

To Determine the Association Between Clinical Outcome and Complications After Closed Reduction and Internal Fixation in Paediatric Diaphyseal Femur Fractures

Arjun Jagadish Bhoomraddi¹, Jagadish V. Bhoomraddi², Mahantesh Patil³, K. Karun John⁴

¹Fellowship in Ganga Hospital, Dept. of Orthopaedics, Coimbatore, Tamil Nadu, India

²Assistant Professor, Dept. of Orthopaedics, KHPIMS, Gadag, Karnataka, India

³Professor & Head, Dept. of Orthopaedics, KHPIMS, Gadag, Karnataka, India

⁴Postgraduate Resident, Department of Orthopaedics, K H PATIL Institute of Medical Sciences, Gadag, Karnataka, India

Received: 23-04-2026 / Revised: 27-05-2026 / Accepted: 22-06-2026

Corresponding Author: Dr K. Karun John

Conflict of interest: Nil

Abstract:

Pediatric diaphyseal femur fractures pose unique management challenges due to the dynamic nature of the growing skeleton and the necessity for achieving both anatomical and functional restoration. Closed reduction and internal fixation with Titanium Elastic Nails has proven to be an effective and reliable treatment modality, offering excellent rates of bone union, minimal soft tissue disruption, and rapid functional recovery. However, the final functional and clinical outcomes are intricately linked to the occurrence and management of complications, which underscores the importance of meticulous surgical technique and individualized patient care

Keywords: Pediatric, Femur.

DOI: 10.25258/ijcpr.18.6.392

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Complications associated with Titanium Elastic Nailing, although relatively uncommon, can influence both the short-term recovery and long-term functional outcomes. These complications may range from minor issues such as local irritation and pain at the entry site to more significant problems including delayed union, malunion, limb length discrepancy, refracture after nail removal, or infection. Overgrowth of the affected limb due to hyperemia and stimulation of the growth plate is another well-documented phenomenon in pediatric femoral fractures. Conversely, growth arrest leading to limb shortening may occur in rare cases, particularly if the injury involves the proximal or distal metaphysis. Therefore, the evaluation of functional and clinical outcomes in relation to these potential complications is essential to determine the true efficacy and safety of Titanium Elastic Nailing in pediatric femoral shaft fractures.[1]

Clinical outcome assessment typically includes parameters such as pain relief, limb alignment, range of motion, muscle strength, and the ability to return to normal daily activities or sports. Radiographic evaluation focuses on fracture healing, callus formation, and restoration of anatomical alignment. Functional assessment tools such as the Flynn

criteria are commonly used to categorize results as excellent, satisfactory, or poor based on factors like limb length discrepancy, malalignment, and complications. Studies have shown that the majority of children treated with Titanium Elastic Nails achieve excellent or satisfactory outcomes when proper patient selection and surgical technique are followed. Nevertheless, understanding the pattern and predictors of complications remains vital to refining the procedure and optimizing patient outcomes.[2]

The shift toward operative fixation with Titanium Elastic Nails represents a paradigm change in the management of pediatric femoral fractures. In the past, prolonged immobilization using traction or spica casts often led to muscle wasting, joint stiffness, and psychological stress for both the child and caregivers. In contrast, the TEN system enables early mobilization, which significantly improves quality of life, facilitates schooling and social reintegration, and reduces the economic burden on families. The reduced need for extended hospitalization also decreases healthcare costs and minimizes the risk of nosocomial infections. Furthermore, early return to function promotes better psychological adjustment and physical

conditioning, both of which contribute to superior functional outcomes in the long run.[3]

Despite its widespread acceptance, continued research is necessary to better understand the association between clinical outcomes and complications in this population. Identifying factors that predispose patients to unfavorable results can guide surgeons in refining their approach to patient selection, nail diameter choice, and postoperative care. For example, maintaining an optimal nail-to-canal diameter ratio of approximately 40% has been shown to enhance stability and minimize the risk of angulation or shortening. Similarly, ensuring symmetrical insertion of nails from both ends of the metaphysis contributes to balanced load distribution and better mechanical performance. Postoperative rehabilitation protocols focusing on progressive weight-bearing and muscle strengthening are equally critical in determining final outcomes.[4]

Pediatric diaphyseal femur fractures pose unique management challenges due to the dynamic nature of the growing skeleton and the necessity for achieving both anatomical and functional restoration. Closed reduction and internal fixation with Titanium Elastic Nails has proven to be an effective and reliable treatment modality, offering excellent rates of bone union, minimal soft tissue disruption, and rapid functional recovery. However, the final functional and clinical outcomes are intricately linked to the occurrence and management of complications, which underscores the importance of meticulous surgical technique and individualized patient care. A comprehensive evaluation of outcomes and their association with complications can provide valuable insights for optimizing treatment protocols and improving the overall quality of care for children with femoral shaft fractures.[5]

Methodology

The present research was designed as an analytical cross-sectional observational study. The purpose of this design was to evaluate and analyze the clinical,

radiological, and functional outcomes of pediatric diaphyseal femoral fractures treated with Titanium Elastic Nailing System (TENS). The analytical cross-sectional nature of the study allowed for simultaneous assessment of exposure and outcome variables among participants during the defined study period. This design was chosen as it facilitated the examination of associations between fracture type, treatment method, and healing outcomes without the need for long-term follow-up beyond six months. Data collection, clinical evaluation, and radiological analysis were systematically performed according to standardized hospital protocols to ensure reliability and reproducibility.

