

Result of Treatment Fracture Shaft of Femur in Children by Titanium Elastic Nail between 3 to 13 Years of Age

¹Dr. Md. Mostafizur Rahman, ²Dr. Tapas Kumer Talukder, ³Dr. Md. Shahidul Alom,
⁴Dr. Enamul Basar, ⁵Dr. Md. Azadur Rahman

¹Associate Professor, Dept. of Ortho Surgery, Rangpur Medical College, Rangpur, Bangladesh

²Assistant Professor, Dept. of Ortho Surgery, Shaheed Ziaur Rahman Medical College, Bogura, Bangladesh

³Associate Professor, Dept. of Ortho Surgery, Manikgonj Medical College, Bangladesh,

⁴Assistant Professor, Dept. of Ortho Surgery, Rangpur Medical College, Bangladesh,

⁵Register, Dept. of Ortho Surgery, Rangpur Medical College Hospital, Bangladesh.

Abstract

Treatment of Displaced diaphyseal femoral shaft fracture in children between 3 to 13 years is controversial. Various methods are available for treatment. Titanium elastic nailing is one of the methods for treatment of femoral shaft fracture in children. In our study we have assessed the outcome of titanium elastic nailing for fracture shaft of femur in children between 3 to 13 years of age. Present indications include all patients with femoral shaft fractures having open physis. Despite its excellent reported results, orthopaedic surgeons still remain divided in opinion regarding its usefulness and the best material used for nails. We thus undertook a retrospective study of paediatric femoral fractures treated with titanium flexible nails at our institute and clinic with a minimum of 2 years follow up.

Material and methods: In this study 50 patients, aged 3 to 13 years, with fracture shaft of the femur were treated with percutaneous retrograde flexible intramedullary (titanium elastic) nailing at in the period from Jan 2016 to Dec 2018. Final limb length discrepancy and any angular or rotational deformities were determined.

Results: Titanium elastic nails were used in 50 all 50 cases. There were 35 midshaft, 10 proximal, and 5 distal fractures. All fractures united at an average of 12 weeks. No malalignment and limb length discrepancy was seen. Minor complications included superficial infection and irritation at nail insertion site. The outcome was excellent in 45 and satisfactory in 5 cases.

Conclusion: Titanium Elastic Nailing System is one of the best methods for treatment of paediatric femoral shaft fractures. It promotes rapid union at fracture site and gives stability which is ideal for early mobilization with lower complication rate and good outcome. It is a simple, easy, rapid, reliable and effective method for management of paediatric femoral fractures between the age of 3 to 13 years, with shorter operative time, lesser blood loss, lesser radiation exposure, shorter hospital stay, and early return to activity. Because of early mobilisation, rapid healing and minimal disturbance of bone growth, titanium elastic nail may be considered to be a physiological method of treatment.

Key words: Fracture, Shaft, Femur, Titanium, Elastic Nail.

INTRODUCTION

Femoral shaft fracture is an incapacitating pediatric injury.^{1,2} Although accounting for less than 2% of all orthopaedic injuries in children³, femoral fractures have a significant impact not only on the patient and their family network, but also on regional trauma resources.^{4, 5} These fractures have been managed with wide variety of methods in past. The treatment has traditionally been age-related, influenced by the type of injury, associated injuries and the location and type of the fracture. To a great extent, the treatment options vary according to the surgeon's preference.³ Because of rapid healing and spontaneous correction of angulation most of the femoral shaft fractures in children younger than three years of age can be treated conservatively.^{4,5} Above three years of age all such fractures, when treated nonoperatively could have, loss of reduction, malunion, intolerance and complications associated with plaster. Near the end of skeletal maturity accurate reduction is necessary as angular deformity is no longer correctable by growth.⁶ Historically treatment with closed means in plaster spica cast, either immediately or after a period of traction, has yielded acceptable results for these fractures^{6, 7, 8} but this treatment produces undue physical and psychological stress for patient and family.^{9, 10, 11} Furthermore, in certain complex fractures and sometimes in subtrochanteric fractures, with tendency for marked flexion of proximal fragment, closed reduction and its maintenance if often unsuccessful.

