

Original Research Article

Functional outcomes after titanium elastic nailing of mid-shaft clavicle fractures in a rural tribal cohort of Western Maharashtra

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ABSTRACT

Background: Mid-shaft clavicle fractures are common injuries, often affecting young active individuals. Although plating has traditionally been used for displaced fractures, Titanium Elastic Nailing (TENS) offers a minimally invasive alternative with potential advantages of faster recovery, cosmesis, and ease of implant removal. Limited evidence exists on outcomes in rural tribal populations, where occupational demands and access to rehabilitation may differ from urban cohorts.

Methods: This prospective observational study was conducted at a tertiary care teaching hospital in Western Maharashtra from January 2023 to June 2024. Thirty adult patients (mean age 34 years; 76.6% male) with displaced mid-shaft clavicle fractures underwent intramedullary fixation with TENS. Patients with open, medial, or lateral third fractures were excluded. Functional outcomes were assessed using the Constant–Murley Score (CMS), Disabilities of the Arm, Shoulder and Hand (DASH) score, and Visual Analogue Scale (VAS) for pain at baseline and scheduled follow-ups. Radiological union and complications were recorded.

Results: Ninety percent of patients achieved radiological union by one month, increasing to 96.7% by three months. The mean union time was 12.2 weeks. At final follow-up, the mean CMS was 96.2, mean DASH score was 2.3, and mean VAS score improved from 7.1 preoperatively to 1.2. Complications were minor, including superficial infection (n=2), nail migration (n=2), skin irritation (n=3), and hypertrophic scarring (n=1). No nonunion, implant failure, or deep infection occurred.

Conclusions: TENS is an effective and safe option for displaced mid-shaft clavicle fractures in rural tribal patients, providing excellent functional outcomes, reliable union, and minimal complications. Its minimally invasive nature makes it particularly suitable for resource-limited settings.

Keywords: Clavicle fractures, Titanium elastic nailing, Intramedullary fixation, Functional outcomes, Rural population, India

INTRODUCTION

Clavicle fractures are among the most frequently encountered injuries of the shoulder girdle, accounting for nearly 80% of all clavicular fractures, with the mid-shaft region being most commonly involved due to its relative structural weakness and exposure to external forces.^{4,5} Traditionally, these fractures were managed

conservatively with slings or figure-of-eight bandages. While such non-operative methods are suitable for minimally displaced fractures, displaced mid-shaft fractures have shown higher rates of malunion, nonunion, cosmetic deformity, and compromised functional recovery.⁵ Over the past two decades, there has been a paradigm shift towards operative fixation for displaced mid-shaft clavicle fractures, supported by increasing

evidence of improved outcomes and reduced complications compared with conservative treatment.^{4,10} Among surgical options, plate fixation has long been considered the gold standard, offering stable and rigid fixation. However, it is associated with relatively higher rates of infection, hardware irritation, and soft tissue complications due to extensive periosteal stripping and larger incisions.^{11,12} In contrast, intramedullary fixation techniques, particularly the TENS, have gained popularity as a minimally invasive alternative. TENS provides adequate stability through biological fixation, requires smaller incisions, preserves periosteal blood supply, allows easier implant removal, and is cosmetically superior.^{13,14} A growing body of literature supports its safety and efficacy, with several randomized controlled trials and meta-analyses demonstrating comparable or superior outcomes compared with plating in appropriately selected patients.¹⁰⁻¹⁴

In the Indian context, studies have shown encouraging results with TENS in terms of functional recovery and union rates, but most reports are from urban or tertiary-care settings.⁶⁻⁹ Very few studies have explored outcomes in rural or tribal populations, where differences in access to healthcare, compliance with rehabilitation, and injury mechanisms may influence results. This gap is particularly relevant in regions like Western Maharashtra, where a large proportion of the population resides in tribal belts with limited surgical and physiotherapy facilities.

Assessment of surgical outcomes requires reliable and validated tools. The CMS, DASH questionnaire, and VAS are widely accepted measures to evaluate functional recovery, disability, and pain, respectively.¹⁻³ Incorporating these standardized outcome measures ensures comparability with international literature and provides a comprehensive understanding of patient recovery. Given these considerations, the present study was designed to evaluate the functional outcomes of mid-shaft clavicle fractures treated with Titanium Elastic Nailing in a rural tribal cohort of Western Maharashtra. By focusing on this underserved population, the study aims to contribute locally relevant evidence that may guide clinical decision-making in similar low-resource settings.

