

## Use of Titanium elastic nailing in children 6-16 years of age with femoral diaphyseal fractures

Ashish Kaushal<sup>1</sup>, Atul Anand<sup>2\*</sup>, Anmol Arpan Nand<sup>3</sup>

<sup>1</sup>Professor, Dept. of Orthopaedics, GR Medical College, Gwalior, Madhya Pradesh, India

<sup>2</sup>Resident, Dept. of Orthopaedics, GR Medical College, Gwalior, Madhya Pradesh, India

<sup>3</sup>Resident, Dept. of Orthopaedics, GR Medical College, Gwalior, Madhya Pradesh, India

Received: 09-11-2021 / Revised: 26-12-2021 / Accepted: 09-01-2022

### Abstract

**Background:** Significant controversy continues regarding the best methods of treating paediatric femoral shaft fractures. Over last 3 decades, operative management of paediatric femoral shaft fractures in age group 6-16 years has been gaining popularity. Titanium Elastic Nailing has now become the choice of fixation in femoral shaft fractures in this age groups. **Objective:** To evaluate the results of titanium elastic nailing system (TENS) in paediatric femoral diaphyseal fractures of children aged 6-16 years. **Material and Methods:** 32 patients (19 boys, 13 girls) in the age range of 6-16 years (average 10.2 years) with recent (< 5 days) femoral shaft fractures (23 closed, 7 Grade- I and 2 Grade- II Gustilo Anderson compound) were fixed with TENS. Evaluation was done on the basis of clinical and radiological evidences. The results were judged using Flynn's scoring criteria. **Results:** Primary union was achieved in all patients without any rotational deformity. Mean operation time was 68 minutes. The results were excellent in 24 patients (75%) and successful in 8 patients (25%). There were 4 cases showing entry site irritation and 2 cases showing superficial infection. Functional outcome was good for those who achieved union. **Conclusion:** It was seen that excellent level of bone union was achieved by performing tens nail fixation in paediatric femoral fractures. Elasticity of nail provided enough counterforce to the muscular forces. TEN is an effective treatment option in selected cases of femoral diaphyseal fractures in the 6-16 years age group.

**Key words:** Paediatric femoral fractures, Intramedullary Nail, Elastic Titanium Nailing.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

### Introduction

Femoral shaft fracture in children is a debilitating injury[1,2]. The treatment has conventionally been depending upon the location, type of fracture, age, patient compliance and associated injuries. The treatment options change with respect to the surgeon's preference also[3]. Above six years of age, these fractures when treated nonoperatively can have loss of reduction, malunion, intolerance to hip spica cast and complications associated with plaster. In children with increasing age angulation is unwanted, as angular deformity is only partially correctable by remodeling with increasing age[6]. This becomes a matter of concern for the parents and they keep wandering restlessly to different doctors. Locked intramedullary nail has been the gold standard of treatment in femoral shaft fractures in skeletally mature children. Almost all of the femoral shaft fractures in children younger than six years of age can be treated conservatively due to rapid and better healing and better remodeling potential in younger children[4,5]. However, the best treatment between 6 and 16 years of age is still a matter of debate[7]. Since the last three decades, there has been a tilt towards operative approach in patients above six years of age[3,6,8]. The various operative methods for such fractures in children comprises of external fixation, compression plating, flexible or rigid intramedullary nail. Titanium Elastic Nailing has now become the choice of fixation in femoral shaft fractures in this age group[9,10]. The advantage of the technique comprises of early union due to micromotion at fracture site, early mobilization, sparing of the physis, earlyweight bearing, small scar, easy implant removal and high patient compliance and full range of knee movement after the surgery[1,3,9,11].

Thirty-two children (19 boys, 13 girls) in the age range of 6-14 years (average 10.2 years) with recent (<4 days) femoral shaft fractures (23 closed, 7 Grade- I Gustilo Anderson and 2 Grade- II Gustilo Anderson compound) were stabilized with Titanium Elastic Nail (TEN), between August 2019 and October 2021. No control group was used in this study. Majority of the fractures i.e., 21 were in the middle third and 6 fractures were in the proximal third, 5 were in the distal third. Most of the fractures were due to road traffic accidents (n=26, 81.25%). Right-sided involvement was seen in 18 cases (56.25%) and associated injuries (head injury in 4 and blunt trauma abdomen in 2) were seen in 6 cases (18.7%). 18 fractures were transverse, 5 minimally comminuted, 5 spiral and 4 were oblique fractures. (Table 1)