Inclusion Criteria

1. Children and adolescents between 5 to 16 years of age.
2. Participants with closed diaphyseal fractures of the femur.
3. Fractures classified as Winquist and Hansen type 0, 1, or 2.
4. Fractures corresponding to AO classification 32A (simple) and 32B (wedge).
5. Participants and their parents/guardians who provided written informed consent to participate in the study.

Exclusion Criteria

1. Pathological fractures resulting from bone diseases or tumors.
2. Segmental fractures involving multiple diaphyseal levels.
3. Polytrauma patients with multiple skeletal or visceral injuries.

All participants fulfilling the inclusion criteria were enrolled after obtaining written informed consent from their parents or legal guardians.

Results

Table 1: Side of Injury

Side	Number of cases n (%)
Left	31 (51.7)
Right	29 (48.3)
Total	60 (100)

Anesthesia Type: General anesthesia was administered in 30 cases (50.0%), and spinal anesthesia was also used in 30 cases (50.0%). Both

anesthesia techniques were used equally among participants, showing an identical distribution.

Table 2: Anesthesia Type

Anesthesia	Number of cases n (%)
General	30 (50.0)
Spinal	30 (50.0)
Total	60 (100)

Healing Status at 4 Weeks: Early callus formation was observed in 55 cases (91.7%), while delayed healing was noted in 5 cases (8.3%). Therefore,

more than nine-tenths of patients demonstrated radiological evidence of early healing at 4 weeks.

Table 3: Healing Status at 4 Weeks

Healing status	Number of cases n (%)
Early callus formation	55 (91.7)
Delayed healing	5 (8.3)
Total	60 (100)

Healing Status at 12 Weeks: Bridging callus formation was present in 52 cases (86.7%), whereas delayed union was observed in 8 cases (13.3%). The

majority of fractures showed progressive healing by 12 weeks.

Table 4: Healing Status at 12 Weeks

Healing status	Number of cases n (%)
Bridging callus	52 (86.7)
Delayed union	8 (13.3)
Total	60 (100)

Healing Status at 24 Weeks: Complete union was achieved in 52 cases (86.7%). Union with delayed healing occurred in 8 cases (13.3%). No cases of

non-union were recorded, and the majority of fractures demonstrated radiological union by 24 weeks

Table 5: Healing Status at 24 Weeks

Healing status	Number of cases n (%)
Complete union	52 (86.7)
Union with delayed healing	8 (13.3)
Total	60 (100)

Discussion

Complication analysis demonstrated a low incidence of major complications and a moderate incidence of minor complications. Most complications in the present study were minimal angulation or minor alignment variation, while major complications such as malunion and delayed union were uncommon. The literature consistently indicates that complications

associated with elastic nailing are usually minor and technique-related. Sarkar et al. reported pain at the entry site as the most frequent complication, followed by mild angulation and superficial infection [6]. Nisar et al. also found that the majority of complications in ESIN were minor and related to nail prominence [7].

Elastic nailing avoids extensive soft tissue dissection, reducing infection risk. Govindasamy et al. reported minimal major complications and no non-union following TENS fixation [8]. Similarly, Pogorelić et al. documented a low complication rate of 8.49%, with most cases managed conservatively [9]. The minimal complication profile in TENS is attributed to preservation of the periosteum and minimal surgical exposure.

Malalignment may occur when fracture stability is insufficient or nail size is inadequate. Kayaokay and Aktuglu noted mild angulation and limb length

discrepancy in some patients but reported no functional impairment in daily activities [10]. This indicates that minor deformities in pediatric patients often remodel due to growth potential.

The relatively low rate of serious complications compared with conservative treatment has been well documented. Saseendar et al. demonstrated higher malunion and limb length discrepancy with spica casting compared with TEN fixation [11]. Elastic nailing therefore reduces complications related to prolonged immobilization, including stiffness, malalignment, and delayed rehabilitation.

Overall, the complication profile observed in the present study supports the safety of TENS. Most complications were minor, manageable, and did not significantly affect long-term function. Proper surgical technique and correct nail selection remain the most important factors in minimizing complications.

The most important objective of this study was to determine factors influencing functional outcome. Statistical analysis demonstrated a significant association between fracture type, complications, and healing progression with Flynn's outcome grading. Patients with stable fractures and early callus formation had better outcomes, while delayed healing and major complications were associated with poor outcomes.

Fracture stability is a key determinant of success. Sinha et al. emphasized that minimally comminuted mid-shaft fractures produce optimal results after TENS fixation [12]. Stable fracture patterns allow effective three-point fixation by elastic nails, maintaining alignment during healing.

