International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2017; 3(3): 216-220

www.orthopaper.com
Received: 08-05-2017
Accepted: 10-06-2017

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Functional outcome of treatment of paediatric diaphysial femur fractures operated using titanium elastic nailing

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DOI: http://dx.doi.org/10.22271/ortho.2017.v3.i3d.43

Abstract
Background: Fractures of the femoral shaft are common childhood injuries and among the most common causes of hospitalization for pediatric orthopedic injuries. The treatment for femoral shaft fractures varies based on the child's age and injury with a trend towards operative stabilization. With newer techniques like Titanium Elastic Nailing (TEN) has given good results of fracture reduction and reduced the time of immobilization over previous methods like hip spica cast, external fixators and enders nailing.
Objectives: to review the experience of clinical recovery in treatment of pediatric shaft femur fracture with titanium elastic nailing.
Methodology: after taking institutional ethics committee patients were enrolled according to inclusion and exclusion criteria. Then the patients were treated by minimally invasive osteosynthesis by titanium elastic nailing. Patients were followed up on third, sixth and twelfth week after the surgery and tenderness at insertion site, range of movement of knee, range of movement of hip, squatting, cross legged sitting, limb length discrepancy, radiological investigation were assessed. Flynn's criteria were used to assess the results.
Observation: common type of fracture were transverse (41.5%) and spiral (39%) fracture. And at 12 weeks only 2 (4.9%) patients had the significant tenderness, 4 (9.8%) of patients had limb length discrepancy of 1 to 2 cms, and 41 (100%) radiological union was seen in (100%) patients. The final outcome according to Flynn's criteria shows that excellent outcome seen in 35 (85.3%) of patients, while 4 (9.8%) patients showed satisfactory outcome.
Conclusion: Titanium elastic nail seems advantageous over other surgical methods particularly in this age group because it is simple, is a load shearing device, internal splint that doesn't violate open physis, allows early mobilization and maintains alignment. Micromotion conferred by the elasticity of the fixation promotes faster external bridging callus formation. The periostium is not disturbed and being a closed procedure there is no disturbance of fracture hematoma, thereby less risk of infection.

Keywords: fracture shaft femur, Titanium Elastic Nailing (TEN), Flynn's outcome measure

Introduction
Femoral shaft fractures are among the most common diaphyseal fractures in children with an estimated annual incidence of 19 fractures per 100,000 children. Several observational studies have identified a bimodal age distribution for femoral shaft fractures with peaks in the toddler age group, where falls are the predominant cause of injury, and in the adolescent age group, where motor vehicle collisions cause most of the fractures [1, 2]. Across all age groups, boys have higher rates of femoral shaft fractures than girls.
Fractures of the femoral shaft are common childhood injuries and among the most common causes of hospitalization for pediatric orthopedic injuries. The strong blood supply of the femoral shaft allows for rapid healing and generally favorable outcomes. The treatment for femoral shaft fractures varies based on the child's age and injury with a trend towards operative stabilization. Children younger than 5 years are placed in spica cast [3]. The Pavlik harness can be employed to keep the distal femoral fragment in alignment with the proximal fragment. For femoral fractures in children aged between 5-15 years surgical treatments have become popular in last decade. Surgical treatments for the above age group includes plates, external fixators and flexible intramedullary nails, the later having some advantage over

former two methods [4].

The rapid healing and significant remodeling potential of children in this age group permit this easy method of immobilization. Previously cast was given for pediatric shaft femur fractures then the trend shifted to enders nailing system and external fixation and after that titanium elastic nailing were introduced which gave better results [5]. Morbidity rates have been reduced in femoral shaft fractures, mainly as the result of changes in methods of fracture immobilization. Current therapies allow for early mobilization, thus reducing the risk of complications associated with prolonged bed rest and hospitalization.

With newer techniques like Titanium Elastic Nailing (TEN) has given good results of fracture reduction and reduced the time of immobilization over previous methods like hip spica cast, external fixators and enders nailing [6]. Keeping the above facts in view the purpose of this study is to review the experience of clinical recovery and outcome in treatment of pediatric shaft femur fracture with titanium elastic nailing.

Materials and methods

This study was approved by Institutional Ethical Committee of Shri Krishna Hospital and Pramukhswami Medical College, Karamsad. Total 40 pediatric patients with 41 diaphyseal femur fractures who were operated at our institute with TEN nail within period from May 2008 to August 2011 meeting the following criteria were included and assessed.

Inclusion criteria

1. All paediatric patients within age group of 5-15 yrs with diaphyseal femur fracture
2. Gender: Both males and females included.

Exclusion criteria

1. Age<5yrs and >15yrs
2. Metaphyseal fractures of femur
3. Metabolic bone disorders Gender, Age, existence of associated injuries and affected side were assessed.

The time interval between admission and surgical treatment was noted.

Patients were enrolled in the study only after the informed written consent of legal guardian of the patient.

