International Surgery Journal
Kakkar RS et al. Int Surg J. 2020 Jul;7(7):2261-2267
http://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: http://dx.doi.org/10.18203/2349-2902.isj20202833

Original Research Article

Functional and radiological assessment of displaced midshaft clavicle fractures treated through open reduction and internal fixation surgery using pre-contoured locking compression plates

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Received: 14 April 2020
Revised: 07 June 2020
Accepted: 09 June 2020

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ABSTRACT

Background: Fractures of the clavicle constitute approximately 2.6% of all the fractures and nearly 44-66% of fractures around shoulder.
Methods: This particular study is intended to assess the functional and radiological outcomes in a series of 32 patients with closed displaced midshaft clavicle fractures treated through open reduction and internal fixation surgery using pre-contoured clavicle locking compression plates.
Results: All 32 patients achieved fracture union within 6 months follow up period. As per Constant-Murley scoring, 56.25% cases had excellent results, 34.37% cases had good, 6.25% cases had fair and 3.12% of the cases had poor results respectively.
Conclusions: Open reduction and internal fixation surgery with pre-contoured locking compression plates in the displaced midshaft clavicle fractures restores the anatomy, biomechanics and contact loading characteristics of the clavicle and significantly reduces the incidence of non-union with improved functional outcomes resulting in better patient satisfaction.

Keywords: Clavicle fracture, Surgical fixation, Clavicle plate, Constant-Murley score

INTRODUCTION

The annual incidence of clavicle fractures is estimated to be between 29 and 64 per 100,000 populations per year. Fractures of the midshaft account for 80% of all fractures and about half of the midshaft clavicle fractures are displaced.[1-7] The clavicle forms a bridge between the axial and the appendicular skeleton.[8] Along with the scapula, clavicle forms a strut that provides stability and allows for the high range of mobility and function of the shoulder girdle. The clavicle, due to its horizontal and anterior location also serves as a shield for the underlying neurovascular structures. Conventionally, conservative management has been the treatment of choice for clavicular fractures.[9] Conservative management of displaced midshaft clavicular fractures are associated with high chances of malunion and clavicular shortening.[9,10] Clavicle fractures with significant shortening allow the shoulder to displace anteriorly and centrally, potentially compromising normal glenohumeral and scapulothoracic function.[11]

METHODS

A retrospective study was conducted in the Department of Orthopaedic Surgery, Grant Medical Foundation Ruby Hall Clinic, Pune, India on 32 cases of closed displaced midshaft clavicle fractures (Robinson's type 2B1 and

2B2) in patients between the age of 18-60 years satisfying the inclusion and exclusion criteria who underwent surgical treatment through open reduction and internal fixation with pre-contoured clavicle locking compression plate between September 2013 to 2019. These patients were followed for 6 months and evaluated radiologically through X-rays and functionally through Constant-Murley scoring system. Statistical analysis was done using independent t-test using the p value ≤0.05.

Inclusion criteria

Inclusion criteria were age between 18-60 years, patients of either sex, isolated closed displaced midshaft clavicle fractures Robinson's type 2B1 and 2B2 (displacement >2 cms and shortening >2 cms), fractures less than 1 week old, and patients who comply with regular follow up for a period of at least 6 months.

Exclusion criteria

Exclusion criteria were patients with history of previous fracture or injury over clavicle and/or shoulder joint, open fracture, fractures in the proximal or the distal third of the clavicle, multiple trauma/neurovascular/brachial plexus injury, and pathological fractures.

