in the operative group.

Radiological evaluation was done for all cases on the preoperative radiographs (Table 3). In the operative group, no statistically significant correlation was detected between any of the preoperative data and the clinical data (DASH and Constant score) (Table 4). On the contrary, among the nonoperative group, Constant score was negatively correlated with all preoperative radiological data with statistical significance. Regarding the DASH score; a positive correlation was detected between it and the preoperative angulation and shortening (Table 5).

Regarding complications, six (12.5%) cases of nonunion were identified in the nonoperative group. Symptomatic malunion was identified in 12 (25%) patients in the nonoperative group with symptoms ranging from mild and transient pain to inability to do some overhead activities and fatigue. In the operative group, three (6.97%) cases of superficial infection were recorded and eight (18.6%) cases with hypertrophied scars. None of the cases showed any neurological deficit in both groups.

Table 1 Patient demographics

Qualitative parameter	Nonoperative group	Operative group	Significance
	n (%)		
Sex			
Male	29 (60.4)	37 (86)	0.006
Female	19 (39.6)	6 (14)	
Side affected			
Dominant	33 (68.8)	29 (67.4)	0.8
Nondominant	15 (31.2)	14 (32.6)	
Mode of trauma			
Fall	21 (43.8)	8 (18.6)	0.08
RTA	16 (33.3)	21 (48.8)	
Sport	11 (22.9)	14 (32.6)	
Fracture classification[a]			
1b	23 (47.9)	16 (37.2)	0.3
1c	25 (52.1)	27 (62.8)	
Quantitative parameters	Nonoperative group (mean ±SD)	Operative group (mean±SD)	Significance
Age	37.4±13.8	39.8±11.8	0.2
Duration between trauma and surgery (days)		4.3±3.5	

RTA, road-traffic accident. [a]Allman classification 1967.

Statistically significant difference between the two groups was detected regarding patient satisfaction with function (*P*=0.014). On the contrary, when patients were asked about their satisfaction with the shape of their shoulders following both methods of treatment, no significant difference was detected (Figs 1–4).

Discussion

Displaced midshaft clavicular fractures were managed by both conservative and operative methods, with variable outcomes and incidence of complications in the literature. Many authors reported excellent results with conservative treatment with rare nonunion and limited effect on shoulder function, and hence, their indications for internal fixation were very limited [5,6]. On the contrary, many authors supported the concept of internal fixation as a management option for displaced midshaft clavicular fractures as their results showed much higher rates of nonunion, symptomatic malunion, as well as adverse effects on shoulder function with conservative treatment [4,9–11,15].

Table 2 Outcome scores

Outcome	Nonoperative group (mean±SD)	Operative group (mean±SD)	*P*
Duration of follow-up (months)	28.7±13.3	20.4±5	0.00
Healing time (months)	16.4±3.3	15.6±3	0.2
Return to activity	18.8±2.6	19.7±3.1	0.41
Final constant score	74.2±4.4	92.5±2.2	0.00
Final DASH score	21.9±7.7	4.5±3.1	0.00
ROM			
Flexion (forward elevation)	135.2±11.1	163.9±11.2	0.00
Abduction	129.4±10.4	159.5±14.3	0.00
External rotation	51.6±6.8	61.5±7.7	0.00
Dissatisfied patients [*n* (%)]	16 (33.3)	5 (11.6)	0.014
Dissatisfaction with shape of shoulder [*n* (%)]	5 (10.4)	4 (9.3)	0.8

DASH, disability of the arm, shoulder and hand; ROM, range of motion.

Additionally, evaluating the results of management of this fracture pattern based on patient-oriented scores and patient satisfaction, authors reported inferior results with conservative treatment compared with operative fixation.

This study showed that all fractures in the operative group united compared with a nonunion rate of 12.5% in the nonoperative group. Earlier studies described very low incidence of nonunion by Neer [5] and Rowe [6] with conservative treatment with higher nonunion with operative fixation for midshaft clavicular fracture. This low incidence resulted in confusion for long time regarding the optimal management for this fracture. On the contrary, with more recent studies, Robinson *et al.* [21] reported a nonunion rate of 21% for the displaced, comminuted midshaft fractures when managed conservatively. Even on evaluating these results in young males, Brinker *et al.* [24] showed a nonunion rate ranging between 20 and 33%. Similarly, in a study by Hill *et al.* [10], a nonunion rate of 15.4% was reported, with ~31% of their patients had an unsatisfactory outcome based on patient-oriented measures. Our results compare well with the recently published incidence of nonunion in literature. In spite of the lower incidence of nonunion in the nonoperative group in this study compared with other studies, however 25% (*N*=12) of patients in this group were unsatisfied with their shoulder function. Additionally, 10.4% (*N*=5) were unsatisfied with the shape of their shoulders.

