



## International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958  
P-ISSN: 2706-6630  
IJOS 2020; 6(4): 542-549  
© 2020 IJOS  
www.orthopaper.com  
Received: 01-08-2020  
Accepted: 07-09-2020

**Dr. Venkatesh V**  
Senior Resident, Department of  
Orthopaedics, Chamarajanagar  
Institute of Medical Sciences,  
Yadapura, Karnataka, India

**Dr. Shreesha Tokur**  
Assistant Professor, Department  
of Orthopaedics, Karwar  
Institute of Medical Sciences,  
Karwar, Karnataka, India

### Minimally invasive (Titanium elastic nailing system) operative technique in pediatric both bone forearm fractures

**Dr. Venkatesh V and Dr. Shreesha Tokur**

**DOI:** <https://doi.org/10.22271/ortho.2020.v6.i4h.2386>

#### Abstract

**Background:** Both bone forearm fracture in paediatric population is one of the most common fractures encountered. Here we present a prospective study conducted to evaluate radiographic & functional outcome of paediatric both bone forearm fractures treated with titanium elastic nailing systems.

**Methods:** In our prospective study we included 18 patients who were between 6 – 15 years, admitted during October 2019 to June 2020 in Chamarajanagar institute of medical sciences & Karwar institute of medical sciences, patients were included according to inclusion & exclusion criteria. All patients were operated under appropriate anaesthesia. Outcome was evaluated using price *et al.* criteria. All the patients were operated using minimally invasive system (titanium elastic nailing).

**Results:** we included 18 patients, out of which 13 (72.2%) were male & 5 (27.7%) were female with male predominance, 10 (55.5%) patients had displaced fracture, 8 (44.4%) had loss of reduction due to unstable & irreducible fracture. 15 (83.3%) patients had right side involvement & 3 (16.7%) had left side involvement, closed reduction & internal fixation done in 14 (77.7%) patients were as 4 (22.2%) patients were treated with minimal open reduction & internal fixation, due to irreducibility. Depending on location of fracture 16 (88.8%) were in middle 1/3<sup>rd</sup>, 2 (11.1%) were in distal 1/3<sup>rd</sup>. patients were analysed depending on Price *et al.* criteria in whom 15 had excellent, 2 had good, 1 had fair result due to local infection & implant prominence. Patients were regularly evaluated at 4, 8 & 12 weeks, finally at 6 months. Union was seen in an average around 4 – 6 weeks.

**Conclusions:** Minimally invasive technique (Titanium elastic nails) for paediatric forearm fractures revealed several advantages, a small incision for insertion, a low rate of complications, good bone healing, and good clinical and radiological results thus achieving maximum range of motion at the earliest.

**Keywords:** Minimally invasive, titanium elastic nailing, paediatric forearm fracture

#### Introduction

Willis C. Campbell (1880-1941) stated, “When satisfactory alignment or fixation in fractures of both bones of the forearm in children is not possible by conservative measures, then skeletal traction or open reduction is required and internal fixation should be applied to prevent bowing [1].”

Fractures of both radius and ulna are the most common diaphyseal injuries in pediatric age group which accounts for 5% to 10% of pediatric fractures [2, 3].

These diaphyseal fractures are more common distally than proximally. Reason being proximally both bone cylindrical and covered with thick envelope of muscle which give protection were as distal more ovoid and covered by tendons vowing for high risk of injury [2, 3-7].

The majority of those fractures are often treated well with closed reduction and cast immobilization thanks to the unique property of the growth potential of the immature bones. Nevertheless, there's 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 [8].

Shoemaker *et al.* opined that the ideal mode of fixation of pediatric forearm fractures should maintain alignment, be minimally invasive and inexpensive and carry an acceptable risk profile [9].

**Corresponding Author:**  
**Dr. Shreesha Tokur**  
Assistant Professor, Department  
of Orthopaedics, Karwar  
Institute of Medical Sciences,  
Karwar, Karnataka, India

As far as Intramedullary fixation cares there are several implants like k-wires, Steinmann pin and rush nails but they need their own disadvantages like Kirschner wires and Rush nails are rigid & difficult to insert through the metaphysis of pediatric bones. Because these disadvantages, flexible intramedullary nail (TENS) were devised to beat this problem which produces a three-point fixation to take care of bony alignment and now become very fashionable method for managing forearm fractures in children <sup>[6]</sup>.

