Percutaneous titanium elastic nail for femoral shaft fracture in patient between 5 and 15 years[☆]

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ABSTRACT

Femoral shaft fracture is the commonest major pediatric orthopedic injury requiring hospitalization. Controversy persists regarding management of femoral fractures in the patients aged between 5–15 years.

11 patients were followed up for the mean period of 12 months and evaluated using Flynn's criteria. All the fractures united between 8–12 weeks. 3 patients had knee stiffness, 1 patient had shortening > 2 cm and 1 had superficial infection.

We conclude that TENs is simple, rapid & effective treatment for displaced pediatric femoral shaft fractures between 5–15 years of age with very less complication rate.

1. Introduction

Femoral shaft fracture is the most common major pediatric orthopedic injury requiring hospitalization. It represents about 1.6% of all the bony injuries in children (Including sub-trochantric & inter-trochantric fractures). They are more common in boys than girls (2.6:1).¹ There is a little disagreement concerning the treatment of long bone fractures in children less than 5 years i.e with hip spica application and adolescents older than 15 years i.e with interlocking intramedullary nailing. But controversy persists regarding the patients aged between 5–15 years, with several available options like traction followed by hip spica, external fixation, flexible stable intramedullary nails (Ender or titanium), plate fixation, and locked intramedullary nailing with no clear consensus for the preferred treatment.²

Over the past two decades the advantages of fracture fixation and early mobilization has been increasingly recognized. Thus there is increasing trend towards internal fixation of the pediatric femoral fractures. In 1882 Mataizeau & his team from France developed and revolutionized the technique of flexible stable intramedullary pinning (FSIP) using titanium pins which is now popularly known as TENS has become the choice of operative management for pediatric femoral shaft fractures.³ The aim of this prospective study is to evaluate the results of treatment of pediatric femoral shaft fractures with titanium elastic nails (TENs).

2. Materials and methods

Study was conducted at tertiary care center from Jan 2012 to Dec 2014. Patients aged between 5 years to 15 years with femoral shaft fractures both closed and open were treated with closed reduction and internal fixation with titanium elastic nails (TENs) (Fig. 1). Patients with extreme proximal or distal femoral fractures closer to the epiphyseal plate (10cm), patients with grade III C open femoral fractures and patients with pathological fractures were excluded from the study. The pre-operative radiographs were evaluated to determine the location and pattern of the fracture.

2.1. Surgical technique

Two retrograde TENs were used in all femoral fractures. A traction table was used for all the patients. Intra-operatively fracture was reduced under x-ray image intensifier. A 1-2-cm longitudinal skin incision was made over the medial and lateral surface of the distal femur, starting 2 cm proximal to the distal femoral epiphyseal plate and entry was made in the femur with the help of bone owl. A proper sized nails (not less than 40% of the narrowest diameter of the diaphysis) were used. To achieve good three point contact the TENs are pre-bent over the length of the bone three times the diameter of the medullary canal. Nail was introduced with a T-handle by rotation movements of the

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Fig. 1. (a) Titanium elastic nails (b) Instrument set.

wrist. Under image intensifier control, the nail was driven with rotatory movement or with a hammer to the fracture site which was aligned to anatomical or near anatomical position and the nail was advanced to the proximal fragment. At the same time the second entry point and in the meantime any traction was released to avoid any distraction (Fig. 2). Fracture reduction was checked under image intensifier, end of the nail were buried and wound closed.

Post operatively patients were kept in supine position and above knee plaster slab was applied. This above knee plaster slab was kept for 2 weeks for rotational stability of fracture as elastic nails as per our opinion does not provide sufficient rotational stability. This plaster was removed after 2 weeks as the fracture gets sticky and thus TENS alone can provide sufficient stability at this point. Antibiotic prophylaxis was given for 3 days. Knee mobilization started after removing the slab. Non weight bearing mobilization with walker was started from 2nd post op day or as per tolerance of the patient. Patients were kept non weight bearing till 4 wks and partial weight bearing was started from 4 wks. Complete weight bearing was allowed after bony union.

Study was conducted in department of Orthopaedics between Jan 2011 to Sep 2012. Thirteen less than 7 days old pediatric femoral shaft fractures in 12 patients (10 boys & 2 girls) were fixed with titanium elastic nails (TENS). 10 fractures were closed and 3 fractures were open (Grade I, II and IIIa; Gustilo-anderson type). There were 6 left sided, 5 right sided and 1 patient had bilateral femoral shaft fractures. Surgery was performed within 3 days of hospital admission. Results were evaluated using Flynn's scoring criteria¹ (Table 1) & radiological union was assessed by Anthony et al⁴ scale for grading callus formation (Table 2).

