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Study of operated fracture mid shaft clavicle

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Abstract
Introduction: It is the study of mid shaft clavicle fracture treated with anatomical locking plates. We wanted to study to study the surgical management and to assess its functional outcome in displaced mid-shaft clavicular fractures. To study the duration of union, complications and compare the results of operated cases with other operative study and conservative study.
Materials and Method: The study consist of 100 patients with mid shaft clavicle fracture. We have treated patient with anatomical locking plates. Clinical outcome and function results were evaluated by Constant and Murley scoring system.
Result: We have operated total 100 cases with anatomical plate in mid-shaft clavicle fractures. Average union time was 11.7 week. We have achieved 80% of excellent result.
Conclusion: Anatomical plate for mid-shaft clavicle fracture are as per shape of the bone. Anatomical reduction is possible and axial alignment and rotational stability is provided. As plates have groove on inner surface so it preserves the periosteal blood supply which will help in faster healing of the bone. Rigid fixation with plate and screws for fresh displaced or comminuted middle third clavicle fracture gives immediate pain relief and prevents the development of shoulder stiffness and non union.

Keywords: Operated fracture, axial alignment, shoulder stiffness

Introduction
Clavicle links the thorax and shoulder girdle and plays important part in movements at shoulder girdle. Clavicle fracture is a common traumatic injury due to its superficial position. It is caused by low velocity or high velocity impact clavicle fracture is about 5-10% of all fractures and 44% of injuries to the shoulder girdle. About 70%to 80% of these fractures are in the mid-shaft of and less in the lateral third (12% -15%) and medial third (5% -8%).
A weak area in the clavicle is present at the mid clavicular region, which causes for most fractures occurring in this region. Several muscular and ligamentous forces act on the clavicle, and familiarity of these various forces is essential to know the displacements of clavicle fractures and why some of the fracture patterns lead to cause problems if not reduced and surgically stabilized. Embryologically clavicle develops from 2 ossification centers separately and then unites so the junction is weakest point. Anatomically it has two curves which make the bone vulnerable for fracture at its middle. Distribution of ligament attachment as well as muscular attachment is as such that medial portion is less mobile than lateral which common to fracture from middle.
"The incidence of mid clavicular fracture is 64 per 100 000 population. Breaks of the shaft form 70% to 80% of all clavicular fractures; lateral fractures contribute 15% to 30%, and medial fractures, at 3%, are rare. Open fracture is an absolute rarity, found in only 0.1% to 1% of cases. The rate of mid clavicular fractures is more than twice as high in men as in women. The peak incidence occurs in the third decade of life. Mid shaft fractures have traditionally been treated non-operatively. Surgical treatment of acute mid shaft fractures was not favoured due to relatively frequent and serious complications. However, the prevalence of non-union or mal-union in dislocated mid shaft clavicular fractures after conservative treatment is higher than previously presumed and fixation methods have evolved. Surgical fixation is accepted as primary treatment for mid shaft clavicular fractures, because results of non-operative treatment are not better than operative treatment clinically and functionally. Also persistent displacement of fragments with soft tissue apposition may cause failure of closed reduction.

There is 15% nonunion rate in displaced fractures of middle-third of the clavicle treated without surgery."
The rate of non-union of mid-shaft clavicle fractures is graded from 0.1 to 0.8%, and the main treatment has been non operative. These data are based on studies in which fractures were not appropriately classified according to age and displacement of fracture. Recent data, centered on thorough classification of fractures, suggest that the incidence of nonunion in displaced comminuted mid shaft clavicular fractures in adults is between 10 and 15%.
After arrival of Anatomical plate, fixation of clavicle fracture incidence are increased because of plate having double contour as well as proper tensity of plate according to the shape of the bone. That is why automatically it reduces the fracture well and achieving compression by nearby 2-screws simple cortical and other are lockable. The main aim of early fixation of clavicular fractures to prevent complications like malunion and non-union emphasize the importance of accurate reduction and rigid fixation and achieving early pain relief and functional recovery.
The purpose of our study is to achieve experience with the surgical treatment of displaced, comminution clavicle fracture with anatomical plate with screw fixation.

