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A comparative study of titanium elastic nailing and plate osteosynthesis for pediatric both-bone diaphyseal forearm fractures

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ABSTRACT

Background: Both-bone diaphyseal forearm fractures are common in children and require stable fixation for optimal functional recovery. Plate osteosynthesis (PO) and titanium elastic nailing (TEN) are widely used surgical techniques. Comparative evidence on outcomes between these methods remains limited.
Methods: This multicentric, comparative study included 70 children aged 5-15 years with diaphyseal both-bone forearm fractures. Thirty-five patients underwent PO and 35 underwent TEN. Functional outcomes were assessed using the price criteria, and radiological union and radial bow restoration were evaluated. Operative duration, hospital stay, and complications were also recorded.
Results: Operative time and hospital stay were significantly shorter in the TEN group compared to PO. Functional outcomes were predominantly excellent in both groups, with no significant difference. Radiological union times and restoration of radial bow were comparable between groups. Complication rates were low and similar in both groups.
Conclusions: TEN provides equivalent functional and radiological outcomes to PO, with shorter surgery and hospitalization.

Keywords: Both-bone forearm fracture, Plate osteosynthesis, Titanium elastic nailing, Pediatric orthopedics, Functional outcome

INTRODUCTION

Both-bone forearm fractures account for nearly 4% of all fractures in the pediatric population and constitute about one-quarter of upper-limb long-bone fractures in children.[1] The most frequent cause is a fall on an outstretched hand, which remains the classic mechanism of injury.[2] Diaphyseal fractures of the forearm are not only the most common open fractures in the pediatric upper extremity but also the leading site for re-fracture in this age group.[3] Fractures situated close to the physis in younger children, as well as those aligned with the primary planes of joint motion, have the highest capacity for spontaneous remodeling. Among available treatment modalities, open reduction and internal fixation (ORIF) using plates is well-documented as a dependable approach for stabilizing diaphyseal both-bone forearm fractures, ensuring stable fixation, precise anatomical alignment, and good functional recovery.[4,5] However, plating carries notable drawbacks, including soft-tissue disruption, risks to neurovascular structures, and postoperative infection associated with hardware removal.[6]

To overcome these challenges, intramedullary fixation methods such as titanium elastic nailing (TEN) have been introduced. TEN minimizes soft-tissue damage, enhances cosmetic appearance, decreases operative duration, and enables easier implant removal, making it a favorable

alternative for many clinicians and families.[7,8] Despite these benefits, some investigations have identified a greater rate of nonunion with intramedullary nails compared with plate fixation.[9] Therefore, the current study aims to evaluate and compare the clinical and functional results of diaphyseal both-bone forearm fractures managed either by plate osteosynthesis (PO) or TEN. This multicenter investigation was conducted over a one-year period to generate robust evidence on the relative effectiveness and safety of the two treatment strategies.

METHODS

Study setting

This was a multicentric, comparative, non-randomized clinical trial conducted over a period of one year from Sept 2019 to Sep 2020 in SCB Medical College, IMS and SUM Hospital, and Shree Jagannath Medical College and Hospital, Odisha.

Sample size

A total of 70 patients were enrolled, with 35 children in each treatment group. One group underwent PO and the other underwent TEN. Allocation to the surgical technique was non-randomized and based on discussion between the operating surgeon and the patient's guardians.

Inclusion criteria

Children aged 5-15 years and irreducible or unstable diaphyseal fractures or comminuted and segmental fractures of both bones of the forearm were included in study.

Exclusion criteria

Open fractures, Monteggia or Galeazzi or pathological or single-bone fractures and Fractures with associated neurovascular injury were excluded.

Data collection and analysis

Demographic and clinical information were recorded using a pre-designed semi-structured proforma. Fractures were classified using the AO/OTA system for diaphyseal fractures.[10]

Operative duration, hospital stay, and postoperative complications were documented. Functional outcomes were assessed using the Price criteria, and restoration of radial bow was evaluated on follow-up AP radiographs using the Firl and Wunsch method, compared with normal values of 7.21±1.03% for bow magnitude and 60.39±3.74% for bow location in children.[11,12]

Quantitative data were expressed as means and compared using Student's t-test, while qualitative data were analyzed using chi-square test, with $p<0.05$ considered statistically significant.

RESULTS

The study included 70 children, with 35 patients in each group. The mean age was comparable between the PO group (11.15±2.35 years) and the titanium elastic nail (TEN) group (10.95±2.41 years, p=0.47). Both groups had similar gender distribution (68.6% male, 31.4% female), mechanism and side of injury. Fracture classification according to AO/OTA and site distribution were also comparable (Table 1).

Table 1: Baseline and intra-operative details of patients, (n=70).

