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Analysis of the Results of Titanium Elastic Nails (TENS) in Paediatric Femur Fractures

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Abstract

Background: Pediatric femur fracture management is a controversial issue even today. Because of the spontaneous healing power of this age group, one school of thought believes in hip spica cast while the other group of orthopedicians prefer surgical management of this fracture.
Aims and Objective: Aim of this study was to analyse the results of pediatric femur fractures treated with Titanium elastic nails (TENS).
Material and Methods: This is a prospective study of 30 cases of pediatric femur fracture treated with TENS in the Department of Orthopedic, SCBMCH, from July 2017 to December 2019 and functional results are analysed with 10 scoring criteria devised by Flynn et al i.e. Flynn criteria. Radiological assessment was done by Anthony et al scale for grading callus formation.
Result: Excellent results achieved in 24 (79%), satisfactory in 4 (15%) and poor in 2(6%) cases as per Flynn criteria. All fracture healed in a mean period of 7.9 weeks (6-12 week). The most common complication was entry site irritation in 6 (20%) that subside after nail removal.
Conclusion: TENS is an effective modality of a surgical method for pediatric femoral shaft fracture with precise technique and proper aftercare
Keywords: TENS; Adolescent femur; Fracture.

Introduction

To this day pediatric femur fracture management is a debatable issue. Until recently application of traction followed by cast application was the preferred method of treatment of diaphysial femur fracture in children [1, 2]. This method was in practice for quite a lot of time as it was relatively easy with rare complications like limb length discrepancy or malunion due to the natural healing power of this age [3].

Recently with advent of newer techniques, orthopaedic surgeons have tried variety of other method to avoid prolonged immobilization specially in poly trauma children [4, 5]. Recent study also showed the increasing awareness of the psychosocial and the economic effect of spica cast immobilization on children and their families [6].

Operative management offers huge advantage to child and family, by short hospitalizations, free movement without cast, better hygiene and shorter school absent.

External fixation has yielded good result with complication like short term loss of knee motion and pin tract infection uncommon but easy to treat [7]. Osteosynthesis with plate is bit more aggressive for paediatric femur fracture in terms of blood loss, soft tissue injury where other less invasive option are available [8]. Ante grade IM nailing is better than cast for adolescent but not In paediatric age group with possible complication like avascular necrosis of head of femur, trochanteric growth arrest and coxa vara [9, 10].

Hence ideal implant for the paediatric femur fracture would be a simple, load sharing, intramedullary nail allowing early mobilisation and maintenance of alignment for few weeks until bridging callus formation without causing serious sequel like that of ante grade nailing. And all these fracture are available with titanium elastic nail which is simple, flexible, available in all sizes and elastic enough to insert easily, used in retrograde manner without injuring the growth plate around hip or knee.

The present study is therefore an attempt to analyze the results of paediatric femur fracture fixed with Titanium Elastic nails.

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Material and Methods

This is a prospective study conducted in Dept. of Orthopaedics, SCB MCH from July 2017 to December 2019. Twenty five cases of pediatric femur fracture fixed with titanium elastic nail.

Inclusion criteria

- Age group 5-15 years,
- shaft of femur fracture
- closed fracture

Exclusion criteria

- Age below 5 and above 15 years,
- Open fracture,
- Fracture involving the epiphyseal ends, comminuted fracture
- Fracture associated with neurovascular injury

All patients were evaluated with complete blood count, standard radiology of the affected limb and standard pre-operative protocol.

Table 1: TENS criteria by Flynn [19]			
	Excellent	Successful	Poor
Limb length discrepancy	<1 cm	<2 cm	>2 cm
Sequence disorder	5 degree	10 degree	>10 degree
Pain	Absent	Absent	Present
Complication	Absent	Mild	Major complication and/or extended period for resolvable morbidity.

Table 2: Anthony et al scale for grading callus formation [9]	
Grade 0	No identifiable fracture healing
Grade 1	Primary bone healing with little r 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

All patients posted for surgery under caudal or general anesthesia after obtaining preoperative fitness and consent for surgery. All except 4 reduced closely fixed with titanium elastic nail under image intensifier retrogradely without injury the distal femoral epiphysis. Patients are followed up at 6 weeks, 3 month, 6 month and 1 year. Non weight bearing advised for first 6 week and gradually weight bearing allowed with confirmation of callus formation on radiology as per Anthony et al scale for grading callus formation. Functional assessment was done according to TENS criteria by Flynn, implant removal was done in all cases between 4-6 month of surgery.

Results

30 patients; 21 (70%) males and 9 (30%) females were available for follow up. Mean age varied from 5-15 years with peak at 5-9 years (68%). Right side was involved in 21 (70%) patients and left in 9 (30%).

