



## International Journal of Orthopaedics Sciences

ISSN: 2395-1958  
IJOS 2019; 5(3): 22-27  
© 2019 IJOS  
www.orthopaper.com  
Received: 19-05-2019  
Accepted: 21-06-2019

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## Results of functional outcome of surgical treatment of fracture clavicle

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DOI: <https://doi.org/10.22271/ortho.2019.v5.i3a.1501>

### Abstract

**Introduction:** Clavicular fractures are relatively common injuries because of its subcutaneous and superficial presence. The annual incidence of clavicle fractures is estimated to be between 29 and 64 per 100,000 populations per year. Males are affected twice as often as females. There is bimodal distribution in incidence of clavicle fractures.

**Material and Methods:** Prospective study of 20 patients operated for fracture of the clavicle and followed for upto 2 years. All the 20 patients were treated by open reduction and internal fixation with precontoured plates and screws. Precontoured S shaped plate was used for middle 1/3 fractures and plate with lateral extension for lateral 1/3 fractures. Final follow up assessed with DASH score, Constant score and Nottingham score.

**Results:** The mean age was  $35.15 \pm 12.67$  years. Majority of our patients were in the age group 15 to 30. Out of all the operated patients 55% were males and 45 % females. 55% had road side accident while 45 % had history of fall from height. Commonest complication was stiffness found in 15 % of the patients followed by delayed union and hardware prominence in 10 %. Complication of infection and non union was seen in 5 % cases each.

Average Constant score at that final follow up was 79.8 with maximum being 93 and minimum being 63.

**Conclusion:** We conclude that operative fixation of shaft clavicle fractures with precontoured clavicular plate is a very good method for treating fractures of the shaft of clavicle. The overall prognosis in our study was very good with excellent improvement of symptoms following the procedure.

**Keywords:** Clavicle, fracture, constant score, plating, pre-contoured

### Introduction

Clavicular fractures are relatively common injuries in the modern society. The clavicle is peculiar of being the only horizontal long bone with a strut like disposition combined with its subcutaneous and superficial location makes it very prone to injury following direct violence<sup>[1]</sup>. Fractures of the clavicle account for 2.6% to 4% of adult fractures and 35% of injuries to the shoulder girdle<sup>[2]</sup>. There is bimodal distribution in incidence of clavicle fractures. The first and largest peak incidence is in males less than thirty years of age. The second, smaller peak of incidence occurs in elderly patients (over eighty years of age), with a slight female predominance<sup>[3]</sup>. The annual incidence of clavicle fractures is estimated to be between 29 and 64 per 100,000 populations per year. Males are affected twice as often as females. Fractures of the shaft account for 69% - 82% of all fractures, lateral-end injuries for 21% to 28% and medial-end injuries for 2% to 3%.<sup>[1-4]</sup> In young adults, these fractures tend to be of the shaft, sustained when a direct force is applied to the point of the shoulder. Although a fall on outstretched hand was traditionally considered as the common mechanism, it has been found that the clavicle most often fails due to direct compression force applied directly to the shoulder. In older patients these fractures tend to be related to osteoporosis, sustained during low-energy domestic falls. Lateral and medial-end fractures are more common in these elderly individuals<sup>[3]</sup>.

A number of classification systems have been proposed to aid in description of clavicle fracture patterns. Allman proposed a classification based solely on the anatomic location and in descending order of fracture incidence and classified these fractures into 3 groups<sup>[5]</sup>.