METHODS

Study design and setting

This was a prospective observational study conducted in the Department of Orthopaedics at a tertiary care teaching hospital catering predominantly to rural and tribal populations of Western Maharashtra. The study period extended from January 2023 to June 2024.

Study population

Thirty adult patients, aged between 20 and 60 years, presenting with displaced mid-shaft clavicle fractures were included.

Inclusion criteria

Displaced mid-shaft clavicle fractures (>2 cm displacement or shortening), closed fractures, age 20–60 years. Patients willing to undergo surgical management and provide informed consent

Exclusion criteria

Open fractures, medial or lateral third clavicle fractures, pathological fractures, patients with associated major neurovascular injuries, patients unfit for anesthesia or lost to follow-up

Sample size

A convenience sample of 30 consecutive eligible patients was enrolled during the study period.

Surgical technique

All procedures were performed under general anesthesia. A small incision was made at the medial end of the clavicle, and the anterior cortex was opened with an awl. A pre-bent titanium elastic nail of appropriate diameter was inserted into the medullary canal and advanced across the fracture site under fluoroscopic guidance until positioned just medial to the acromioclavicular joint.

In cases requiring assistance, a small incision over the fracture was used to aid reduction. Postoperatively, patients were placed in a sling for comfort. Early pendulum and assisted shoulder mobilization exercises were initiated from the second postoperative day, with overhead abduction and flexion restricted for six weeks. Routine implant removal was performed after radiological union.

Follow-up and outcome measures

Patients were followed up at four-week intervals for at least 12 weeks. Clinical and radiological assessments were performed at each visit. Functional outcomes were measured using the Constant–Murley Score (CMS), Disabilities of the Arm, Shoulder and Hand (DASH) score, and Visual Analogue Scale (VAS) for pain. Radiological union was defined as cortical continuity with bridging callus across at least three cortices.

Statistical analysis

Data were tabulated using Microsoft Excel and analyzed with SPSS v21.0 (IBM Corp., USA). Continuous variables were expressed as means with standard deviations, while categorical data were summarized as frequencies and percentages. Comparative analyses were performed using paired t-tests for functional scores across follow-up intervals. A p value of <0.05 was considered statistically significant.

Ethical considerations

The study protocol was approved by the Institutional Ethics Committee (Approval No.: EC/17/2023). Written informed consent was obtained from all participants before inclusion in the study. The study adhered to the ethical principles of the Declaration of Helsinki.

RESULTS

Patient demographics

A total of 30 patients with displaced mid-shaft clavicle fractures were included. The mean age was 34 years (range: 20–60 years). The majority were male (76.6%, n=23).

The most common mode of injury was road traffic accidents (RTA), followed by falls on the shoulder and fall on an outstretched hand. The right side was more frequently involved than the left.

Table 1: Baseline characteristics of patients (n=30).

Parameter	Value
Mean age (in years)	34 (range 20–60)
Male: Female ratio	23: 7
Side involved	Right: 18, Left: 12
Mechanism of injury	RTA: 20, Fall on shoulder: 6, FOOSH: 4

Table 2: Radiological union.

Follow-up	Patients with union (%)
1 month	27 (90.0)
3 months	29 (96.7)
Mean time to union (weeks)	12.2

Table 3: Functional outcomes.

Outcome measure	Pre-op/baseline	Final follow-up
Constant–murley score (CMS)	–	96.2 (Excellent)
DASH score	–	2.3
VAS score	7.1	1.2

Table 4. Complications.

Complication	Number of patients
Superficial infection	2
Skin irritation	3
Nail migration	2
Hypertrophic scar	1
Non-union/deep infection	0
Implant failure	0

Union

Radiological evidence of union was observed in 90% of cases at one month and in 96.7% by three months. The mean time to complete union was 12.2 weeks.

Functional outcomes

Functional assessment showed progressive improvement during follow-up. At the final evaluation, the mean Constant–Murley Score (CMS) was 96.2, representing excellent shoulder function. The mean DASH score decreased to 2.3, indicating minimal residual disability. Pain improved significantly, with the mean Visual Analogue Scale (VAS) score reducing from 7.1 preoperatively to 1.2 at final follow-up ($p<0.05$).

