Plate fixation in midshaft fracture clavicle

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Background
Fractured clavicle accounts for around 4% of all fractures and up to 44% of fractures of the shoulder girdle. Fractures of the middle third (or midshaft) account for ~80% of all clavicle fractures. When midshaft clavicle fractures are completely displaced or comminuted, in elderly patients or female patients, the risk of nonunion, cosmetic deformity, and poor outcome may be markedly higher; therefore, surgical stabilization of a complex midshaft clavicular fracture with either plate-and-screw fixation or intramedullary device is indicated.

Objectives
We aimed to evaluate the efficacy of open reduction and internal fixation for displaced midshaft clavicle fractures in 15 patients using plates and screws. Patients were followed-up for an average of 16.5 months (10–24 months).

Study design
This was a prospective study in 15 patients treated with fixation by means of plates and screws for fixation of midshaft-displaced fractures of the clavicle.

Patients and methods
This study included 15 patients with acute displaced midshaft fractured clavicle treated surgically with plates and screws at the Zagazig University Hospital and Health Insurance Hospital from June 2008 to August 2010. There were 10 male and five female patients aged between 18 and 52 years, with an average of 34.6 years.

Results
Patients were followed-up for an average of 16.5 months (range, 10–24 months). Fifteen patients were included in this study; of them, 10 were asymptomatic healthy patients according to the Constant–Murley score evaluation (66.6%) and four presented with symptomatic results due to nonunion, tender scar, prominent implant, and superficial infection in one patient each.

Conclusion
Operative fixation of displaced fractures of the clavicular shaft results in improved functional outcome and a lower rate of malunion and nonunion compared with nonoperative treatment at the end of 1.5 years of follow-up. This study supports primary plate fixation of completely displaced midshaft clavicular fractures in active adult patients.

Keywords:
clavicle, fracture, plate

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Introduction

Fractures in the middle-third clavicle account for 69–82% of fractures of the clavicle. The junction of the outer and middle third is the thinnest part of the bone and is the only area not protected by or reinforced with muscle and ligamentous attachments. These anatomic features make it prone to fracture, particularly with a fall on the shoulder, which results in an axial load to the clavicle [1]. There is a high prevalence of symptomatic malunion and nonunion after nonoperative treatment of displaced midshaft clavicular fractures [2]. Management of midshaft clavicular fractures is often challenging, and the outcome can be unsatisfactory. Traditionally, midshaft clavicular fractures have been managed conservatively, even when substantially displaced. Recent literature has shown a high nonunion rate in displaced midshaft clavicular fractures, with a nonunion rate of up to 15% [3,4]. The treatment of nonunions produces inferior results compared with acute fractures [5,6]. Displaced and shortened fractures of the middle third of the clavicle are common in young, athletic populations and are frequently high-energy injuries sustained in road traffic accidents or sports injuries. Patients with displaced and shortened midshaft fractures of the clavicle often require operative fixation [7]. Closed treatment for displaced middle-third fractures gives poor results. Several techniques of fixation have been described in the literature, including the use of plates, Kirschner wires, Steinman pins, external fixators, and even plaster constructs. Previously used intramedullary devices were smooth and hence lacked compression at the fracture site [8]. Most clavicular fractures unite uneventfully with conservative treatment; many patients with these fractures experience residual deformity, function deficits, and cosmetic problems [9]. Previously accepted universal healing rates for clavicular fracture are now thought to be overly optimistic [10]. Nonunion rates

for displaced midshaft clavicular fractures following conservative management are thought to be higher than those previously believed. Risk factors predisposing to nonunion with compromised shoulder function following midshaft clavicular fracture include marked displacement of fracture fragments [11–13], age, female sex, comminuted fracture pattern, shortening greater than 20 mm [14], severity of trauma, and refracture. The indications for primary operative treatment of midshaft clavicular fracture should include open injury, shortening or displacement greater than 20 mm, multiple trauma, floating shoulder, and cosmesis [15].

