

# A Clinical study of surgical management of Diaphyseal fracture of Femur in children age 5 to 16 year using Titanium Elastic Nail System (TENS).

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## Abstract:

**Introduction:** Trauma is a leading cause of morbidity and mortality in children after acute infection. Among which paediatric femoral shaft fracture accounts 1.6% of all paediatrics bony injury. There is little controversy regarding treatment of femoral shaft fracture in infants and toddlers using Spica casting and femoral shaft fracture in adolescent using rigid antegrade intramedullary nail. The purpose of the study is to evaluate functional and radiological outcome following fixation of paediatric femoral shaft fracture in age group 5 to 16 years using titanium elastic nail system.

**Material and Methods:** 32 patients with 35 femoral shaft fracture with 3 cases of bilateral femoral shaft fracture included in the study. The cases included were of both sexes with mean age 8.4 years. All cases were closed and fresh fracture with mean duration between trauma and surgery was 2.62 days. All cases were treated with two Titanium elastic nail. Follow up of cases done at regular interval 6th week, 12 week and 24 week. Clinical and Radiological evaluation was done on each follow up using TENS Outcome score by Flynn's Criteria.

**Results-** The average time for union and full weight bearing was 10.94 weeks and 11.22 with standard deviation of 1.32 and 1.03 respectively. The final functional outcome was excellent in 28 (80%) of cases and satisfactory in remaining 7 (20%) with some minor complication which were resolved with intervention. Range of motion excellent in 34(97.14%) and satisfactory in 1 (2.86%).

**Conclusion:** It is a technically simple, easy, rapid, reliable and effective method for management of paediatric femoral fractures between the age of 5 to 16 years, with shorter operative time, shorter hospital stay, early return to the function thus cutting the cost of treatment and having psychosocial advantages and reasonable time to bone healing and physis sparing so less chance of limb length discrepancy.

**Keywords:** Femur shaft fracture, Titanium elastic nail, Adolescent, Physeal injury, Hip spica, Antegrade intramedullary nail

## Introduction

After acute infection, trauma is a leading cause of morbidity and mortality in children although femoral shaft fractures account for 1.6% of all paediatric bony injuries. Femoral shaft fracture has a significant impact not only on the patient and family network but also on regional trauma resources.

The most common mode of injury in children younger than 4 year of age is fall from one metre height, in 4 to 12 years of age sports related accidents and 13 to 14 years of age road traffic accidents are most common mode of injury (1).one should suspect the child abuse when child with multiple fractures in different stages of healing. In children age less than 1 year incidence of child abuse rate ranging from 16.7 to 32.2% and children more than 1 year incidence is 1.5 to 6% (2).

There is little controversy regarding treatment of

adolescent femoral shaft fractures with intramedullary nail fixation. Similarly, there is little controversy over the treatment of infants and toddlers with femoral shaft fractures by using Spica casting. There are different opinion about treatment are for patients who are too old for early Spica casting and yet too young for adult type of treatment with a reamed rod (3).

The treatment options for femoral shaft fractures depending on age include early Spica casting, traction, external fixation, ORIF with plating, flexible intramedullary nails and reamed intramedullary rods.

In children, fractures of the femoral shaft are commonly treated by various types of traction for about 3 weeks, followed by plaster cast immobilization. The two major drawbacks with plaster cast treatment are prolonged bed rest leading to separation of the child from performing routine activities and the expenditure incurred on the treatment during the stay in the hospital (4). In preschool children with femur fracture treatment with traction and casting leads to significant complication compared to elastic nail like angular deformity and limb length discrepancy (5).

External fixation, however, does allow for early discharge from hospital, is less cumbersome than the hip Spica cast, and can be effective for controlling the fracture position,

