SJIF Impact Factor: 6.711

WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

ISSN: 2457-0400
Volume: 9.
Issue: 5
Page N. 229-234
Year: 2025

Original Article www.wjahr.com

THE OUTCOMES OF USING FLEXIBLE NAILS TO FIX CHILDREN'S AGED FIVE-TEN WITH TIBIAL DIAPHYSIS FRACTURES

[*1]Omar Farooq Khaleel, [2]Saad Abdulsalam Fathi and [3]Mohammed Hameed Sulaiman

[1]M.B.Ch.B./F.A.B.H.S (Orthopedics), Al Salam Teaching Hospital.
[2]M.B.Ch.B./F.I.B.M.S (Orthopedics), Al Salam Teaching Hospital.
[3]M.B.Ch.B./F.A.B.H.S (Orthopedics), Al Salam Teaching Hospital.

Article Received date: 16 March 2025 **Article Revised date:** 01 April 2025 **Article Accepted date:** 22 April 2025

***Corresponding Author: Omar Farooq Khaleel**
M.B.Ch.B./F.A.B.H.S (Orthopedics), Al Salam Teaching Hospital.

ABSTRACT

Background: Tibial diaphysis fractures are common in children. It accounts for roughly 10 to 15% of pediatric fracture cases. These fractures are typically caused by non-accidental injuries, recreational/sport-related injuries, and traffic accidents. The surgical treatment of tibia fractures in children is a matter for controversy. In certain circumstances, such as failed close reduction, open fracture, fracture with neurovascular injuries, patients with polytrauma, and fracture with compartment syndrome, surgical intervention is recommended. **Objectives:** Is to evaluate the outcomes of flexible intramedullary nailing for treating tibial diaphysis fractures in children. **Methods:** The study is a prospective interventional study. Twenty patients with displaced fracture shaft of tibia fractures who treated by flexible nail at Al Salam Teaching Hospital in Mosul-Iraq between April 2023 and March 2025 are included in this study. Patients weighing more than 40 kilograms, those with vascular injuries, segmental fractures, knee or ankle fractures, and compartment syndrome in the leg were excluded from the study. The study questionnaire was divided into five parts. The first section provides demographic and trauma information of the study participants. The second part covers fractures details. The third part covers operative details. The fourth part for postoperative outcome. And the last part covers the post-operative complications of the study's patients. **Results**: The study included 20 patients, of them; the mean age of the study patients is 8.69 ± 1.13 years. The study found that the mean of callus formation was 4.5 ± 1.4 weeks, radiological union was 12.1 ± 3.2 weeks and full weight bearing was 8.0 ± 1.1 weeks. Postoperative complications It's evident that shortening of affected limb was prevalent among 12 (60%) patients, lengthening of affected limb was prevalent among no patients. Moreover; anteroposterior and lateral angulation of less than 5 ° were prevalent among 16 (80%) patients. Furthermore; rotation of less than 5 ° was prevalent among all patients. While pain at the site of fracture was present among 18 (90%) patient, but nail protrusion and skin irritation were prevalent among 15 (75%) patients and lastly limitation of knee movement was prevalent among 18 (90%) patients. **Conclusion:** Pediatric tibial diaphysis fractures can be effectively treated using elastic nails, which regulate length, angulations, and rotation while offering stability through three points of fixation per nail. Even if there were problems with elastic nails, they were all preventable and mild, requiring only minimal intervention.

KEYWORDS: Pediatrics, Fracture, Long bone, Intramedullary nail.