**Table 1: Patient and fracture parameters from the study**

Parameters	No. of patients	Percentage
<b>Gender</b>		
Boy	19	59.37%
Girl	13	40.62%
<b>Site of fracture</b>		
Proximal 1/3rd	6	18.75%
Middle 1/3rd	21	65.62%
Distal 1/3rd	5	15.62%
<b>Side Involved</b>		
Right	18	56.25%
Left	14	43.75%
<b>Fracture pattern</b>		
Transverse	18	56.25%
Minimally comminuted	5	15.62%
Spiral	5	15.62%
Oblique	4	12.5%
<b>Fracture Type</b>		
Closed	23	71.87%
Compound GA-I	7	21.87%
Compound GA-II	2	6.25%

\*Correspondence

**Dr. Atul Anand**

Resident, Dept. of Orthopaedics, GR Medical College, Gwalior, Madhya Pradesh, India

E-mail: [atulanand98765@gmail.com](mailto:atulanand98765@gmail.com)

**Material and method**

Majority of the patients (n=28) underwent surgery within 5 days of their admission. Open, old and pathological femoral shaft fracture, severe comminution, subtrochanteric and supracondylar femur fractures were excluded from the study. The surgery was performed under general anaesthesia or spinal anaesthesia with the patient on the traction table in supine position. Fractures were reduced using fluoroscopic guidance. Two Titanium Elastic Nails of identical diameter were used. The diameter of the individual nail was chosen as per Flynn *et al's* formula<sup>1</sup> (**Diameter of nail = Width of the narrowest point of the medullary canal on Anteroposterior and Lateral view × 0.4 mm**). The diameter of the nail was such that each nail occupied at least 35% to 40% of the narrowest medullary cavity. Nails were inserted in retrograde fashion from distal to proximal with

medial and lateral incision 2cm above the physis, after making an entry using an awl under fluoroscopic guidance. The nails were pre bent sufficiently before insertion so that the maximum curvature of the bowed nails rested at the same level in the fracture zone to ensure a good equal recoil force. The nails were driven proximally such that both were divergent and the tips got anchored minimum 1 cm distal to the physis. Derotationsplint was applied to prevent rotation at fracture site postoperatively. Patients were mobilized without weight bearing on the third to fifth day postoperatively. Partial weight bearing was started at 4-6 weeks and full weight bearing by 6-8 weeks depending on the type of fracture and callus formation. The results were evaluated using Flynn *et al's* criteria for TEN. (Table 2)

**Table 2: Flynn scoring criteria for Titanium Elastic Nail**

Parameters	Excellent	Successful	Poor
Limb length discrepancy	<1 c.m.	<2 c.m.	>2 c.m.
Malalignment	<5°	5-10°	>10°
Pain	Absent	Absent	Present
Complications	Absent	Mild	Major

Nails were removed six to eight months post-surgery when the union was well appreciated radiologically. Parameters studied were intraoperative duration, duration of union, patient compliance, complaints, complications, malalignment of the affected side knee and limb length discrepancy.

**Results**

Thirty-two children (19 boys, 13 girls) in the age range of 6-14 years (average 10.2 years) with recent (< 4 days) femoral shaft fractures (23

closed, 7 Grade- I Gustilo Anderson and 2 Grade- II Gustilo Anderson compound) were studied. The mean duration of surgery was 68 min (50-110 min). The size of the elastic nail ranged from 2mm to 4mm. The mean hospital stay was 4 days (2-8 days) in normal patients. Patients with head injury and blunt trauma abdomen had a longer stay period comparatively (7-16 days). Majority of the patients were comfortable after the surgery and were discharged within 48 hours of surgery. Radiological union was achieved in all cases in a meantime of 7.1 weeks (6-9 weeks). (Figure1-2)



**Figure 1: Case 1 illustration**



Figure 2: Case 2 illustration

The results were excellent in 24 patients (75%) and successful in the remaining 8 patients (25%) and poor in none, according to Flynn's criteria. (Table 3) No nail breakage was found because of the ample strength of the nail chosen according to the formula. There were 4 cases who showed entry site irritation and 2 showed superficial infection. One of the infections resolved within seven days of oral course of sensitive antibiotics and the other resolved only after TENS nail removal. (Figure 3)



Figure 3: Clinical photograph showing entry site superficial infection.

