# Dual fixation of midshaft clavicle fractures in adults: intramedullary Kirschner wire with augmentative plate fixation

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**Received** 17 December 2016
**Accepted** 25 September 2017

**The Egyptian Orthopaedic Journal**
2017, 52:208–214

**Background**
The clavicle is one of the most commonly fractured bones in the body. In adults, clavicle fractures represent 2.6–5% of all fractures and 44% of all shoulder girdle injuries. Although fracture union usually occurs regardless of the treatment selected, controversy exists regarding optimal management. Although most clavicle fractures can be managed nonoperatively, still there has been debate on how to best treat displaced midshaft clavicular fractures. Without fixation, nonunion rates as high as 15–21% have been reported. Operative fixation for displaced midshaft fractures improve the functional outcomes and decrease nonunion rates. Operative management including open or closed reduction with plate fixation or intramedullary (IM) fixation results in improved outcomes and lower rates of nonunion compared with nonoperative management and is recommended for patients with multiple risk factors for nonunion, especially significant displacement or clavicle shortening. This study was conducted to assess the results and reliability of combined IM and plate fixation of displaced mid-clavicular fractures in adults.

**Patients and methods**
Thirty-three adult patients with comparable demographics having displaced mid-clavicular fracture were submitted to surgical fixation by both IM Kirschner wire and short small reconstruction plate. Results were assessed at the end of this period according to Constant and Murley Score (CMS). The CMS is a 100-point functional shoulder-assessment tool in which higher scores reflect increased function.

**Results**
At the end of the follow-up period, the mean score was 95.33±9.0. Thirty-two (97%) patients had excellent results, and only one (3%) patient had poor result. The mean final CMS for pain was 14.70±1.74. The mean final CMS for activity of daily living was 19.67±1.91. The mean final CMS for active forward flexion was 9.82±1.04 (145°–174°). The mean final CMS for active abduction was 9.82±1.04 (145°–174°). The mean final CMS for active external rotation was 9.88±0.70. The mean final CMS for active internal rotation was 9.88±0.70. The mean final CMS for strength was 23.88±2.36. Time of union in the studied patients ranged from 8 to 12 weeks, with a mean of 8.25±0.84 weeks.

**Conclusion**
Our research data suggest that a relatively new technique using IM Kirschner wire with augmentative anteroinferior short small fragment contoured reconstruction plate fixation is a suitable, reproducible, and effective alternative for surgical fixation of displaced midshaft clavicle fractures in adults and provides reliable functional results.

**Keywords:**
adults, anteroinferior reconstruction plate, dual fixation, intramedullary Kirschner wire, midshaft clavicle fracture

Egypt Orthop J 52:208–214

1110-1148

## Introduction

The clavicle is one of the most commonly fractured bones in the body. Its subcutaneous location on the anterosuperior aspect of the thoracic cage, along with its function as a strut connecting the upper limb to the chest, makes it susceptible to injury [1]. In adults, clavicular fractures represent 2.6–5% of all fractures and 44% of all shoulder girdle injuries. Clavicular fractures are most commonly classified by anatomic location. Approximately, 69–82% of clavicular fractures are middle-third fractures. Instability and shortening occurs in approximately 27% of this last group. Fractures involving the lateral third of the clavicle make up 21–28% of fractures. Fractures involving the medial third of the clavicle make up 2–3% of fractures [2,3].

Although fracture union usually occurs regardless of the treatment selection, controversy exists regarding optimal management. Conservative management was and may be still the most common approach to nondisplaced clavicular fractures in adults in the form of immobilization in a broad arm sling or figure-of-8 strapping with early rehabilitation [4–7].

Although most clavicle fractures can be managed nonoperatively, still there has been debate on how to best treat displaced midshaft clavicular fractures. Without fixation, nonunion rates are as high as 15–21% [8–11].