1- INTRODUCTION

Tibial diaphysis fractures are common in children. It accounts for roughly 10 to 15% of pediatric fracture cases. These fractures are typically caused by non-accidental injuries, recreational/sport-related injuries, and traffic accidents.[1-2]

In the majority of cases, the therapy consists mostly of close reduction and plaster application.[1-3] The surgical treatment of tibia fractures in children is a matter for controversy.[4] In certain circumstances, such as failed close reduction, open fracture, fracture with neurovascular injuries, patients with polytrauma, and fracture with compartment syndrome, surgical intervention is recommended.[5] Another indication for surgical intervention is an unstable fracture in children older than ten years.[6]

Historically, pediatric fractures have been treated non-operatively; however, this leads to prolonged immobilization and a longer hospital stay, which can be more costly than operative therapy. Thus, there has been a tendency to treat pediatric fractures surgically.[7-9] Flexible intramedullary nailing involves inserting flexible metal "nails" in an opposing pattern into the long bone fracture's medullary canal so that each one maintains three points of contact.[10] Flexible intramedullary nailing has gained popularity in the pediatric group for long-bone fractures due to its efficacy and lower risk of complications.[11] In addition to that; flexible intramedullary nails in the femur offer advantages such as closed insertion, fracture hematoma preservation, and a physeal sparing entry location.[12] The "C" shape of flexible intramedullary nails, which creates three points of fixation and functions as an internal splint, allowed for biomechanical stability.[13] Callus development is improved by the regulated motion that flexible intramedullary nails provide at the fracture site.[14]

Since its introduction, flexible nail has continued to evolve with modifications like end caps, pre-bent nails, and improved operative techniques, making it the gold standard of long bone shaft fracture management in children.[15] It is generally less invasive than plating, causing less disruption of the fracture site (the "zone of injury") and, especially when metalwork is removed, requiring only a small incision at the site of nail insertion, offering better the cosmetic outcome and shorter surgical times.[16]

Although flexible nailing in the femur has been extensively studied, little studies have been conducted on tibial fractures. This study evaluated the outcomes of flexible intramedullary nailing for treating tibial diaphysis fractures in children.

2-PATIENT AND METHODS

The study is a prospective interventional study. The parents of patients enrolled in the trial provided written consent. Twenty patients with displaced fracture shaft of tibia fractures who treated by flexible nail at Al Salam Teaching Hospital in Mosul-Iraq between April 2023 and March 2025 are included in this study. Patients weighing more than 40 kilograms, those with vascular injuries, segmental fractures, knee or ankle fractures, and compartment syndrome in the leg were excluded from the study.

Following admission, each patient underwent a clinical evaluation, any related injuries were noted, and appropriate treatment was started. The patients also provided a brief history and were given IV fluid, adequate analgesics, and temporary splintage. Antero-posterior and lateral radiographs of the leg, including knee and ankle joints, were taken before surgery. Preoperative investigations including CBC, viral screen, and blood group testing. Prior to surgery, all of the included patients putted on above-knee posterior slab and underwent a pre-anesthesia checkup.

General anesthesia was used for all surgical procedures. After being disinfected, the affected limb was draped. Wound debridement was performed if the fracture was open. By measuring the medullary canal's narrowest diameter and applying Flynn's formula, which states that nail diameter = 0.4 × medullary canal diameter, the proper nail size was established prior to surgery. The nail was manually countered into a "C" shape. To facilitate nail passage and aid in fracture reduction, the nail tips were bent to a 45° angle. About 2.5 to 3 cm distal to the proximal tibial physis, a little stab wound was made. The cortical surface of the tibia was then reached by blunt dissection. A bone awl was used to create the entry point into the medial cortex. The medial nail was inserted perpendicular to the medial cortex using an inserter. When the nail reaches the distant cortex, spin the inserter to direct it towards the medullary canal. The nail was advanced to the fracture site, followed by close reduction and distal advancement. The nail was evaluated for correct intramedullary place in both anteroposterior and lateral views. The lateral nail was inserted similarly. Both nails advance distally until the tips are near the distal tibial physis. Some of the nail was kept for proximal remove. Both nails advance distally until the tips are near the distal tibial physis. To prevent angular deformity, both nails are choosing from the same size.

Following the operation, all patients received an above-knee posterior slab for 6 weeks. Post-operative X-rays were taken, providing an anteroposterior and lateral picture of the entire operated site. Patients were observed for 2 weeks, 6 weeks, 12 weeks, and 6 months. Patients were discharged on the third post-operative day, with the exception of children with open fractures, who were discharged on the 14th post-operative day after sutures were removed.