Understanding the applied anatomy

First bone to ossify (5th week of gestation) and the last one (sternal end ossification center) to fuse (at 22-25 years of age). The only long bone to have intramembranous only ossification and lie horizontally in S-shape (the medial end convex forward and the lateral end concave forward). The clavicle forms a bridge between the axial and the appendicular skeleton. Along with the scapula, clavicle forms a strut that provides stability and allows for the high range of mobility and function of the shoulder girdle. The lateral end clavicle gives attachment to coracoclavicular ligaments inferiorly that has two components trapezoid ligament, conoid ligament. The conoid (medial) ligament gives primary restraint to anterior and superior displacement, while the trapezoid (lateral) is the major restraint to the posterior displacement at the AC joint overall giving vertical stability to the AC joint. Three muscles originating from clavicle-deltoid, sternohyoid, pectoralis major. Three muscles inserting on the clavicle-sternocleidomastoid, subclavius, and trapezius. The medial end clavicle is wide and rounded while lateral end is flat joined in middle by a tubular middle segment. The middle third is vulnerable to fracture due to change in configuration from lateral flat to broad medial; transmitting the forces in an uneven way concentrating them in thin center and also due to changed shape from lateral concave to medial convex giving torque to force. The mechanical forces cause shearing effect on this middle third. The middle-third fractures displace with superior angulation, the medial end migrates superiorly due to pull of sternocleidomastoid while the lateral end is pulled downward by the weight of the arm, subclavius muscle and intact coracoclavicular ligaments and inward by the pull of the pectoralis major and latissimus dorsi (Figure 1).

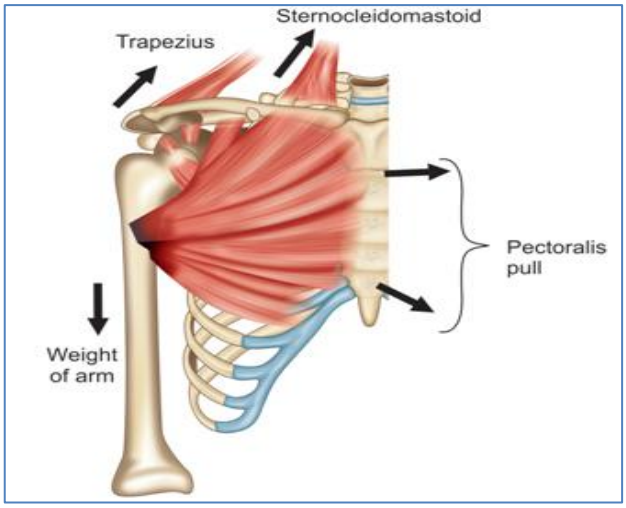

Figure 1: The deforming muscular forces.

Pre-operative protocol

Before the surgical intervention, all the patients were temporarily immobilized with splint, underwent routine investigations, obtained anaesthetic, consent and medical clearance, analgesics and antibiotics. Radiological assessment of both the clavicle through xray were done to assess and compare the length of normal and fractured clavicle, to evaluate and measure the shortening of the fractured clavicle and identification of the fracture geometry through MedSynapse radiology software.

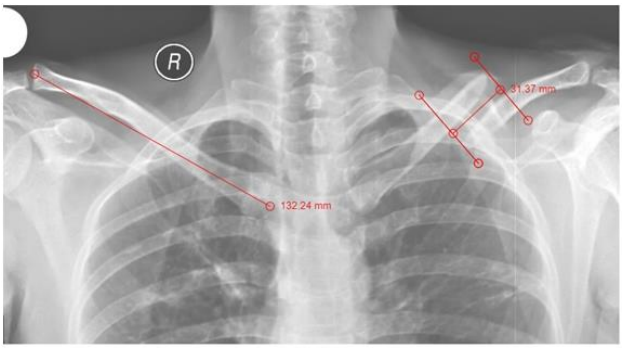

Figure 2: Pre-operative radiological assessment.

Surgery

Figure 3 under block/GA. Supine position on a radiolucent operating table to provide appropriate access to the clavicle. Placement of an inter-scapular drape-roll allowed retraction of the shoulders and assisted with reduction. A standard transverse incision was placed over the antero-superior aspect of the clavicle approximately measuring about 5-9 cm depending on the fracture geometry. The underlying soft

tissue was dissected through the subcutaneous layer and the platysma sub-periosteally. Subcutaneous dissection permitted identification of the supraclavicular sensory nerve branches in half of the cases and the major fibers of these nerves identified and protected with small vessel loops throughout the case. Minimal periosteal dissection was carefully done to provide adequate visualization and fracture exposure. Post fracture reduction with bone clamps/towel clip, the normal length and rotational angulation were assessed and restored followed by superior placement of the plate along with screws under the guidance of C arm. If necessary, a lag screw fixation was carried out using a 3.5 mm cortical screw. If a combination of locking and cortex screws were being used, cortex screws were inserted first to ensure that the plate has appropriate bone contact (flush to the bone). Procedure was confirmed with X-ray fluoroscopy. Closure was done in layers.

