International Journal of Medical Research Professionals
P-ISSN: 2454-6356; E-ISSN: 2454-6364
DOI: 10.21276/ijmrp

IJMRP

Original Research Article.

Treatment of Long Bone Fracture in Children by Titanium Elastic Nailing Stabilization

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ABSTRACT

Purpose: To demonstrate the effectiveness of intramedullary fixation of displaced long bones shaft fractures in skeletally immature children using the elastic stable intramedullary nails.

Patients and Methods: The case records of 20 children who underwent fixation with titanium intramedulary nails because of long bones fractures were reviewed. There were 2 humeral, 3 forearm, 10 femoral and 5 tibial fractures. The average age of the patients was 11 years, and they were followed-upto 20 months. Subjective satisfaction was assessed.

Results: All patients achieved complete healing at a mean of 7.5 weeks. Complications observed in patients were: one neuropraxia, six entry site skin irritations, two protrusions of the wires through the skin and two skin infections at the entry site. In a subjective measure of outcome at follow-up, 89% of patients were very satisfied while 11% were satisfied. There was no report of patient's unsatisfaction. The implants were removed at a median time of six months from the index operation.

Conclusion: Elastic Stable Intra-medullary Nailing is the method of choice for the pediatric patients, because it is minimally invasive and shows very good functional and cosmetic results. It allows an early functional and cast-free follow-up with a quick pain reduction.

Keywords: Titanium Elastic Nail (TEN); Pediatric Long Bone Shaft Fractures; Diaphyseal Fractures.

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Article History:

Received: 08-12-2018, **Revised:** 03-01-2019, **Accepted:** 27-01-2019

Access this article online	
Website: www.ijmrp.com	Quick Response code
DOI: 10.21276/ijmrp.2019.5.1.033	

INTRODUCTION

For surgical treatment of long bone fractures in children, the important fact to consider is that excellent result can be achieved with non-operative care with reported union rates more than 90%, occasional reduction can't maintain due to unstable fracture making operative intervention necessary. Recently, Elastic Stable Intra-medullary.[1] Nailing is intended for fixation of diaphysial fracture of long bones where the medullary canal is narrow. In pediatric fracture, flexibility of the TENS allows it to be inserted at a point which avoids disruption of the bone growth plate.[2] The biomechanical principal of TEN is based on the symmetrical bracing action of two elastic nail inserted into the metaphysis against the medullary canal of bone at three bony point. This produces optimal result by flexural, axial, translational and rotational stability.[3,4] Therefore, in this 20 months follow up study we assessed effectiveness of intramedullary fixation of displaced long bones shaft in pedriatic patients along with the satisfaction rate of the surgical outcome.

MATERIALS AND METHODS

Study Design

It is a surgical study of 20 patients with diaphyseal fractures of long bones. This study was undertaken to evaluate the outcome of titanium elastic nail fixation for long bone fractures in children at Anugrah Narayan Magadh Medical College & Hospital, Gaya, Bihar, from april-2017 to november-2018.

Inclusion Criteria

a) 5-16 years of age
b) Diaphyseal fractures
c) Simple fractures (Closed fractures)
d) Ipsilatertal fracture

Exclusion Criteria

1) Metaphyseal fractures
2) Compound fractures
3) Pathological fractures

As soon as the patient was brought to casualty, patient's airway, breathing and circulation were assessed. Then a complete survey was carried to rule out other significant injuries. Plain radiographs of antero-posterior and lateral views of the involved extremity including one joint above and one joint below were taken to access the extent and geometry of fracture. On admission to ward, a detailed history was taken relating to the age, sex, occupation, mode of injury, past and associated medical illness Routine blood investigations were done for all patients. Patients were operated as early as possible once the general condition of the patient was stable and patient was fit for surgery. The diameter of the individual nail is selected as per Flynn et al formula, as follows

Diameter (nail) = Width (narrowest point of the medullary canal on AP & lateral view) X 0.4mm.[5]

In case of single nail usage its diameter should be more than 60% of the narrowest diameter of the medullary canal.

Pre-operative planning of Nail size and Nail length

The selected nails were laid over the thigh, leg and determined that it was of the appropriate length by fluoroscopy.

Preoperative preparation of patients

- Patients were kept nil by mouth overnight before surgery.
- Adequate amount of compatible blood was kept ready for any eventuality.
- The whole of the extremity below the umbilicus, including the genitalia was prepared appropriately.
- A systemic antibiotic, usually a 3rd generation cephalosporin was administered 1 hour before surgery.
- Nail diameter should measure 40% of the narrowest diameter of the diaphysis.
- Nails should be contoured with long bend such that apex of the convexity will be at the level of fracture to provide optimal three point fixation.

