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Management of Metaphyseal Tibial Fractures by Expert Tibial Nail System

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ABSTRACT

Background: Metaphyseal tibial fractures contain distal and proximal metaphyseal fractures which account for (3-11%) and (5-11%) of total tibial fractures, respectively. Numerous treatment options exist for treating metaphyseal tibial fractures. **Objectives:** The aim of the current work was to assess the clinical and radiological functional outcomes of expert tibial intramedullary nail in treatment of metaphyseal tibial fractures in adult.

Patients and Methods: This prospective study included a total of 12 patients who had metaphyseal tibial fractures, attending at Zagazig University Hospital and Damietta Specialized Hospital. Patients were operated by closed reduction and internal fixation with expert interlocking tibial nail and followed up for average 6 months from November 2019 to December 2020. **Results:** All patients underwent full history taking, Clinical examination and Radiographic views were taken for other skeletal injuries if suspected. 2 patients (16.7%) has proximal tibial fracture, 1 (8.3%) of them had excellent final result and 1 (8.3%) had good final result. 2 patients (16.7%) had segmental tibial fracture,1(8.3%) of them had excellent final result and 1 (8.3%) had fair final result. 8 (66.7%) patients had distal tibial fractures, 6 (50%) had excellent final result, 1 (8.3%) had good final result,1 (8.3%) had poor final result.

Conclusion: It could be concluded that intramedullary fixation with expert interlocking tibial nail is a safe and effective method for the treatment of metaphyseal tibial fractures. Multiple reduction aids as percutaneous clamps, blocking screws/wires help in obtaining and maintaining reduction. The nail design allows the distal or proximal segment to be controlled through placement of multiple locking screws within a small distance from the articular surface. The alignment can be well maintained despite the short metaphyseal segment. Expert nail showed excellent and good results in more than 83% in this study.

Keywords: Anteroposterior, Expert Tibial Nail, Intramedullary, Minimally Invasive Plate Osteosynthesis, Total Knee Arthroplasty

INTRODUCTION

Rising incidence of high velocity trauma due to motor vehicle accidents usually results in fractures of long bones. The tibia is the most commonly fractured long bone in the body due to its location, structural anatomy and sparse anteromedial soft tissue coverage [1].

Tendency towards operative management of tibial fractures is in vogue to reduce the complications associated with conservative treatment. Various operative methods like open reduction and plating, intramedullary nailing and external fixation have their own indications, advantages and disadvantages [2,3,4].

Intramedullary nailing (IMN) has numerous advantages for fracture fixation, including its potential for minimally invasive exposure, biologically friendly implant insertion, longer implant to span more complex fractures and load sharing fixation to allow earlier weight bearing. The major advancement in intramedullary nailing of metaphyseal tibial fractures was the introduction of modern implants like Expert Tibial Nail System (ETNS) [5].

The Expert Tibial Nail System (ETNS) was introduced worldwide in 2005. In addition to the standard static and dynamic locking options, the (ETNS) has multi-directional locking options in the distal and proximal part of the nail which enable the surgeons to use it in management of metaphyseal tibial fractures with less complications related to ORIF by plate and screws like soft tissue damage , wound infection and delayed weight bearing it also overcomes the malreduction complications related to conventional intramedullary nails when used in metaphyseal tibial fractures as procurvatum and flexion deformity which occur when used in proximal metaphyseal fractures [6,7].

The aim of the current work was to assess the clinical and radiological functional outcomes of expert tibial intramedullary nail in treatment of metaphyseal tibial fractures in adult.

PATIENTS AND METHODS

This prospective study included a total of 12 patients (8 males and 4 females) aged from 18- 60 years who had metaphyseal tibial fractures, attending at Zagazig University Hospital and Damietta Specialized Hospital. Patients were operated by closed reduction and internal fixation with expert interlocking tibial nail and followed up for average 6 months from November 2019 to December 2020.

Ethical Consideration:

An approval of the study was obtained from Zagazig University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the operation. This work has been carried out in accordance with The Code of

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Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion criteria: Extra articular metaphyseal tibial fractures. Closed fractures. Open fractures: Gustilo grade I & II.