The mode of injury was due to RTA 18 (60%), fall 9 (30%) and sports 3 (10%). 7 (24%) patients are associated with poly trauma like head injury, chest injury or other bone fracture. Fracture involving the middle third in 19 (64%), upper third in 7 (23%) and lower third in 4 (13%) patients.12 patients (40%) had transverse, 9 (30%) oblique and 6 (20%) have spiral fracture and 3 (10%) have comminuted fracture.

25 (83%) fracture were reduced closely and limited open reduction in 5 (17%) was done. Nail diameter used were 3.5 mm in 16 patients (53%), 3 mm in 8 (27%), 2.5 mm 4 (13%) and 4 mm in 2 (7%). Average period of union radiologically 7.9 weeks (6-12 weeks). Complication were hard ware prominence and bursitis in 6 cases (20%), pain around knee in 7 cases(24%), restricted of knee motion in 4 cases(12%), limb length discrepancy in 7 cases (24%). There were no nonunion or implant breakage.

Functional assessment done as per TENS criteria described by Flynn et al. was excellent in 24 cases (79%), satisfactory in 4 (15%) and poor in 2 (6%).

Table 3: Patient Profile	
Variable	**Value**
(a) Gender	
Male	21(70%)
Female	9(30%)
(b) Side involved	
Right	21(70%)
Left	9(30%)
(c) Type of fracture(configuration)	
Transverse	12(40%)
Oblique	9(30%)
spiral	6(20%)
comminuted	3(10%)
(d) Cause of injury	
Road traffic accident	18(60%)
Fall from height	9(30%)
Sports	3(10%)

Table 4: Functional assessment by ten scoring criteria by Flynn et al.					
Sr. No.	Limb Length Discrepancy	Malalignment	Pain	Complication	Results
1	-	<5	-		E
2	-	<5	-		E
3	-	<5	-		E
4	9 mm L	10-May	P	Bursitis +Stiffness	S
5	-	<5	-		E
6	-	<5	P	Bursitis	S
7	-	<5	-		E
8	10 mm L	10-May	P		S
9	-	<5	-		E
10	-	<5	-		E
11	13 mm L	15-Oct	P	Bursitis + Ulceration +Stiffness	P
12	5 mm S	<5	-		E
13	-	<5	-		E
14	-	<5	-		E
15	-	<5	-		E
16	12 mm L	10-May	P	Bursitis+ Ulceration +Stiffness	P
17	-	<5	-		E
18	-	<5	-		E
19	-	<5	-		E
20	-	<5	-		E
21	-	<5	-		E
22	7 mm S	<5	P	Bursitis	S
23	-	<5	-		E
24	-	<5	-		E
25	-	<5	-		E
26	-	<5	-	Bursitis	E
27	10 mm L	<5	-		E
28	-	<5	-		E
29	-	<5	P		E
30	-	<5	-		E

Discussion

In this present study, 30 children with shaft of femur fracture were treated by titanium elastic nailing system. The age of the children varied from 5-15 years with a peak at 5-9 year (68%). Anis Shiha et al. (2004) also reported a peak of 54.5% in 5-9 year age group [10]. YHD Lee et al. (2007) documented a higher occurrence of femoral shaft fracture in 5-9 age group [11].

Our series have male predominance 21 (70%) over female 9 (30%) as the male child has more outdoor and sporting activity, more susceptible to trauma. Hassan et al. (2006) reported 88% male child was having femur fracture out of 25 children [12].

70% cases had right side and 30% had left side injury in our study. Saikia (2007) reported 54.5% right sided fracture femur in children [18]. It may be due to right side is the dominant side in most of the children.

The most common cause of injury in our study group was due to road

Table 5: Complications of TENS		
Complication	**No. of cases**	**Percentage**
Pain in knee	7	24%
Infection		
Superficial	2	6%
Deep	0	
Delayed union and nonunion	0	
Limb length discrepancy	7	24%
Lengthening	5	16%
Shortening	2	8%
Mail alignment		
a.Varus Angulation	2	8%
b.Valgus Angulation	2	8%
c.Anterior	0	
d.Posterior	0	
e.Rotational	0	
Bursa at the tip of nail	6	20%
ROM of knee restricted	4	12%

traffic accident (RTA) 18 (60%) cases followed by fall from height 9 (30%). Miguel Mari Beltran et al. (2007) also reported 58% and Hassan et al. (2006) reported 88% cases of RTA in their series [12]. Houshian S et al. (2004) where as reported 48% fall from height and 33% RTA in their series [13].

