Zagazig University Medical Journal
www.zumj.journals.ekb.eg

https://doi.org/10.21608/zumj.2022.145600.2588 Volume 30, Issue 2, March 2024

Manuscript ID ZUMJ-2206-2588
DOI 10.21608/ZUMJ.2022.145600.2588

ORIGINAL ARTICLE

Elastic Intramedullary Nailing for Management of Both Bone Leg Fracture in Skeletally Immature Patients

Ali Tawfeek Al-alfy[1], Islam Sameeh Abdelfattah[1], Ibrahim Suliman Alajil[2*], Ehab Mohamed Shehata[1]

[1] Department of Orthopedic, Faculty of medicine, Zagazig University, Egypt.

[2] Department of Orthopedic, Faculty of medicine, Tripoli University, Libya.

***Corresponding author:**
Ibrahim Suliman Alajil
Department of Orthopedic, Faculty of medicine, Tripoli University, Libya

E-mail:
Ibrahimalagail95@gmail.com

Submit Date 2022-06-23
Accept Date 2022-07-17

ABSTRACT

Background: Tibial shaft fracture is the third most common skeletally immature long bone fracture after the femur and forearm, representing 15% of all skeletally immature bone fractures. The purpose of this study was to improve outcomes of management of tibial shaft fractures in skeletally immature patients 15 years of age or less by elastic intramedullary nailing. **Methods**: This study was a prospective study conducted at Orthopedic Surgery Department, Faculty of Medicine, Zagazig University in the period from October 2021 to April 2022. Twenty-four patients were included in this study, all of them suffering from displaced diaphyseal fractures either closed or open fracture Gustilo & Anderson type I & II of the bone leg in skeletally immature patients aged less than 15 years. **Results**: All patients in this study achieved full union by the end of follow-up, with mean union time 10 weeks, 50% of the fractures united completely within 7 to 9 weeks, while 41.7% united from 10 to 12 weeks. Only 2 patients 8.3% had delayed union. No unsatisfactory outcome reported in this study, all patients were either excellent 79.2% or satisfactory in 20.8%. According to Flynn criteria. Regarding the complications, the incidence of complications in our study was 25%, distributed as follow 8.3% of patients suffering from entery site irritation, other 8.3% patients presented with delayed union. **Conclusions**: Elastic intramedullary nailing is an effective and safe treatment method for tibial shaft fractures in skeletally immature patients, even those with open fractures.

Keywords: Tibial shaft fractures; Elastic Intramedullary Nailing; Fracture Both Bone Leg.

INTRODUCTION

Tibial shaft fracture is the third most common skeletally immature long bone fracture after the femur and forearm, accounting for 15% of all skeletally immature bone fractures [1]. Tibial fractures are often successfully treated with closed techniques and cast immobilization. Although operative treatment is uncommon in skeletally immature tibial fractures, operative indications include open fractures, polytrauma, concomitant neurovascular injuries, and unstable fractures [2]. Casting or flexible nailing can be used to treat younger skeletally immature patients with displaced tibial shaft fractures, depending on the occurrence of neurovascular damage, polytrauma, or accompanying ipsilateral limb fractures. Flexible nailing is thought to be safe, repeatable, and less intrusive [3].

In a prior study, 24 percent of patients suffered loss of accepted alignment (5° to 15° varus or recurvatum) with non-operative treatment, compared to 2% of patients who were treated with flexible nails [4].

In contrast to adult traumas, rigid intramedullary nailing may not be possible in skeletally immature tibial fractures due to restrictions such as the proximal tibia physeal plate and small canal diameter in these patients. Although external fixation may be an option in skeletally immature tibial fractures with soft tissue injuries or open wounds, various problems are widely known, including pin tract infections, mal-unions, delayed unions, non-unions, and re-fractures [2]. So, the purpose of this study was to improve outcomes of management of tibial shaft fractures in skeletally immature patients 15 years of age or less by elastic intramedullary nailing.