Operative intervention has been recommended in prior studies for angulation  $>10^\circ$ , malrotation, and displacement  $>50\%$  <sup>[8]</sup>. Hence, the current study is intended to review the clinical, radiological and functional outcome of Flexible Intramedullary Titanium Elastic Nailing of Fracture Shaft of Radius and Ulna in Childrens at a Tertiary Care Teaching Hospital.

### Methodology

In our prospective, Non randomized study we included patients depending on

Inclusion criteria being: Age 6 – 15 years

Closed fractures

Gustilo Anderson type 1 open fractures

Failed closed reductions

Exclusion criteria: Age  $< 6$  yrs &  $> 15$  yrs

Green stick fractures

Undisplaced fracture's

### Radius entry site & tens insertion



### Ulna Entry Site & Tens Insertion



### Results

**Sex Ratio:** According to the study conducted out of 18, males were 13 (72.2%) & females were 5 (27.2%) showing male predominance.

### Open fractures GA type 2 & above

This prospective study is done in a tertiary care hospital (Chamarajanagara institute of medical sciences, Chamarajanagar & Karwar institute of medical sciences, Karwar) from October 2019 – June 2020 for a patient population of 18. After the preoperative evaluation patients were surgically managed under regional or general anesthesia. Fractures were reduced under C arm guidance,

Initially radius was fixed either from dorsal surface or lateral distal surface 1 cm above the physal plate, reduction held with traction 2mm/ 2.5mm TENS was inserted to intramedullary canal after doing entry with an bone awl, TENS was precontoured to fit at the fracture site for 3 point fixation, TENS was passed from distal fragment to proximal fragment across fracture site confirmed under C arm, next the ulna was fixed through entry from tip of the olecranon or from the medial surface of olecranon after doing entry with a bone awl followingly 2mm/ 2.5mm TENS was passed through the entry hole passed across fracture site secured with three point fixation with precontouring the TENS, TENS was cut close to the skin & buried under the skin, skin closed with ethilon or skin staples. Final C arm images were taken and alignment, reduction was checked. Distal pulse was checked after the surgery, regular post-operative x rays were taken at intervals 4, 8, 12 weeks & finally at 6 months, at the final visit patients were evaluated for functional status of the operated limb using price *et al.* criteria.

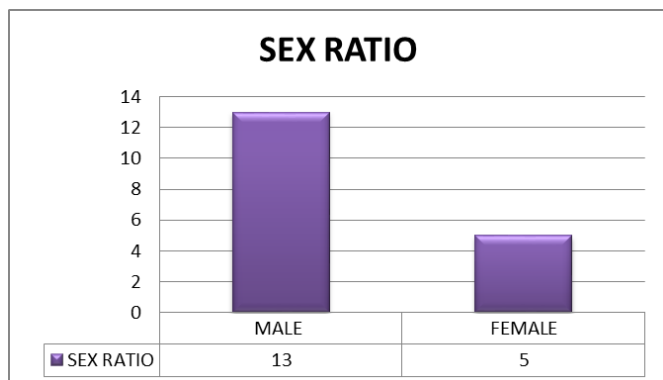


Fig 1: Sex Ratio

Table 1: Fracture Pattern

Fracture pattern	No of patients	Percentage
Transverse	11	61.1%
Oblique	7	38.8%

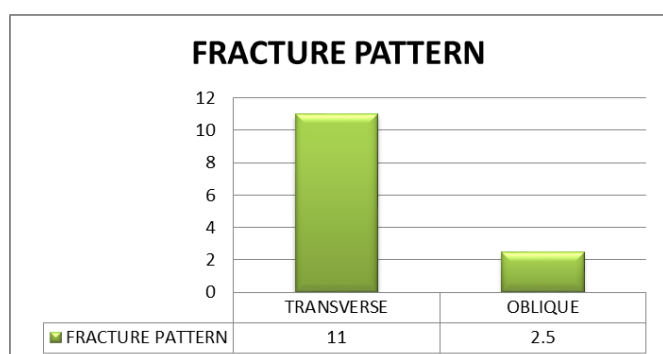


Fig 2: Fracture pattern

Out of 18 patients we had 11 transverse & 7 oblique fracture patterns.

