Short plate fixation for midshaft clavicle fractures

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Abstract

Background
The standard of care for plating displaced midshaft clavicle fractures has been 6 cortices of purchase on each side of the fracture. The use of locking plates and screws may provide equivalent biomechanical strength with fewer cortices of purchase on each side of the fracture.

Patients and methods
A prospective case series study was conducted including fourteen patients with acute midshaft clavicle closed fractures with a variable degree of comminution. All patients were male with a mean age of 30.5 years. All fractures were fixed using a 3.5 locked reconstruction plate with 4 locking screws. The arm sling was kept for 4-6 weeks according to fracture pattern and fracture healing progress.

Results
All fractures achieved union in a mean period of 11.7 weeks. QuickDASH scoring system was used for clinical evaluation. At 12 weeks, the mean score was 3.41 and 10 patients resumed their activities and returned to work. At 6 months, the Quick DASH score improved to 0.69 and all patients resumed their pre-fracture level of activity. Only one case experienced failure of fixation who fell on the affected shoulder one week post-operative.

Conclusion
The use of short locked plates with four locking screws in the midshaft fracture clavicle did not compromise fracture fixation strength. Its advantages include decreased surgical exposure, elimination of time needed for contouring of long plate to match the complex morphology of the clavicle, and hence less operative time and morbidity.

Level of evidence
Therapeutic level IV.

Keywords
Midshaft; fracture clavicle; locked plate; locking screws.

Introduction

Fracture clavicle is relatively common, presenting 44 % of fractures around the shoulder girdle and 2.6% of all fractures[1]. Fracture of the middle third clavicular is the most common type of clavicular fracture ranging from 69% to 82%[2-4]. Early reports have considered this fracture to be a benign injury and conservative treatment was the main line of treatment reporting a low incidence of non-union and function disability[5]. But these results were based on the assessment of the range of motion and radiographic evidence of union[6]. A systematic review study has shown that the incidence of non-union is as high as 15.1% in displaced clavicular fractures[7]. On the other hand, symptomatic malunion of midshaft clavicular fracture has been reported to cause shoulder dysfunction. Relatively recent studies stated that malunited midshaft clavicular fracture may lead to pain, loss of strength, easy fatiguability, and manifestations of compression of brachial plexus and vessels in addition to cosmetic concerns[8-10].

Operative fixation of a clavicular fracture may be achieved using plate and screws or by intramedullary fixation. Although it is a more invasive procedure, plate osteosynthesis allows restoration of length and alignment anatomically and provides rigid fixation[11].

The principles of surgical fixation of a fractured clavicle include the need for insertion of three bicortical screws at least on each side of the fracture. However, the number of screws is a topic of debate after the introduction of the locking plate fixation system[12-14]. A recent biomechanical study compared plate fixation in a simulated midshaft fracture clavicle using three non-locking screws versus two locking screws of each side of the fracture. Cyclic tensile loads were applied along the long axis of the clavicle

and pullout forces to failure were applied along the long axis of screws. No significant differences were detected between the two groups[15].

Our study aimed to evaluate the fixation of midshaft clavicular fractures using a reconstruction locked plate fixed by two cortical locking screws on each side of the fracture regardless of the degree of comminution of fracture.

Patients and Methods

This study was conducted as a prospective case series. It included all cases with isolated acute midshaft clavicular fracture indicated for surgical fixation. Patients younger than 16 years old, fractures neglected for more than 3 weeks, pathological fractures, or patients with minimally displaced fractures were not included in the study. At the final enrolment, fourteen patients with midshaft fracture clavicle were included.

All included cases were right-handed males. The mean age was 30.5 ranging from 20 - 46 years old. Eleven patients were smokers and the dominant side was affected in six patients. None of the patients gave a history of medical disease. Fall to the ground on outstretched hand was the cause of fracture in eleven patients (79%), while road traffic accident was the cause in the remaining three (21%).

Cases involved in high energy trauma were managed according to the algorithm devised by ATLS (advanced trauma life support) guidelines. Local examinations of injured limbs included assessment of vascular and neurological status and skin condition. Radiographic assessment of fractures was done with aid of plain X-rays and CT scan with 3 D reconstruction for all cases.

