

# Treatment of Paediatric Forearm Fractures with Titanium Elastic Nails

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## ABSTRACT

**Background:** A prospective analysis of a case series of diaphyseal forearm fractures in children treated with titanium elastic nails is presented.

**Methods:** Between 2012 and 2014, 45 children aged 5-15 years with displaced diaphyseal forearm fractures underwent titanium elastic nailing. Both bones were fractured in 32 patients, ten fractured only the radius, and three experienced ulna fracture. Eighteen children had unstable irreducible fractures, twenty had loss of reduction, and seven had open fractures. Titanium elastic nails were used to stabilize the fractures. All fractures were immobilized postoperatively with an above-elbow plaster slab for 2 weeks till the swelling is completely resolved followed by encouraging range of motion exercises.

**Results:** Closed reduction and TENS was successful in 33 cases, including 25 double-bone fractures and eight single-bone fractures. Open reduction was unavoidable in seven fractures of both bones, and in five single-bone open fractures. Bone union was achieved in all patients at an average of 7 weeks.

**Conclusion:** Titanium elastic nails fixation of pediatric forearm fractures revealed several advantages, a small incision for insertion, a low rate of complications, unhindered bone healing, and good clinical and radiological results.

**Key words:** Diaphyseal; Radius and ulna; Pediatric; Forearm fractures; Fracture fixation; TENS

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## INTRODUCTION

Fractures of forearm bones are the most common traumatic pediatric orthopedic injuries. The majority of these fractures can be treated well with closed reduction and cast immobilization due to the unique property of the growth potential of the immature bones. Nevertheless, there is a subset of patients in whom surgical intervention is indicated. The most common indications for surgery are failure of closed reduction, open fractures, and fracture instability. In these situations, if left untreated, malunion is more likely to occur, which will disturb the function of the upper extremities<sup>1,2</sup>. A variety of surgical techniques are available to achieve adequate stabilization of these types of fractures in children, who have an open physis with the bone still growing, including plating, external fixation, and intramedullary nailing. Children aged >10 years do not remodel as predictably; thus, reduction standards are less uniform. Operative intervention has been recommended in prior studies for angulation >10°, malrotation, and displacement >50%<sup>3,4,5,6</sup>. This article analyzes the results of 45 diaphyseal forearm

fractures in children who underwent flexible intramedullary nail fixation.

## PATIENTS AND METHODS

At our institution, between 2012 and 2014, 45 children with displaced diaphyseal forearm fractures were treated using titanium elastic nails. An unacceptable alignment was defined as less than 50% cortical contact between the fragments, and greater than 10° of angulation in either the sagittal or coronal plane. Only displaced fractures were included in our study and any greenstick fractures were excluded from our study. Two children with displaced open fracture type 1 (Gustilo Anderson) who failed with closed reduction were also included in our study. All patients were immobilized postoperatively in an above-elbow plaster slab for 4 weeks. Patients underwent regular postoperative follow-up in the clinic at 2-week intervals. Follow-up examination of patients included progress of fracture healing, range of motion (ROM), angular deformities, and measurement of limb length. Union was assessed clinically by the absence of pain and tenderness. Radiological assessment included the presence of a bridging callus and partial obliteration of the fracture line on two views.

### Inclusion criteria:

- Age between 5 and 15
- Closed displaced fractures
- Unacceptable closed reduction
- Open displaced fractures (type 1 and 2)

**Exclusion criteria:**

- Age beyond range of 5 to 15
- Greenstick fractures
- Undisplaced fractures
- Acceptable reduction
- Open fractures (type 3)

**Operative technique:**

Under general anesthesia, a pneumatic tourniquet is positioned in case an open reduction is needed. A closed reduction is attempted, a percutaneous intramedullary nailing is performed without opening the fracture site. If an acceptable reduction cannot be obtained, then open reduction through limited approach and intramedullary fixation is performed.

The radial bone is approached through one cm longitudinal incision performed on the lateral side of the distal metaphysis. A hole is drilled in the bone with an awl, first perpendicularly and then obliquely towards the elbow. Then an appropriate size titanium flexible intramedullary nail (with its proximal 5mm pre-bent at 30) is introduced and pushed retrograde with a hammer if necessary, to the fracture site. The fracture is reduced by external manipulation and the nail is pushed proximally and fixed into the proximal metaphysis. The distal end of the nail is then cut 5-10 mm from the bone. The skin is closed with one stitch. Same procedure is performed for the ulna starting distally and pushing the nail retrograde (fig 1 & 2).

**RESULTS**

**Patient demographics and clinical data:** Of the pediatric patients with forearm fracture included in this study, there were 32 male and 13 female patients with a mean age of 9 years (range: 5-15). The right forearm was fractured in 27 patients, and 23 patients suffered fracture of the left forearm. Only those fractures that involved the middle third of the radius and ulna were included in the study. Both bones were fractured in 32 (71.11%) patients. The radius only was fractured in ten (22.22%) patients, and the ulna only was fractured in three (6.66%). There were seven (15.55%) open fractures (Gustilo and Anderson Type I). All patients had isolated forearm fractures without associated injuries. The mechanism of injury was sports related in 30 patients (66.66%), a fall from a height at home in eleven (24.44%), and a traffic accident in four (8.88 %).

