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Original Article

PRIMARY DYNAMIZATION OF INTERLOCKING INTRAMEDULLARY NAIL IN TREATMENT OF TIBIAL SHAFT FRACTURES IN ADULTS

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Abstract

Purpose: *Static intramedullary interlocking nail (IMILN) is common method of treatment fracture of shaft of tibia in adults. However, sometimes it is associated with delayed union or non-union. The aim of this work was to evaluate outcomes of primary dynamization of interlocking intramedullary nail without proximal locking screws in treatment of mid and distal shaft tibia fractures in adults.* ***Methods:*** *It is a prospective case series study which included 20 skeletally mature patients presented by mid shaft or distal shaft tibial fractures, AO types A, B1, and B2, and Gustilo-Anderson grades 1 or 2. All patients were treated by IMILN without proximal locking screws (primary dynamization). Functional assessment was done by Bostman score and VAS score for pain at last follow up. Radiographic assessment was done by X-ray A/P and lateral views of whole leg including knee and ankle joints and mRUST score at last follow up.* ***Results:*** *Mean age for participants was 33.25 ± 8.26 years. Mean operative time was (66.25± 4.83) min. Mean final Bostman score was 28.05±2.33. Mean final VAS was 0.75±1.45. Mean time of radiographic union was 14±1.86 weeks.* ***Conclusions:*** *Primary dynamization of IMILN without proximal locking screws technique showed short operation times, fast radiographic union, good functional outcomes, and a trend towards pain relief. These findings are supporting the use of primary dynamization for enhancing fracture healing and functional recovery.*

Keywords: *Primary Dynamization, Interlocking Intramedullary Nail, Tibial Shaft Fractures.*

1. Introduction

Tibial shaft fracture in adults has increased due to a large number of road traffic accidents happening in the modern days. The patient presents by: severe leg pain, inability to bear weight, deformity, and should be examined for deformity, angulation, malrotation, contusions, blisters, open wounds, and neurovascular status [1]. The aim of fracture management is to establish union as soon as possible and to start early weight bearing [2]. There are deferent treatment choices for tibial shaft fracture in adults: conservative treatment, open reduction and fixation by plates and screws, closed reduction with intramedullary interlocking nail (IMILN) [3]. Non-surgical treatment increases the risk of delayed recovery, stiffness of ankle and knee, malunion, and nonunion. Loss of periosteum and hematoma and increased risk of infection result from open reduction of the fracture. Meanwhile, IMILN surgery minimizes all of these risks, therefore becoming a preferred method of treatment nowadays [1]. Tibial IMILN has both static and dynamic locking options, the common method of treatment in adults is static IMILN. Although, it is sometimes associated with delayed union or non-union, static IMILN has produced improved outcomes for tibia shaft fractures in a few studies in adults [3, 4]. Primary dynamization has increased the rate of union and allow early weight-bearing. The purpose of this research is to demonstrate the radiological and functional results of primary dynamization without proximal locking screws in treatment of mid-shaft and distal shaft tibial fractures in adults.

2. Patients and Methods

This prospective case series study was carried out on 20 skeletally mature patients, presented by mid shaft or distal shaft tibial fractures, admitted to department of orthopaedics and traumatology, Sohag university hospitals, in the period from September 2023 to September 2024, after approval of the ethical committee. An informed written consent was obtained from all patients before participation in the study. The inclusion criteria were patients with mid or distal tibial shaft fractures AO types; A, B1, or B2, Gustilo-Anderson classification grades 1 or 2. The exclusion criteria were; proximal shaft fractures, patients have mid or distal s tibial haft fractures of AO types; B3 or C [5], Gustilo-Anderson classification grade 3, osteoporotic bone in old age, skeletal immature patients <18 years , sclerotic bone, and bone deformity. All patients were subjected to history taking and clinical examination. The patient was clinically evaluated by: General assessment by ATLS protocol and Radiologically by X-ray; anteroposterior (A/P) and lateral views of whole leg including knee and ankle joints. All patients operated within the first two weeks after trauma. All patients were treated by closed reduction and dynamized IMILN (insertion of distal locking screws only without proximal ones). Several factors we applied in our study to prevent rotation in absence of proximal locking screws included; we used the largest possible nail diameter, proximal nail angle (Herzog's angle), early weight-bearing, and shape of fracture. Also, we included mid or distal shaft tibia fractures which are far from proximal end of nail.

