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Fracture Shaft of Clavicle: A Functional Study after Fixation with Locking Clavicle Plate Using Infra-Clavicle Incision

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Introduction

Diaphyseal clavicle fractures are one of the most commonly encountered fractures accounting for 5% of all fractures and 44% of all shoulder fractures. [1, 2, 3] They are also the least seriously taken fractures. Almost all of them are being treated with conservative methods. [4, 5] However, the main aim of operative treatment for displaced and comminuted fractures of the clavicle is to prevent shortening, malunion and nonunion resulting in restriction of movement of the shoulder joint.[6, 7] There are various methods for treating clavicle midshaft fractures, such as intramedullary K-wires or Steinmann pins fixation and plate fixation. In particular, plate fixation can help obtain firm anatomical reduction in severe displaced or comminuted fracture. This study was under taken to find the functional outcome of the acute mid shaft clavicle fractures as well as the non-union of the mid shaft fractures after operative management using locking compression clavicular plate.

Keywords: Diaphyseal clavicle, K-wires, clavicular plate.

Methods

A total of 30 patients were operated between September 2010 and March 2012 with open reduction and internal fixation using clavicular locking compression plate for the fracture of middle third shaft of clavicle. Operative indications were shortening ≥ 2 cm, impending skin disruption and irreducible fracture, comminuted fractures, displacement ≥ 2 cm, symptomatic mal-union and non-union. The same plate was used in all the surgeries.

The fractures were classified according to Allman classification and only types I fracture of the clavicle were included in the study.

There were 28 males (93%) and 2 females (7%) with a mean age of 33.8 years. A total of 16 (53%) clavicles were right sided and 14 (47%) were left sided.

24 (80%) were acute injuries while 3 (10%) were in non-union, 2 (6.6%) was in delayed union and 1 (3.3%) was

symptomatic malunited fracture. Of the total acute injuries 2 (8.3%) were comminuted fractures and the rest 22 (91.6%) were simple fractures without any comminution.

The mechanism of injury was either from fall on out stretched arm, direct trauma to the clavicle or from fall on the shoulder. None of them were pathological fractures.

All 3 non-unions were male patients. In delayed unions, 1 was male and 1 was female.

All the three patients more than 45 years had a history of brief unconsciousness following fall but neurological examination and NCCT revealed normal study. Rest of the patients had no associated complications of injury or any comorbidity.

Bone grafting was done in 8 (26.6%) cases i.e., in the 3 (10%) non unions, 2(6.6%) delayed union, 1 (3.3%) symptomatic mal union and in 2 (6.6%) comminuted fractures due to loss of comminuted fragments as they were very small and a gap remained after reduction.

All cases were followed up till 6 months after surgery and the following observations were made:

The majority of cases were males i.e., 28 cases (93%) and only 2 (7%) were females.

Of the total cases 23 (76.6%) occurred in the age group between 25 and 40 years. The two cases of delayed union were in the age group of 25 and 30 years. One cases of non-union was in the age group of 30 to 35 years and rest two non-unions were in the age group of 35 to 40 years.

Out of the total 30 patients, 16 (53.3%) had fall on out-stretched arm, 9 (30%) had a history of direct trauma to the clavicle and 5 (16.6%) had fall on their shoulder. The two comminuted fracture had a history of direct trauma (100%) to the clavicle.

2 (8.3%) of the acute fracture were comminuted while rest 22 (91.6%) of acutely fractured were either transverse or oblique without any comminution. All had shortening of more than 2 cm (average- 2.5 cm, range- 2.1 to 3.0 cm). Depending upon the mechanism of injury, the average shortening in all the three mechanisms were almost the same.

Operative Technique

A total of 30 patients with fracture middle third shaft of clavicle (Allman type1) were operated in the Central Institute of Orthopaedics, Safdarjung Hospital, New Delhi, from a period between September 2010 and March 2012 fulfilling the inclusion criteria set at the start of the study.

All surgeries were performed under general anesthesia with the patient in supine position with sand bag under the inter-scapular region. The effected limb was cleaned, painted and draped.

In all patients, clavicle was approached through infraclavicular incision. All fractures were openly reduced and internally fixed with clavicular locking dynamic compression plate applied over the superior aspect of the fractured clavicle.