Type 1 fractures occur within the middle third of the clavicle whereas type 2 and 3 fractures represent involvement of the lateral and medial thirds of the clavicle respectively. Neer further sub classified lateral end fractures of the clavicle into the three types, recognising the importance of the coracoclavicular ligaments for the stability of the medial fragment [5]. The Edinburgh classification proposed by Robinson is more detailed classification system and more widely accepted. Primarily it divides fracture clavicle into three types, type 1 (medial), and type 2 (middle) and type 3 (lateral). Each of these types is further sub classified according to their displacement, articular involvement and degree of comminution [5]. Traditionally, clavicle fractures have been treated non operatively with one of the many options of immobilization; most common being figure of 8 bandage and arm sling. Conservative treatment is recommended as literature reported high rate of good outcome and with low rate of non union following non operative treatment. There is a general agreement that undisplaced fractures or minimally displaced fractures should be treated non operatively but the choice of treatment for these displaced diaphyseal fractures of the clavicle is still widely debated [2, 6-7].

Recent studies have shown significantly higher non-union rates in conservatively treated patients (ranging between 10% and 15%). These studies have also found higher rates of delayed union, non-union, shoulder pain, shoulder weakness and residual pain with non-operative treatment [8]. Outcomes following non operative treatment of displaced clavicle fractures are less favourable than was once perceived, with several studies observing increased rates of non-union and symptomatic malunions. Hence, primary open reduction internal fixation is recommended for these fractures to prevent clavicle shortening or angular deformity that can cause pain and poor functional results. Operative treatment decreases the chances of non-union, have good outcome and good patient satisfaction although there is risk of complication as associated with any surgical procedure [3, 7]. Different modalities have been described in literature for operative fixation of fracture clavicle; each has their advantage and drawbacks. K-wire fixation is not recommended now due to reports of wire breakage and migration to a variety of anatomical location with potentially catastrophic consequences. External fixator has been used to treat these fractures, although the technique is most commonly recommended only for open fractures or septic non union [3, 4, 8]. Intramedullary devices and plating have been used for fixation of clavicle fractures with generally good results. A variety of devices, including Knowles pins, Hagie pins, Rockwood pins, and minimally invasive titanium nails are different intramedullary devices used successfully to treat these fractures. Sigmoid shape and narrow medullary canal of clavicle pose specific problem in insertion of these implants. Irritation at the entry site, pin tract infection and high rate of the implant breakage are other problems. Intramedullary fixation is therefore less widely used than plate fixation for clavicle fractures [1, 3, 5].

Biomechanically, plating technique provides stronger construct than intramedullary fixation. Open reduction internal fixation with plating technique provides rigid stabilization, pain relief and facilitates early mobilization. Different types of plates are available for fixation of the clavicle fractures. Reconstruction plates have fallen into disfavour, since they are susceptible to deformation at the fracture site, leading to malunion. LCDCP and LCP are more rigid and stronger than reconstruction plates but require

extensive contouring hence decrease their strength and increase operative time. These plates remain prominent, may irritate the skin and may need to be removed [3].

Site-specific precontoured locking plates have recently been introduced, with the option of multiple locking screws. These plates are designed to fit the anatomical shape of the normal clavicle, eliminate the need of contouring which decreases surgical time and potentially reduces the risk of the fatigue fracture. Biomechanical studies investigating the impact of torsional and bending load forces on plates support the concept that improved function is achieved when using a locking plate. These plates are strong enough to allow early rehabilitation; the titanium composition of most precontoured plates is thought to diminish stress shielding, as its modulus of elasticity is closer to that of the native bone than traditional stainless steel. They are less prominent after healing leading to lower rates of hardware removal after union [4, 9, 10]. The complications related to the use of plate fixation are infection, plate failure, hypertrophic or dysesthetic scars, implant loosening non-union, refracture after plate removal and very rarely intraoperative injury to sub clavicular structures. But open reduction internal fixation of clavicle fractures with plating technique is standard method to treat these fractures with overall good final results [9, 11, 12].