Exclusion criteria:

Age < 18 or > 60 years. Intra-articular extension. Open fractures: Gustilo type III. Pathological fractures. Pre-existing tibial shaft deformity. Knee stiffness with knee flexion < 90°.

All patients underwent full history taking, clinical examination included primary survey according to Advanced Trauma Life support, (ATLS) protocol. Inspection of skin condition and any swelling or deformity. Palpation for tenderness and crepitus. Examination of the neurovascular status (dorsalis pedis) posterior and anterior tibial arteries, common peroneal and tibial nerves) to exclude any vascular injuries, neurological injuries, or compartmental syndrome. Examination of other regions that were subjected to trauma and detection of any associated injuries.

Radiological evaluation: Anteroposterior and lateral views of the affected leg with visualization of the ankle and knee joints were taken to assess of the fracture according to the AO classification. The level of fracture. Radiographic views were taken for other skeletal injuries if suspected.

Preoperative preparation:

Closed reduction and temporary stabilization with above knee splint were done in emergency room. IV fluids were given when indicated. Adequate amount of compatible blood if needed was prepared. Investigations included: complete blood count, PT & PTT, FBG, liver and kidney function tests. The patients were assessed for fitness for surgery by clinical history, examination, and routine preoperative laboratory investigation. IV antibiotics in the form of 2 gm. ceftriaxone half an hour before surgery. Shifting of the patients 30 minutes before surgery to operation theatre. Preparation of the theatre and full instrument set ensuring availability of all nail lengths and diameters. Availability of C-Arm machine.

Surgical Technique:

Fig. (1): Intraoperative photos showing (A): Skin incision, (B): Paratenon opened as a separate layer, (C):Patellar tendon (D): Vertical incision of patellar tendon.

Fig. (2): AP & lateral fluoroscopic images of proximal tibia showing opening of the medullary canal with curved awl.

Fig. (3): (A): Intra operative image showing insertion of guide wire, (B,C): AP&Lateral view showing position of blocking wire, (D): Reamer passed with blocking wire in place.

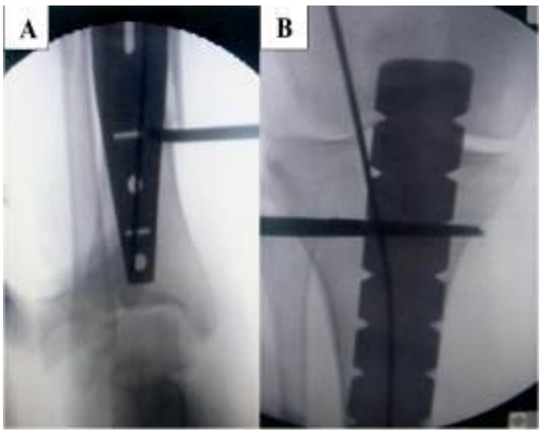

Fig. (4): (A,B): Fluoroscopic images showing AP views of distal and proximal tibia with the ruler about 1 cm above the ankle joint distally and at the level of the entry point proximally to measure accurate nail length.

Fig. (5): Intra operative and fluoroscopic image showing nail insertion with the blocking wire aiding reduction.

Fig. (6): (A,B): AP and Lateral fluoroscopic images showing locking the nail distally with 4 interlocking screws (2 mediolateral & 2 anteroposterior).

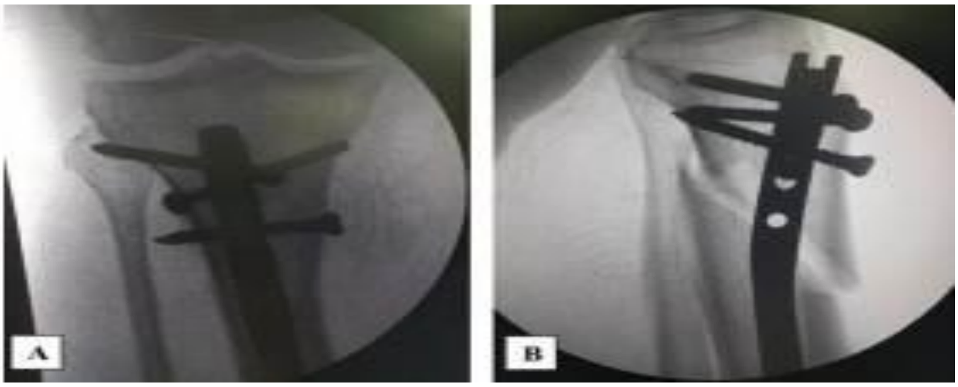

Fig. (7): (A, b) AP and Lateral fluoroscopic images of proximal tibia showing locking the nail proximally with 4 interlocking screws.