While it is unclear why there is such a dramatic difference between the outcome of clavicular fractures in previous reports and those in contemporary studies, there are several possibilities. The initial reports often included data on clavicular fractures in children, with better healing abilities and remodeling potential [5–8]. Second, the use of patient-oriented outcome measures has been shown to reveal functional deficits in the upper extremity that are not detected by traditional surgeon-based scores [4,10,11]. Additionally, there are changing patient expectations nowadays such as a rapid return to pain-free function following the fracture. Lastly, it may be that injury patterns are changing. A recent study on patients with polytrauma revealed that the presence of clavicular fracture was associated with a mortality rate of 32% (34 of 105 patients) (mainly owing to concomitant chest and head injuries) [9].

Table 3 Preoperative radiological data

Radiologic data	Nonoperative group (mean±SD)	Operative group (mean±SD)	*P*
Displacement (mm)	17.5±4.2	18.9±2.5	0.07
Angulation (degrees)	12.5±5.9	14.7±5.5	0.06
Shortening (mm)	9.7±3.5	10.9±3.1	0.09

Malunion was a common outcome in the nonoperative group. Symptomatic malunion was detected in 25% (*N*=12) of cases in the nonoperative group. Our results compare well with the study by Hill *et al.* [10] who published an unsatisfactory outcome rate of 31%. Nowak *et al.* [25] reported 46% of their patients with displaced clavicle fractures experienced symptomatic outcomes when managed conservatively.

In terms of functional outcome, Constant score was significantly better in the operative group at the final follow-up. Regarding patient-oriented evaluation, DASH score was significantly better in the operative group. This was comparable with the results published by the Canadian orthopedic society in a multicenter study on 2007 [22].

Patient satisfaction was significantly better (*P*=0.014) in the operative group with five patients unsatisfied of the inflamed scar and four patients with the shape of their shoulders with bulging osteosynthesis. In the

Table 4 Correlation between radiologic and clinical data in non-operative group

	Radiologic data					
	Displacement	*P*	Angulation	*P*	Shortening	*P*
Constant	–0.3	0.03	–0.4	0.01	–0.4	0.00
DASH	0. 2	0.2	0.3	0.05	0.4	0.01

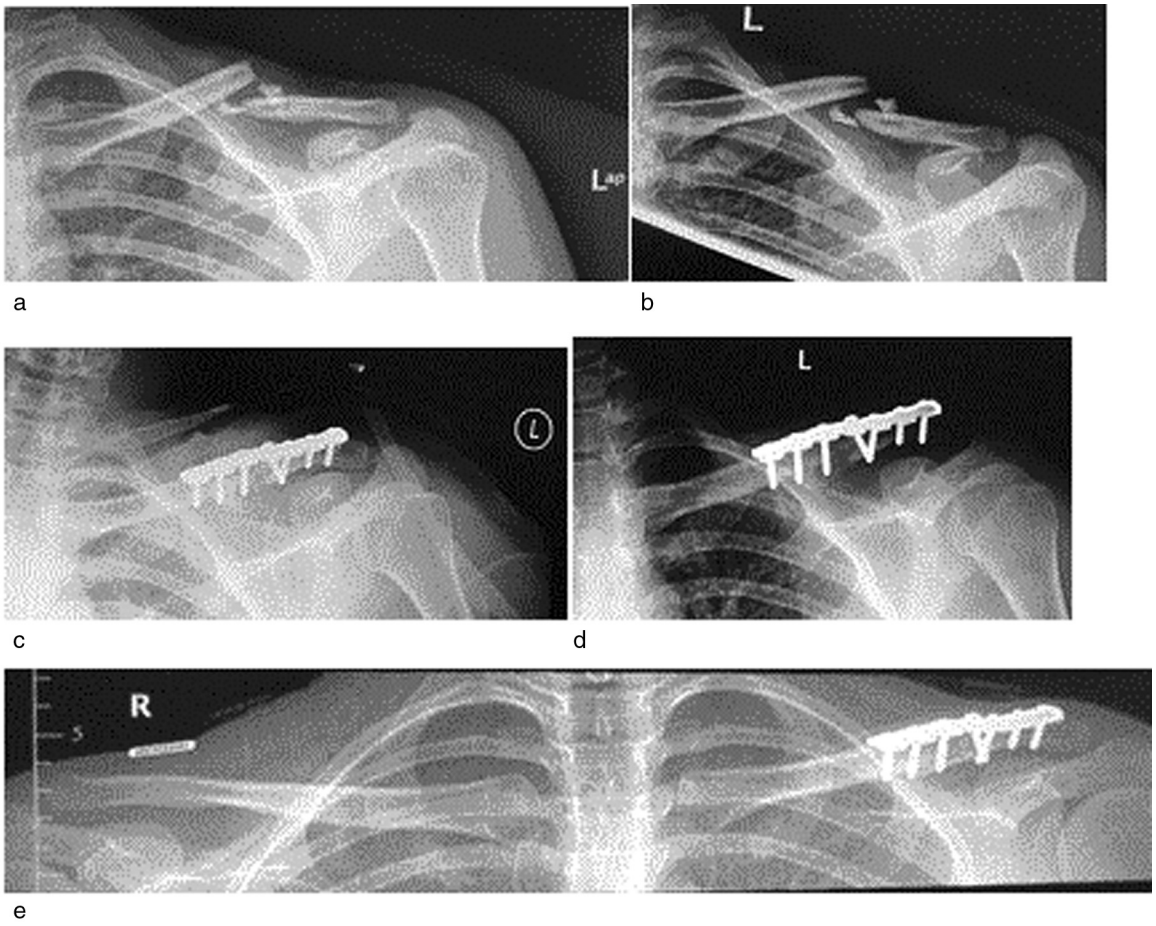
DASH, disability of the arm, shoulder and hand.

