OUTCOMES OF DISPLACED MIDCLAVICULAR FRACTURES IN ADULTS TREATED WITH ANTEGRADE TITANIUM ELASTIC INTRAMEDULLARY NAILS

Bipul Borthakur[1], Russel Haque[2]

[1]Associate Professor, Department of Orthopaedics, Assam Medical College and Hospital, Dibrugarh, Assam.
[2]Postgraduate Tutor, Department of Orthopaedics, Assam Medical College and Hospital, Dibrugarh, Assam.

ABSTRACT

BACKGROUND

Clavicle fractures were traditionally treated nonoperatively, but due to higher rates of delayed union, non-union, symptomatic, malunion cosmetic deformity and other complications. There is an increasing trend for operative management. Plating and intramedullary nailing are the most popular surgical options. The use of intramedullary titanium nails requires smaller incisions, avoidance of significant soft tissue stripping, minimal complications, and early return to work. The aim of the study was to evaluate the clinical outcome of displaced midclavicular fractures (DMCFs) in adults treated with titanium elastic nails (TENs).

MATERIAL AND METHODS

Prospective study was conducted between 2009 and 2013 in which 34 patients (26 males and 8 females) with mean age of 39.1 years with OTA type B DMCFs underwent surgical fixation with TENs. Evaluation done by Constant and DASH scores at 6, 12 weeks, 3, 6, and 12 months to determine outcomes.

RESULTS

Closed reduction was possible in 20 patients (58.82%). All the patients achieved clinical and radiological union at 9.38±1.44 weeks. The final Constant and DASH scores were 93.37±3.06 and 5.63±2.66. There were no major complications, only minor complications of shortening >0.5 cm (n=3, 8.82%), superficial infection (n=3, 8.82%) and medial TEN protrusion (n=7, 20.58%).

CONCLUSION

The intramedullary fixation of DMCFs with TENs is a minimally invasive, safe, and effective procedure, which provides good functional outcome, high union rate, early pain relief, return to work, and better cosmetic results with minimal complications in indicated cases.

LEVEL OF EVIDENCE

Level III.

KEYWORDS

Displaced midshaft clavicle fracture, Intramedullary clavicle nailing, Titanium elastic nailing system (TENS).

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INTRODUCTION: Fractures of the clavicle commonly seen by fall on an outstretched hand or by direct injury comprise 35% of all shoulder injuries.[1] They are common injuries in young individuals especially those who participate in activities and sports where high-speed falls or violent collisions are frequent and account for 2.6-10% of all fractures.[2] The majority of clavicular fractures (80-85%) occur in midshaft of the bone with over half of these being displaced where the typical compressive forces applied to the shoulder and the narrow cross-section of the bone combined and result in bony failure.[3]

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Corresponding Author:
Dr. Bipul Borthakur,
Associate Professor, Department of Orthopaedics,
Assam Medical College and Hospital, Dibrugarh, Assam.
E-mail: drbborthakur@rediffmail.com
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Displaced Midshaft Clavicle Fractures (DMCFs) have traditionally been treated nonoperatively due to reports suggesting that nonunion were rare and malunion often asymptomatic.[4] However, recent studies have found higher rates of delayed union, nonunion, symptomatic malunion, poor functional outcome with cosmetic deformity in conservatively treated DMCFs.[5] Thus, there is a recent shift towards operative treatment for DMCFs.[6] Internal fixation of displaced midshaft clavicular fractures are commonly done by plating and intramedullary nailing. Although, plate fixation is considered as the gold standard surgical treatment.[7] it is associated with complications such as infection, wound dehiscence, ugly scar, hardware prominence, and nonunion.[8] Intramedullary fixation with Titanium Elastic Nails (TENs) is minimally-invasive procedure with fewer complications and an early return to work.[9] The aim of the study was to evaluate the clinical outcome of

displaced midclavicular fractures in adults treated with titanium elastic nail.

MATERIAL AND METHODS: We conducted a prospective study to analyse the outcomes and complications of closed displaced midshaft clavicular fractures treated with single titanium elastic intramedullary nails. The study was conducted between 2009 to 2013 and a total of 34 patients were treated. Fracture was classified based on Orthopaedic Trauma Association (OTA) classification scheme for midclavicular fractures.[10]

Inclusion Criteria Included:

- Age 18 to 65 years.
- OTA type B (Diaphyseal) except B3.3
- Duration ≤2 weeks.
- Shortening or displacement ≥2 cm.
- Minimal comminution.