Classification

Allman proposed a classification based solely on the anatomic location of the fracture, and Neer classified lateral-end fractures on the basis of whether they were undisplaced (type I) or displaced (type II). Displaced lateral-end fractures were further subclassified on the basis of the integrity of the coronoid and trapezoid ligaments. In type IIA injuries the ligaments remain intact, whereas in type IIB injuries the coracoclavicular ligaments are partially or completely detached. Craig further modified the Neer and Allman systems by the inclusion of the additional subdivisions of medial and lateral-end fractures. The Edinburgh classification, based on an analysis of clavicular fractures, was the first to subclassify shaft fractures on the basis of their displacement and degree of comminution (Table 1) [16].

Patients and methods

In this prospective study, the records of 15 patients with displaced midshaft clavicular fractures treated operatively at the Zagazig University and Health insurance Hospitals between June 2008 and August 2010 were investigated. Reconstruction plating was carried out in 10 patients and one-third plating was performed for the remaining five patients. As regards sex, five (33.3%) were women and 10 (66.6%) were men and their age ranged from 18 to 52 years, with an average of 34.6 years. As regards the affected side, 10 patients had fracture on the right and five on the left. The cause of injury was road traffic accident in eight patients, fall in four patients, and direct injury in three patients; the duration of follow-up ranged between 10 and 24 months, with an average of 16.5 months. The union average was 14.2 weeks (Table 2). Cases with open reduction and internal fixation with plates with type IIB1 fractures are presented in Fig. 1 and those with type IIB2 fractures in Fig. 2.

Table 1 The Edinburgh classification [16]

Type I medial-end fracture
IA Undisplaced IA1 — extra-articular
IA2 intra-articular
IB Displaced IB1 — extra-articular
IB2 Intra-articular
Type II shaft fracture IIA — cortical alignment
IIA1 Undisplaced
IIA2 Angulated
IIB Displaced IIB1 — simple or wedge comminuted
IIB2 Isolated or comminuted segmental
Type III lateral-end fracture IIIA — cortical alignment
IIIA1 Extra-articular
IIIA2 Intra-articular
IIIB Displaced IIIB1 — extra-articular
IIIB2 Intra-articular

Evaluation methods

The Constant–Murley score [17] is a practitioner-completed objective score on a scale of 100 points divided into sections for pain, activity, range of movement, and strength and is measured for both arms. The Constant–Murley score is divided into four subscales: Pain (15 points); Activities of daily living (ADL) (20 points); Range of Motion (ROM) (40 points), and Strength (25 points). The Pain and the ADL scales are self-reported by patients. The ADL score is divided into four items: Sleep (two points); Work and Recreational Activities/Sport (four points each); Positioning the Hand in the Space (10 points). ROM is evaluated as the active elevation of the arms on the sagittal and lateral planes and the internal and external rotation of the shoulders, 10 points each. Finally, strength is evaluated as the pounds of pull that the patient can resist in abduction up to a maximum of 25 points. The total possible score is 100 points, indicating an asymptomatic and healthy person, and the worst score is 0 points.

Surgical technique

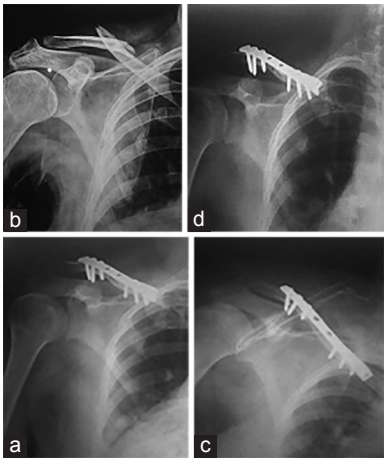
Under general anesthesia the patient was placed in a beach-chair position; the affected shoulder was elevated with a towel, and the ipsilateral upper extremity was draped. An anterosuperior incision centered above the fracture and parallel to the long axis of the clavicle was made; a deep surgical dissection was performed subperiosteally, and the fracture fragments were approached with minimal stripping of soft tissues. The fracture fragments were reduced anatomically along the fracture edge to its main proximal or distal parts, followed by fixation with a plate after contouring either reconstruction plating of 3.5 mm or one-third dynamic compression plate (DCP) plating of appreciable length according to the configuration of the anatomically reduced fractured clavicle. Limb abduction to 90° consistently increased the distance of the neurovascular