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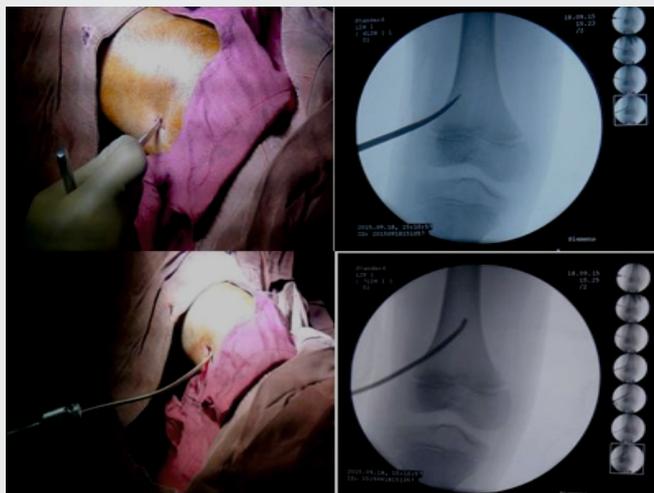


Figure 1: Entry point made with bone awl and prebent nail passed through

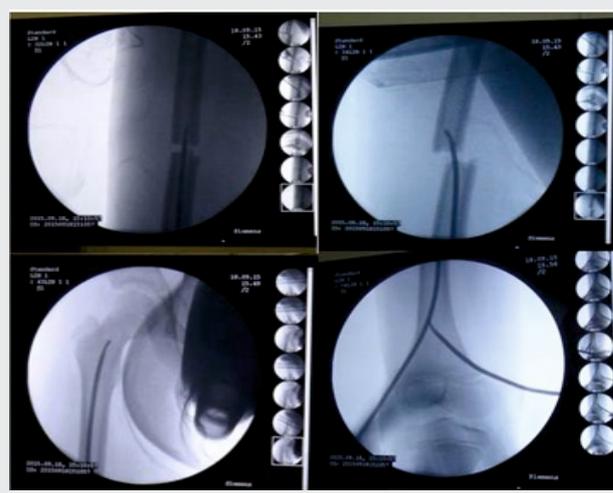


Figure 2: Nail progressed through fracture site

theoretically leading to reduced rates of malunion. But carries certain complications like pin track infection and re fracture after external fixation removal (6).

The femoral shaft fracture treated with reamed rigid intramedullary nail can start early weight bearing and less chance of rotational malunion, angular deformity. However, the use of reamed rigid nails introduced through the piriformis fossa has been associated with avascular necrosis of the femoral head in children and adolescents. Rigid nails in children younger than 13 years have also been associated with growth disturbance with femoral neck deformity, including coxa valga and thinning of the femoral neck. Compression plating of fractures of the femoral shaft provided excellent stability and maintenance of length in unstable fractures, but required a large exposure, resulting in extensive soft tissue injury and stripping of the fracture site and skin scarring (7).

Titanium elastic stable intramedullary nailing of long bone fractures in the skeletally immature has gained wide spread popularity because of its clinical effectiveness and low risk of complications. Many studies have supported the use of

this technique in the femur, citing advantages that include closed insertion, preservation of the fracture hematoma, and a physel sparing entry point (4, 8, 9).

### Material and Methods

32 patients with 35 closed diaphyseal fractures of the femur (3 bilateral femur shaft fracture) were treated with titanium elastic nailing (TENS) in our institution. Children and adolescents aged between 5 to 16 years were included in the study with the average age being 8.4 years (Table-1). 25 (78.12%) patients were boys and RTA was the most common mode of injury accounting for (53.12%) cases followed by self-fall 8(25%). Fractures involving the middle 1/3rd accounted for 21(60%) cases followed by proximal 1/3rd accounted for 13(37.14%). Transverse fractures accounted for 20(57.14%) cases, oblique fractures 08(22.86%) cases, spiral fractures 05 (14.29%) cases and comminuted fractures 02(5.71%) cases.

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 2.62 days. All surgeries were performed on fracture table under radiographic control. Closed reduction done in all patients. Two prebent flexible nails were inserted across the fracture in a retrograde



Fig.3 Second Nail introduced through medial entry across the fracture site

Table 1- Demography

1	Number patients treated	32
2	Number of fractures treated (including 3 bilateral cases)	35
3	Male	25
4	Female	7
5	Male: Female ratio	3.5: 1
6	Mean Age	8.4 years



Figure 4: preoperative and immediate postoperative radiographs



Figure 5: After 6 weeks and 15 weeks post operative radiographs

after active and passive movements started at hip, knee and ankle were started. Patient kept non weight bearing till next follow up. Progression of union at fracture site was monitored on serial radiographs on each follow up, usually taken at 6th week, 12th week and 24th week there after every 6th month. Full weight bearing was allowed once radiographic union was achieved.