Statistically analysis done by using the SPSS (scientific package for social sciences) version 30.0 software. Descriptive statistics, such as frequencies and percentages, were used to present categorical variables in tables and figures.

3-RESULTS

The study included 20 patients, of them; the mean age of the study patients is 8.69 ± 1.13 years. Moreover; distribution of patients' genders, side and site of fracture, mechanism of injury, pattern and type of fracture, and the presence or absence of associated injury are shown in table 3.1.

Table 3.1: Distribution of the study patients according to their basic information.

Ages	Number	Percent
Gender:		
Male	12	60 %
Female	8	40 %
Side of fracture:		
Right	13	65 %
Left	7	35 %
Site of fracture:		
-Upper	2	10 %
-Middle	7	35 %
-Lower	11	55 %
Mechanism of Injury:		
-High energy trauma	13	65 %
-Low energy trauma	7	35 %
Pattern of fracture:		
Short oblique	11	55 %
Spiral	4	20 %
Transverse	5	25 %
Type of fracture:		
Open Type I Gustilo	4	20 %
Open Type II Gustilo	1	5 %
Closed	15	75 %
Associated injury:		
Present	6*	30 %
Absent	14	70 %

*four with head injury, one fracture radius and one with fracture clavicle.

Figure 3.1 shows distribution of patient according to the duration of operation. It's evident that the main duration of the operation last 35.18 ± 7.92 minutes.

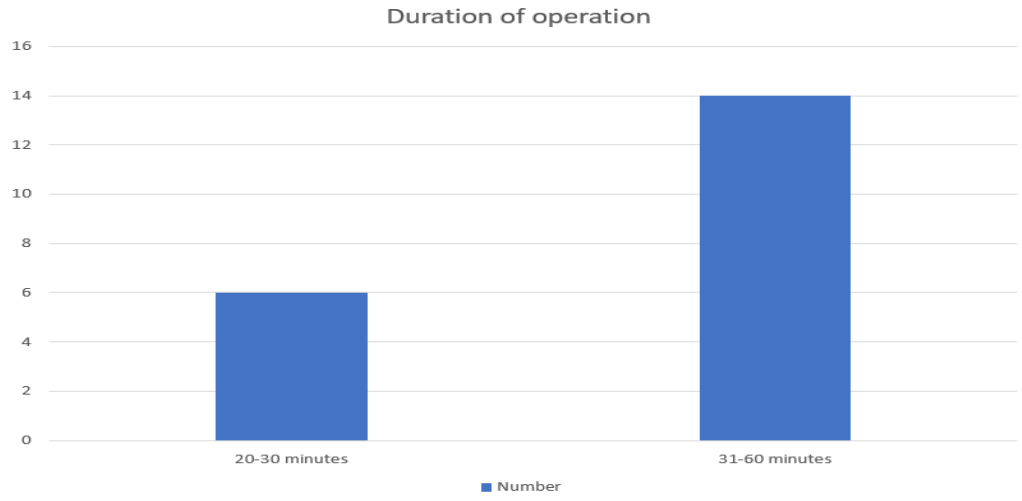

Figure 3.1: Distribution of the study patients according to their duration of operation.

Figure 3.2 illustrates distribution of the study patients according to postoperative immobilization period in weeks.