3. Results

Eleven Patients (9 boys and 2 girls) were available for follow up. The predominant mode of injury was due to road traffic accident (RTA) (55%). Right-sided involvement was seen in 5 cases (45%) and left side in 6 cases (55%). Mid-diaphyseal fracture of femur was found in 8 patients (73%), 2 patients (18%) had fracture in distal one-third of femur and 1 patient (9%) had sub-trochanteric femoral fracture. 6 patients (55%) had transverse fracture, 3 patients (27%) had oblique fractures, 1 patient (9%) had spiral fracture and 1 patient (9%) had butterfly fragment (comminuted). Patients were followed up for the mean period of 12 months (6 months -18 months). All the fractures united radiologically between 8 weeks to 12 weeks (Mean 9 weeks)

(Fig. 3 & 4). Full weight bearing was possible after 12 weeks after surgery (Table 3).

Average operating time was 50 min and average hospitalization time was 6 day. Results were excellent in 6 patients, satisfactory in 4 patients & poor in 1 patient according to Flynn's scoring criteria. 3 patients had post operative knee stiffness as the patients did not co-operate for knee mobilization exercises in early post operative period and even after removal of boot and bar plaster at 2 weeks. So patients were put on regular physiotherapy including continues passive motion (CPM). All the patients regained complete range of knee motion after average duration of 2 weeks of physiotherapy and none of the patients had residual knee stiffness. One patient had shortening of more than 2 cm, this patient had a spiral fracture and the patient started weight bearing early. One patient had superficial infection at entry site which healed on regular dressing & antibiotics also two patients had severe skin irritation at entry site for which the nail had to be removed after 6 months in 1st case and 7 months in 2nd case. There were no instances of osteitis or septic arthritis, rotational deformity, or pulmonary embolism, there was also no re-fracture after nail removal and no need for any secondary surgical procedure or readmission after discharge, except for nail removal (Tables 4 and 5).

4. Discussion

Over the past 20 years, pediatric orthopedic surgeons have tried a variety of methods to treat pediatric lower limb fractures to avoid prolonged immobilization and complications. Each method has had its own complications: spica cast immobilization alone or following traction had resulted in limb-length discrepancy, angulations, rotational deformity, psychological and economic complications.^{5,6} External fixation had resulted in pin-tract infection, loss of knee range of motion, delayed union, non-union, and refracture after fixator removal.^{7,8} Solid antegrade intramedullary nailing had resulted in avascular necrosis of the femoral head, trochanteric epiphysiodesis, and coxa valga.

The ideal device to treat paediatric femoral and/or tibial fractures should be a simple, load sharing internal splint, allowing early mobilization while maintaining length and alignment for several weeks until bridging callus forms, without endangering the blood supply to the epiphysis.^{1,2} TENS has all the above properties and thus serves as the ideal implant for pediatric femoral fractures. TENS fixation was used as early as 1982 by French surgeons; one of the main criticism was the cost of treatment.³

Buechsenschuetz et al² in their study including 71 femoral shaft

Fig. 2. (a) Incision (b) Entry with bone awl (c) Nail insertion (d) Nail insertion fluoroscopic (e) Nail negotiating fracture (f) Entry wound.

Table 1
TENS outcome score (Flynn et al ¹).

	Poor results	Satisfactory results	Excellent results
Limb length inequality	> 2cm	< 2cm	< 1cm
Mal-alignment	> 10 degrees	10 degrees	5 drgrees
Pain	Present	None	None
Complication	Major & lasting morbidity	Minor & resolved	None

Table 2
Anthony et al scale for grading callus formation.⁴

Grade 0	No identifiable fracture healing
Grade 1	Primary bone healing with little or no new bone formation
Grade 2	Periosteal new bone formation on two sides of femur
Grade 3	Periosteal new bone formation on three or four sides of femur

fractures in 68 patients compared clinical and functional results of 90-90 traction and spica casting with elastic stable intramedullary nail found no difference between the two groups for standard clinical/

Fig. 3. (a) Pre op x rays right femur (b) Immediate post operative (c) 9 months post operative with healed fracture (d) Patient squatting with full ROM.

functional criteria but elastic nailing group was associated with a lower overall cost than traction and casting group also it resulted in better scar acceptance, and higher overall parent satisfaction.

Ligier et al⁹ and Flynn et al¹ in their studies have reported that TENs can give rotational stability if good care is taken intra-operatively during nail insertion and postoperatively, especially for comminuted, spiral, and long oblique fractures.

Gamal EL-ADL et al¹⁰ in their prospective clinical study to assess the results of operative treatment of paediatric femoral and tibial fractures found that the average hospital stay was 5.7 days and most of the fractures united within 3 months. Mean time to bone healing was 85 days, with a range between 42–140 days and thus concluded that titanium elastic nail fixation is a simple, easy, rapid, reliable and effective method for management of paediatric femoral and tibial fractures between the age of 5 to 16 years, with shorter operative time, lesser blood loss, lesser radiation exposure, shorter hospital stay, and reasonable time to bone healing.