Table 2: Sidedness

Sidedness	No of patients	Percentage
Right	15	83.3%
Left	3	16.7%

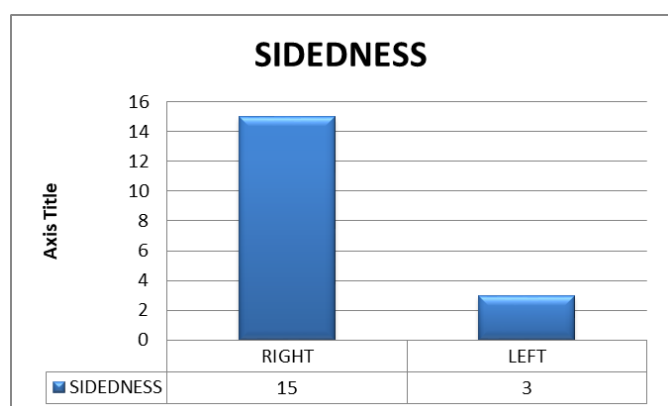


Fig 3: Sidedness

Out of 18 patient we had 13 with dominant upper limb involvement & 3 were left side involvement.

Table 3: Mode of surgical management

Mode of surgical management	No of patients	Percentage
Closed	14	77.7%
Mini open	4	22.2%

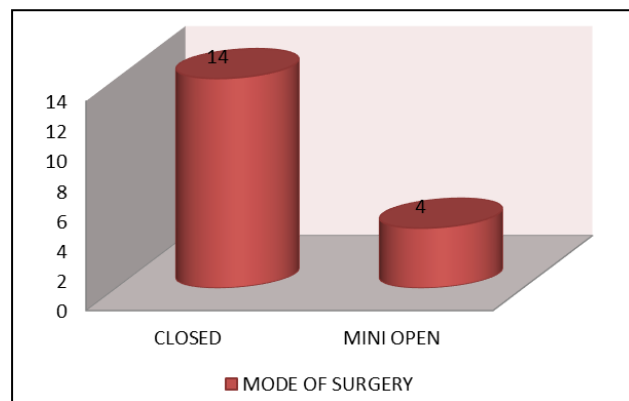


Fig 4: Mode of surgical management

Out of 18 patients we did 14 closed reduction & internal fixation with TENS, were as 4 patients fracture had to be minimally opened at fracture for reduction due to irreducibility.

Table 4: Fracture location

Fracture location	No of patients	Percentage
Proximal 1/3 <sup>rd</sup>	0	0
Middle 1/3 <sup>rd</sup>	16	88.8%
Distal 1/3 <sup>rd</sup>	2	11.1%

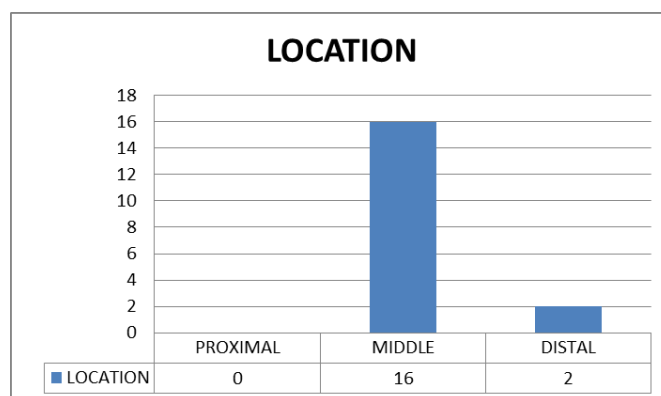


Fig 5: Location

We had 16 patients with middle 1/3<sup>rd</sup> fracture & 2 patients with distal 1/3<sup>rd</sup> fractures.