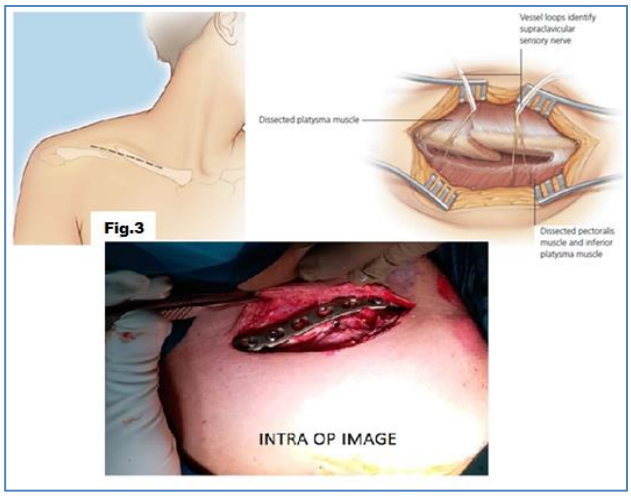

Figure 3: Intra OP image.

Post-operative protocol

Adequate antibiotics and analgesics were given post-surgery. Immediate post-operative check X-ray was taken to assess alignment and fixation. Majority of the patients were discharged on the 1st post-operative day with an arm sling. Suture removal was done after 13-15 days depending upon healing. The splint continued till 4 weeks following which the patients were advised to follow post-operative physiotherapy rehabilitation with gentle range of motion exercises with a limited abduction of 90 degrees. Strengthening exercises and resumption of daily activities was allowed after 8 weeks as tolerated by the patient.

RESULTS

In our study of 32 patients, majority of the patients were male 78.12% and patients were mostly in the age group between 21-49 years with mean age of 32.5 years. Majority of the patients sustained these injuries following RTA 84.37%. Radiological union was seen at 8 weeks in 2 (6.25%) cases, 10 weeks in 5 (15.62%) cases, 12 weeks in 17 (53.12%) cases, 14 weeks in 7 (21.87%) cases and 16 weeks in 1 (3.12%) cases with the average mean of 11.42 weeks (Figure 4 and 5). One 3.12% case had superficial infection which resolved completely with oral antibiotics and one (3.12%) case had implant prominence for which the implant was removed post union. There were no cases of deep infection, neurovascular injury, hypertrophic scar, implant failure, stiffness, nonunion or malunion in the present study. All 32 patients achieved fracture union within 6 months follow up period. As per Constant-Murley scoring, 56.25% cases had excellent results, 34.37% cases had good, 6.25% cases had fair and 3.12% of the cases had poor results respectively (Figure 2).

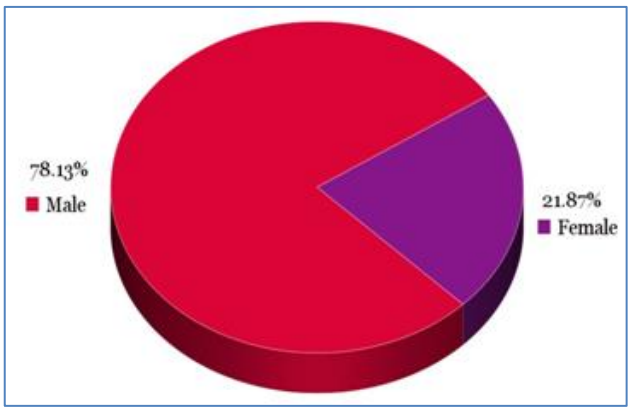

Figure 4: Gender distribution.

Table 1: Mode of injury.

Mode of injury	Frequency	Percentage
RTA	27	84.37
Ground level fall	3	9.37
Direct blow	2	6.25
Total	32	100

Table 2: Radiological union in weeks.

