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Original Article

Internal fixation of displaced middle third fractures of clavicle with precontoured locking plate

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ABSTRACT

Background: The traditional method of treating displaced mid clavicular fractures with conservative methods gives poor results. When there is displacement more than 2 cm and shortening, internal fixation of the clavicle, when performed properly, gives better results. **Methods:** We reviewed the results of 20 cases of middle third clavicle fractures (Edinburg type 2B) with displacement more than 2 cm which were treated with open reduction and internal fixation with precontoured locking plate and screws.

Results: In all the fractures radiological union was evident by 10–16 weeks. None of the patients had complications like malunion, nonunion, deep infections, and implant failure and neurovascular damage. There was no problem with hardware and implant removal was not done. The average constant score was 95.45. All the patients were satisfied with the cosmetic appearance of surgical scar.

Conclusions: Precontoured locking plate fixation gives excellent results, facilitates early return to function, results in better cosmesis and avoids complications of conservative methods like nonunion, malunion and also implant removal is not necessary.

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1. Introduction

Fractures of the clavicle are common injuries especially in young, active men. Midshaft fractures account for 80% of all clavicle fractures.¹ Approximately 2–5% of all fractures in adults and 10–15% in children involve the clavicle.^{2–4} In our hospital, from January 2008 to December 2011, out of 1790 cases of all fractures, 114 were clavicle fractures i.e., 6%. Displaced and shortened fractures of the middle third of clavicle occur as a result of high energy injuries in Road traffic Accidents and sports injuries (Fig. 1a and b).

These fractures have been traditionally treated with conservative methods resulting in unsatisfactory patient outcome. While undisplaced fractures are predominately treated by

conservative methods, fractures with displacement more than 2 cm when treated by nonoperative methods have higher rate of nonunion, poor clinical outcome and decrease in shoulder strength and endurance.^{5,6}

With the development of more predictable implants, internal fixation of the clavicle, when performed properly gives better results. Plate fixation provides immediate rigid stabilization, pain relief, facilitates early mobilization and return to pre injury activities.^{5,7} The introduction of anatomically contoured clavicle locking plates has reduced the need for plate removal.⁸

The aim of our study is to analyze the results of internal fixation of displaced fractures of middle third of clavicle with precontoured locking plate and screws.

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Fig. 1 – a. Intra-op photograph showing displacement of fracture fragments. b. X-ray showing displacement.

2. Materials and methods

During the period from January 2008 to December 2011, 114 patients were treated for clavicle fractures in our hospital. Out of these, 20 cases of middle third clavicle fractures (Edinburg type 2B) with displacement more than 2 cm were treated with open reduction and internal fixation with precontoured locking plate and screws.

Most of patients were in the age group between 21 and 40 years (63%). The youngest was 18 years and oldest was 59 years with an average age of 32.1 years. There were 16 males and 4 females. 14 of the fractures were sustained following Road Traffic Accident (70%) and 6 cases (30%) following fall from height. Right clavicle was fractured in 11 cases and left in 9 cases. 5 cases had comminution at fracture site. 4 cases were maluniting at the time of surgery. All the cases had displacement more than 2 cm 2 patients had associated brachial plexopathy. On an average the timing of surgery was 3 days post injury. Two cases with primary brain injury were operated on 37th and 50th day after recovery from head injury. 13 cases had associated injuries. 6 patients had rib fractures, 1 had scapula fracture, 2 cases had tibia fracture, 1 case had patella fracture and 2 cases had facial bone fractures. 2 cases had multiple injuries viz; head injury, rib fractures with hemothorax and brachial plexopathy.

Patients with isolated clavicle fracture were in hospital for 5 days. Those patients requiring treatment for associated major injuries stayed for long time ranging from 14 days to 44days.

All the cases were operated with precontoured locking plate fixed on superior surface with 3.5 mm locking screws. Interfragmentary screw was used in 3 cases.

3. Surgical technique

Under general anesthesia, the patient was placed in supine position with a folded towel placed under the affected shoulder and the arm draped free for intra-operative mobilization. An incision along the superior border of clavicle was

taken. The fracture site was exposed and at the junction of the medial and middle thirds of the clavicle, the inferior surface is exposed so that a protective instrument can be inserted during drilling. After reducing the fracture, the plate was fixed over the superior surface with at least 3 bicortical locking screws on either side of the fracture (Fig. 2a–c). Interfragmentary screw was used in oblique fractures and to fix large butterfly fragment (Fig. 3a and b). In 2 cases of comminuted fractures no.1 Prolene was passed circumferentially to tie the fracture fragments. The wound was closed in two layers.

