Plate fixation for acute clavicular shaft fractures

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Setting
A study carried out in Kasr Al, Aini School of medicine and New Kasr Al-Aini Teaching Hospital, Cairo University, Cairo, Egypt.
Aim of the work
To assess the efficacy of the primary treatment of clavicular shaft fractures by plate fixation in terms of functional outcome.
Methods and study design
During the period between March 2008 and August 2010, we carried out a prospective study that included 20 patients with displaced clavicular shaft fractures who were treated with primary open reduction and internal fixation with 3.5 mm reconstruction plates.
Results
All the fractures achieved clinical union at a mean of 11 weeks. According to the DASH (disabilities of the arm, shoulder, and hand) Scoring System [1], the results were excellent in 16 patients, good in three patients, and fair in one patient.
Conclusion
Open reduction and internal fixation of displaced clavicular shaft fractures improve the functional outcomes and can lead to early return to activities, preventing unacceptably high complication rates of nonoperative management of these fractures.

Keywords:
clavicle fractures, clavicular shaft fractures, plate fixation

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Introduction

Clavicle fractures in adults account for ~5% of all fractures and 35–43% of shoulder girdle injuries. According to Allman, fractures occur most commonly in the middle one-third of the bone (76–82% Allman type I) and less often in the lateral one-third (12–21% Allman type II) and medial one-third (3–6% type III) [1–3].

Robinson [4] proposed another classification system that isolated diaphyseal shaft fractures from the medial and lateral ends including a larger part of the bone, the intermediate three-fifths of the diaphysis.

Classically, only Alleman type II, which includes the lateral third of the clavicle, was amenable to operative treatment as many forces are involved in the displacement of the fracture parts in type II [5], but displaced shaft clavicular fractures (Alleman type I) have been shown to be problematic in certain cases [6,7].

Recent studies have shown that the union rate after midshaft clavicular fractures is not as favorable as was once believed [8–10].

The incidence of nonunion of the clavicle following a mid-shaft fracture has traditionally been reported to be 1% or less on the basis of two landmark studies from the 1960s [11,12]. This figure has been used to avoid primary internal fixation. However, a number of recent studies on completely displaced, mid-shaft fractures of the clavicle have reported nonunion rates between 15 and 20% [7,10,13] because of better follow-up, inclusion of more severe fractures, and exclusion of children from the series (with their intrinsically good prognosis) [7,14].

A meta-analysis of recent studies has reported a rate of nonunion of displaced mid-shaft clavicular fractures of 15.1% after nonoperative care compared with 2.2% after plate fixation [13].

Moreover, malunion of the clavicle has been found to be a definite clinical entity [15]; late neurovascular complications and thoracic outlet syndrome have been recorded [7].

Even after healing of nonoperative treatment, without serious complications, recent studies using patient-oriented outcome measures [such as the DASH (disabilities of the arm, shoulder, and hand) Scoring System] have suggested that some residual impairment in shoulder function is common [6].

Many published articles have documented the success of open reduction and internal fixation for nonunion of displaced clavicle fractures with low complication rates.

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Plate fixation allows early mobilization of the shoulder while providing secure fixation, with a predictably high rate of union and a low risk of complications, and most authors have advocated this technique [16–21].

Shaft fractures occur most commonly in young active adults, whereas lateral and medial-end fractures are more common in elderly individuals [4].

A study carried out by the Canadian orthopedic trauma society on 111 patients showed not only an overall improvement in shoulder functions (at 1 year) in operated cases but also a much rapid return of function and decrease in pain in the operative group [22,23].

Materials and methods

During the period between March 2008 and August 2010, a prospective study included 20 patients with displaced fractures of the clavicular shaft who were admitted and treated primarily by a reconstruction plate and screws.

There were 17 men and three women. Mechanisms of injury were a fall on an outstretched hand in 14 cases, motor car accidents in two cases, and a fall from a motor bike in four cases.

Certain criteria were established to include patients in the study for acute fixation: young active adults (age from 20 to 50 years) with isolated displaced clavicular shaft fractures (in the middle 3/5) and more that 2 cm shortening, with skin tenting (impending skin rupture). Patients with pathological fractures or active infection were not included. Patients with debilitating medical conditions or not falling within the previously mentioned age group were not included.

Surgical technique

After stabilization of the general condition of the patient in the emergency room, a radiographic examination was performed. Radiographs of the chest were performed routinely to detect any concomitant fractures of the ribs or a pneumothorax. The patients were operated in the supine beach chair position, with the arm draped free for easy manipulation. A curvilinear anterosuperior subcutaneous approach along the Langers lines was used in all cases. The fracture was reduced, ensuring a perfect anatomical reduction in most cases. Little soft tissue stripping was carried out, especially of the comminuted fragments, and a plate was used as a neutralization plate if considerable comminution was present, with avoidance of compression. Care was taken to avoid inadvertent plunging of the bone by slow-speed drilling and the use of hand-held bone drilling. In all cases, the fracture was fixed with a contoured 3.5 mm reconstruction plate in the superior aspect of the clavicle. In three cases, interfragmentary screws were used (Figs 1–3).

