

## Functional and radiological outcomes of titanium elastic nailing in adult both-bone forearm fractures with proximal one-third radial shaft fractures: A prospective single-arm clinical study.

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### Abstract

#### Background:

Adult diaphyseal fractures of both forearm bones require restoration of alignment, radial bow, and forearm rotation. Proximal one-third radial shaft fractures are technically demanding because open plating in this zone requires greater soft-tissue dissection and carries a risk of posterior interosseous nerve irritation.

#### Objectives:

To evaluate the functional and radiological outcomes of titanium elastic nailing in adult patients with both-bone forearm fractures associated with proximal one-third radial shaft fractures.

#### Methods:

This prospective single-arm study was conducted with 30 adult patients who underwent titanium elastic nailing. Patients were followed for at least one year. Forearm supination-pronation, pain by visual analog scale, radiological union, and return to work were assessed serially.

#### Results:

The cohort consisted predominantly of men [80.0%], and the most common age group was 31-40 years [36.7%]. Road traffic accident was the leading mechanism of injury [56.7%]. Closed reduction with titanium elastic nails was achieved in 29 patients, while one patient required limited open reduction for soft-tissue interposition. Fracture union was obtained in all 30 patients, with an average union time of 5 months. At final follow-up, all patients were pain-free, had painless near-maximum forearm rotation, and had returned to their previous work. No iatrogenic neurovascular or tendon injury, implant failure, delayed union, non-union, or secondary procedure was observed.

#### Conclusion:

Titanium elastic nailing provided stable fixation, reliable union, and excellent early functional recovery in this selected adult fracture pattern. It appears to be a useful minimally invasive option for proximal one-third radial shaft fractures associated with both-bone forearm injuries.

#### Recommendations:

Early TENS fixation with careful case selection, meticulous technique, and structured follow-up is recommended to achieve stable union and favorable function.

**Keywords:** Adult forearm fractures; both-bone forearm fracture; proximal radial shaft fracture; titanium elastic nailing; intramedullary fixation; functional outcome

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## Introduction

Fractures of the radius and ulna in adults are among the most functionally important long-bone injuries because even small degrees of angulation, malrotation, or loss of radial bow can compromise pronation and supination. For that reason, adult diaphyseal forearm fractures have often been described as functionally equivalent to intra-articular injuries that demand precise restoration of anatomy and stable fixation [1,2]. Conventional open reduction and internal fixation with compression plating remains a widely accepted standard because it allows direct reduction, rotational control, and high union rates [1,2].

Despite these advantages, plate osteosynthesis requires a relatively extensive exposure, periosteal stripping, and greater manipulation of the fracture environment. In proximal one-third radial shaft fractures, the dissection becomes more demanding because of the surrounding supinator-pronator musculature and the proximity of the posterior interosseous nerve. Anatomical studies and clinical reports have emphasized the importance of careful handling of this region during surgery because nerve irritation or injury can adversely affect postoperative recovery [3,14].

These concerns have renewed interest in intramedullary fixation strategies that preserve fracture biology and reduce soft-tissue trauma. Modern intramedullary devices offer a minimally invasive alternative and have shown acceptable union and functional outcomes in selected adult forearm fractures [3-7]. Comparative studies have reported that intramedullary fixation can approach plate fixation in terms of healing and functional restoration, while potentially reducing surgical dissection and implant-related morbidity [4,6,7]. More recent work has suggested that hybrid fixation and newer nail designs can further expand the indications for intramedullary treatment in adults [8-12].

The proximal radial shaft represents a particularly relevant indication for such a strategy. Huang et al. demonstrated that the titanium elastic nail can serve as an alternative treatment for adult proximal radial shaft fractures, especially when soft-tissue preservation is prioritized [8]. Other adult series of forearm intramedullary fixation have also reported reliable union with acceptable complication rates, although concerns regarding rotational stability, implant irritation, and delayed union persist in some cohorts [5,9,10,13]. Therefore, patient selection, fracture morphology, and meticulous operative technique remain central to the success of nailing in this region. In this context, the present prospective study was undertaken to evaluate the functional and radiological outcomes of titanium elastic nailing in adult patients with both-bone forearm fractures associated with proximal one-third radial shaft fractures. The specific objectives were to assess forearm rotational recovery, pain relief, radiological union, procedure-

related complications, and time to return to previous work following treatment with titanium elastic nails.