Figure 1: Instruments (1. Titanium elastic nails 2. Bone awl 3. Inserter 4. Beveled tamp 5. Hammer 6. Steffe cutter)

Pre-requisites of ESIN for stable internal fixation

- Under anesthesia, closed reduction and internal fixation with TENS nails are done under c-arm guidance.
- Both the nails should be bent symmetrically to same extent. The nails are pre-bent so that the height of the curve is three times greater than the diameter of the medullary canal.
- It is always necessary to use nails of same diameter to prevent loss of reduction towards the side of stronger nail. The entry point of both nails should be at the same level.
- When inserted, nails should have maximum cortical contact at the fracture site in the opposite directions.

Postoperative Care

- Patients were kept nil orally 4 to 6 hours at post-operative stage.
- IV fluids / blood transfusions were given as needed.
- Analgesics were given according to the needs of the patient and their limb was kept elevated over a pillow.
- IV antibiotics were continued for 5 days and switched over to oral antibiotics on the 5th day and continued till the 10th day.
- Sutures were removed on the 10th postoperative day and patients were discharged.
- Post-operatively, patients were immobilized with long leg cast with a pelvic band for femur fracture or with above knee POP cast for tibia fracture for 6 weeks. Such immobilization was continued for another 2-3 weeks based on radiological assessment.
- The period of immobilization was followed by active hip and knee / knee and ankle mobilization with non-weight bearing crutch walking for lower limb fractures, active shoulder and elbow/elbow and wrist mobilization for upper limb fractures.
- Full weight bearing is started by 8 - 12 weeks depending on the fracture configuration and callus response.
- In patients with humerus fracture and an ipsilateral radius or ulna fracture, the forearm fracture was stabilized with either

Kirschner wire fixation or titanium flexible nails and placed into a posterior elbow splint. Patients without ipsilateral upper extremity fracture were either splinted or placed into a soft dressing and given a sling to comfort for 10–14 days.

- No routine physical therapy was prescribed.
- Mobilization out of bed without restriction was permitted for patients with isolated injuries.
- Patients with lower extremity fractures were permitted to bear weight on the upper extremity as tolerated. In case of forearm bone fractures we immobilized the patient for 3 weeks in a posterior slab followed by ROM exercises for elbow and wrist, sling for another 3 weeks.

Follow up

Assessment done at 6, 12, 24 weeks and at 1 year. At each follow up patients are assessed clinically, radio logically and the complications if present were noted. The suspected complications include:

Major Complications

1) Angulations exceeding the guidelines (>100 – saggital/coronal; or > 100 rotational malalignment) at final follow-up
2) Leg length discrepancy exceeding the guidelines (>2cm – shortening/lengthening) at final follow-up
3) Deep infection
4) Loss of reduction requiring new reduction or surgery
5) Surgery to revise nail placement
6) Compartment syndrome requiring surgery
7) Neurological damage after nailing
8) Delayed or nonunion leading to revision[6]

Minor Complications

a. Pain at the site of nail insertion
b. Minor angulations (< 100 – saggital/coronal; <100 rotational malalignment) at final follow-up (24 weeks)
c. Minor leg length discrepancy(< 2cm – shortening/lengthening) at final follow-up (24 weeks)
d. Inflammatory reaction[6]
e. Superficial infection at site of nail insertion

The final outcome based on the observations was done as per Flynn's criteria as follows[1]

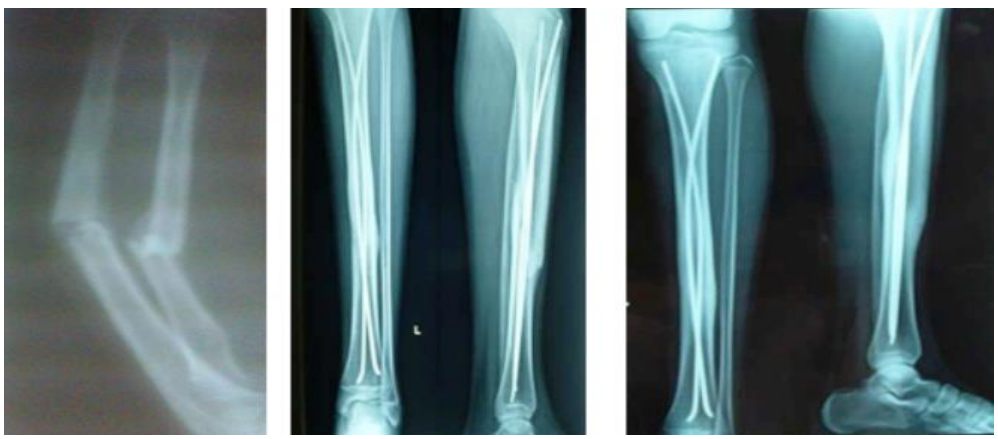
A. Excellent: There is anatomical or near anatomical alignment, no leg length discrepancy with no preoperative problems.
B. Satisfactory: There is acceptable alignment and leg length with resolution of preoperative problems.
C. Poor: There is presence of unacceptable alignment or leg length with unresolved preoperative problems.

