

## Comparative study of reconstruction plates versus non-reconstruction plates (dynamic compression plate and locking compression plate) with respect to complications and functional outcome in operative management of middle third clavicular fractures

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### Abstract

**Introduction:** Clavicle fracture is a common traumatic injury and account for approximately 2.6% of all fractures. The middle-third fractures (80-85%) are most common of all clavicular fractures and were conservatively treated. Several recent multicenter, randomized control studies reported that open reduction and internal fixation (ORIF) had much lower nonunion and malunion rates as well as better shoulder function compared with non-operative treatment there are few precise data on the complications and functional outcome rates of each plate based on different fracture classifications. The current study aims to understand the complications and functional outcome with various plates.

**Material and Methods:** A prospective study was done in 40 patients with mid clavicular fractures type B according to Robinsons classification selected by purposive sampling method, during December 2018 to May 2021 in a tertiary care teaching hospital. After obtaining institutional ethical clearance and informed consent, history was collected, findings on general, systemic and local examination were recorded. Clavicular fixation was done under general anaesthesia using plates (reconstruction plate/dynamic compression plate/locking compression plate) and cortical screws. Follow up done to note complications and functional outcomes with different plates and analyzed statistically by chi-square test with  $P < 0.05$  as significance level.

**Results:** Majority of the patients were in the age group of 19-29 years (20 patients/50%) with mean patient age was 32 years. Majorities were males (32 patients/80%). In 20 patients (50%) reconstruction plates were used. In 10 patients (25%) locking compression plates were used.

In 10 patients (25%) Dynamic compression plates were used. The functional outcome was assessed by Constant and Murley score, 29 patients (67.5%) had excellent functional outcome, good functional outcome in 5 patients (12.5%), fair functional outcome in 6 (15%) patients and poor in 2 patients (5%).

**Conclusions:** Functional outcome was either excellent or good (80%) and complications (45%) were less common in patients managed with non-reconstruction plate compared to reconstruction plate, which was statistically significant.

**Keywords:** Middle third clavicular fractures, operative management, complications, constant and murley score, functional outcome

## Introduction

Clavicle is the bony link from thorax to shoulder girdle and contributes to movements at shoulder girdle. Clavicle fracture is a common traumatic injury around shoulder girdle due to their subcutaneous position. It has been reported that fractures of the clavicle account for approximately 2.6% of all fractures<sup>[1]</sup>. The middle-third fractures are most common and account for approximately 80-85% all clavicular fractures<sup>[2]</sup>. The narrow cross section of the bone in the middle shaft combined with typical muscle forces acting over it predispose to fracture the bone in this locality. Further, Robinson modified Allman classification based on the degree of displacement and comminution<sup>[3]</sup>. Most mid-shaft clavicle fractures generally unite with any method of immobilization. Hence, non-operative treatment was the established and accepted modality of these fractures. This was evident by non-union rates shown by various studies done earlier<sup>[4, 5]</sup>.

Several recent multicenter, randomized control studies reported that open reduction and internal fixation (ORIF) had much lower non-union and malunion rates as well as better shoulder function compared with non-operative treatment<sup>[6, 7, 8]</sup>. Operative management includes intramedullary fixation, internal fixation with plates and screw and external fixation. Though ORIF effectively improves treatment outcomes, complications such as infection, hardware irritation and implant failure diminish both patient satisfaction and functional outcome of the operation<sup>[8]</sup>.

Plates generally used were reconstruction plate, Dynamic compression plate, Low-contact dynamic compression plate, locking Compression Plate and One third semi tubular plate. However, there are few precise data on the complications and functional outcome rates of each plate based on different fracture classifications. The current study aims to understand the complications and functional outcome with various plates like reconstruction plate, low contact dynamic compression plate and locking compression plate.

## Material and Method

A prospective study was done in patients with mid clavicular fractures type B according to Robinson's classification. The study was carried out during December 2018 to May 2021 in a tertiary care teaching hospital. During this period 43 patients of clavicular fractures were treated surgically.

### Inclusion criteria

- Patients within the age group of 16-60 years.
  - No medical contraindication to general anaesthesia.
  - All clavicular fractures threatening to pierce the skin.
  - All middle third displaced clavicular fractures.
  - All fractures with > 20 mm shortening.
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- All compound fractures of the clavicle.
  - All clavicular fractures with non-union.
  - Pathological fractures.