Functional outcome was good for all those who achieved union. Full weight bearing was allowed in a meantime of 8.4 weeks (7-10 weeks). Three patients all with proximal 1/3rd had varus angulation (9°, 10° and 6° each) whereas one with distal 1/3rd fracture had valgus angulation (9°). Angulations less than 5 degrees were ignored. Limb length discrepancy of less than 1 cm was found in five and between 1-2cm was found in two patients. (Table 4) All 4 cases with long nail end (>2 cm) had entry site irritation and hence was significantly associated with entry site irritation (*P* value.0001). Primary union was achieved in all patients within the stipulated time. Results were better for children less than 10 years of age. The timing of union was shorter in children <10 years of age and hence early weight bearing. In children >10 years of age the timing of union was longer and it increased with the increasing age. However, union also depended upon the type and location of fractures. Fractures near the isthmus and without comminution united earlier. There were no major complications like nail bending/failure, iatrogenic fracture, non-union, deep infection, joint penetration of nail or any neurovascular complications. Nail removal was quite easy and there were no complications during or after nail removal. The mean time of nail removal surgery was 15 mins(13-22mins).

#### Discussion

Although femoral shaft fractures constitute fewer than 2% of all paediatric fractures(Loder et al), there has been a constant confusion over the choice of treatment especially between 6-16 years; within the orthopaedics fraternity. Until recently the older conservative treatment was the preferred method for the treatment of diaphyseal fractures in children and young adolescents. However, to avoid the effects of prolonged immobilization, loss of school attendance, delayed mobilization, intolerance and for better nursing care (Carey and Galpin, 1996, Beatty and Kasser, 2001 and Salem et al, 2006), the operative approach has been gaining popularity for the last two to three decades(Saikia et al,2007).

Plate osteosynthesis is still widely used. But it is associated with a large exposure, relatively longer duration of immobilization and the risks of delayed union, infection and a second surgery with large dissection for plate removal[13,14]. External fixation comes with the risk of poor patient compliance, pin tract maintenance and infection. Reports of damage to the physis, avascular necrosis of femoral head, coxa valga and growth disturbances have been reported with interlocking nail when attempted in skeletally immature patients[15,16].

Titanium elastic nail seems advantageous over other surgical methods particularly in this age group because it is simple, is a load-sharing internal splint that doesn't violate physis, allows early mobilization and maintains alignment. Micromotion due to the elasticity of the fixation promotes much faster external bridging callus formation. The periosteum is unstripped and being a closed procedure there is no disturbance to the fracture hematoma, therefore there is far lesser risk of infection. Flynn *et al* in their study found TEN to be advantageous over hip spica in treatment of femoral shaft fractures in children[7]. Buechsenschuetz *et al*, documented titanium nail superior in terms of union, scar acceptance and overall patient satisfaction compared to traction and casting[18]. Ligier *et al* operated 123 femoral shaft fractures with elastic stable intramedullary nail and all the fractures united. Out of the total only 13 children developed entry site irritation[19]. Similarly, Narayanan *et al* found pretty good outcome in 79 femoral fractures treated with TEN[3].

No study comparing the efficacy of Ender Nail, Rush Nail or Titanium Elastic Nail were found. However, all the nails give good results. Rush Nail and Ender Nail provide poor rotational stability and require multiple nails to achieve good fixation. However, Ender Nail is non elastic and flexible enough for paediatric fractures as stated by Ligier *et al*,1988& Heinrich *et al*,1998.

Fracture geometry, age, compounding, comminution and the location are important determinants for selection of surgical technique. Flynn *et al* stated that Transverse, short oblique and minimally comminuted fractures are best suited for TEN. Narayanan *et al*[3] stated that transverse, short oblique, short spiral fractures with

minimum comminution in the 5-12 years age group were the best indications for TEN. Lascombes *et al*[21] stated that TEN could be indicated in all femoral diaphyseal fractures of children above six years of age till epiphysis closed except severe Type III open fractures. Titanium elastic nail does not provide adequate stability in comminuted, long oblique or spiral fractures and may even cause shortening. Appropriate alternatives other than titanium elastic nail(TEN) must be considered in such situations.

The most common complication of Titanium elastic nail is probably entry site irritation, infection and pain[3,12]. Other complications include limb length discrepancy, angulation of fracture, refractures and deep infection. Entry site irritation in our study was seen in four cases while 2 cases had superficial infection all associated with prominent nail end i.e.>2 cm. In our study all patients with varus angulations >5 degrees had proximal 1/3rd shaft fractures probably due to the muscle pull and due to wider canal diameter with respect to the combined nail diameter. All the above findings in our study came out to be statistically significant.

