

Functional Outcome of Flexible Intramedullary Nailing in Children with Femoral Shaft Fractures

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ABSTRACT

Femoral shaft fractures are the second most common long-bone fractures in children. An ideal treatment should ensure proper alignment, patient comfort, and family convenience. This study aims to investigate the functional outcomes of using flexible titanium intramedullary nails for pediatric femoral shaft fractures, addressing the limited local evidence for their effectiveness.

OBJECTIVE: To determine the functional outcome of flexible intramedullary nailing in children with femoral shaft fractures

STUDY SETTING: The study was conducted at Orthopedics Surgery Unit-II, Jinnah Hospital, Lahore.

DURATION OF STUDY: September 16, 2022, to March 16, 2023

STUDY DESIGN: Descriptive case series

SUBJECTS & METHODS: A total of 60 patients with femoral shaft fractures were enrolled in the study. Brief history-taking, physical and radiological examinations, and investigations were performed. Retrograde intramedullary nailing was done with two nails of the same diameter under an image intensifier. Follow-up of the patients was performed at 3-weekly intervals until radiological union occurred. Functional assessment was done. Data were entered and analysed in SPSS v25.0. Gender-, BMI-, and age-stratified data to account for effect modifiers. A p-value ≤ 0.05 was considered statistically significant after applying the Chi-square test.

RESULTS: A total of 60 patients with femoral shaft fractures were included in this study. There were 46(76.7%) male and 14(23.3%) female. The mean age of the patients was 7.18 ± 2.259 years. Of 58 patients, 58 (96.7%) had satisfactory functional outcome.

CONCLUSION: Intramedullary elastic nailing of simple shaft of femur fractures in children is an effective method with negligible complications. Treatment cost can be significantly lowered by using the much cheaper stainless steel flexible nails rather than the more expensive titanium nails.

KEY WORDS: Femoral Shaft Fractures, Intramedullary Nailing, Flynn's Criteria.

INTRODUCTION

Femoral shaft fractures are among the most prevalent orthopaedic injuries in the pediatric population, accounting for approximately 1-2% of all fractures in children, with a higher incidence observed in males than females^{1,2}. These injuries typically result from high-energy traumas, such as motor vehicle accidents or falls from heights, particularly in older children and adolescents. The management of femoral shaft fractures in this demographic has evolved significantly over the years, shifting from conservative methods like traction and casting to surgical interventions that offer enhanced outcomes and quicker recovery times^{3,4}.

Flexible intramedullary nailing (FIN) has emerged as a preferred technique, providing stable fixation and prompt patient mobilisation. This method utilises titanium elastic nails (TEN), which provide a well-tolerated and biomechanically favourable option for fracture stabilisation, particularly for diaphyseal femoral fractures^{5,6}. Studies suggest that FIN use is associated with favourable union rates and high rates of functional recovery. For instance, Hashmi et al. reported that 90% of patients achieved satisfactory functional outcomes, showcasing the effectiveness of this technique in pediatric cases².

Numerous studies support the efficacy of flexible intramedullary nailing for pediatric femoral fractures. For instance, Soomro et al. evaluated 52 pediatric patients treated with elastic intramedullary nails, reporting a low complication rate and significant improvements in mobility and comfort³. Similarly, Kalbitz et al. highlighted the advantages of this technique, emphasising its applicability in age groups typically at high risk of injury⁷. The technique's ability to accommodate children's physiological growth patterns while minimising soft-tissue disruption positions it as a viable first-line treatment^{8,9}.

In the Pakistani context, the epidemiology of pediatric femoral fractures reflects unique social and cultural dynamics. Road traffic injuries and falls, prevalent in urban areas, contribute significantly to these injuries¹⁰. Access to timely orthopaedic intervention can be impeded by healthcare disparities, which may prolong recovery and complicate outcomes. Understanding local demographics and the outcomes of flexible intramedullary nailing in this setting is essential to optimise treatment protocols and ensure the best possible care for affected children.

The current study aims to investigate the functional outcomes of flexible intramedullary nailing for femoral shaft fractures in children within the Pakistani population, seeking to fill a gap in the literature regarding specific outcomes and complications in this demographic. By assessing the clinical effectiveness of FIN, we aim to provide insights that inform both clinical practice and healthcare policies to improve pediatric orthopaedic care in Pakistan.