### Exclusion criteria

- An age less than 16 years and more than 60 years.
- Any medical contraindication to surgery (Heart diseases, renal failure or active chemotherapy).
- Associated Head injury.
- Lack of consent.

Patients were selected by purposive sampling method.

Sample size was calculated using formula for finite population. Where,  $Z_{\alpha}$  is the standard normal deviate, 1.96 at 95% confidence interval.

As per study by Stanley *et al.* mid clavicular fractures form almost 80% of all cases attending Orthopaedic OPD [2].

Hence

P = Prevalence is 80%. i.e.  $P = 0.8$ ,  $1-P = (1-0.8)$ .

e = Allowable error was 4% (i.e. 4% of prevalence was considered).

N = Study population (Patients with middle clavicular fractures who attended orthopaedic department in the institution in the previous 2 years) = 43.

$$\text{Sample size}(n) = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \frac{z^2 \times p(1-p)}{e^2 N}}$$

$$\text{Sample size}(n) = \frac{\frac{(1.96)^2 \times 0.8(1-0.8)}{(0.04)^2}}{1 + \frac{(1.96)^2 \times 0.08(1-0.08)}{(0.08)^2 \times 43}}$$

Sample size(n)required is = 39

Sample size rounded up to 40.

After obtaining institutional ethical clearance and informed consent, data was collected on socio-demographic details, mode of injury, site of pain and swelling over the clavicle and past medical illness. General and systemic examination was done.

Local examination was done in the following steps: guarding the injured side (with flexed elbow supported by the other hand), skin abrasion laceration or contusion, tenderness, abnormal mobility, crepitus, restricted movements, neurovascular status on the affected side and associated injuries were noted. Plain radiograph of clavicle with shoulder in anteroposterior view was taken to assess the site of fracture and the fracture type (displacement and comminution). The affected upper limb was immobilized in an arm pouch. Routine investigation like haemoglobin %, total count, differential count, ESR, blood urea, random blood Sugar, serum creatinine, ECG, HbsAg and HIV were done. Patient posted for surgery after stabilization. Preanaesthetic checkup and preparation of parts done and patients were operated under general anesthesia.

### Instruments used for plate fixation

- 3.5mm reconstruction plate, Locking Compression Plate. Dynamic compression plate.
- 2.7 mm drill bit.
- 3.5mm universal drill guide.
- Hand drill/pneumatic drill.
- 3.5mm Tap for cortical screw.
- Depth gauge.
- 3.5mm cortical screw of varying sizes (12-22mm).
- Hexagonal screw driver.
- General instruments like retractor, periosteal elevator, reduction clamps and bone lever.

### Procedure

Patient in supine position surgical site prepared and draped. About 7-9 cms, incision was made in the anterior aspect of clavicle over the fracture site. The skin, subcutaneous tissue, platysma, overlying fascia and periosteum were divided and osseous ends were freed with minimal soft tissue dissection. Fracture fragments were reduced and plate was applied over the superior aspect of the clavicle. After securing neurovascular structures the plate was fixed to the medial and lateral fragment with 3.5mm cortical screw. Wound was closed in layers

after ensuring meticulous haemostasis and sterile dressing was applied.

Post-Operative care included IV fluids, antibiotics, analgesics, tranquilizers and check X-rays. After suture removal patients were discharged with arm pouch. The fracture was considered to be united when clinically there was no tenderness, radiologically the fracture line was not visible and full unprotected function of the limb was possible.

### Follow up

- Regular follow up for every 4 weeks was done till radiological union to assess for tenderness, instability, deformity and shoulder movements.
- Rehabilitation of the affected extremity were done according to the stage of fracture union and time duration from day of surgery.
- The functional outcome were assessed by Constant and Murley score which included subjective measures of pain, daily activities and objective measures on degree of movement<sup>[9]</sup>. Total score result was graded as 90-100 Excellent, 80-89 Good, 70-79 Fair and 0-70 Poor.

Data recorded in a structured questionnaire and entered in Microsoft excel 2007. Statistical analysis was done using SPSS software version 22. Chi-square statistic was used with  $P < 0.05$  as statistically significant.