All fractures were closed and belonged to group I according to Allman's classification[16]. Degree of comminution was classified according to AO classification, 6 patients were classified as B1, 4 cases as B2, and 4 cases as B3 patterns[17].

Pre-operative preparation included immobilization in a broad arm sling and pre-operative routine labs. Written informed consent was received from all patients to be included in the study.

Surgical Technique:

All patients were operated under general anesthesia. Prophylactic antibiotic, 1 gm ceftriaxone, was given with induction of anesthesia after hypersensitivity testing. In the beach chair position, the shoulder was draped with the arm free to allow manipulation. Through an anterior approach to clavicle[17], fractures were reduced either directly or indirectly. Locked reconstruction plates with sufficient length - to allow fixation by two bicortical locked screws on each side of the fracture - were applied on the antero-superior border of the clavicle. Bone fragments were not stripped from attached soft tissues to keep their blood supply, and plates were used to restore the length and rotation of the clavicle. The surgical wound was closed in layers after proper hemostasis and broad arm sling was applied. Operative time starting from skin incision till skin closure was documented in all cases.

Parenteral antibiotics were given for one day followed by oral antibiotics for 5 days. Two weeks post-operative, skin sutures were removed and pendulum shoulder exercises were allowed. After the third week, passive shoulder elevation above 90^{o} was encouraged. After 6 weeks, active shoulder elevation of more than 90^{o} was allowed. The arm sling was kept for 4-6 weeks according to fracture characteristics and consolidation of fracture through follow-up visits. Strenuous work and vigorous exercises were allowed after the full bony union.

X-ray clavicle antero-posterior view was ordered immediate post-operative and at 4^{th}, 6^{th}, $8^{th,}$ and 12^{th} weeks follow-up, to assess fracture alignment, the progression of healing, or any sign of failure of fixation. After 12 weeks, monthly X-rays were done till full bony union was evident.

Clinical assessment of patients was performed using The QuickDASH scoring system at three and six months post-operative. Data were statistically described in terms of mean +/- standard deviation (SD), median, range, frequencies (number of cases), and percentages when appropriate.

Results

All our cases achieved union within 11.7 weeks ranging from 8-20 weeks. The patient who achieved union after 20 weeks was a heavy smoker and fracture was comminuted (B3). The mean operative time was 75 minutes ranging from 60-90 minutes.

At 12^{th} week follow-up, the mean QuickDASH score was 3.41 ranging from 0 – 18.2. Ten patients (71%) resumed their pre-fracture level of activity and returned to work. At the final follow-up, 6 months post-operative, the mean Quick DASH score was 0.69 ranging from 0 – 2.3 and all patients resumed their full activity.

The main complication we noticed was symptomatic hardware prominence in five patients (35%). This was attributed to the positioning of the plate on the superior surface of the clavicle. These patients were scheduled for hardware removal after one year. Two patients (14%) suffered from tingling along with the distribution of supraclavicular nerves which improved gradually in subsequent follow-up visits.

One patient fell on the affected shoulder one week

post-operative and X-rays showed a failure of fixation with backing out of the plate and lateral locked screws. The distal fragment was angulated 30^{o} but bone contact was maintained. Revision surgery was offered but the patient preferred to keep a broad arm sling till full union. Bone healing was achieved 10 weeks post-operative without further displacement and hardware was removed one month later. The First QuickDASH score of this patient was 18.3 but improved markedly to 2.3 at the final follow-up visit. We did not face wound healing problems, infection, or painful neuroma in our study. (Fig 1,2)