### Materials and Methods

This study included the clinical and radiological evaluation of results of 20 patients of displaced fractures of shaft clavicle treated with plates and screws. Displaced fracture of shaft clavicle with displacement of more than shaft width, shortening by over 2 cm, threat of skin perforation at the fracture ends and age between 15 and 60 years were included in the study. Pathological fractures and open fractures were excluded. All trauma patients were screened for clavicle fractures and associated injuries. After initial screening and management; patients with suspected clavicle fractures were subjected to x rays of clavicle anteroposterior and 45 degree cephalad views. Closed reduction and clavicular brace were given to all patients with clavicle fractures and check x rays were done. Patient having displaced clavicular fractures fulfilling the inclusion criteria were taken up for surgery. All the 20 patients were treated by open reduction and internal fixation with precontoured plates and screws. Precontoured S shaped plate was used for middle 1/3 fractures and plate with lateral extension for lateral 1/3 fractures. The procedure was done under general anesthesia in a "beach-chair semi sitting" position with a small pad behind the shoulder blade. An incision was given parallel to the inferior border of the clavicle. The skin, platysma and subcutaneous tissue were raised as a single flap. Clavipectoral fascia was dissected along with the platysma muscle. Trapezius was erased posteriorly while pectoralis major anteriorly. Soft tissue dissection was done gently and carefully. After removal of the interposing soft tissue and clearing of the fragment ends, the fracture was anatomically reduced and fixed with adequate length of the 3.5-mm precontoured plate S shaped or lateral end locking clavicular plate. When drilling the screw holes, a drill stopper was used in order to avoid injury to sub clavicular structures. Postoperatively, patients were monitored with respect to vitals, neurovascular status, soakage and any other complications. Check x ray was done on the first post-operative day and primary wound inspection was done on second postoperative day. I.V. antibiotics were continued for 5 days and switched over to oral if wound was healthy. Sutures were removed on the 14<sup>th</sup> postoperative day.

Thereafter patients were reviewed in the outpatient department at 6 weeks interval till last follow up. On final follow up patients were examined clinically for pain, swelling, status of wound, shoulder function, stiffness or any other complications. At the same time x rays were done to assess fracture union, maintenance of reduction and status of implant. Scoring was done as per Constant score, DASH score, and Nottingham score.

## Results

Most of the patients were in the age group of 15-30 years. Youngest patient was 15 years of age and oldest was 55 years of age. The mean age of the patients in the study was 35.15 years. In our study there was male predominance with 55% patients being males in comparison to 45% females. Road side accident was the most common mode of injury in 55% of the patients followed by fall from height in 45% of the patients. None of our patients had sports related injury. Clavicle fractures were on right side in 55% of the patients while in 45% it was on left side. No patient had bilateral fracture. Majority of our patients (85%) had Middle third fracture. Rests of the patients (15%) were Allman type 2 i.e. fractures of the Lateral third of the clavicle. With respect to the Edinburgh classification majority (85%) of the fractures were Type 2b1 i.e. displaced fractures with or without butterfly fragment. While 15 % of the patients had type3b1 i.e. lateral shaft fracture displaced and extra articular. Majority of the patients (80%) were operated within 2 hours operative time, earliest being in 35 minutes and longest being in 4 hours with average being 1.45 hours. Majority of the patients presented to the hospital within first week of injury. Earliest being on the day of injury and latest being one 28th day post injury. Average time for presentation was 9.97 days post injury. Majority of the patients had stay of 5 -10 days. Shortest duration of stay was 4 days and longest 16 days with average of 6.67 days. Wound infection was found in only one of the patients. The infection in that patient was deep infection leading to skin necrosis which later led to the implant exposure. Minimum period taken for union was 3.5 months and maximum period taken was 6.5 months. Majority of the patients (55%) had radiological union between 4 -6 months. Delayed union was seen in 10 % of the cases and Non-union was seen in one of the patients. Mean period for union was 4.85 months. Commonest complication was stiffness found in 15 % of the patients followed by delayed union and hardware prominence in 10% each. Complication of infection and non-union was seen in 5 % cases each (Table 1). Majority of the patients had Nottingham score of 80 -90 at 3 months which improved to greater than 90 at the final follow up. Maximum Nottingham score at the final follow up was 96 and minimum being 82. Average Nottingham score was  $90.5 \pm 3.25$  at final follow up (Table 2). Majority of the patients had DASH score of 11-20 at 3 months which improved to less than 10 at the final follow up. Maximum DASH score at the final follow up was 16 and minimum being 4. Average DASH score was 10.5 at final follow up (Table 3). Most of the patients had <70 constant score at 3 months which improved to 80-90 at final follow up. Mean constant score at 3 months was 64.7 with maximum being 81 and minimum being 56. On final follow up maximum patients (65%) had constant score between 80 & 90. While constant score was between 70 and 80 in 20%, <70% in 20% patients and >90 in 5 % of cases (Table 4). Average constant score at that final follow up was 79.8 with maximum being 93 and minimum being 63. At 3 months all of the patients of lateral