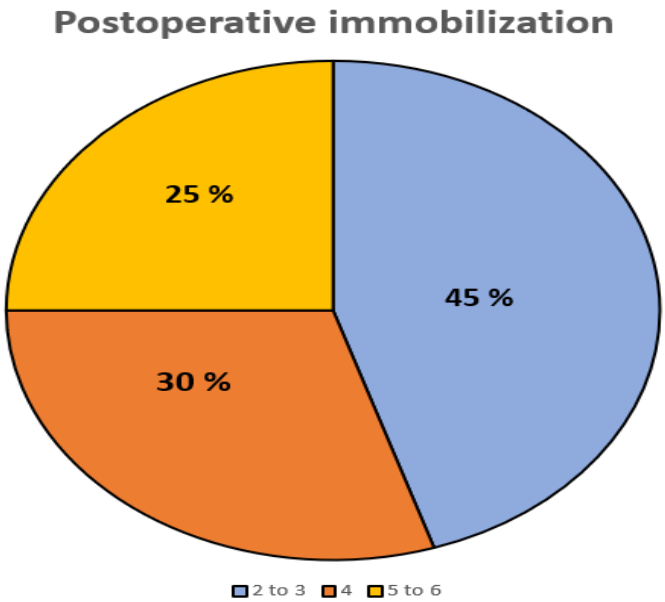

Figure 3.2: Distribution of the study patients according to their postoperative immobilization period.

Table 3.2 illustrates the study patients' mean and the standard deviation of radiological and clinical parameters.

Table 3.2: The mean and the standard deviation of radiological and clinical variables obtained from the study' patients.

Variable	Mean ± Standard deviation
Callus formation (weeks)	4.5 ± 1.4
Radiological union (weeks)	12.1 ± 3.2
Full weight bearing (weeks)	8.0 ± 1.1

Table 3.3 shows the number and the percentages of different postoperative complications facing the study patients. It's evident that shortening of affected limb was prevalent among 12 (60%) patients, lengthening of affected limb was prevalent among no patients. Moreover; anteroposterior and lateral angulation of less than 5 ° were prevalent among 16 (80%) patients. Furthermore; rotation of less than 5 ° was prevalent among all patients. While pain at the site of fracture was present among 18 (90%) patient, but nail protrusion and skin irritation were prevalent among 15 (75%) patients and lastly limitation of knee movement was prevalent among 18 (90%) patients.

Table 3.3: Postoperative complications.

Ages	Number	Percent
Shortening:		
- Absent	12	60 %
- Less than 5 mm	8	40 %
Lengthening:		
- Absent	20	100 %
- Present	0	0 %
Angulation in antero-posterior view:		
- Less than 5 °	16	80 %
- More than 5 °	4	20 %
Angulation in lateral view:		
- Less than 5 °	16	80 %
- More than 5 °	4	20 %
- **Rotation Less than 5 °:**	20	100 %
Pain at fracture site:		
- Absent	18	90 %
- Present	2	20 %
Nail protrusion and skin irritation:		
- Absent	15	75 %
- Present	5	25 %
Limitation of knee movement:		

- Absent	20	100 %
- Present	0	0 %

4- DISCUSSION

One of the most frequent fractures in children that necessitates hospitalization is a tibial fracture. Over 20% of tibia fractures necessitate hospitalization. Children's diaphyseal tibial fractures are typically treated with casting and careful reduction.[17] However, this process necessitates ongoing monitoring and extended immobilization. Re-displacement and malalignment are frequent, especially in isolated tibia fracture patients. Operative therapy is used to prevent the aforementioned issues.[18] External fixation or plate and screw implants are options for fixing unstable tibia fractures, however they come with risks of infection, overgrowth, and refracture.[19]

This study showed that the mean age of the study patient was about nine years and male gender was predominant affected by tibial fracture, comparable results obtained from Azeez O Tella et al.[20] From the other hand; most of the study patients had right side and middle site of fracture, which goes with Woo Young Choi et al demographic information of his study sample.[21] Additionally; most of the study patients presented with high energy trauma (RTA) which is comparable to Rshid Anjum et al study findings.[22]

Regarding pattern of the fracture, this study found that the majority of patients had short oblique fracture and from closed type, consistent results was shown by Božo Topalović.[23] Moreover; only 30 % of the study patients had associated other injuries, which closed to what was seen by Zenon Pogorelić et al.[24]

This study found that the mean duration of operation time is 35 minutes. Furthermore; the majority of the study patients were immobilized for 2-3 weeks, Mariwan Saleem Mohammed et al had comparable findings (38 minutes).[25]