Table 5 Correlation between radiologic and clinical data in operative group

	Radiologic data					
	Displacement	*P*	Angulation	*P*	Shortening	*P*
Constant	0.13	0.4	0.3	0.06	–0.3	0.09
DASH	–0.35	0.8	0.1	0.5	0.1	0.4

DASH, disability of the arm, shoulder and hand.

Figure 1



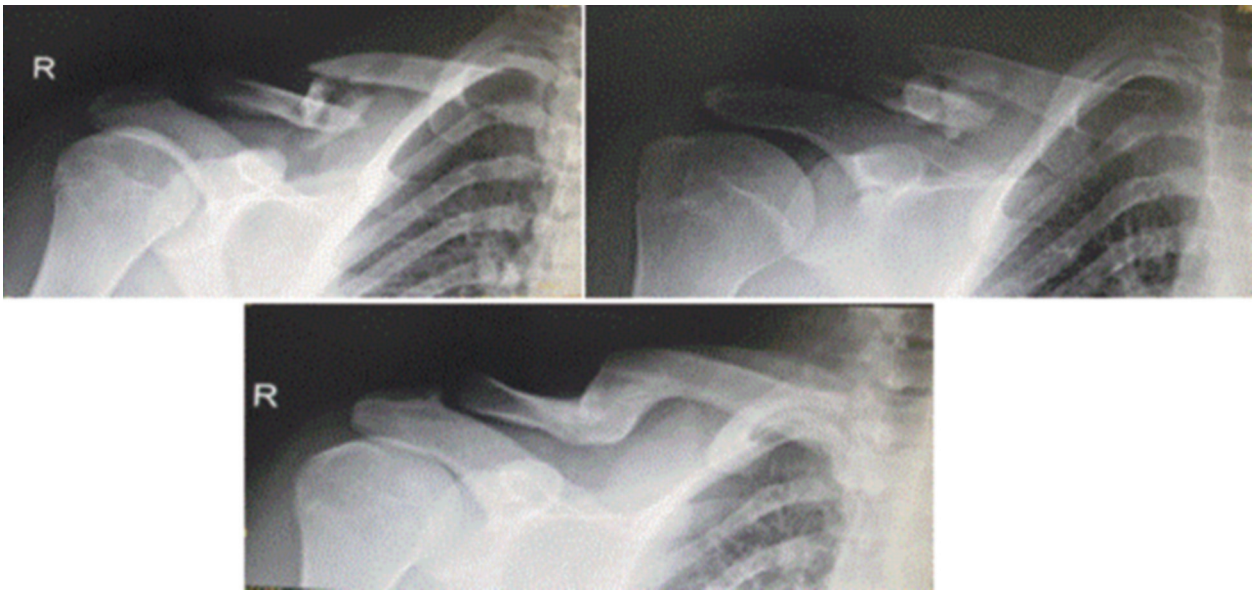
A 29-year-old woman with displaced fracture of the left clavicle managed by open reduction and internal fixation. (a, b) Preoperative anteroposterior and anteroposterior views in cephalic tilt, (c) immediate postoperative radiograph, (d) 6-week postoperative anteroposterior radiography, and (e) 31-month postoperative radiograph showing both shoulders.

nonoperative group, patients were unsatisfied owing to pain, diminished shoulder function, or shoulder shape asymmetry.