Postoperative care:

IV fluids/ blood transfusion if necessary. Parenteral antibiotics were continued for the first 48 hours then oral antibiotics were given for another week. IM analgesics, Anti-edematous medications and proton pump inhibitors were given. Anti-coagulant prophylaxis was started 12 hours post-operative when early weight bearing was not allowed. Limb elevation over pillows. Inspection for active bleeding. X-ray of the operated tibia including knee and ankle joints in both AP and lateral views. Patients with good soft tissue condition were allowed to do range of motion exercises from 2nd post-operative day.

Patients with soft tissue injury were put in plaster splint for 2 weeks, then range of motion exercises were permitted. Toe touch was allowed from 2nd post-operative day in cases with cortical contact at the fracture site more than 50 %. Partial weight bearing started at 3 weeks then increased to full weight bearing as the patient tolerated and union status in X-ray. In cases with cortical contact at the fracture site less than 50%, weight bearing was delayed 6 weeks until fracture callus was visible. Stiches were removed 2 weeks after surgery. Clinical and radiological follow-up was done after 2, 6, 12, 24 Weeks and evaluation according to Johner-Wruhs, criteria.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 15 for Windows® (SPSS Inc, Chicago, IL, USA).Qualitative data was presented as number and percent. Comparison between groups was done by Chi-Square test. Quantitative data was tested for normality by Kolmogrov-Smirnov test. Normally distributed data was presented as mean ± SD. $P < 0.05$ was considered to be statistically significant.

RESULT

This study included 12 patients: 8 males and 4 females, 3 patients (25%) were suffering from chronic illness (e.g., diabetes mellitus and hypertension) and 9 patients (75%) did not have medical history. 10 patients (83.3%) had closed fractures and 2 patients (16.7%) open fractures. 8 patients (66.7%) had distal metaphyseal tibial fracture, 2 patients (16.6%) had proximal metaphyseal tibial fracture and 2 patients (16.6%) had segmental tibial fracture.

The youngest patient was 18 years old and the oldest was 60 years old with the mean age 36.33 years. In this study, the youngest patient was 18 years old, and the oldest patient was 60 years old with the mean age 36.33 years. 3 patients (25%) were between 18-25 years old.

5 patients (41.67%) were between 26-40 years old. 4 patients (33.33%) were between 41-60 years old. There were 8 males and 4 females **(Table 1).**

Table (1): Age and sex distribution of the studied case.

Age/years: Mean ±SD (Min-Max)	36.33±13.54 (18-60)	
- **18:25 years**	3	25
- **26:40 years**	5	4
- **41:60 years**	4	1 .
Sex:		
- **Male:**	8	6
- **Female:**	4	6

Table 2 shows that 8 patients (66.7%) had no varus or valgus angulation, 3 patients (25%) had between 1-5 ° angulation, 1 patient (8.3%) had between 6-10° angulation and 0 patient had >10°angulation.

Table (2): Distribution of the studied cases according to Varus / Valgus deformity.

Varus / valgus deformity	N=12	%
• None	8	66.7
• 1-5°	3	25
• 6-10 °	1	8.3
• >10°	0	0

Table 3 shows that 10 patients (83.3%) had 0-5° a anteroposterior angulation, 2 patients (16.7 %) had between 6-10° angulation, 0 patient (0%) had between 11-20°angulation and 0 patient (0%) had >20°.

Table (3): Distribution of the studied cases according to anteroposterior angulation.

Recurvatum / Procurvatum =12 %		
• 0-5°	10	83.3
• 6-10°	2	16.7
• 11-20°	0	0
• >20°	0	0

Table 4 shows that group, 11 patients (91.7 %) had no or 1-5° internal /external rotation, 1 patients (8.3) had between 6-10° internal /external rotation and no patients had >11° rotational deformity. 10 patients (91.7 %) had 0-5mm limb shortening, 1 patients (8.3 %) had between 6-10mm shortening and no patients had >10mm shortening.