third fractures had score <70 while majority (81.25 %) of the patients of middle third fractures had score <70. Majority of the middle third fractures (77%) had Constant core >80% while 66 % of lateral third had Constant score <80%.

At the final follow up majority of the patients had satisfactory (70%) outcome while 30% had unsatisfactory outcome. Out of satisfactory outcome patients majority (93%) had good score while one of the patients had excellent score. Out of the unsatisfactory outcome patients majority had fair outcome (66%) while rest 33% had poor outcome.

**Table 1:** Complications depicted as percentage.

Complications	No of patients	Percentage
Stiffness	3	15%
Infection	1	5%
Delayed Union	2	10%
Non Union	1	5 %
Hardware Prominence	2	10%

**Table 2:** Nottingham scoring at 3 months and final follow up.

Nottingham score	3months	Final follow up
< 80	3	0
80-90	17	9
>90	0	11

**Table 3:** DASH score at 3 months and final follow up

Dash score	At 3 months	Final follow up
0-10	0	13
11-20	16	7
>21	4	0

**Table 4:** Constant score at 3 months and final follow up

Constant score	3 months	Final follow up
>90	0	1
80-90	1	13
70-80	3	4
<70	16	2

## Discussion

Clavicle fractures are common injuries in young, active individuals, especially those who participate in activities where high-speed falls are frequent, and they account for approximately 2.6% of all fractures. Different modalities have been described in literature for operative fixation of fracture clavicle with their advantage and drawbacks. Despite the relative high prevalence of clavicle fractures, the optimal treatment of displaced clavicle fractures still remains a matter for debate.

**Age:** Clavicle fractures are seen most commonly in young and active population who are involved in outdoor activities. The age of the patients treated in literature vary between 25-46 years. Saha *et al* [1]. Reported 37 cases of fracture clavicle between ages 15-58 with average age 33.03 years. In a study of 108 cases done by Ngarmukos *et al* [13], the average age was 34 years with range of 14-66 years. The patients in our study were between the age of 15-55 years and the mean age was  $35.15 \pm 12.67$  years. Majority of our patients were in the age group 15 to 30. The findings in our study were consistent with literature [1, 13-16]

**Sex:** In literature male distribution varies from 30 % to 88%. Assobhi *et al* [2] in their study of 19 patients had sex distribution of 89 % male to 11% females. While in study by

Wijdicks *et al* [13]. 77% of the patients in plate group were males in the plate group. The male predominance was also observed in our study with 55% of the patients were males and 45 % females. But females were slightly higher in our study as compared to literature [1, 17-19] which was probably because of hilly and tough terrain with difficult geography and rural background where females in this difficult geographic area are more involved in the outdoor activities like collecting firewood, grass for cattle, and other household work, thus having frequent fall from height and trees.

**Mode of injury:** In literature fall from height remains the more common mode of injury with relative incidence varying from 31% to 84 % [2, 20, 21]. 55% of our patients had road side accident while 45 % had history of fall from height. Males were more commonly injured by road side accident while females had fall from height. In our study these were the only two mechanisms of injury and majority of the patients had road side accident which is similar to the observation by Khorami *et al* [20] and Marlow *et al* [2].