Healing progression also influenced functional outcome. Early callus formation was associated with favorable results, whereas delayed union correlated with poorer outcomes. The biological explanation lies in micromotion-induced callus formation. Elastic nails stimulate secondary bone healing; when healing is delayed, mechanical stability and rehabilitation are compromised. Mishra et al. demonstrated that rapid callus formation correlates with early recovery and return to activities [13]. Complications showed the strongest association with outcome. All cases with major complications demonstrated poor functional results. This relationship is well supported in the literature. Sarkar et al. noted that technical errors such as improper nail size or insertion can lead to angulation and delayed union [6]. Kayaokay and Aktuglu also reported that angulation and limb discrepancy influence functional scores [14].

Demographic factors such as age and gender showed less influence on final outcome. Suggu et al. found no significant association between demographic variables and functional outcome [15]. This indicates that surgical factors and fracture characteristics are more important determinants than patient demographics.

Therefore, the present study demonstrates that functional recovery after TENS depends primarily on fracture stability, early healing, and absence of complications rather than patient age or gender. The findings confirm that successful outcome is achieved when appropriate fracture selection, proper surgical technique, and biological healing are maintained.

Conclusion

Overall, the Titanium Elastic Nailing System provides a safe, minimally invasive, and reliable method for treating pediatric diaphyseal femoral fractures. It allows early mobilization, stable fracture healing, and good functional recovery, making it an effective treatment modality for school-age children when performed with proper technique and follow-up.

References

1. Uddin M Minhaz, Islam Tasmia, Hossain M Sharif, Rashid M Harun Are, Bose Barshan, Rana M Sohel. Outcome of closed intramedullary fixation of femoral shaft fracture by titanium elastic nail in children. *Int J Res Orthop*. 2025;11(2):264-68.

2. Nury Jumadurdy S, Mohamed I N. Functional outcomes of femoral diaphyseal fractures using titanium elastic nail: a retrospective study. *World J Adv Res Rev*. 2024;22(1):1431-35.
3. Lu Y, et al. Elastic stable intramedullary nailing and temporary external fixation for unstable femoral shaft fractures in children aged 5–11 years. *Front Pediatr*. 2022;10:914834.
4. Liu W, et al. Elastic Stable Intramedullary Nailing Versus Plate Internal Fixation in pediatric femoral shaft fractures. *Indian J Orthop*. 2024;(in press).
5. Gupta S, Hegde J. Prospective study of management of diaphyseal fractures of femur in paediatric age group by titanium elastic nailing system. *J Med Thesis*. 2016;2:19-23.
6. Sarkar S, Bandyopadhyay R, Mukherjee A. Titanium elastic nail - Complications in the treatment of paediatric diaphyseal fracture of femur [corrected]. *Open Orthop J*. 2013;7:12-7.
7. Nisar A, Bhosale A, Madan SS, Flowers MJ, Fernandes JA, Jones S. Complications of Elastic Stable Intramedullary Nailing for treating paediatric long bone fractures. *J Orthop*. 2013 Feb 26;10(1):17-24.
8. Govindasamy R, Gnanasundaram R, Kasirajan S, Ibrahim S, Melepuram JJ. Elastic Stable Intramedullary Nailing of Femoral Shaft Fracture-Experience in 48 Children. *Arch Bone Jt Surg*. 2018 Jan;6(1):39-46.
9. Pogorelić Z, Vodopić T, Jukić M, Furlan D. Elastic Stable Intramedullary Nailing for Treatment of Pediatric Femoral Fractures; A 15-Year Single Centre Experience. *Bull Emerg Trauma*. 2019 Apr;7(2):169-175.
10. Kayaokay K, Aktuglu K. Titanium elastic nailing in pediatric femoral diaphyseal fractures in the age group of 6-15 years mid-term and long-term outcomes. *Pak J Med Sci*. 2018 Nov-Dec;34(6):1529-1533.
11. Saseendar S, Menon J, Patro DK. Treatment of femoral fractures in children: is titanium elastic nailing an improvement over hip spica casting? *J Child Orthop*. 2010 Jun;4(3):245–251.
12. Sinha SK, Kumar V, Singh A. Outcomes of fracture shaft femur in pediatric population managed at emergency. *J Clin Orthop Trauma*. 2017 Oct-Dec;8(4):313-319.
13. Mishra AK, et al. Diaphyseal femoral fractures in children treated with titanium elastic nail system. *Nepal Med Coll J*. 2013 Jun;15(2):95–97.
14. Kayaokay K, Aktuglu K. Titanium elastic nailing in pediatric femoral diaphyseal fractures in the age group of 6-15 years mid-term and long-term outcomes. *Pak J Med Sci*. 2018 Nov-Dec;34(6):1529-1533.
15. Suggu SR, Karuppanan S, Sivanandan HM, Moitra S. A Prospective Study on the Functional Outcome of Diaphyseal Fractures of

Femur Treated with TENS Nailing in Pediatric
age Group (5-15 years). J Orthop Case Rep.
2022 Sep;12(9):102-109.