Table (4): Distribution of the studied cases according to rotational deformity and shortening.

Rotation	N=12	%
• 0-5°	11	91.7
• 6-10°	1	8.3
• 11-20°	0	0
• >20°	0	0
• 0-5mm	11	91.7
• 6-10mm	1	8.3
• 11-20mm	0	0
• >20mm	0	0

Table 5 shows that the patients (75 %) were able to do strenuous activities, 1 patients (8.3%) had limited ability to do strenuous activities, 1 patients (8.3%) had severely limited ability to do strenuous activities, and 1 patients (8.3%) were not able to do strenuous activities

Table (5): Distribution of the studied cases according to ability to do strenuous activities.

Strenuous activities N=12 %		
• Possible	9	75
• Limited	1	8.3
• Severely limited	1	8.3
• Impossible	1	8.3

Table 6 shows that 2 patients (16.7%) has proximal tibial fracture, 1 (8.3%) of them had excellent final result and 1 (8.3%) had good final result. 2 patients (16.7%) had segmental tibial fracture,1(8.3%) of them had excellent final result and 1 (8.3%) had fair final result. 8 (66.7%) patients had distal tibial fractures, 6 (50%) had excellent final result, 1 (8.3%) had good final result,1 (8.3%) had poor final result.

Table (6): Relation between level of fracture and final result.

Level of fracture N=12 %		
Proximal		
• Excellent	1	8.3
• Good	1	8.3
Segmental		
• Excellent	1	8.3
• Fair	1	8.3
Distal		
• Excellent	6	50
• Good	1	8.3
• Poor	1	8.3

Table 7 shows that 6 patients (50%) were operated upon in the first 5 days after trauma, of which 4 (33.3%) had excellent result, 1 had good result and 1 (8.3%) had poor result. 4 patients(33.3%) were operated upon 6-10 days after trauma, of which 3 (25%) had excellent result and 1 (8.3%) had good result. 2 patients (16.6%) were operated upon 11-15 days, of which 1 (8.3%) had excellent result and 1 (8.3%) had fair result.

Table (7): Relation between time elapsed before surgery and final result.

Time elapsed before surgery N =12 %		
First 5 days		
• Excellent	4	33.3
• Good	1	8.3
• Poor	1	8.3
6-10 days		
• Excellent	3	25
• Good	1	8.3
11-15 days		
• Excellent	1	8.3
• Fair	1	8.3

Table 8 shows that, 3 patients (25%) were from 18-25 years old, of which 2 (16.6%) had excellent results and 1 (8.3%) had good results. 5 (41.6%) were from 26-40 years, of which 3 (25%) had excellent results, 1 (8.3%) had good results and 1 (8.3%) had fair results. 4 patients (33.3%) were from 41-57 years old, of which 3(25%) had excellent results and 1(8.3%) had poor results

Table (8): Relation between age of the patient and final result.

Age of patient and result N=12 %		
18-25 years old		
• **Excellent**	2	16.6
• **Good**	1	8.3
26-40 years old		
• **Excellent**	3	25
• **Good**	1	8.3
• **Fair**	1	8.3
41-60 years old		
• **Excellent**	3	25
• **poor**	1	8.3

DISCUSSION

The tibia is the most commonly fractured long bone. Metaphyseal tibial fractures are treated either conservatively, or operatively with intramedullary nails, plate and screws, or external fixation. Intramedullary nailing (IMN) has numerous advantages for fracture fixation, including its potential for minimally invasive exposure, biologically friendly implant insertion, longer implants to span more complex fractures, and load-sharing fixation to allow earlier weight bearing [(8)].

These clinical advantages and recent improvements in implant design have generated interest in expanding the indications for IMN. As IMN is used for more metaphyseal and peri-articular fractures, technique related complications have been identified. Malreduction often occurs because nails do not inherently align metaphyseal segments as they do with simple diaphyseal fractures [(8)].