Exclusion Criteria: Were OTA type A, C, and B3.3, floating shoulder, bony injuries, or any pre-existing disease of ipsilateral upper arm, bilateral clavicular fractures, brachial plexus injury, vascular injury, grossly comminuted fractures, pathological fractures, and open fractures.

Operative Technique: Patients were placed in supine position on OT table and general anaesthesia was administered. The sternoclavicular joint was palpated and marked. A small skin incision was made 1 cm lateral to the sternoclavicular joint. The entry point in the anterior cortex was made with a pointed awl. A titanium elastic nail (of size 2 mm or 2.5 mm according to canal diameter and patients stature) fixed to a T-handle was inserted via the entry point (Fig. 1). Prior to introduction, nail tip was straightened slightly to allow better gliding in the medullary canal. The nail was advanced with corkscrew movements until it reached the fracture site. Closed reduction was performed under fluoroscopic control using percutaneously introduced towel clips (Fig. 2). If closed reduction failed, an accessory incision of 3-4 cm was made directly over the fracture site for manipulation.

The nail was then advanced till it reached medial to the acromioclavicular joint. Care was taken to prevent penetration of the thin dorsal cortex. After complete introduction, the nail was cut short and slightly bent at the medial end to prevent soft tissue irritation at the same time maintaining enough length for easy extraction later on. The fascia and skin were closed in layers. Postoperatively, the affected limb was placed in a sling for 3-4 weeks, which prevented the arm from drooping and interfering with bony union while allowing early postoperative mobilisation. Postoperatively, active exercises were started as per pain tolerance. However, overhead abduction and elevation were avoided to prevent rotational malalignment till 4 weeks. Heavy activities were delayed till union was achieved. All patients were reviewed in the outpatient department at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months after surgery. At the final follow up, patients were examined for range of motion, bilateral clavicle length difference between the sternal ends to acromial ends, and status of union.

Absence of pain, tenderness, and frank mobility clinically and trabecular continuity on radiograph were used as criteria to define union. Time to achieve union and to return to normal activities was recorded. All intraoperative and postoperative complications were recorded. Patients were evaluated on functional outcome using the Constant score.[11] and Disabilities of the Arm, Shoulder, and Hand (DASH) score.[12] Constant score at 12 months was taken to be the primary outcome measure. In our study, implant removal was not done routinely. It was done as per need and will of the patient after fracture union. Statistical analyses were performed by using the SPSS 20.0 program. Comparison between evaluative scores at baseline and subsequent follow-ups was done using Wilcoxon Signed-Rank Tests. $p<0.05$ was considered significant.

RESULTS: Out of a total of 34 patients who met the inclusion criteria, there were 26 males and 8 females with a mean age of 39.1 years [SD 10.02, range 19-56 years]. The demographic and clinical characteristics of the patients are given in Table 1. Based on OTA classification system, 28 fractures were type B1 and 3 were B2 and 3 were B3 (Fig. 3). The mean trauma surgery delay was 5.91 days [SD 1.96, range 2-10 days]. Closed reduction was possible in 20 patients (58.82%) while remaining 14 patients (41.18%) required open reduction. Titanium elastic nails of diameter 2.5 mm were used in 18 patients while rest 16 patients required 2 mm diameter. All the patients achieved clinical and radiological union at a mean of 9.38 weeks [SD 1.44, range - 7-14 weeks] (Fig. 4). In patients where closed reduction was done, the union occurred earlier at mean duration of 8.9 weeks [SD 1.45, range - 6-12 weeks], whereas in open reduction group, the mean duration for union was 10.36 weeks [SD 1.60, range 9-14 weeks], which was statistically significant ($p=0.0093$) (Table 2).

The patients were followed up postoperatively with Constant score and DASH scores at 6 weeks, 3 months, 6 months, and at last follow up at 12 months (Table 3). All patients were followed up either at outpatient department or their home and none were lost to follow up. The primary outcome measure of Constant score at 12 months was 93.37 (SD-3.06, range: 89-100). The final mean DASH score was 5.63 (SD-2.66, range: 2-10). The difference in Constant and DASH scores between 6 weeks and 12 months were statistically significant. ($p<0.001$) 3 (8.82%) cases were complicated with shortening >0.5 cm, 3 (8.82%) had superficial infection, and 7 (20.58%) patients had medial TEN protrusion (Table 4). There were no major complications in our study such as nonunion, nail breakage, cortical perforation, and refracture.

