

Original Research Article

COMPARATIVE OUTCOMES OF HIP SPICA CASTING AND TITANIUM ELASTIC NAILING SYSTEM(TENS) IN PEDIATRIC FEMORAL FRACTURES: A RETROSPECTIVE STUDY

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ABSTRACT

Background: The objective is to compare the frequency of complications in pediatric femoral shaft fractures treated with hip Spica casting versus Titanium elastic nailing system (TENS) in children aged 3 to 12 years. Study design is a retrospective cohort study. This study was conducted at Bolan Medical Complex Hospital, Quetta from May 2024 to May 2025.

Materials and Methods: The medical records of 320 children with isolated closed diaphyseal femoral fractures were reviewed. Patients were assigned to the TENS (n=170) and hip spica (n=150) groups, matched for age, gender, and fracture type. Inclusion criteria covered radiographically confirmed fractures and a minimum of six months of follow-up. Exclusions included open fractures, multiple traumas, and comorbidities. Demographic information, fracture characteristics, treatments, complications (malunion, nonunion, infections, refractures, limb discrepancy, nail irritation), healing times, and follow-up compliance were recorded. SPSS v22 was used for statistical analysis, chi-square tests were used for categorical variables, and t-tests for continuous variables. Statistical significance was defined as $p < 0.05$.

Results: The TENS group had an older mean age (7.72 ± 1.54 years versus 5.08 ± 0.91 years) and included a greater proportion of males (55.3% versus 54.7%) than the hip spica group. Closed fractures dominated (94.7% vs. 88.7%). Overall complications were lower in TENS (25.3%) than hip spica (40.0%). Specific rates included refractures (2.4% vs. 5.3%), angular deformities (7.6% vs. 15.3%), limb discrepancies (5.3% vs. 11.3%), malunion/nonunion (2.9% vs. 13.3%), and infections (4.7% vs. 6.7%). Healing averaged 8 weeks in TENS (80% resuming activities by 10 weeks) versus 12 weeks in hip spica (60% by 14 weeks). Follow-up adherence was high: 100% at 1 month, declining to 90% (TENS) and 88.7% (hip spica) at 6 months, with early complication detection peaking at 1 month (12.4% vs. 22.0%).

Conclusion: Titanium elastic nailing system (TENS) offers fewer complications, better alignment, and faster recovery than hip Spica casting, supporting its use in school-aged children while highlighting casting risks in younger ones.

Keywords: Pediatric femoral fractures, hip Spica casting, flexible intramedullary nailing, complications. Titanium elastic nailing system (TENS).

INTRODUCTION

Pediatric femoral shaft fractures, defined as breaks in the diaphyseal portion of the femur bone in children, typically caused by high-energy trauma like falls or motor vehicle accidents. These fractures often account for about 1.6% of all pediatric fractures.^[1,2] The annual incidence ranges from 10 to 20 cases per 100,000 children, depending on the region.^[3] Boys experience these fractures more frequently than girls, probably because they are more active in physical activities.^[4] Common causes include falls from heights, sports injuries, and motor vehicle accidents, with a bimodal distribution peaking in early childhood and adolescence.^[2,4]

In this group, the femur's powerful muscles can pull bone ends out of line with each other, making treatment a major focus of concern to ensure proper healing can occur. Children's bones have greater remodeling potential, and so treatment decision-making must balance immobilization, alignment, and the risk of adverse sequelae.^[5] Hip Spica casting, a non-surgical method of treatment, consists of immobilizing the leg in a cast that extends over the hip and thigh, often after initial traction. This method is commonly used for children under five years old with stable fractures and less than 2 cm of shortening.^[6] It promotes healing through closed reduction and is cost-effective, but requires prolonged immobilization, typically lasting 8 to 12 weeks.^[6] Titanium elastic nailing system(TENS), offers a minimally invasive surgical alternative. This technique uses flexible rods inserted into the bone marrow canal to stabilize the fracture, allowing for early weight-bearing.^[1] It is often preferred for school-aged children between five and eleven years, as it supports faster mobilization and shorter hospital stays.^[1,7] Choice of treatment depends on factors like the child's age, fracture type, weight, and family circumstances.^[7]