METHODS

This study was a prospective study conducted on 24 patients (16 males, 8 females) ages (5-14) years, most of patients were aged above 10 years, followed by patients aged from 8 to 10 years. The right side was the most affected side by 58.3%. While road traffic accidents (RTA) were the most common cause of fractures by 62.5%, sport injuries in five patients (20.8%), fall in four patients (16.7%). Most of patients were 42.A.1, followed by 42.A.2 or 42.A.3 according to AO/OTA classification. Also, most of patients (66.7%) had closed fractures, and 25% of them were Gustillo type I. Most of fractures occurred in the middle third of the leg. 29.2% had associated fractures and 70.8% had no associated injuries, only 7 patients had associated injuries; two had supracondylar fractures both treated by close reduction and pinning, another two had distal radius fractures one treated conservatively and the other need K-wire fixation, one patient had both bone forearm fracture treated conservatively, and two patients had fracture clavicle treated by figure of eight bandage.

Approval taking Institutional Review Board (IRB# 8056-14-9-2021) Patients and/or their careers were asked for approval as well as informed written consent. This investigation was carried out in accordance with the World Medical Association's code of ethics (Declaration of Helsinki) for human studies.

Inclusion criteria: Patients with tibial shaft fractures in skeletally immature patients, closed fractures with associated fractures requiring operative treatment, Open fractures, (Gustilo and Anderson type I & II) which might have been difficult to cast and maintain adequate reduction, male or female patients less than 15 years.

Exclusion criteria: Age more than 15 years old, patient with pathological fractures, patients with metabolic disease affecting the bone, patients unfit for surgical intervention.

Pre-operative:

All patients underwent Full history taking, Proper clinical examination, Standard plain radiograph X-rays anteroposterior & lateral X-rays of the affected limb (including the knee & ankle joints) was taken. Fracture patterns were classified according to (AO-OTA) classifications, and open fractures were classified according to Gustilo and Anderson classification. Laboratory investigations included Complete blood count (CBC), Liver and kidney functions, (RBS), viral markers, Prothrombin Time (PT), Partial Thromboplastin Time (PTT), International Normalized Ratio (INR). Patients were put under observation in the hospital till time of surgery with management of any associated injuries and medical conditions. The fractured leg was splinted by above knee plaster slab. Analgesic and anti-edematous measures were prescribed. Antibiotics were prescribed preoperatively at the time of induction and for 48 hours postoperatively for closed fractures and seven days for open fractures at least.

Surgical technique:

All patients were treated by elastic intramedullary nailing inserted under image intensifier control, using two pre-bent titanium nails inserted in antegrade fashion. The procedure was performed under general or spinal anaesthesia, with a tourniquet, and under perfect aseptic circumstances. The patient was placed on a radiolucent surgical table in a supine posture. An image intensifier was rotated to acquire antero-posterior and lateral images of the entire tibia from the knee to the ankle joint. As an operation field, the entire leg, including the knee and ankle joints, was prepped. External manipulation was used until enough reduction was attained and fluoroscopy confirmed it. The individual nail diameter was determined by computation [nail diameter = minimum canal diameter x (0.3- 0.4)]. To avoid varus or valgus angulation, both nails were always the same size [5].

Each nail was hand-bent to a 30° angle at the same place, ensuring that the tip is in the same plane as the plane generated by bending and the peak of curvature is at the level of the fracture site. The curve of both nails required to be equal to accomplish optimal reduction, stability, and alignment of the fracture. A 2cm skin incision was created proximate to the desired bone entrance hole. Begin on the anterolateral or anteromedial side. The following safeguards were taken in relation to the access point:

In antegrade nailing, the entry point should be 2–4 cm distal to the proximal tibial physeal or proximal to the distal tibial physis in retrograde nailing. The anterolateral and anteromedial entry sites should be located on the same level. The entry hole should be somewhat larger than the nail's diameter. A bone awl was used to make the holes. To accommodate the orientation of the developing nail, it was guided diagonally at a 45° angle towards the distant cortex. The nail was held in a cannulated T-handle, with the horizontal bar of the T-handle and the curved tip of the nail aligned in the same plane (allowing identification of the curved tip as it travelled through the medullary canal) (Fig 1).