Union in weeks	Number of cases	Percentage
8	2	6.25
10	5	15.62
12	17	53.12
14	7	21.87
16	1	3.12
Total	32	100

Out of 32 cases, one 3.12% case had superficial infection which resolved completely with oral antibiotics and one 3.12% case had implant prominence for which the implant was removed post union. There were no cases of deep infection, neurovascular injury, hypertrophic scar, implant failure, stiffness, nonunion or malunion in the present study.

Table 3: Complications.

Post-operative complications	Number of cases
Superficial infection	1
Deep infection	0
Stiffness	0
Implant prominence	1
Neuro vascular injury	0
Non-union/mal-union	0
Implant failure	0
Hypertrophic scar	0

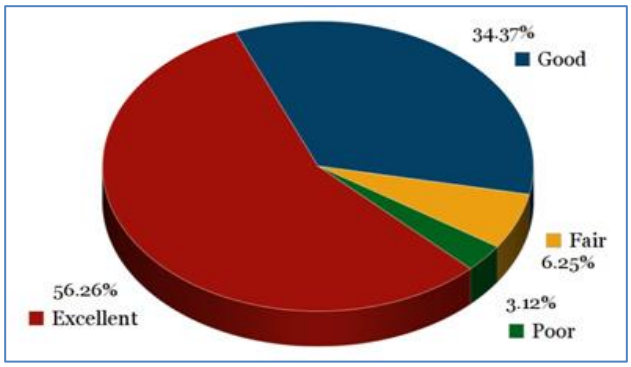

Figure 5: Functional outcome.

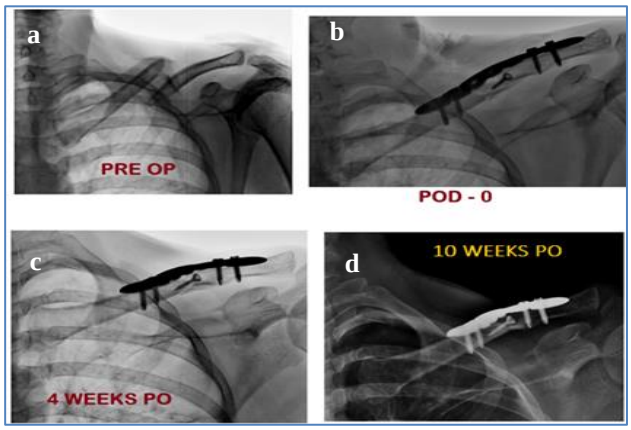

Figure 5 (a-d): Case 47/F, radiological union seen at 10 weeks post-operative.

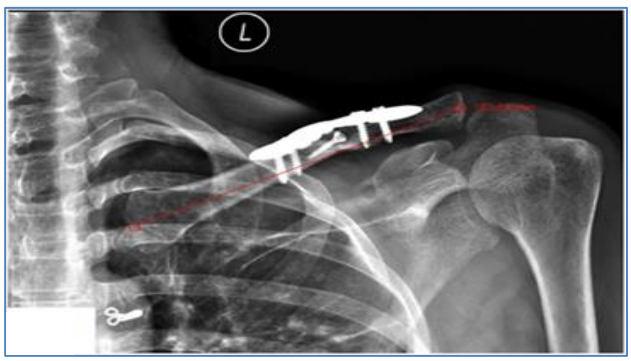

Figure 6: 10 weeks post-operative radiological assessment.

DISCUSSION

Biomechanically, the clavicle serves as a strut between the shoulder and the chest wall, allowing the shoulder to function at a distance from the center of the body. The clavicle, due to its horizontal and anterior location also serves as a shield for the underlying neurovascular structures.[12,13] Midshaft fractures typically result in superior displacement of the medial portion secondary to pull of the sternocleidomastoid and trapezius and the weight of the arm displaces the lateral segment inferiorly.[14] A posteroanterior view with 15 degrees caudal tilt has been described as beneficial in assessing the clavicle shaft for length/shortening.[15] Clavicle fractures are conventionally treated conservatively. By treating the fracture mid-shaft clavicle conservatively many problems had been reported like persistent pain, non-union, delayed and restriction of range of motion, cosmetically unsound, bony prominence and bursa formation over the bony ridge. Studies conducted by Hill et al in 1997, Nordqvist et al in 1998 and Robinson et al in 2004 found poor results following conservative treatment of displaced middle third clavicle fracture.[16-18] Recent literature on primary plate fixation of acute midshaft clavicular fractures have described high rates of excellent results with rates of union ranging from 94-100% and low rates of infection and surgical complications hence with adequate surgical technique, prophylactic antibiotics, and better soft-tissue handling, pre contoured locking plate fixation has been a reliable and reproducible technique.[19-21] The objective of this study was to determine the satisfaction of patients in terms of their ability to perform activities of daily living and to return to their occupation post-surgery.

