SJIF Impact Factor: 5.464

WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

ISSN: 2457-0400
Volume: 7.
Issue: 7
Page N. 101-107
Year: 2023

Original Article www.wjahr.com

THE EARLY FUNCTIONAL OUTCOMES OF INTRAMEDULLARY NAILING IN MANAGEMENT OF CLOSED UNSTABLE SEGMENTAL AND COMMINUTED DIAPHYSEAL TIBIAL SHAFT FRACTURE IN PATIENTS MORE THAN 20 YEARS OLD

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Received date: 15 May 2023 **Revised date:** 05 June 2023 **Accepted date:** 25 June 2023

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ABSTRACT

Background: two or more distinctive fracture lines separating an interposed cortical segment excluding butterfly fragmentation define segmental tibia fractures. They are often resulted from high-energy and sometimes by low-energy traumas as twisting. These fractures treated by different modalities reamed intramedullary nail has get acceptance but challenging procedure. **Aim of the study:** To evaluate the early functional outcome of intramedullary tibial nailing in the treatment of closed unstable segmental and comminuted diaphyseal tibial shaft fracture in patients more than 20 years old regarding post-operative pain, mobilization, infection rate and union rate. **Patients and Methods:** This study is a case series interventional prospective study which done in Mosul Teaching Hospital; it started from the November 2021 to February 2023 in Mosul city. It included 40 patients more than 20 years old with closed unstable segmental and comminuted diaphyseal tibial shaft fracture which treated by reamed Intramedullary Nail. The patient's conditions assessed clinically as, well as, radiologically for fracture union and complications rate evaluated via Johner and Wruhs criteria. **Results:** Of the 40 patients, 34(85.0%) were male and 6(15.0%) were female and mean age was 32.65 years. Segmented type of fracture was found in 22(55.0%) of the patients in comparison to comminuted type which found in 18(45.0%) patients. The mechanisms of injury were distributed as RTA in 22(55.0%), FFH in 15(37.5%), and sport in three (7.5%). The mean time for the operation was 109.05 min, 30.0% were ≤90 min. and 70.0% were >90 min. The mean duration period of fracture union was 22.91 weeks; 60.0% were ≤20 weeks while 40.0%>20 week. Only four (10%) patients developed infection postoperatively; one (2.5%) patient had superficial infection at entry site and three (7.5%) patients had deep infection. Knee joint pain found in 11(27.5%) of patients at 3 months while at the 6 months only 5(12.5%) still had the pain. Delayed union found in only one patient representing 2.5% of the study sample. Postoperatively excellent activity found in 16(40.0%), good activity found in 13(32.5%) of the study sample. **Conclusion:** The reamed intramedullary nailing after proper resuscitation and stabilization method can result in excellent alignment as; well as, union with minimal morbidity and low infection rate.

KEYWORDS: Closed Unstable Segmental Fracture of tibia, Locked Intramedullary Nailing.

INTRODUCTION

Segmental tibia fractures (STF; AO 42-C2) are defined by two or more distinct fracture lines separating an interposed cortical segment(s) excluding butterfly fragmentation. Comminution may be present at both fracture sites, and the size of the middle or centerpiece might range from three to 20 cm,[1] they are often resulted from high-energy and some by low-energy traumas as twisting. STFs are often part of multiple injuries; nearly 50% of them are open and account for 6.5–8% of tibia fractures. Unfortunately, little attention paid to STFs despite the plethora of literature on tibia fracture.[2] Approximately 1% to 2% of entire fractures seen by an orthopedic surgeon are segmental tibial