Statistical Analysis

Descriptive statistics like numbers, percentages, average, standard deviations, were used. Data was presented in the form of tables and graphs wherever necessary. Inferential statistical tests like Chi- square and Fisher's exact probability test were applied to know the association between incidence of complications and clinical variables

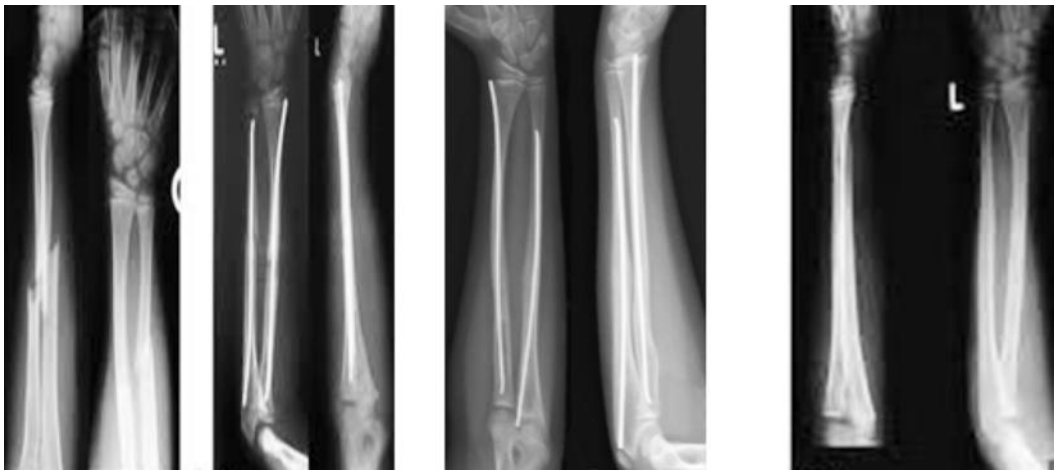
Preoperative **6 Weeks** **12 Weeks**

Figure: 2 Femur



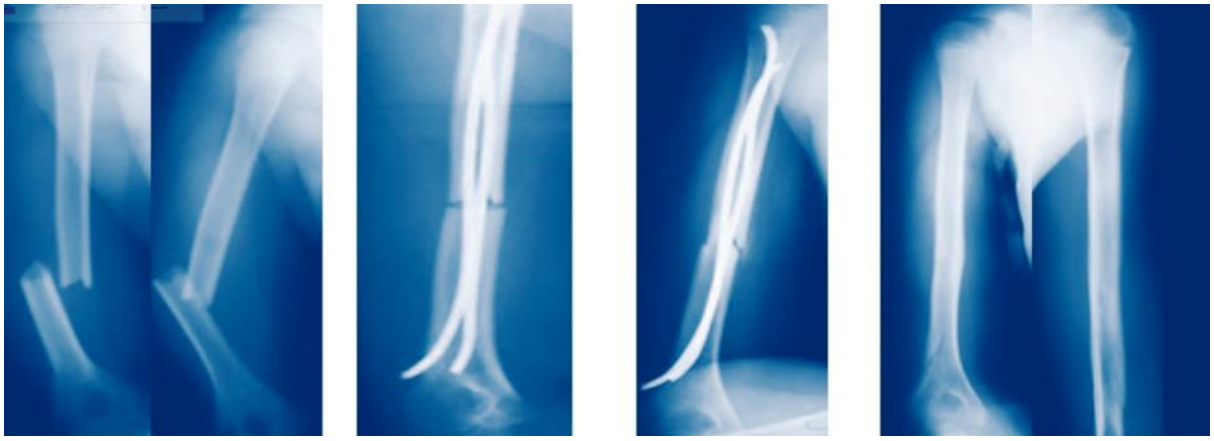
Preoperative **6 Weeks** **12Weeks**

Figure: 3 Tibia



Preoperative 6 Weeks 12Weeks

Figure: 4 Fore arm



Pre-operative 6 Weeks 12Weeks 24 Weeks

Figure: 5 Humerus

RESULTS AND DISCUSSION

In the present study 13(43.3%) of the patients were 5-8 years, 7 (23.3%)were 9 to 12 years and 10 (33.3%) were 13 to 16 years age group with the average age being 9.8 years. Canale ST et al et al studied children ranged from 5-16 years with a mean of 10.2 years.[8] Bhasker A et al studied children ranged from 7.2-16 years with a mean of 12.2 years.[8]

There were 9(30%) girls and 21 (70%) boys in the present study. The sex incidence is comparable to other studies in the literature. In their study Sanders JO et al. out of 118 cases, had 80 (67.7%) boys and 38 girls.[9] Study of Reeves et al. showed 48 (72.7%) male and 18 (27.3%) females out of 66 patients.[10]

In the present study RTA was the most common mode of injury accounting for 16 (53.3%) cases, followed by self fall injuries that accounted for 11 (36.7%) cases and fall from height accounted for 3 (10%) of the cases.