In this study, 32 cases of closed displaced midshaft clavicle fractures (Robinson's type 2B1 and 2B2) were treated surgically through open reduction and internal fixation using pre contoured clavicle locking compression plates. There was a predominance of RTA as a mode of injury in our study, accounting for 84.37% of the patients which was comparable to the studies done by Ramkumar et al, Attia et al and Jiang et al.[22-24] Based on gender analysis, there was a predominance of males in our study, accounting for 78.12% of the patients which is comparable to a study published by Hundekar.[25]

Age groups between 21-49 years were most commonly injured and the mean age in the present study was 32.5 years which was comparable to a study done by Bostman et al.[26] All fractures in our study had united by 6 months, both clinically and radiologically and the results were comparable to a study done by Lazarus.[27] As per the Constant-Murley functional scoring, post-operative results were satisfactory in all the 32 patients with good to excellent functional outcome in 90.62% and all the patients returned to pre-injury daily activities which was comparable to several studies done by Choudhary et al.[28] Reddy et al, Cho et al and Lee et al.[29-31]

Table 4: Comparison of final functional outcomes with other operative study of displaced midshaft clavicle fractures.

Study	Total cases	Excellent (%)	Good (%)	Fair (%)	Poor (%)
Reddy et al[34]	30	19 (63.3)	11 (36.7)	0	0
Cho et al[30]	41	31 (75.6)	7 (17.07)	2 (4.87)	1 (2.43)
Our study	32	18 (56.25) (p value ≤0.05)	11 (34.37) (p value ≤0.05)	2 (6.25) (p value ≤0.05)	1 (3.12) (p value ≤0.05)

In the present study, there were no non-union, malunion, hardware failure, neurovascular injury, stiffness and deep infection which was comparable with the study published by Jeffrey et al and had depicted similar results.[32] Mechanical studies suggest clavicles plated superiorly exhibit significantly greater stability than those plated anteriorly.[35] In our series, implant removal was not done in any of the patients during the period of study including the one patient who showed hardware prominence (n=1). The advent of anatomically pre-contoured locking compression plates has been a boon to the management of these fractures where a considerable amount of intra operative time is used to contour the conventional plates. Also pre-contoured plates have a theoretical advantage of reduced plate fatigue fracture compared to non-contoured plates which are subjected to intra operative bending.[37-39] Another study by Zlowodski et al describes that there was a 57% relative risk reduction for non-union using a pre-contoured locking plate in comparison to 86% of the non-union for patients treated conservatively.[40] This study is comparable to a Belgium study done by Verborgt et al and Canadian orthopedic trauma society, which depicts that early primary plate fixation of displaced midshaft clavicle fractures resulted in improved patient-oriented outcomes, improved surgeon-oriented outcomes, earlier return to function. Midshaft clavicle fractures with more than 2cm of shortening appear to be at higher risk for nonunion therefore considering surgical fixation provides better results.[33,34,36,41]

CONCLUSION

In our study, the management of clavicle fracture with locking plate fixation along with adequate post-operative rehabilitation resulted in predictably early union rates and excellent results in terms of patient outcome. The outcomes were encouraging and comparable to those reported in the literature. Hence, as per our study, we conclude that open reduction and internal fixation surgery with pre-contoured locking compression plates in the displaced midshaft clavicle fractures restores the anatomy, biomechanics and contact loading characteristics of the clavicle and significantly reduces the incidence of non-union with improved functional outcomes resulting in better patient satisfaction.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Kakkar RS, Mehta D, Sisodia A. Functional and radiological assessment of displaced midshaft clavicle fractures treated through open reduction and internal fixation surgery using pre-contoured locking compression plates. Int Surg J 2020;7:2261-7.