## Methodology

### Study design and setting

This hospital-based cross-sectional prospective single-arm clinical study was conducted in the Department of Orthopaedics, Malla Reddy Institute of Medical Sciences, Hyderabad, Telangana, India, from February 2025 to September 2025. The study was designed to evaluate the functional and radiological outcomes of the titanium elastic nailing system fixation in adult patients with both-bone forearm fractures associated with proximal one-third radial shaft fractures. All enrolled patients underwent titanium elastic nailing, and no separate comparison group was included. The study incorporated baseline cross-sectional clinical and radiological assessment followed by prospective postoperative follow-up to document fracture union, functional recovery, pain status, complications, and return to previous work.

Malla Reddy Institute of Medical Sciences is a tertiary care teaching hospital providing outpatient, emergency trauma, inpatient, radiological, operative, and rehabilitation services. The Department of Orthopaedics caters to patients from Hyderabad and surrounding urban, semi-urban, and rural regions of Telangana, including trauma referrals from peripheral hospitals and primary care facilities. The availability of regular orthopaedic trauma admissions, emergency fracture care, operation theatre facilities, fluoroscopic support, radiology services, and structured postoperative follow-up made the study setting suitable for evaluating outcomes after titanium elastic nailing in this defined fracture pattern.

### Study population

The study population included adult patients presenting to the Department of Orthopaedics with radiologically confirmed both-bone forearm fractures in which the radial shaft fracture was located in the proximal one-third. Patients were screened clinically and radiographically before enrolment. A total of 30 consecutive eligible patients were included in the final analysis, and all participants completed the planned postoperative follow-up.

### Sample size determination

The sample size was estimated using the single-proportion formula:

$$n = Z^2pq / d^2$$

where n represents the required sample size, Z is the standard normal value at 95% confidence level [1.96], p is the expected proportion of favourable outcome or fracture union after titanium elastic nailing [95%], q is 1 - p [5%], and d is the allowable absolute error [8%].

$$n = 1.96^2 \times 0.95 \times 0.05 / 0.08^2$$

$$n = 3.8416 \times 0.0475 / 0.0064$$

$$n = 28.5$$

The minimum required sample size was therefore approximately 29 patients. Considering feasibility, availability of eligible cases during the study period, and completion of follow-up, 30 patients were included in the study.

### Sampling technique

A consecutive sampling technique was used. All adult patients who presented during the study period, fulfilled the eligibility criteria, provided written informed consent, and underwent titanium elastic nailing were enrolled until the required sample size was achieved.

### Inclusion criteria

Patients were included if they were aged 18 years or above; had radiologically confirmed fractures of both bones of the forearm; had a radial shaft fracture involving the proximal one-third; were planned for operative fixation using titanium elastic nails; were medically fit for surgery and anaesthesia; provided written informed consent; and were willing to attend regular postoperative and radiological follow-up.

### Exclusion criteria

Patients were excluded if they were younger than 18 years of age; had isolated radius or isolated ulna fractures; had radial shaft fractures not involving the proximal one-third; had pathological fractures, old neglected fractures, or malunited fractures; had open fractures with severe soft-tissue loss or contamination requiring an alternative fixation method; had intra-articular fracture extension; had associated neurovascular injury requiring separate repair; had associated ipsilateral upper-limb injuries likely to interfere with functional outcome assessment; had previous surgery, deformity, or chronic disability of the affected forearm; or were unwilling to participate or unable to complete follow-up.

### Operative procedure

After routine preoperative evaluation and radiographic confirmation of fracture morphology, all patients underwent titanium elastic nailing under standard aseptic precautions. Surgery was performed under appropriate anaesthesia with fluoroscopic guidance. The ulna was stabilized first, followed by preparation of the radial entry point and insertion of the titanium elastic nail. Closed reduction was attempted in all cases as the preferred method. Limited open reduction was performed only when satisfactory closed reduction could not be achieved because of soft-tissue interposition at the fracture site. The operative aim was to obtain stable intramedullary

fixation while preserving fracture biology and minimizing soft-tissue dissection.