Postoperatively, a shoulder immobilizer was used to immobilize the shoulder. Elbow and wrist movements were started in the immediate postoperative period. The initial phase of the rehabilitation program involved passive mobilization of the shoulder, which was started in the third week. The second stage was usually started after the fifth postoperative week, with the aim of restoration of the entire range of motion of the shoulder. Muscle-strengthening exercises were started after motion had been restored.

Results

The function of the shoulder was assessed using the DASH scoring system, which measures the clinical outcome using 30-item questionnaires.

Seven items on symptoms (pain, tingling), two items on social impact, and 21 items on impact on daily functions, 0 (best function) to 100 (worst).

A low score indicated a low degree of disability. The patients had to fill in 27/30 of the questions.

It was found that 16 patients showed excellent results (0–15 points), three patients showed good results (15–30 points), and one patient showed fair results (more than 30 points). The patient with fair results had a painful scar that necessitated removal of the plate after 4 months with clinical healing.

Muscle strength was assessed manually and compared with that of the contra-lateral, normal shoulder.

Radiographic assessment was carried out postoperatively; no immediate postoperative problems were encountered.

The mean duration of follow-up ranged from 6 months to 16 months (mean of 1 year).

The healing period ranged from 10 to 15 weeks, mean 11 weeks.

Complications

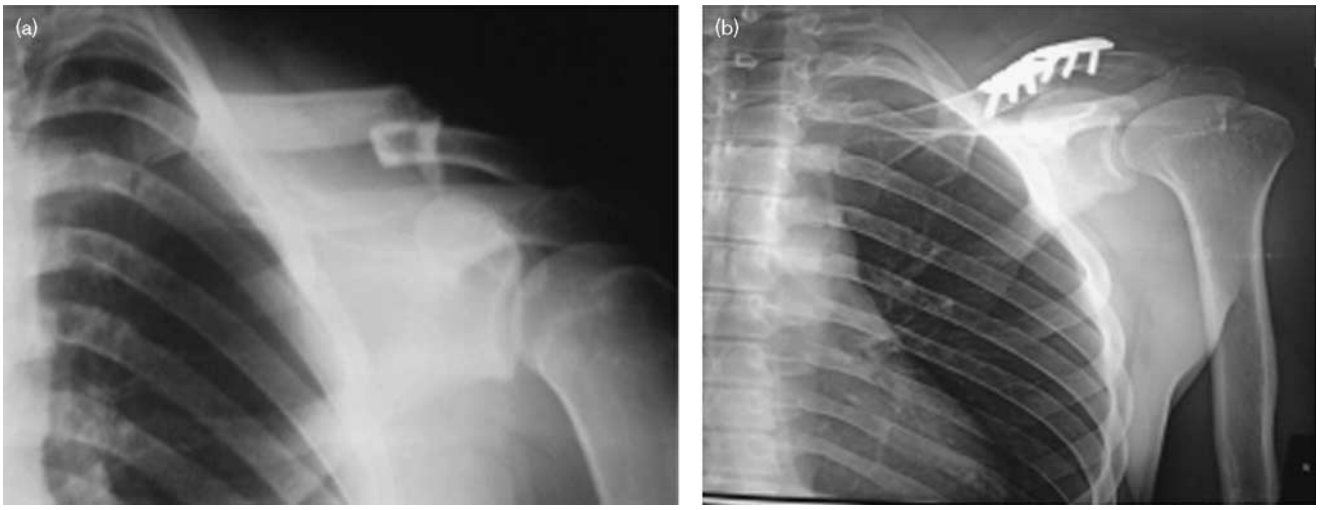
(1) No intraoperative complications developed, and no early or late wound infection or refracture was encountered.
(2) One patient had a painful scar that necessitated removal of the plate after 4 months.

Discussion

Jupiter and Leffert [16], noted that fracture displacement of greater than 2 cm was associated with nonunion in their series of patients. Since then, the treatment of displaced mid-shaft clavicle fractures has evolved over the past several years on the basis of recent clinical studies reporting high rates of nonunion and symptomatic malunion with nonoperative treatment [9,10,15,22,23].