Table 2 Patient's data and follow-up

Patient number	Age (years)	Sex	Side	Fracture type	Trauma type	Fixation methods	Follow-up (months)	Union (weeks)	Complications	Results
1	23	Male	Right	IIB1	Road traffic accident	Reconstruction plate (3.5 mm)	14	16		
2	36	Male	Right	IIB1	Falling	Reconstruction plate (3.5 mm)	16	12		
3	40	Female	Left	IIA2	Direct	1/3 DCP plate	10	10	Superficial infection	
4	48	Female	Left	IIB1	Falling	Reconstruction plate (3.5 mm)	12	14		
5	18	Male	Left	IIB1	Road traffic accident	Reconstruction plate (3.5 mm)	16	12		
6	22	Male	Right	IIB2	Road traffic accident	1/3 DCP plate	12	16		
7	32	Male	Left	IIB1	Direct	Reconstruction plate (3.5 mm)	24	15		
8	33	Male	Left	IIA2	Road traffic accident	Reconstruction plate (3.5 mm)	20	20	Nonunion	
9	43	Female	Right	IIB1	Road traffic accident	Reconstruction plate (3.5 mm)	18	14		
10	45	Male	Right	IIA2	Road traffic accident	1/3 DCP plate	16	16	Tender scar	
11	48	Female	Right	IIB1	Road traffic accident	1/3 DCP plate	14	15		
12	52	Male	Left	IIB1	Direct	1/3 DCP plate	20	12		
13	22	Female	Right	IIB2	Falling	Reconstruction plate (3.5 mm)	22	15	Prominent implant	
14	28	Male	Right	IIA 2	Falling	Reconstruction plate (3.5 mm)	18	14		
15	30	Male	Right	IIB 1	Road traffic accident	Reconstruction plate (3.5 mm)	16	12		
Average	34.6						16.5	14.2		

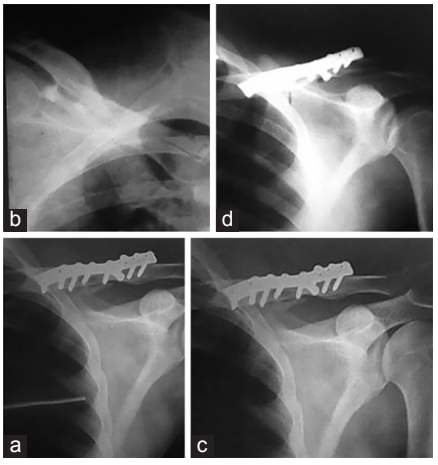
DCP, Dynamic compression plate.

Figure 1



A 48-year-old female patient with type IIB1 fracture: (a) Preoperative radiograph of displaced midshaft fracture clavicle. (b) Postoperative fixation with a plate. (c) Postoperative 2 months. (d) Complete union in abduction at 6 months on radiography.

Figure 2



A male patient (case 6) with type IIB2 fracture: (a) Preoperative radiograph of displaced midshaft fracture clavicle. (b) Postoperative fixation with a plate and interfragmentary screw. (c, d) Postoperative complete union in abduction at 4 months on radiography.

structures from the clavicle. Anteroinferior reconstruction plating for midclavicular fractures decreases the risk of screw pullout from the lateral fragment and achieved a high rate of bone union. A longer screw can be used in the anteroinferior direction such that holding strength is increased. In our study, the reconstruction plate was easily contoured to an S shape, causing less shielding because of its malleable properties. With locking compression plates there is a high risk of stress shielding, which might result in

implant-induced osteopenia. The wound was closed in layers, and dressing was applied with shoulder support.

