



## Functional and radiological outcome of diaphyseal both bones forearm fractures treated with titanium elastic nail system (TENS) in children

**Gokul Anand M , Abraham M Antony , Maghil John Santhosh J , Boblee James \***

Department of Orthopaedics , Aarupadai Veedu Medical College and Hospital,  
Vinayaka Mission's Research Foundation (Deemed to be University),  
Kirumampakkam, Puducherry - 607402, India.

Dr. Boblee James\*

Professor

Department of Orthopaedics  
Aarupadai Veedu Medical College and Hospital  
Vinayaka Mission's Research Foundation (Deemed to be University)  
Kirumampakkam, Puducherry - 607402, India.

Email- [bobleejames@yahoo.com](mailto:bobleejames@yahoo.com)

Mobile number: +91 9003424419

### Abstract

#### Background:

Forearm fracture are common injuries seen in paediatric age. They can be managed either non-operatively or surgically. In non-operative treatment following closed reduction fracture was immobilized with above elbow plaster and maintenance of reduction will be checked by serial X-rays till the fracture union is achieved. When non-operative treatment fails to reduce or when reduction is not maintained, surgical intervention is required. The surgical treatment for paediatric diaphyseal fractures of both bones remains challenging for an orthopedic surgeon.

#### Aim

The purpose of this study is to evaluate the functional and radiological outcome of diaphyseal both bones forearm fractures which are surgically managed with Titanium Elastic Nail System (TENS) in children.

#### Materials and methods

A prospective study was conducted from October 2017 to September 2020 at Aarupadai veedu medical college and hospital, Puducherry. 34 patients were included in the study out of which 23 were male and 11 were female. The age ranges from 5 – 18 years with mean age of 12 years. All patients were followed up for a minimum of 6 months.



## Results

This study evaluates in terms of functional and radiological outcome following TENS for forearm fractures. According to Price criteria, we had excellent outcomes in 70.6%; good in 20.6% and fair in 8.8% patients. Radiological fracture union were achieved in all 34 patients. The average time for union was 10 weeks ranging from 6 to 14 weeks. There were no cases of non-union or loss of reduction in our study. 4 patients had Hypertrophic scar along with superficial infection.

## Conclusion

In our study following TENS, all fractures were united and had excellent to good functional outcome with less complications. Based on our results, we are concluding that, TENS is an effective and minimally invasive procedure of choice for treating pediatric displaced diaphyseal fractures.

**Keywords:** Pediatric both bone forearm fracture; functional and radiological outcome; intramedullary fixation; and Titanium Elastic Nail System (TENS)

## INTRODUCTION

Fractures of radius and ulna shafts common injuries in Pediatric age<sup>1</sup>. The forearm fractures in children are different from adult forearm fractures<sup>2</sup>. Long bones in children have small medullary canal and more cancellous bones near the epiphysis<sup>3</sup>. The functions of the hand and the forearm are necessary for the upper extremity to function perfectly<sup>4</sup>. The traditional management pediatric forearm fractures remain conservative with closed manipulation and immobilization with an above elbow cast for 4 to 6 weeks<sup>5</sup>. Management of displaced diaphyseal fractures of forearm in children remains challenging<sup>5</sup>. For displaced diaphyseal fractures surgical options are titanium elastic nails (TENS) and plate osteosynthesis<sup>6</sup>.

Conservative methods may lead to complications like deformity, loss of reduction, mal-union, non-union and loss of motion, whereas with recent development in the field of surgical instrumentation, surgical experience and improved rehabilitation techniques have put surgical treatment on the upper hand<sup>5</sup> in indicated forearm fractures. Gandhi and Wilson suggested that mid diaphyseal fractures in children could not remodel adequately, whereas distal forearm fractures remodels adequately<sup>7</sup>. The capacity to remodeling is better before ten years of age<sup>8</sup>.

Displaced diaphyseal fractures can be treated with TENS for pediatric age group<sup>9</sup>.

The titanium elastic nailing system (TENS) provides the following properties

1. Axial stability; 2. Flexural stability; 3. Rotational stability and 4. Translational stability<sup>10</sup>. All four properties are needed to achieve for a better outcome.

## MATERIALS AND METHODOLOGY

This is a prospective study conducted in Aarupadai Veedu Medical College and hospital, Puducherry, from October 2017 to September 2020. In this study we

included displaced closed radius and ulna fracture in skeletally immature patients. We had treated 34 closed forearm fracture using TENS & all patients were followed up for minimum 6 months.

Detailed history was elicited along with a complete general, systemic, and local examination. Any deformity, vascular injuries, compartment syndrome & peripheral nerve injuries were looked carefully. The clinical diagnosis was confirmed by taking plain forearm x-rays anteroposterior & lateral views along with the proximal and distal joints (figure 1).

