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## Analysis of pediatric diaphyseal femoral fracture treated with titanium elastic nailing system

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### Abstract

With many modalities available in literature to treat a pediatric femur diaphyseal fracture, it often creates a debate amongst the orthopedicians to choose a treatment of choice. The frequency of such fractures is increasing over the years due to increasing road traffic accidents. Until recently the conservative management was the preferred method to treat such injuries, however because of advantages such as early mobilization, reduced hospital stay, reduced loss of school days, less psychological impact and better nursing care, Titanium elastic nailing system (TENS) has gained the popularity over last two decades. In north eastern region of India to the best of our knowledge, no such study has been done to assess the functional outcome of TENS in pediatric femur diaphyseal fracture in age group of 6-11 years. Hence we retrospectively analysed the result of pediatric femoral diaphyseal fractures in 32 children (23 boys and 9 girls) in the age group of 6-11 years stabilized with titanium elastic nail (TEN).

**Results:** Using Flynn criteria, outcome was excellent in 90.62% (n=29) children and satisfactory in 9.27% (n=3) children at the final follow up period of 6- 8 months after operation. Patients achieved union over a mean period of 8 weeks. Pin site irritation was found in 12.5% (n=4) patients initially which later subsided with physiotherapy at final follow up (6 months). No cases with superficial or deep infection were reported. No child reported any rotational or sagittal plane deformities.

**Conclusion:** Titanium elastic nailing system provides an effective mode of treatment in pediatric femoral diaphyseal fracture in the age group of 6-11 years with advantages of early mobilization and union.

**Keywords:** Femur fractures, Titanium elastic nail, flexible intramedullary nailing

### Introduction

Femoral diaphyseal fracture accounts for 1.4-1.7<sup>[1]</sup> % of all the fractures in childhood with boys having higher rate of incidence than girls. With bimodal distribution, this fracture is common in early childhood due to relative weakness in cortical strength and then later in mid-adolescence due to high energy trauma associated with road traffic accidents. Management options depends on many factors primarily- age, weight, skeletal immaturity, type of fracture, social situation (i.e., involvement of caregivers, local expertise, wishes and social circumstances of family, child abuse), fracture location, mechanism of injury and the presence of concomitant injuries. Management modalities for femoral diaphyseal fracture in children of age 6-11 years includes casting, traction, external fixation, plating, and elastic stable intramedullary nailing (ESIN) with TENS. Choosing a treatment of choice remains a topic of debate in such injuries. An ideal fixation device for such injuries will have characteristics to act as a load-sharing “internal splint”, maintaining reduction for a few weeks until callus forms and most importantly it should neither cause injury to the physis nor to femoral head vascular supply. Titanium Elastic nailing system (TENS) provides such benefits along with allowing for enough fracture site motion for callus formation. Other advantages of TENS include early weight bearing, small scar, less injury to the surrounding soft tissue, better patient compliance, ease of removal and high patient satisfaction<sup>[2-4]</sup>. There is very limited literature available about the functional outcome of pediatric femoral diaphyseal fractures treated with TENS from the north eastern region of India. We conducted a retrospective analysis of pediatric femoral diaphyseal fractures treated with TENS with the objective of evaluating its role and efficacy in the 6-11 years age group.

### Materials and Methods

We retrospectively analysed 32 cases of fresh (<5 days old) pediatric femoral diaphyseal

fractures in between the age group of 6-11 years (at the time of injury) treated using titanium elastic nail (Nebula TIT elastic nail Product code-T190) at a tertiary care centre in Imphal, Manipur; operated by a single surgeon. Inclusion criteria were a) patients in age group 6-11 years with closed femur diaphyseal fracture, b) recent fracture (< 5 days old). The exclusion criteria were a) open fractures, b) patient with extreme proximal or distal femur fracture closer to epiphyseal plate, c) pathological fractures, d) metabolic bone disorders, e) ipsilateral physeal injury to knee or ankle f) ipsilateral tibia fracture or contralateral tibia/ femur fracture g) comminuted fractures, h) associated neurovascular injury, i) comminuted fractures. Total of 32 consecutive patients (23 boys and 9 girls) were included. All the patients were operated within 5 days of injury. All patients were evaluated and treated for life/limb threatening injuries and other associated injuries. Displaced fractures were immobilized using skin traction with Thomas splint till the date of surgery. As a part of pre-operative planning radiographs of thigh were taken with one joint above and one below both in anteroposterior and lateral view. Fracture geometry and medullary canal diameter were assessed.