### Results and Observations

In this present study there were 40 patients of closed middle third clavicle fractures. Majority of the patients with middle third clavicle fracture (20 patients/50%) were in the age group of 19-29 years. The youngest patient was 19 years and oldest patient was 55 years. The mean patient age was 32 years. Majorities were male, 32 patients (80%) and females were 8 patients (20%). (Table 1)

**Table 1:** Distribution of patients by age and gender

| Characteristics of patient | Group       | Frequency of middle third clavicle fractures | Percentage |
|----------------------------|-------------|--|------------|
| Age                        | 19-29 years | 20   | 50 %       |
|                            | 30-39 years | 12   | 30 %       |
|                            | 40-49 years | 2  | 5 %        |
|                            | 50-59 years | 6  | 15%        |
| Gender                     | Male        | 32   | 80%        |
|                            | Female      | 8  | 20%        |

**Table 2:** Distribution of patients by Characteristics of injury

| Characteristics of injury | Group                                | Frequency of middle third clavicle fractures | Percentage |
|---------------------------|--------------------------------------|--|------------|
| Mode of injury            | Fall on shoulder from two wheeler    | 12   | 30%        |
|                           | Road traffic accident                | 12   | 30%        |
|                           | Simple fall on shoulder              | 8  | 20%        |
|                           | Run over by a bullock cart           | 2  | 5%         |
|                           | Fall on outstretched hand (Indirect) | 6  | 15%        |
| Side affected             | Right                                | 16   | 40%        |
|                           | Left                                 | 24   | 60%        |
| Associated injuries       | Scapular body fracture               | 2  | 5%         |
|                           | Bimalleolar fracture                 | 2  | 5%         |
|                           | None                                 | 36   | 90%        |
| Robinsons classification  | Type -2 middle third B1              | 32   | 80%        |
|                           | Type -2 middle third B2              | 8  | 20%        |
| Time interval for surgery | < 7 days                             | 28   | 70%        |
|                           | 7-14 days                            | 12   | 30%        |

Out of the Middle third clavicle fractures that occurred 12 patients (30%) were due to fall on shoulder from two wheeler, 12 patients (30%) were due to road traffic accident, 8 patients (20%) were due to fall on the shoulder after slipping and in 2 patient (5%) it was due to run over by a bullock cart directly over the clavicle. Indirect injury occurred in 6 patients (15%) due to fall on outstretched hand. (Table 2)

Out of 40 patients 24 patients (60%) had left sided clavicle fracture and 16 patients (40%) had right sided fracture. In middle third clavicle fracture 4 patients (10%) had associated injuries among them 2 patient (5%) had scapular body fracture and 2 patient (5%) had bimalleolar fracture. All the Patients were immobilized in an arm pouch. There were no associated medical illnesses in any patient. (Table 2)

In type-2 middle third fracture type-2 B1 (displaced with simple or single butterfly fragment) occurred in 32 patients (80%) and type-2 B2 (displaced with comminuted or segmental) fracture occurred in 8 patients (20%). Out of 40 patients, 28 (70%) were operated in the first week and 12 patients (30%) were operated in the second week due to fixed OT days. (Table 2).

**Table 3:** Distribution of patients by intra operative and post-operative conditions

| Intraoperative and post-operative conditions |       | Group                     | Frequency of middle third clavicle fractures | Percentage |
|--|-------|---------------------------|--|------------|
| Type of plate                                |       | Reconstruction plate      | 20   | 50%        |
|  |       | Locking Compression Plate | 10   | 25%        |
|  |       | Dynamic compression plate | 8 + 2*                                       | 25%        |
| Duration of union                            |       | 8-12 weeks                | 36   | 95%        |
|  |       | >12 weeks                 | 4  | 5%         |
| Type of complication                         | Minor | Hypertrophic scar         | 8  | 20%        |
|  |       | Plate prominence          | 6  | 15%        |
|  |       | Delayed Union             | 4  | 10%        |
|  |       | Plate Loosening           | 2  | 5%         |
|  | Major | Plate Breakage            | 2  | 5%         |
| Functional outcome                           |       | Excellent                 | 29   | 67.5%      |
|  |       | Good                      | 5  | 12.5%      |
|  |       | Fair                      | 6  | 15%        |
|  |       | Poor                      | 2  | 5%         |

Fractures were fixed with plate and cortical screws. In 20 patients (50%) reconstruction plates were used. In 10 patients (25%) locking compression plates were used. In 10 patients (25%) Dynamic compression plates were used. (Table 3)