Complications in the operative group included wound-related complications: hypertrophic scar in eight patients, of which five patients were complaining of itching or pain at the scar site, three cases of superficial infection, and one case of delayed union. A bulge due to osteosynthesis was detected at fracture site in four cases, and implant removal was done owing to disfigurement caused by the plate.

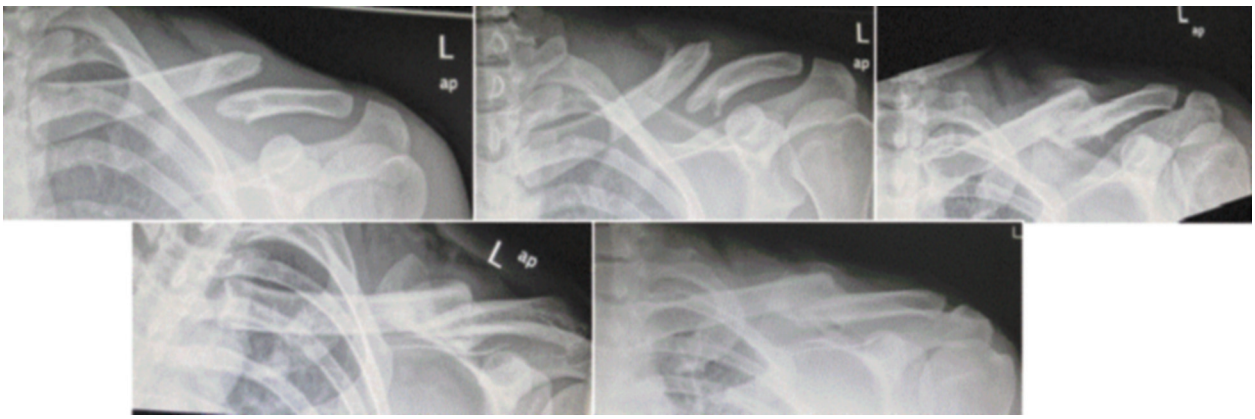
Our study has limitations. It is a retrospective study with no possible randomization of cases into both groups; however, cases were selected from the database registry

Figure 2



A 34-year-old male patient with comminuted fracture of the middle third clavicle managed conservatively (patient refused surgery). (a, b) Immediate posttrauma radiograph and (c) 29-month posttrauma radiograph with malunion.