We tried closed reduction for displaced forearm fractures and fractures which fails to reduce or which fails to maintain reduction were immobilized in above elbow slab initially and surgery was advised (figure 2). After obtaining written/informed consent from the parent/legal guardian, patients are subject to relevant investigations and surgical procedure.

#### **SURGICAL TECHNIQUE:**

All surgeries were done under General anaesthesia. Appropriate diameter size TENS was selected and pre-bended to achieve three-point fixation. Under c-arm guidance through 2 cms incision, radius entry was made using awl just proximal to the Lister tubercle between the second and third extensor tendon compartments. Appropriate pre bended TENS inserted through the entry point by oscillating twist motion and TENS advanced till the fracture site. Maintaining the fracture reduction TENS advanced into the distal fragment. Nail advanced about 1 cm short of the proximal radial physis to leave the room for final impaction. Cases with narrow medullary canal, we used mallet to advance the nail. If the nail fails to advance, the tip could be stuck, tap the nail 5 mm backward and then rotate the tip, then advance nail again. Through 1 cm incision, ulna entry was made about 3 cm distal to the olecranon tip and 4 mm lateral to the posterior crest. Appropriate pre bended TENS inserted through the entry point by oscillating twist motion and TENS advanced till the fracture site. Same steps were followed as per radius. After confirming the fracture reduction and nail position under c-arm, the nails were are withdrawn 1 cm, then cut and flushed to the distal end of the bone (figure 3). Wounds were sutured and above elbow slab applied.

Pre operatively antibiotic was given at time of induction and post operatively 2 further does of antibiotics continued. Wound inspected regularly and suture were removed on 12 post operative date (POD). Post operatively forearm immobilized for 6 weeks and all the patients were followed up on 6<sup>th</sup>, 12<sup>th</sup> week and 6<sup>th</sup> month

During follow up, wound status and range of motion (ROM) were clinically assessed and compared with the non-operated limb. Forearm rotation in each patient was clinically graded according to the Price et al. system <sup>11</sup>. Radiologically fracture alignment, reduction, fracture healing and implant position were assessed.



**Figure 1 :** X- ray of bilateral forearm with wrist and elbow joint AP & lateral view.



Shows displaced diaphyseal fracture of left forearm.

**Figure 2:** Initial close reduction with above elbow immobilisation.



**Figure 3:** Post- operative x- ray of left forearm with wrist and elbow joints.

## RESULTS

Thirty -four patients were included in this study out of which 23 patients were male and 11 patients were female. The age ranges from 5-18 years with mean age of 12 years. Left side (67.6%) was more affected than right side (32.4%) (figure 1). Road traffic accident (44.1%), were the most common mode of injury in our study followed by fall from height (35.3%) and sport injury (20.6%). The most common site of injury was middle third fracture (58.8%) followed by distal third (23.5%) and Proximal third (17.6%). Based on the pattern of fracture, the most common pattern in radius is transverse fracture (64.7%) and in ulna is oblique fracture (67.6%).

The functional outcome was analyzed using price scoring system and we had excellent outcomes in 24 cases (70.6%), good outcome in 7 cases (20.6%) and fair outcomes in 3 cases (8.8%). In this study, all fractures were united with range 6- 14 weeks, with mean of 10 weeks. In our study, most of the patients had no complication (76.5%) but 4 patients (11.4%) had Hypertrophic scar and superficial infection which was treated with dressing and oral antibiotics. There were no non-union or malunion reported.

## DISCUSSION

Treatment of displaced diaphyseal fractures is still challenging<sup>11</sup>. Fractures close to physis in younger children will remodel adequately, whereas in older children with diaphyseal fractures, remodeling may not be adequate<sup>12</sup>. In children aged less than 9 years, upto 15<sup>0</sup> of remodeling can occur whereas in children above 9 years remodeling can occur only upto 10<sup>0</sup><sup>8</sup>.

In our study, RTA was found to be the most common mode of injury with 44.1% followed by self fall with 35.3% whereas it was found that incidence of self -fall and sports related injuries were high in study done by Ritcher et al<sup>13</sup>.

Based on AO-Pediatric comprehensive classification of long bones, the result shows that 25 patients had 22-D/5.1 (73.5%). Nine patients (26.5%) had 22-D/4.1. 20 patients were injured in the middle third which was more common and followed by 8 patients in distal third and 6 patients in proximal third. In this study we have observed that radius had transverse fracture 64.7% and ulna had oblique fracture 67.6%, which is similar to the study done by Yung et al<sup>14</sup>. The minimum time taken for surgery was 25 minutes, and the maximum time taken was 60 minutes, which is comparable to Richter et al. in 1998, which was 40 min<sup>15</sup>. Fracture union time range from 6- 14 weeks<sup>16</sup>.