### Surgical technique

All patients were operated under general anesthesia. Patient was positioned in supine on the fracture table (Fig. 1). Nail diameter was determined based on Flynn *et al*'s formula and intraoperative assessment (Nail diameter= width of narrowest point of medullary canal on anteroposterior and lateral radiographs \* 0.40) or at least  $1/3^{\text{rd}}$  of the narrowest diameter of diaphysis. Fractures were reduced with appropriate maneuvering over the fracture table. Utmost attention was given to rotational and angular alignment with the help of fluoroscopic images intraoperatively. Nail insertion was done in a retrograde manner (ascending). Entry point was made with lateral and medial incision 2-3 cm proximal to growth plate in a sagittal plane. Awl was used to perforate the near cortex of bone under direct vision. After reaching the medullary canal, awl was lowered  $45^{\circ}$  to shaft and advanced in an oscillating manner. Nails were prebent about 3 times the diameter of the medullary canal at the level of isthmus (Fig. 2). Nails were driven across the fracture site (Fig.3) on both the sides and by avoiding corkscrew phenomenon. In 2 cases open reduction was performed where finger was used with the help of small skin incision to negotiate the entry of nail into proximal fragment, without inserting any instruments. Traction was released at this point, so that the distraction disappeared and fracture ends collapsed. Final seating of the nail of medial side should be at least to the level of lesser trochanter and the one on lateral side towards greater trochanter. Optimally the nail tips should be at same level. Align them so that nail tips diverge. For fracture in proximal third advance lateral nail into greater trochanter and medial nail into femoral neck taking care not to penetrate the femoral

neck. Nail's advancement and final positioning was confirmed under the image intensifier taking control of rotation of the limb. Nail were cut with only 1-2 cm nail outside cortex and snugly fitting to metaphyseal flare. Postoperatively quadriceps strengthening exercises started as soon as pain subsides. Non weight bearing ambulation with walking aids was started over next few days followed by partial weight bearing after appearance of callus radiologically around 4 weeks post operatively and full weight bearing was started at 8-9 weeks depending on radiological union. All patients were followed radiologically as well as clinically till minimum of 6 months post operatively. Final outcome was assessed as per Flynn's criteria (Table 1). Limb length was measured. Radiographs were used to assess coronal and sagittal plane deformities. Foot progression angle was used for assessing rotational deformity. A case has been shown with subsequent follow up. (Fig. 4, 5)



Fig 1: Operation theatre setup with patient on the fracture table.



Fig 2: Nail being prebent.



Fig 3: Fluoroscopy and clinical image of TEN driven on both sides in a retrograde manner.



Fig 4: a) Femur diaphyseal fracture in an eight (8) year old male child; b) post-operative radiographs with TENS in situ; c) 8 weeks post-operative radiographs with callus formation; d) after implant removal, 6 months post operatively.



Fig 5: clinical photographs of a patient from our series.

Table 1: Flynn's criteria: TEN outcome scoring.

|                         | Excellent result | Satisfactory result | Poor result                                 |
|-------------------------|------------------|---------------------|---|
| Limb length discrepancy | <1.0 cm          | <2.0 cm             | >2.0 cm                                     |
| Malalignment            | <5°              | <10°                | > 10°                                       |
| Pain                    | None             | None                | Present                                     |
| Complication            | None             | Minor and resolved  | Major complication and/or lasting morbidity |
| Total =32               | n=29             | n=3                 | n=0   |