This study included 12 patients: 8 males and 4 females. According to Johner-Wruhs's criteria, 8 patients (56.6 %) had excellent final result, 2 patients (16.6%) had good final result, 1 patient (8.3 %) had fair final result, and 1 patient (8.3%) had poor final result.

Several studies showed comparable results to the results of this study as follows; **Yaligod *et al.*** [(9)] performed a study on 28 patients with distal metaphyseal tibial fracture fixed by expert nail. Type I and type II open fractures were included in the study. The fractures extending into distal tibial articular surface, open type III fractures were excluded. The average follow up was 19 months with range being 6 months to 30 months. Twenty-three out of 27 patients (85%) had fracture union without the need for any further surgical intervention. The average time to union in these 23 patients was 15.6 weeks with a range between 14 to 20 weeks. In our study the time to union ranged from 12 to 24 weeks. 9 patients (75%) achieved union between 12-16 weeks, 1 patient (8.3%) achieved union 17-20 weeks, 1 patient (8.3%) achieved union 21-24 weeks and 1 patient (8.3%) had non-union.

El Attal *et al.* [(10)] performed a study on 91 patients with distal tibial fractures who were treated by expert interlocking tibial nail. Malalignment of > 5° was observed in 5.4%. A secondary malalignment after initial good reduction was detected in only 1.1% of cases. In our study 8 patients (66.7%) had no varus or valgus angulation, 3 patients (25%) had between 1-5 º angulation, 1 patient (8.3%) had between 6-10 º angulation and 0 patient had > 10 º angulation.

Nork *et al.* [(11)] performed a study on 36 patients with distal metaphyseal tibial fractures treated with expert tibial nail. Complications included one deep infection at the site of an open fibular fracture. The infection responded to local debridement and intravenous administration of antibiotics. In our study 1 patient (8.3%) had deep infection which was treated with surgical debridement with good outcome.

Nork *et al.* [(12)] performed a study on 35 patients with 37 proximal tibial fourth fractures who were treated primarily with expert tibial nail. Acceptable alignment was obtained in 34 of 37 fractures (91.9%). Two patients had 5-degree coronal plane deformities (one varus and one valgus), and 1 patient had a 7-degree varus deformity. Four patients were lost to follow-up. In the remaining 31 patients with 33 fractures, the proximal tibial fractures united in 31 fracture. 2 patients had non united fractures. Complications included deep infections in 2 patients that were successfully treated.

In this study, blocking screws /wires were used to help in centering of the guide wire and nail insertion. **Ricci *et al.*** [(13)] performed a study on 12 consecutive patients treated with intramedullary nailing and blocking screws for fractures of the proximal third of the tibial shaft. Postoperatively, all patients had less than 5 degrees of angular deformity in the planes in which blocking screws were used to control alignment. One patient had postoperative malalignment (6 degrees of valgus), but a lateral blocking screw to control valgus deformity was not used in this patient. One patient was lost to follow-up. Eleven patients were followed up to union (n = 10) or establishment of a nonunion (n = 1). Ten of eleven patients maintained their postoperative fracture alignment at their last follow- up examination (average follow-up of thirty-three weeks). One patient progressed from 6 degrees of valgus immediately after surgery to 10 degrees of valgus at union. This patient did not have a blocking screw to control valgus angulation.

Expert interlocking tibial nail has multiple locking options in multiple directions proximally and distally which improve fracture stability when compared with the conventional tibial nail. **Laflamme *et al.*** [(14)] performed a study on ten paired fresh-frozen human cadaver tibiae. One tibia of each pair was randomized to be instrumented with an intramedullary nail, while the other was stabilized with a 13-hole stainless steel lateral tibial head plate. Specimens were tested in varus- valgus, flexion-extension and torsion, before and after a 2-cm gap osteotomy was performed in the proximal segment. Testing of the nailed tibiae was performed with and without additional oblique proximal screws. The addition of the proximally placed oblique screws increased the stability of the nail construct in varus/valgus by 50%, in flexion/extension by 47% and in torsion by 18%. There was no significant difference observed between the stability of the intramedullary nail construct with oblique screws and the plated construct.