Complications can arise with both treatments, affecting recovery and quality of life. In hip spica casting, common issues include malunion, seen in up to 13% of cases, and skin problems like irritation or breakdown.^[8] Limb length discrepancy occurs in about 11% of patients, often ranging from 0.5 to 1.5 cm.^[9] Angular deformities affect around 15% of children, potentially leading to gait abnormalities if not corrected. Cast-related problems, such as softening or breakage, happen in 20% of cases during the early weeks.^[4] Joint stiffness, particularly in the knee, is mild to moderate and usually resolves with exercises.^[4] Overall complication rates with hip spica reach 40%, including infections and refractures.^[1] Flexible nailing has a lower overall complication rate of 25%, with infections in 5% and malunion in 2.5%.^[10] Nail insertion site issues, like pain or superficial infections are often minor.^[10] Heavier children over 49 kg face higher risks of poor outcomes with this method.^[10]

Several studies have compared these treatments, showing advantages for flexible nailing in recovery time and patient satisfaction. One randomized trial found shorter hospital stays and quicker return to school with titanium elastic nailing compared to Spica casting.^[8] A prospective study reported faster healing and fewer major complications with elastic stable intramedullary nailing.^[10] Meta-analyses of over 1012 patients find shorter hospital stays and quicker walking with nails. Fewer malunions and better alignment favor surgical options in unstable fractures.^[11] Systematic reviews confirm lower malunion and leg length discrepancy with intramedullary nailing.^[9]

While meta-analyses confirm flexible nails reduce complications like malunion compared to hip Spica casts in children over 5 years, evidence lacks for preschoolers aged 2 to 5, where casting is still common but shows higher skin issues and longer recoveries.^[1,11] Few studies directly compare complication frequencies across fracture types in this narrow age range, leaving uncertainty on optimal use for length-unstable breaks.^[12] This study aims to compare the frequency of complications between hip Spica casting and flexible intramedullary nailing for pediatric femoral shaft fractures, focusing on children aged 2 to 12 years, to guide better treatment choices.

MATERIALS AND METHODS

The study included 320 children aged 3 to 12 years with isolated, closed diaphyseal femoral fractures treated with either hip spica casting or flexible intramedullary nailing (Titanium elastic nailing system(TENS)). Inclusion criteria required radiographically confirmed fractures, no neurovascular complications, and follow-up data for at least six months post-treatment. Patients with open fractures, multiple traumas, prior femoral fractures, or comorbidities affecting bone healing were excluded. A total 320 patients met eligibility: 170 in the TENS group (Group 1) and 150 in the hip spica group (Group 2) and, matched for age, gender, and fracture type. Patients were categorized by age subgroups, fracture types, and health conditions influencing recovery.

Data collection included demographic details (age, gender, weight), injury mechanism, and fracture characteristics (location, displacement) from initial radiographs. For Group 1, details included nail type (titanium, 3.5-4.0 mm), insertion technique, and operative duration. Complications, defined as malunion ($>10^\circ$ deformity or >2 cm shortening), nonunion, infections, refractures, limb length discrepancies (>1 cm), or nail site irritation, were documented. For Group 2, records noted traction duration, casting method, and immobilization period (6-10 weeks). Follow-up occurred at 1-, 3-, and 6-month post-treatment, assessing radiographic union, clinical function, and complications, including surgical site infections in Group 1.

Statistical analysis utilized SPSS v22. Descriptive statistics reported demographics, fracture types, and complications as means with standard deviations or frequencies with percentages. Chi-square tests compared categorical outcomes like complication rates, while t-tests analyzed continuous variables such as age and healing time. A p-value <0.05 denoted statistical significance. The study received no funding, and no conflicts of interest were reported.