The nail was inserted into the entry hole, bent tip downwards. Once in the medullary canal, it was rotated to point in the direction of the nail passage. By moving the T-handle back and forth, the nail was forced down the canal. The nail was softly pounded across the fracture site using a mallet. To anchor into the cancellous bone, the nail was advanced towards the metaphysis (Fig 2). The second nail was advanced using the same rotating movements and light taps. However, it was never rotated on its own axis through a full

360° to avoid winding itself around the first nail. Both nails were progressed and impacted just proximal to the distal tibial epiphyseal plate at their final distal positions (Fig 3). The image intensifier confirmed the fracture reduction and nail position. The patient's heel was impacted if the fracture was distracted. Both nails' ends were trimmed, leaving about 1-1.5 cm of each nail outside the entry hole. Wound irrigation and closure were carried out in layers. A sterile bandage and a plaster cast below the knee were inserted.

Post-operative follows up: long leg splints were worn for four weeks following surgery. When there was radiographic evidence of a bridging callus and a pain-free limb, partial weight bearing was initiated 6 weeks later. Frontal and sagittal plane angulations were measured using anteroposterior and lateral plain radiographs taken immediately after surgery, as well as at two, six, and twelve weeks and at the final follow-ups. There was a 3- to 6-month follow-up period, and the examination comprised an assessment of knee range of motion (ROM), limb rotation and alignment, and symptoms of nail entry site irritation. After the fractures were clinically and radiographically healed, the nails were regularly removed during a second surgical surgery. Flynn's criteria were used to evaluate clinical results [6].

Statistical analysis:

All data was gathered, collated, and statistically examined (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.). The mean SD & (range) were used to convey quantitative data, and & were used to express qualitative data (percentage). When appropriate, percentages of categorical variables were compared using the Chi-square test or the Fisher exact test. All the tests were two-sided. P-value 0.05 was deemed statistically significant (S), p-value 0.001 was deemed statistically highly significant (HS), and p-value 0.05 was deemed statistically insignificant (NS).

RESULTS

The mean age was 9.91±2.7 years and the range were five –fourteen years old. patients included in this study were males (66.7%). While females represented 33.3% five out of six females injured due to RTA, and the far most of them had 42A2 fracture according to AO/OTA classification. That 58.3% of patients need more than 2 days to be operated on. While 10 patients operated within the first 48 hours, 60% of them were operated on the same day of admission. With mean time 2.91 ± 1.58 days (table 1). Time of complete bone union ranged from 7-18 with a mean of 10±2.4 weeks. 12 patients (50%) bone union occurred at 7 to 9 weeks, while (41.7%) of patient’s bone union occurred at 10 to 12 weeks and 8.3% of patients bone union occurred after 12 weeks (table 2).

Radiological follow up for studied group defined that, almost of patients 91.7% achieved well bone union. But 8.3% of patients represented radiological delayed union (table 3).

Table 4; showed that 6 patients (25.0%) had complications, distributed as follows 8.3% of patients suffering from entery site irritation, other 8.3% patients presented with delayed union. otherwise, one patient presented with lower limb discrepancy "lengthening", and one patient with mal union and one patient with acquired post-operative infection.

Table (1): Distribution of the studied patients according to age and sex.

Variable	**The studied group (24)** **mean ±** SD. **(Range)**	
Mean Age (years): **(Range)**	9.92±2.7 (5-14)	
Variable	**NO (24)**	**%**
Age grouping **5 to7 Years** **8 to 10 years** **>10 Years**	 5 7 12	 20.8% 29.2% 50%
Sex **Male** **Female**	 16 8	 66.7% 33.3%
Time before Surgery **Less than 48 hours** **More than 48 hours**	 10 14	 41.7% 58.3%

Table (2): Time to complete bone union among the studied group.