The use of conventional tibial nail in treating proximal metaphyseal tibial fractures yielded bad results as reported by **Lang *et al.*** [(15)] who performed a study on thirty-two extra articular fractures of the proximal third of the tibia treated with conventional locked intramedullary nails. Thirty of the 32 fractures eventually healed; however, 9 (28%) underwent exchange nailing and 4 (13%) required bone grafting. At final follow-up, 27 out of 32 fractures (84%) had angulation of 5 degrees or greater in the frontal or sagittal plane. Nineteen of the 32 fractures (59%) had 1 cm or more of displacement at the fracture site. In 8 fractures (25%), there was loss of fixation. He concluded that Fractures of the proximal third of the tibial shaft did not appear to respond as favorably to intramedullary nailing as did fractures in the distal 2/3 of the tibia. Valgus, apex anterior angulation, and residual displacement at the fracture site were common after nailing.

Lee *et al.* [(16)] carried out a biomechanical analysis of operative methods in the treatment of extra-articular fracture of the proximal tibia. Three groups of tibial bones consisting of 5 specimens per group were included: lateral plating using a locking compression plate- proximal lateral tibia (LCP-PLT), double plating using a LCP-PLT and a locking compression plate-medial proximal tibia, and intramedullary nailing using an expert tibial nail. To simulate a comminuted fracture model, a gap osteotomy measuring 1 cm was created 8 cm below the knee joint. For each tibia, a minimal preload of 100 N was applied before loading to failure. A vertical load was applied until tibial failure. Under axial loading, fixation strength of double plating was 17.5% greater than that of lateral plating using a locking compression plate, and 60% less than that of intramedullary nailing using an expert tibial nail. He concluded that intramedullary nailing using an expert tibial nail was found to be the most stable implant for use in treatment of comminuted extra-articular fractures of the proximal tibia.

Meena *et al.* [(17)] compared between intramedullary nailing and proximal plating in the management of closed extra-articular proximal tibial fracture. He performed a study on 44 patients with extra-articular fracture of the proximal tibia. 19 patients were treated with expert tibial nail and 25 were treated with proximal tibial locked plate. In nailing group he used blocking screws, reduction clamp, unicortical plate, or a temporary fixator to achieve reduction. Postoperative hospital stay, time period to full weight-bearing, and union time were significantly less in the nailing group as compared to the plating group. Surgical site infections (SSIs) were seen in two patients in the plating group, one of which was resolved with debridement while the other necessitated implant removal due to infection while there was no infected cases in nailing group. Delayed union occurred in two patients in the nailing group, for which dynamization was performed by removing the distal screw. One case in the nailing group presented nonunion, which ultimately required exchange nailing with bone grafting and fibular osteotomy. There was nonunion in one patient in the plating group; bone grafting was done in that case, which eventually led to fracture healing. The alignment of the tibia, measured in the immediate postoperative and 1-year follow- up X-rays, did not show a significant difference between the groups.

Bisaccia *et al.* [(18)] performed a study on 75 patients comparing Nail and plate in the management of distal extra-articular tibial fractures. 41 patients were treated with expert tibial nail, while 34 were treated with distal tibial locked plate. The mean union time was 21.8 weeks for the nailing group and 24.2 weeks for the plating group. The infection rate for the nailing was 0 while the same rate was 5.88% for the plating group. In the IMN group, 8 patients developed anterior knee pain (19.5%). The full weight bearing time was longer in the plating group compared to the nailing group (15.3 ± 2.9 weeks versus 12.8 ± 3 weeks, respectively).

Guo *et al.* [(19)] carried out a meta-analysis Comparing intramedullary nailing and plate fixation for treating distal tibial fractures. It showed that intramedullary nailing reduced the time of surgery and radiation and the risk of wound complications compared with plate fixation. Intramedullary nailing was found to have priority for distal tibial metaphyseal fractures.

CONCLUSION

It could be concluded that intramedullary fixation with expert interlocking tibial nail is a safe and effective method for the treatment of metaphyseal tibial fractures. Multiple reduction aids as percutaneous clamps, blocking screws/wires help in obtaining and maintaining reduction. The nail design allows the distal or proximal segment to be controlled through placement of multiple locking screws within a small distance from the articular surface. The alignment can be well maintained despite the short metaphyseal segment. Expert nail showed excellent and good results in more than 83% in this study.

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