We had encountered injuries other than femur fracture in 24% cases. 2 cases of head injury and 1 case of multiple rib fracture, 1 case of forearm fracture and 1 case of ipsilateral tibia fracture and are managed accordingly. Zhon-Liau Lee(2005) had associated injuries in 12 out of 18 children i.e.66.6%. 5 Shirzad Houshian (2004) also reported 10% cases of associated head and chest injury [13].

In our series 19 (64%) fractures were in the middle third, 7 (23%) upper third and 4 (13%) in distal third. Hassan (2006) et al. reported all cases in middle third [12]. Bhuyan (2007) similarly reported 15 cases (68.1%) in the middle1/3rd of femur [18].

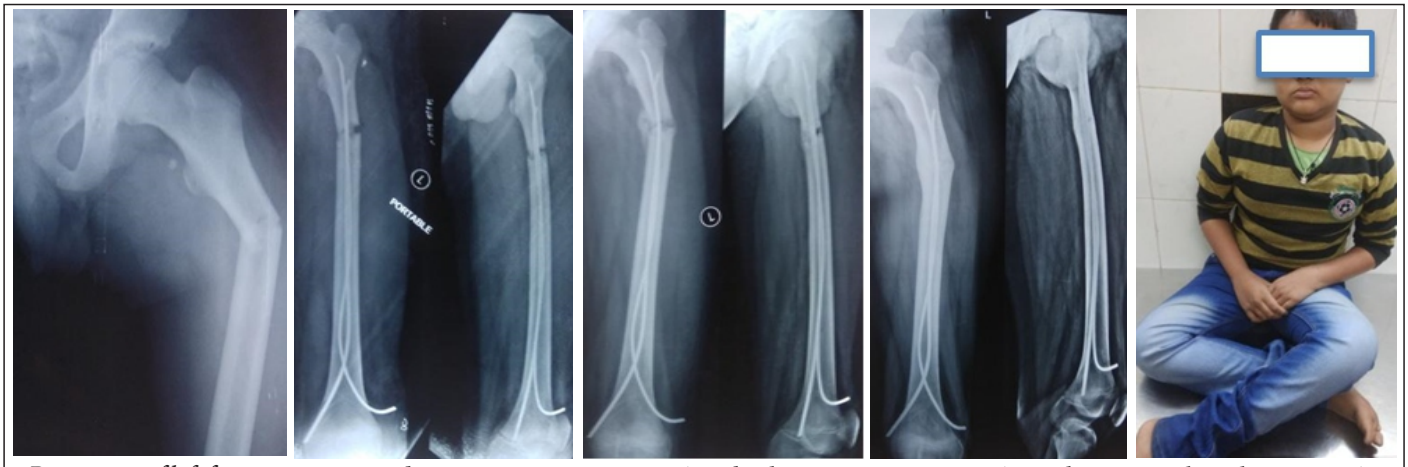
Transverse pattern is the most common pattern 12 (40%) in our study. This has been supported by Rockwood and Wilkin's Fracture in Children, 6th Edition (page-896) which states "The most common femoral fracture in children (over 50%) is a simple transverse, closed, non comminuted injury" [19]. Lee (2007) reported 35 (56%) transverse, 15 (24%) oblique, and 13 (21%) spiral fractures in his series of 63 patients [11].

X-ray fracture right femur (AP) | Immediate post op | 6 Month post op | Cross leg sitting at 6 month | Full weight bearing

Figure 1: X-rays and clinical pictures of Case-I

X-ray fracture left femur | Immediate post op | 6 Month post op | Complication showing nail tip profusion | Restricted knee flexion on cross leg sitting

Figure 2: X-ray and clinical picture of Case-2



Pre op xray of left femur proximal third fracture | Immediate post op | x ray at 6 weeks showing Anthony Grade II callous | Xray at 6 month | Clinical picture at 6 month

Figure 3: X-ray and clinical picture of Case-3

Close reduction was done in 25 (83%) cases and limited open reduction was done in 5 (17%) cases due to soft tissue interposition. Nitish Gogi (2006) similarly failed with 5 cases (total 37 cases) due to soft tissue interposition for which he had done open reduction. Hassan et al. (2006) had done 7 open reductions out of 25 cases [12].

We used 3 mm and 3.5 mm nails in maximum 80% cases. The nail size was 40% of narrowest canal diameter. Nails of equal diameter were used in each case for equal bending, rotational, translational and axial force. Al-Sayed (2006) used similarly 22 nails of 3 mm and 3.5 mm diameter out of 25 cases [12]. He used equal nail diameter in each case. Saikia (2007) advocated about using of equal diameter nail [18].