Results

The study included 10 men and five women with an average age of 34.6 years (range, 18–52 years), and reconstruction plating was carried out in 10 patients and five patients were operated with DCP plates. The cause of fracture was road traffic accident in eight patients (53.3%), fall in four patients (26.6%), and direct injury in three patients (20%). Fractures were classified according to the Edinburgh classification of clavicular fractures: type IIA2 in four patients (26.6%), type IIB1 in nine patients (60%), and type IIB2 in two patients (13.3%). The mean union period was 14.2 weeks; there was one patient (6.6%) with superficial skin infection treated with dressing and antibiotics, one patient with prominent scar, one patient with prominent implant, and nonunion in one patient.

ROM of the affected shoulders was gradually regained. Many patients returned to occupational activities.

Negligence while performing inappropriately early activities was found to be associated with nonunion.

Discussion

Fractures of the midshaft clavicle with 100% displacement and more than 2 cm shortening require surgical fixation. Plates-and-screws fixation is the most commonly used method. However, plates and screws require significant soft-tissue stripping, which may compromise the blood supply to the clavicle and interfere with subsequent healing.

The bicortical screws on the clavicle may act as multiple stress raisers leading to fractures. Bostman *et al.* [18] studied 103 patients treated with open reduction and internal fixation using plates; among those patients, 43% had complications; 15% had major complications; and 14% required reoperation.

A recent clinical study comparing plate fixation with nonoperative treatment for mid-clavicle fractures has shown that two (3.2%) out of 62 patients in the plating group and seven (14.2%) out of 49 patients in the nonoperative group developed nonunion. The wound infection rate in that study was 4.8% (3/62); the patients were managed with antibiotics and local wound care and subsequently underwent removal of metal work once the fracture had healed [19].

In this study, no major complications occurred, and the total complication incidence was 26.6% in four of 15 patients. One patient in the plating group developed superficial wound infection that required surgical dressing and antibiotics that responded after 10 days (6.6%). One patient developed nonunion and required reoperation with bone graft, which united at 20 weeks. Scar-related symptoms occurred in one patient (6.6%) because of tender scar and keloid formation.

One patient (6.6%) presented a prominent hardware and required removal of implant after union was completed. External fixators have been used in open fractures and nonunion of midshaft clavicle.

Pin-track infection is common. Smooth intramedullary devices lacked compression at the fracture site and therefore migrated [20,21].

The new-generation intramedullary device is designed with a differential pitch and allows compression at the fracture site and minimizes hardware migration. It requires a very small incision at the fracture site with minimal soft-tissue dissection and avoids the risk of impaired blood supply to the bone.

Conclusion

There is a high prevalence of symptomatic malunion and nonunion after nonoperative treatment of displaced midshaft clavicular fractures. Operative fixation of a displaced fracture of the clavicular shaft results in improved functional outcome and a lower rate of malunion and nonunion compared with nonoperative treatment at follow-up. Slightly displaced clavicular midshaft fracture is currently treated nonoperatively. There is considerable debate about whether acute displaced fractures should be treated operatively. Nonunion rate after displaced fracture has been underestimated for a long time and malunion clinical impact often minimized. It is known that operative treatment decreases these rates; however, operating all displaced fractures may lead to over treatment. Hardware removal remains the most common reason for surgical intervention. This study supports primary plate fixation of completely displaced midshaft clavicular fractures in active adult patients. Caution must be exercised when instrumenting midshaft clavicle fractures regardless of chosen plate position. Limb abduction to 90° provides an added measure of safety during clavicle instrumentation. Nonoperative treatment and those after plate fixation of displaced midshaft clavicular fractures.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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