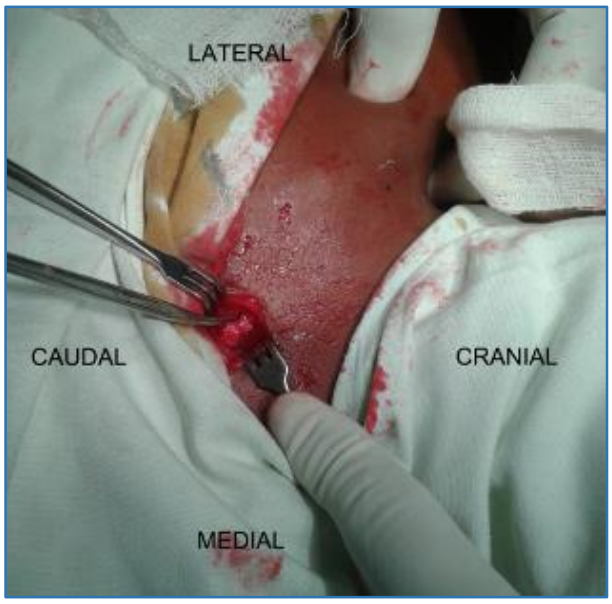

Fig. 1: Surgical Incision 1 cm Lateral to the Sternoclavicular Joint

Fig. 2: Closed Reduction Using Percutaneous Towel Clip under Fluoroscopic Guidance

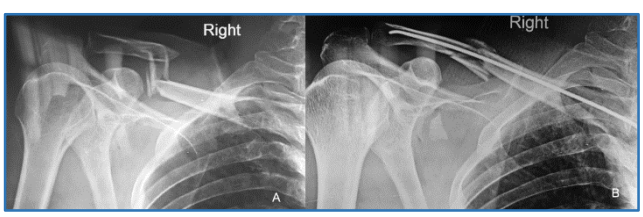

Fig. 3a, 3b

Fig. 3a: Comminuted Fracture of Clavicle with Significant Shortening.

Fig. 3b: Postoperative Radiograph Showing Good Reduction and Maintenance of Alignment and Length with TENs.

Fig. 4a, 4b, 4c

Fig. 4a: Preoperative x-ray showing displaced midshaft clavicle fracture (OTA B2. 1).

Fig. 4b: Immediate postoperative x-ray showing good reduction.

Fig. 4c: Postoperative after implant removal showing union and maintenance of length.

Fig. 5: Cosmetically Acceptable Small Surgical Scar

Characteristics		Study Group
Age, years (Mean±SD)		39.1±10.02
Sex	Male, n (%)	26(76.47%)
	Female, n (%)	8(23.53%)
Side	Left, n (%)	13(38.24%)
	Right, n (%)	21(61.76%)
OTA Classification, n (%)	B1	28(82.35%)
	B2	3(8.82%)
	B3	3(8.82%)
Mode of Injury, n (%)	RTA	24(70.59%)
	Fall	5(14.71%)
	Assault	5(14.71%)

Table 1: Demographic and Clinical Characteristics of 34 Patients Included in the Study

Parameters Analysed		Results	
Duration of Injury, Days (Mean± SD)		5.91±1.96	
Type of Reduction, n (%)	Closed	20(58.82%)	
	Minimally Open	14(41.18%)	
Nail Diameter, n (%)	2 mm	16(47.06%)	
	2.5 mm	18(41.18%)	
Union, n (%)		34(100%)	
Union Time, Weeks (Mean± SD)	Average	9.38±1.44	
	Closed Group	8.90±1.45	p=0.0093
	Open Group	10.36±1.60	
Final Constant Score, (Mean±SD)		93.37±3.06	
Final Dash Score, (Mean±SD)		5.63±2.66	

