

ORIGINAL ARTICLE

Outcome Comparison Between Titanium Elastic Nailing and Hip Spica Casting in Pediatric Femoral Shaft Fractures

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Received: 16 August 2026
Accepted: 22 August 2026
Published Online: 23 August 2026

Published by:
Gopalganj Medical College, Gopalganj,
Bangladesh

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DOI: 10.5281/zenodo.22070593

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ABSTRACT

Background: Femoral shaft fractures are one of the most frequent fractures that require hospitalization in children, and the best treatment for school-age children is still a topic of debate between operative fixation using titanium elastic nailing (TEN) and conservative treatment using hip spica casting. This study aimed to compare the functional outcome results of TEN with hip spica casting in children with femoral shaft fractures. **Methods & Materials:** This comparative study was conducted at from Department of Orthopedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, Bangladesh July 2025 to December 2025 and comprised 60 children with femoral shaft fractures, who were equally divided into two groups: TEN group (n=30) and hip spica casting group (n=30). Demographic, injury, treatment, radiological, and functional variables were recorded and compared between the two groups. Data were entered and analyzed on SPSS version 26. **Results:** Both groups showed similar outcomes at baseline. The time to partial and full weight-bearing, return to school, and radiological union was shorter in the TEN group than in the hip spica group, while the hospital stay was longer in the TEN group. The overall treatment-related complications (16.7% vs. 40%) and residual deformity were lower in the TEN group, and the final functional outcome and return to normal activity by 12 weeks were better with TEN. **Conclusion:** The results of this study indicate that titanium elastic nailing showed better outcomes than hip spica casting in children with femoral shaft fractures in terms of functional recovery and complication rate, and should be considered as the treatment of choice in the appropriate patient population in school-age children.

Keywords: Titanium elastic nailing, Hip spica casting, Pediatric femoral shaft fracture, Functional outcome

(The Insight 2026; 9(3): 636-641)

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INTRODUCTION

Femoral shaft fractures are one of the most frequently occurring musculoskeletal injuries that require hospital admission in children and represent a relatively small percentage of all pediatric fractures, but cause a disproportionate burden on health services due to the length of time they spend in hospital and immobilized [1]. The age distribution of epidemiological data reveals a bimodal pattern with peaks in toddlers and school-age children, coinciding with road traffic accidents as the main mechanism of injury [2]. In resource-limited environments, treatment decisions and follow-up are further complicated by delayed presentation, the use of traditional bone-setters, and socioeconomic factors [3]. Closed reduction with skeletal traction and hip spica casting has been the standard treatment for children under 6 years of age historically because of the significant remodeling capacity

of the immature skeleton [4]. In children aged 5-12 years, however, where remodeling potential is less, and the social, educational, and economic consequences of prolonged immobilization are more significant, the best management approach is still controversial [5]. In this age group, titanium elastic nailing (TEN), a minimally invasive intramedullary fixation technique, has become more popular than conservative casting due to its ability to mobilize the child earlier, provide more predictable alignment, and reduce recumbency time [6]. Comparative studies have generally found that operative fixation results in a shorter time to weight-bearing and return to school, and fewer complications from prolonged immobilization, including skin breakdown, joint stiffness, and loss of reduction [7]. Several systematic reviews have combined data from multiple pediatric trauma centers to confirm the benefit of TEN about malalignment and ambulatory

recovery, with varying results regarding hospital stay across centers [8]. However, there are some disadvantages to TEN, such as the need for anesthesia, irritation at the nail entry point, and a second surgery to remove the nail [9]. There is also a lack of a standard protocol, especially in low- and middle-income countries, due to regional differences in resources, surgeon preference, and availability of fluoroscopy and implants [10]. The choice of treatment also has direct implications for the family, as prolonged immobilization in hip spica often requires extended periods of time off work for the caregiver and the child's schooling, while operative fixation emphasizes surgical and anesthetic risk, rather than nursing-care demands [11]. Comparative evidence generated locally is needed to weigh the competing considerations, not extrapolated from series from other healthcare settings and patient populations. This study was conducted to compare the demographic, injury-related, treatment, radiological, and functional outcomes of children with femoral shaft fractures treated with titanium elastic nailing versus hip spica casting to provide evidence to support the decision of treatment in this age group, given this ongoing controversy and the relative lack of comparative outcome data from South Asian pediatric orthopedic practice.

