

A Prospective Study on Factors Affecting the Outcome of Pediatric Femoral Shaft Fractures Managed By Elastic Nails

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ABSTRACT

Background: There are numerous methods for the management of pediatric femoral shaft fractures, ranging from conservative fixed traction and hip spica cast application to operative elastic nails fixation. Nowadays elastic nails i.e. intramedullary titanium elastic nail system [TENS] is more commonly being used to treat femoral shaft fractures in pediatric population. Many studies had supported excellent results with this instrumentation and attributed the variation in age, weight, immobilization protocols, technical factors like fracture pattern, reduction and complications as the reasons for poor outcomes in their individual studies. Hence, this study been conducted to identify the perioperative and demographic factors that could affect the final outcomes of the procedure.

Materials and Methods: A prospective cohort study done in multicenter between September 2013 and December 2016 on closed femoral shaft fractures in patients of age between 6-15 years managed with TENS. Various perioperative and demographic factors were assessed. The patients were followed up regularly clinically and radiologically up to 1 year. The final results were assessed using Flynn criteria and graded as poor, satisfactory and excellent. Total 60 patients included in this study.

Results: Mean age of the patients was 8.77 years. 80% of the patients weighing over 40 kg had satisfactory to excellent outcomes and 20% had poor outcomes (P=0.005). The mean injury-surgery interval was 5.4 days, surgical time was between 50 and 140 min and open reduction was required in about 20

cases (33.33%). 6 (10%) Patients had immobilization beyond 6 weeks and satisfactory outcomes (P=0.001). We had 10 patients with minor complications (2 entry site bursitis and 8 superficial infections) and two major complications (chronic osteomyelitis) leading to satisfactory and poor outcomes respectively. Fracture union was noted between 4.5 and 10 months with 97% of patients attaining union within 8 months.

Conclusion: Intramedullary TENS is an excellent modality to treat femoral shaft fractures in pediatric population. However, factors like weight of the patient >40kg, immobilization beyond 6 weeks, minor and major complications in the perioperative period could pose risks for poor to satisfactory outcome.

Keywords: Pediatric Femoral Shaft Fracture, Titanium Elastic Nailing System, Flynn Criteria.

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INTRODUCTION

There are numerous methods for the management of pediatric femoral shaft fractures, ranging from conservative fixed traction and hip spica cast application to operative elastic nails fixation, nowadays there has been an inclination to treat the patient aggressively with surgical methods owing to the difficulties of prolonged immobilization, need to return school early and associated injuries occurring more frequently.^{1,2} In pediatric population there is the need to preserve physis, surgical methods like external fixation, plating, and intramedullary devices have been debated over the years.³ The intramedullary devices

especially, devices like titanium elastic nailing system is commonly being used as it is minimally invasive, minimal blood loss, preserving fracture site biology and early rehabilitation.⁴ Many studies have shown excellent result with the usage of elastic nails in school going children.⁵⁻⁷ Few patients with poor outcomes was attributed to the variation in age, weight, immobilization protocols, technical factors like fracture pattern, reduction, choice of implant size and complications.⁶⁻⁸ Here, we wanted to do a prospective cohort study on factors affecting the outcome of pediatric femoral shaft fractures managed by elastic nails.

MATERIALS AND METHODS

This was a prospective cohort study which was conducted in multicenter between September 2013 and December 2016 namely shri sidhdhi vinayak hospital poothkalan Delhi, Dr. BSA hospital Rohini Delhi, Hindurao hospital Delhi. Closed femoral shaft fractures between age 6-15 years, hemodynamically stable, were fixed with titanium elastic nailing system and had a follow up for one year were included in the study. Surgical procedures were done under general or spinal anesthesia with the prior consent for the procedure and complying with the principles of the technique. Patient's age, sex, weight, mode of injury, level and type of fracture pattern, type and duration of surgery, immobilization and complications were noted. All patients had similar post-op rehabilitation and immobilization protocol. Patients were followed

up clinically and radiologically up to 1 year. Full weight bearing was advised only when grade 2 callus was noted as per the grading given by Anthony et al.⁹ The final outcomes at the end of one year were given as poor, satisfactory and excellent based on the Flynn criteria. [Table 1]

All the data were entered into excel worksheet and analysis was done using SSPS software version 20.0. The categorical variables were presented in number and percentage and continuous variables were presented as mean±SD and median. Normality tested by Kolmogorov-smirnov test/nonparametric tests. If necessary, Statistical analysis was done using chi-square test/fisher's exact test. Statistical significance considered for P values less than 0.05.