fractures, 10.3 cases per 100,000 persons reported each year. Men experience more occurrence than women do There is evidence to support the idea that segmental tibial shaft fractures have become less common over time. According to research by Court-Brown et al, the prevalence of adult tibial shaft fractures decreased generally from 27 per 100,000 in 1990, to 14 per 100,000 in 2008.[3] This tendency mostly related to increased traffic safety. According to a 2017 extensive study that included information from the National Trauma Data Bank, the annual incidence was 16.9 per 100,000 people.[4] In management, the most important factor in reducing the rate of infection is the early administration of antibiotics. A debridement at bedside and temporary splinting essentially applied. Closed-reduction and non-operative treatment in a long cast is acceptable for fractures in <5 degrees of varus-valgus, <10 degrees in anterior-posterior angulation, >50% cortical apposition, less than 1-cm shortening and <10 degrees of rotational mal-alignment after reduction.[5] Operative Treatment External Fixation Considered a treatment of choice in polytrauma instances or where there has been a major soft tissue compromise and damage-control orthopedics is required.[6] Intramedullary Nailing (IMN) for operative fixation, this is the preferred course of action. When comparing outcomes of IMN with external fixation, IMN is associated with decreased mal-alignment and compared to closed treatment, IMN is associated with decreased union time and time to weight bearing. Percutaneous Plating-Shaft this method is often use in the distal tibia or proximal-third fractures that are too proximal or distal for intramedullary nailing. Conventionally, tibial shaft fractures treated with traction, casting, functional bracing, external fixation, plating, and intramedullary nailing.[7] The treatment of choice for isolated, displaced closed tibia fractures has recently migrated to intramedullary nailing because of high rates of union and low rates of mal-union. Despite this shift, closed treatment remains a potentially viable option. Patients was placed in above knee long casts and after three to five weeks, changed to functional braces In Sarmiento's 1989 series of 780 tibial fractures, the nonunion rate was 2.5%, shortening of < 10mm occurred in 90% of patients, and an acceptable angular deformity of < 10 degrees was generally attained.[8] The treatment of tibial shaft fractures with intramedullary nail fixation can result in positive outcomes and repeatable outcomes. Various studies have revealed varying intramedullary tibial nailing union rates. With modern implants and proper surgical methods, union rates of >90% are expected.[9] When intramedullary nail fixation fails to repair a tibial shaft fracture, exchange reamed nailing techniques are usually effective.[10]

PATIENTS AND METHOD

The study is a case series interventional prospective study carried out in orthopedic unit in Mosul teaching hospital from November 2021 to February 2023 in Mosul city. Forty patients more than 20 years old with closed unstable segmental and comminuted diaphyseal tibial shaft fracture with or without fibula fracture included in this study, 34 were male and six were female according to inclusion and exclusion criteria presented to the casualty unit. Patients' ages below 20 years old and patients with open stable and unstable or closed stable tibial shaft fracture were exclude from the study. Athrough history and physical examination performed and investigations carried out. Verbal and written consents taken from each patient and before participate in the study. All patients were sent for pre-operative investigations including complete blood count, viral screen test (HIV, Hepatitis B virus, Hepatitis C virus, and Covid-19), and the patients were operated under spinal or general anesthesia. Prophylactic antibiotic injection was used for all patients with use of 3rd generation cephalosporine (ceftrixon vial 1g twice daily IV) with respect to any associated drug allergy in every patient before the anesthesia within 1 hour. For patient who had allergy to cephalosporine group they received aminoglycosides (Gentamicin injection 3-5 mg/kg/ day) instead. Final assessment in this study was conducted at 6 months using the Johner and Wruh˝s criteria, taking into consideration as, well as, subjective symptoms of gait, pain, deformity, range of motion of knee, ankle joint, shortening, and healing rate (Table 1).

Table (1): Johner and Wruhs Criteria for Final Assessment of Functional Outcome of Intramedullary Nail in Diaphyseal Tibial Shaft Fracture.[11]

	Excellent (left = right)	Good	Fair	Poor
Non-union, osteomyelitis, amputation	None	None	None	Yes
Neurovascular disturbances	None	Minimal	Moderate	Severe
Deformity				
Varus/valgus	None	2-5°	6-10°	>10°
Anteversion/recurvation	0-5°	6-10°	11-20°	>20°
Rotation	0-5°	6-10°	11-20°	>20°
Shortening	0-5 mm	6-10 mm	11-20 mm	>20 mm
Mobility				
Knee	Normal	>80%	>75%	<75%
Ankle	Normal	>75%	>50%	<50%
Subtalar joint	>75%	>50%	<50%	
Pain	None	Occasional	Moderate	Severe
Gait	None	Normal	Insignificant limp	Significant limp
Strenuous activities	Possible	Limited	Severely limited	Impossible

Data analyzed using statistical package for social science (SPSS) version 19-computer software. The study approved by the scientific council of orthopedic surgery of the Arab board for medical specializations and permission obtained from directorate of the health of Ninevah (DOH). In the operative theater preparation of C-arm and orthopedic table done and the patient was positioned supine on a radiolucent adjustable "A" frame, the injured leg was placed with the knee bent 90 degrees and the leg draped loose Figure (1), from the other side, intraoperative fluoroscopy introduced. It must be possible to get a radiographic image of the tibia with true anteroposterior and lateral views of the knee, tibial shaft, and ankle. Over the skin stretching from the inferior pole of the patella's center to the tibial tuberosity, a vertical incision for dividing the patellar tendon measuring about 5 cm long was performed Figure (2).