METHODS & MATERIALS

This comparative study was carried out at Department of Orthopedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, Bangladesh July 2025 to December 2025 in which children with radiologically confirmed femoral shaft fractures were consecutively enrolled and divided into two groups: the titanium elastic nailing (TEN) group and the hip spica casting group, based on the fracture characteristics, age, and the surgeon's discretion, with a final sample of 60 children (30 in each group) analyzed. Children aged 3 to 12 years with closed or Grade I open diaphyseal fractures of the femur who presented within one week of the fracture and had a minimum follow-up of 12 weeks were included, whereas children with pathological fractures,

associated ipsilateral lower-limb fractures, polytrauma that prevented early mobilization, pre-existing neuromuscular or skeletal disorders that affected bone healing, and children lost to follow-up before radiological union was documented were excluded. Demographic data (age, sex, residence, socioeconomic status), injury and clinical data (side, mechanism of injury, fracture location, pattern, fracture type, associated injury), treatment-related data (time from injury to treatment, hospital stay, time to partial and full weight-bearing, return to school or normal activity, need for additional manipulation), radiological and functional outcome during follow-up (time to radiological union, limb-length discrepancy, angular deformity, knee and hip range of motion), treatment-related complications (infection, nail-entry-site irritation, cast sores, malalignment, delayed union), and final treatment outcomes (functional outcome grade, overall satisfactory outcome, return to normal activity by 12 weeks, residual deformity) were recorded. Data were collected on a structured proforma and analyzed using SPSS version 26. Continuous variables were presented as mean $\pm$ SD and compared between the two groups by independent-samples t-test; categorical variables were presented as frequencies and percentages and compared by chi-square test or Fisher's exact test, with a p-value < 0.05 being considered statistically significant throughout the analysis.

RESULTS

Table 1 shows the demographic data of the 60 study subjects, divided into two groups: TEN and hip spica, with 30 subjects in each group. The mean age was 7.4 ± 2.1 years in the TEN group and 6.9 ± 2.0 years in the hip spica group, with the majority of children aged 6-8 years. There was a male predominance in both groups (73.3% and 70.0%, respectively), a majority were living in rural areas, and a similar distribution across lower, middle, and upper socioeconomic strata.

Table 1: Demographic characteristics of the study participants, n=60.

Variables	Category	TEN group, n=30, n (%)	Hip spica group, n=30, n (%)
Age, years	Mean $\pm$ SD	7.4 ± 2.1	6.9 ± 2.0
	3-5 years	7 (23.3)	9 (30.0)
	6-8 years	13 (43.3)	12 (40.0)
	9-12 years	10 (33.3)	9 (30.0)
Sex	Male	22 (73.3)	21 (70.0)
	Female	8 (26.7)	9 (30.0)
Residence	Rural	20 (66.7)	21 (70.0)
	Urban	10 (33.3)	9 (30.0)
Socioeconomic status	Lower	13 (43.3)	14 (46.7)
	Middle	14 (46.7)	13 (43.3)
	Upper	3 (10.0)	3 (10.0)

The injury and clinical features of the two groups are presented in Table 2. The right side was more frequently involved than the left side, and road traffic accidents were the most common mechanism of injury, followed by falls from height and falls while playing. Femoral shaft fractures occurred most

commonly in the middle third of the shaft; transverse fractures were the most common fracture type, and associated injuries occurred in a small number of children in both groups.

Table II: Injury and clinical characteristics of the participants.