Operative fixation for displaced midshaft fractures improves the functional outcomes and decreases nonunion rates [12]. Operative management including open or closed reduction with plate fixation or intramedullary (IM) fixation results in improved outcomes and lower rates of nonunion compared with nonoperative management and is recommended for patients with multiple risk factors for nonunion, especially significant displacement or clavicle shortening [13].

IM fixation is less invasive, entails smaller incisions and smaller surgical scar with better cosmesis and higher overall patient satisfaction, restores anatomy adequately, and has less prominent hardware than plate and screws. It is associated with less need for reoperation for its removal, which can be done under local anesthesia, with no empty screw holes after plate removal, and has a shorter hospital stay compared with plate fixation [14]. However, IM fixation does not provide compression at the fracture site and at the same time lower rotational stability compared with plate fixation that makes it not suitable for the comminuted fractures that may lead to nonunion or malunion in shortened position. Because of the possibility of migration, backing out or breakage of IM fixation devices and possibility of skin irritation, plate fixation continues to be the method preferred by many surgeons [15–17].

The most common complaint after plate fixation of clavicle fractures remains symptomatic prominent hardware necessitating its removal after fracture healing [18]. When the hardware is removed, it requires the same extended incision and leaves screw holes behind in the clavicle that can act as stress risers for refracture [19]. The risks of painful prominent hardware, infection and nonunion is often associated with open reduction and internal fixation that can be minimized with percutaneous pin fixation [20].

## Patients and methods

Patients were recruited from the Casualty Orthopaedic Department at El-Hadra University Hospital, Alexandria, Egypt, El Qabary Ministry of Health Hospital and The Alexandria Police Hospital. From August 2014 to September 2016 we collected 33 patients. We included adult patients with displaced fracture of mid-third clavicle. Patients with fracture of medial or lateral thirds clavicle were excluded. Informed consent was obtained from all individual participants included in the study.

We conducted this prospective study on 33 adult patients (Table 1). They were 28 (84.8%) men and five (15.2%) women. The age at the time of presentation ranged from 24.0 to 55.0 years, with a mean 38.18±7.92 years. Right side was affected in 20 (60.6%) patients and left side in 13 (39.4%) patients. Twenty-one (63.6%) patients were manual workers, eight (24.2%) were office workers and four (12.1%) were housewives. The underlying mechanism of injury was road traffic accident in 27

**Table 1 Characteristic features of the studied patients**

| | *n* (%) |
|---|---|
| Age (years) | |
| ≤30 | 7 (21.2) |
| 31–40 | 13 (39.4) |
| 41–50 | 11 (33.3) |
| >50 | 2 (6.1) |
| Range (minimum–maximum) | 24.0–55.0 |
| Mean±SD | 38.18±7.92 |
| Median | 38.0 |
| Sex | |
| Male | 28 (84.8) |
| Female | 5 (15.2) |
| Side | |
| Right | 20 (60.6) |
| Left | 13 (39.4) |
| Occupation | |
| Manual worker | 21 (63.6) |
| Office worker | 8 (24.2) |
| Housewife | 4 (12.1) |
| Mechanism of injury | |
| RTA | 27 (81.8) |
| Direct | 6 (18.2) |
| Associated injuries | |
| No | 30 (90.9) |
| No. of distal end radius | 1 (3.0) |
| No. of humerus | 1 (3.0) |
| No. of scapula | 1 (3.0) |
| Associated medical conditions | |
| No | 27 (81.8) |
| HTN | 3 (9.1) |
| DM | 3 (9.1) |

DM, diabetes mellitus; HTN, hypertension; RTA, road traffic injury.