Materials & Method
The present study includes 100 cases of mid shaft clavicle fracture in adults admitted in Dhiraj General Hospital attached to Dhiraj Hospital, Sumandeep Vidyapeeth Medical College, Piparia, Baroda between March 2015 to August 2017.

Inclusion criteria
1. Age >18 yrs.
2. Closed mid shaft clavicle fractures
3. No medical contradictions to general anesthesia.

Exclusion criteria
1. Age < 18 yrs.
2. Lateral third, Medial third and open fractures of clavicle.
3. Pathological fractures
4. Undisplaced fractures
5. Fractures associated with head injury.
6. Fractures associated with neuro-vascular injury
7. Fractures associated with acromio-clavicular joint dislocation.

Collection of data for patients presenting with fracture mid shaft clavicle are as follows
- History
- Clinical examination
- Radiological examination
- Baseline investigations
- Fracture anatomy assessed with X-rays.
- Diagnosis – Clinical and Radiological.
- Informed written consent will be taken for Surgical procedure.
- Surgery – Open reduction and Internal fixation.
- Post Operative treatment:
- Routine antibiotic and analgesic.
- Evaluation by X-rays

➢ **Complications**
- Preoperative
- Intraoperative
- Immediate
- Late

➢ **Follow up**
Assessment at 1 month
- Clinical assessment of pain and stiffness
- Radiological assessment
- Assessment at 3 month
- Assessment of Radiological and clinical union.
- Assessment at 6 months
- Assessment of Radiological and clinical union and functional ability of shoulder
- Assessment of any complications
- Assessment of function using constant and murley score.

Operative Treatment
The chief goal in this method of treatment is to achieve a healed clavicular strut in an normal anatomical position as possible. The healed clavicular bone in good position provides stability to the shoulder girdle. It may be by any of these methods:

The anatomical plate with its lower profile and its pre contoured shape in two planes to fit the S-shaped clavicle more easily and achieving compression by nearby 2-screws simple cortical and other are lockable so, it is the preferred implant.

The anatomical plate

Procedure
- Patient in supine position with one towel in between the scapula. Entire upper limb from base of neck to hand were prepared and draped.
- About 7-9 cms, incision was made in the anterior aspect centering of clavicle over the fracture site.
- The skin subcutaneous tissue and platysma were divided without undermining the edges.
- The overlying fascia and periosteum were next divided. The osseous ends were freed from surrounding tissue
- Minimal soft tissue and periosteum dissection was done.
- Fracture fragments were reduced and plate was applied over the superior aspect of the clavicle.
- At the level of the medial and middle third junction of the clavicle, the inferior surface is exposed so that a protective instrument can be inserted during drilling to prevent injury to neurovascular structure and lung underneath it.
- The anatomical plate was applied to the medial and lateral fragment with locking screws/ cortical screws and at least three screws in medial and lateral fragment were applied.
- Wound was closed in layers after ensuring meticulous hemostasis and sterile dressing was applied.

Operative Photographs

Post-Operative care

- Patients were kept nil orally for 4 to 6 hours post-operatively.
- Intravenous fluids were given as needed.
- Antibiotics were continued for 12 days.
- Analgesics and tranquilizers were given according to the needs of the patient.
- The operated upper limb was immobilized in an arm pouch.
- Check X- rays were taken to study the alignment of fracture fragments.
- The wound was inspected at 3rd postoperative day.
- Suture/staple removal was done on 12th postoperative day.
- Patients were discharged with the arm pouch.

Rehabilitation

- Rehabilitation of the affected arm was started at the end of 2 weeks. Gentle pendulum exercises to the shoulder in the arm pouch were allowed.
- At 4 to 6 weeks gentle active range of motion of the shoulder was allowed but abduction in limited to 80 degrees.
- At 6 to 8 weeks active range of motion in all planes were allowed.