Table 5: Type of fracture

Type of fracture	No of patients	Percentage
CLOSED	15	83.3%
OPEN TYPE 1 & 2	3	16.6%

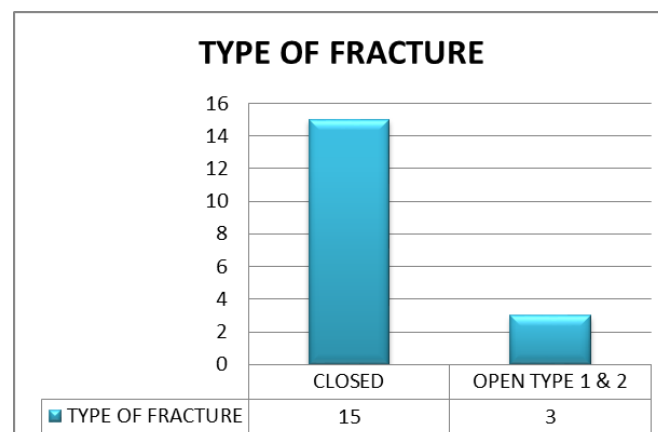
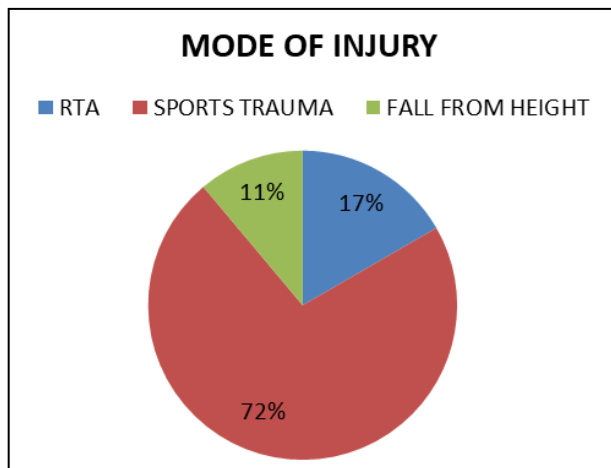


Fig 6: Type of fracture

In our study we found that 15 were having closed fracture remaining 3 were open fracture of gustilo Anderson type 1 or 2.

**Table 6:** Mechanism of injury

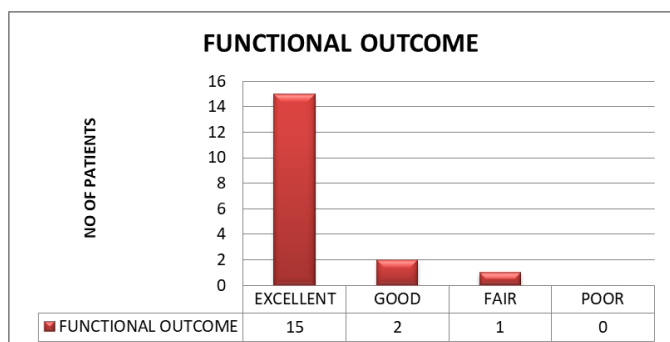
Mechanism of injury	No of patients	Percentage
Road traffic accident	3	16.6%
Sports trauma	13	72.2%
Fall from height	2	11.11%



**Fig 7:** Mode of injury

**Table 7:** Grading system for functional outcome according Price *et al.* [6]

Outcome	Symptoms	Loss of forearm rotation	No of patients & percentage
Excellent	No complaint with strenuous activity	< 15°	15 (83.3%)
Good	Mild complaint with strenuous activity	15° - 30°	2 (11.1%)
Fair	Mild complaint with daily activities	31° - 90°	1 (5.5%)
Poor	All other results	>90°	0



**Fig 8:** Functional outcome depending on Price *et al.* criteria

Patients were evaluated according to Price *et al.* criteria depending on loss of rotation & symptoms occurrence we had 15 excellent functional results, 2 good & 1 Fair results. Fair was due to local entry site skin infection & implant prominence which caused local bursa formation & irritation under the skin. This poor result patient was managed with implant removal and appropriate antibiotic therapy which was initiated early & once bony union was seen implant was removed.

The average time required for union was around 10 – 12 weeks

The average follow up was done till 24 – 26 weeks.