Last few decades has seen increasing trend towards operative management of femoral shaft fractures in paediatric patients but opinion regarding optimal method of fixation of these fractures remains divided.¹² External fixation, although producing acceptable results, is fraught with many complications as is plate osteosynthesis and rigid intramedullary nailing which may also require a second major surgery for removal of implant.^{13, 14, 15, 16, 17, 18, 19, 20, 21} Flexible intramedullary nailing introduced for femoral fractures by Nancy group in 1982,²² has become popular with many orthopaedic surgeons and remains the treatment of choice for these fractures. The perceived advantage of this

technique includes early union due to repeated micromotion at fracture site, respect for the physis, early mobilization, early weight bearing, scar acceptance, easy implant removal and high patient satisfaction rate.^{1,3,9,11}

We report a prospective study with the objective of evaluating the role and efficacy of Titanium Elastic Nail in selected cases of femoral diaphyseal fractures in the 3-13 years age group at our institute and at various clinics.

MATERIALS AND METHODS

Fifty children (40 boys, 10 girls) in the age range of 3-13 years (mean age 8.3 years) with recent (< 3 days) closed femoral shaft fractures were stabilized with Titanium Elastic Nails (TEN), between January 2016 and December 2018. All patients with open fractures, pathological fractures, metabolic bone disease or neuromuscular disorders were excluded from the study.

Indication for surgery in all cases was displaced femoral shaft fracture with open femoral physis. A written informed consent was obtained from each patient or their family for inclusion in this study. Majority of the patients i.e. 25 (50%) were in the age group of 3-6 years, followed by 20 (40%) patients in 7 to 10 years age group and 5 (10%) in age group between 11 to 13 years. The youngest patients was 3 years old and oldest patient was 13 year. Most of the fractures were due to road traffic accidents (n=35, 70%), the others (n=15, 30%) were fall from tree, bicycle and sports injury. There were male (n=40, 80%) and, female (n=10, 20%) patients. Right sided involvement were seen in 30 cases (60%) and left were seen in 20 cases (40%). 10 fractures were in the proximal third, 35 in the middle third and 5 were in the distal third. 36 fractures were transverse, 4 were spiral and 10 were short oblique. All patients (n=50) underwent surgery within seven days of their injury.

The surgery was performed under general anesthesia with the patient on the fracture table in supine position and under radiographic (C-arm) control. Two prebent flexible nails of identical diameter were inserted across the fracture in a retrograde fashion. The diameter of the individual nail was selected as per Flynn *et al.*'s formula.¹ (Diameter of nail = Width of the narrowest point of the medullary canal on Anteroposterior and Lateral view \times 0.4 mm) and intraoperative assessment. The diameter of the nail was chosen so that each nail occupies at least 40% of the medullary cavity but in practice intraoperative decision regarding nail diameter was taken by operating surgeon. Fractures were reduced using fluoroscopic guidance. Nails were inserted in retrograde fashion with medial and lateral incision 2.5-3.5 cm above the physis. Although, fracture reduction was attempted with closed means in almost all cases but open reduction had to be done in 2 cases. Both nails were inserted about 2 cm proximal to distal femoral physis from medial and lateral sides. Medial nail was directed till it was within 2 cm of proximal femoral capital physis whereas lateral nail was inserted till it was about 1 cm from greater trochantric physis. Titanium elastic nails were used in all fractures. All titanium nails were prebent before insertion and cut close to bone leaving 1.5-2 cm of nail protruding for later easy removal after insertion. After completion of the procedure, rotational stability was assessed in all cases by rotating distal fragment under radiographic control. Average operative time for this procedure was 37 (range 25-110) minutes. Under usual circumstances, most patients were discharged within 2-3 days postoperatively after inspection of surgical site. Average hospital stay for patients was 5.1 (3-9) days.