2.1. *Operative technique*

Antibiotics were injected prophylactically 30 minutes before the skin incision. The patient is in a supine position with a thigh rest for the contralateral thigh and a roller rest for the affected side knee. A tourniquet was applied to the operated side. The patient was evaluated clinically by aligning the patella, iliac crest, and second ray of the foot in a line, as well as under the C-Arm in antero-posterior (AP) and lateral views. Strict aseptic conditions were followed for preparing and draping the skin. A midline incision that extends from the patella's distal pole to 3 cm distally. Patellar tendon splitting technique is used. Care is taken to avoid causing any damage to the knee joint other than the anterior fat pad. The C-arm provides direction for the curved awl entry point. Guidewire insertion start point is anterior to articular plateau and medial to lateral tibial spine. Reduction was done by longitudinal traction through the foot and correct translation and angulation of the fracture. Anteroposterior and lateral views were used to center the ball tip guidewire, which was inserted through the fracture site up to 1 cm from the ankle joint line. Reaming the tibial canal in 0.5-mm increments, beginning with a reamer that is smaller than the canal's measured diameter. A ruler is used to measure length under C-Arm. For more stability we use the largest possible nail diameter. The nail is placed in the canal and fastened to the jig. The guide wire is taken out. The C-Arm checks the nail's proximal end, which is maintained between 0.5 and 2.0 cm from the subchondral bone. Two distal locking screws were inserted from medial to lateral. No proximal locking screws were inserted, fig. (1). Reduction and rotation were checked under C-Arm.

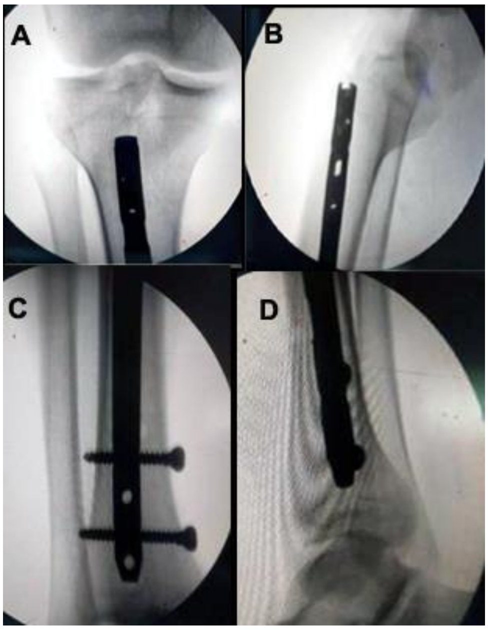

Figure (1) Intraoperative C-arm images of intramedullary interlocking nail fixation of fracture shaft tibia, (**a.** & **b.**) No proximal screws inserted in AP and lateral views. (**c.** & **d.**) Two distal locking inserted in AP and lateral views.

The incision and sites of screw insertion were closed with sutures. Dressing and bandage were applied with raising the legs and moving the ankle and toes actively. All patients received IV antibiotics for three days, followed by two weeks of oral treatment. Anti-inflammatory, anti-edematous drugs, calcium, and vitamin D supplements were given to all patients. All patients in our study had been treated by; elastic stockings, physical calf compression, and early mobilization. From the first post-operative day, patients were urged to perform range-of-motion exercises for their ankles, calves, and knees. On the second postoperative day, they were encouraged to full weight bear. Dressing was done one-week postoperatively. And stitches were removed two weeks postoperative. The patients were evaluated Clinically by; Bostman score [6] and Visual Analogue Scale (VAS) [7]. Radiographical evaluation was done by; X-ray to evaluate fracture union, and stability of fixation by the mRUST score [8]. Follow-up intervals were: two, four, eight weeks and three, six, and twelve months.

2.2. *Statistical analysis*

The data were tested for normality using the Kolmogorov-Smirnov test and Shapiro test. Categorical variables were described by number and percent (N, %), where continuous variables described by mean ± (SD) or median (interquartile range "Q1-Q3"). Descriptive statistics were applied to summarize the demographic characteristics and other key variables. This included calculating frequencies and percentages for categorical variables such as gender, fracture type, and treatment outcomes. To analyze the associations between different categorical variables, the Chi-square test was conducted. A P-value less than 0.05 was regarded as statistically significant.

