



Flexible Intramedullary Nailing for Fixation of Displaced Midshaft Clavicle Fractures

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Introduction: Fracture of the clavicle is common in occurrence with incidence of approximately 5% of all fractures seen in hospital emergency. These fractures are generally managed conservatively. Titanium elastic nails are a promising minimally invasive treatment for displaced mid-clavicular fractures, which may be an alternative to plate fixation or even nonoperative treatment. **Objective:** The aim of this study was to assess the cosmetic outcome (malunion, asymmetry, and scar formation), rate of bone healing and alignment of the clavicle ($<30^\circ$ or $>30^\circ$) related to the flexible intramedullary nailing of midshaft fracture clavicle. **Materials and Methods:** Between June 2012 and June 2014 in GMC and Hospital Amritsar, 50 patients with displaced, noncomminuted fracture of midshaft clavicle of either side underwent flexible intramedullary nailing with titanium elastic nail. Implant removal was performed in 90% cases after the fracture united completely. **Results:** In this study, all fractures were united. Mean duration of radiological union was 10.3 weeks ranging from 6 to 20 weeks. Mean disabilities of arm shoulder and hand score after 6 months of follow-up was 7.7 ranging from 0.8 to 44.2. Mean constant self-evaluated score was 80.2 ranging from minimum 43 to maximum 98 after 6 months of follow-up. **Conclusion:** Flexible intramedullary nailing, a minimally invasive technique for stabilization of displaced midshaft clavicle fractures is a simple procedure with excellent functional outcome in terms of quick return to activities and a high patient satisfaction rate with very good cosmetic outcome.

Key words: Intramedullary clavicle nailing, middle one-third clavicle fractures, Titanium Elastic Nailing System

INTRODUCTION

Fracture of the clavicle is common in occurrence with the incidence of approximately 5% of all fractures seen in hospital emergency admissions. Midshaft clavicular fractures are clearly the most common¹ with a reported variable incidence of 69.2% to 76.2%.^{2,3} About 3/4 of the midshaft fractures are appreciably displaced.^{2,3} These fractures are more common in men (68%) than women (32%).⁴ Road traffic accidents were the most common cause of the injury.⁴

Standard treatment for this fracture pattern is nonoperative, using an arm sling or figure-of-eight bandage for external fixation.⁴ Conservatively displaced fractures are noted to have a higher incidence of nonunion in between 10% and 15% and even when they do unite, often result in an unsightly cosmetic deformity in the center of the clavicle, shoulder dropping, shoulder discomfort, and patient dissatisfaction.^{5,6} The amount of pain and disability during the first 3 weeks of conservative

treatment has been underrated. It may also be associated with venous congestion of arms, and a displaced fragment might compress the brachial plexus leading to neuropraxia after conservative treatment.⁷

Furthermore, decreased shoulder function due to clavicular shortening of more than 1–2 cm after nonoperative fracture management has been reported. In athletes, either professional or amateur⁸⁻¹⁰ restoration of the clavicle length and early return to full activity with unimpaired function is of great importance.

Surgery has been indicated for completely displaced fractures, potential skin perforation, shortening of clavicle by more than 20 mm, neurovascular injury, and floating injury.¹¹ The gold standard for the surgical treatment has been open reduction and plate fixation through a large incision.¹² Plating is the most commonly used surgical treatment; however, plating requires relatively extensive periosteal stripping, which may

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Flexible intramedullary nailing for fixation of displaced midshaft clavicle fractures

jeopardise the blood supply at the fracture site, thus adversely affecting fracture healing. Stress shielding produced by rigid plates can lead to an 8% refracture rate after plate removal. Surgical time is considerable, and infection rates of up to 18% have been reported. In addition, the relatively long scar can be a cosmetic issue in some patients, and some individuals experience discomfort induced by the plate underneath the skin. Thereafter, additional procedures required for plate removal.

Intramedullary devices behave as internal splints that maintain alignment without rigid fixation. Intramedullary device has advantages of a smaller incision, less dissection, and load sharing fixation with relative stability that helps in callus formation.¹³ Due to flexibility of titanium nails is that it can manage itself in the bone and provide a 3-point fixation within the S-shaped clavicle.¹³ This study was undertaken to evaluate the results of displaced clavicle fracture treated by titanium elastic nail.