Variables	Category	TEN group, n=30, n (%)	Hip spica group, n=30, n (%)
Side of fracture	Right	17 (56.7)	16 (53.3)
	Left	13 (43.3)	14 (46.7)
Mechanism of injury	Road traffic accident	15 (50.0)	14 (46.7)
	Fall from height	9 (30.0)	10 (33.3)
	Fall during play	6 (20.0)	6 (20.0)
Fracture location	Proximal third	4 (13.3)	5 (16.7)
	Middle third	20 (66.7)	19 (63.3)
	Distal third	6 (20.0)	6 (20.0)
Fracture pattern	Transverse	13 (43.3)	12 (40.0)
	Oblique	10 (33.3)	11 (36.7)
	Spiral	5 (16.7)	4 (13.3)
	Comminuted	2 (6.7)	3 (10.0)
Fracture type	Closed	27 (90.0)	28 (93.3)
	Grade I open	3 (10.0)	2 (6.7)
Associated injury	Present	5 (16.7)	4 (13.3)
	Absent	25 (83.3)	26 (86.7)

Treatment-related and early recovery characteristics are compared between groups in *Table III*. Time from injury to treatment was similar (2.3 ± 1.1 vs. 2.1 ± 1.0 days, $p=0.465$), but the TEN group had a longer hospital stay (4.8 ± 1.5 vs. 3.2 ± 1.2 days) and significantly shorter time to partial weight-bearing,

full weight-bearing, and return to school/normal activity (all $p<0.001$). There was a greater need for additional manipulation in the hip spica group (16.7%) than in the TEN group (3.3%) ($p=0.085$).

Table III: Treatment-related and early recovery characteristics.

Variables	Category	TEN group, n=30	Hip spica group, n=30	p-value
Time from injury to treatment, days	Mean $\pm$ SD	2.3 ± 1.1	2.1 ± 1.0	0.465
Hospital stay, days	Mean $\pm$ SD	4.8 ± 1.5	3.2 ± 1.2	<0.001
Time to partial weight-bearing, weeks	Mean $\pm$ SD	3.8 ± 1.1	7.6 ± 1.5	<0.001
Time to full weight-bearing, weeks	Mean $\pm$ SD	7.2 ± 1.4	10.3 ± 1.8	<0.001
Return to school/normal activity, weeks	Mean $\pm$ SD	8.6 ± 2.0	12.5 ± 2.7	<0.001
Required additional manipulation	Yes	1 (3.3)	5 (16.7)	0.085
	No	29 (96.7)	25 (83.3)	

Radiological and functional results at follow-up are shown in *Table IV*. Time to radiological union was shorter in the TEN group (9.1 ± 1.6 vs. 11.0 ± 2.0 weeks, $p<0.001$). The TEN group had a higher incidence of radiological union by 12 weeks, LLD

<1 cm, and full knee and hip ROM compared to the hip spica group, but these differences were not statistically significant ($p>0.05$).

Table IV: Radiological and functional outcomes during follow-up.

Variables	Category	TEN group, n=30, n (%)	Hip spica group, n=30, n (%)	p-value
Time to radiological union, weeks	Mean $\pm$ SD	9.1 ± 1.6	11.0 ± 2.0	<0.001
Radiological union by 12 weeks	Yes	29 (96.7)	25 (83.3)	0.085
	No	1 (3.3)	5 (16.7)	
Limb-length discrepancy	None, <1 cm	27 (90.0)	22 (73.3)	0.096
	1-2 cm	3 (10.0)	7 (23.3)	
	>2 cm	0 (0.0)	1 (3.3)	
Angular deformity	None or <5°	28 (93.3)	23 (76.7)	0.071
	5-10°	2 (6.7)	6 (20.0)	
	>10°	0 (0.0)	1 (3.3)	
Knee range of motion at final follow-up	Full	28 (93.3)	23 (76.7)	0.071
	Mild restriction	2 (6.7)	7 (23.3)	
Hip range of motion at final follow-up	Full	29 (96.7)	26 (86.7)	0.161
	Mild restriction	1 (3.3)	4 (13.3)	

Complications after treatment are summarized in *Table V*. The incidence of any treatment-related complication was 16.7% in the TEN group and 40.0% in the hip spica group ($p=0.045$). The TEN group had only superficial infection, and the hip spica

group had only skin irritation/cast sores. The hip spica group had a higher incidence of clinically relevant malalignment, LLD ≥ 1 cm, and delayed union.