Variable	The studied group (24)	
Time of complete bone union(weeks): **mean** ± SD. **(Range)**	 10±2.4 (7-18)	
Variable	**n. (24)**	**%**
Union time **7 to 9 weeks** **10 to 12 weeks** **> 12 weeks**	 12 10 2	 50% 41.7% 8.3%

Table (3): Radiological follow up for the studied group.

Variable	The studied group (24)	
Radiological follow up. Well, union. **Delayed union**	 22 2	 91.7% 8.3%

Table (4): post-operative complications among the studied group

Variable	NO (12)	%
Complications **No** **Yes**	 18 6	 75.0% 25.0%
***Sort of complications** **Lower Limb discrepancy "lengthening"** **Entery site irritation** **Infection** **Delayed union** **Mal union** **Non-Union**	 1 2 1 2 1 0	 4.2% 8.3% 4.2% 8.3% 4.2% 0.0

*Patient may have more than complication

Figure (1): The entry point and the first nail insertion.

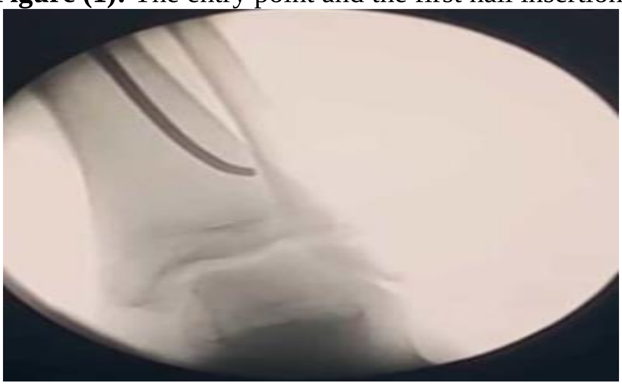

Figure (2): The first nail advanced distal.

Figure (3): The two nails advanced at distal tibial end.

DISCUSSION

The study was conducted on 24 patients suffering from displaced diaphyseal fractures and open fracture Gustilo & Anderson type I & II of both bone leg in skeletally immature patients, their ages ranged from 5-14 with a mean of 9.92±2.7 years. 12 patients (50%) were older than 10 years, while 29.2% of patients were between 8 to 10 years and 20.8 % between 5 to7 years which treated with intramedullary elastic nail at Zagazig University Hospital (ZUH), Egypt. Eladawy et al. [7] studied children's age varied from 4 years to 15 years with a mean age± SD of (9.63 ± 1.88) years. El Hayek et al. [8] reported that the mean age of their patients was 11 years and 8 months and had only one patient under the age of six who sustained polytrauma with a floating knee. This also coincides with Berger et al. [9] who reported the use of (E.I.N) in children up to 15 years old.

In this study, many patients included were males 16 (66.7%). while females represented 8 (33.3%). The predominance of male may be because the increased risk of boys for all fractures due to higher risk plays activities being more acceptable for boys. Furthermore, they are more exposed to the outside environment, such as riding a vehicle and participating in sports, than their female counterparts. Other studies have found similar conclusions of male preponderance [7, 10, 12]. These results showed that the time before surgery ranged from 1-6 with a mean of 2.9±1.6 day. 10 patients operated within the first 48 hours, and 58.3% of patients operated after 2 days. A Previous study by Eladawy et al. [7] showed that the time before surgery ranged from 1-8 with a mean of 4±2 days.