MATERIALS AND METHODS

The present prospective study comprised of a total of 50 cases of either sex of different age groups with displaced noncomminuted fracture midshaft clavicle [Figure 1] of either side admitted from June 2012 to June 2014 in the Department of orthopaedics of Government Medical College Amritsar.

Clinical history, general physical examination, and local examination were performed. Patients were accordingly investigated for operative and anesthetic complications. The supportive and prophylactic therapy in the form of analgesics, antibiotics, antitetanus injection, intravenous fluids, and matched blood transfusion, wherever required were given to stabilize the patient. Thereafter, the injured part was X-rayed to confirm bony injury and fracture geometry. Classification of fracture clavicle was done according to AO classification and an informed written consent of the patient was obtained before inclusion in the study. Exclusion criteria from the study was–

- Patients having undisplaced fracture middle third of clavicle
- Patients having fracture clavicle in medial and lateral third
- Patients with bony injuries of ipsilateral upper limb, nerve injuries were not considered for the study as it would affect the outcome.

Operative technique

The patient was laid supine on a radiolucent operation table, under general anesthesia. Part was scrubbed, painted, and draped with sterile OT sheets with the respective arm so draped as to be freely movable. A small incision of 1–1.5 cm was made near the sternal end of the clavicle. The anteroinferior edge of the cortex was opened after soft-tissue

dissection with an awl or a drill bit. The thickness of the nail was determined according to the diameter of medullary cavity. The original curvature of the nail tip was straightened slightly to facilitate better gliding in narrow medullary canal. The small and flattened tip helped in negotiating the nails against far cortex and preventing perforation of the cortex. A flexible nail of appropriate thickness was mounted on a Jacob's chuck and inserted in the medullary canal manually. Under image intensifier, the nail was advanced to the fracture site. When the tip reached the fracture, reduction was performed manually or percutaneously by means of a reduction clamp and the nail was pushed into the distal fracture fragment [Figures 2 and 3]. In case of failure of closed reduction, open reduction was done, and the tip of the nail introduced under direct vision through a second small (2–3 cm) skin incision directly over the fracture site. The soft tissue, if found interposed, was cleared. Then, the nail was advanced manually or with a gentle tap of a hammer into the distal fracture fragment. At the transition to the acromial end of the clavicle, accurate maneuvering of the tip of the nail was done under image intensifier control to avoid perforation of the curved thin dorsal cortex; thus, after reaching the end position, the nail was cut close to the entry point to minimize soft-tissue irritation, at the same time leaving sufficient protruding end for extraction later [Figure 4]. Then, the surgical wound at entry point was closed with skin suturing. If second incision over fracture site was given during reduction, wound closure was done with subcutaneous tissue suturing and skin suturing. Aseptic dressing done and arm pouch was applied for few days.

Postoperative care

Appropriate postoperative antibiotics and analgesics were given for few days. Active movements of the shoulder started as early as possible within tolerable limit. Overhead abduction or flexion was restrained for 6 weeks since increasing rotational loads on the clavicle could result in proximal migration of the nail. The first postoperative dressing was done on the 3rd day.