Fig. (1): Knee bent at 90 degrees and the leg draped free.

Fig. (2): Longitudinal incision.

The proximal tibial cortex curvedly breached with the curved bone awl Figure (3), the awl placed parallel to the tibial crest. The starting position can be verified using image intensification; just medial to the lateral spine of tibia must be the starting place Figure (4). A T-handled reamer with a distal anterior curve putted into the tibia following the insertion of the awl Figure (5).The distal reamer tip directed anteriorly to keep the reamer in the canal while the reamer aligned with the crest of the tibia. A guide wire of ball tip then placed into the tibial diaphysis after the reamer has been removed Figure (6).

Fig. (3)

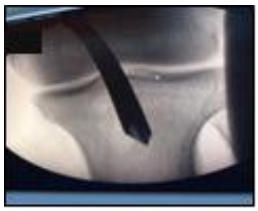


Fig. (4)

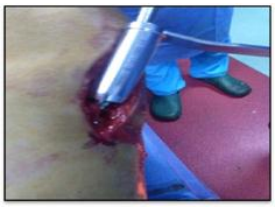


Fig. (5)

Fig. (6)

Fig. (3): The awl is parallel to tibial crest. Fig. (4): Confirmation of starting point. Fig. (5): T- handled reamer. Fig. (6): A ball tip guide wire is inserted.

The tibia aligned using the proper manual traction and manipulation so that the guide wire can pass through the fracture site and into the distal tibia. To keep the tibia properly aligned when reaming, care made to place the ball tip into the center of the plafond on both the anteroposterior and lateral fluoroscopic views Figure (7). The next step is sequential reaming in increase of 0.5 mm, and over reaming by 1–1.5 mm is likely necessary. Preoperative templating may be done from radiographs to ensure that the appropriate nail size is present in the operating room but the definitive nail length is measured from the guide wire Figure (8), the nail put into the tibia while mounted on a handler Figure (9). After the nail has been placed, a fluoroscopic examination of the fracture's general alignment and the nail's position should be performed Figure (10).

Fig. (7)

Fig. (8)

Fig. (7): The ball tip into the center of the plafond. Fig. (8): Nail length measured from guide wire.

The distal cross screws inserted by hand with an image intensifier Figure (11), or with frame. Distal screws inserted first, and subsequently the distal fragment reduced to the proximal fragment if the fracture site is distracted. The proximal cross screw locking jig used to implant one or two proximal cross screws through percutaneous incisions Figure (12 a. b).

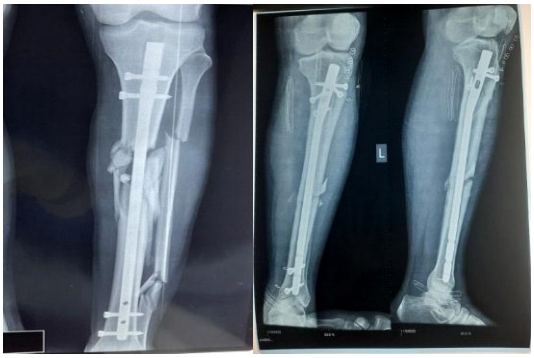




Fig. (9): Fig. (10): Fig. (11): Fig. (12 a,b):

Fig. (9): Introduction of tibial nail. Fig. (10): Fracture reduction check up by fluoroscopy. Fig. (11): Insertion of distal screws (free hand technique). Fig. (12 a, b): Proximal screw locking jig.

As soon as the patient wakes up from anesthesia, active mobilization of the knees, ankles, and toes begins. All of the patients in the present study allowed standing without bearing any weight on the first day postoperatively. Sutures removed at two weeks postoperative day. Depending on sort of fracture, the rigidity of the fixation, and associated injuries, partial weight bearing with crutches or a walker started. Further follow up was done at six weeks, three months and six months postoperatively, each patient was assessed clinically, and radiografically according to the standard Performa, check X-rays taken and patient assessed clinically for fracture union Figure (13 a, b).



a. b.

Fig. (13 a b): Radiological assessment during the follow up.

Data were analyzed using statistical package for social science (SPSS) version 19-computer software. The numerical data expressed in mean and standard deviation while the nominal data expressed in frequencies and proportions. Chi-square test used to compare between proportions. Fissure Exact test was used instead of Chi square when the expected value for any cell <5. P value ≤ 0.05 considered statistically significant.

