

Original Research Article

Outcome of closed intramedullary fixation of femoral shaft fracture by titanium elastic nail in children

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ABSTRACT

Background: Femoral shaft fractures are most common fractures in paediatric orthopaedic age group. The best treatment between six to fourteen years of age is a matter of debate. Titanium flexible elastic intramedullary nailing has become a well-accepted method of treatment of paediatric femoral shaft fractures. This study aims to evaluate the functional outcome of treatment of femoral shaft fracture by closed intramedullary titanium elastic nail (TEN) in children age between 6 to 14 years.

Methods: This prospective observational study was conducted over a period of two years from July 2017 to June 2019. Thirty children (23 boys, 7 girls) aged 6-14 years with femoral diaphyseal fractures were stabilized with retrograde titanium elastic nail. The results were evaluated by using Flynn's TEN scoring criteria. Two nails were used in each fracture.

Results: Mean age was 11.1 ± 1.8 years with male female ratio 3.3:1. Male patients were predominant in this study. Type of fracture were observed that 10(33.3%) cases were oblique, 18 (60.0%) cases were transverse and spiral 2 (6.7%). Radiological union in all cases were achieved in a mean time of 9.6 ± 1.9 weeks. Objective evaluation showed that 21 (70.0%) patients had knee flexion $>130^\circ$, 7 (23.3%) had restricted motion of $120-130^\circ$, and 2 (6.7%) had a range of $100-120^\circ$. The results were excellent in 23 patients (76.7%), satisfactory in 7 patients (23.3%) and there was no poor result.

Conclusions: TEN fixation of paediatric femoral shaft fractures is an excellent method of treatment in children aged 6-14 years.

Keywords: Femoral shaft fractures, Titanium elastic nailing, Closed intramedullary fixation

INTRODUCTION

Femoral shaft fractures are the most common lower extremity fracture in children, with an annual incidence up to 1 per 500.¹ Automobile accidents accounts for 90% of femoral shaft fractures in children. The injuries are more common in boys, especially during the toddler years of and early adolescence. The mechanism of injury varies from simple falls to high energy trauma. Although these

fractures are dramatic and disabling injuries for the child and parents. The good part is that they unite rapidly with minimal complication if aligned well.²

Various methods of treatment can be used successfully depending upon the age of the patient and the type of fracture but there is no consensus on one method as the best option.³ Femoral shaft fractures in children younger than six years of age can be treated conservatively. In

adolescents antegrade locked intramedullary nail is preferred. In children between six to fourteen years of age, diaphyseal femur fracture, many times, do not recover completely with conservative treatment.⁴ Commonly used option includes conservative with skin or skeletal traction, hip spica cast and operative with external fixation, open reduction and internal fixation with plating and close reduction and internal fixation under image intensifier with the locked or flexible titanium elastic nail (TEN).⁵ During the last decade, there has been an increasing tendency to change from non-operative treatment to minimally invasive treatment by retrograde TEN and external fixation. The most common flexible intramedullary nail recommendation is for transverse, short oblique mid shaft femoral diaphyseal fractures in skeletally immature children older than six.

Over the past 20 years, paediatric orthopedists have tried a variety of methods to treat paediatric 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. External fixation had resulted in pintract infection, loss of knee range of motion, delayed union, nonunion, and refracture after fixator removal. Solid antegrade intramedullary nailing had resulted in avascular necrosis of the femoral head, trochanteric epiphysiodesis, coxa vulga. The ideal device to treat paediatric femoral 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.⁶

More so, a minimal invasive procedure is associated with a reduction in soft-tissue trauma, more rapid recovery, shorter hospital stays, earlier mobilization or early functional activity which encourages faster healing of fracture, preservation of tone of the muscles, restoration of the joint movements, promotion of mental recovery and prevention of psycho-social complications.^{4,7}