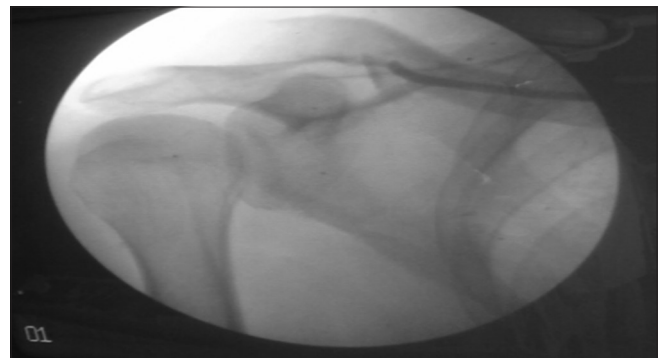


Figure 1: Titanium Elastic Nailing System at fracture site

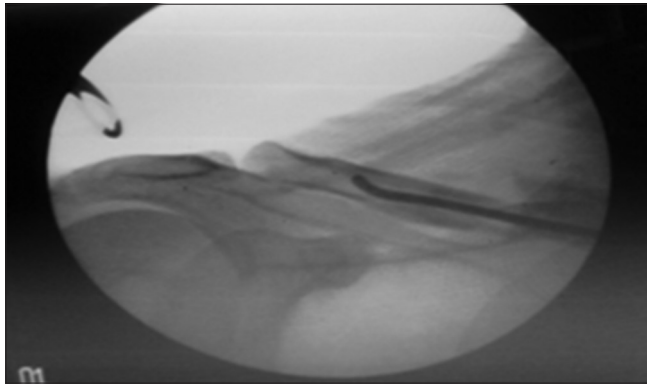


Figure 2: Titanium Elastic Nailing System crossing fracture site

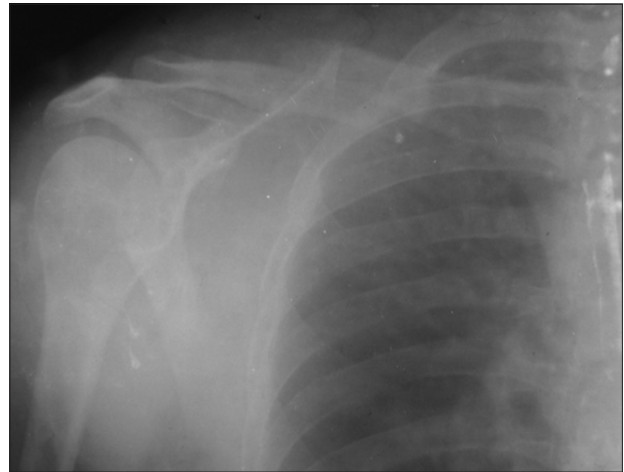


Figure 3: Preoperative X-ray

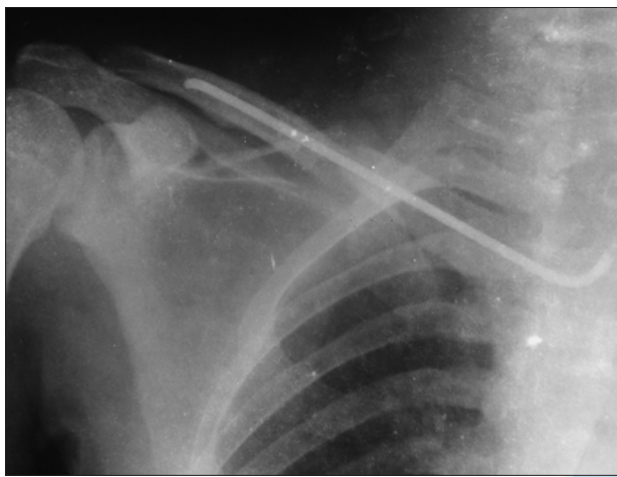


Figure 4: Postoperative xray (with insertion of Titanium Elastic Nailing System)

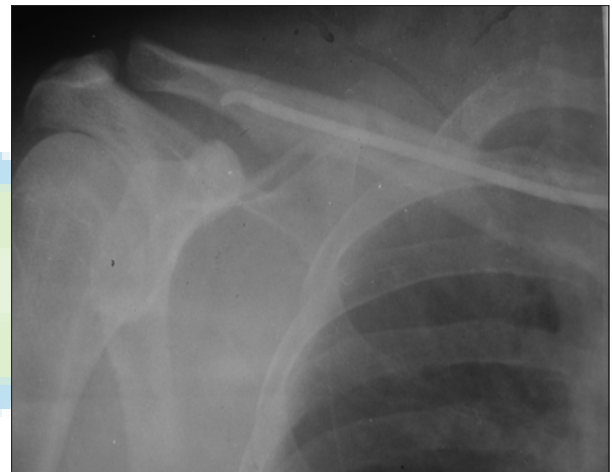


Figure 5: X-ray at 6 weeks of follow-up

Stitches were removed on 11th day. Patient was called for follow up every 3–4 weeks, till complete union achieved.

Outcome assessment done by

- Disabilities of Arm Shoulder and Hand (DASH) score: 0 (best) to 100 (worst)
- The self-evaluated constant score (0–100 points)
- Subjective data were evaluated with reference to the cosmetic outcome (malunion, asymmetry, and scar formation), bone healing, and complications (nonunion).