In this study time to union was assessed radiologically and clinically, time of complete bone union ranged from 7-18 with a mean of 10±2.4 weeks. 12 patients (50%) bone union occurred at 7 to 9 weeks, while (41.7%) of patient's bone union occurred at 10 to 12 weeks and 8.3 % of patients bone union occurred after 12 weeks. These findings were in consistent with Ahmad et al. [13] who reported that the mean duration to union was 10.02 weeks (range of 8–17 weeks), and that union was obtained in less than 10 weeks in 32 patients (84.21 percent), in 10-14 weeks in 05 patients (13.15 percent), and in 14 weeks in 1 patient (2.63 percent) who was an open fracture in a 12 year old boy. The average time for union in the Heo et al. [2] trial was 10.5 weeks. The mean time to union in Uluda and Tosun [14] was 10.85 weeks with a range of 6–20 weeks. Union time in paediatric tibial shaft fractures varies with age and is longer in the advanced age group as well as in open fractures. In Gordon and O'Donnell's [15] research of 50 tibial fractures, union was completed in 8-10 weeks with a mean age of 11.7 years, although delayed union was noted in patients with a mean age of 14.

In Eladawy et al. [7] study the mean time to union was 8.90 ± 1.29 weeks, which was comparable to other studies using the same method of fixation. In (6) work it was 10 weeks (ranged from 7 to18 weeks), and in Sankar et al. [16] the mean time to union was 11 weeks (range 6–18 weeks), with closed fractures healing more rapidly than open fractures. Our findings were consistent with those of Qidwai [17], who reported a mean duration to union of 9.4 weeks in a study of 84 tibial fractures (including thirty open fractures) in children (mean age, 10.2 years) treated with Kirschner wires. The time to union reported by Srivastava et al. [18] was 20.7 weeks (range 8–42 weeks), which was longer than the previous investigations. The union, on the other hand, was described as "painless complete weight bearing with radiographic indications of tricortical callous development." This contrasts with previous research that only looked at radiographic union.

Radiological follow up for studied group defined that, almost of patients 91.7% achieved well bone union. But only 2 patients (8.3%) represented radiological delayed union. This were in agreement with Eladawy et al. [7]. who reported (95.8%) of their patients were united and only one case had delayed union. Gavaskar and Singh [12] did not encounter any delayed union, nonunion, malunion or nail migration. Complications were defined as follows using modified criteria published by Flynn et al. [6]: (1) delayed union: union that takes more than 24 weeks, (2) nonunion: union that takes more than 9 months or requires an extra procedure, (3) malunion: malalignment of more than 10 degrees in any plane, and (4) LLD: shortening or overgrowth of more than 20 mm. The following are the major and minor complications: (1) minor complications include delayed union, skin-tissue irritation from nails, transient superficial infection, and any other complication that did not interfere with walking; and (2) major complications include nonunion, deep infection, LLD, and any other complication that was not classified as minor [14]. Our study showed only 6 patients (25.0%) had complications, distributed as follow 2 (8.3%) of patients suffering from enter site irritation, other 2 (8.3%) patients presented with delayed union. Otherwise, one patient presented with lower limb discrepancy "lengthening", mal union. Only 1 patient acquired post-operative infection, and finally no cases encountered non-union complication. This agreed with Pandya and Edmonds [19] and Eladawy et al. [7] who revealed that the most complications were infection and delay union that have minimal incidence (12.5%). Also there were consistency with Gavaskar and Singh [12]. Who documented two cases developed skin irritation at entry site by prominent nail end and subsided after nail removal, one case (3.33%) had infection, and Limb length discrepancy: -Limb shortening was noted in 2 cases (7%).

CONCLUSIONS

Elastic intramedullary nailing is an effective and safe treatment method for tibial shaft fractures in skeletally immature patients, even those with open fractures. As it has smaller incisions, shorter surgical times, early motion, rapid healing, easy hardware removal, low infection rates and shorter hospital stay.

Conflict(s) of interest: None

Financial Disclosures: None

REFERENCES

1- **Prasad VD, Sangeet G, Venkatadass K, Rajasekaran S.** Ender's nailing of displaced tibia shaft fractures in children-A nine-year experience. Injury, 2021; 52(4), 837-43.