J. M .Flynn et al, in their study assessing 234 cases, demonstrated 136(58.1%) cases of RTAs, 46 (19.6%) cases of self fall and remaining 43(28.8%) were as a result of fall from height.[6] We also assessed the type of fractures and observed that transverse fractures accounted for 10(33.3%) cases, communited fractures contributed to 8(26.7%), oblique fractures were 7(23.3%) and spiral fractures were 5(16.7%). Fractures involving the middle 1/3rd accounted for 16 (53.34%) cases, upper 1/3rd accounted for 7 (23.33%) cases, and lower 1/3rd accounted for 7 (23.33%) cases.

In this study we found that the bone involved in fractures were 12 femur 12 (40%), 10 tibia (33.34%), 4 humerus (13.33%) and 4 forearm bone fractures (13.33%). In one surgical study, they had 42 (24.28%) femoral, 3.6 (20.80%) tibial, 53 (30.64%) humeral and 42 (24.28%) forearm bone fracture.[11]

All the patients were prepared and operated as early as possible once the general condition was stable and the patient was fit for surgery. The average duration between trauma and surgery was 3.96 days and average duration of surgery is 59.9 minutes.21 (70%) cases were immobilized postoperatively for 6 weeks and such immobilization was for 9 weeks in rest of the 9 (30%) of the cases with an average duration of stay in hospital for 11.6 days. Union was achieved in <3 months in 24 (80%) of the patients with average time to union being 12.1 weeks. Unsupported full weight bearing walking in case of lower limb fractures, carrying weights in case of upper limb fractures was started in < 3 months for 24 (80%) of the patients. All patients with femur and tibia fractures had full range of hip and ankle motion in the present study and 2 (6.66%) patients had mild restriction in knee flexion at 12 weeks.

2 (6.67%) had developed pain at site of nail insertion during follow up evaluation, all of which resolved by the end of 12 weeks follow up. Superficial infection was seen in 1(3.3%) case. 1 (3.33%) patient had bone shortening (femur – 1cm) and 1 (3.33%) patient had bone lengthened (femur – 1.2 cm). No patient in our study had major limb length discrepancy (i.e. > ± 2cm). Nail back out was not seen in any of the cases. 1(3.33%) patient presented with

varus angulations, 1(3.33%) patient presented with valgus angulations and no patients had anteroposterior angulations or rotational malalignment. Proximal migration of the medial nail was noticed in one case in our study; during removal a cortical window was made and the nail was removed. Similar to our result, Bar-on E et al also noticed proximal migration of the nail in one case.[12]

In the present study, the final outcome was excellent in 22 (73.33%) cases, satisfactory in 8 (26.67%) cases and there were no poor outcome cases. In Heinrich et al study, the final outcome was excellent in 89% cases, satisfactory in 11% cases and there were no cases showing poor outcome.[13]

CONCLUSION

The development of the TENs fixation method has put an end to criticism of the surgical treatment of pediatric long bone fractures, as it avoids any growth disturbance by preserving the epiphyseal growth plate. It also avoids bone damage or weakening through the elasticity of the construct, which provides a load sharing, biocompatible internal splint, and finally it entails a minimal risk of bone infection. Based on our experience and results, we conclude that "Elastic Stable Intramedullary Nailing" technique is an ideal method for treatment of pediatric diaphyseal fractures of long bones. It gives elastic mobility promoting rapid union at fracture site and stability which is ideal for early mobilization. It gives lower complication rate, good outcome when compared with other methods of treatment. It is a simple, easy, rapid, reliable and effective method for management of pediatric long bone fractures between the ages of 5 to 16 years, with shorter operative time, lesser blood less, lesser radiation exposure, shorter hospital stay, and reasonable time to bone healing. Our study results provide new evidence that expands the inclusion criteria for this treatment and shows that TENS can be successfully used regardless of fracture location and fracture pattern.

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Source of Support: Nil.

Conflict of Interest: None Declared.

Cite this article as: Pravas Kumar, Prahlad Kumar, Shree Prakash Singh. Treatment of Long Bone Fracture in Children by Titanium Elastic Nailing Stabilization. Int J Med Res Prof. 2019 Jan; 5(1):152-56. DOI:10.21276/ijmrp.2019.5.1.033