The skin over the infraclavicular region was pulled proximally so that the incision mark would lie over the fractured clavicle. The fracture site was marked with a skin pencil. Infraclavicular incision was marked then and infiltrated with 1: 1000 epinephrine diluted in 200 ml of normal saline.

Incision was given along the shaft of clavicle after pulling the infra-clavicle skin up. Skin and fascia along with the platysma was incised in a single plane and up to the bone in one go. We made no attempts for saving the supraclavicular nerves as these would lie in the surgical field and hamper fracture reduction and plate placement.

A meticulous hemostasis was achieved before exposing the fracture site especially in cases of non-union and freshening the fractured ends.

In acute fractures, there was no problem in achieving the reduction. But in cases where the fracture was old non-

union or where there was comminution at the fracture site, freshening and reduction took a little more time for removing the fibrous tissue around the fracture site and meticulous dissection so as to avoid removing the comminuted fragments from their soft tissue attachments.

Bone grafting was done in cases of non-unions and in cases of comminuted fractures where the fragments were very small and on reduction, a gap was seen at the fracture site.

Care was taken not to go deep to the clavicle to avoid injury to the subclavian vessels and cords of the brachial plexus.

After reduction was achieved, clavicle locking compression plate (LCP) was used to internally fix the fracture fragments. The plate was precontoured and was placed on the superior surface of clavicle. A minimum of 6 cortical purchases were taken on each side of the fracture site with atleast one locking screw at each side. Large butterfly fragments were fixed with a lag screw.

The wound was closed in three layers after obtaining absolute hemostasis; the first was of platysma covering the plate; the second of subcutaneous sutures; and the third of interrupted skin sutures.

No drain was given.

At the end of the procedure, the limb was immobilized in RJ strapping and arm sling.

First post-operative wound inspection was done at third day. No inspection was done after that if the wound condition was ok. Patient was discharged and called on the 15th day of surgery for removal of stiches.

Post-Operative Rehabilitation

The patient wore an arm sling for at least 2 weeks followed by light activities of daily living and range of movement exercises. Patient was followed radio graphically and clinically at immediate post op, 4, 8, 12 weeks and at 6 months. Stitches were removed 15 days after surgery. Heavy lifting was restricted until radiographic healing was noted. At each follow up, patient was assessed, examined and interviewed according to the Constant score. The results of the study were compared using standardized normal statistical tests for different variables.

Results

There were 2 (6.6%) superficial infections which healed on dressing and secondary suturing. There were no incidences of deep infections. 2 (6.6%) patients complained of prominent hardware and 2 (6.6%) patients had paraesthesia at the operative site which subsided subsequently and were followed by anesthesia at the operative site. All the seven complications were independent of each other. At the end of 6 months, there were no restrictions of movements at the shoulder joint, no hardware loosening or hardware failures.

The parameters of Constant Score were evaluated and the following observations were made:

- Pain was present in during the first 4 weeks after surgery (mean pain score- 13.9). After the first 4 weeks none of the patients complained of pain during normal activities (mean pain score- 15).
- There was restriction in the activities of daily living (ADL) initially following surgery which gradually improved and at the end of 6 months there was no restrictions in the activities of daily living (mean score at 4 weeks- 16.8 to mean score at 6 months- 20).
- The range of motion of the affected shoulder also improved at the end of 6 months (mean score at 4 weeks- 35.5 to mean score at 6 months- 39.5).
- Power at the affected shoulder was also observed and a definite improvement was noticed (mean score at 4 weeks- 21.6 to mean score at 6 months- 24.8).

- The average constant score at 4, 8, and 12 weeks and at 6 months were 88.1 (range 70-97), 95.63 (range 90-100), 98.53 (range 92-100), and 99.27 (range 94-100) respectively. This shows an obvious improvement in the shoulder function as early as 4 weeks after the surgery.

Clinical and radio-graphical union was present in all patients within a mean period of 7.15 weeks (range-6weeks to 10 weeks).

All patients were relieved of pain following surgery.

All attained good range of motion at the end of 6 months.

None of the plates were loose at the end of 6 months.