Postoperatively patients were nursed in supine position with the operated leg elevated on a pillow. Long knee brace was used in three cases of distal third fractures, where stability of fixation seemed not adequate. Postoperative rehabilitation included hip and knee mobilisation started on first postoperative day followed by partial weight bearing after significant pain and inflammation has resolved after 14 days. Patients were mobilized without weight bearing on the fifth to seventh day postoperatively. Partial weight bearing was started at three weeks and full weight bearing by six to eight weeks depending on the fracture configuration, callus response and associated injuries.

Table 1: Demographics

Patients treated	50
Patients followed	50
Fractures followed	50
Boys:Girls	4:1
Mean age	8.3 years(4.5-12.1)
Nail used -Titanium Elastic Nail	

Table 2: Fracture characteristics

Location	
Proximal	10
Midshaft	35
Distal	5
Pattern	
Transverse	36
Short Oblique	10

Spiral fracture	04
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Table 3: Age distribution of the Patients

Age group	%
3-6 years	50
7 to 10 years	40
11 to 13 years	10

Progression of union at fracture site was monitored on serial radiographs, usually taken at intervals of 4 weeks, and full weight bearing was allowed once radiographic union was achieved.

Postoperative radiographs were assessed for nail prominence (measured from nail bone interface to nail tip), and both postoperative and final follow up radiographs were assessed for coronal or sagittal malalignment and any obvious implant related or unrelated complication. Rotational malalignment and limb length discrepancy were assessed clinically at latest follow up (bilateral fractures were excluded from this assessment for obvious reason of lack of normal comparison). Significant malalignment was defined as $> 10^\circ$ in coronal plane and $> 15^\circ$ in sagittal plane. We routinely removed the nails after achieving solid union. All fractures were rated according to the system described by J M Flynn et al. as excellent, satisfactory or poor.¹

**Fig 1: Preoperative x-ray of femur (AP and Lat View)**

All patients were followed radiologically as well as clinically until fractures healed and for any complication. Statistical analysis was done using Fischer's exact test to evaluate

- The significance of association between the occurrence of skin site irritations and by long, untrimmed nail ends
- Association of angulation of fracture with smaller and mismatch nail diameter
- Outcome between patients < 10 years and > 10 years.

The results were evaluated using Flynn *et al.*'s scoring criteria for TEN.¹² Nails were removed six to eight months post surgery when the fracture line was no longer visible radiologically.

Table 4: Flynn scoring criteria for titanium elastic nail

	Excellent result	Satisfactory result	Poor result
Leg length discrepancy	< 1 cm	< 2 cm	> 2 cm
Malalignment	< 5 degrees	< 10 degrees	> 10 degrees
Pain	None	None	Present
Complication	None	Minor and resolved complication	Major complication or lasting morbidity



Fig 2: Six months postoperative (AP and Lat View) with solid union



Fig 3: After complete union



Fig 4: Two years followup (AP and Lat View) after removal of TENS

RESULTS

Majority of the patients i.e. 25 (50%) were in the age group of 3-6 years, followed by 20 (40%) patients in 7 to 10 years age group and 5 (10%) in age group between 11 to 13 years. The youngest patients was 3 years old and oldest patient was 13 year. 40 patients were boys (80%) and 10 (20%) patients were girls. Left femur was involved in 20 (40%) patients and right femur in 30 (60%) patients. The major causes of fracture in our study were road traffic accidents in 35 (70%) patients and others 15 (30%) were due to fall from tree, bicycle and sports injury. In the present series 35 (70%) cases had fracture at middle, 10 (20%) had in proximal third and 5 (10%) had distal third fractures. 36 (72%) were transverse fractures, 4 (8%) were spiral fracture and 10 (20%) were oblique fractures. The average time interval between trauma, and surgery was 6.05 days with average time taken for surgery was 53 minutes the duration of stay in the hospital was 3- 7 days for 40 (80%) patients, 8-12 days for 10 (20%) patients. The average duration of stay in the hospital in our study was 5.1 days. Mean age of patients was 8.3 years (range 3-13 years). During serial radiographic monitoring for fracture union, early callus was seen in an average of 3.8 (range 2-6) weeks after surgery and full radiographic union was achieved at 12 (range 6-18) weeks without further intervention. Post operative immobilisation was used in 8 fractures due to unstable fracture pattern. Early weight bearing was allowed in 20 cases. Mean time for achieving unassisted full weight bearing in these 20 cases was 10.5 weeks as compared to 15 weeks for remaining cases. Nail removal was done in 50 fractures at an average of 11 (5-16) months postoperatively. All patients regained full range of motion of knee and hip after removal of nails.