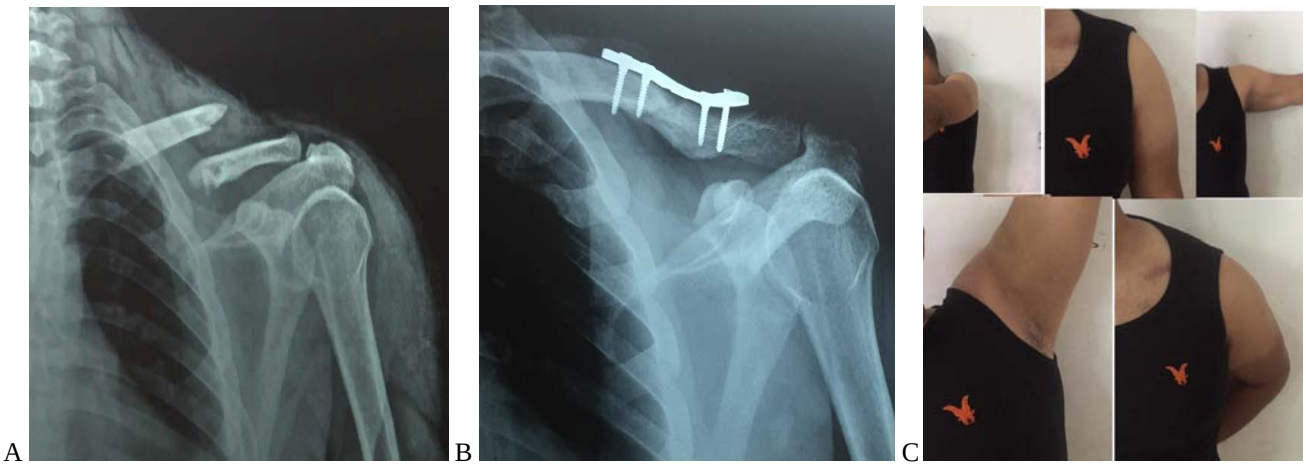

Figure 1: male patient, 32 years old; A: Pre-operative X-ray; B: Full union after 12 weeks; C: 12 weeks follow-up range of motion.