Methodology of Study

After getting approval from the ethical committee, patients of either gender with paediatric shaft femur fracture were included in the study. All cases were given first aid in the casualty and thorough examination was done to find associated injury. And then x ray pelvis with both hips and femur with hip and knee were taken. All cases were given non adhesive skin traction and symptomatic treatment in the ward. All cases underwent routine preanaesthetic work up and investigations. All patients and legal gardian were explained about the procedure, inclusion in the study. Then the patients were treated by minimally invasive osteosynthesis by titanium elastic nailing.

Patients were followed up on third, sixth and twelfth week after the surgery and tenderness at insertion site, range of movement of knee, range of movement of hip, squatting, cross legged sitting, limb length discrepancy, radiological investigation were assessed. Flynn's criteria [7] were used to assess the results.

Flynn's Criteria	Excellent	Satisfactory	Poor
Length Discrepancy	<1cm	<2cm	>2cm
Malalignment	5 grades	10 grades	>10 grades
Pain	No	No	Yes
Complications	None	minor and solved	major and/ Or residual morbidity

Results

In our study patients were of age group of 5-15 years. Average age was 8.3 years. There was increased incidence of fracture in age group 5-10. Among the 40 patients followed we could notice a prevalence of males. There were 24 (60%) males and 16 (40%) females. Ratio between male to female was 1.5:1. [Table 1]

Side wise distribution shows that 61% of fractures were on right side. 41.5% were presented within 24 hours of fracture while 58.5% patients were presented after 24 hours of fracture. Transverse (41.5%) and spiral fracture (39%) were common type of fracture. While 2 patients had communition type of fracture. [Table 1]

Significant tenderness was seen in 78% of patients at 3 weeks after the ten nailing. Which was decreasing in next follow up visit. And at 12 weeks only 2 (4.9%) patients had the significant tenderness. At 12 week limb length discrepancy of 1 to 2 cms seen in 4 (9.8%) of patients. Radiological union was seen in all (100%) patients at 12 weeks. Above knee immobilization was needed in 3 patients at 3 weeks, which was removed in 2 patients at 6 weeks and remaining was removed by 12 weeks. The knee movement improvement was seen during each follow up, and full knee extension seen in 39 (95.1%) and full knee flexion seen in all 41 (100%) fracture patients by 12 weeks. Cross leg sitting and squatting was achieved in 39 (95.1%) of patients by 12 weeks. [Table 2]

The final outcome according to Flynn's criteria is seen in table 3. That shows that excellent outcome seen in 35 (85.3%) of patients, while 4 (9.8%) patients showed satisfactory outcome and 2 (4.9%) patients showed poor outcome. It shows that 2 out of 3 patients with completed age of 13 had poor outcome. Gender wise result of technique shows that out of 25 male patients 21 had excellent outcome. While 2 had poor and 2 had satisfactory outcome. Among types of fracture one of the transverse and one spiral fracture had poor outcome. [Table 3]

Table 1: Distribution of all the patients.

No.		Frequency	Percent
I	Age		
	5	7	17.5
	6	5	12.5
	7	4	10
	8	8	20
	9	4	10
	10	4	10
	11	2	5
	12	2	5
	13	3	7.5
	14	1	2.5
	Total	40	100.0
II	Gender		
	Male	24	60
	Female	16	40
	Total	40	100
III	Side of fracture		
	Right	25	61
	Left	16	39
	Total	41	100
IV	Injury and operative interval		
	<24 hours	17	41.5
	24 – 48 hours	12	29.5
	>48 hours	11	29
V	Type of fracture		
	Transverse	17	41.5
	Oblique	6	14.6
	Spiral	16	39
	Communition	2	4.9
	Total	41	100

Table 2: follow up findings

		3 weeks	6 weeks	12 weeks
I	Tenderness			
	Less significant	9 (22%)	35 (85.3%)	39 (95.1%)
	Significant	32(78%)	6 (14.7%)	2 (4.9%)
	Total	41 (100%)	41 (100%)	41 (100%)
II	Limb length discrepancy (in Cms)			
	- 1 to 0	2 (4.9%)	2 (4.9%)	1 (2.4%)
	0 to 1	39 (95.1%)	38 (92.7%)	36 (87.8%)
	1 to 2	0 (0%)	1 (2.4%)	4 (9.8%)
	Total	41 (100%)	41 (100%)	41 (100%)
III	Radiological status			
	Uniting	41 (100%)	29 (70.7%)	0 (0%)
	United	0 (0%)	12 (29.3%)	41 (100%)
	Total	41 (100%)	41 (100%)	41 (100%)
IV	Adjuvant modality			
	No any	38 (92.5%)	40 (97.6%)	41 (100%)
	Above Knee immobilization	3 (7.5%)	1 (2.4%)	0 (0%)
	Total	41 (100%)	41 (100%)	41 (100%)
V	Knee Extension			
	Full movement		34 (82.9%)	39 (95.1%)
	Not applicable		1 (2.4%)	0 (0%)
	10		3 (7.3%)	0 (0%)
	20		2 (4.9%)	1 (2.4%)
	50		1(2.4%)	1 (2.4%)
	Total		41 (100%)	41 (100%)
VI	Knee flexion			
	Full Movement		37 (90.2%)	41 (100%)
	Not Applicable		1 (2.4%)	0 (0%)
	70		1 (2.4%)	0 (0%)
	100		2 (4.9%)	0 (0%)
	Total		41 (100%)	41 (100%)
VII	Cross Leg Sitting & Squatting			
	Not possible		2 (4.9%)	0 (0%)
	Partial		4 (9.8%)	2 (4.9%)
	Full		34 (82.9%)	39 (95.1%)
	not Applicable		1 (2.4%)	0 (0%)
	Total		41 (100%)	41 (100%)