METHODOLOGY

This descriptive case series was conducted at the Orthopedics Surgery Unit-II, Jinnah Hospital, Lahore, over six months from 16 September 2022 to 16 March 2023. After obtaining approval from the institutional ethics review committee, consecutive pediatric patients presenting to the trauma centre with femoral shaft fractures were screened for eligibility. Written informed consent was obtained from the parents or legal guardians prior to enrollment. Children of either sex aged between 4 and 11 years with femoral shaft fractures, including Anderson-Gustilo grade I open fractures, were considered eligible for inclusion. Patients with pathological fractures, compound fractures of higher grade, comminuted fractures (Winquist type III and IV), associated lower limb fractures, polytrauma, head injury, neuromuscular disorders, cerebral palsy, metabolic bone disease, or other conditions that could confound functional assessment were excluded.

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A total sample size of 60 patients was calculated at a 95% confidence level and a 7% margin of error, assuming a satisfactory functional outcome rate of 93% based on previously published literature. Non-probability consecutive sampling was employed until the required sample size was achieved. At presentation, all enrolled patients underwent detailed clinical assessment, including history, physical examination, and radiological evaluation. Standard anteroposterior and lateral radiographs of the affected femur were obtained to confirm fracture characteristics and to guide operative planning. Baseline demographic and clinical data were recorded using a pre-designed pro forma.

All procedures were performed under general anaesthesia following preoperative anaesthetic assessment and administration of prophylactic intravenous antibiotics. Retrograde flexible intramedullary fixation was carried out using two titanium elastic nails of equal diameter under image intensifier guidance. Nail diameter was selected according to Flynn's formula, calculated as 40% of the narrowest diameter of the medullary canal measured on both anteroposterior and lateral radiographs. Standard-length nails (440 mm) with diameters ranging from 2.0 to 4.0 mm were used. The nail ends were left protruding approximately 0.5–1.0 cm distally to facilitate subsequent removal. Postoperative radiographs were obtained on the first postoperative day to confirm alignment and implant position.

Postoperatively, patients were encouraged to perform quadriceps and hamstring strengthening exercises, along with active and passive range-of-motion exercises of the knee joint, as tolerated. Follow-up assessments were conducted at three-week intervals until radiological union was achieved. At each visit, clinical examination and radiographic evaluation were performed to assess fracture healing, alignment, and any procedure-related complications. Functional outcome was assessed at final follow-up using Flynn's criteria, and outcomes were graded as excellent, good, fair, or poor. For analytical purposes, excellent, good, and fair outcomes were categorised as satisfactory, while poor outcomes were categorised as unsatisfactory.

Data were entered and analysed using SPSS version 25.0. Quantitative variables, such as age, were summarised as means and standard deviations. In contrast, categorical variables, including gender, age groups, body mass index categories, and functional outcomes, were presented as frequencies and percentages. Stratified analyses were performed to evaluate the association between a satisfactory functional outcome and gender, age group, and BMI. The chi-square test was used to assess statistical significance, and a p-value ≤ 0.05 was considered significant.

RESULTS

A total of 60 children with femoral shaft fractures were enrolled. The cohort was predominantly male, with 46 males (76.7%) and 14 females (23.3%). The mean age was 7.18 ± 2.26 years. Most patients were in the 4–8 year age group (68.3%), while 31.7% were aged 9–11 years. Regarding nutritional status, 48 children (80.0%) had normal BMI and 12 (20.0%) were overweight (Table 1).

Functional outcomes assessed using Flynn's criteria demonstrated excellent results in 36 patients (60.0%), good in 18 (30.0%), fair in 4 (6.7%), and poor in 2 (3.3%). When categorised into satisfactory (excellent, good, fair) and unsatisfactory (poor) outcomes, 58 patients (96.7%) achieved a satisfactory functional outcome (Table 2).

On stratified analysis, satisfactory functional outcome did not differ significantly by gender (male: 95.7% vs female: 100.0%; $p = 0.427$) or by age group (4–8 years: 95.1% vs 9–11 years: 100.0%; $p = 0.327$). However, BMI showed a statistically significant association with outcome, as all children with normal BMI achieved satisfactory outcomes compared with 83.3% of overweight children ($p = 0.004$) (Table 3).