RESULTS

A total of 50 patients met the inclusion criteria of diaphyseal midshaft, noncomminuted clavicle fractures. In this study, mean age of patients was 31.2 years ranging from minimum 18 years to maximum 54 years. Males were 32 and females were 18 in this study. The right side was involved in 29 cases and the left side in 21 cases. Mechanism of injuries was

roadside accident in 33 patients, fall from height in 12 patients, assault in 3 patients, and sports injury in 2 patients. According to AO classification, 36% were type B1, 60% type B2, and 4% cases were type B3. The duration from injury to surgery was <1 week in 41 patients, 8 patients were operated within 2–3 weeks of injury, and 1 patient operated after 28 days. During surgery closed reduction succeeded in 52% and open reduction needed in 48% cases. The mean time of surgery was 54.8 min ranging minimum 25 min to maximum 85 min. All fractures were united. Mean duration of radiological union was 10.3 weeks ranging from 6 to 20 weeks [Figure 5]. There was a soft-tissue irritation by cut part of flexible nail at entry point in eight patients. There was a hypertrophic scar formation over entry point of nail in two patients. There was a proximal migration of nail into medullary cavity of clavicle in two patients. None of the patients had infection, nonunion, and implant breakage. Most of the patients had well-aligned union, and no patients had angulation more than 30°. In the present

Flexible intramedullary nailing for fixation of displaced midshaft clavicle fractures

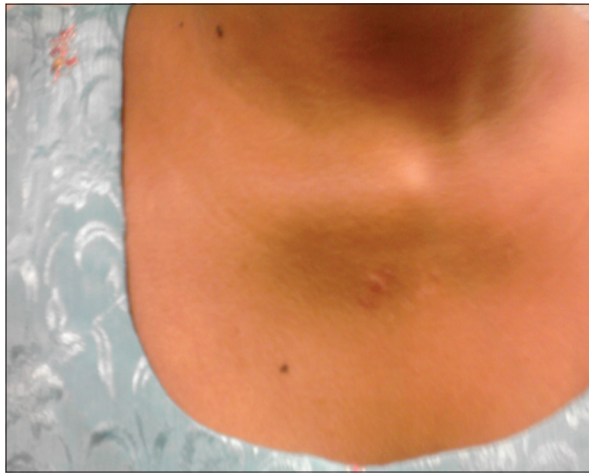


Figure 6: Single scar

study, nail removal was done in 45 cases, and in 5 cases, implant was not removed because of refusal of patients. The mean time of nail removal was 7.1 months. In the present study, mean DASH score after 6 months of follow-up was 7.7 ranging from 0.8 to 44.2 [Figures 6 and 7]. Mean constant self-evaluated score was 80.2 ranging from minimum 43 to maximum 98 after 6 months of follow-up.

DISCUSSION

This study was done with objective to study the outcome of operative treatment with flexible intramedullary nail. In the present study, mean age of patients was 31.2 years. This incidence is in accordance with earlier studies showing the mean age of fracture clavicle 37 years.⁹ This highest incidence in young age group is seen because they are most commonly involved in traveling, driving, sports activities, and also are victims of assault.

In our study, displaced midshaft fracture clavicle seen predominantly in males comprised of 32 males (64%) and 18 females (36%). The sex distribution of earlier reported study was 70% male and 30% female.¹⁴ Hence, the incidence in present study closely correlates with the previous studies. This is probably due to type of society in which outdoor activities are predominantly preferred by males which predispose them to traffic accidents.

In the present study, the right side was involved more commonly in 29 cases (58%) and the left side in 21 cases (42%). Many studies also reported similar incidence of the right side involvement, for example, 58.8% right and 41.2% left.¹⁵ Force of trauma having been borne by the right side as being the dominant side.