#### Conclusion

The titanium elastic nailing is an effective and viable treatment option in selected cases of femoral diaphyseal fractures in the 6-16 years age group and should be preferred over other treatment options in cases of transverse, short oblique and short spiral fractures with minimal comminution. It is definitely advantageous over conservative methods at this age group. It also leads to reduction in concerns of the parents regarding patient compliance, hygiene, nursing care, loss of studies, time of union, complications and postop radiological appearance.

#### References

1. Flynn JM, Skaggs DL, Sponseller PD, Ganley TJ, Kay RM, Kellie Leitch KK. The operative management of pediatric fractures of the lower extremity. *J Bone Joint Surg Am.* 2002;84:2288–300.
2. Heybeli M, Muratli HH, Çeleb L, Gülçek S, Biçimoglu A. The results of intramedullary fixation with titanium elastic nails in children with femoral fractures. *Acta OrthopTraumatol Turc.*2004;38:178–87
3. Narayanan UG, Hyman JE, Wainwright AM, Rang M, Alman BA. Complications of elastic stable intramedullary nail fixation of pediatric femoral fractures and How to avoid them. *J PediatrOrthop.*2004;24:363–9.
4. Buckley SL. Current trends in the treatment of femoral shaft fractures in children and adolescents. *Clin OrthopRelat Res.* 1997;338:60–73.
5. Gwyn DT, Olney BW, Dart BR, Czuwala PJ. Rotational control of various pediatric femur fractures stabilized with Titanium Elastic Nails. *J PediatrOrthop.* 2004;24:172–7.
6. Metaizeau JP. Stable elastic nailing for fractures of the femur in children. *J Bone Joint Surg Br.*2004;86:954–7.
7. Flynn JM, Luedtke LM, Theodore J, Ganley TJ, Dawson J, Davidson RS, et al. Comparison of titanium elastic nails with traction and a spica cast to treat femoral fractures in children. *J Bone Joint Surg Am.* 2004;86:770–7.
8. Canale ST, Tolo VT. Fractures of the femur in children. *J Bone Joint Surg Am.* 1995;77:294–31.
9. Bhaskar A. Treatment of long bone fractures in children by flexible titanium nails. *Indian J Orthop.*2005;39:166–8.
10. Sanders JO, Browne RH, Mooney JF, Raney EM, Horn BD, Anderson DJ, et al. Treatment of femoral shaft by pediatric orthopedist: Results of a 1998 survey. *J PediatrOrthop.* 2001;21:436–41.
11. Hunter JB. The principles of elastic stable intramedullary nailing in children. *Injury.* 2005;36:A20–4
12. Flynn JM, Hresko T, Reynolds RA, Blasler RD, Davidson R, Kasser J. Titanium elastic nails for pediatric femur fractures: A multicenter study of early results with analysis of complications. *J PediatrOrthop.* 2001;21:4–8.

13. Reeves RB, Ballard RI, Hughes JL, Jackson Internal fixation versus traction and casting of adolescent femoral shaft fractures. *J Pediatr Orthop.* 1990;10:592–5.
14. Ward WT, Levy J, Kaye A. Compression plating for child and adolescent femur fractures. *J Paediatr Orthop.* 1992;12:626–32.
15. Beaty JH, Austin SM, Warner WC, Canale ST, Nichols L. Interlocking intramedullary nailing of femoral-shaft fractures in adolescents: Preliminary results and complications. *J Pediatr Orthop.* 1994;14:178–83.
16. Letts M, Jarvis J, Lawton L, Davidson D. Complications of rigid intramedullary rodding of femoral shaft fractures in children. *J Trauma.* 2002;52:504–16.
17. Buford D, Christensen K, Weather P. Intramedullary nailing of femoral fractures in adolescents. *Clin Orthop Relat Res.* 1998;350:85–9.
18. Buechsenschuetz KE, Mehlman CT, Shaw KJ, Crawford AH, Immerman EB. Femoral shaft fractures in children: traction and casting versus elastic stable intramedullary nailing. *J Trauma.* 2002;53:914–21.
19. Ligier JN, Metaizeau JP, Prevot J, Lascombes P. Elastic stable intramedullary nailing of femoral shaft fractures in children. *J Bone Joint Surg Br.* 1988;70:74–7.
20. Heinrich SD, Drvaric DM, Darr K, MacEwen GD. The operative stabilization of pediatric diaphyseal femur fractures with flexible intramedullary nails: A prospective analysis. *J Pediatr Orthop.* 1994;14:501–7.
21. Lascombes P, Haumont T, Journeau P. Use and abuse of flexible intramedullary nailing in children and adolescents. *J Pediatr Orthop.* 2006;26:827–34.

**Conflict of Interest: Nil    Source of support: Nil**