4. Post-op protocol

Wound inspection done on 2nd post-op day. IV antibiotics were given and discharged on 5th day. Sutures were removed in 7–10 days. The limb was kept in a sling post-operatively for 2 weeks. Patients were advised to use the arm for light weight activities of daily living till 6 weeks. At six weeks check x-ray was taken and full range of shoulder movements started. Subsequent follow-up was done in 8th week, 12 week, 6 months and 1 year. Those with unsatisfactory callus formation at 3 months were again called after 1 month for repeat x-ray. Union was considered if clinically the fracture site was non-tender, radiologically when there was visible callus. Functional outcome was assessed based on Constant Shoulder Score.⁹

5. Analysis of results

By 6 weeks all the patients were advised to start shoulder abduction. Radiological union was evident by 10–16 weeks. All the patients were satisfied with the cosmetic appearance of surgical scar (Fig. 4a and b). None of the patients had early or late infection. 2 patients had dysesthesia at operated site. One patient developed peri arthritis of shoulder and Manipulation under anesthesia was done on 5th month and subsequently had full range of movements. None of the patients had complications like malunion, nonunion, deep infections, and implant failure and neurovascular damage. Two patients who

Fig. 2 – a. Pre-op X-ray showing displaced shortened fracture of left clavicle. b. Intra-op photograph showing precontoured locking plate fixation. c. Post-op X-ray showing fracture reduced, clavicular length restored & fixed with 3 screws on either side of fracture.

had Brachial Plexopathy pre-operatively had excellent neurological improvement by 6 months. None of the patients had problem with hardware and implant removal was not done. The average Constant score was 95.45. [Table 1](#) shows the data of all patients.

6. Discussion

The clavicle is s-shaped long bone, convex ventrally on its medial half and concave laterally. It is tubular in cross section medially and flat laterally. The junction between these two is the weak spot. Both the lateral and medial side are stabilized by strong ligamentous and muscular structures. The Midshaft is left relatively unprotected. Hence most fractures occur in midshaft.¹⁰ The midshaft fractures result in shortening due to displacement of fracture fragments. Displacement and in turn shortening is caused by unopposed muscular forces that occur when the shaft is fractured. The sterno-cleido-mastoid pulls the medial fragment superiorly and posteriorly and the pectoralis major and deltoid muscles and gravity pull the lateral fragment inferiorly and anteriorly. The shoulder girdle is pulled medially because of medialising force components of pectoralis, trapezoid and latissimus dorsi muscles.¹¹

Historically these fractures have been treated conservatively. “Watchful expectancy and skillful neglect” has been the basic principle in managing these fractures, resulting in malunion, shortening and in some cases non-union. Early reports by Neer (1960) and Rowe (1968) formed the basis of idea of

closed treatment methods. Rowe stated that “Fortunately for man, the nature has endowed the clavicle with excellent reparative powers”.¹² At that time clavicle malunion was felt to have no clinical relevance and of radiological interest only. Also the reported incidence of nonunion was less than 1%.¹³

Conservative management remains treatment of choice for undisplaced midshaft clavicle fractures (Edinburgh type 2A). In the metaanalysis of 1145 conservatively treated fractures, 986 of which were undisplaced showed a nonunion rate of 5.9% only.¹⁴ The nonunion rate for displaced fractures (Edinburgh type 2B) however was 15.1% when treated conservatively.

Recent literature is challenging the traditional belief that midshaft clavicle fractures uniformly heal without functional deficit. This is supported by several studies by members of Canadian Orthopaedic Trauma Society, who reported higher rate of nonunion and functional deficits after non surgical treatment of midshaft clavicle fractures when compared to internal fixation.¹⁵

A retrospective study of 52 non-operatively treated patients showed that displaced fractures with shortening of 2 cm or more are predictive of higher non-union or symptomatic malunion rates.⁵ Other studies have shown that non-union rates may be as high as 20% in displaced and comminuted fractures after conservative treatment and strength and endurance deficit are more common in these cases.^{1,6}

Patient based outcome scores in some studies have been published stating that malunion with shortening after midshaft fractures may lead to symptoms such as pain, loss of strength, rapid fatigability, paresthesia of the arm and hand and

Fig. 3 – a. Pre-op X-ray. b. Interfragmentary screw along with plating.

problems with sleeping on back as well as cosmetic complaints.^{5,6,16,17}

Causes of symptoms:

- 1) Glenoid orientation/scapular winging: Because of the shortened lever arm of the shoulder girdle, there is a change in orientation of the glenoid with winging of the scapula, which leads to functional problems of the shoulder in overhead movements. The winging of the scapula result in pain while lying on the back.^{16,18}
- 2) Muscular: Shortening of the clavicle has a negative effect on muscle-tendon tension and muscle balance, which may result in loss of strength and endurance.^{5,16}

Neurovascular problems/thoracic outlet syndrome has been described after clavicular malunion, often associated with large callus formation. We had 2 cases of brachial plexopathy (Fig. 5a and b).