Of the study patients 36 patients (90%) united at the end of 12 weeks. In 4 patients (20%) delayed union occurred. In 2 patients it was due to large butterfly fragment at fracture site which united at 16 weeks and another 2 patients it was due to plate breakage which went on to unite after replating at 20 weeks. (Table 3)

In middle third clavicle fixation 8 patients (20%) had hypertrophic skin scar and in 6 patients (15%) plate prominence occurred. In 4 patients (10%) delayed union occurred. In 2 patient (5%) plate loosening occurred which went for malunion and in 2 patient (5%) plate breakage occurred. (Table 3)

The functional outcome was assessed by Constant and Murley score, 29 patients (67.5%) had excellent functional outcome, good functional outcome in 5 patients (12.5%), fair functional outcome in 6 (15%) patients and poor in 2 patients (5%). Patients were advised for removal of the plate at the end of 1 year. No patient has turned up for implant removal. So Implant removal was not done in any patient till the end of this study. (Table 3)

**Table 4:** Type of plate used versus fracture type and length of plate (by no. Of holes)

|  | Reconstruction Plate | Locking compression Plate | Dynamic compression plate | Total    |
|--|----------------------|---------------------------|---------------------------|----------|
| <b>Type of fracture</b>                    |                      |                           |                           |          |
| Robinson type II B1                        | 20                   | 6                         | 6                         | 32 (80%) |
| Robinson type II B2                        | 1                    | 3                         | 4                         | 8 (20%)  |
| <b>Length of plates by number of holes</b> |                      |                           |                           |          |
| 6 Holes length                             | 12                   | 4                         | 4                         | 20 (50%) |
| 7 holes length                             | 6                    | 2                         | 2                         | 10 (25%) |
| 8 holes length                             | 8                    | -                         | 2                         | 10 (25%) |

\*For one broken reconstruction plate 8 hole dynamic compression plate was used during re-plating.

The plates were intra-operatively bent to the contour and curvature of the clavicle. The length of the plate to be used was determined according to the extent of comminution at the fracture. The aim was to place at least three screws in the medial and lateral main fragments through both cortices of the bone. In 4 patients (10%) 7 hole reconstruction plates were used. In 4 patients (10%) 8 hole reconstruction plates were used and in another 12 patients (30%) 6 hole reconstruction plates were used. In 2 patient (5%) 7 hole Locking Compression plates were used. In 8 patients (20%) 6 hole dynamic compression plates were used. The size of cortical screws used was in the range of 12 to 20 mm. (Table 4)

**Table 5:** Relationship by type of fracture, complications and Functional outcome of Reconstruction plates versus Non reconstruction plates

|                    |                     | Reconstruction Plates (21) | Non Reconstruction Plates (LCP, DCP) 19 | Total   | chi-Square Statistic/P Value |
|--------------------|---------------------|----------------------------|---|---------|------------------------------|
| Type of fracture   | Robinson type II B1 | 20 (62.5%)                 | 12 (37.5%)                              | 32(80%) | 6.416/0.011309               |
|                    | Robinson type II B2 | 1(12.5%)                   | 7(87.5%)                                | 8(20%)  |                              |
| Complications      | Present             | 18(81.9%)                  | 4 (19.1%)                               | 22(55%) | 16.8512/0.00004              |
|                    | Absent              | 3(16.7%)                   | 15(83.3%)                               | 18(45%) |                              |
| Functional outcome | Excellent and Good  | 14(43.75%)                 | 18(56.25%)                              | 32(80%) | 4.9123/0.026666              |
|                    | Fair and poor       | 7(8.75%)                   | 1(1.25%)                                | 8(20%)  |                              |

Reconstruction plate was most commonly used in Robinson type B I where as non-reconstruction plates (LCP and DCP) in Type BII fractures which was statistically significant. Functional outcome was either excellent or good (80%) and complications (45%) were less common in patients managed with non-reconstruction plate compared to reconstruction plate, which was statistically significant. (Table 5)

## Discussion

Clavicle fractures are usually treated conservatively. In a study conducted to analyze the results of conservative treatment by Hill *et al.* in 1997 Nordqvist *et al.* in 1998 Robinson *et al.* in 2004 found poor results following conservative treatment of displaced middle third clavicle fracture [10, 11, 12]. Comparative study by Naveen *et al.* concluded that anatomic reduction with plate fixation and early mobilization of displaced clavicle fractures, especially in young active adults provide good outcomes and less complications [13]. So there are specific indication like displacement, with or without comminuted middle third clavicle fracture (Robinson Type- 2B1, 2B2) for which operative treatment is needed.