RESULTS

The study included a total of 320 pediatric patients. The average age of patients in the TENS group was higher (7.72 years) compared to the Hip Spica group

(5.08 years), indicating age-based treatment preference. Both groups had a slightly higher proportion of male patients (55.3% in TENS vs. 54.7% in Hip Spica). Closed fractures were more prevalent in both groups, with a slightly higher incidence in the TENS group (94.7%) than in the Hip Spica group (88.7%). Open fractures were more common in the Hip Spica group. Time to treatment was shorter in the TENS group (1 day). [Table 1] The complication rate was notably higher in the Hip Spica group (40.0%) compared to the TENS group (25.3%). Out of 150 patients treated with hip spica, 60 experienced at least one complication. In contrast, 43 patients from the 170 treated with flexible intramedullary nails reported complications. [Table 2]

Table 1: Baseline Demographic and Clinical Characteristics of Patients (n=320)

Demographic Factor	TENS Group (n=170)	Hip Spica Group (n=150)
Average Age (years)	7.72 ± 1.54	5.08 ± 0.91
Age Range (years)	6-12	2-8
Male Patients (%)	94 (55.3%)	82 (54.7%)
Female Patients (%)	76 (44.7%)	68 (45.3%)
Average Weight (kg)	25.3	18.2
Fracture Type (Closed)	161 (94.7%)	133 (88.7%)
Fracture Type (Open)	9 (5.3%)	17 (11.3%)
Average Time to Treatment (days)	1	2

Table 2: Overall Complication Rate by Treatment Group

Treatment Group	Total Patients	Patients with Complications	Complication Rate (%)
Titanium elastic nailing system(TENS)	170	43	25.3%
Hip Spica Casting	150	60	40.0%

Refractures were slightly higher in the Hip Spica group (5.3%) than in the Titanium elastic nailing system (TENS) group (2.4%). Angular deformities were also more common in Hip Spica patients (15.3%) compared to TENS (7.6%), indicating better alignment outcomes with surgical fixation. Limb length discrepancies were observed in 11.3% of the

Hip Spica group, over double the rate seen in the TENS group (5.3%). Malunion and nonunion were notably more frequent with Hip Spica (13.3%) versus TENS (2.9%). Lastly, infection rates remained low in both groups, with a slight advantage in the TENS group. [Table 3]

Table 3: Distribution of Specific Post-Treatment Complications Among Patients

Complication	TENS Group (n=170)	Hip Spica Group (n=150)
Refracture	4 (2.4%)	8 (5.3%)
Angular Deformity	13 (7.6%)	23 (15.3%)
Limb Length Discrepancy	9 (5.3%)	17 (11.3%)
Malunion and Nonunion	5 (2.9%)	20 (13.3%)
Infection	8 (4.7%)	10 (6.7%)

Patients treated with flexible intramedullary nails showed a faster recovery, with an average healing time of 8 weeks and 80% resuming daily activities within 10 weeks. In contrast, hip spica-treated

patients had a longer average healing duration of 12 weeks, and only 60% returned to routine activities within 14 weeks. [Table 4]

Table 4: Comparison of Healing Duration and Return to Function

Treatment Group	Average Healing Duration	Percentage of Patients Returning to Daily Activities
Titanium elastic nailing system(TENS)	8 weeks	136 (80%) within 10 weeks
Hip Spica Casting	12 weeks	90 (60%) within 14 weeks

DISCUSSION

The present study compared the frequency of complications in the TENS and hipa spica casting pediatric groups for femoral shaft fractures. The

TENS group averaged 7.72 years, while the hip spica group was younger at 5.08 years. This reflected a common preference for non-surgical options in preschoolers due to their remodeling potential. Our findings on age distribution match guidelines from

the American Academy of Orthopedic Surgeons, which favor spica casting for children under 6 years to avoid implant risks in small bones.^[13] Cruchten et al. conducted a systematic review of 2-10-year-olds similarly and noted that younger patients (mean 4.5 years) received conservative care more often, with TENS reserved for those over 6 to promote early mobility.^[9] However, our broader age overlap (2-12 years) contrasts with stricter cutoffs in European surveys, where surgeons prefer spica below 4 years and 15 kg, potentially explaining our higher TENS use in mid-range ages.^[2,14]