## Results

Total of 32 consecutive patients (23 boys and 9 girls) in the age group of 6-11 years were included in the study as per inclusion and exclusion criteria. Mean age of the patients was 9.3 years (range 6-11 years). Road traffic accidents was the most common mode of injury (62.5%, n=20) followed by fall from height (28.12%, n=9) and sports injury (9.375%, n=3). There was 1 case with associated injury of ipsilateral both bone un-displaced forearm fracture, which was managed conservatively with casting. All the fractures were operated within 5 days of injury (median 3 days). 81.25% (n=26) of the fractures were in middle 1/3<sup>rd</sup> region, 12.5% (n=4) in proximal 1/3<sup>rd</sup> and 6.25% (n=2) in distal 1/3<sup>rd</sup> region of femur. The fracture pattern was short oblique in 50% (n=16), simple transverse in 43.75% (n=14) and spiral in 6.25 % (n=2). Reduction was achieved through closed technique with the help of maneuvering, traction by fracture table in 30 cases. Only in 2 cases reduction was carried out with the help of small incision and introducing finger through it, without inserting any instruments. Nail size was determined using Flynn formula and intraoperative assessment. In 3 cases nail

size of 1/3<sup>rd</sup> diameter was inserted due to difficulty in inserting the one as found by Flynn formula. Most common nail diameter used was 3.5 mm (n=18, 56.25%). There were no intraoperative complications reported. No signs of superficial or deep infection was reported in any of cases. Mean hospital stay was 8.2 days (range 6-9 days). Radiological union was seen in all the cases. Union was achieved over a period of 8-10 weeks in 87.5% of patients (n=28), 6-8 weeks in 6.25% cases (n=2) and 10-12 weeks in 6.25 % cases (n=2). One patient (3.125%) had 4 mm lengthening. No case of angular or rotational deformity was reported. Terminal range of knee flexion was restricted in one case which was improved with physiotherapy and was achieved comparable to other limb after nail removal. Refracture was not reported in any case. Pain at nail entry site was seen in 4 (12.5%) cases initially but later subsided with physiotherapy. Nails were extracted after 6- 8 months after clinical and radiological assessment, without any complications. As per Flynn criteria excellent outcome was found in 90.62% (n=29) and satisfactory in 9.37% (n=3) cases.

Table 2: Important findings of our study

| Total no. of patients 32 |                            |    |        |
|--------------------------|----------------------------|----|--------|
| Sex                      | Boys                       | 23 | 71.87% |
|                          | Girls                      | 9  | 28.12% |
| Mechanism of injury      | Road traffic accidents     | 20 | 62.5%  |
|                          | Fall from height           | 9  | 28.12% |
|                          | Sport injuries             | 3  | 9.375% |
| Fracture location        | Proximal 1/3 <sup>rd</sup> | 4  | 12.5%  |
|                          | Mid 1/3 <sup>rd</sup>      | 26 | 81.25% |
|                          | Distal 1/3 <sup>rd</sup>   | 2  | 6.25%  |
| Fracture pattern         | Simple transverse          | 14 | 43.75% |
|                          | Simple oblique             | 16 | 50%    |
|                          | Spiral                     | 2  | 6.25%  |
| Radiological union       | 6-8 weeks                  | 6  | 18.75% |
|                          | 8-10 weeks                 | 24 | 75%    |
|                          | 10-12 weeks                | 2  | 6.25%  |

## Discussion

With many modalities available in literature to treat a pediatric femoral diaphyseal fracture, it often creates a debate amongst the orthopedicians to choose a treatment of choice. Until recently the conservative management was the preferred method to treat such injuries however because of advantages such as early mobilization, reduced hospital stay, reduced loss

of school days, less psychological impact and better nursing care, TENS or ESIN have gained popularity over last two decades. Plate osteosynthesis is associated with extensive dissection, disturbing fracture hematoma, more intraoperative blood loss, relatively longer duration of immobilization, risks of delayed union, implant failure, infection, large dissection for plate removal and stress riser effect leading to higher risk

of refracture. Sub-muscular plating with advantage of minimal soft tissue stripping has been found to be useful for comminuted fractures and those with risk of shortening but are frequently associated with malalignment and resulting in malunion. It requires longer operation time and more radiation exposure<sup>[5, 6]</sup>. Interlocking nail is being used widely in skeletally mature children but Beaty *et al.*, reported the complication of segmental osteonecrosis of the femoral head with the piriformis entry in his series<sup>[7, 8, 9]</sup>. Other complications associated with this procedure while taking entry at medial tip of greater trochanter has been trochanteric physis injury leading to coxa valga with the growth. External fixator is a suitable choice in open or severely comminuted fractures and provides good stability and early mobilization but is associated with complications like pin tract infection and delayed starting of weight bearing<sup>[10]</sup>.