Angulation measured at final follow up in both coronal and sagittal planes revealed no significant malalignment and there was no limb length discrepancy.

Other complications included two cases of superficial infection which were treated with a prolonged course of antibiotics. There was no case of physal damage. One of the most frequent complaints of patients was irritation at nail insertion site due to prominence of nail leading to bursitis in 5 patients which resolved after removal of nails. Proper imaging under C arm with images in different degree of rotation can avoid this complication. According to the criterion of J M Flynn et al. there were 45 excellent, 5 satisfactory and no poor results.

Table 5: Complications

Malunion (coronal/sagittal)	0
Limb length discrepancy	0
Superficial infection	2
Proximal migration	0
Bursitis at nail insertion site	5
Perforation of cortex of femoral neck	0

**Fig 5: Superficial skin breakdown at lateral nail insertion site of titanium flexible nail.****Table 6: Results according to Flynn's et al.'s criteria**

Excellent	Satisfactory	Poor	Total
45	5	0	50

DISCUSSION

In the present study 25 (50%) of the patients were 3-6 years, 20 (40%) were 7 to 10 years and 5(10%) were 11 to 13 years age group with the mean age being 8.3 years. J N Ligier et al. studied children ranged from 5-16 years with a Paper ID: NOV164051 where mean age was 10.5 years.

There were 40(80%) boys and 10 (20%) girls in the present study. The sex incidence is comparable to other studies in the literature. In the study by

J N Ligier et al. out of 118 cases, 80 (67.7%) were boys and 38 (32.3%) were girls. In study of 130 children done by H Neville et al. there were 100 (77%) male and 18 (23%) females.

In our study right femur was affected in 30(60%) patients, left side was involved in 20(40%) patients. In a study conducted by J N Ligier et al. on 128 patients right side was involved in 64 (50%) patients, left side was involved in 59(46.1%) patients and bilateral femur was involved in 5(3.9%) patients. In a study by Memduh heybel and Hasan et al. 13(38%) patients had right while 20(58%) patients had left and 4% patients had bilateral femoral shaft fractures.

In a study on 34 patients by Memduh heybel and Hasan et al. 28 (82%) were due to road traffic accident and 6(18%) were due to fall. In the present study road traffic accident was the most common mode of injury accounting for 35 (70%) cases, other modes were for 15 (30%) cases and of them fall from height accounted for 3 (6%) cases. In their study J M Flynn et al. assessed 234 cases, of which 136(58.1%) were following road traffic accident, 46 (19.6%) were following self fall and remaining 43(28.8%) were as a result of fall from height.

Fractures involving the middle third accounted for 35 (70%) cases, proximal third 10 (20%) and distal third 5 (10%) of cases in our study. In their study J N Ligier et al. show among 123 femoral shaft fractures 42 were in proximal third, 45 in the middle third, 36 were in the distal third. In a study by H. Neville Burwell et al. 24% fractures occurred at proximal third, 66.2% at middle third and 9.8% at distal third.

In our study, transverse fractures accounted for 36 (72%) cases, short oblique fractures 10 (20%), spiral fractures 4 (8%) and there were no segmental fractures. In their study J N Ligier et al. out of 123 femoral fractures studied, 47 (38.2%) were transverse fractures, 7 (23.3%) oblique fractures, 19 (15.4%) spiral fractures and 4 (3.2%) were segmental fractures. In a study by Memduh heybel and Hasan et al. on 34 patients, 15(43%), 11(31%), 6 (17 %) and 3(9%) were transverse, oblique, spiral and segmental fractures respectively.