Follow up

- Regular follow up for every 4 weeks was done.
- Local examination of the affected clavicle for tenderness, instability deformity and shoulder movements were assessed.
- X-rays were taken at each follow up visits to known about progressive fracture union and implant position.
- Rehabilitation of the affected extremity were done according to the stage of fracture union and time duration from day of surgery.
- Patients were followed up till radiological union.
- The functional outcome were assessed by Constant and Murley score

Grading of Results
Constant and Murley Scoring
Category
A) Subjective: 35 points
1) Pain - 15 Points
• No pain - 15
• Bearable pain - 10
• Disabling pain – 5

2) Activities of daily living: - 10 Points
• Ability to perform full work - 10
• Ability to perform Leisure activities/ Sports - 06
• Unaffected sleep - 04

3) Level at which work can be done: 10 points
• Up to Waist - 02
• Up to Xyphoid - 04
• Up to Neck - 06
• Up to Head - 08
• Above head – 10

B) Objective: 65 points
a) Range of motion: 40 points
• Full -40
• Full but painful - 25
• Restricted - 15

b) Strength of abduction: 25 Points
• Full: 25
• Partial: 15
• Weak: 05

A normal shoulder in a 25 year old man resists 25 pounds without difficulty. The score given for normal power is 25 points, with proportionately less for less power.
Patients were graded as below with a maximum of 100 points.

Total Score	**Result**
90-100	Excellent
80-89	Good
70-79	Fair
0-70	Poor

Observations and Results
The present study consists of 100 patients of mid shaft clavicle fracture treated by open reduction and internal fixation with Anatomical locking plates at Dhiraj General Hospital and S.B.K.S.M.I.R.C. between March 2015 to august 2017. The following were the observations made and the data are analyzed as follows.

Table 1: Age Distribution

Age	No. of Patients	Percentage
20-29	46	46%
30-39	34	34%
40-49	6	6%
50-59	8	8%
60-69	6	6%
Total	100	100%

Table 2: Sex Distribution

Sex	No. of Patients	Percentage
Male	88	88%
Female	12	12%
Total	100	100%

Table 3: Mode of Injury

Mode of Injury	No. of Patients	Percentage
Road traffic accident	74	74%
Fall on outstretched Hand	20	20%
Direct trauma	06	06%
Total	100	100%

Table 4: Duration of Union

Duration	No. of Patients	Percentage
8-12 weeks	94	94%
More than 12 weeks	06	6%
Total	100	100%

Table 5: Complications

Complication	No. of Patients	Percentage
Infection	6	6%
Implant loosening	2	2%
Implant prominence	2	2%
Delayed union	6	6%
Total	16	16%

Table 6: Final Results

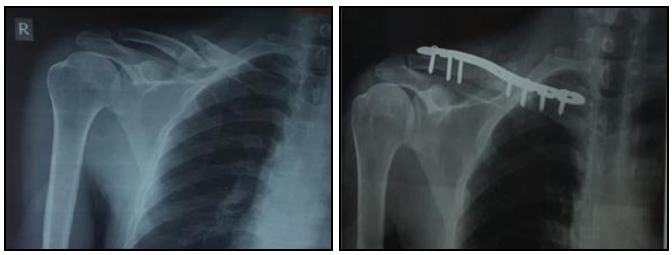
Result	No. of patients	Percentage
Excellent	80	80%
Good	12	12%
Fair	6	6%
Poor	2	2%
Total	100	100%

Table 7: Comparison of final result with other operative study of midshaft clavicle fracture.

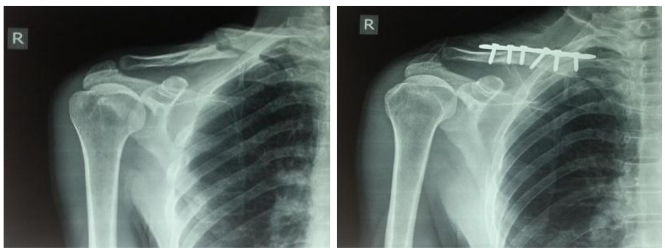
Study	Total cases	Excellent	Good	Fair	Poor
Reddy *et al*.	30	63.3% (19)	36.7% (11)	0	0
Cho *et al*.	41	75.6% (31)	17.07% (7)	4.87% (2)	2.43% (1)
Our study	100	80% (80)	12% (12)	6% (6)	2% (2)

Table 8: Comparison of final result with other conservative study of mid-shaft clavicle fracture.