### Postoperative care and follow-up

Postoperatively, the operated limb was immobilized using a long-arm splint or cast with the forearm in supination for 4 weeks. Patients were followed at regular intervals in the orthopaedic outpatient department. Clinical assessment included pain evaluation using the visual analog scale and measurement of forearm supination and pronation. Radiological assessment was performed using serial forearm radiographs to evaluate callus formation, maintenance of reduction, implant position, and fracture union. After cast removal, active and passive elbow, wrist, and forearm range-of-motion exercises were gradually encouraged. All patients were followed according to the study protocol to assess radiological healing and functional recovery.

### Outcome measures

The primary outcome measure was functional recovery of forearm rotation, assessed by improvement in supination and pronation. The secondary outcome measures included time to radiological union, pain status during follow-up, return to previous work, maintenance of fracture reduction, implant-related complications, iatrogenic nerve, vessel, or tendon injury, delayed union, non-union, implant failure, and requirement for secondary intervention or bone grafting.

### Bias

Potential selection bias was minimized by enrolling consecutive eligible patients using predefined inclusion and exclusion criteria. Since this was a hospital-based single-arm study, the findings may primarily represent patients treated in a tertiary care orthopaedic trauma setting and may not be fully generalizable to community or primary-care populations. Referral bias may also have occurred because more complex trauma cases are commonly referred to tertiary centres. To reduce information and observer bias, all patients were assessed using a uniform clinical and radiological follow-up protocol. However, the absence of a comparison group remains an important methodological limitation, and the findings should not be interpreted as evidence of superiority over plate osteosynthesis.

### Statistical analysis

Data were entered into a spreadsheet and analyzed using descriptive statistics. Categorical variables, including sex, side involved, mode of injury, reduction method, union status, complications, and return to work, were expressed as frequencies and percentages. Continuous variables, including age, time to union, pain score, and range of motion, were

summarized using mean and standard deviation where applicable. Serial follow-up observations were reviewed descriptively to identify trends in pain reduction, improvement in forearm rotation, radiological progression of union, and return to function. As the study was single-arm with a limited sample size and no control group, no comparative inferential statistical testing was performed.

### Ethical considerations

Ethical approval was obtained from the Institutional Ethics Committee of Malla Reddy Institute of Medical Sciences, Hyderabad, Telangana, India, before commencement of the study. The study was conducted in accordance with accepted ethical principles for biomedical research involving human participants. Confidentiality of patient identity and clinical data was maintained throughout the study, and the collected information was used only for academic and research purposes. Written informed consent was obtained from all participants before enrolment. Each patient was informed in a language understandable to them about the nature of the fracture, the proposed surgical procedure, the purpose of the study, follow-

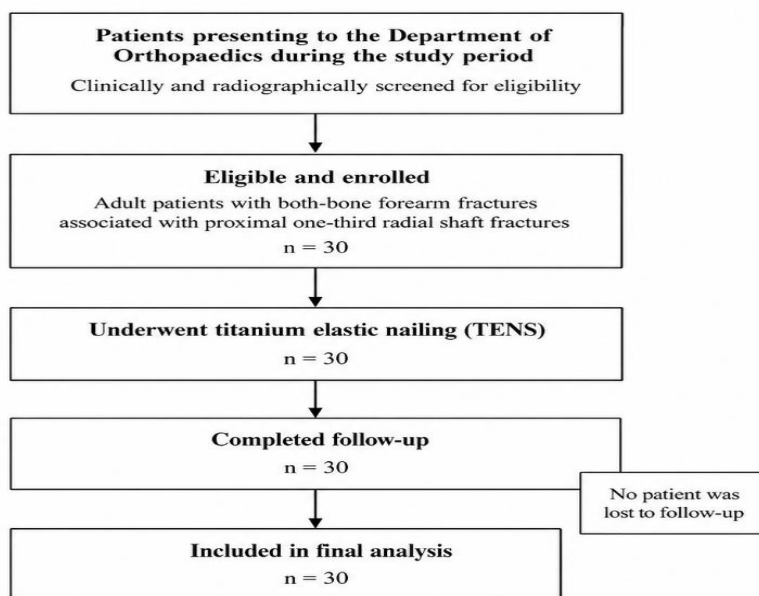
up requirements, potential benefits, possible risks, confidentiality of data, and the voluntary nature of participation. Patients were also informed that they could withdraw from the study at any stage without any effect on their standard treatment.