Mechanism of injuries classified mainly as roadside accident, fall, and sports injuries. The present study showed mechanism of injuries were roadside accident in 33 cases (66%), fall in



Figure 7: Functional recovery at follow up of 6 months

12 cases (24%), assault in 3 cases (6%), and sports injury in 2 case (4%). Reported mechanism of injuries was roadside accident in 46%, fall in 20%, 34% sports injuries¹⁶ and roadside accident in 62%, fall in 15%, sports injuries in 15%, and assault in 8% cases.¹⁷

Diaphysis noncomminuted type B1 was 36%, diaphysis wedge type B2 was 60%, and diaphysis segmental type B3 was 4%. These findings were in accordance with earlier reported literature with type B1 23%, B2 73%, and type B3 14%.¹⁷

In the present study, the duration from injury to surgery was <1 week in 41 patients (82%). The mean duration of injury to surgery was 3.9 days. The duration from injury to in surgery earlier reported literature was 4 days,¹⁸ 6 days,¹⁹ and 6 days.¹⁶

In the present study, closed reduction succeeds in 26 cases (52%) and open reduction needed in 24 cases (48%). In earlier studies, closed and open reduction was 58% and 42%¹⁸ and 50% and 50%, respectively.¹⁹ These data showed that flexible intramedullary nailing is a technically demanding procedure. Reasons to failure of closed reduction were as follows:

1. Fractures situated in lateral part of midshaft
2. Segmental type B3 fractures
3. Soft-tissue interposition
4. Failure of maintenance of reduction during engagement of distal fragment of fracture
5. Excessive time elapse since injury to surgery
6. Inadequate straightening of tip of the flexible nail
7. Ill-defined medullary cavity of clavicle.

The mean time of surgery was 54.8 min ranging minimum 25 min to maximum 85 min. It is in accordance with data given in older literature having mean time of surgery 62 min with mean time for close reduction group was 39 min and for open reduction was 85 min.¹⁹

In the present study, mean duration of union was 10.3 weeks ranging from minimum 6 to maximum 20 weeks. The average duration of radiological union after flexible intramedullary nail fixation shown in older studies were 2.2 month¹⁷ and

7.7 weeks¹⁹ which are in accordance with the present study.

In the present study, all 50 cases (100%) had fracture union. An older study showed union in 98% cases and 2% nonunion.²⁰ Another study showed union in 100% cases and no nonunion.¹⁶

Soft-tissue irritation at entry point in eight patients, hypertrophic scar formation over scar of entry point of the nail in two patients, proximal migration of nail in two patients, and there was no complication of infection, nonunion, angulation more than 30% and implant breakage in any case. Overall, it can be stated that in the present study, there was no any major complication regarding management and healing leading to reoperation. Minor complications were seen and that were managed on outdoor basis.

Meantime of nail removal shown in earlier studies were 7.1 months,¹⁸ 7 months,¹⁹ 19 weeks,¹⁶ and 7.2 months.¹⁷

Failure to union is not a major problem nowadays, but functional outcome and cosmesis are main concerns.

The Disability of Arm Shoulder and Hand (DASH) score was calculated on scale 0-100, considering score 0 best and 100 worst. In the present study, minimum DASH score was 0.8 (best), and the maximum was 44.2 (worst). The mean DASH score was 7.7. In 76% cases DASH score was less than 10 and in 88% cases were having DASH score <20. In earlier studies, it was 6.8 (0–43),²⁰ 2.5 (0.5–8.0),¹⁷ and 3.4 ($\pm$ 4.8)²¹ which was in accordance with the present study.

The Constant Self Evaluated Score calculated on scale 0–100 where 0 is worst and 100 best. The minimum self-evaluated constant score was minimum 43 (worst) to maximum of 98 (best). The mean constant self-evaluated score was 80.2. In 88% cases, constant self-evaluated scores were more than 70 and 12% cases were having scores <70. In older literature of flexible intramedullary nail fixation of displaced midshaft clavicular fractures, the values calculated were 98.3,¹⁸ 98 ranging 93–100,¹⁹ 81 ranging 46–100,²¹ 95.3 $\pm$ 3.9,¹⁶ 95.2 ranging 86.5–97.0¹⁷ and 97 $\pm$ 4.2.²¹

CONCLUSION

The acute treatment of middle-third clavicle fractures remains a subject of controversy.

Above data demonstrates early pain relief in combination with good shoulder function after acute operative treatment with Titanium Elastic Nailing System (TENS) resulting in quick return to activities and a high patient satisfaction rate. Hence, TENS is a promising minimally invasive treatment for displaced mid-clavicular fractures, which may be an alternative to open reduction internal fixation (ORIF) or even nonoperative treatment.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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Flexible intramedullary nailing for fixation of displaced midshaft clavicle fractures

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