The evaluation of

outcome done using TENS outcome scoring system by Flynn et al's criteria (Table 2).

**Results:**

32 patients with 35 closed femoral shaft fracture (3 cases were bilateral femoral shaft fracture) with mean age was 8.4 years treated with two Titanium elastic nails. Closed

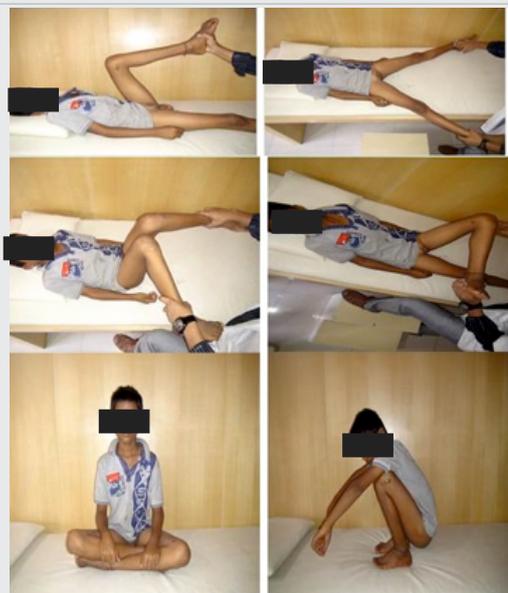


Figure 6: Clinical photograph showing range of motion, sitting cross leg and squatting

fashion. Both nails were inserted about 2 cm proximal to distal femoral physis from medial and lateral sides. Lateral nail was directed till it was within 2 cm of proximal

femoral capital physis whereas medial nail was inserted till it was about 1 cm from greater trochanteric physis. The size of the flexible nail should be approximately 40% of the diameter of the femoral canal at its most narrow point. The diameter of the individual nail was selected as per Flynn et al's formula (Diameter of nail = Width of the narrowest point of the medullary canal on Antero posterior and Lateral view  $\times$  0.4 mm). All titanium nails were bent at insertion site and cut close to bone leaving 1.5-2 cm of nail protruding for later easy removal (Fig 1,2 and 3). Average operative time for this procedure was 61.71 (range 40-100) minutes. Average post-operative hospital stay for patients was 6.4 (4-12) days. Post-operative immobilization used in all cases using high groin above knee cast for 6 weeks there

Table 2 TENS outcome score (Flynn et al)

Variables at 24 weeks	Results		
	Excellent	Satisfactory	Poor
Limb length inequality	< 1.0 cm	2.0 cm	> 2.0 cm
Malalignment	5 degrees	< 10 degrees	10 degrees >
Unresolved pain	Absent	Absent	Present
Other complication	None	Minor but resolved	Major and lasting morbidity

Table- 3: Functional Outcome as per TENS scoring system

Clinical Outcome	No of Patients	Percentage
Excellent	28	80.00%
Satisfactory	07	20.00%
Poor	00	00%
Total	35	100%

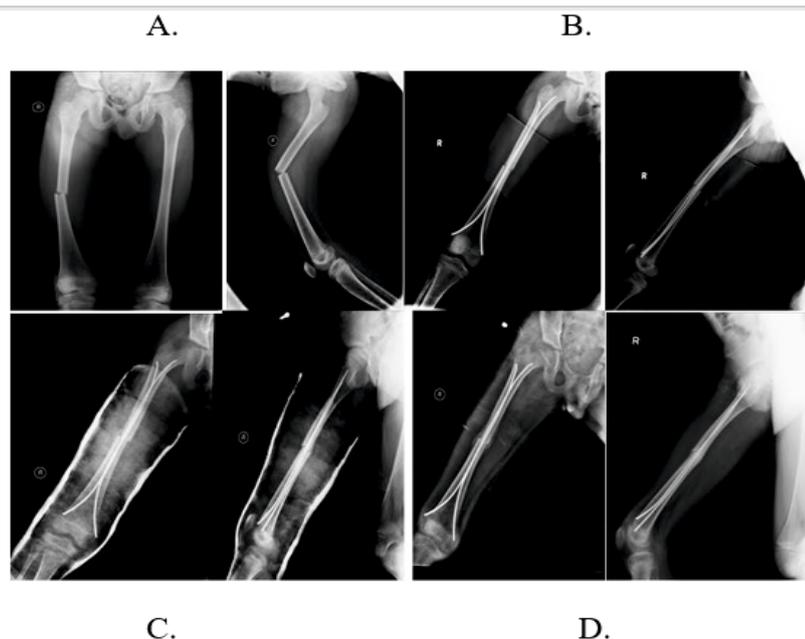


Fig.7 A) Pre-operative, B) Immediate post-operative, C) After 6week and D) After 12weeks