## Discussion

Most diaphyseal both bone forearm fractures in children are being treated non operatively with plaster casting. Where acceptable closed reduction cannot be achieved or maintained in patients with completely unstable forearm fractures, surgical intervention is required [10].

Restoring stability and early initiation of movements are the main strategy in reducing malunion and provide full functional range in pediatric both bone forearm fracture. Traditional method of treatment with closed reduction and casting of fixing both bone fracture had its own fallacy such failure of reduction, malunion, angulation and loss of function [11].

In studies conducted by Thomas *et al.* Kay *et al.* Eric N. Bowman *et al.* showed failure of reduction was 39%, 64% and 51% respectively and failure rates were more in children more than 10 years of age as bone remodeling is less [12-14].

Causes for these complication were complete displacement of fracture ends with no contact, angulations of more than 100° and malrotation of more than 45° [12].

Rodriguez- Merchan in their literature clearly mentioned that rotational deformity does not remodel *et al.* [15]

Malunited fracture with angulation or malrotation leads to limb length discrepancy and loss of function such as supination and pronation causing limitation in daily activities as described by Daruwalla *et al.*, and Morrey *et al.*, in their studies [16, 17].

In our current study 18 patients were considered who were included according to inclusion and exclusion criteria. In present study we included all both bone forearm fractures which were displaced and could not be corrected by closed reduction, angulation more than 10° and rotation of more than 45°. Male patients were considerably higher about 72.2% in our study which was same as other studies [4, 5]. Fractures at the middle 1/3<sup>rd</sup> of forearm were most common (88.8%). Most of the forearm fractures were closed fractures and were related to sport trauma. Selecting the patients for conservative or operative depended on displacement, rotation and angulation of fracture fragments. Fractures with more than 10° angulation and rotation of more than 45° were selected for operative management rest were treated conservatively. These parameter was obtained by the experience of cadaveric studies conducted Matthews LS *et al.* [18] and Daruwalla JS [16] were they concluded the rotation more than 45° and angulation more than 10° leads to malunion and restriction of forearm rotation from 5% - 30%.

Many methods for internal fixation were available such as open fixation with plate and screw commonly used in adults. In children fixation with rigid intramedullary nail like k nails, rush nails were used. More recently with advent of titanium elastic intramedullary nailing system its becoming more popular among surgeons. Advantages being it provides a stable three point fixation, minimally invasive, preserve fracture hematoma and periosteal blood supply which promotes early fracture union. Three point fixation provides rotational stability, end to end reduction of the fracture fragments elasticity provides micro motion at the fracture site promotes early callus formation [19].

Three point fixation includes entry site at metaphysis, second point at opposite cortex inner wall of cortex at diaphysis at apex of nail near fracture site and third contact at other metaphysis were nail ends [19]. Intramedullary nailing although is not free of complications such as skin irritation and infection at the nail insertion site, migration or implant breakage, refractures after implant removal, nerve and tendon

injury decreased range of pronation and supination, 546on-union, delayed union and compartment syndrome [5, 20]. Infection, ugly surgical scar, deformity and radio ulna synostosis will be significantly reduced. Gorter *et al.* reported forearm refractures in patients who had elastic nails removed between two and four months after injury. Also there was low risk of infection as the implant was buried subcutaneously [21]. In our study with 18 patients 14 underwent closed reduction & TENS fixation were as 4 patients had to undergo mini open reduction at the fracture site due to soft tissue interposition & irreducibly hinged fragments. In our study we had excellent 15(83.3%) patients, 2(11.1%) had good results, were as 1

patient had fair results due to entry site infection which was treated accordingly with appropriate antibiotics, once the fracture was healed TENS was removed which helped in wound settlement. Majority of the both bone forearm fractures were closed & mainly involving sports related trauma. Good union rates were seen at between 2 months to 4 months with an average union time around 10<sup>th</sup> week – 12<sup>th</sup> week. None of the patients had limitation of movement, compartment syndrome, 546on-union or deformity. Our present results were comparable with other studies by Flynn *et al.* Richter D *et al.* Jeffery *et al.* which has been summarized.

Table 8.