**Side:** In study by Widjwicks *et al* [3] there was right side predominance in 54 % of cases. Similarly in study by Khorami *et al* [20] there was right predominance with 53 % fractures on right side. In our study 55 % of the patients had fractures on right side which is just like as reported in literature [3, 20].

**Classification:** Majority of our patient (85%) were middle third fractures while only 15 % were lateral third. All the Lateral third fractures were Neer type 2A. Findings of our study just similar to that reported in the literature.<sup>21,22,23</sup> Majority of the middle third fractures were due to road side accident (58%) while majority of the lateral third fractures were due to fall from height (67%).

**Interval between injury and surgery:** In study by Saha<sup>1</sup> *et al* time interval between injury and surgery in 80 patients varied from 3 to 27 days with average time interval of 12.84 days while in study by Narsaria [10] *et al* time interval varies between 1 -14 days with average of 7.2 days. In our study majority of the patients (45%) was operated within first week of injury. Earliest being on the day of injury and latest being one 28th day post injury. Average time for getting operated post injury was 9.97 days.

**Hospital stay:** In study by Assobhi *et al* [2] the average hospital stay was 2.3 days varying between 1- 4 days and similarly in study by Narsaria *et al* [11] it was 2.8 days. In our study hospital stay varied between 2 to 14 days. Majority of the patients had hospital stay between 5-10 days (45%) while 25% had greater than 10 days stay. Average hospital stay was found to be 7.12 days. It was much longer than what is reported in literature [1, 2, 11]. This is most likely because of protocol of our hospital as we routinely discharge patients after giving intravenous antibiotics for 5 days.

**Associated injuries:** Associated injuries are increasingly common in patients with fractures of the clavicle, compared with the incidence reported in older traditional studies. Patients are victims of high-energy vehicular trauma are more likely to have associated injuries which include chest injury, scapular fractures, proximal humerus fractures or any other injury. In study by Ngarmukos *et al*. [13] there were no associated fractures of the upper limb, but the 5% of patients had fractures of the ipsilateral scapula. In our study 5% patients had associated chest injury, 10% of the patients had associated abdominal injury and lower limb fracture in 5%.

Potentially fatal vascular disruption and brachial plexus lesion are not uncommon, particularly with high energy injuries. In our study no such fatal injuries were seen, but in one of the patient during the surgery small rent was found in one of the patients in subclavian artery due to the sharp spike of the lateral fragment. Cardiothoracic vascular surgeon was called and he applied 2 sutures to close this rent. Post operatively this patient had normal peripheral pulse and capillary refill time.

**Radiological union:** Radiological union was described as obliteration of the fracture lines on both AP and 45 Degree cephalad view. Literature revealed that the union time of surgically treated fractures varies between 3-12 months. Average union time has been reported to be 22.6 weeks, 7.3 months, 12.1 weeks and 8.5 weeks in the studies done by Saha [1] *et al*, Assobhi *et al* [2], Choudhary *et al* [7], Smekal *et al* [29] respectively. Most of the fractures 85% of patients had union by 6 months while mean period for union was 4.85 months which was similar to study by Khorani *et al* [20] where average time was 4.9 months. In our study majority of the patients had radiological union while 1 patient (5%) had non union as the fracture had not united at 8.5 months of follow up.

**Non-union:** Non-union is common after fixation of clavicular fractures and incidence of non-union rates have been reported between 0% to 10.18 % in literature [14, 15, 21, 25, 23, 28]. In our study non-union was there in 5% of cases which was well within the range described in literature.

**Delayed union:** Chen and colleagues [22] reported a rate of 7% for delayed unions and Marlow *et al* [21] showed 6.3 % delayed union rates. In literature rate of delayed union varies between 1.1 to 7%. Delayed union in our study was observed in 2 patients i.e. which is slightly higher than reported in literature.

**Stiffness:** Decreased level of function seems to be the common complication observed after locking plate osteosynthesis [27]. Ngarmukos *et al* [13] had reported frozen shoulder in nearly 8% of the cases. In our study post-operative stiffness was found in 3 patients i.e. 15 % all the patients were improving on follow up.