Study	Total cases	Excellent	Good	Fair	Poor
Shukla *et al*	25	0	68% (17)	20% (5)	12% (3)
Giorgi *et al*	59	16.94% (10)	61.01% (36)	15.25% (9)	6.77% (4)
Our study	100	80% (80)	12% (12)	6%(6)	2% (2)



Case 1: (Full union)



Case 2: (Full union)

Case 3: Complication Case Implant Loosening

Discussion

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* 12 in 1997 [12], Nordqvist *et al* in 1998 and Robinson *et al* 41 in 2004 found poor results following conservative treatment of displaced middle third clavicle fracture.

Plates such as Sherman plates, dynamic compression plates, and semi-tubular plates can be effective in achieving anatomical reduction, applying direct compression to the fracture site, and producing resistance to torque. It is very difficult to hold the plates to clavicle in severely comminuted cases.

In contrast, reconstruction plates can be manipulated to fit the shape of the clavicle as desired to obtain firm fixation. With these plates penetration of the opposite cortex may cause damage to the subclavian artery and brachial plexus. In our study, anatomical locking plates were used in treatment of clavicle mid-shaft fractures.

In our study of 100 patients of mid-shaft clavicle fractures were treated with anatomical lock plates. Our experience with these methods of fixation has given favourable results.

Our study of patients with middle third clavicle fractures is compared with following study.

1. Bostman *et al* study in which treated only middle third clavicle fractures, in this totally 103 patients were treated by open reduction and internal fixation with plate and

screws.
2. Cho *et al* study in which 41 patients with a clavicle mid-shaft fracture were treated by internal fixation.
3. Reddy *et al* study in which 30 patients were treated with anatomical locking plate.

The findings, the end results and various other data have been analyzed and compared in the following discussion.

In our study fractures were commoner in 2nd and 3rd decade with average age being 32.52 years. Bostman *et al* study patients average age was 33.4 years. Cho *et al* study average age was 45 years & Reddy *et al* average age was 33.8 years. From this we can infer that clavicle mid-shaft fractures occur in young and active patients.

In our study there were 88 male patients (88%) and 12 female patients (12%). In Bostman *et al* series also commonly males are affected which were 76 Patients (73.79%) and females 27 Patients (26.21%). In Cho *et al* series also commonly males are affected which were 29 male (70.73%) compared to female 12 Patients (29.27%) & Reddy *et al*. series also commonly males are affected which were 17 male (56.66%) compared to female 13 Patients (43.34%). Male predominance can be drawn from this inference.

In our study, 74 patients (74%) were due to road traffic accident, 20 patients (20%) were due to fall on outstretched hand, 6 patients (6%) were due to direct trauma. Reddy *et al* 37 study all patients were males, 17 patients (56.66%) were road traffic accident and 13 patients (43.34%) were due to fall on out stretched hand, because of increased incidence of road traffic accident for transportation is very much increased in short time in our country and relatively the expansion of highway security is not improved in relation with it. so that is why incidence of road traffic accident is very high in our country. In present study compared to other studies, clavicle mid-shaft fractures is more common in road traffic accident and fall on outstretched hand was also another common mode of injury.

We had 52 patient (52%) incidence of fractures in right side and 48 patients (48%) of the fracture in left side. As usual right handed people are very common and dominant extremity is likely to get injury more common. In our study even though there is no much difference but 4% cases are more on right side than left side. As in our study more of the cases were due to road traffic accident, so rule of injury to dominant extremity was not applicable in these cases.

In this study all the patients were followed up regularly at 1 month, 3 month and 6 month. Average duration of follow up of this study was 12.34 months with minimum follow up of 7 month and maximum follow up was 18 month (case no.1). In Cho *et al*. 20 study average duration was 13.6 months among which minimum duration is of 7 month and maximum is 35 months.