2- **Heo J, Oh CW, Park KH, Kim JW, Kim HJ et al.,** Elastic nailing of tibia shaft fractures in young children up to 10 years of age. Injury. 2016; 47(4), 832-836.

3- **Abdelbaset A, Fawaz K.** Treatment of tibial fractures in children by flexible intramedullary nails. Egypt Orthop J. 2018; Vol. 54 (2):85-92.

4- **Stenroos A, Puhakka J, Nietosvaara Y, Kosola J.** Treatment of Closed Tibia Shaft Fractures in Children: A Systematic Review and Meta-Analysis. Eur J Pediatr Surg. 2019; 30(6):483-9.

5- **Chen YN, Lee PY, Chang CW, Ho YH, Peng YT et al.** Biomechanical investigation of titanium elastic nail prebending for treating diaphyseal long bone fractures. Australarian physical & engineering science in medicine. 2019; 40(1): 115-26.

6- **Flynn JM, Hresko T, Reynolds RA, Blasier RD et al.,** Titanium elastic nails for pediatric femur fractures: a multicenter study of early results with analysis of complications. J Pediatr Orthop. 2001; 21:4–8.

7- **Eladawy AM, Megahed RM, Yosef AE, Salama MI.** Management of Open Tibial Shaft Fractures in Children with Intramedullary Elastic Nail. Egy Jl Hos Med. 2021; 84(1), 1984-8.

8- **El Hayek T, Griffet J, Leroux J, Boudjouraf N, Abou-Daher A.** Elastic stable intramedullary nailing of tibial shaft fractures in children. 2011;297–304.

9- **Berger P, De Graaf J, Leemans R. The** use of elastic intramedullary nailing in the stabilisation of paediatric fractures. Injury. 2005; 36(10), 1217-20.

10- **Pennock AT, Bastrom TP, Upasani VV.** Elastic Intramedullary Nailing Versus Open Reduction Internal Fixation of Pediatric Tibial Shaft Fractures. J Pediatr orthop. 2017; 37(7): 403-8.

12- **Gavaskar B, Singh R.** Management of diaphyseal long bone fractures in paediatric age group by tens. Int J Orthop.2020; 6(1), 460-3.

13- **Ahmad I, Akhtar M, Qureshi SA, Nadeem A, Ilahi D et al.,** Efficacy of Titanium Elastic Intramedullary Nailing System (TENS) in the treatment of Paediatric Tibial Shaft Fractures. Pakis J Med & Health Sci. 2021; 15(1), 137-40.

14- **Uludağ A, Tosun HB.** Treatment of unstable pediatric tibial shaft fractures with titanium elastic nails. Medicina, 2019;55(6), 266.

15- **Gordon JE, O'Donnell JC.** Tibia fractures: what should be fixed? J Pediatr Orthop. 2012; 32, S52-S61.

16- **Sankar WN, Jones KJ, David Horn B, Wells L.** Titanium elastic nails for pediatric tibial shaft fractures. J Child Orthop. 2007; 1(5), 281-6.

17- **Qidwai SA.** Intramedullary Kirschner wiring for tibia fractures in children. J Pediatr Orthop. 2001; 21(3), 294-7.

18- **Srivastava AK, Mehlman CT, Wall EJ, Do TT**. Elastic stable intramedullary nailing of tibial shaft fractures in children. J Pediatr Orthop. 2008; 28(2), 152-8.

19- **Pandya NK, Edmonds EW.** Immediate intramedullary flexible nailing of open pediatric tibial shaft fractures. J Pediatr Orthop. 2012; 32(8), 770-6.

To cite:

Alajil, I., Elalfy, A., Abdelfattah, I., Shehata, E. Elastic Intramedullary Nailing for Management of Both Bone Leg Fracture in Skeletally Immature Patients. *Zagazig University Medical Journal*, 2024; (486-492): -. doi: 10.21608/zumj.2022.145600.2588