3. Results

This study included twenty patients with a mean age 33.25 ± 8.26 years (range 18 - 48 years). 85% of patients were men. The left side was involved in 45% of patients. The mean operative time was 66.25±4.83 minutes (range 61.25 - 70 minutes). 10.5 ± 1.1 months was the average follow-up duration. Around two thirds of the patients were non-smokers, tab. (1). At the last follow-up, the mean Bostman score was (28.05 ± 2.33 (range, 26-29.75) points. The final VAS was (0.75 ±1.45). There is no limitation of knee and ankle ROM, tab. (2). The healing rate was100%. The mean duration of solid radiographic union, fig. (2) was 14 ± 1.86 (range 11 - 17) weeks with mean mRUST score was 14.25 ± 1.89, tab. (3). One patient experienced superficial infection at distal locking screws site which improved later on with daily dressing and antibiotics.

Table (1) Demographics data of the study

Character	Value	Character	Value
Age (years)		**Level of fracture**	
▪ ***Min. - Max.***	18 – 48	▪ ***Distal 1/3***	4(20%)
▪ ***Mean±SD***	33.25±8.26	▪ ***Mid shaft***	16(80%)
Sex		**AO**	
▪ ***Male***	17(85%)	▪ ***A1***	5(25%)
▪ ***Female***	3(15%)	▪ ***A2***	7(35%)
Mechanism of injury		▪ ***A3***	8(40%)
▪ ***MCA***	19(95%)	**Type**	
▪ ***FFH***	1(5%)	▪ ***Simple***	7(35%)
Side		▪ ***Open***	13(65%)
▪ ***Right***	11(55%)	**Operation time (min)**	
▪ ***Left***	9(45%)	▪ ***Min. - Max.***	60 – 75
Smoking		▪ ***Mean±SD***	66.25±4.83
▪ ***No***	13(65%)	▪ ***Median(Q1-Q3)***	65(61.25-70)
▪ ***Yes***	7(35%)	**Follow up duration (months)**	
Fibular fracture		▪ ***Min. - Max.***	9:12
▪ ***Absent***	4(20%)	▪ ***Mean±SD***	10.5±1.1
▪ ***Present***	16(80%)	▪ ***Median(Q1-Q3)***	10 (9-11)

Table (2) Functional outcomes of study group

Characteristic	Value	Characteristic	Value
Range of motion of knee		▪ ***Mean + SD***	0.75 ± 1.45
▪ ***Full***	20 (100%)	▪ ***Median (Q1 – Q3)***	0 (0 – 1)
Range of motion of ankle		**Bostman score**	

▪ ***Full***	20 (100%)	▪ ***Min - Max***	21 – 30
VAS		▪ ***Mean + SD***	28.05 ± 2.33
▪ ***Min - Max***	0 - 5	▪ ***Median (Q1 – Q3)***	29 (26 – 29.75)

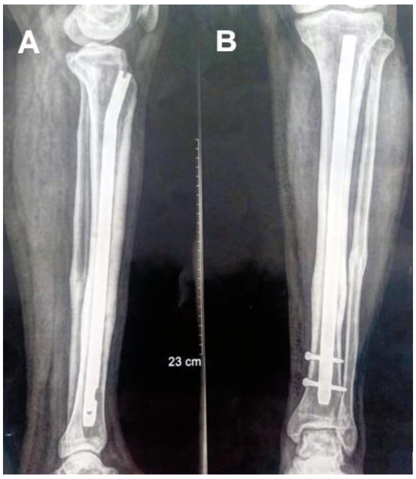

Figure (2) **a.** AP and **b.** Lateral X-ray 3 months postoperative of fracture distal shaft tibia fixed by primary dynamized IMILN showing solid union.

Table (3) Radiographic outcomes of study group

Character	Value	Character	Value
Time of radiographic Union (weeks)		**mRUST score**	
▪ ***Min - Max***	11 -17	▪ ***Min - Max***	12 – 16
▪ ***Mean + SD***	14 + 1.86	▪ ***Mean + SD***	14.25 + 1.89
▪ ***Median (Q1 – Q3)***	14 (12.5 – 15.5)	▪ ***Median (Q1 – Q3)***	15 (12 – 16)