Study	No of patients	Mean age (years)	Implant used	Avg time radiological union	Functional criteria	Functional outcome	Complications
Fynn jm <i>et al.</i> [5]	103	10.6	Titanium nails	6.9 – 8.9 weeks	Children hospital of pheladelphia forearm fracture fixation outcome classification	Excellent= 77.7% fair = 14.6% poor= 7.8%	Major – 4 (3.8%) minor- 11(10.6%)
Richter d <i>et al.</i> [22]	30		Titanium nails	13 weeks	Tscherne score	Excellent= 80% good= 16.6% fair= 3.3%	Major – 4 (3.8%) minor- 11(10.6%)
S.-n. Kang <i>et al.</i> [23]	90	8.4(2-15)	Elastic nails	2.9 months (1.1 to 8.7)	Daruwalla criteria	Excellent 59 good 17 fair 5 poor 9	Superficial radial nerve palsy 2 compartment syndrome delayed union 1 malunion 1 remodelled wound related problems 7 failure to remove implant 1
Jeffrey e. Martus <i>et al.</i> [24]	203	9.7	Tens 97% 3% k=wires or steinman pins		Clavien-dindo classification with modifications	Excellent 163 good 24 fair 5 poor 13	Overall complication 21% 17% were grade 2 or greater
Harish k <i>et al.</i> [11]	27	10.2	Tens	10.5 weeks	Price <i>et al</i>	Excellent 20 good 5 fair 2 poor 0	6 minor complications
Amit kumar <i>et al.</i> [25]	60	10.5	Tens	10 weeks	Price <i>et al</i>	Excellent 57 good 3	7 minor complications
Our study	18	10.5	Tens	10-12 weeks	Price et at	Excellent 15 good 2 fair 1 poor 0	Local wound site infection

## Conclusion

Closed reduction and TENS fixation was successful in 15 cases, mini open reduction was performed in 3 cases. Bone union was achieved in all patients at an average of 10.2 weeks without any significant complications after a follow-up of 6 months with only one case having local wound infection which was treated accordingly.

Pediatric both bone forearm fractures is quite challenging fracture to manage. But With advent of titanium elastic

nailing system treating pediatric both bone forearm fractures which were unable to achieve reduction under closed manipulation, fractures with angulations, rotation and displacement has become simple. Titanium elastic nails are providing excellent union rates promoting early callus formation and provides early functional recovery. Hence titanium nailing system is an excellent choice surgical management of pediatric both bone forearm fractures.



## Clinical Pictures & Radiographs

### Case 1



Pre-Op X Ray



Post OP X Ray



6 Weeks Post OP



6 Months Post OP

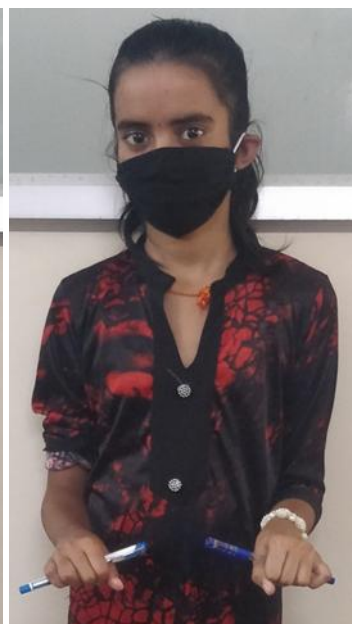
### Clinical functional status



Neutral



Supination



Pronation

**Case 2****Pre OP X RAY****3 Months Post OP X RAY****6 months post OP****Clinical functional status**

Neutral



Supination



Pronation

**Conflicts of Interest:** None**Source of Funding:** Nil**References**

1. Watson Jones. Fractures & joint injuries 6th edition 2;662-663.
2. Mann DC, Rajmaira S. Distribution of physeal and nonphyseal fractures in 2,650 long-bone fractures in children aged 0-16 years J Pediatr Orthop 1990;10:713.
3. Worlock P, Stower M. Fracture patterns in Nottingham children. J Pediatr Orthop 1986;6:656.
4. Shoemaker S, Comstock C, Mubarak S, Wenger DR, Chambers HG. Intramedullary Kirschner wire fixation of open or unstable forearm fractures in children J Pediatr Orthop 1999;19:329-37.
5. Fynn JM, Jones KJ, Garner MR, Goebel J. Eleven years' experience in operative management of pediatric forearm fracture, J Pediatr orthop 2010;30:313-19.
6. Price CT, Scott DS, Kurzner ME, Flynn JC. Malunited forearm fractures in children J Pediatr Orthop 1990;