Closed reduction and TENS fixation was successful in 33 cases, including 25 both-bone fractures and 8 single-bone fractures. Open reduction with a mini-open procedure was carried out in seven fractures that affected both bones and in five open fractures. The average period of follow-up was 20 months (range: 10-36).

All of the fractures healed within an average of 7 weeks (range: 6-9). No non-unions or delayed unions were found. There was no notable difference in the healing time either for fractures of both bones or for isolated radial or ulnar fractures. Furthermore, there was no difference in healing time for the subset of patients that required a mini-open reduction. No notable complications were encountered in the study patients. No deep infection was seen in our patients.

All implants were routinely removed under intravenous sedation. The average time for removal of the implants in this study was 8 months (range: 6-10). There were no complications after implant removal in our patients.

**Table 1: Summary of patient demographics and outcomes**

No. of patients	45
Average age in years	09 ( 5 -15 )
Follow up (wks )	20 ( 10-36 )
Union time (wks )	07 (6-9 )
Complications	None

**DISCUSSION**

Most diaphyseal fractures in children are treated conservatively with plaster casting. Where acceptable closed reduction cannot be achieved or maintained in patients with completely unstable forearm fractures, surgical intervention is required<sup>7</sup>. Complete fractures were more frequently treated by surgical intervention, especially in older child with limited remodeling capacity<sup>8</sup>. The use of an external fixator<sup>9</sup> is not seen as a first-line treatment in management of forearm diaphyseal fractures in children<sup>10</sup>. The classic methods of open reduction with plating could offer anatomical reduction sparing the physis and could provide early mobilization of joints. However, the disadvantages of surgical intervention included the need for surgical dissection, removal of implants, risk of refracture from the screw holes, or further neurovascular compromise. In rare instances it has even led to radio-ulna synostosis<sup>11</sup>.



**Fig. 1: Fracture of middle third both bones operated with closed TENS fixation**



**Fig. 2: Fracture of middle third both bones operated with closed TENS fixation**

Recently there is a growing technique towards titanium elastic intramedullary nailing for fixation of forearm fractures in children. This technique offers stable fixation without disturbance of the periosteal blood supply and fracture hematoma, which contributes to fracture healing. This technique also allows for micro-motion at fracture site to stimulate the callus formation to bridge the fracture gaps. End-to-end reduction helps to control rotational

alignment, and micromotion at the fracture site promotes the formation of external callus by converting shear stress into fracture compression<sup>13</sup>. Titanium intramedullary nails function as an internal splint and provide three-point fixation to maintain fracture alignment<sup>12</sup> to promote rapid union, reduces the risk of infection and synostosis, and avoids unsightly incisions that are necessary for plate fixation and hardware removal<sup>4</sup>. Intramedullary titanium nail removal is a minor procedure that does not create stress and thus decreases the risk of refracture.

Intramedullary fixation of forearm fractures has been reported unsuccessful in the adult literature and only recently the technique has been adapted to the management of forearm fractures in children.<sup>13,14,16,17</sup> Amit et al reported 20 unstable diaphyseal fractures of the forearm in adolescent patients treated with closed intramedullary nailing. All fractures healed within 6 weeks. There were no cross-union, non-union, infection or refracture. Amit et al favored that technique rather than plate fixation because of the appropriate reduction, reduced complication rate, negligible cosmetic defect, and the ability to perform rod removal under local anesthesia.<sup>14</sup>

Further previous studies of fracture-fixation technique in children were developed in France using flexible intramedullary rods<sup>13,15</sup>. Because of the excellent results with flexible nails, these authors recommended intramedullary nailing for most children. Two series on intramedullary fixation of pediatric forearm fractures were recently presented in the United States<sup>15</sup>. Stanley and Wilkins reported on 50 patients with mid shaft fractures of the radius and ulna treated with closed reduction and percutaneous intramedullary pinning<sup>15</sup>. Intramedullary pins (Kirschner wires) were used for fracture fixation. All fractures healed in about 8 weeks. There was no reported loss of reduction after initial fracture fixation and no reported long-term complications with forearm rotation.

The use of intramedullary fixation of forearm fractures in the adult population has been discouraged because of the high rate of non-union and decreased functional results reported with this technique<sup>16,17</sup>. Previous series have shown that in non comminuted fractures, the non-union rate is less than 10% and the functional results equaling those achieved with plating<sup>15</sup>. In the pediatric patient, non-union has not been reported in the literature, and good/excellent functional results are reported in nearly 95% of cases<sup>13,14,15</sup>. These excellent clinical results support the use titanium elastic intramedullary nails in the operative treatment of forearm fractures in the pediatric patient.

**CONCLUSION**

Closed reduction and TENS fixation was successful in 33 cases, including 25 both-bone fractures and 8 single-bone fractures. Open reduction with a mini-open procedure was carried out in seven fractures that affected both bones and in five open fracture. Bone union was achieved in all patients at an average of 7 weeks without any significant complications after a follow-up of 20 months.

In conclusion, independent of the age group all unstable and potentially unstable fractures of the paediatric forearm shaft should be approached surgically, as the functional results after this study found to be excellent. This somewhat aggressive attitude is justifiable with the use of titanium elastic nails.

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