(81.8%) patients and direct trauma in six (18.2%) patients. All patients had fracture in the midshaft of their clavicles. One (3%) patient had associated ipsilateral fracture in the distal end radius, one (3%) had associated ipsilateral fracture in the humerus and one (3%) had associated ipsilateral fracture in the scapula, while the remaining patients (90.9%) had pure fracture in the mid-third clavicle only. Six (18.2%) patients had associated medical co-morbidities; three of them (9.1%) had hypertension, and the others (9.1%) had diabetes mellitus. The remaining 27 (81.8%) patients were medically fit. There were no statistically significant relationship between the final score and the following items, namely, the associated injuries ($P=0.194$), the time lapse before surgery ($P=0.180$), and the associated medical condition ($P=0.119$).

The patients were complaining of acute onset of pain in the shoulder girdle following trauma, swelling, ecchymosis, and loss of function with severely painful limited range of shoulder motion. On physical examination, the affected side was tender, edematous, bruised, deformed because of tenting of the overlying skin by the displaced fracture, and lastly, sometimes a crepitus could be felt at the site of the fracture. Neurovascular examination could not be fully fulfilled during the primary situation owing to pain. Unfortunately, one (3%) patient was discovered 2 months postoperatively to have brachial plexus partial affection. The time lapse before surgery in the studied patients ranged from 2 to 15 days, with a mean of 6.52±3.57 days.

Radiographic evaluation was ordered to make a diagnosis and plan for treatment. The basic studies that were recommended were standard anteroposterior and lateral radiographs of the affected shoulder.

After preoperative assessment including history taking, symptoms and clinical examination followed by plain radiography and/or computed tomography scan evaluation. All patients were treated using IM Kirschner wire (K-wire) (2–3 mm) with augmentative plate fixation (small set 3.5 mm contoured reconstruction plate). Surgery was performed with the patient under general anesthesia. Standard loading dose of a broad-spectrum prophylactic antibiotic was given. The patients were placed in the semi-setting (beach-chair) position. Scrubing, draping, and towelling of the whole ipsilateral upper extremity was done. An image intensifier was prepared to be used for the operation.

A skin incision of approximately 4 cm was made just overlying the fracture site localized by image intensifier. After exposure of the fracture, open reduction was tried and then retrograde insertion of the K-wire through the fracture site was done. A four-hole small fragment 3.5-mm contoured reconstruction plate was applied in an anteroinferior direction. The protruding lateral end of the K-wire was shortened and bent close to its entry point into the skin followed by wound closure was performed in layers using simple interrupted sutures. After the surgery, the patient was placed in a broad arm sling.

Patients were discharged with their arm immobilized in a sling. Early gentle mobilization was permitted when pain allows, with no overhead abduction for the first 6 weeks. The shoulder sling was discarded at 2 weeks and active-assisted exercises were started, but the patients were advised not to lift any heavy object for 6 weeks. At that time, passive and strengthening exercises were started. The sutures were removed after 2 weeks. The K-wire was removed at 6 weeks to avoid any further skin irritation. All patients were followed up clinically and radiologically for at least 6 months.

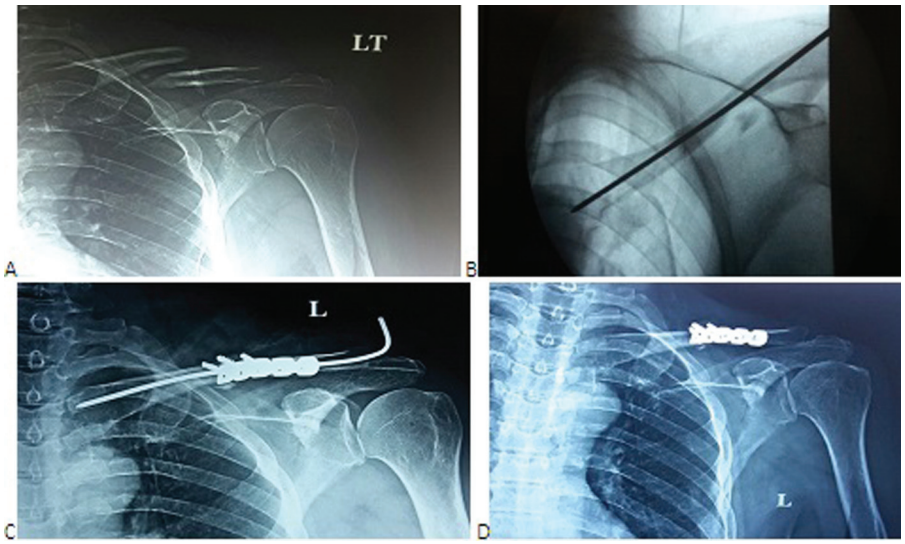
Results were assessed at the end of this period according to Constant and Murley Score (CMS). The CMS is a 100-point functional shoulder-assessment tool in which higher scores reflect increased function. It combines four separate subscales: subjective pain (15 points), Activity of Daily Living (20 points), objective clinical assessment of range of motion (40 points), and strength (25 points).