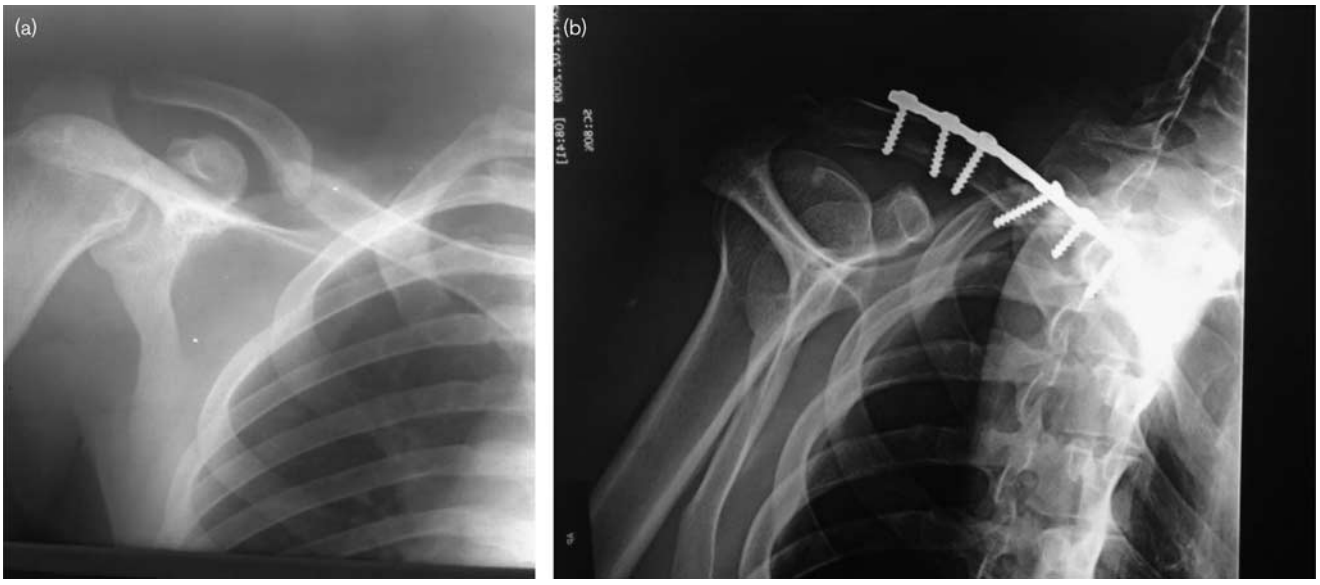
Mid-shaft fractures are the most common clavicle fractures, accounting for up to 80% of all clavicle fractures. Most of the fractures in this group are mild to moderately displaced and can be treated nonoperatively. However, a number of recent studies on completely displaced (more than 2 cm shortening), mid-shaft fractures of the

Figure 1



(a) Preoperative radiograph of a mid-shaft fracture of the shaft of the clavicle. (b) Fixation by a plate and screws with a 3.5 mm reconstruction plate with cortical screws 3.5 mm in diameter.

Figure 2



(a) Preoperative radiograph of a displaced clavicular mid-shaft fracture. (b) Fixation by a 3.5 mm reconstruction plate and cortical screws.

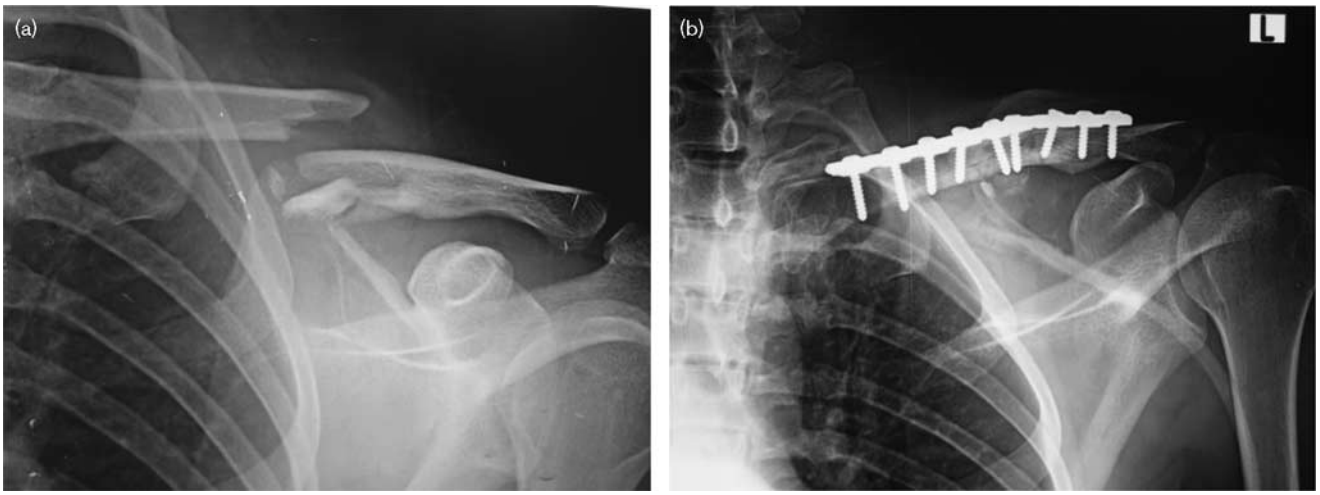
clavicle have reported nonunion rates between 15 and 20% compared with 2.2% after plating [7,10,13]. The nonunion rate of fractures of the lateral part of the clavicle can increase to 37% when a nonoperative treatment protocol is initially adopted [5].