In our study middle third clavicle fracture 94 patients (94%) united by the end of 12 weeks. In 6 patients (6%) delayed union occurred. In 4 patients it was because of large butterfly fragment at fracture site which united at between 14 to 16 weeks. 2 patients had superficial infection which was treated with debridement and fracture was united at 20 weeks. Average duration of radiological union is 11.7 weeks (almost 12 weeks). So this study is comparable to other studies like,

- In Reddy *et al* majority of the cases are united by the end of 10 weeks (86.6%) and between 10 – 12 weeks (13.4%).average duration of radiological union was 10.6 weeks.
- In Cho *et al* study, average duration of union was 12.7 weeks.
- In Shukla *et al* study in which fracture clavicle were treated conservatively had duration of union is more than 20 weeks in all the cases with average radiological union rate is 23.4weeks.
- In Altamimi *et al* study non-operative treatment with a sling (65 patients), the mean time to radiographic union was 28.4 weeks.

After studying overall scenario of operative treatment for clavicle which was compared with conservative management as well as with other studies of operative management, our result is 80% excellent (80pt.) as they had timely union with good range of movement. Only 2 patients had poor result which had delayed union (20 weeks) because of comminution with infection.

After invention of anatomical locking plate for clavicle it has changed the scenario of fracture fixation which is giving excellent result as far as shoulder function is concerned and cosmetic look remains undisturbed. Using of anatomical plate alignment of fracture union was in the anatomical position as well as faster rate of union. The advantages of these plates is strong fixation due to locking between the screw and plate, and blood supply preservation due to less contact between plate and cortical bone. Surgery time can be reduced using this plate because plate is pre-contoured as per shape of clavicle and periosteal stripping could be minimized.

Complications

In our study 6 patients had infection, out of which 4 patients had superficial infection which were treated with change of antibiotics according to pus culture sensitivity and regular dressing. & two patients with pus discharging sinus which was treated with debridement and sinus excision. Delayed union was occurred in this patient.

In our study 2 patients had complication of pull out of most lateral screw at the end of 6 weeks postoperatively. The cause in this patient was because of non-compliance with the post-operative protocol. The patient went for farming in the field before the fracture union. With further advice of not to lift heavy weights in the affected limb clavicle fracture and strapping with adhesive bandage it went to unite at the end of 12 weeks and no re-surgery was performed for this.

In Bostman *et al* study 7 patients (6.80%) had implant loosening. Technical errors of fracture fixation and early lifting of weights were the main reason. No re-surgery were performed.

In our study 2 patients had complain of implant prominence. We adviced this patient for removal of plate as the fracture was united but he refused at that time. In all cases we had put the plate over the superior surface, so the direction of the screws is superior to inferior which is naked eye visible so chances of complication like lung apical injury can be avoided.

To avoid such complication, plate can be applied to inferior surface of clavicle but it is more challenging and superior plating was biomechanically better than inferior plating because the superior surface of the clavicle was the loadbearing side.

Using of low profile implant and proper coverage of implant with overlying platysma muscle while suturing the wound can avoid problem of subcutaneous impingement by prominent implant.

In our study 6 patients had delayed union out of which 2 patients had delayed union because of infection which was

treated with surgical debridement and fracture was united at the end of 20 weeks. While 4 patients had delayed union due to a large butterfly fragment in the inferior portion of clavicle which went on to unite with the main fragments at the end of 14 to 16 weeks. None of the patient required bone grafting.

Likely causes for delayed union in clavicle fixation are post-operative infection, severe comminution at fracture site, implant failure, excessive periosteal stripping and soft tissue interposition between fractured fragments. One can avoid such problems by taking aseptic precautions during surgery, sufficient knowledge of fracture fixation and implant, usage of interfrgmnetary screw for large butterfly fragments or encircelage wire to hold the small fragments. The tension surface of clavicle is superior surface, therefore, a plate applied to the superior surface can act as a tension band, which allows compression across the fracture. Avoid excessive periosteal stripping which can hamper the blood supply to the healing fragments and removal of soft tissue interposition between the fractured fragments fractured ends as they can lead to failure of union.