In the present series, 40 (80%) patients underwent surgery within 4 days after trauma, 8(16%) in 5- 7 days, 2 (4%) beyond 7 days. Mean duration between trauma and surgery was 6.05 days. Gamal El-Adl et al. operated 56.1% of cases between 3-4 days after injury, 21.2% cases between 4-7 days and 22.7% cases after 7days. K C Saikia et al. operated 77.27% patients within 7 days of injury. In the study of Memduh heybel and Hasan et al. the mean interval was 2.09 days.

In the present study, duration of surgery was < 45 mins in 30(60%) cases, 45- 75 mins in 20(40%) cases. The mean duration of surgery in our study was 53 minutes. In Khurram Barlas et al. study, the mean duration of surgery was 70 mins. In a study by Memduh heybel and Hasan et al. the mean duration of surgery was 55 minutes.

In our study the duration of stay in the hospital was 3- 7 days for 40(80%) patients, 8-12 days for 10 (20%) patients. The mean duration of stay was 7 days. The mean duration of hospitalization in a study by Memduh heybel and Hasan et al. was 5.5 days. The mean hospital stay in a study by Winquist RA et al. was 13.3 days.

During serial radiographic monitoring for fracture union, early callus was seen on an average of 3.8 (range 2-6) weeks after surgery and full radiographic union was achieved at 12 (range 6-18) weeks without further intervention. Average time to union was 12 weeks in this study. In a study conducted by Winquist RA et al. average time of union was 12 weeks. Study conducted by Memduh heybel and Hasan et al. mean time of union was 7.4 weeks.

In the present study, 14 (28%) patients developed pain at site of nail entry site during initial follow up evaluation. It resolved completely in all of them by the end of 24 weeks. J M Flynn et al. reported 38 (16.2%) cases of pain at site of nail insertion out of 234 fractures treated with titanium elastic nails.

Superficial infection was seen in 2(4%) case in our study which were controlled by antibiotics. J M Flynn et al. reported 4 (1.7%) cases of superficial infection at the site of nail insertion out of 234 fractures treated with titanium elastic nails.

All patients had full range of hip and knee motion by 12 weeks in the present study. J M Flynn et al. reported 2 (0.9%) cases of knee stiffness out of 234 fractures treated with titanium elastic nails.

In the present study, the final outcome was excellent in 45 (90%) cases, satisfactory in 5 (10%) cases and there were no case of poor outcome. J M Flynn et al. treated 234 femoral shaft fractures and the outcome was excellent in 150(65%) cases, satisfactory in 57(25%) cases and poor in 23(10%) of cases.

TENS is the ideal device for the treatment of most femoral fractures in children because it is simple, load sharing internal splint that allows mobilization and maintenance of alignment and extremity length until bridging callus forms. Micro motion conferred by the elasticity of the fixation promotes faster external bridging callus formation. The periosteum is not disturbed and being a closed procedure there is no disturbance of the fracture hematoma, thereby less risk of infection. J M Flynn et al. found TENS advantageous over hip spica in treatment of femoral shaft fractures in children. Buechsenschuetz et al. documented titanium nail superior in terms of union, scar acceptance and overall patient satisfaction compared to traction and castin. Mazda et al. treated 34 femoral shaft fractures with TENS. They observed that elastic properties of titanium provide a very good stability and it is a safe surgical treatment for immature femoral shaft fracture. Transverse, short oblique and minimally comminuted fractures are suitable for TENS as stated by J M Flynn et al. Titanium elastic nail does not provide adequate stability in comminuted, long oblique or spiral fractures.

CONCLUSIONS

Based on our experience and results, we conclude that Titanium Elastic Nailing System is one of the best method for treatment of paediatric femoral shaft fractures. It promotes rapid union at fracture site and gives stability which is ideal for early mobilization with lower complication rate, good outcome.

It is a simple, easy, rapid, reliable and effective method for management of paediatric femoral fractures between the age of 3 to 13 years, with shorter operative time, lesser blood loss, lesser radiation exposure, shorter hospital stay, and early return to activity.

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