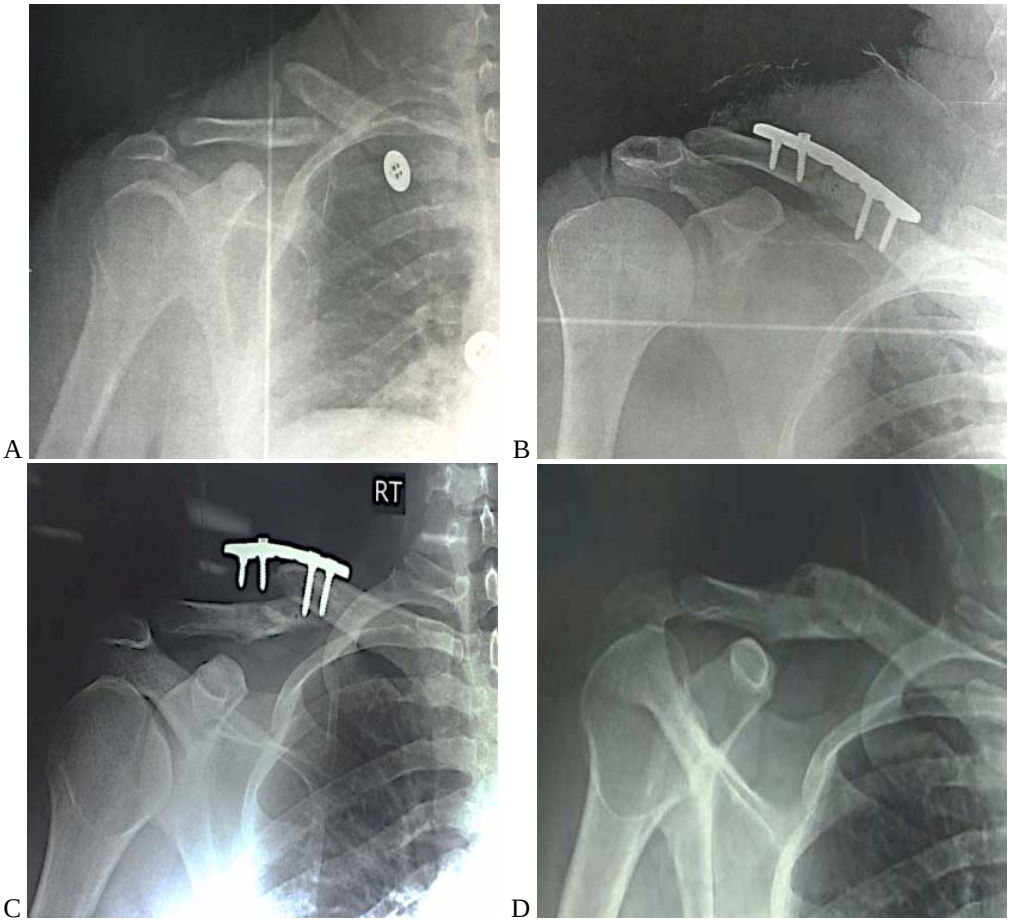

Figure 2: male patient, 41 years old; A: Pre-operative X-ray; B: Immediate post-operative X-rays; C: failure of fixation 4 days post-operative due to falling on the affected shoulder ; D: X-ray after plate removal after healing of fracture 16 weeks post-operative.

Discussion

Fracture clavicle represents 44% of all shoulder injuries[1]. The majority of these fractures occur in the middle third[2]. The high risk of nonunion of displaced fractures[7] and shoulder dysfunction that results from malunited fractures[8-10] increased the role of surgical fixation of these fractures. Plate fixation provides a robust construct in terms of stiffness and failure loading but carries a higher risk of fracture after hardware removal in comparison to intramedullary fixation[19]. The number of screws needed to achieve good stability of the fracture s a point of debate after the introduction of the locked plating system[12-14].

To our knowledge, a single biomechanical controlled laboratory study compared fixation of simulated fracture clavicle using three conventional cortical screws versus two locking screws of each side of the fracture. The author declared that there were no significant differences between the two groups[15].

The same cohort study reviewed retrospectively two groups of patients. The first group included 21 patients with fracture midshaft clavicle fixed by plate and three regular cortical screws on each side of the fracture. The second group included 20 patients with midshaft clavicle fractures surgically fixed using a locked plate with two locking screws on each side of the fracture. All patients achieve union within 12 weeks post-operative. Functional results were not reported in detail but no difference between the two groups was found.

The main difference was the plate length which was significantly shorter in the two screws group. The main complication was painful hardware that needed removal of the implant in five cases in total[15].

A single case of implant failure was reported in the 3-screws group as the patient was not compliant and tried to resume activity earlier than instructed. The patient was treated by replating[15].

This study declared that there is no mechanical advantage of fracture fixation using six screws over four locking screws, and the single case with metal failure that occurred in the six screws group was related to the patient's non-compliance.

The same in our study we faced a single case of mechanical failure of fixation that was related to a traumatic event and all our cases achieved union within 11.7 weeks on average.

Julianne Kwak-Lee et al recorded operative time in a comparative study between fixation using a contoured anatomical plate and intramedullary fixation of midshaft clavicular fracture[18]. Operative times were measured from incision to skin closure. The plate group included 67 patients and the average time was 131.8 minutes (range 30-246 minutes).

In our study, The average operative time was 75 minutes (range 60- 90 min). This difference may be attributed to the usage of shorter plates, as it saved the time needed for plate contouring to accommodate the complex morphology of the clavicle. Insertion of a lesser number of screws, smaller skin incision, and soft tissue dissection in addition to the small size of our study group are possible causes of our shorter operative time.

In the same study[18], authors reported 11 cases (16.4%) who developed numbness along their incision and only two patients (2.9%) with symptomatic hardware although plates were applied on the superior surface of the clavicle.

The rate of tingling and numbness in our study was comparable to this study as it was reported in 14 % of our cases, but symptomatic hardware was reported in five patients (35% of cases). This may be explained by the design of anatomical plates that fits the curve of the clavicle and their relatively low profile in comparison to reconstruction locked plates. But this advantage should be plotted against the cost of hardware.

Conclusion

The use of short plates may decrease surgical exposure, operative time, and hence morbidity without compromising the fracture stability. Besides, theoretically, we think that the fixation of a shorter segment of clavicle decreases the segment weakened by the stress shielding effect of the plate and may decrease the incidence of refracture after plate removal which is the main disadvantage of plating if compared to intramedullary fixation methods. However, this theory needs a bigger study and a longer period of follow-up.