The ideal device for the treatment of most femoral fractures in these children would be a simple load sharing implant that allows early mobilization of the limb and maintenance of alignment and limb length until bridging callus forms. The device would exploit the ability of child's bone for rapid healing and ability to remodel without risking damage to the epiphysis and the blood supply to the capital femoral epiphysis. TENs also known as elastic stable 4 intramedullary nailing (ESIN) has become the choice of stabilization in pediatric femoral shaft fractures.⁴

The ideal fracture for this technique is a transverse or short oblique diaphyseal fracture with minimal comminution in a long bone. However, such is the versatility of the method that the indications have widened considerably with time and personal experience. These fractures are easiest to nail

and the results are generally good. However, if one is prepared to accept some operative difficulties, all types of fractures can be efficiently stabilizing with ESIN with appropriate experience.

Objectives

The objective of this study was to evaluate the outcome of treatment of femoral shaft fracture by closed intramedullary TEN in children age between 6 to 14 years.

METHODS

This prospective observational study conducted at Department of Orthopedics and Traumatology, Dhaka Medical College Hospital, Dhaka, Bangladesh from July 2017 to June 2019. A total 30 patients with mild diaphyseal transverse, short oblique or short spiral fractures of the femur with minimal comminution in children 6-14 years old admitted in hospital for operation during the study period.

Inclusion criteria

Cases with femoral mid-diaphyseal transverse, short oblique or short spiral fractures with minimal comminution; closed fractures of the shaft of femur, all patients between 6 to 14 years of age; fractures within 02 weeks of age were included; and cases were purposively selected irrespective of sex, occupation, mechanism of injury and associated other injuries.

Exclusion criteria

Cases with open fractures of the shaft of femur, undisplaced fracture treated by non-operative method, age of the patient before 6 years and after 14 years, infected cases, and pathological fractures were excluded.

Data collection procedure

Data were collected with a pre-tested structured questionnaire containing history, clinical, laboratory investigations, pre-operative, per-operative, postoperative follow up findings complications and all other variables of interest. Data sheet was formulated to evaluate the final outcome according to TEN scoring criteria. The functional result was assessed according to the criteria of Flynn's scoring system, that is excellent, satisfactory and poor results.

Statistical analysis of data

Data were collected, compiled and tabulated according to key variables and functional assessment scoring. The analysis of different variables was done according to standard statistical analysis by using statistical package for the social sciences (SPSS) version 17. For all analyses level of significance was set at 0.05 and p value <0.05 was considered significant at 95% confidence level.

RESULTS

Age of the patients in this series ranged from 6 to 14 years. Maximum patients 19 (63.3%) were age 11-14 years, 11 (36.7%) patients were age range 6-10 years. Mean age was 11.1 ± 1.8 years. In the present series, maximum patients were male 23 (76.7%) and female 7 (23.3%) female. Male female ratio 3.3:1. Male patients were predominant in this study (Table 1).

Table 1: Patients demographic characteristics (n=30).

Characteristics	Number of patients	Percentage
Age (year)		
6-10	11	36.70
11-14	19	63.30
Mean $\pm$ SD	11.1 ± 1.8	
Sex		
Male	23	76.70
Female	7	23.30

Table 2 shows the type of fracture were observed that 10 (33.3%) cases were oblique, 18 (60.0%) cases were transverse and spiral 2 (6.7%).

Table 2: Type of fracture (n=30).

Type of fracture	Number of patients	Percentage
Transverse	18	60.00
Oblique	10	33.33
Spiral	2	6.70

Among 30 patients, maximum 26 (86.67%) patients were operated within 1-2 weeks of receiving the injury, 4 (13.3%) patients within 1 week. Mean interval between injury and operation was 8.43 ± 2.98 days (Table 3).

Table 3: Time interval between injury and operation (n=30).

Time interval (weeks)	Number of patients	Percentage
<1	4	13.30
$\geq 1-2$	26	86.67
Mean $\pm$ SD	8.43 ± 2.98	

Duration of union time

Among 30 patients, radiological evaluation of fracture site union showed that 20 (66.7%) cases united within 7-10 weeks and 10 (33.3%) cases united within 10-13 weeks. The mean union time was 9.6 ± 1.9 weeks (Figure 1).