### Results

#### Participant flow

During the study period, consecutive adult patients presenting to the Department of Orthopaedics with both-bone forearm fractures were screened clinically and radiographically for eligibility. Patients were assessed based on age, fracture pattern, location of the radial shaft fracture, medical fitness for surgery, suitability for titanium elastic nailing, willingness to participate, and ability to attend follow-up. Thirty adult patients fulfilled the predefined eligibility criteria, provided written informed consent, and were enrolled in the study. All 30 enrolled patients underwent titanium elastic nailing and were followed according to the study protocol. No enrolled patient was excluded after recruitment, no patient was lost to follow-up, and all 30 patients were included in the final analysis.

**Participant Flow Diagram**



**Figure 1.** Flow diagram of participant recruitment and follow-up.

A total of 30 adult patients with both-bone forearm fractures associated with proximal one-third radial shaft fractures were included in the study. The cohort was predominantly male, with the highest proportion of patients in the 31-40 years age group.

The right forearm was more commonly involved, and a road traffic accident was the leading mode of injury. The baseline demographic and injury-related profile is presented in Table 1.

**Table 1. Baseline demographic and injury characteristics of study participants [n = 30]**

Variable	Number	Percentage [%]
Age group [years]		
18-30	8	26.7
31-40	11	36.7
41-50	7	23.3
>50	4	13.3
Sex		
Male	24	80.0
Female	6	20.0
Side involved		
Right	18	60.0
Left	12	40.0
Mode of injury		
Road traffic accident	17	56.7
Self-fall	9	30.0
Other trauma	4	13.3

Titanium elastic nailing was performed successfully in all patients. Closed reduction was achieved in the majority, while one patient required limited open reduction because of soft-tissue interposition at the fracture site. No patient sustained

intraoperative iatrogenic injury to nerves, vessels, or tendons, and no secondary procedure, such as bone grafting, was required. These procedural details are summarized in Table 2.

**Table 2. Operative details of study participants [n = 30]**

Variable	Number	Percentage [%]
Closed reduction with TENS	29	96.7
Limited open reduction with TENS	1	3.3
Iatrogenic nerve injury	0	0
Iatrogenic vessel injury	0	0
Iatrogenic tendon injury	0	0
Secondary intervention required	0	0
Bone grafting required	0	0

Radiological union was achieved in all patients. The average time to union was 5 months. Serial postoperative radiographs demonstrated satisfactory fracture healing without evidence of

implant failure, loss of reduction, delayed union, or non-union. Radiological outcomes are shown in Table 3.

**Table 3. Radiological outcomes following TENS fixation [n = 30]**

Radiological outcome	Number	Percentage [%]
Fracture union achieved	30	100
Average time to union	5 months	-
Delayed union	0	0
Non-union	0	0
Implant failure	0	0
Loss of reduction	0	0

Functional recovery was favorable in the entire cohort. At final follow-up, all patients were pain-free and had regained painless near-maximum forearm supination and pronation. All patients

returned to their previous work at approximately 5 months after injury. Functional outcomes are detailed in Table 4.



**Figure 1: PRE OP X RAY**

**Table 4. Functional outcomes at final follow-up [n = 30]**

Functional outcome	Number	Percentage [%]
Pain-free at final follow-up	30	100
Painless near-maximum forearm range of motion	30	100
Return to previous work by approximately 5 months	30	100

Overall, the study demonstrated that TENS fixation in adult both-bone forearm fractures with proximal one-third radial shaft involvement resulted in excellent fracture union, good functional recovery, and a very low complication rate.



**Figure 2: Immediate Post OP X RAY**



**Figure.3: After 5 Months X-RAY**

### Discussion

The present prospective study evaluated titanium elastic nailing in a selected group of adult both-bone forearm fractures associated with proximal one-third radial shaft fractures. The principal findings were consistent union in all patients, an average union time of 5 months, complete pain relief at final follow-up, restoration of painless near-maximum forearm rotation, and absence of major procedure-related complications. These results support the view that

intramedullary fixation can be a useful biologic alternative in carefully selected adult forearm fractures, particularly when the proximal radius is involved [3,6,8,11].

Compression plating has traditionally been regarded as the benchmark for adult forearm shaft fractures because of its ability to restore length, radial bow, and rotational alignment with high union rates [1,2]. However, the price of this stability is broader soft-tissue exposure and periosteal stripping. In proximal radial shaft fractures, these concerns become more relevant because the operative corridor is constrained by

surrounding musculature and by the proximity of the posterior interosseous nerve [3,14]. A minimally invasive intramedullary technique aims to reduce this dissection burden while still providing acceptable alignment and fracture stability.