References

1. Verborgt O, Pittoors K, Van Glabbeek F, Declercq G, Nuyts R, Somville J. Plate fixation of middle-third fractures of the clavicle in the semi-professional athlete. Acta Orthop Belg. 2005;71(1):17–21.
2. Jeray KJ. Acute midshaft clavicular fracture. J Am Acad Orthop Surg. 2007;15(4):239-248.
3. Postacchini F, Gumina S, De Santis P, Albo F. Epidemiology of clavicle fractures. J Shoulder Elbow Surg. 2002;11(5):452-456.
4. Robinson CM. Fractures of the clavicle in the adult: epidemiology and classification. J Bone Joint Surg Br. 1998;80(3):476-484.
5. Neer CS. Fracture of the distal clavicle with detachment of the coracoclavicular ligaments in adults. J Trauma. 1963;3:99–110.
6. Hillen RJ, Burger BJ, Pöll RG, de Gast A, Robinson CM. Malunion

after midshaft clavicle fractures in adults. Acta Orthop. 2010;81(3):273 279.
7. Zlowodzki M, Zelle BA, Cole PA, Jeray K, McKee MD; Evidence-Based Orthopaedic Trauma Working Group. Treatment of acute midshaft clavicle fractures: systematic review of 2144 fractures. J Orthop Trauma. 2005;19(7):504-507.
8. Ledger M, Leeks N, Ackland T, Wang A. Short malunions of the clavicle: an anatomic and functional study. J Shoulder Elbow Surg. 2005;14:349–54.
9. Nowak J, Holgersson M, Larsson S. Sequelae from clavicular fractures are common: a prospective study of 222 patients. Acta Orthop. 2005;76:496–502.
10. McKee MD, Pedersen EM, Jones C, Stephen DJ, Kreder HJ, Schemitsch EH, Wild LM, Potter J. Deficits following nonoperative treatment of displaced midshaftclavicular fractures. J Bone Joint Surg (Am) 2006;88:35–40.
11. Khan LA, Bradnock TJ, Scott C, Robinson CM. Fractures of the clavicle. J Bone Joint Surg (Am) 2009;91:447–60
12. Cantu RV, Koval KJ. The use of locking plates in fracture care. J Am Acad Orthop Surg. 2006;14(3):183-190.
13. Hak DJ, Althausen P, Hazelwood SJ. Locked plate fixation of osteoporotic humeral shaft fractures: are two locking screws per segment enough? J Orthop Trauma. 2010;24(4):207-211.
14. Robertson C, Celestre P, Mahar A, Schwartz A. Reconstruction plates for stabilization of mid-shaft clavicle fractures: differences between nonlocked and locked plates in two different positions. J Shoulder Elbow Surg. 2009;18:204-209.
15. Larsen CG, Sleasman B, Chudik SC. A Biomechanical and Clinical Comparison of Midshaft Clavicle Plate Fixation. Are 2 Screws as Good as 3 on Each Side of the Fracture. The Orthopaedic Journal of Sports Medicine, 5(9), 2017;1–7.
16. Allman FL. Fractures and ligamentous injuries of the clavicle and its articulation. J Bone Joint Surg Am. 1967;49(4):774–784.
17. Andermahr J., McKee M., Nam D., Schatzker J.: anterior approach of clavicle, AO foundation surgery reference, 2015.
18. Kwak-Lee J., Ahlmann E. R., Wang L., Itamura J.M.: Analysis of Contoured Anatomic Plate Fixation versus Intramedullary Rod Fixation for Acute Midshaft Clavicle Fractures. Advances in Orthopedic Surgery 2014; 2014: 1-7.
19. Hulsmans M.H., Heijl M.V., Houwert R.M., Burger B.J., Verleisdonk E.J.M., Veeger D.J., Meijden O.A.. Surgical fixation of mishaft clavicle fracture: A systematic review of biomechanical studies. Injury. 2018; 49:753-765.