Discussion

The best treatment strategy for displaced midshaft clavicular fractures remains a topic of debate. Currently, the decision for non-operative or operative treatment of displaced midshaft clavicular fractures is predominantly based upon the personal preferences of the treating surgeon.[8, 9] In a similar way, when operative treatment is favored, the type of fixation, intramedullary or (locking) plate fixation, is at the discretion of the surgeon. [8, 11, 12, 13, 47]

Primary surgical treatment is recommended for female sex, fractures with displacement of more than a shaft width, comminution, and advanced age, which are associated with a higher risk of complications, especially with a combination of these factors. [10, 14, 15]

The incidence of clavicle fracture is more among males as compared to female. [16, 17, 18, 19]

There are three basic mechanisms, apart from uniaxial tension, which can elevate local stress levels in slender bones sufficiently to initiate crack propagation and subsequent fracture. These are bending, torsion and compressive buckling with resultant bowing i.e., direct blow to the clavicle, fall on out stretched hand and fall on shoulder. [8, 21, 22, 23, 24]

In our study, the most common mechanism of fracture was fall on the out stretched hand in 16 cases (53.3%) followed by direct trauma in 9 cases (30%) and fall on shoulder in 5 cases (16.7%). In the two comminuted fractures, the mechanism of injury was direct trauma to the clavicle. In western culture, injury to the clavicle is mainly due to various out-door sporting activities like fall from bicycle or during horse riding; while in our scenario, it was mainly due to fall on out-stretched hand or road traffic accidents.

Shortening following acute fracture of the clavicle has been the most important independent factor that causes the fracture of clavicle, which usually unites to go in to malunion or nonunion.[8, 12, 25, 26, 27, 29, 30, 31] The most recent data provided by Bajuri [28] et al showed that a displacement of 21 mm or more and a shortening of 15 mm or more were significantly associated with reduced shoulder function. A biomechanical assessment by Ledger et al [25] revealed that shortening of 15 mm or more is associated with reduced muscular strength during the extension, adduction and internal rotation of the humerus, with reduced peak abduction in the injured shoulder. Hill [8] examined 242 clavicle fractures out of which 66 (27%) were displaced clavicular shaft fractures out of which 52 fractures were reviewed and found a 15% rate of mal- and nonunion and a 31% rate of dissatisfied patients. These nonsatisfying results correlated with shortening by 2 cm or more.

Although nonunion is a rare phenomenon for fracture shaft of clavicle, it has been extensively described in the literature.[8, 17, 24, 32, 33, 34] In our study, 3 (10%) of the 30 cases were of non-union, and 2 (6.6%) of the fracture in delayed union (total- 5 cases or 16.6%), which is by far, more than that stated by Robinson (0.4-4%). All the three nonunions were males while one male and one female

presented with symptomatic delayed union. The age group of all was between 25 and 39 years.

It has been estimated that about 2/3rd of the diaphyseal clavicular fractures treated conservatively would have some degree of malunion. Shortening of more than 1.4 to 2 cm has been described to be a critical deficit for development of symptomatic mal-union.[8, 9, 11, 12, 13, 25, 26, 27, 35] Internal fixation of displaced fractures of the clavicle can prevent symptomatic malunion.

Open reduction and plating is not without any complications. Complications have been reported by many authors and some even advice against operative intervention because of the complications.[18, 24, 32, 36, 37, 38, 39, 40] The complication rates have decreased as the new modalities of treatment for fracture clavicle have evolved. Earlier, the complications were associated with the use of intramedullary pins as they had the tendency to migrate to the thoracic cavity. But with the introduction of plating in clavicle fractures, this complication has been eradicated. .

Wound infection is one of the most commonly encountered complications in clavicle plating. [7, 39, 41]

Many authors have cited prominent hardware to be one of the most common complications following plate fixation of clavicle and also the most common cause for removal of hardware.[7, 9, 10, 18, 40, 42, 43, 44, 45, 46] The uses of reconstruction plate and low profile clavicular dynamic compression plate have decreased the complaints of hardware prominence.

Unfortunately, surgical treatments for clavicle fractures leave distinct scars on the shoulder. [42]

Implant breakage and failure used to be a common complication when intramedullary fixation was done.[2, 48, 49] With the advent of extra medullary fixation in the form of plates, the incidence of implant failure has decreased. [18, 41]

We had no incidence of plate fracture or plate loosening in any of the 30 patients. This is because of the presence of locking screws in the locking compression plate and also because it is a more rigid construct as compared to the intramedullary implants, reconstruction plate and 1/3rd semi-tubular plate. [50, 51, 52]

Post-operatively, there have been reports of non-union and mal-unions in various series.[7, 18, 41] They have been attributed to comminution of the fracture [20, 41], poor implant selection and infection.[18] The simple principles of soft tissue respect and minimal stripping of the soft tissue at the fracture site using infra-clavicle incision along with accurate fracture reduction with proper plate seating and screw placement can avoid these complications. In locking compression plate fixation, screws can be placed both in locking and compression mode which makes it a versatile implant.