Figure 3

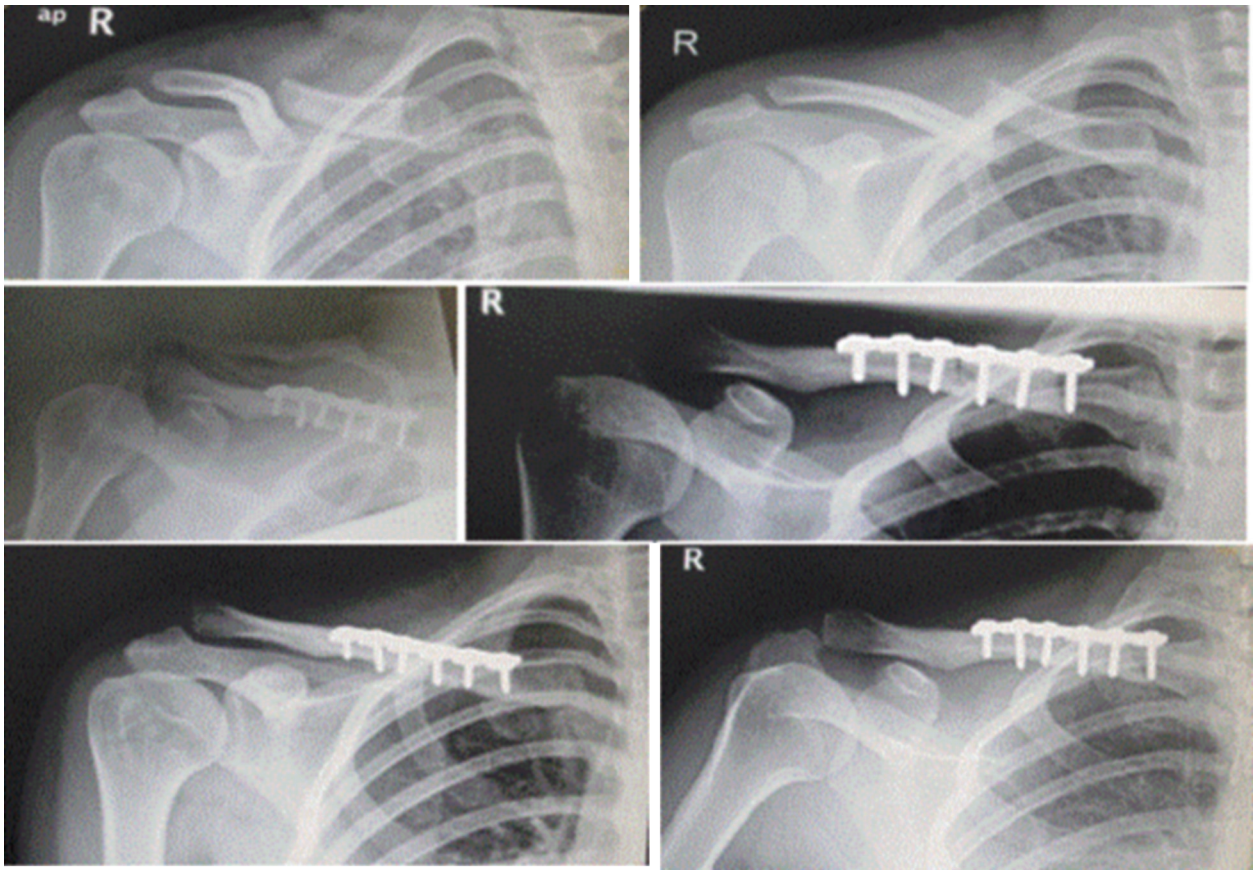


A 28-year-old male patient with displaced midthird clavicle fracture managed conservatively (after refusal of surgical treatment). (a, b) Posttrauma radiography, (c, d) 8-week posttrauma radiography with evident callus and decreased displacement, and (e) 19-month posttrauma radiography with malunion.

sequentially in the defined period starting with cases in the more recent years with completed follow-up and with no preference to the patient data or results (including degree of displacement). Moreover, evaluation of the patient demographics and preoperative data revealed matched results in all variables except for the sex, with significant number of male patients went into operative management compared with females who preferred nonoperative management. However, this retrospective study gave us a good chance to evaluate cases of nonoperative treatment with severe displacement, as it was not possible initially to offer them conservative treatment as the principal method of management.

The definition of displaced clavicular fracture and its margins is not clear in the literature. In this study, most of the cases were initially indicated for surgery owing to severe displacement; however, some of them refused operation and hence were included into the conservative group. This ensured matched fracture severity between the compared groups. Longer follow-up may be needed to reveal further long-term related effects of malunion on the acromioclavicular joint and on scapular position. In this study, measurement of shoulder power as part of the Constant score did not show significant difference between groups. However, shoulder weakness was considered an important adverse

Figure 4



A 47-year-old male patient with midthird displaced clavicle fracture managed by open reduction and internal fixation. (a, b) Preoperative radiography, (c) immediate postoperative radiography, (d) 6-week postoperative radiography, and (e, f) 21-month postoperative radiography.

effect for clavicular malunion by some authors [26–28].

Conclusion

Midshaft clavicle fractures represent a spectrum of injury with each patient requiring individualized assessment and treatment according to patient requirements and preinjury level of activity. Operative management in severe deformities ends with better results, especially in high-demand patients.

Deformities following midshaft clavicular fractures include shortening, displacement, and angulation; the most significant deformity related to complications was found to be displacement followed with shortening, with much better results with operative management. Nonunion is significantly more frequent with conservative treatment. No clear significant relation was detected between the degree of deformity at the time of injury and nonunion. This may need to be evaluated through larger number of conservatively managed cases to evaluate the main determinants of nonunion following clavicular fracture. This may add another sharp indication for internal fixation in this type of fracture.

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Conflicts of interest

There are no conflicts of interest.

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