Our findings compare favorably with earlier adult intramedullary series. Weckbach et al. and Lee et al. reported that modern nailing techniques can provide satisfactory functional healing in adult forearm fractures, although concerns about torsional control and non-union remain [5,6]. Ozkaya et al. observed comparable functional healing and patient satisfaction between locked nailing and plate osteosynthesis [4]. Zhao et al., in a meta-analysis, likewise found that intramedullary fixation can offer outcomes comparable to plating in selected cases [7]. The present series is aligned with that literature, but it specifically adds prospective experience in the proximal one-third radial shaft subgroup.

The study also parallels the observations of Huang et al., who reported that titanium elastic nailing can serve as an alternative treatment for adult proximal radial shaft fractures [8]. That point is clinically important because the proximal radial shaft is one of the fracture zones in which surgeons often worry about soft-tissue disruption and nerve irritation during open plating. In the current study, only one patient required limited open reduction because of soft-tissue interposition, and no iatrogenic nerve, vessel, or tendon injury occurred. This outcome is noteworthy in view of anatomical evidence showing variability in the course of the posterior interosseous nerve around the supinator region [14].

At the same time, the present findings should be interpreted with balance. Other adult nail series have reported delayed union, implant-related problems, tendon irritation, and occasional non-union, indicating that the success of nailing is not universal across all forearm fracture patterns [9,10,12,13]. The excellent outcomes observed here likely reflect strict case selection, the use of postoperative immobilization, and the focus on a defined fracture configuration. The absence of a placebo comparison group prevents conclusions about superiority. Nevertheless, the current data suggest that titanium elastic nailing can achieve reliable healing and early functional restoration while preserving soft tissues in this demanding fracture subset.

### Generalizability

These findings are generalizable to adult patients with similar diaphyseal both-bone forearm fractures treated in tertiary care settings using TENS, particularly where careful patient selection, standardized operative technique, and regular postoperative follow-up are feasible within routine orthopaedic practice and rehabilitation.

### Conclusion

Titanium elastic nailing provided favorable results in this prospective series of adult both-bone forearm fractures with proximal one-third radial shaft involvement. The technique achieved union in all patients, allowed excellent recovery of painless forearm rotation, and was associated with the absence of major intraoperative injury, secondary procedures, or radiological failure. The findings suggest that, in carefully selected adult patients, TENS offers a minimally invasive and biologically respectful alternative to more invasive fixation methods in a fracture zone where soft-tissue preservation is particularly valuable. Larger comparative studies are required to define its precise role against plate osteosynthesis, but the present results support its use as a practical surgical option.

### Limitations

This study was conducted at a single center with a small sample and without a comparison group treated by plate osteosynthesis. The analysis was descriptive and focused on fracture union, pain, and forearm rotation. Although follow-up was adequate for early healing and functional assessment, longer-term implant-related events and formal patient-reported outcome measures were not evaluated systematically or at later review in this cohort.

### Recommendations

Based on the present findings, titanium elastic nailing can be considered a useful option for selected adult both-bone forearm fractures with proximal one-third radial shaft involvement. Careful patient selection, proper preoperative planning, gentle soft-tissue handling, accurate nail insertion, and close radiological follow-up are essential for optimal outcomes. Early mobilization after stable fixation should be encouraged to restore forearm rotation and functional recovery. Larger comparative studies with longer follow-up are recommended to validate these results, define indications more clearly, and compare TENS with plate osteosynthesis in diverse clinical settings and populations.

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### Abbreviations

TENS – Titanium Elastic Nailing System  
RTA – Road Traffic Accident  
ROM – Range of Motion  
PIN – Posterior Interosseous Nerve

OPD – Outpatient Department  
SD – Standard Deviation  
ORIF – Open Reduction and Internal Fixation  
AP – Anteroposterior  
PP – Postoperative Period

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### Conflict of interest

The authors declare no conflict of interest.

### Author contributions

**TGS**-Concept and design of the study, results interpretation, review of literature, and preparation of the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. **VC** - Design of the study, results interpretation, review of literature, preparing the first draft of the manuscript, and revision of the manuscript. **SKB**- design of the study, results interpretation, review of literature, and preparation of the first draft of the manuscript. Statistical analysis and interpretation, revision of the manuscript

### Data availability

Data is Available

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