Table V: Complications following treatment.

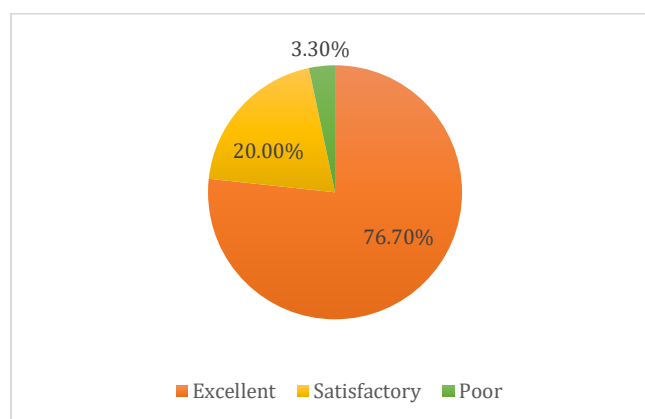
Variables	Category	TEN group, n=30, n (%)	Hip spica group, n=30, n (%)	p-value
Any treatment-related complication	Present	5 (16.7)	12 (40.0)	0.045
	Absent	25 (83.3)	18 (60.0)	
Superficial infection	Present	2 (6.7)	0 (0.0)	0.492
	Absent	28 (93.3)	30 (100.0)	
Nail-entry site irritation	Present	3 (10.0)	NA	NA
	Absent	27 (90.0)	NA	
Skin irritation/cast sore	Present	0 (0.0)	5 (16.7)	0.052
	Absent	30 (100.0)	25 (83.3)	
Clinically relevant malalignment	Present	1 (3.3)	5 (16.7)	0.085
	Absent	29 (96.7)	25 (83.3)	
Limb-length discrepancy ≥ 1 cm	Present	3 (10.0)	8 (26.7)	0.095
	Absent	27 (90.0)	22 (73.3)	
Delayed union	Present	1 (3.3)	4 (13.3)	0.161
	Absent	29 (96.7)	26 (86.7)	

The final treatment results are compared between groups in Table VI. The TEN group had an excellent functional outcome in 76.7% of cases compared to 50.0% of the hip spica group ($p=0.047$). The TEN group had a more favorable overall

outcome with return to normal activity at 12 weeks (90.0% vs. 63.3%, $p=0.015$) and no residual deformity (6.7% vs. 23.3%, $p=0.071$), and a lower overall complication rate.

Table VI: Comparison of final treatment outcomes between TEN and hip spica casting.

Variables	Category	TEN group, n=30, n (%)	Hip spica group, n=30, n (%)	p-value
Final functional outcome	Excellent	23 (76.7)	15 (50.0)	0.047
	Satisfactory	6 (20.0)	11 (36.7)	
	Poor	1 (3.3)	4 (13.3)	
Overall satisfactory outcome	Yes	29 (96.7)	26 (86.7)	0.161
	No	1 (3.3)	4 (13.3)	
Returned to normal activity by 12 weeks	Yes	27 (90.0)	19 (63.3)	0.015
	No	3 (10.0)	11 (36.7)	
Residual deformity at final follow-up	Present	2 (6.7)	7 (23.3)	0.071
	Absent	28 (93.3)	23 (76.7)	
Overall complication	Present	5 (16.7)	12 (40.0)	0.045
	Absent	25 (83.3)	18 (60.0)	


Figure 1: Final functional outcome.