Objective evaluation of outcome revealed that 21 (70.0%) exhibited wide range of knee fixation more than 130 degrees, 2 (6.7%) patients restricted knee motion range

100-120 degree and 7 (23.3%) patients restricted knee motion range of 120-130 degree (Table 4).

Table 4: Outcome of patients based on range of knee motion (n=30).

Range of knee motion (degree)	Number of patients	Percentage
100-120	2	6.70
120-130	7	23.70
>130	21	70.00

Evaluation of final outcome revealed that satisfactory results in 7(23.3%) cases and excellent results were found 76.7% patients (Table 5).

Table 5: Final outcome.

Outcomes	Excellent	Satisfactory	Poor
Limb length discrepancy (cm)	<1.0	<2.0	>2.0
Malalignment ($^{\circ}$)	5	10	>10
Pain	Absent	Absent	Present
Complications	Absent	Mild	Major complications
Final results (%)	76.70	23.30	0.00

The final outcomes for femoral shaft fracture patients were shown in Table 6. Excellent results were linked to $\leq 5^{\circ}$ malalignment and leg length inequality of 1.0 cm or less. Pain was absent in all cases. There were mild complications in 5 patients. Effective outcomes with titanium elastic nailing ($p < 0.05$) were eliminated if significant associations.

Table 6: Final outcome according to Flynn's et al TEN scoring criteria (n=30).

Final outcome	Excellent	Satisfactory	P value
Leg length inequality (n=7)			
<1.0	5	0	0.017
<2.0	0	2	
No leg length inequality	18	5	
Mal alignment (varus/valgus)			
5 degree	2	0	<0.0010
10 degree	0	5	
No mal alignment	21	2	
Pain			
Present	0	0	
Absent	30	30	
Complications			
Mild	0	5	<0.001
Absent	23	2	

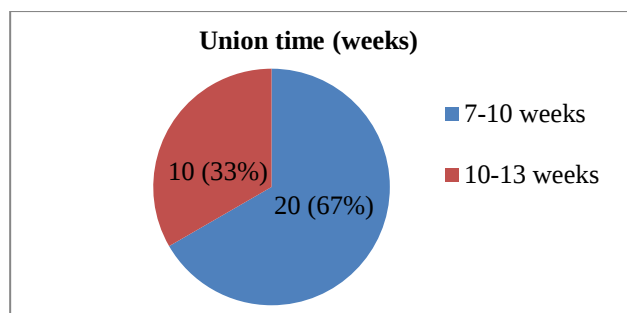


Figure 1: Duration of union time (n=30).

DISCUSSION

The femoral shaft fractures constitute less than 2% of all children fracture or femur fractures represents -0.9% to 2.3% of all bony injuries in children and the ideal choice of treatment has remained a constant challenge.⁸ Conservative treatment for children diaphyseal femoral fractures was preferred in children and young adolescents. However, to avoid the effects of prolonged immobilization, the operative approach has been gaining popularity for the last two decades.² It is also important to consider the additional home care required for children, the costs of rehabilitation and of missed school for the children.

The ideal device to treat paediatric femur fractures would be a simple, load-sharing internal splint allowing mobilization and maintenance of alignment for a few weeks until bridging callus forms.^{9,10} Titanium elastic nail appear to be a good implant in this age group of 6 to 14 years. It is simple, load sharing internal splint, respects epiphysis on either end and vascularity of femoral head, preserves periosteum and fracture hematoma, allows early mobilization, allows micromotion at fracture site and thus early callus formation, and maintains alignment and limb length till bridging callus takes over.^{4,7}