Data from all patients were collected in a patient file, and then it was transferred into a master table and fed to the computer on SPSS, version 20 (IBM Corp., Released 2011, Armonk, NY, United States of America) statistical programme for statistical analysis.

## Results

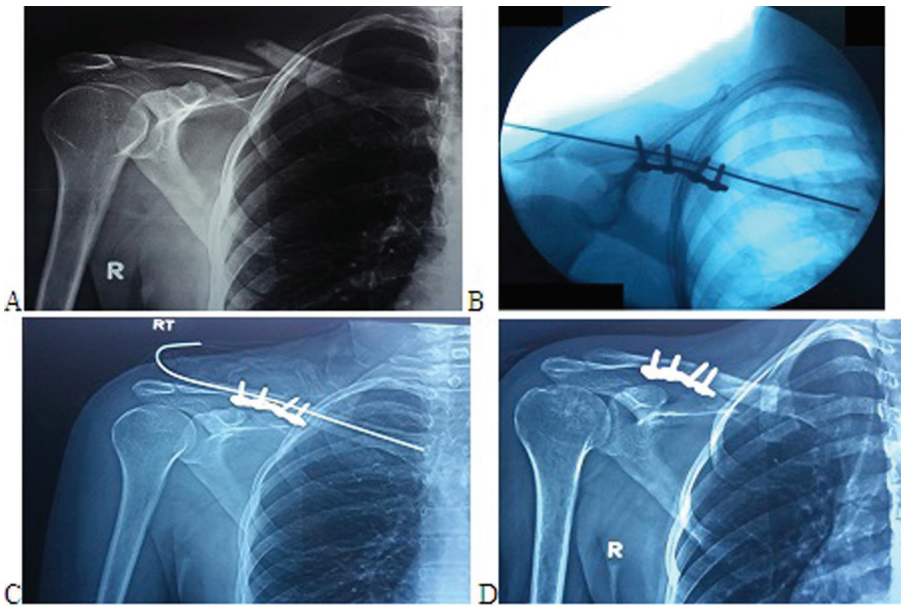
In this study, during a 2-year period from August 2014 to September 2016, 33 adult patients with displaced midshaft clavicle fractures were included, and they underwent surgical fixation. At the end of the follow-up period, the mean score was 95.33±9.0 ranging from 48 to 100 according to the CMS. Thirty-two (97%) patients had excellent results (Figs. 1 and 2), and only one (3%) patient had poor result (Fig. 3). The mean final CMS for pain was 14.70±1.74 ranging from 5 to 15. The mean final

**Figure 1**




A 44-year-old adult male patient showing excellent result. (a) Preoperative radiograph anteroposterior (AP) view with fracture of his left clavicle. (b) Picture of C-arm after open reduction and introduction of the intramedullary K-wire. (c) The immediate postoperatve radiograph. (d) AP view 2 months postoperatively after removal of the K-wire and achieving union of the fracture.