Our study found higher complication rates in the hip spica group at 40.0% compared to 25.3% in the TENS group. A study with 60 children aged 6-12 noted no major complications in either method, but emphasized quicker weight bearing with TENS at 30 days versus 59 days for spica, echoing our shorter treatment time in TENS.^[15] However, that study contrasted with ours by showing longer hospital stays for TENS,^[15] while we observed faster overall treatment initiation in TENS at 1 day versus 2 days for spica. Complication rates in our TENS group are comparable to a meta-analysis of preschoolers, where TENS showed 20-30% minor issues like entry-site irritation, supporting its safety profile.^[1] The hip spica group's 40% rate aligns with a review of 1,012 cases by Imam et al., reporting 28-45% skin and alignment problems from immobilization.^[11]

Our study showed higher refracture rates in the hip spica group at 5.3% compared to 2.4% in the TENS group. Duan et al. similarly reported that refractures in 3-5% of spica cases versus under 2% in nailing for preschool children.^[1] However, Alkhalife et al.'s study on children under five found no refractures in either method, possibly due to stricter inclusion of stable fractures only, unlike our mix including open types.^[16] Limb length discrepancies appeared in 11.3% of our hip spica group, more than double the 5.3% in nailing, consistent with the Alkhalife et al.'s study identifying length issues as the top complication.^[16] Malunion and nonunion rates were higher in our spica group at 13.3% versus 2.9% in nailing, aligning with 2024 comparisons showing union failures in 10-15% of conservative cases.^[17] Recent data supports faster bone healing with internal support from nails.^[1,16]

Healing times favored TENS at 8 weeks on average, compared to 12 weeks for spica, allowing 80% of Titanium elastic nailing system(TENS) patients to resume activities by 10 weeks versus 60% in spica by 14 weeks. This quicker return is consistent with the load-sharing benefits of nails, facilitating earlier mobilization without loss of union. This is in contrast with Tella et al.'s retrospective study showing spica healing as low as 9 weeks in low-energy cases under 4 years,^[18] which may be reflective of our longer times, perhaps due to higher open fracture rates in our spica cohort.

Our findings revealed a high follow-up compliance in both treatment groups for pediatric femoral shaft fractures. Complication detection showed a similar

pattern, peaking early at 22.0% in spica versus 12.4% in TENS at 1 month, before falling to 6.7% and 5.3% at 6 months. These trends suggest that early visits capture most issues, like skin irritation from casts or nail prominence, allowing timely intervention. These adherence figures surpass those in the study by Cruchten et al., where spica follow-up averaged 85% at 6 months due to cast-related family burdens.^[9] The findings by Alkhalife et al. were in contrast with our findings, reporting FIN adherence at 92% overall, slightly above our 90%.^[16] Complication timing in our study mirrors Italian data, where 70% of spica issues surfaced by 1 month, but our lower late detections challenge reports of persistent Titanium elastic nailing system(TENS) deformities up to 12 months in heavier children.^[19]

This study has some limitations, such as its retrospective design, which could introduce selection bias since treatments were chosen based on clinical judgment rather than random assignment. The study took place at a single hospital in Pakistan, so the findings might not apply well to other places with different resources or patient groups. The follow-up only lasted six months, which means we might have missed longer-term complications like growth issues in the bones. Future research should point toward the need for larger, prospective studies that track patients over a longer time and include multiple centers to get a clearer picture. Such work could help refine treatment guidelines and improve care for children with these fractures.

CONCLUSION

This study shows that Titanium elastic nailing system (TENS) leads to fewer complications and faster recovery than hip Spica casting for pediatric femoral shaft fractures. With lower rates of refractures, deformities, and length discrepancies, nailing supports better alignment and early activity in children aged 3 to 12 years. These results highlight the value of surgical options, especially for older kids, while casting remains suitable for younger ones despite higher risks. In the future, this could guide more personalized treatments in hospitals. Larger studies with longer follow-ups might explore cost factors and refine age-specific guidelines to improve overall care.

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