The internal fixation by locking compression plate (LCP) in our study provided rigid fixation and allowed early mobilization of the limb. There was rapid improvement in the pain score after the 4th week and all of the patients were pain free at the end of 8 weeks. There was slight pain at the end of internal rotation but overall range of motion score at the end of 6 months was near normal. Constant score at the end of 6 months was excellent in all the patients.

Open reduction and internal fixation with plates, such as Sherman plates, dynamic compression plates, and semitubular plates, can be effective in obtaining anatomical reduction, applying direct compression to the fracture site, and producing resistance to torque. However, in severely comminuted fracture cases, it is disadvantageous in achieving firm fixation. [32, 53, 54]

The advantages of LCPs include strong fixation due to locking between the screw and plate, and blood supply preservation due to minimal contact between plate and

cortical bone. With conventional screws and plates, fracture site stability is provided by friction between the plate and bone cortex. Accordingly, screws need to be fixed onto both cortices. In contrast, when an LCP is used, an external force is transmitted from the cortical bone through the conically threaded plate hole to the plate because the screw head is locked firmly in the threaded plate hole. Therefore, the plate does not need to be compressed onto the cortical bone for stability, which results in good preservation of the blood supply, and the plate thread is also helpful in preventing screw loosening or instability. When LCPs are used to treat clavicle midshaft fractures, the risks of injury to the subclavian artery or brachial plexus can be reduced because fixation can be achieved without the tip of the screw reaching the opposite bone cortex and periosteal stripping can be minimized to promote rapid union. It is believed that the surgery time can be reduced using LCPs because accurate plate contouring is not necessary and periosteal stripping could be minimized using self-tapping screws. [55, 56, 57, 58]

We, through our study and comparing our result with the current and available literature conclude that LCP has indeed become the treatment of choice for displaced mid clavicular fractures and in the treatment of symptomatic non unions and mal unions.

Figure 1: Infraclavicular scar

Figure 2: Full internal Rotation

Figure 3: Full over-head abduction

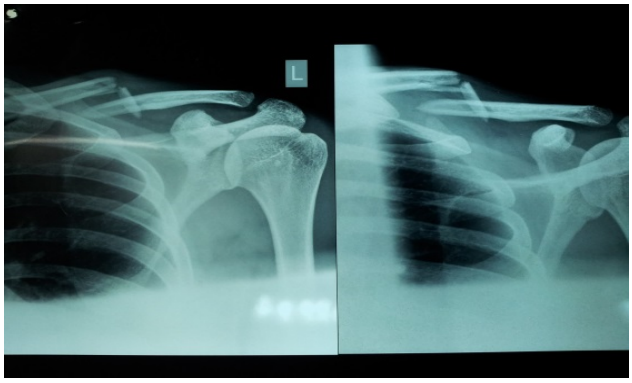

Figure 4: Preoperative x-ray showing comminution with over riding

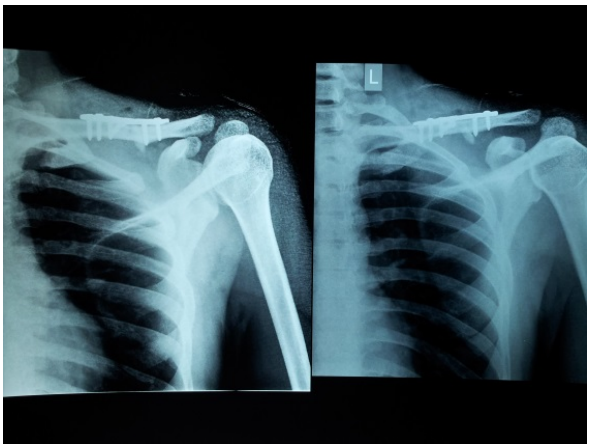

Figure 5: Post-operative x-ray

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