**Figure 2**



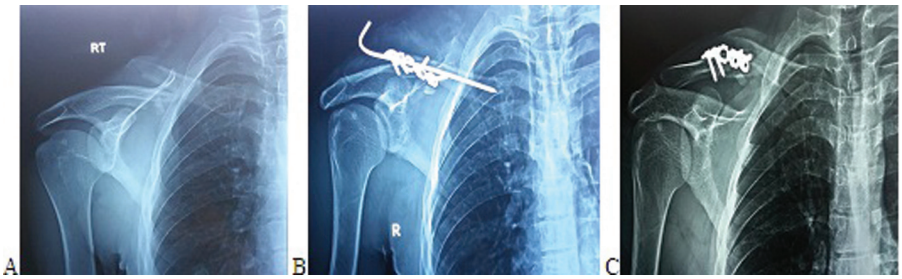

A 29-year-old adult female showing excellent result. (a) Preoperative radiograph anteroposterior (AP) view with fracture of her right clavicle. (b) Picture of C-arm after open reduction and final fixation by K-wire and reconstruction plate. (c) The immediate postoperatve radiograph. (d) AP view 2 months postoperatively after removal of the K-wire and achieving union of the fracture.

CMS for activity of daily living was 19.67±1.91 ranging from 9 to 20. The mean final CMS for active forward flexion was 9.82±1.04 (145°–174°) ranging from 4 to 10. The mean final CMS for active abduction was 9.82±1.04 (145°–174°) ranging from 4 to 10. The mean final CMS for active external rotation was 9.88±0.70 ranging from 6 to 10. The mean final CMS for active internal rotation was 9.88± 0.70 ranging from 6 to 10. The mean final CMS for strength was 23.88±2.36 ranging from 15 to 25. Time of union in the studied patients ranged from 8 to 12 weeks with a mean 8.25±0.84 weeks (Table 2).

## Discussion

No consensus exists concerning the optimal treatment of displaced midshaft clavicle fractures. The decision to treat midshaft clavicular fractures operatively or nonoperatively remains controversial. The traditional treatment of midshaft clavicle fractures has been

**Figure 3**




A 32-year-old adult male patient showing poor result. (a) Preoperative radiograph anteroposterior (AP) view with fracture of his right clavicle. (b) The immediate postoperatve radiograph. (c) AP view 7 months postoperatively after removal of the K-wire with implant failure following direct trauma at surgical scar.

nonoperative [21,22]. Although minimally displaced fractures do well, recent outcome studies have shown higher incidences of fracture malunion, nonunion, and patient dissatisfaction after conservative treatment of displaced midshaft clavicle fractures [23].

Collinge *et al.* [24] described anteroinferior plating of clavicle fractures. The potential advantages included a less prominent implant, a more direct approach, use of longer screws for fixation because of clavicular anatomy, stiffer fixation with anteroinferior comminution because of stability of the plate in this plane [25], and potentially lower frequency of neurovascular injury because of screw fixation projection. The results were 4% nonunion, 4% implant removal, and a 6% infection rate.

In our study, three (9%) cases developed skin irritation around the entry of the K-wire laterally that was controlled by local care and oral antibiotics in all cases within 2 weeks. There was no deep infection in any case. Nonunion and implant failure occurred in one (3%) case. All fractures united with an exception of one case which, presented with implant failure owing to retrauma by a direct blow to the point of shoulder at the site of the previous surgery 7 weeks postoperatively. This fracture was revised by removal of the implant, refreshening of fracture ends, autogenous iliac bone grafting, and fixation by eight-hole small fragment dynamic compression plate. This fracture united after 3 months.

Lim *et al.* [26] implanted anteroinferior reconstruction plates in 38 fractures and noted statistically significant improvements in visual analogue pain scales but similar time to union and American Shoulder and Elbow Scores. In addition, many reports indicate that anteroinferior plating is associated with lower rates of implant prominence as compared with superior plating [27].

Plate and screw fixation requires a more extensive exposure than IM devices leaving hypertrophic ugly scar but has the advantage of more secure fixation. IM fixation has been proposed as a minimally invasive technique for operative treatment of displaced midshaft clavicle fractures [28].