Table 1: Flynn et al¹⁰ criterion for assessment of the results

	Excellent	Satisfactory	Poor
1. Limb length discrepancy	<1cm	<2cm	>2cm
2. Malalignment	Up to 5°	5° -10°	>10°
3. Pain	None	None	Present
4. Complications	None	Minor	Major or lasting morbidity

Figure 1: Mid shaft transverse fracture managed by TENS

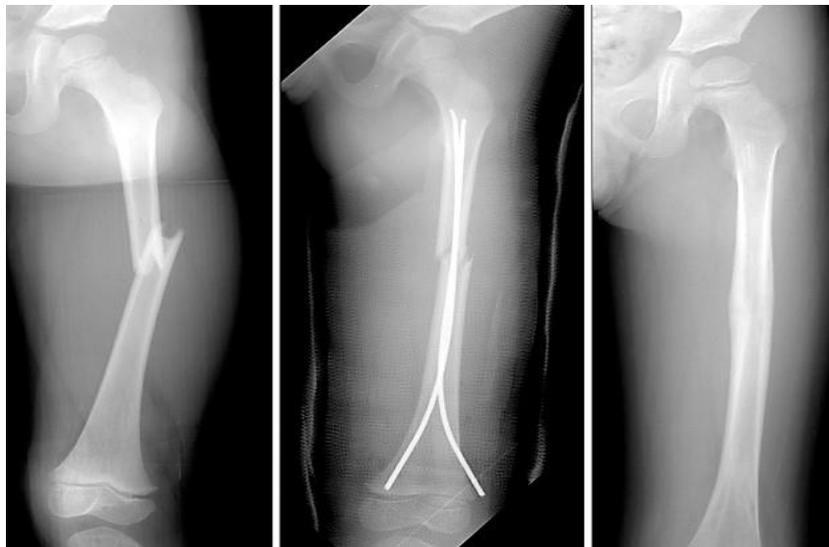


Figure 2: Mid shaft spiral fracture managed by TENS.



RESULTS

60 patients fulfilling the inclusion criteria were considered in the study. The mean age was 8.77 years (range 6-15 years) the majority of the patients (63.33%) were males (38) and involvement of the right side (56.6%) and most commonly due to road traffic accidents (40 patients). Mid shaft fractures were seen more frequently (34 patients), followed by the proximal shaft and distal

shaft (18 and 8 patients respectively). The most common pattern of fracture was the transverse (30 patients). 45% of patients having proximal and distal shaft fractures with pattern of long oblique, spiral and comminuted type had satisfactory outcomes. However, statistically this was insignificant with p values of 0.09 and 0.7 respectively [Table 2].

Table 2: Demographic factors affecting final results

Flynn et al outcomes	Poor	Satisfactory	Excellent	Total	P value	Chi square statistics
Age distribution in year						
5-6	0(0.00%)	4(33.3%)	8(66.67%)	12(100.0 %)	0.251	X2=5.375 df=4
7-8	2(3.33%)	0(0.00%)	22(91.67%)	24(100.0%)		
> 8	0(0.00%)	6(25.0%)	18(70.0%)	24(100.0%)		
Mode of injury						
RTA	2(5.00%)	4(10.0%)	34(85.0%)	40(100.0%)	0.319	X2 = 2.88 df=2
Fall	0(0.00%)	6(30.0%)	14(70.0%)	20(100.0%)		
Sex						
Male	2(5.26%)	4(10.52%)	32(84.2%)	38(100.0%)	0.917	X2= 0.172 df =2
Female	2(9.09%)	2(9.09%)	18(81.81%)	22(100.0%)		
Side involvement						
Left	0(0.00%)	4(15.38%)	22(84.62%)	26(100.0%)	0.654	X2=0.848 df =2
Right	2(5.88%)	6(17.47%)	26(76.47%)	34(100.0%)		
Level of fracture						
Proximal shaft	0(0.00%)	8(44.44%)	10(55.56%)	18(100.0%)	0.099	X2 = 7.801 df =4
Mid shaft	2(5.88%)	2(5.88%)	30(88.24%)	34(100.0%)		
Distal shaft	0(0.00%)	0(0.00%)	8(100.0%)	8(100.0%)		
Type of fracture pattern						
Comminuted	0(0.00%)	2(33.33%)	4(66.67%)	6(100.0%)	0.718	X2=3.692 df =6
Oblique	0(0.00%)	2(16.67%)	10(83.33%)	12(100.0%)		
Spiral	0(0.00%)	4(33.33%)	8(66.67%)	12(100.0%)		
Transverse	2(6.67%)	2(6.67%)	26(86.67%)	30(100.0%)		