Concerning the radiological and clinical outcomes of the study patients. The current study found that the average time for callus formation was 4.5 weeks, the average radiological union started at 12 weeks and full weight bearing occurred at 8 weeks, which are parallel to the meta-analysis conducted by Daniele Fanelli et al.[11] From the other hand, postoperative complications; the study found that the majority of patients had absent shortening or lengthening of tibia, moreover; the majority of the study patients had less than 5 ° AP and lateral angulation, less than 5 ° rotation. Comparable results obtained by Zenon Pogorelić[24] and Mariwan Saleem Mohammed et al.[24] While; postoperative pain at fracture site was present among only 10% of patients, nail protrusion and skin irritation among 25% and limitation of movement among no patients, which goes with P R Onta et al study findings.[26]

The study's findings are limited by its retrospective design, which mostly relied on patient records. Additionally, the study only included a small number of patients at a single center and did not compare elastic nail fixation to other surgical techniques for treating similar fractures.

5- CONCLUSION AND RECOMMENDATION

Pediatric tibial diaphysis fractures can be effectively treated using elastic nails, which regulate length, angulations, and rotation while offering stability through three points of fixation per nail. Even if there were problems with elastic nails, they were all preventable and mild, requiring only minimal intervention.

ACKNOWLEDGEMENT

We are grateful for the help provided by the medical team at Al Salam Teaching Hospital, as well as the careful consideration received from the Nineveh Directorate of Health. Without the help of each of these individuals, this study would not have been possible.

CONFLICT OF INTERTEST

About this study, the authors disclose no conflicts of interest.

REFERENCES

1. Weber B, Kalbitz M, Baur M, Braun CK, Zwingmann J, Pressmar J. Lower leg fractures in children and adolescents—Comparison of conservative vs. ECMES treatment. Frontiers in Pediatrics, 2021 Mar 4; 9: 597870.
2. Koivisto ST, Laaksonen T, Ahola JA, Helenius I, Stenroos A. Epidemiology and management of proximal tibia fractures in children and adolescents: a population-based study based on the Kids' Fracture Tool. Acta orthopaedica, 2022 Oct 20; 93: 826.
3. Olmedo Gárate C, Artigas Preller C. Pediatric Diaphyseal Tibia and Distal Tibia Fractures. InFoot and Ankle Disorders: A Comprehensive Approach in Pediatric and Adult Populations, 2022 Jul 10 (pp. 335-349). Cham: Springer International Publishing.
4. Ghannam MK, Al Karaki V, Medawar J, Hoyek F. Distal Tibial Metaphyseal Fractures in Children Treatment by Intrafocal Pinning: A Case Report. Int J Foot Ankle, 2021; 5: 059.
5. Jensen KO, Prediger B, Könsgen N, Teuben MP. Initial surgical management of injuries to the lower extremities in patients with multiple and/or severe injuries–A systematic review and clinical practice guideline update. European Journal of Trauma and Emergency Surgery, 2024 Nov 5; 1-22.
6. Chakraborty S, Salama K, Lee LH. Tibia fractures in children: a single-centre 11-year retrospective study for evaluating the management and outcomes in an acute general orthopaedic hospital. Cureus, 2023 Mar 21; 15(3).