Narsaria and colleagues compared between elastic IM nailing and plating of 66 patients. They concluded that elastic IM nailing is a safe, minimally invasive surgical technique with a lower complication rate, faster return to daily activities, excellent cosmetic and comparable functional results, and can be used as an equally effective alternative to plate fixation in displaced midshaft clavicle fractures [29].

Smekal *et al.* [30] demonstrated improved CMSs in the operative group, which was more satisfied with cosmetic appearance and had higher overall satisfaction. In comminuted fractures that are at risk of telescoping and shortening, IM fixation is not suitable and plate fixation remains the procedure of choice in these cases [31].

In the present study, we can apply this dual method of fixation to comminuted fractures to overcome the inevitable shortening and telescoping of fracture ends in case of IM fixation only. The augmentative plate in this situation adds the advantage of maintaining the length beside IM fixation to avoid malunion in a shortened position.

The anterior–inferior placement of these plates optimized our plate contouring, reduced plate prominence, and enhanced screw length without endangering posterior vital structures.

We designed this prospective study to combine the advantages of both surface and medullary fixation of displaced midshaft clavicle fractures in adults. The procedure reported in this study is effective in regaining clavicle length, achieving union, and

**Table 2 Final score items in the studied patients**

| | *n* (%) |
|---|---|
| Time lapse before surgery (days) | |
| Range (minimum–maximum) | 2.0–15.0 |
| Mean±SD | 6.52±3.57 |
| Median | 6.0 |
| Final score | |
| Excellent (91–100) | 32 (97.0) |
| Poor (<60) | 1 (3.0) |
| Range (minimum–maximum) | 48.0–100.0 |
| Mean±SD | 95.33±9.0 |
| Median | 97.0 |
| Pain | |
| No | 32 (97.0) |
| Yes | 1 (3.0) |
| Range (minimum–maximum) | 5.0–15.0 |
| Mean±SD | 14.70±1.74 |
| Median | 15.0 |
| Activity of daily living | |
| Range (minimum–maximum) | 9.0–20.0 |
| Mean±SD | 19.67±1.91 |
| Median | 20.0 |
| Flexion | |
| Range (minimum–maximum) | 4.0–10.0 |
| Mean±SD | 9.82±1.04 |
| Median | 10.0 |
| Abduction | |
| Range (minimum–maximum) | 4.0–10.0 |
| Mean±SD | 9.82±1.04 |
| Median | 10.0 |
| Strength | |
| Range (minimum–maximum) | 15.0–25.0 |
| Mean±SD | 23.88±2.36 |
| Median | 25.0 |
| External rotation | |
| Range (minimum–maximum) | 6.0–10.0 |
| Mean±SD | 9.88±0.70 |
| Median | 10.0 |
| Internal rotation | |
| Range (minimum–maximum) | 6.0–10.0 |
| Mean±SD | 9.88±0.70 |
| Median | 10.0 |
| Time to union (weeks) | |
| Union | 32 (97.0) |
| Failure | 1 (3.0) |
| Range (min–max) | 8.0–12.0 |
| Mean±SD | 8.25±0.84 |
| Median | 8.0 |

improving pain and function. The incision is smaller than the standard formal incision used with plates and screws thus improving the cosmetic outcome.

The primary limitation of our study was that it was a small prospective study including a small number of patients and done at a single center. Larger randomized controlled trials are needed for further evaluation of outcomes and complications of this method of fixation of displaced midshaft clavicle fractures in adults.

## Conclusion

Our research data suggest that a relatively new technique using IM K-wire with augmentative anteroinferior short small fragment contoured reconstruction plate fixation is a suitable, reproducible, and effective alternative for surgical fixation of displaced midshaft clavicle fractures in adults and provides reliable functional results.

### Financial support and sponsorship

Nil

### Conflicts of interest

There are no conflicts of interest.

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