Table 3: Perioperative factors affecting final results

Flynn et al outcomes	Poor	Satisfactory	Excellent	Total	P value	Chi square statistics
Injury surgery Interval in days						
< = 5	0(0.00%)	4(15.38%)	22(84.62%)	26(100.0%)	0.654	X2=0.848 df=2
> = 5	2(5.88%)	6(17.65%)	26(76.47%)	34(100.0%)		
Type of surgery						
Open	2(5.8%)	6(17.64%)	26(76.5%)	34(100.0%)	0.690	X2 = 0.742 df=2
Closed	0(0.00%)	4(15.4%)	22(84.6%)	26(100.0%)		
Weight in kg						
20-30	0(0.00%)	0(0.00%)	6(100.0%)	6(100.0%)	0.005	X2= 14.62 df =4
30-40	0(0.00%)	4(12.50%)	40(87.50%)	44(100.0%)		
40-50	2(20.00%)	6(60.00%)	2(20.00%)	10(100.0%)		
> 50	0(0.00%)	0(0.00%)	0(0.00%)	0(100.0%)		
Duration of surgery in minutes						
50	0(0.00%)	0(0.00%)	6(100.00%)	6(100.0%)	0.438	X2=5.868 df =6
60	0(0.00%)	4(12.50%)	28(87.50%)	32(100.0%)		
75	0(0.00%)	0(0.00%)	4(100.00%)	4(100.0%)		
90 and more	2(11.11%)	6(33.33%)	10(55.56%)	18(100.0%)		
Post op immobilization weeks						
4	2(6.25%)	0(0.00%)	30(93.75%)	32(100.0%)	0.001	X2 = 11.56 df =8
6	0(0.00%)	4(18.18%)	18(81.82%)	22(100.0%)		
8	0(0.00%)	6(100.00%)	0(0.00%)	6(100.0%)		
Full weight bearing in weeks						
8	2(14.29%)	0(0.00%)	12(85.71%)	14(100.0%)	0.324	X2=9.223 df =8
9	0(0.00%)	0(0.00%)	2(100.00%)	2(100.0%)		
10	0(0.00%)	2(9.09%)	20(90.91%)	22(100.0%)		
11	0(0.00%)	0(0.00%)	2(100.00%)	2(100.0%)		
12	0(0.00%)	8(40.00%)	12(60.00%)	20(100.0%)		

Table 4: Complications affecting final results

Flynn et al outcomes	Poor	Satisfactory	Excellent	Total	P value	Chi square statistics
Major complications						
Nil	0(0.00%)	10(17.24%)	48(82.76%)	58(100.0%)	<0.001	X ² = 30.00 df = 2
Yes	2(100.0%)	0(0.00%)	0(0.00%)	2(100.0%)		
Minor complications						
Nil	2(4.00%)	0(0.00%)	48(96.00%)	50(100.0%)	<0.001	X ² = 30.00 df = 2
Yes	0(0.00%)	10(100.0%)	0(0.00%)	10(100.0%)		

Valgus angulations were noted in 12 patients and varus angulations were seen in 8 patients. The injury surgery interval was between 1 and 12 days with a mean of 5.4 days. There was no statistical difference in the final outcomes between patients operated before or after 5 days (P value = 0.6). The surgical duration was about 50-140 min but most of the cases done within one hour (63.33%). Open reduction was required in about 20 cases (33.33%) and it could be statistically said that there was no difference in final outcomes whether the method is open or closed. Weight of the patient appeared to be an important factor to affect the final outcomes with 92% of patients below weight 40 kg showing excellent results and about 80% of patients above 40 kg showing satisfactory to poor results (P=0.005). Postoperative immobilization was between 4 and 8 weeks depending upon the case. Follow-up radiographs shows that most patients receiving immobilization for 4 weeks (53.3%) patients and with prolonged immobilization beyond 6 weeks had satisfactory outcomes (P = 0.001). The median hospital stay was 11 days. However, early discharge (< 5 days) or discharge after suture removal had no significance in final outcomes. Significant osseous union (3 or 4 cortical unions) was noted between 4.5 and 10 months post-surgery with 97% of patients attaining union within 8 months. These results can also be correlated with the mean time to weight bear i.e. 10.4 weeks and range between 8 and 12 weeks. There was no significant change in final outcome among patients who had full weight bearing at 8 weeks or 12 wks. (p = 0.32) [Table 3] We had 10 patients with minor complications (2 bursitis, 8 superficial infections) and two major complications (chronic osteomyelitis). These patients were readmitted and managed accordingly. However these patients ended up having satisfactory outcomes at end of 1 year with joint stiffness being common in patients with minor complications and poor outcome with osteomyelitis. (p = 0.001). [Table 4]