RESULTS

The present study included 40 patients closed unstable segmental and comminuted diaphyseal tibial shaft fracture in patients more than 20 years old, the mean age was 32.65±6.72 years, the sample included 34(85.0%) males and 6(15.0%) females. Segmented type of fracture was found in 22(55.0%) of the patients while comminuted type found in 18(45.0%). The mechanisms of injury among the present study were distributed as RTA in 22(55.0%), FFH in 15(37.5%), and sport in 3(7.5%) (Table2).

Table (2): The socio-demographic characteristics of the study sample.

Sociodemographic characteristics			
Age/ years	**Mean±SD**	**32.65±6.72**	
Study parameters		**No.**	**%**
Gender	**Males**	34	85.0
	Females	6	15.0
Type of fracture	**Segmented**	22	55.0
	Comminuted	18	45.0
Mechanism of injury	**RTA**	22	55.0
	FFH	15	37.5
	Sport	3	7.5

The operative time and time of fracture to union were demonstrated in (Table 3), and showed that the mean time for the operation was 109.05±17.86 min. with 12(30.0%) were ≤90 min. and 20(70.0%) were >90 min.; The mean duration period of fracture union was 22.91±4.03 weeks; 24(60.0%) were ≤20 weeks while 16(40.0%) >20 weeks.

Table (3): The operation time and time of fracture to union.

Operational time characteristics			
Operation time (min.)	**Mean±SD**	**109.05±17.86**	
	≤90/ No. (%)	12	30.0%
	>90/ No. (%)	28	70.0%
	p-value*	0.011	
Duration period of fracture union			
Time to union (weeks)	**Mean±SD**	22.91±4.03	
	≤20/ No. (%)	24	60.0%
	>20/ No. (%)	16	40.0%
*Chi square test			

Post-operative complications were demonstrated in (Table 4), only 4 patients developed infection postoperatively; 1(2.5%) patient had superficial infection at entry site which was treated by daily dressing and oral antibiotics for one week and, 3(7.5%) patients had deep infection which treated by wound debridement and IV antibiotics and the difference between the two infections was statistically insignificant. Knee joint pain was found in 11(27.5%) of patients at 3 months while at the 6 months only 5(12.5%) still had the pain; the difference was statistically insignificant. Delayed union was found in only one patient (2.5%) of the study sample treated with Nail dynamization.

Table (4): Post-operative Complications.

Operational time characteristics		**No.**	**%**
Infection	**Superficial**	1	2.5
	Deep	3	7.5
Anterior knee pain	**3 months**	11	27.5
	6 months	5	12.5
Knee range of motion	**≥80%**	38	95.0
	<80%	2	5.0
Delayed union		1	2.5

Johner and Wruhs method which was used to determine if the patients postoperatively could return to previous functional activities or not, was demonstrated in (Table 5), and revealed that 16(40.0%) of the patients had excellent activity result which was significantly differed from good activity that found in 13(32.5%) of the study sample.

Table (5): Post-operative Activities.

	Returned No. (%)	**Not returned No. (%)**	**Total No. (%)**
Excellent	16(40.0)	0(0.0)	16(40.0)
Good	13(32.5)	5(12.5)	18(45.0)
Fair	0(0.0)	6(15.0)	6(15.0)
Poor	0(0.0)	0(0.0)	0(0.0)
Total	29(72.5)	11(27.5)	40(100.00)