Radiological and clinical union occurred with an average of 7.9 weeks (6-12 weeks) in our series. 56% cases achieved union within 6-8 weeks. Houshian et al. (2004) reported median union time of 7 (5-9) weeks [13]. S K Bhuyan (2007) similarly achieved union in an average 8.7 weeks (range 6-12 weeks) [18].

Hard ware prominence around knee and nail site irritation was most common complication 6 (20%), all c responded to analgesic and subsided with implant removal. Saikia (2007) had 4 cases of nail site irritation leading to 2 superficial infections which needed oral antibiotics [18].

Restricted range of motion of knee noted in 4 (12%) cases at 6 month, this was due to protrusion of nail tip in the distal femur and all regained full range after nail removal. Slongo (2005) reported the similar cause for knee stiffness due to excessive length of nail [5].

Limb length discrepancy noticed in 7 (24%), 4 cases of lengthening average 11mm and 3 had shortening average 6 mm. This limb length discrepancy was not described as a complaint by the patient and none of them required additional surgery. Houshian S et al (2004) found a leg-length discrepancy of up to 1 cm in 6 children [13].

In our series angular malalignment occurred in 4 (16%) cases which were > 5 degree. Memduh (2004) had angulation less than 10 degrees toward varus/valgus or antero/posterior only in four femurs (11.4%) [16]. Flynn (2001) reported 6 out of 58 cases were having angular malalignment > 5 degree with 2 cases having > 15 degree [17].

Functional assessment was done by using TEN scoring criteria by Flynn et al. In our series excellent results were obtained in 24 (79%), satisfactory 4 (15%) and poor in 2 (6%) patients. Saikia et al. (2007) had excellent results in 13 (59%), satisfactory 6 (27.2%) and poor in 3 (13.6%) cases [18]. Singh (2006) had excellent results in 25, satisfactory in 8 and poor in 2 cases [15].

The result of the present study is comparable with other series of management for paediatric femoral shaft fracture discussed below (Table- 6).

Roop Singh et al.(2006) treated 35 cases with TENS and followed up the patients for 2 years . They got excellent results in 25 (71%) cases, satisfactory in 8 (23%) and poor results in 2 (6%) as per Flynn's criteria. Average union tie was 9.6 weeks with all united. Most common complications was the soft tissue discomfort near the knee produced by the nail ends. They observed shortening in 3 cases, restriction of knee motion in 5 patients. They believed that with

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

Study	No of cases	Union time in weeks	Limb length discrepancy	Flynn score (excellent)	Satisfactory	Poor	Nail tip bursitis
Hassan Al-Sayeed et al.(2006)	25	9	5(>1.5 cm))	-	-	-	-
Roop Singh et al.(2006)	35	9.6	3(<1cm)	25(71%)	8	2	
Saikia et al.(2007)	22	8.7	3(<1.5cm)	13(59%)	6	3	4(18%)
Bhuyan et al(2014)	40	9	6	33(82.5%)	7	-	7(17.5%)
Kawalikar et al.(2018)	11	9	1(>2cm)	6(54.5%)	4	1	3(27%)
Present study	25	7.9	6(<1.1)	19(76%)	4	2	5(20%)

proper operative technique and aftercare TENS may prove to be an ideal implant for pediatric femoral fracture fixation [15].

B.K.Bhuyan et al. (2014) in a short term study of 40 patients, all were radiologically united at 8-10 weeks period (mean 9 weeks) and full weight bearing was possible in a mean time of 9.5 weeks. According to Flynn's criteria, excellent result was found in 33 patients (82.5%) and satisfactory in 7 patients (17.5%). Limb lengthening was noticed in 6 cases, varus mal-alignment was in 4 cases and rotational mal-alignment was seen in 3 cases. They concluded TENS is a safe and effective method for the treatment of pediatric femoral shaft fractures, because it is minimally invasive, relatively easy to use and shows very good functional and cosmetic results [20].

A.Kawalikar et al. (2018) in their study of 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. They 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 [21].

Conclusion

Titanium elastic nailing system is an effective and minimally invasive method of treatment for femur fracture in children. The biomechanical principle of using two symmetrical titanium elastic nails, supporting inner bone at three points produce bending, axial, translational and rotational stability, allows certain amount of micro-motion at the fracture site thus ensuring optimal development of external callus.

The most common disadvantage of this technique, is hard ware prominence at the entry site which causes irritation and restriction of knee movement. This usually subsides with implant removal. Limb length discrepancy noted in some, is never an issue because of rapid remodeling potential of this age.

The cons of this study include small sample size to say it as the treatment modality of choice. Also TENS may not be a good choice of implant for the fracture near the ends of the femur. As our study was not a comparative study with other surgical alternative like plate or external fixation, we cannot claim it as a superior modality than others.

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