DISCUSSION

In recent times the change has been observed in the management of pediatric femoral shaft fractures from a conservative to surgical approach, due to the problems of prolonged immobilization, loss of reduction and mal union, need to return to school at the earliest, change in the pattern of injury and more polytrauma cases. Among the available surgical management options of pediatric shaft of femur fractures, there is an inclination to use intramedullary elastic nail system more often, supported by its excellent results and patient outcomes. Many studies that used intramedullary titanium elastic nail system for pediatric shaft fracture management and computed the outcomes using criteria defined by Flynn et al¹⁰ had supported excellent results. However, some of the patients had poor outcomes in their studies. Variations in the age, weight, delayed presentation, associated

complications and pattern of fractures were few of the reasons attributed to poor outcomes.

The results from our multi-center study of 60 patients that were included showed that the weight of the patient was the single most important demographic factor affecting the final outcomes assessed by Flynn et al criterion. The patients having weight below 40 kg 92% of them had shown excellent results. 80% of the patients having weight over 40 kg had shown satisfactory to poor results. Moroz et al⁶ in their study of 222 patients from six centers showed that age and weight had the significant impact on the final outcomes. Patients with weight below 39 kg had excellent to satisfactory result, whereas patients with weight above 54 kg had poor to satisfactory results. The mean age in their study was 10.2 years and there was a significant association with children below age 10 having excellent results and above 11 years having only satisfactory outcome. In our study mean age was 8.77 years (range 6-15 years), the age matched final outcomes had shown no significant differences. With regard to the mode of injury, the isolated closed femoral fractures included in our study caused by either road traffic accident or fall had not shown any significant variation in final outcomes. The mid shaft transverse fractures were the most common occurring pattern. 45% of patients in our study with proximal and distal shaft fractures that were long oblique or spiral, comminuted types had satisfactory outcomes attributed to the valgus and varus angulations respectively. However, this was statistically insignificant. These similar findings were supported by Moroz et al⁶ who reported a loss of reduction in proximal and distal fractures in some set of patients that correlated with age before and after ten years. However, the final outcomes did not show significant differences. The short working length and decreased resistance to axial loading in comminuted fracture patterns causes valgus/varus angulations at the respective sites.

Among the perioperative factors included in our study, the injury surgery interval before or after 5 days, duration of the surgery (range 50-140min), undergoing open or closed reductions and hospital stay for the pediatric shaft femur fractures (mean 11days) treated with TENS did not show any significant variation in the final outcome. Immobilization beyond 6 weeks had a strong association with poor to satisfactory outcomes. Prolonged immobilization was required in only a few patients involving comminuted and long oblique fractures, predisposing the patient to knee joint stiffness, hence the poor category of Flynn criterion. 99% of our patients had full weight bearing by 10 weeks and similarly had shown significant osseous union by 8 months. Similar results were exhibited by Saikia et al⁴ in a set of 22 patients who achieved grade 2 callus in an about 8.7 weeks and hence full weight bearing was possible in a mean time of 8.8 weeks.

In our study, both minor complications (entry site bursitis and superficial infections) and major complication (chronic osteomyelitis) significantly reported satisfactory and poor outcomes respectively. The similar findings were supported by Narayanan et al¹¹ in their 5 year experience with 79 pediatric femur fractures treated by TENS. They encountered entry site pain/irritation in about 41 patients and one deeper tissue infection. Complications were usually minor and manageable with proper techniques and principles followed.

In the analysis of our patients according to Flynn criteria, the most commonly reported reason for the poor to satisfactory outcomes was the knee joint stiffness, followed by loss of reduction, varus angulations by 5°. We encountered only 5 patients with limb length discrepancy. However, some studies shows limb lengthening to be the major reason for poor outcomes.^{12,13}

CONCLUSION

For the management of closed femoral shaft fractures in pediatric population especially school going age group intramedullary titanium elastic nailing system is an excellent modality of operative treatment. However, patient related factors like weight of the patients, period of postoperative immobilization beyond 6 weeks, possible minor and major complications may pose a risk factor for poor to satisfactory outcomes and should be considered and explained accordingly. Following principles of instrumentation and proper indications may further reduce the complication rate and improve the outcomes of surgery.

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