L A Moroz et al¹¹ assessed a total of 229 children with 234 fractures of the diaphysis of the femur retrospectively, clinical assessment

included the range of movement in the hip and knee, rotational alignment, time to weight bearing and nail removal, signs of irritation or local infection from the tip of the nail, and signs of deep infection and post-operative complications also radiological assessment included an assessment of the position of the nail, frontal and sagittal alignment, loss of reduction, callus formation, disturbance of trochanteric growth, osteonecrosis of the femoral head and femoral length. Varus and valgus angulation was measured from the anatomical axis and concluded that Titanium elastic nailing is currently the most popular method for treating fractures of the shaft of the femur in children of school age, and confirmed that the outcome after treatment is excellent or satisfactory in most patients.

The results of the present series are comparable to those of the other series on management of femoral shaft fracture in children (Table 6). It has definite advantages over the other techniques that have been used in the management of pediatric femoral shaft fractures. Notable advantages of this technique are early union due to micro-motion at fracture site, early mobilization, early weight bearing, scar acceptance and high patient and parent satisfaction rate. Besides these TENs due to

Fig. 4. (a) Pre op x rays Left femur (b) Immediate post operative (c) 10 months post op Lat (d) Patient squatting with full ROM.

Table 3
Patient Profile.

VARIABLE	VALUE
(a) Gender	9 (82%)
Male	2 (18%)
Female	
(b) Side involved	5 (45%)
Right	6 (55%)
Left	
(c) Type of Fracture (Gustilo and Anderson)	8 (73%)
Closed Fracture	1 (9%)
Grade I open	2 (18%)
Grade II open	
(d) Type of fracture (Configuration)	6 (55%)
Transverse	3(27%)
Oblique	1 (9%)
Spiral	1 (9%)
Communitied	
(e) Mean Age	10.3 years

Table 4
Results.

Variable	Value
(a) Mean duration of hospital stay	6 days
(b) Mean time for radiological union	10.5 weeks
(c) Flynn's criteria results	
Excellent 6 (55%)	
Satisfactory 4 (36%)	
Poor 1 ((%)	

its retrograde entry do not injure or affect either the epiphysis or the blood supply to femoral head. The excellent biocompatibility and elasticity of titanium have further enhanced the utility of TENs. More importantly elasticity promotes callus formation by limiting stress shielding thus leading to early weight bearing and faster union.

Table 5
Patient profile and results.

Sr. no	Age	Sex	Side	Type of fracture	Type of fracture	Mode of trauma	Hospital stay	LLD	Time of radiological union	Flynn's criteria results
1	12	Male	Right	Closed	Transverse	Fall from height	4 days	None	10 weeks	Excellent
2	9	Male	Right	Closed	Transverse	RTA	5 days	0.5 cm	8 weeks	Excellent
3	8	Male	Left	Closed	Oblique	RTA	8 days	1 cm	12 weeks	Satisfactory
4	6	Female	Left	Grade I open	Comminuted	Fall at home	9 days	1 cm	10 weeks	Satisfactory
5	10	Male	Left	Grade II open	Spiral	RTA	5 days	2 cm	12 weeks	Poor
6	6	Male	Left	Closed	Transverse	RTA	6 days	None	10 weeks	Excellent
7	14	Male	Right	Closed	Transverse	Fall from height	7 days	0.5 cm	12 weeks	Excellent
8	15	Male	Right	Closed	Transverse	RTA	6 days	None	12 weeks	Excellent
9	15	Male	Right	Grade II open	Oblique	RTA	5 days	1 cm	12 weeks	Satisfactory
10	7	Female	Left	Closed	Transverse	Fall at home	4 days	None	8 weeks	Excellent
11	11	Male	Left	Closed	Oblique	Fall from stairs	6 days	0.5 cm	10 weeks	Satisfactory

Table 6
Studies showing results of TENS in femoral shaft fractures.

Study	Number of patients	Hospital stay in days (Mean)	LLD	Time for bony union (Mean)	Flynn's Score		
					Excellent	Satisfactory	Poor
Gamal El-ADL et al. (2009)	66 (73 fractures)	5.7	None	12 weeks (85 days)	75.8%	24.2%	0
Sakia et al. (2007)	22 (22 fractures)	9.8	3 (1.5 cm or less)	8.7 weeks	13 (59%)	6 (27.2%)	3 (13.6%)
Roop singh et al. (2006)	35 (35 fractures)	12.3	3 (1 cm or more)	9.6 weeks	25 (71.4%)	8 (22.8%)	2 (5.8%)
Hassan Al-Sayed et al. (2006)	25 (25 fractures)	12	5 (1.5cm or more)	9 weeks	–	–	–
L A Moroz et al. (2006)	229 (234 fractures)	–	–	–	150 (65%)	57 (25%)	23(10%)
Nishikant Kumar et al. (2010)	20 (20 fractures)	–	4 (1 cm or more)	8 weeks	–	–	–
Present study	11 (11 fractures)	6	1 (2 cm or more)	9 weeks	6 (55%)	4 (36%)	1 (9%)

5. Conclusion

Thus we conclude that Titanium elastic nailing is simple, rapid & effective treatment for displaced pediatric femoral shaft fractures between 5–15 years of age with very less complication rate. It also reduces the hospital stay and helps in early mobilization of children.

Conflict of interest

There is no conflict of interest or any financial gains from anywhere for conducting this study.

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