- 10:705-712.
7. Reed MH. Fractures and dislocations of the extremities in children J Trauma 1977;17:351.
  8. Shivanna, Maruthi C. Treatment of Paediatric Forearm Fractures with Titanium Elastic Nails. Indian Journal of Orthopaedics Surgery 2015;1(4):251.
  9. Shoemaker SD, Comstock CP, Mubarak SJ, Wenger DR, Chambers HG. Intramedullary Kirschner wire fixation of open or unstable forearm fractures in children. J Pediatr Orthop 1999;19(3):329-337.
  10. Wyrsh B, Mencia GA, Green NE. Open reduction and internal fixation of pediatric forearm fractures. J PediatrOrthop 1996;16:644-650
  11. Harish k *et al.*, Functional outcome of both bone fracture forearm managed with titanium elastic intramedullary nail system in pediatric age group. National Journal of Clinical Orthopaedics 2018;2(1):37-41.
  12. Eric N Bowman, MPH, Charles T Mehlman, DO MPH, Christopher J. Lindsell, PhD, and Junichi Tamai, MD. Nonoperative treatment of both-bone forearm shaft fractures in children: Predictors of early radiographic failure, J Pediatr Orthop 2011;31(1):23-32.
  13. Thomas EM, Tuson KW, Browne PS. Fractures of the radius and ulna in children Injury 1975;7(2):120-124.
  14. Kay S, Smith C, Oppenheim WL. Both-bone midshaft forearm fractures in children J Pediatr Orthop 1986;6(3):306-310.
  15. Rodríguez-Merchán EC. Pediatric fractures of fore arm. Clin Orthop Relat Res 2005;432:65-672.
  16. Daruwalla JS. A study of radioulnar movements following fractures of the forearm in children Clin Orthop 1979;139:114-120.
  17. Morrey B, Askew L, An K *et al.* A biomechanical study of normal functional elbow motion, J Bone Joint Surg [Am] 1981;63:872-877.
  18. Mathews LS, Kaufer H, Garner DF, Sonstegard DA. The effect on supination- pronation of angular mal-alignment of fractures of both bones of the forearm J Bone joint Surgery Am 1982;64:14-7.
  19. Schemitsch EH, Jones D, Henley MB *et al.* A Comparison of Malreduction after Plate Fixation and Intramedullary Nail Fixation of Forearm Fractures, J Orthop Trauma 1995;9:8-16.
  20. Akash Patel, Lily Li, Amarjit Anand. Systematic review: Functional outcomes and complications of intramedullary nailing versus plate fixation for both-bone diaphyseal forearm fractures in children Injury, Int J Care Injured 2014;45:1135-1143.
  21. Implant removal associated complications in children with limb fractures due to trauma. Gorter EA, Vos DI, Sier CF, Schipper IB. Eur J Trauma Emerg Surg 2011;37(6):623-627.
  22. Richter D, Ostermann P, Ekkernkamp A, Muhr G, Hahn MP. Elastic intramedullary nailing: a minimally invasive concept in the treatment of unstable forearm fractures in children, J Pediatr Orthop 1998;18:457-61.
  23. Kang SN, Mangwani J, Ramachandran M, Paterson JMH, Barry M. Elastic intramedullary nailing of paediatric fractures of the forearm. A decade of experience in a teaching hospital in the United Kingdom, J Bone Joint Surg [Br] 2011;93-B:262-5.
  24. Jeffrey E Martus, Ryan K Preston, Jonathan G Schoenecker *et al.* Complications and Outcomes of Diaphyseal Forearm Fracture Intramedullary Nailing: A Comparison of Pediatric and Adolescent Age Groups J Pediatr Orthop 2013;33:598- 607.
  25. amit K. Tens (Titanium elastic nail system): A good option for managing both bone forearm fracture. National Journal of Clinical Orthopaedics 2019;3(1):15-18.