Table 2: Outcome Analysis

	6 Weeks	3 Months	6 Months	12 Months	P Value (6 Weeks-12 Months)
Constant Score (Mean±SD)	72.5±4.28	82.75±6.06	91.48±3.54	93.37±3.06	p < 0.001
DASH Score (Mean±SD)	11.96±5.55	7.48±2.65	5.94±2.86	5.63±2.66	p < 0.001

Table 3: Comparison of Functional Scores at Follow Ups

Complications	n (%)
Medial TEN protrusion	7(20.59%)
Superficial infection	3(8.82%)
Shortening > 0.5cm	3(8.82%)

Table 4: Complications Noted in Study Group

DISCUSSION: The present trend is to treat displaced midshaft clavicular fractures by operative methods owing to high rates of malunion, nonunion, prolonged pain, and disability with nonoperative treatment.[13] Various operative treatment modalities are available including plating, nailing, and external fixation. Plating is the most commonly used procedure and is biomechanically superior to other modalities as it better resists torsional and bending forces.[14] However, plating requires long incision and relatively extensive periosteal stripping leading to ugly scar, dysaesthesia, compromised blood supply hindering fracture healing, and hardware prominence. Increased duration of surgery and extensive exposure is associated with high infection rates up to 18%.[15] Rigid plates cause stress shielding, which leads to higher rates of re-fracture after implant removal.[16] Intramedullary nailing with TENs have been used for fixations of DMCFs with excellent results and minimal complications.[17]

Due to its elastic nature, the nails match the contour of the clavicle without compromising its strength being composed of titanium alloy. The entry through the medial cortex, the tight fit inside the curved cavity, and the anchor at the lateral end by its curved tip provides stable 3-point bony fixation.[16] The incision is considerably smaller giving better cosmetic results (Fig 5) and biological fixation without opening the fracture site can be achieved in majority of the cases leading to better union rates.[16] Micromotion at fracture site leads to secondary bone healing by callus formation. Being intramedullary, there is less stress shielding, which leads to lower refracture rates as compared to plate fixation.

Our study with a follow up of 12 months revealed union in all 34 patients. No patients were lost to follow up. The average time of union was 9.38±1.44 weeks, which is comparable to other studies in literature.[18],[19] However, the union time was shorter in closed group, which was statistically significant (p=0.0093). The final mean Constant and DASH scores were 93.37±3.06 and 5.63±2.66 respectively. The functional results were comparable to other similar studies: mean Constant score 95.2 in the study by Jubel et al[17], mean Constant score of 95.2±1.9, and mean DASH score of 5.0±2.3 in study by Mueller et al[20]. The most common complication encountered in our study was medial TEN protrusion (n=7; 20.58%).

This complication has been recorded most frequently in other studies as well with a range of 5.2-38.8%.[21],[17],[22]

The medial protrusion causes skin irritation and pain and may even lead to skin perforation. This complication can be prevented by anatomical reduction of the fracture to prevent telescoping, cutting the nail tip as near to the medial cortex as possible, by burying the bent nail tip below layer of soft tissue, preventing early abduction >90º postoperatively (Not less than 2 weeks), and using medial end caps.[22],[17]

Clavicular shortening >0.5 cm occurred in 3 (8.82%) of our patients who had slightly comminuted fractures. However, this did not affect their functional results. Smekal et al did not recommend the use of TEN in grossly comminuted fractures as it would lead to shortening.[23]

It is for the same reason we excluded grossly comminuted OTA type B3.3 from our study. However, as per Lazarides et al., shortening causes unsatisfactory results only when it is more than 18 mm in males and 14 mm in females.[24] The other complication, which occurred in our study was superficial skin infection (n=3; 8.82%), which is less than what is reported in literature (up to 18%).[5] The present study did not report some complications that have been described in the literature such as nonunion, nail breakage, nail dislocation, refracture, or secondary revision.[17]

The limitations in our study were relatively small sample size done at a single centre, short follow-up time, and having no comparison groups. However, we were able to interpret our results by comparison with other studies published in literature using similar methods. Thus, we can conclude that intramedullary fixation of DMCFs with TENs is a minimally invasive, safe, and effective procedure, which provides good functional outcome, high union rate, early pain relief, return to work, and better cosmetic results with minimal complications in indicated cases.

Ethical Standard Statement: All patients gave the informed consent prior to being included into the study. All procedures involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments. The study was approved by the Research Ethics Committee of the Institution.

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