Variables	PO, (n=35)	TEN, (n=35)	P value
Age (in years)	11.15±2.35	10.95±2.41	0.47
Sex distribution (%)			
Female	11 (31.4)	11 (31.4)	-
Male	24 (68.6)	24 (68.6)	
Injury mechanism (%)			
Fall	23 (65.7)	23 (65.7)	NA
Road traffic accident	12 (34.3)	12 (34.3)	
Injured side (%)			
Left limb	14 (40)	17 (48.6)	0.75
Right limb	21 (60)	18 (51.4)	
AO/OTA fracture type (%)			
22A3.1	4 (11.4)	5 (14.3)	0.98
22A3.2	21 (60)	21 (60)	
22A3.3	7 (20)	5 (14.3)	
22B3.1	1 (2.9)	1 (2.9)	
22B3.2	2 (5.7)	3 (8.6)	
Fracture location (%)			
Proximal one-third	4 (11.4)	5 (14.3)	0.81
Middle one-third	25 (71.4)	25 (71.4)	
Distal one-third	6 (17.2)	5 (14.3)	
Operating time	65.61±5.91 min	42.95±6.38 min	<0.01
Length of hospital stay (days)	7.98±1.44	4.82±0.67	<0.05

Functional outcomes assessed using the Price criteria showed that the majority of patients in both groups achieved excellent results (PO: 80%; TEN: 85.7%), with no statistically significant difference (p=0.59). Radiological assessment demonstrated similar outcomes, with mean time to union being 8.15±1.09 weeks for PO and 7.85±1.00 weeks for TEN (p=0.55). Maximum radial bow and its location were also comparable between groups (p>0.5), indicating effective restoration of forearm anatomy with both techniques (Table 2).

The overall complication rates were low in both groups. Infections occurred in 11.4% (4 patients) of patients in each cohort, while neuropraxia was observed in 5.7% (2 patients) of the PO group and none in the TEN group. No cases of malunion, delayed union, synostosis, or implant failure were reported in either group (Table 3).

Table 2: Functional and radiological outcomes of patients, (n=70).

Variables	PO, (n=35)	TEN, (n=35)	P value
Price criteria (%)			
Excellent	28 (80)	30 (85.7)	0.59
Good	5 (14.3)	5 (14.3)	
Fair	2 (5.7)	0 (0)	
Poor	0 (0)	0 (0)	
Radiological outcome			
Radiological union	8.15±1.09 weeks	7.85±1.00 weeks	0.55
Maximum radial bow	4.96±0.39 mm	5.23±0.35 mm	0.53
Location of maximum radial bow	61.85±5.14%	62.56±4.69%	0.61

Table 3: Comparison of complications among patients, (n=70).

Complications	PO, (n=35)	TEN, (n=35)	P value
Infections	4	4	0.99
Malunion	0	0	-
Delayed union	0	0	-
Synostosis	0	0	-
Neuropraxia	2	0	0.48
Implant failure	0	0	-

DISCUSSION

The present multicenter analysis evaluated and compared the functional and radiological results of diaphyseal both-bone forearm fractures managed by PO and TEN. This study's findings showed that surgical duration was markedly shorter in TEN group (44.75±6.38 minutes) than in PO cohort (69.71±5.91 minutes, $p<0.01$). Likewise, patients treated with TEN had a significantly reduced hospital stay (5.01±0.67 days) compared to those treated with plates (8.32±1.44 days, $p<0.05$). These observations are in line with work of Abdulkareem et al who also documented considerably quicker procedures with TEN (33.4±8.3 min) relative to PO (47.7±8.8 min).[13] However, unlike our results, their study did not demonstrate significant difference in hospitalization duration. In contrast, Topak et al reported findings similar to ours, noting shorter operative time and hospital stay with TEN.[14]

Functional and radiographic outcomes were nearly identical between both treatment modalities. Based on the Price scoring system, excellent results were achieved in 80% of patients in the PO cohort and 85.7% of those treated with TEN, with no significant variation. Radiological healing also occurred within a similar timeframe (PO: 7.65±1.09 weeks; TEN: 7.45±1.00 weeks, $p>0.05$). Thapa et al likewise found no considerable difference in union time between these two fixation techniques (PO: 7.33 weeks, TEN: 7.86 weeks).[15] Additionally, the magnitude and position of the maximum radial bow were comparable in both groups and were consistent with the normal pediatric standards outlined by Firl.[12]

Complications following surgery were minimal and occurred at comparable rates in both groups. Infection was observed in 11.4% of cases for each method, while neuropraxia appeared exclusively in the PO group (5.7%). No instances of malunion, delayed healing, cross-union, or hardware failure were recorded. These outcomes closely resemble those reported by Topak et al, Thapa et al and Freese et al who noted similar overall complication profiles for both PO and TEN techniques.[14-16] Although slight variations in the nature of complications-such as irritation at nail entry sites, minor infections, or temporary nerve deficits-were described across studies, none were shown to meaningfully affect patient recovery or long-term function.[17]

This study has some limitations. First, the sample size did not allow for gender-based subgroup analysis, which may influence union rates. Second, radiographic assessments could be subjective and may have affected evaluation of anatomical restoration and union. Despite these limitations, the study provides evidence that both PO and TEN are effective in achieving satisfactory functional and radiological outcomes in pediatric both-bone forearm fractures, with TEN offering the advantage of reduced operative time and shorter hospitalization.

CONCLUSION

This study reveals that both PO and TEN are effective and reliable methods for managing diaphyseal both-bone forearm fractures in children, providing comparable functional and radiological outcomes. TEN offers the advantages of decreased operative time and lowered hospital stay, while maintaining low complication rates similar to PO. Restoration of the radial bow and time to fracture union were equivalent between 2 techniques. Overall, TEN represents a minimally invasive alternative to plating, particularly suitable for pediatric patients, without compromising anatomical or functional recovery.

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