Drawbacks of conservative management can be effectively overcome by surgically treating these fractures achieving near normal anatomic, cosmetic and functional profile. Plate fixation provides immediate rigid fixation, cortical compression and rotational control, helping to facilitate early mobilization.^{5,7} Recent advances in plate technology have added to the treatment choices for midshaft clavicle fractures. The development of locking plate technology has specific advantages for clavicular fixation. Specifically, having the plate and

Fig. 4 – a. Showing surgical scar. b. Showing full range of abduction by 8 weeks.

screws as a single construct may enhance the ability of the plate to resist the large inferiorly directed torque on the outer segment and therefore may limit the potential for plate pull-out. Also the precontoured plates in s-shape follow the axial course of the clavicle when they are placed in a superior position.^{19–22} In transverse clavicle fractures, compression across the fracture site is achieved. For oblique fractures or butterfly fragments, lag screw fixation is possible with the plate functioning in neutralization mode. Secure rotational control of the fracture is achieved. Fixation is rigid enough to allow the patient to minimally weight-bear on the extremity or to use the arm for activities of daily living, if necessary.²³

Disadvantages being superior clavicle plating may result in a greater risk to underlying neurovascular structures and hardware prominence and irritation necessitating implant removal and cosmetic concerns.^{24,25} Other reported complications include infection, hardware failure, and hypertrophic scarring.^{15,26}

Table 1 – Shows the data of all patients.

Age	Sex	Hospital stay (days)	Timing of surgery	Mode of injury	Fracture type	X-ray findings	Type of surgery	Associated injuries	Complications	Constant score
35	M	44	37 days	RTA	Midshaft left	Displacement > 2 cm/MRI – Fracture of left clavicle with a large hematoma between the fractured fragments indenting the subclavian vessels and brachial plexus	Locking plate	Head injury/rib #/brachial plexus injury/left upper limb monoplegia		90
50	M	5	2 days	RTA	Midshaft right	Displacement > 2 cm	Locking plate	8th rib fracture		94
19	M	5	4 days	RTA	Midshaft right	Displacement > 2 cm	Locking plate	Facial bone #s/rib #s		98
24	M	23	4 days	Fall from lorry	Midshaft left	Displacement > 2 cm	Locking plate	Mandible #		96
40	M	14	1 day	RTA	Comminuted # midshaft left	Comminuted # midshaft left with displacement > 2 cm	Locking plate	# scapula left		98
40	M	11	50 days	RTA	Maluniting # midshaft left	Displacement > 2 cm	Locking plate	head injury/rib #/brachial plexopathy/left scapula #/left hemothorax		88
18	M	5	8 days	Fall	Maluniting # midshaft right	Maluniting # midshaft right	Locking plate	Nil	Dyesthesia	96
18	F	5	6 days	Fall	Maluniting # midshaft right	Maluniting # midshaft right with displacement > 2 cm	Locking plate	Nil		94
26	M	15	7 days	RTA	Midshaft right	Displacement > 2 cm	Locking plate	ribs #/bilateral haemopneumothorax		98
38	M	8	3 days	RTA	Midshaft right	Displacement > 2 cm	Locking plate with interfragmentary screw	Head injury		96
50	F	7	2 days	Fall	Midshaft left	Displacement > 2 cm	Locking plate	# Medial condyle lt. tibia		95
50	M	6	2 days	Fall	Midshaft left	Displacement > 2 cm	Locking plate	Nil	Frozen shoulder	94
35	F	5	2 days	RTA	Midshaft right	Comminuted # midshaft right with displacement > 2 cm	Locking plate	# rib		98
59	M	6	5 days	Fall	Midshaft right	Displacement > 2 cm	Locking plate		Dyesthesia	96
41	M	23	4 days	RTA	Midshaft left	Displacement > 2 cm	Locking plate	#Intercondylar # left tibia		95
28	M	5	1 day	RTA	Comminuted # midshaft right	Comminuted # midshaft right with displacement > 2 cm	Locking plate with interfragmentary screw	Nil		96
26	F	7	1 day	RTA	Comminuted # midshaft left	Comminuted # midshaft left with displacement > 2 cm	Locking plate	Nil		98

(continued on next page)

Table 1 – (continued)

Age	Sex	Hospital stay (days)	Timing of surgery	Mode of injury	Fracture type	X-ray findings	Type of surgery	Associated injuries	Complications	Constant score
36	M	4	0 days	RTA	Comminuted # midshaft left	Comminuted # midshaft left with displacement > 2 cm	Locking plate with interfragmentary screw	Nil		96
31	M	13	2 days	RTA	Midshaft right	Displacement > 2 cm	Locking plate	# Patella left		95
23	M	13	7 days	RTA	Midshaft right	Displacement > 2 cm	Locking plate	Head injury		98
Means Fracture.

Fig. 5 – a. MRI showing large hematoma pressing on neurovascular structures. b. X-ray showing large callus formation.

We have used precontoured locking plate with minimum 3 locking screws on each side, fixed over superior surface of clavicle. We have seen better outcome, shorter time to union no case malunion or nonunion. Patients had excellent functional outcome with Constant score of 95.45. All the fractures united within 16 weeks. Bone grafting was not necessary. As none of the patients complained about hardware prominence, we have not done plate removal.

7. Conclusions

The traditional method of treating displaced mid clavicular fractures with conservative methods gives poor results. When there is displacement more than 2 cm and shortening, pre-contoured locking plate fixation gives excellent results, facilitates early return to function and avoids complications of conservative methods like nonunion, malunion and brachial plexopathy. It is the most predictable method to maintain

anatomical reduction of displaced fractures and results in better cosmesis and also implant removal is not necessary.

Conflicts of interest

The author has none to declare.

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