DISCUSSION

Due to their extensive tissue damage, and higher incidence of sequelae, segmental fractures of the tibia pose a challenge to orthopedic surgeons who treat them. Since high-energy trauma, modes of injury are frequently associated with severe type of soft tissue abnormalities. Recently the treatment of choice for isolated unstable closed tibia fractures has been IMN which has shown high rates of union and low rates of mal-union or rotational mal-alignment.[12] The mean age of cases in the present study was 32.65±6.72 years, which was parallel to the results of Madadi *et al.*,[13] in which, mean age at admission was 31.3±12 years. But lower than that found in a study conducted by Milner *et al.*,[14] in which 164 patients who evaluated were at an average of 36 years. The present study sample included 34(85.0%) male and 6(15.0%) female. This male predominance was found also in Madadi *et al.*,[13] in which male gender represented 89.9% of the study sample compared to 10.1% of female gender. Moreover, Khan *et al.*,[15] study found that out of the 81 their patients, 64(79%) were males. The major mechanism of injury among the current study sample were RTA which found in 22(55.0%), followed by FFH in 15(37.5%), and sport in three (12.5%); Khairnar *et al.*,[16] study found that 54(90.0%) of tibia fracture was because of road traffic accident and six (10.0%) was due to FFH. In study of Radhakrishna *et al.*,[17] the road traffic accident was found in 12(86.7%) of the sample. This goes with study conducted by Bonnevialle *et al.*,[18] on 38 patients, 25(65.0%) were motor vehicle accidents, 8(22.0%) were fall from height and five (13%) were due to sports. The mean time for the operation in the present study was 109.05±17.86 min.; 12(30.0%) of the operation were done in ≤90 min. while 20(70.0%) were done in >90 min.; This time was slightly longer than that in a study conducted by Yu *et al.*,[19] which was 91.9 min;. In Abdul Khaleque *et al.*,[20] study, the mean operating time in this series was 65 minutes (range 50 to 140)this may be due to more experience with IM system by them .The present study revealed that mean duration period of fracture union was 22.91±4.03 weeks; 60.0% were ≤20 weeks while 40.0%>20 weeks .

In the study conducted by Burç *et al.*,[21] the union achieved in all the patients within a mean of 18.2 weeks (range 8 to 52 weeks). Four patients required dynamization because of delayed union and grafting performed in one. Sarmiento and Latta study.[22] found that the healing occurred at a median of 15.2 weeks with the longest healing time was 30 weeks. Post-operative complications assessed in the current study, found that only four patients developed infection postoperatively; one (2.5%) patient had superficial infection and, three (7.5%) patients had deep infection. Intramedullary nail placement carries an intrinsic risk of infection.[23,24] In Abdul Khaleque *et al.*,[20] study, superficial wound infection at the site of incision was found in three (10.0%) cases out of 30 studied cases. Furthermore, the study conducted by Smet *et al.*,[25] reported that the superficial infection rate found in 3.5 %. Two cases had deep infection in this series. It is likely that in these injuries plating and intra-medullary nailing leads to marked vascular damage to bone leading to more chances of infection. The most common complication 1 year after treating a tibia shaft fracture with an IMN is anterior knee pain, which reported in up to 40 % of patients in the Song *et al.*, study.[26] In the present study, Anterior knee joint pain was found in 11(27.5%) of patients at 3 months while at the 6 months only 5(12.5%) still had the pain; Connelly *et al.*,[27] found that 22 % of patients had persistent anterior knee pain 22 years after surgery. Katsoulis *et al.*,[28] reviewed 11 retrospective studies and 9 prospective studies to assess the incidence and predictors of anterior knee pain after tibia nail implantation for a tibia shaft fracture. A total 1460 patients evaluated and the mean incidence of anterior knee pain was 47.4 % ranging from 10.0 % to 86.0 %. Eight researches mentioned that following the nail removal, knee pain disappeared. The results of this analysis revealed that a transtendinous way and a prominent nail more closely related to anterior knee pain. LeFaivre *et al.*[29] examined 56 individuals treated for IMN and found that 15 (26.7%) denied having any knee pain, while 41 (73.2%) had at least moderate knee discomfort. It is interesting to note that 25 of the 41 individuals with knee discomfort said the pain did not interfere with their daily activities. In this study only one patient had delayed union, delayed union was not directly addressed in some studies.[22,23,29] While Giannoudis *et al.*[30] observed greater rates of delayed union in segmental (20 out of 27), which was probably due to the higher frequency of vascular complications in the segmental fractures. In the current study, Johner and Wruhs method which was used to determine if the patients postoperatively could return to previous functional activities or not, revealed that excellent activity found in 16(40.0%) of the patients and good activity that found in 13(32.5%). Fair activity was found in six (15.0%), no poor activity reported in this study. Burç *et al.*,[21] study reported that the functional results were excellent in 45 patients (61.6%), and good in 28 patients (38.4%) according to the Johner-Wrush criteria. Moreover, Khairnar *et al.*,[16] study found that 91.67% of the studied patients have got excellent, 3.33% good and 1.67% poor results.

CONCLUSION

The reamed intramedullary nailing after proper resuscitation and stabilization method can end result in excellent alignment as, well as, union with minimal morbidity and low infection rate in treatment of Closed Unstable Segmented and Comminuted Diaphyseal Tibial Shaft Fracture in patients more than 20 years old.

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