Fig.8 After 24 weeks and implant Removal

reduction done in all 35 cases. The patients were evaluated both clinically and radiologically on each follow up. Follow up done at 6th week, 12th week and 24 week. The assessment done for pain, range of motion at hip and knee, limb length the complications (Fig 4,5,6 and 8).

Duration of surgery for majority of patients between 40 and 100 minutes while the average duration of surgery is 61.71 minutes. The average duration of hospital stay and post-operative immobilisation was 6.4 days and 6.22 weeks respectively.

Union was achieved in < 10 weeks in 15(42.86%) of patients, 11-14 weeks in 20(57.14%) of the patients with average time to union being 10.1 weeks. Unsupported full weight bearing walking was started in < 10 weeks for 14 (40%) of the patients, 11-14 weeks in 21(60%) of patients.

Complications:Pain- In the present study, 6 (18.75%) patients had developed pain at site of nail insertion during initial follow up evaluation which resolved completely in all of them by the end of 12 weeks.

Range of motion- All patients had full range of hip movement in the present study and 6 (17.14%) patients had mild restriction in knee flexion at 12 weeks and all improved with physiotherapy except 1 (2.86%) needed knee manipulation under general anaesthesia, 6 (17.14%) had developed pain at site of nail insertion during follow up evaluation, all of which resolved by the end of 24 weeks follow up.

Infection- Superficial infection was seen in 3 (8.57%) cases in this study which was controlled by antibiotics.

Limb length discrepancy- 3 (8.57%) patients had limb shortening with average of 0.7 cm. No patient in this study had major limb length discrepancy (i.e.  $> \pm 2$ cm).

Nail impingement- Nail impingement was seen in 1 (62.86%) of the cases while no patients presented with

varus or valgus, anteroposterior or rotational malalignment.

The final functional outcome was excellent in 28 (80%) of cases and satisfactory in remaining 7 (20%) cases while there were no poor outcome cases (Table 3). Also the outcome of some of the additional variables like range of movement excellent in 34(97.14%), satisfactory in 1(2.86%), time for union and unsupported weight bearing was excellent in all 35 cases. There is no statistically significant difference of level and pattern of fractures to the time for union and time weight bearing (P value 0.405 and 0.258 respectively).

### Discussion:

The treatment of femoral shaft fractures in children, particularly those who are between 5 to 16 years of age is controversial. Operative treatment is becoming more accepted. Each of the surgical methods described have specific advantages and potential complications that must be appreciated by the treating surgeon. The present study was conducted to assess the union rates and function outcome results of titanium elastic nailing system (TENS) fixation of closed femoral shaft fracture in children between 5 to 16 years.

Because of the increasing costs of health care, surgical fixation of children's shaft femur fractures with resultant early mobilization and discharge from the hospital has become increasingly popular. Recognizing the relative safety and efficacy of femoral shaft fracture fixation with Titanium elastic intramedullary nails, several large medical centers in the United States and Europe have reported on series of femoral fractures in children and adolescents, proving the value of this method.

In the present study, the mean age being 8.4 years with

youngest 5 years, oldest 14 years. Fabiano Prata Nascimento et al (10) treated femoral shaft fractures in age range 5 to 14 yrs with mean age being 9.6 yrs. Alenjandro Uribe Rios et al (11) conducted a prospective study regarding effects of stainless steel flexible nails in children aged between 5 and 12 yrs, in a study group of 48 patients. The mean age was 8.6 years. In the present study RTA was the most common mode of injury accounting for 17(53.12%) cases, self-fall while playing accounted for 18 (25.00%) and fall from height in 7(21.88%) cases. Bar-on E, et al (12) conducted study on 20 femoral shaft fractures. Motor vehicle accident was the cause of injury in 15 (75%) cases. In the study conducted by Alenjandro Uribe Rios et al (11) the commonest mechanism of injury was road traffic accidents in 37(77%) patients and 8 (16.7%) patients had fall from height.