Table 3: Result according to Fynn criteria

Fynn's criteria		RESULT		
		Poor	Satisfactory	Excellent
Age (Years)	5	0	1	6
	6	0	0	5
	7	0	0	4
	8	0	1	8
	9	0	1	3
	10	0	0	4
	11	0	0	2
	12	0	0	2
	13	2	0	1
	14	0	1	0
	Total	2	4	35
Sex	Male	2	2	21
	Female	0	2	14
	Total	2	4	35
Types of fracture	Transverse	1	2	14
	Oblique	0	1	5
	Spiral	1	0	15
	Communition	0	1	1
	Total	2	4	35

Discussion

Although femoral shaft fractures constitute fewer than 2% of all paediatric fractures, the choice of treatment has remained a constant challenge to the orthopaedics fraternity. Until recently conservative treatment was the preferred method for the treatment of diaphysial fractures in children and young adolescents. However to avoid the effects of prolonged immobilisation to reduce the loss of school days and for better nursing care, the operative approach has been gaining popularity for the last 2 decades. Present study consists of 40 patients with 41 diaphyseal femur fractures treated by minimally invasive osteosynthesis by titanium elastic nailing.

Patients in this study ranging from 5 to 15 yrs with average age of 8.2 years. Majority in age group 4 to 10. Age distribution in Flynn JM *et al*, study was 6 to 16 yrs with average age of 10.2. [6] Age distribution in Saika KC *et al* study was 6 to 16 yrs with average age of 10 yrs [8]. The study by Gyaneshwar T *et al* (2016) have mean age of fracture femur shaft similar to the present study i.e. 8.6 years [9]. In present study out of 40 patients 24 (60%) male and 16 (40%) female. In Flynn study 60 males and 33 females. In Saika studies 18 boys and 4 girls. The mode of injury in present study was road traffic accident (RTA). This findings are coincides with other studies. [6, 8] Most common associated injury was head injury followed by other long bone fracture.

Most of the patients in present study were operated within 24 to 48 hours of injury. Which is quite good as compare to study by Gyaneshwar T *et al*. [9], in which most of the patients were operated after 4 to 5 days. Also in present study the average hospitalization was 3 to 5 days. In present study all the patients had closed femoral diaphyseal fracture. Among them 17 were transverse, 16 were spiral, 6 were oblique and 2 were minimally comminuted. So, transverse and spiral were common type of fracture. Which is similar to study by Ligier *et al*. [10] and Thapa SK *et al*, [11].

In present study at 6 weeks 12 fractures were united and 29 were uniting. At 12 weeks all fractures were united with average union time of 10 weeks. In Flynn study average union time was 9 weeks [6]. In Saika studies average union time was 8.7 weeks [8]. So, rate of union was quite good with comparision to that study. It might be because the timely presentation and starting treatment and TEN nailing. Also 34 patients achieved full rate of movement at 6 weeks 39 patients achieved it at 12 weeks while only 2 with persistent extension lag. In our study at 6 weeks 29 patients were able to do squatting and cross legged sitting and at 12 weeks 39 patients were able to do squatting and cross legged sitting.

In the present study, the total outcome according to Flynn's criteria [7] was excellent in 35 (85.37%) of patients and satisfactory in 4 (9.76%) with only 2 (4.9%) had poor results. As compare to the study by Gyaneshwar T *et al*, [9] in which 58.82% had excellent result. The more excellent result might be because of early operative procedure as compare to that study. also range of movement also achieved good as compare to other study i.e. 95% of patient achieved full knee extension, cross leg sitting and squatting position while 100% patients achieved full knee flexion by 12 weeks.

The entry site irritation and pain was the common side effects. However they were relieved in most of the patients during follow up visits. Limb length discrepancy of only upto 1 cm was seen in 5 patients in present study. Review by Khoriati *et al*. [12], also shows that limb length discrepancy is not common with TEN nailing. Other rare complications include limb length discrepancy, angulation of fracture and infection. Elastic nailing may be advantageous as both antegrade and retrograde nails can be used to avoid operating in the zones of injury. The nursing care of patients with elastic nails is simpler. Contraindications to its use will include open or severely comminuted fractures [12].

In present study, Titanium elastic nail seems advantageous over other surgical methods particularly in this age group because it is simple, is a load shearing device, internal splint that doesn't violate open physis, allows early mobilization and maintains alignment. Micromotion conferred by the elasticity of the fixation promotes faster external bridging callus formation. The periostium is not disturbed and being a closed procedure there is no disturbance of fracture hematoma, thereby less risk of infection. Flynn found advantages of TEN nailing over hip spica in treatment of femoral shaft fractures in children. Transverse, short oblique and minimally comminuted fractures are suitable for TEN nails.

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