TENS has given good results over other surgical treatment options particularly in the 6-11 years age group because of its various properties namely acting as a load-sharing internal splint, neither endangering physis nor the blood supply of femoral head and of early mobilization. Due to elasticity of fixation it promotes faster callus formation. Being a closed procedure it also gives an advantage of not disturbing fracture hematoma and less risk of infection. Advantages of TENS over hip spica in treatment of femoral shaft fractures in children has been well documented by Flynn *et al.* in his series of treatment of femoral fracture in 83 consecutive school going children<sup>[11]</sup>. Buechsenschuetz *et al.*<sup>[12]</sup>, in his

study proved the superiority of TENS as compared to traction and casting in terms of early union and overall patient satisfaction. Ligier *et al.*<sup>[13]</sup> in his series of 123 femoral shaft fractures with elastic stable intramedullary nail also described these advantages of TENS.

In our series of study mean age is 9.2 years. In the study done by Flynn *et al.*<sup>[14]</sup> mean age is 10.2 years. Flynn *et al.*<sup>[14]</sup> demonstrated that TENS is suitable for transverse, short oblique and minimally comminuted fractures. In our series 50% were simple oblique fracture, 43.75% were simple transverse and 6.25% were spiral fractures. TENS has given satisfactory results as advocated by Ligier *et al.*<sup>[13]</sup> in his study of 123 femoral fractures. They reported good results with no patients of non-unions and delayed unions. Similarly in our study all fractures went on to union. Most common complication associated with this procedure is entry site irritation and pain due to nail tip. Flynn *et al.*<sup>[14]</sup> reported 6.89% (n=4) cases of soft tissue irritation at entry site. In our series Pain at nail entry site was seen in 12.5% (n=4) cases initially but later it subsided with physiotherapy in all.

In our study, excellent outcome was found in 90.62% (n=29) and satisfactory in 9.37% (n=3) cases. In series done by Flynn *et al.*<sup>[14]</sup> excellent outcome was found in 67.2% (n= 39) cases, satisfactory in 31.03% (n=18) cases and poor in 1.7% (n=1) (Fig 4). We achieved comparatively better results, probably because of exclusion of comminuted fractures and late adolescent age group patients in our study.

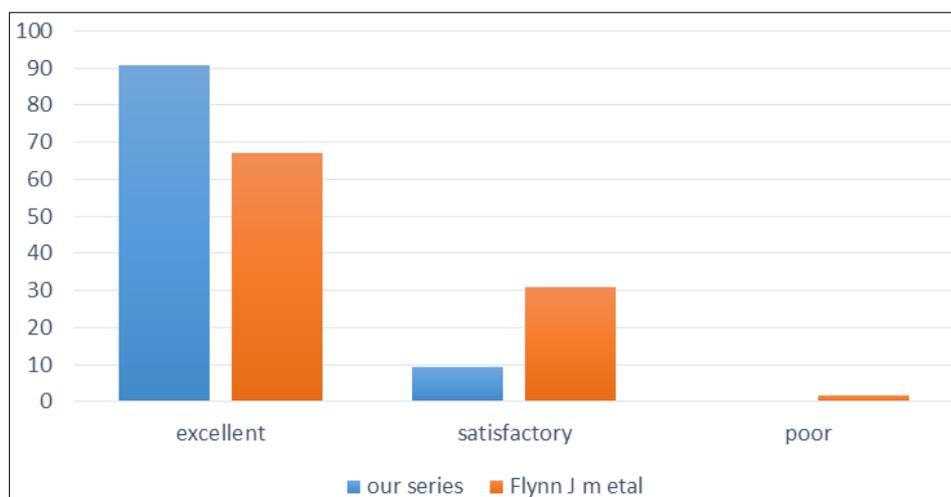


Fig 4: Comparison of our series with Flynn J M *et al.* with respect to TEN scoring criteria by Flynn *et al.*<sup>[14]</sup> (in percentage).

## Conclusion

Based on our study, our conclusion is that use of Titanium elastic Nailing system is an effective method of treatment in pediatric femoral diaphyseal fracture in 6-11 years age group.

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