Table 1. Baseline demographic and clinical characteristics of study participants (n = 60)

Variable	Category	n	%
Gender	Male	46	76.7
	Female	14	23.3
Age group (years)	4–8	41	68.3
	9–11	19	31.7
Body mass index	Normal	48	80.0
	Overweight	12	20.0

Table 2. Distribution of functional outcome according to Flynn's criteria

Functional outcome	n	%
Excellent	36	60.0
Good	18	30.0
Fair	4	6.7
Poor	2	3.3
Satisfactory	58	96.7
Unsatisfactory	2	3.3

Table 3. Stratification of satisfactory functional outcome by gender, age group, and BMI

Variable	Category	Satisfactory n (%)	Unsatisfactory n (%)	p-value
Gender	Male	44 (95.7)	2 (4.3)	0.427
	Female	14 (100.0)	0 (0.0)	
Age group	4–8 years	39 (95.1)	2 (4.9)	0.327
	9–11 years	19 (100.0)	0 (0.0)	
Body mass index	Normal	48 (100.0)	0 (0.0)	0.004
	Overweight	10 (83.3)	2 (16.7)	

DISCUSSION

The study assessed functional outcomes of flexible intramedullary nailing (FIN) in a cohort of 60 children with femoral shaft fractures. Notably, the majority of participants were male (76.7%), aligning with the literature indicating a higher prevalence of such injuries in males than in females^{11,12}. The mean age of 7.18 years corroborates previous findings, which commonly document adolescence and early childhood as peak ages for femoral shaft fractures^{13, 14}. In this cohort, 80% of the children presented with a normal Body Mass Index (BMI), which also parallels similar studies that show a substantial number of pediatric patients within normal BMI ranges when sustaining these injuries^{15, 16}.

According to Flynn's criteria, 60% of participants achieved excellent results, 30% good, 6.7% fair, and 3.3% poor. Overall, 96.7% achieved satisfactory outcomes (excellent, good, and fair combined). This finding is consistent with current literature; for instance, studies by Hussien et al. noted satisfactory functional outcomes in 94.8% of cases treated with elastic stable intramedullary nailing¹⁷. Furthermore, Quarta et al. reported comparable outcomes, highlighting an excellent functional recovery rate, which suggests that flexible intramedullary nailing remains an effective solution for these fractures^{18, 19}.

The stratified analysis showed that gender and age group did not significantly affect satisfactory functional outcomes (male: 95.7%, female: 100%; 4–8 years: 95.1%, 9–11 years: 100%). This lack of significant difference in outcomes by gender corresponds with findings from Sebaei et al., who reported that gender had no considerable effect on the functional outcomes following FIN for femoral fractures¹⁶. On the contrary, BMI demonstrated a significant association with outcomes: children with normal BMI achieved 100% satisfactory outcomes, whereas only 83.3% of overweight children did ($p = 0.004$). This aligns with findings by Koroğlu et al., who suggested that obesity may complicate the surgical management of fractures, potentially leading to less favourable outcomes in children with elevated BMI^{14, 20}.

Moreover, another aspect worth noting from the collected data involves the complexity of managing femoral shaft fractures in the pediatric population. Previous studies, such as that of Wang et al., have explored various treatment approaches, supporting the idea that traditional methods (such as casting) are increasingly

being replaced by surgical methods, such as FIN, due to lower complication rates and shorter recovery time¹¹. The current study contributes to this body of evidence by underscoring the efficacy of FIN within the Pakistani context, a demographic that faces unique challenges due to limited healthcare accessibility^{10,21}.

In conclusion, this study's findings support the existing literature by confirming the functional outcomes of flexible intramedullary nailing in pediatric patients with femoral shaft fractures. With especially favourable outcomes in younger, normatively sized children, this technique remains a commendable option for treating such injuries. Future investigations with broader samples and multicenter studies could further elucidate the nuances of complications and recovery trajectories in different populations, especially where healthcare resources differ significantly.

CONCLUSION

Intramedullary elastic nailing of simple shaft of femur fractures in children is an effective method with negligible complications. Treatment cost can be significantly lowered by using the much cheaper stainless steel flexible nails rather than the more expensive titanium nails.

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