In children less than five years of age, early and immediate spica cast is typically the treatment of choice. Surgical treatment is indicated for patients with head or multiple injuries with severe soft tissue damage. Currently, there has been growing trend towards surgical treatment with widening of indications to include isolated femoral fracture in children over the age of five years.¹¹ A systemic review of treatment methods of pediatric femoral fractures has been performed. In absence of any large randomized trials, the literature provides little evidence supporting one method of treatment over another.¹²

In this study, the total numbers of cases were 30 which are similar to the number of cases in the study of Mishra et al.² The mean age at injury of this study was 11.1 ± 1.8 years; range 6 to 14 years almost similar to Kumar et al who found mean age 10.8 years; range 6 to 14 years.¹³ Moroz et al documented that mean age at the time of fracture 10.3 years.³ In present study among 30 patients 23 (76.7%) were male and 7 (23.3%) were female. Male-female ratio

was 3.3:1. In the study of Kumar et al male-female ratio was 3:1 and Khazzam et al reveals male-female ratio was 2.75:1, which is near similar to our study.^{7,13}

In this study 60.0% cases were transverse, 33.3% cases were oblique and 6.7% cases were spiral fractures, near about similar to the study of Khazzam et al reveals 47.8% transverse, 30.4% oblique and 17.4% were spiral. Another study done by Moroz et al reveals that transverse 47.7%, oblique 20% and spiral 12.4%.³

In this study maximum 60.0% patients were operated after 1 week of receiving the injury, 13.3% patients within 1 week and 86.7% patients time interval more than 1 week. Mean interval between injury and operation was 8.43 ± 2.98 days. In another study Srivastava et al operate within a week of injury, which was similar to this study.¹⁴

In current study, radiological evaluation of fracture site union showed that 20 (66.7%) cases united within 7-10 weeks and 10 (33.3%) cases united within 10-13 weeks. The mean union time was 9.6 ± 1.9 weeks. Our findings correlate the study of Mishra et al showed radiological union in all cases was achieved in a mean time of 9.5 weeks.² Kumar et al stated that radiological union was achieved in a mean time of 8 weeks.¹³

In this study, in terms of deformity in sagittal plane like anterior-posterior angulation and in the coronal plane like varus deformity occurred $5-6^\circ$ in 3 (10.0%) patients, 6-8 valgus deformity occurred in 4 (13.3%) patients and majority of the patients 23 (76.7%) had no mal-alignment were observed. Kumar et al reveals that out of 20 patients 3 patients showed 10 degree or less angulations in the lateral plane and one patient had an eight-degree angulation in the anterior-posterior plane, this finding correlate our study.¹³

In current study, 21 (70.0%) exhibited wide range of knee fixation more than 130 degrees, 2 (6.7%) patients restricted knee motion range 120-130 degree and 7 (23.3%) patients restricted knee motion range of 100-120 degree. Rajak et al noted the mean range of knee flexion score at the end of follow up was 0-1200. Kumar et al stated at the end of study period 75% patients could do full range of motion at knee joint.¹³

In the final outcome of the study according TEN outcomes scoring by Flynn et al demonstrated that satisfactory results in 7 (23.3%) cases and excellent results were found 76.7% patients. Mishra et al noted similar results out of 30 patients, excellent in 80% cases and satisfactory in 20% cases.² Gamal et al reveals 75.8% were excellent and 24.2% were satisfactory outcome. There are no poor results.¹⁵

Limitations

The limitation of this study was that it involved low sample size and focused only short-term functional changes and

complications and therefore only short durations of follow-up. Future research with larger, multicenter cohorts and longer follow-up periods is recommended to confirm the findings and investigate functional outcome, growth anomalies, and satisfaction with surgical treatments.

CONCLUSION

In this study outcome of paediatric femoral shaft fractures treated by flexible elastic intramedullary nail demonstrated excellent to satisfactory result in all of the cases. Seventy-three percent of the cases returned to routine pre injury activities without limitations and twenty-six percent with mild limitations. Intramedullary fixation with TEN may be the preferred method for the treatment of femoral shaft fractures in children aged 6 to 14 years.

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