We used price scoring system to assess the function of the forearm fractures and we had excellent outcomes in 24 cases (70.6%), good outcome in seven cases (20.6%) and fair outcomes in 3 patients (8.8%). In our study, 4 patients (11.8%) had hypertrophic scar, and superficial infection. The superficial infection was treated with regular dressing and oral antibiotics. There were no other complications encountered such as malunion, nonunion, and implant failure.

## CONCLUSION

In our study, we had 34 patients with displaced forearm fractures and were treated surgically using close reduction with TENS. All 34 patients had complete union without any major complications. According to price criteria we had excellent results in 24 cases and good and fair outcome respectively 7 & 3 patients. The complication rate in TENS fixation is very minimal and though being a minimally invasive procedure, it provides adequate stability for the fracture fixation. Even though, the sample size is less, we had an excellent to good outcome in our study. Therefore, we are concluding that TENS is safe mode of treatment of choice for displaced forearm fracture in pediatric age group.

### Author Contributions

The authors contributed equally for its content, writing, and reviewing and/or editing of the manuscript before submission.

### Conflicts Of Interest

The authors declare no conflict of interest.

### Acknowledgement

The authors are grateful to the authorities of Aarupadai Veedu Medical College and Hospital, Vinayaka Missions Research Foundation ( Deemed to be University) and to all the patients who participated in the study.

### References

1. Small RF, Yaish AM. Radius and Ulnar Shaft Fractures. StatPearls [Internet]. 2021 May 15.
2. Rodríguez-Merchán EC. Pediatric fractures of the forearm. *Clinical Orthopaedics and Related Research*®. 2005 Mar 1;432:65-72.
3. Khuntia S, Swaroop S, Patro BP, Sahu S. Paediatric Long Bone Fractures Managed with Elastic Intramedullary Nails: A Retrospective Study of 30 Patients. *Cureus*. 2020 Apr;12(4).
4. Forro SD, Munjal A, Lowe JB. Anatomy, shoulder and upper limb, arm structure and function.
5. Vopat ML, Kane PM, Christino MA, Truntzer J, McClure P, Katarincic J, Vopat BG. Treatment of diaphyseal forearm fractures in children. *Orthopedic reviews*. 2014 Apr 22;6(2).
6. Kelly BA, Shore BJ, Bae DS, Hedequist DJ, Glotzbecker MP. Pediatric forearm fractures with in situ intramedullary implants. *Journal of children's orthopaedics*. 2016 Aug 1;10(4):321-7.
7. Gandhi RK, Wilson P, Mason Brown JJ, Macleod W. Spontaneous correction of deformity following fractures of the forearm in children. *Journal of British Surgery*. 1962 Jul;50(219):5-10.
8. Vittas DI, Larsen EI, Torp-Pedersen SO. Angular remodeling of midshaft forearm fractures in children. *Clinical orthopaedics and related research*. 1991 Apr 1(265):261-4.
9. Noonan KJ, Price CT. Forearm and distal radius fractures in children. *JAAOS- Journal of the American Academy of Orthopaedic Surgeons*. 1998 May 1;6(3):146-56.
10. Li Y, Stabile KJ, Shilt JS. Biomechanical analysis of titanium elastic nail fixation in a pediatric femur fracture model. *Journal of Pediatric Orthopaedics*. 2008 Dec 1;28(8):874-8.



11. Price CT, Scott DS, Kurzner ME, Flynn JC. Malunited forearm fractures in children. *Journal of pediatric orthopedics*. 1990 Nov 1;10(6):705-12.
12. Sinikumpu JJ, Lautamo A, Pokka T, Serlo W. The increasing incidence of paediatric diaphyseal both-bone forearm fractures and their internal fixation during the last decade. *Injury*. 2012 Mar 1;43(3):362-6.
13. Rodríguez-Merchán EC. Pediatric fractures of the forearm. *Clinical Orthopaedics and Related Research®*. 2005 Mar 1;432:65-72.
14. Yung SH, Lam CY, Choi KY, Ng KW, Maffulli N, Cheng JC. Percutaneous intramedullary Kirschner wiring for displaced diaphyseal forearm fractures in children. *The Journal of bone and joint surgery. British volume*. 1998 Jan;80(1):91-4.
15. Goyal D, Sharma SL, Meena L, Lamoria R, Bansal M. Functional outcome of diaphyseal fractures of forearm in adolescents treated with TENS.
16. Caruso G, Caldari E, Sturla FD, Caldaria A, Re DL, Pagetti P, Palummieri F, Massari L. Management of pediatric forearm fractures: what is the best therapeutic choice? A narrative review of the literature. *Musculoskeletal Surgery*. 2021 Dec;105(3):225-34.