In the present study Middle third clavicle fracture commonly occurred between the age group of 19 to 29 years in 10 patients (50%). The youngest patient age was 19 years and oldest patient age was 55 years. The average patient's age was 32 years. In Bostman *et al.* study

patients average age was 33.4 years and the youngest patient age was 19 years and oldest patient age was 62 years<sup>[14]</sup>. In study by Naveen *et al.*, there were 148 males (66%) and 78 females (35%) with a mean age at operation of 43.5 years (13 to 87)<sup>[13]</sup>.

In this study 4 patients (10%/5% had scapular fracture and another 5% had bimalleolar fracture) with middle third clavicle fracture had associated injuries. These Patients were treated conservatively which was low compared to study by Naveen *et al.*, where 14 patients (23.3%) had associated injuries<sup>[13]</sup>. In this present study 80% of patients were with Robinson Type-2 B1 (Displaced with simple or butterfly fragment) and 20% were Type-2 B2 (displaced with comminution). In Bostman *et al.* study also Robinson type-2B1 was common in 81 patients (78.64%). Robinson type-2 B2 occurred only in 22 patients (21.36%)<sup>[14]</sup>.

In this study majority of the middle third clavicle fracture cases united between 8 to 12 weeks i.e. 18 patients (90%). In study by Naveen *et al.*, The average duration required for union was 9.27 weeks in operative group<sup>[13]</sup>.

In the current study out of 40 patients, reconstruction plate was used in 21 patients, Locking compression plate in 9 and dynamic compression plate in 10 patients. In study by Naveen *et al.*, One hundred fifty-nine patients were treated with reconstruction plates and 67 patients were treated with non-reconstruction plates. Among the 67 patients, 19 were treated with locking reconstruction plates, 20 with DCPs and 28 with pre-contoured LCPs<sup>[13]</sup>.

In the present study for 2 (5%) broken reconstruction plate 8 hole dynamic compression plate was used during re-plating which was slightly higher when compared to study by Yung-Cheng Chiu *et al.* Eight (2.6%) of the patients who received revision surgeries with non-reconstruction plate fixation<sup>[15]</sup>.

In study by Yung-Cheng Chiu *et al.* In AO/OTA 15-2A and 15-2B fractures, there was no significant difference in implant failure rates between reconstruction plates and non-reconstruction plate. This finding suggests that the strength of reconstruction plates may be sufficient for non-comminuted fractures, which can be relatively easily fixed by anatomic reduction. In comminuted (AO/OTA15-2C) fractures, the strength of the plate is the most important factor for fracture stability, especially when anatomic reduction is hard to achieve<sup>[15]</sup>. Cho and his colleagues compared the complication rates between reconstruction plate and non-reconstruction plate for the treatment of midshaft clavicular fracture and found no significant difference between the two types of implants<sup>[16]</sup>.

In the current study functional outcome was either excellent or good (80%) and complications (45%) were less common in patients managed with non-reconstruction plate compared to

reconstruction plate, which was statistically significant. The advantage of rigid internal fixation and early mobilization of fresh displaced clavicle fracture is that it gives immediate pain relief and prevents the development of shoulder stiffness and non-union.



**Fig 1:** Fixation of dynamic compression plate



**Fig 2:** Fixation of reconstruction plate

## Conclusions

In this study primary open reduction and internal fixation with plate and screws of fresh middle third clavicle fractures provides a more rigid fixation and does not require immobilization for longer periods. Reconstruction plate was most commonly used in Robinson type B I where as non-reconstruction plates (LCP and DCP) in Type BII fractures Reconstruction plates were used as it can be contoured to the shape of the clavicle. Two reconstruction plate breakage occurred due to the non-compliance with the post-operative protocol. Dynamic compression plate is strong and precontoured gives better stability in comminuted and three part fractures. All the fractures united and there was no nonunion. Functional outcome was better and complications were less common in patients managed with non-reconstruction plate compared to reconstruction plate, which was statistically significant.

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