**Infection:** Infection had traditionally been one of the most feared complications following fixation of displaced clavicular fractures. However, significant improvements have been made in a number of areas that are well recognized to decrease infection, including perioperative antibiotics, better soft tissue handling, two-layer soft tissue closure, and fixation that is superior biomechanically. In literature infection rates among the post-operative patients vary between 0 to 18%.<sup>1,28</sup> In our study infection was found only in 5% of cases which is consistent with what has been described in literature. Smekal *et al et al* [29] reported device protrusion in 20 % of the patients and Bostman *et al* reported symptoms in 2% of the cases [30]. In our study 15% of the patients had implant related irritation while hardware prominence was there in 2 patients i.e. 10%. No patient had numbness or brachial plexus symptoms. In our study complications of numbness or brachial plexus involvement were not found in any of the patients. This was much better as compared to study by Bostman *et al* [30] where brachial plexus symptoms were found in 2 % of the cases.

**Nottingham score:** The Nottingham Clavicle Score is a specific patient reported outcome measure of injuries to the clavicle. In our study patients had Nottingham clavicle score was significantly better in middle 1/3 fracture as compared to lateral 1/3 fractures ( $p < .05$ ). Males had better Nottingham score as compared to females at 6 months ( $p = .023$ ).

**Dash score:** The Disabilities of the Arm, Shoulder and Hand (DASH) scoring system was developed to assess the disability for any patient with any condition affecting the upper limb by covering domains including symptoms, physical function and psychological function. The average DASH score in our study was 9.5 at 6 to 12 month follow up. DASH score varied between 4-20 which was much more as comparison to studies in literature <sup>[11]</sup>. The probable reason being the small follow up of our patients as compared to the studies reported in literature.

**Constant score:** It is one of the first outcome measures developed to assess the shoulder function. It comprises of both clinician assessed physical examination findings and subjective patient reported assessments. In study by Robinson *et al* the average Constant score was found to be 92.0 at the time of the final follow up. Similarly in study by Chen *et al* <sup>[22]</sup> it was found to be 87.1 while Saha *et al* <sup>[1]</sup> reported that average Constant score was 86.33. In literature it varies between 86% to 96% which implies that maximum patient had satisfactory result as per constant score. In our study mean Constant score was  $79.8 \pm 7.31$ . At 3 months majority of the patients (80 %) had poor Constant score while at final follow up majority of the patients 70 % had excellent to good (satisfactory result) score. There were poor scores in 2 of the patients on the last follow up i.e. 10%. The maximum Constant score being 93 and the minimum being 76. This was much lesser in comparison to what is quoted in literature. Short follow up may be responsible for it as most of the patients are still recovering on each follow up visit. Males had a significantly better Constant score in comparison to females ( $p = .008$ ) fact indicating that males had better and early improvement range of movement and better shoulder fixation than the female counterpart. Middle 1/3 fractures had significantly better Constant score at 3 months compared to lateral shaft. ( $p = .004$ ) Patients with road side accident at 6 months had better Constant score as compared to patients with history of fall ( $p = .026$ ).

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 centre. Larger randomized controlled trials are needed to further evaluate outcomes and complications of precontoured plates

### Conclusion

Our study showed that operative fixation of the aforesaid entities with precontoured clavicular plates gave very good patient oriented, surgeon oriented outcomes with very early rehabilitation leading to satisfactory clinical outcome in majority of the patients. There was excellent fracture healing following the use of these plates in the fractures of the shaft of the clavicle. We conclude that operative fixation of shaft clavicle fractures with precontoured clavicular plate is a very good method for treating fractures of the shaft of clavicle. The overall prognosis in our study was very good with excellent improvement of symptoms following the procedure. The use of this implant warranties quicker rehabilitation and return to

normal activities of daily living with better patient satisfaction and clinical outcome.

**Conflict of interest:** none

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