International Journal of Research in Orthopaedics
Wahid AHMA et al. Int J Res Orthop. 2024 Sep;10(5):940-944
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20242386

Functional outcome of femoral shaft fracture in pediatric patients treated by titanium elastic nailing system

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Received: 05 June 2024
Revised: 08 July 2024
Accepted: 11 July 2024

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ABSTRACT

Background: Pediatric femoral shaft fractures are common, typically occurring in early childhood due to low-energy incidents and during adolescence due to high-energy trauma. These fractures represent around 2.2% of all bone injuries in children, with an incidence of 20-25 per 100,000 children per year, and are more prevalent in boys.
This prospective study aims to assess the outcomes of treating pediatric femoral shaft fractures with TENs.
Methods: This prospective study at North Bengal Medical College and Hospital included Twenty-three patients, aged 4 to 12 years, with diaphyseal femur fractures treated using TENS (Titanium Elastic Nailing System) for one year, from January 2023 to December 2023.
Results: Most patients (52.17%) were 9-12, with a higher prevalence of males (73.91%). The most common fracture type was transverse (69.57%), predominantly on the right side (69.57%). Union rates were 21.74% at 8 weeks, 56.52% at 10, and 21.74% at 12 weeks. Complications included limb lengthening (21.74%) and malalignment (13.04%). Functional outcomes at 12 weeks post-operation were mostly excellent (60.87%) or satisfactory (30.43%), with one poor result (8.70%).
Conclusions: Titanium elastic nailing system (TENS) is effective for pediatric femoral shaft fractures, achieving high bone union rates and minimal complications. Most fractures healed within 10 weeks, and patients had excellent or satisfactory functional outcomes, supporting TENS as a beneficial treatment for children aged 4 to 14.

Keywords: Functional outcome, Femoral shaft fracture, Pediatric patients, TENS.

INTRODUCTION

Pediatric femoral shaft fractures are frequent injuries managed by orthopedic surgeons. These fractures usually happen either in early childhood, when the transition from weak woven bone to stronger lamellar bone is taking place, or during adolescence, when children are more likely to experience high-energy trauma.[1] Researchers have observed a bimodal distribution, with the initial peak typically occurring in the age range of 1 to 3 years, often associated with low-energy incidents, and a second peak during early adolescence, commonly linked to high-energy trauma. This latter period constitutes the majority of femoral shaft fractures in this demographic. Although the causes of these fractures vary depending on the child's age, falls from heights and road traffic accidents are the most prevalent contributors.[2] Femoral shaft fractures represent

around 2.2% (approximately) of all bony injuries in children.[3] The incidence of pediatric femoral shaft fractures is 20-25 per lakh children per year.[4] These fractures are 2.6 times more common in boys than girls.[2] These injuries necessitate hospitalization and result in significant disability, imposing both physical and psychological stress on the patient as well as their parents.[5] The treatment for these injuries primarily depends on the patient's age, location, pattern, and whether the fracture is closed or open. Skin traction followed by casting or early spica casting is typically used for children under five years old, yielding good results.[6] For patients older than 15, fractures are treated with interlocking intramedullary nails, similar to the approach used in adults.[7] Treatment options for children aged 6 to 14 vary and include traction followed by casting, TENS nailing, ORIF, intramedullary nailing, and external fixation. The literature has no consensus on the best approach for this age group.[8]

Regardless of the treatment method, the objectives should stabilize the fracture, maintain proper length and alignment, promote bone healing, and minimize morbidity and complications for the child and their family9. For children over the age of 6, treating fractures nonoperatively can result in loss of reduction, malunion, discomfort, and complications associated with plaster.[10,11] Operative treatment offers several advantages over non-operative treatment, including better fracture reduction, more stable fixation, faster mobilization, shorter hospital stays, less disruption to social life, and an earlier return to school. Additionally, it is suitable for patients with open fractures, multiple injuries, and head trauma.[8] The ideal device for treatment should be a single load-sharing implant that allows mobilization and maintains alignment until bridging callus forms without jeopardizing the physis or blood supply to the femoral head. In children aged 5 to 15 years, TENS meets these criteria effectively.[12]

The biomechanical concept behind the titanium elastic nail (TEN) relies on the "3-point principle," which involves the symmetrical bracing action of two elastic nails inserted into the metaphysis. Each nail applies pressure against the inner bone at three distinct points.[13,14] However, there is a lack of studies and limited data regarding the effectiveness of TENs in treating femur shaft fractures in Bangladesh. This prospective study aims to assess the outcomes of treating pediatric femoral shaft fractures with TENs.