Complications

Minor complications were observed in eight patients. These included superficial infection in two cases, skin irritation at the nail entry site in three cases, nail migration in two cases, and hypertrophic scarring in one case. No patient developed deep infection, nonunion, implant failure, or neurovascular injury. Implant removal was performed routinely following radiological union without difficulty.

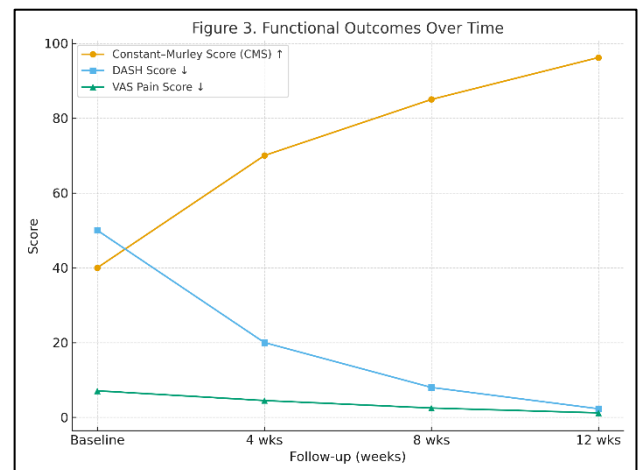


Figure 1: Functional outcomes over time.

DISCUSSION

Mid-shaft clavicle fractures are traditionally managed non-operatively; however, displaced fractures often result in symptomatic malunion, cosmetic deformity, and poor function if left untreated.^{4,5} The study supports the growing body of evidence that surgical stabilization, particularly using TENS, provides reliable union and excellent functional outcomes.¹⁰⁻¹⁴

In the present study, 90% of patients achieved radiographic signs of union at one month, and 96.7% united by three months, with a mean time to union of 12.2

weeks. These findings are consistent with Fuglesang et al and Silva et al who reported union rates above 95% with TENS and plating, respectively.^{10,11} The excellent union rate in our series underscores the biological fixation advantage of TENS, achieved with minimal periosteal stripping and preservation of fracture hematoma.¹³⁻¹⁴

Functional recovery was remarkable, with a mean Constant–Murley Score of 96.2 and DASH score of 2.3 at final follow-up. This compares favorably with Agrawal and Belapurkar et al who reported CMS scores averaging 94 in Indian patients treated with intramedullary fixation.⁷ Similarly, Rahangdale et al observed rapid functional recovery with TENS in rural populations, highlighting its suitability in low-resource settings.⁸ The improvement in VAS scores from 7.1 to 1.2 in our cohort mirrors results by Kumar et al confirming that intramedullary fixation achieves both pain relief and functional restoration.⁹

Complications in the series were minor and included superficial infection, nail migration, skin irritation, and hypertrophic scarring. Importantly, there were no cases of nonunion, implant failure, or deep infection. These findings align with Wang et al and Fu et al who also observed low rates of major complications with TENS, though nail-related issues remain a recognized drawback. In the study, careful selection of nail diameter and meticulous medial entry technique mitigated these risks.^{12,13}

The rural tribal context of this study adds novelty. Unlike urban populations, patients in this region often engage in manual labor and have limited access to prolonged rehabilitation. Early recovery and return to activity, observed in our series, highlight the value of TENS in such communities. Furthermore, the smaller incision and superior cosmesis associated with TENS may be particularly relevant for younger, active patients.⁶

Strengths

The strengths of this study include its prospective design, standardized surgical technique, and focus on an underserved rural cohort.

Limitations

However, limitations must be acknowledged: the modest sample size (n=30), lack of a comparative plating or conservative treatment arm, and relatively short follow-up period of three months restrict the generalizability of findings. Quantitative long-term functional scoring and evaluation of late complications such as refracture after nail removal were beyond the study scope.

CONCLUSION

Titanium Elastic Nailing is a safe and effective treatment for displaced mid-shaft clavicle fractures in rural tribal populations of Western Maharashtra. It provides high

union rates, excellent functional outcomes, significant pain relief, and low complication rates. Its minimally invasive nature, superior cosmesis, and ease of implant removal make it particularly suitable for resource-limited settings where access to rehabilitation may be restricted. Future studies with larger sample sizes, longer follow-up, and comparative arms are needed to validate these findings further.

Future directions

Larger randomized controlled trials with longer follow-up are needed, particularly in rural and resource-limited populations, to establish cost-effectiveness and patient satisfaction. Comparative studies with plating in similar cohorts may provide stronger evidence to guide treatment decisions.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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