Functional outcome

In our study functional outcome based upon constant& murley score. In the subjective scoring pain, activities of daily living and level at which work can done is included. In assessment of pain, 86% (86pt.) had no pain and 14% (14 pt.) had bearable pain. In assessment of daily activities 78% (78 pt.) patients can perform full work, 16% (16 pt.) patients can perform leisure activities and 6% (6pt.) Cannot perform daily activities with unaffected sleep. In assessment of level of work done 80% (80pt.) patients can do work above the head, 14% (14pt.) patients can able to do work up to the level of neck, 4% (4 pt.) Patients can able to do work up the level of neck and 2% (2pt.) Patients can do work up to the level of xyphiod. In the objective scoreing range of motion and strength of abduction is included. In assessment of range of motion, 90% (90pt.) Patients had full range of motion without pain, 8% (4pt.) Patients had full range of motion with pain and 2% (2pt.) Patients had restricted range of motion. In assessment of strength of abduction, 88% (88 pt.) Patients had full strength of abduction and 12% (12pt.) Patients had partial weakness of abduction strength.

The final result according to the Constant Murley scoring of our study is Excellent in 80 patients (80%), Good in 12 patients (12%), Fair in 6 patients (6%), Poor in 2 patients (2%). So our results were satisfactory in 92 cases (92%) and unsatisfactory in 8 cases (8%). In Reddy *et al*. the results were satisfactory in all 30 cases (100%). In the operative study of Cho *et al*. the results were satisfactory in 38 cases (92.67%) and unsatisfactory in 4 cases (7.33%). In the conservative study of Shukla *et al* the results were satisfactory in 17 patients (68%) and unsatisfactory in fair in 8 patients (32%). In the conservative study of Giorgi *et al* the results were, satisfactory in 46 cases (77.95%) and unsatisfactory in 10 cases (22.05%). Conventionally, it was believed that clavicle is giving excellent result with conservative treatment. It has been found out from various study like Hill *et al* 12, Nordigvist *et al* 40, Robinson *et al* 8 that in displaced fractured it gives satisfactory result in fewer number of patients and it takes much longer time average 20 weeks to that in operatively treated cases in which average duration was 12 weeks. More of cases of conservative series complained of unsightly appearance in mal-united fractures, as well as persistent pain because of projecting bone spike beneath the skin.

In older days proper implant for internal fixation were not available and at that time the cosmetic look, range of motion and overhead loading were not considered much but as evolution of implant occur people have realised the cosmetic look, good and early functional range of motion and overhead loading are the main criteria to decide for the conclusion of excellent result and criteria for arriving the result facing clavicle fracture are also improved along with the improvement of implant for fixation of clavicle fracture. Evolution of plates occurring and invention of newer designed anatomical locking plates have been available so fixation of clavicle was much improved. Here in our study, it is our observation that proper fixation with proper implant is giving excellent result because we have used anatomical locking plates in combination with simple cortical and locking cortical screw.

The advantage of rigid internal fixation and early mobilization of displaced mid-shaft clavicle fracture is that it (displaced comminution middle third) gives immediate pain relief and prevents shoulder stiffness and non-union.

Conclusion and Summery

- 100 patients with mid-shaft clavicle fractures were treated surgically with anatomical locking plate and screws.
- Patients above 18 years were included in this study with male predominance. Road traffic accidents was the cause for this fracture in most of the patients.
- All our patients were operated with anatomical with locking plate and screws for middle third clavicular fractures.
- The duration of union range from 8-12 weeks in 94 patients, 6 patients went for delayed union and united at 20 weeks.
- The functional outcome assessment according to Constant and Murley score showed excellent functional outcome in 80 patients (80%) and good functional outcome in 12 patients (12%) and fair functional outcome in 6 patients (6%) and poor outcome in 2 patients (2%).
- Considering the subjective as well as objective criteria according to Constant- Murley scoring system we achieved 92% satisfactory result. Pain relief is faster, union time is shorter and early range of motion with less complication. From this we can conclude that mid-shaft clavicle fracture can be safely and confidently treated with internal fixation and one can achieve excellent result.

In future we would like to do the comparative study of displaced fractured of mid-shaft clavicle fracture surgically treated with other intramedullary implants like CC screw and nail.

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