METHODS

This prospective study was conducted in the Orthopedic Department at North Bengal Medical College and Hospital from January 2023 to December 2023. Twenty-three patients, aged 4 to 14 years, with diaphyseal femur fractures were included. Treatment involved internal fixation using TENS (Titanium Elastic Nailing System). Patients were monitored over 6 months through clinical and radiological assessments. The functional outcomes were evaluated using Flynn's scoring criteria.[15]

Inclusion criteria

Patients aged 4 to 14 years with diaphyseal femur fractures. Children with closed, displaced diaphyseal femur fractures. Children of both sexes who are eligible for surgery.

Exclusion criteria

Patients younger than 4 years old and older than 14 years old. Any open fractures with secondary infections, suspected deep infections, or delayed presentations (over 10 days). All metaphyseal fractures, with or without epiphyseal involvement. Cases where parents or the patient decline surgery. Children with comorbid conditions such as epilepsy, heart diseases, neuromuscular diseases, or bleeding disorders.

The study protocol was approved by the Ethics Committee of the Institution. Data will be collected using a structured questionnaire containing all the variables of interest. The patient was placed supine on a radiolucent table and given spinal anesthesia. The fracture was reduced and aligned using image intensifiers. Preparation from hip to knee followed. A pre-bent nail was used for three-point fixation with the fracture at the bend's center. Entry points for the nails were selected at the top of the femoral condyles. A lateral leg incision was made, and the vastus lateralis retracted. The next largest drill bit was used to create a perpendicular hole in the cortex, which was then enlarged with a curved bone awl. Nails were inserted medially and laterally, aligned with a 'C' arm, and advanced to the fracture site. The reduction was ensured using an 'F' tool. The first nail was partially advanced and rotated for fracture reduction before inserting the second nail. Both nails were fully advanced after traction release. Any deformities were corrected by nail rotation. If mal-rotation occurred, repositioning and nailing were repeated. Nails were cut to 1-2 cm outside the cortex, the wound was sutured, and a sterile dressing was applied. Postoperatively, knee and hip mobilization began once the pain subsided, with weight bearing advised after radiographic healing signs, typically after three weeks. Weekly follow-ups continued until fracture union. All data were presented in a suitable table or graph according to their affinity. All the data were analyzed using SPSS software V.26 (IBM Statistics, Chicago, USA) and Microsoft Office.

RESULTS

In this study, the age distribution of patients was as follows: 52.17% were between 9 and 12 years, 30.43% were between 13 and 14 years, and 17.39% were between 5 and 8 years (Table 1). Gender distribution indicated a higher prevalence of male patients (73.91%) compared to female patients (26.09%) (Figure 1). The predominant type of fracture observed was transverse, accounting for 69.57% of cases, with oblique fractures comprising 21.74% and spiral fractures 8.70%. Fractures were more

frequently located on the right side (69.57%) than on the left side (30.43%) (Table 2).

Table 1: Age distribution of the study patients (n=23).

Age in years	Frequency (N)	%
5-8	4	17.39
9-12	12	52.17
13-14	7	30.43
Total	23	56.52

Table 2: Pattern and side of fractures.

Pattern of fracture	Frequency (N)	%
Transverse	16	69.57
Oblique	5	21.74
Spiral	2	8.70
Frequency of side		
Right	16	69.57
Left	7	30.43

Table 3: Post-operative time for union.

Time for union	Frequency (N)	%
8 weeks	5	21.74
10 weeks	13	56.52
12 weeks	5	21.74

Table 4: Patient complications.

Complications	Frequency (N)	%
Limb lengthening	5	21.74
Infection	2	8.70
Nail protrusion	2	8.70
Malalignment	3	13.04

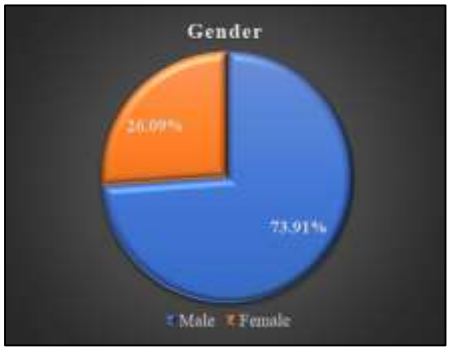

Figure 1: Gender distribution of the study patients (n=23).

Union rates post-operation showed that 21.74% of patients achieved union at 8 weeks, 56.52% at 10 weeks, and another 21.74% at 12 weeks (Table 3). The most common complication was limb lengthening, occurring in 21.74% of cases, followed by malalignment in 13.04% of cases. Both infection and nail protrusion were observed in 8.70% of cases (Table 4).