Therefore, we adopted a regimen of acute fixation of completely displaced mid-shaft clavicular fractures. It is known that these two parts should be managed operatively to achieve a high union rate.

Fixation by plate and screws is always an acceptable choice, but has some disadvantages such as the need for wider exposure and periosteal stripping, which can disturb the blood supply and healing process. Also, removal of hardware leads to an increasing risk of refracture because of osteoporosis and stress riser after screw removal but less serious than pin migration with injury of vital organs that can develop from intramedullary fixation. Biomechanically, the ability of the intramedullary nail to resist torsional forces is much lesser than that of plates [24].

In our series, fixation by plate and screws was carried out in all cases; we used the superior surface as the side of fixation.

Figure 3



(a) Comminuted mid-shaft clavicular fracture. (b) Fixation by plate and screw with interfragmentary screws taken through the plate.

Some authors have recommended that the clavicle plate be placed anteriorly, and it is possible that this might decrease the incidence of symptomatic hardware removal because of plate prominence or serious complications because of injury of vital structures [25], but we found that in the majority of our patients, the larger superior clavicle surface was most amenable to satisfactory plate placement, and there was no injury of the lung, pleura, or vascular structures with slow-speed drilling. In addition, it was found that superior plate placement was biomechanically more stable than anterior plate placement [26].

Hardware removal led to a painful scar only in one patient, and removal was performed after 4 months, with complete healing of the bone, and no refracture was encountered. This rate of hardware removal is lower than that reported in other series perhaps because of fewer patients [27] or avoidance of the use of a semitubular plate for fixation, which led to the removal of plates in 82 patients out of 111 patients in one series [28].

We used a nonlocked reconstruction plate that could be easily contoured to adapt to the curvature of the bone, and allows better fixation by skipping of comminution and better contouring to hold the solid area of the bone, thus preventing screw loosening until complete healing. Although we used nonlocked plates with perforation of both cortices, the use of slow-speed drilling led to the avoidance of inadvertent drilling. Considerable data have been obtained in favor of the use of a reconstruction plate, but there is no consensus on the use of locked or nonlocked plates.

Reconstruction plates can be manipulated to fit the contour of the clavicle and fracture pattern to achieve firm fixation, are lighter and thinner than dynamic compression plates, and are durable to multidirectional mechanical stress imposed on the fracture site than a semitubular plate [29,30].

In one study in which both locked and nonlocked reconstruction plates were used, the use of nonlocked plates did not result in complications, such as injuries to the subclavian artery and brachial plexus, but screw loosening occurred in three patients during the follow-up period. Although nonunion, pain, or functional disabilities were not observed in these cases, it is believed that a reconstruction locked plate may be used as an alternative to reconstruction plates to reduce the number of cases of screw loosening [31].

However, in another biomechanical testing, it was found that unicortical fixation using precontoured plates and locking screws has a biomechanical profile similar to that of gold standard nonlocked bicortical screws in cyclic axial compression and axial load to failure. Nonlocking constructs were stiffer under rotational testing. This technique may provide a suitable biomechanical environment for bony healing. This may also improve the safety of clavicle plating by protecting infraclavicular structures from injury during drilling or screw penetration as it obviates the need for bicortical fixation [32].

Fractures of the shaft of the clavicle occur in younger adults compared with fractures involving one end. Patients recover faster and can enjoy a productive life with a fully functional shoulder having full power for a longer period of time, experiencing little discomfort in daily activities and with no complaints of an unpleasant appearance. A high rate of healing and a low rate of nonunion, and a better functional outcome can be achieved after fixation in a common fracture (up to 5% of all fractures). Plate fixation has been found to allow early rehabilitation, with more rapid return to work.

Conclusion

Clavicular shaft fractures are the most common of clavicular fractures that occur in young active adults,

with a high rate of malunion and nonunion. Therefore, if these patients are identified before they develop nonunion or malunion, a surgical fixation technique could be used to treat their fractures acutely before the development of complications.

Acknowledgements

This study supports the high union rate of operative fixation by primary plating of displaced clavicular shaft fractures, with good functional results and a low rate of complications.

Conflicts of interest

There are no conflicts of interest.

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