DISCUSSION

The two treatment groups were similar in baseline demographic and injury characteristics in our study of 60 children, making it possible to compare the treatment-related outcomes. Children who were treated with titanium elastic nailing (TEN) had significantly shorter time to partial and full weight bearing and earlier return to school compared to those who were treated with hip spica casting. This is similar to the results of a recent study by Ijaz et al., where TEN also reduced the time to independent ambulation and school attendance compared to cast immobilization [12]. A similar benefit of operative fixation over conservative casting was reported in children younger than 5 years, in which the overall

complication rates were comparable, but short-term radiological alignment was better in the nail group, indicating that the benefit of TEN over spica casting extends beyond the 6-12-year age range traditionally recommended for elastic nailing [13]. The hospital stay in the TEN group in this study was longer than the weight-bearing and school-return periods would indicate, but is comparable to the total inpatient period reported for nailing outside a fast-track pathway, as a result of pre-operative work-up and post-operative observation [14]. In our study, radiological union occurred earlier in the TEN group, consistent with longer-term follow-up data that showed that elastic nailing resulted in reliable union with limited residual angulation even after multi-year follow-up, and with

multicenter radiographic data that showed that the residual angulation after flexible nailing normalized progressively over the first postoperative year [15,16]. In this study, the complication rates, such as malalignment, delayed union, and skin-related complications, were lower in the TEN group, consistent with a series of developing world cases in which flexible intramedullary nailing resulted in a low overall complication rate despite limited resources, and with systematic comparisons of nailing versus other fixation options, which demonstrated acceptable adverse-event profiles for elastic nails compared to more invasive constructs [17, 18]. In our study, the higher incidence of cast sores and skin irritation in the hip spica group is similar to the known risk of pressure-related skin complications with prolonged cast immobilization, which is also reported by Luo et al., where conservative management had a distinct complication pattern compared to operative fixation [19]. In this study, functional outcomes (overall satisfactory outcome, residual deformity, and outcome grading) favored TEN, as has been reported for low-grade comminuted fractures with elastic nailing compared to other constructs, and as early outcome data from flexible nailing series have shown, predominantly excellent to satisfactory functional grading using recognized pediatric scoring systems [20, 21]. In our study, the TEN group had better preservation of ROM at the knee and hip, which is consistent with Yaokreh et al., who reported more restricted knee motion in the conservatively treated group than in the TEN group [22]. The incidence of limb-length discrepancy and angular deformity in the hip spica group was generally within an acceptable range, but higher than in the TEN group, which is likely due to the fact that a cast is less effective than retrograde elastic nails in maintaining precise alignment during remodeling. The results of these studies collectively reinforce the evidence that TEN is a safe and effective treatment for femoral shaft fractures in school-age children and highlight that hip spica casting, when indicated, is an effective and less invasive treatment option that avoids the risks associated with anesthesia and implants, especially in younger children or in areas where operative resources are limited.

LIMITATIONS

The study was conducted at a single center in a small number of patients and with a relatively short follow-up period, which may reduce the generalizability and long-term validity of the functional and radiological results.

CONCLUSION

This study demonstrated that the use of titanium elastic nailing is superior to hip spica casting in the treatment of pediatric femoral shaft fractures. Children who were treated with TEN had earlier weight-bearing, radiological union, and return to school compared to those managed conservatively. The TEN group also had fewer treatment-related complications, residual deformity, and malalignment. The functional outcomes and overall satisfaction were significantly improved with TEN. The results of this study are consistent with the use of titanium elastic nailing as the treatment of choice for the appropriately selected school-age child with a femoral shaft fracture. However, hip spica casting is still a useful non-invasive option in certain clinical situations.

RECOMMENDATIONS

These findings should be confirmed by larger multicenter studies with longer follow-up and cost-effectiveness analysis to further validate the findings and optimize treatment protocols for pediatric femoral shaft fractures.

FUNDING

No funding sources.

CONFLICT OF INTEREST

None declared.

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee.

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