7. Murphy D, Raza M, Monsell F, Gelfer Y. Modern management of paediatric tibial shaft fractures: an evidence-based update. European Journal of Orthopaedic Surgery & Traumatology, 2021 Jul; 31(5): 901-9.
8. Sleem B, Khalek JA, Hajj A. Pediatric Tibial Shaft Fractures: A Comprehensive Review.
9. Strain RG. Fracture of the tibial diaphysis: epidemiology, management and outcomes (Doctoral dissertation, University of Leeds).
10. Hunt A, Judkins N, Biggs A, Sedgwick P, Hing CB, Yeo A. The use of flexible nails in the treatment of paediatric long bone fractures: Experience at a level one paediatric trauma centre, a cohort study. Journal of Clinical Orthopaedics and Trauma, 2024 Feb 1; 49: 102355.
11. Fanelli D, Perrotta G, Stocco F, Agilinko J, Castioni D, Mercurio M, Gasparini G, Barker S. Outcomes and complications following flexible intramedullary nailing for the treatment of tibial fractures in children: a meta-analysis. Archives of Orthopaedic and Trauma Surgery, 2022 Jul 1; 1-4.
12. Kumar O, Kumar V, Choudhary NK, Kumar R, Kumar A. Clinical Study of Ender's nails fixation in tibial shaft fracture in Paediatric patient.
13. Bekos A, Sioutis S, Kostroglou A, Saranteas T, Mavrogenis AF. The history of intramedullary nailing. International orthopaedics, 2021 May; 45: 1355-61.
14. Rizvi SH, Chang SH. Effects of composite intramedullary nail on cell phenotype-related activities and callus growth during the healing of tibial bone fractures. Composites Part B: Engineering, 2022 Jan 1; 228: 109429.
15. Hunt A, Judkins N, Biggs A, Sedgwick P, Hing CB, Yeo A. The use of flexible nails in the treatment of paediatric long bone fractures: Experience at a level one paediatric trauma centre, a cohort study. Journal of Clinical Orthopaedics and Trauma, 2024 Feb 1; 49: 102355.
16. Torode IV. Consist of avulsion injuries or'pull-off'fractures, typically of the anterior superior iliac spine Include iliac wing fractures Simple ring fractures (stable)(eg rami. Postgraduate Paediatric Orthopaedics: The Candidate's Guide to the FRCS (Tr&Orth) Examination, 2024 Jan 24; 92.
17. Martus JE. Operative fixation versus cast immobilization: tibial shaft fractures in adolescents. Journal of Pediatric Orthopaedics, 2021 Jul 1; 41: S33-8.
18. English W, Pearce P. Orthopaedic Trauma. InHamilton Bailey's Emergency Surgery 2025 (pp. 341-379). CRC Press.
19. Toro-Aguilera Á, Zuriarrain SW, Masdeu MG, Sayol RR, Billi AM, Carrera I, de Caso J. Risk factors for infection in fixation of distal tibia fractures. Injury, 2021 Jul 1; 52: S104-8.
20. Tella AO, Aldhilan MM. The outcome of titanium elastic nail fixation of pediatric long bone fractures–a retrospective analysis. Orthopedic Reviews, 2024 Oct 8; 16: 118449.
21. Choi WY, Park MS, Lee KM, Choi KJ, Jung HS, Sung KH. Leg length discrepancy, overgrowth, and associated risk factors after a pediatric tibial shaft fracture. Journal of Orthopaedics and Traumatology, 2021 Dec; 22: 1-7.
22. Anjum R, Raina P, Singh S. Fixation of Paediatric tibial fractures with TENS; A prospective study. Int J Adv Res, 2015; 3: 251 4.
23. Topalović B, Mratinković I, Radulović B, Bjelobrk M, Milankov V. Treatment dynamics of tibial shaft fractures in children: The role of gender, age and treatment method. Medicinski pregled, 2024; 77(5-6): 165-70.
24. Pogorelić Z, Vodopić T, Jukić M, Furlan D. Elastic stable intramedullary nailing for treatment of pediatric femoral fractures; a 15-year single centre experience. Bulletin of Emergency & Trauma, 2019 Apr; 7(2): 169.
25. Mohammed MS, Yousif OS, Barawi OA. Results of Flexible Nails for Fixation of Tibial Diaphysis Fractures in Children. Medical Journal of Babylon, 2021 Apr 1; 18(2): 117-20.
26. Onta PR, Thapa P, Sapkota K, Ranjeet N, Kishore A, Gupta M. Outcome of diaphyseal fracture of tibia treated with flexible intramedullary nailing in pediatrics age group; A prospective study. Am. J. Public Health, 2015; 3: 65-8.