4. Discussion

A number of fixation techniques are available for tibial shaft fracture. Intramedullary nails have shown promise in enabling earlier weight bearing and attaining satisfactory union rates, alignment, decrease reoperations, and infection rates [9]. It has been noted that dynamic nailing promotes bone healing by lowering the interlocking tibial nailing system's maximum tensile stresses. At the fracture site, dynamic fixation enhances the contact area between bone fragments and allows for interfragmentary motion. With the right axial loading, finite element biomechanical calculations have shown a significantly higher osteogenic response, which leads to earlier and stronger callus formation and eventual fracture bridging, since callus formation requires only a tiny amount of relative deformation [10]. The current study presented outcomes of primary dynamization of interlocking intramedullary nailing without proximal locking screws for the treatment of mid-shaft and distal shaft tibia fractures. Of the 20 patients in our study, three were females and 17 were males. This study found a preponderance of male involvement, which can be explained by the fact that men engage in more outdoor activities and perform greater labor than women. In a study by Hernández-Vaquero et al. [11], similar male participation was observed. This also agrees with Somani et al. [12] who found male predominance. In our study, the dynamic nailing had short operation time. This finding aligns with the proposed advantages of dynamization, which may simplify the surgical procedure and reduce operative time [13]. The principles of stability in our study to prevent rotation included; using of the largest nail we could use, superior nail angle (Herzog's bend), early weight-bearing, and fracture configuration. Inclusion criteria included mid or distal shaft tibia fractures and we chose not to insert proximal locking screws which far from fracture site. This finding is consistent with the proposed benefits of dynamization encouraging early weight-bearing which allows controlled axial compression at the fracture site, promoting callus formation and earlier union [11,14]. The time to radiographic union in our investigation was significantly short with the dynamization technique 14 ± 1.86 weeks, further supporting the potential advantages of dynamization in enhancing fracture healing. This supports the idea that dynamization promotes the formation of good callus, as suggested by Hernández-Vaquero et al. (11). Moreover, their finding that the dynamization group exhibited a faster time to union agrees with the results of our study [11]. Similar findings showing quicker union in dynamic groups have also been published by another study by Josh Vaughn et al. [15]. After analyzing 35 cases of non-union and delayed union of tibial fractures treated with nail dynamization, they discovered that in 53% of cases, dynamization was effective in encouraging union. Hernández-Vaquero et al. similarly reported similar outcomes of improved union with dynamization, although their findings had no statistical significance [11]. In a comparative investigation involving 60 patients with tibial diaphyseal fractures, Somani et al. [12] demonstrated that dynamic IMN assembly is safe for treating type 1 open or closed tibial fractures with simple or restricted comminution fracture patterns. His research revealed findings that were comparable to those of a meta-analysis by Loh et al. [13], it found that primary dynamic IMN fixation had fewer problems and quicker bone union. In our study, functional outcomes, as assessed by the Bostman score and the Visual Analog Scale (VAS) for pain, were significantly good. However, the mRUST mean was 1.89 ± 14.25. This finding is in line with previous studies that reported improved functional outcomes and reduced pain levels with dynamization [16]. However, the dynamic nailing technique showed a trend towards improved pain relief, with a high percentage of patients reporting no pain or mild pain. This finding is consistent with the proposed benefits of dynamization in reducing pain and improving functional outcomes [17]. Loh et al. [17] reported that, there was no apparent variance in malrotation between the two groups ($p = 0.59$), non-union ($p = 0.91$), delayed union ($p = 0.88$) and malunion ($p = 0.38$) [17]. Somani et al. [12] reported that, in comparison to the static group, the dynamic group had fewer biological problems, and the findings were statistically significant. Regardless of this positive result, not all fracture types may benefit from dynamic nailing. It has been proposed that the best nailing techniques for tibial diaphyseal fractures with restricted comminution are dynamic nailing systems (AO types A, B1, and B2, or Gustilo-Anderson types 1 and 2 fractures), and may result in malunion in tibial fractures that are extremely comminuted (AO types B3, C or D fractures and Gustilo-Anderson type 3 fractures). Highly comminuted fractures are often statically fixed to leverage on increased stability and thus reducing risk of malrotation [17]. Several limitations should be acknowledged in our study including; the sample size of the study was relatively small, lack of comparison with standard static intramedullary interlocking nail, the study did not assess long-term outcomes beyond the follow-up duration, leaving the potential for late complications or changes in functional status unaddressed, the study was conducted at a single center, which may introduce potential selection bias or variations in surgical techniques and postoperative protocols, and the study did not assess patient-reported outcomes or quality of life measures.

5. Conclusion

Primary dynamization of interlocking intramedullary nailing for the treatment of mid-shaft and distal shaft tibia fractures in adults has several advantages; in the form of significant short operation times, faster radiographic union, better functional outcomes, and a trend towards improved pain relief. These findings are supporting the use of primary dynamization for enhancing fracture healing and functional recovery.

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