Figure 2: X-ray before surgery.

Figure 3: Operation procedure during operation.

Figure 4: Operation procedure during operation.

Figure 5: Operation procedure during operation.

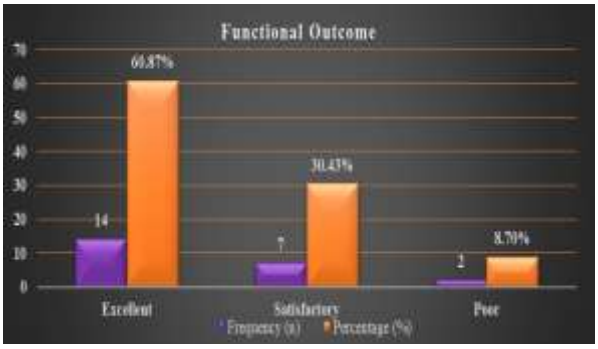

Figure 6: Functional outcome of the study children (n=23).

DISCUSSION

In the last two decades, pediatric femoral shafts in patients older than six years have been treated operatively because of the benefits of reduced duration of hospitalization and immobilization, shorter rehabilitation period, and, most importantly, less psychological impact on the child. Studies that compare operative versus conservative methods reflect the trend toward operative management of these fractures.[16,17] TENS has only recently emerged as the implant of choice for treating pediatric femur shaft fractures. TENS has a short learning curve associated with minimal complications when performed properly. It allows for abundant callus formation and early union due to nails permitting micromotion at the fracture site and avoids disrupting the fracture hematoma as it is a closed procedure.[18] In our study, most of the patients were 9-12 years old and most were male. The findings of our study are consistent with the results of Debnath et al.[9] A study by Sandhu et al. showed that males comprised 60.33% of the population.[19] This could be explained by the fact that boys tend to be involved in outdoor activities more often than girls and have a higher chance of getting into road traffic accidents. These results are supported by various other studies conducted elsewhere about age. Literature has shown that fracture has a bimodal distribution with a peak at the ages of 2 and 17, possibly due to various factors.[20,21] Our study comprised 16 cases (69.57%) with transverse fractures, 5 cases (21.74%) with oblique fractures, and 2 case (8.70%) with spiral fractures. Other studies also reported transverse fracture was the common fracture pattern.[9,22,23] In most cases, the injured limb (69.57%) was right-sided in our study. The average period for bone union was 10.1 weeks in our study; in most cases, 22 cases (55%) were united by 10 weeks, and the average hospital stay was 10.5 days. In our study, complications like limb length discrepancy were seen in 5 cases (21.74%), infection in 2 case (8.70%), nail protrusion in 2 case (8.70%), and malalignment in 3 cases (13.04%). Several studies found complications such as limb length discrepancy, malalignment, pain, and infection.[8,9] The functional outcome evaluated was excellent in 14 cases (60.83%), satisfactory in 7 cases (30.43%), and poor in 2 case (8.70%). In comparison with other studies, the functional outcome was excellent in 80.82% of the cases in the study conducted by Ramprakash et al, the result was excellent in 71.4% of the cases in the study conducted by Roop et al, and it was excellent in 65% of the cases in the study conducted by Moroz et al (24-26).

This study has several limitations. The small sample size of only 13 patients restricts the generalizability of the findings. The study was conducted at a single center, which may introduce selection bias and limit the applicability of the results to other settings. Additionally, the follow-up period of six months may not be sufficient to observe long-term complications and outcomes. Finally, the lack of a control group limits the ability to compare the effectiveness of TENS against other treatment methods for pediatric femoral shaft fractures. Further multi-center studies with larger sample sizes and longer follow-up periods are needed.

CONCLUSION

This prospective study demonstrates that using Titanium Elastic Nailing System (TENS) in pediatric femoral shaft fractures yields positive outcomes, with a high rate of bone union and minimal complications. Most fractures healed within 10 weeks, and most patients experienced excellent or satisfactory functional results. The findings support TENS as a viable option for treating femoral shaft fractures in children aged 4 to 14, offering benefits such as early mobilization, reduced hospital stays, and favorable recovery outcomes. This study underscores the effectiveness of TENS, aligning with existing literature and providing valuable data from Bangladesh.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Wahid AHMA, Tarafder MWH, Haque E, Rahman SMT, Noor-e-Tahrima. Functional outcome of femoral shaft fracture in pediatric patients treated by titanium elastic nailing system. Int J Res Orthop 2024;10:940-4.