In this study, transverse fractures accounted for 20 (57.14%) cases, oblique fractures accounted for 8(22.86%) cases and spiral fractures accounted for 5(14.29%) cases and comminuted fractures accounted for 2(5.71%) cases. Heinrich SD, et al (13), noted 35 (44.87%) transverse fractures and 14 (17.94%) oblique fractures in their study and Cramer KE. et al (14), noted 35 (61.4%) transverse fractures and 16 (28.07%) spiral fractures.

In the present study, The mean duration of surgery Minimum duration taken for surgery is 61.71 minutes. In Khurram Barlas et al (15) study, the average duration of surgery was 70 minutes. In a study by K C Saikia et al (16), the duration of surgery ranged from 50 – 120 minutes with a mean of 70 minutes.

The average duration of hospital stay in the present study was 6.4 days. The mean hospital stay was 12 days in Kalenderer O, et al (17) study. Greisberg J et al (18) compared the study of flexible intramedullary nailing with hip Spica casting. They noted average hospital stay of 6 days in flexible intramedullary nail versus 29 days in hip Spica casting group. Compared to the above studies conducted on conservative methods and cast bracing, the average duration of hospital stay was less in this study i.e. 6.4 days. The reduced hospital stay in this series is because of proper selection of patients, stable fixation and fewer incidences of complications.

In the present study, average time to union was 10.94 weeks. Oh C.W et al (19) reported average time for union as 10.5 weeks. Aksoy C, et al (20) compared the results of compression plate fixation and flexible intramedullary nail insertion. Average time to union was 7.7 (4 to 10) months in the plating group and 4 (3 to 7) months for flexible intramedullary nailing..

In the present study, 6 (18.75%) patients had developed pain at site of nail insertion during initial follow up evaluation which resolved completely in all of them by the end of 12 weeks. Superficial infection was seen in 3 (8.57%) cases in this study which was controlled by antibiotics. J.M.Flynn et al (8) reported 38 (16.2%) cases

of pain at site of nail insertion and 4(1.7%) out of 234 fractures treated with titanium elastic nails.

All patients had full range of hip motion in the present study but 6(17.14%) had mild restriction and 1(2.86%) had moderate restriction at knee joint at 6 week follow up vigorous physiotherapy was given, By 12 weeks follow up all patients had full range of motion except 1(2.86%) patients had terminal 45° restriction in knee flexion, which was treated with knee manipulation under anaesthesia then normal range of knee flexion was achieved at six months. Loss of motion at the knee was seen in 14 (53.84%) patients in Herscovici et al (21) study.

No case had limb lengthening and 3(8.5%) cases had limb shortening with average of 7mm in the present study. Beaty et al (22) reported, two patients had overgrowth of more than 2.5 cm necessitating epiphysiodesis, after conservative treatment. Ozturkman Y. et al (23) observed mean leg lengthening of 7mm in 4 patients and mean shortening of 6 mm in two children.

The advantages of the present study include minimal scarring, closed reduction, load sharing device, fracture heals by secondary callus formation which is stronger and refracture is not a risk..

The development of the TENS fixation method has put an end to criticism of the surgical treatment of paediatric long bone fractures, as it avoids any growth disturbance by preserving the epiphyseal growth plate, it 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

### Conclusion

It is a technically simple, easy, rapid, reliable and effective method for management of paediatric femoral fractures between the age of 5 to 16 years, with shorter operative time, lesser blood loss, lesser radiation exposure, shorter hospital stay, early return to the function thus cutting the cost of treatment and having psychosocial advantages and reasonable time to bone healing and physis sparing so less chance of limb length discrepancy.

### LIMITATIONS:

Small sample size and short duration of time is a limitation of the study. Further larger multicentric studies are required to verify the findings.

In this study, patients who were treated with Titanium Elastin Nailing were not compared with patients who had other treatment modalities.

Accurate measurement of time to union, time to partial and full weight bearing and time of bridging callus is influenced by the frequency of follow-up, which in our

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