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Ahmed Elsaed Ragab Zaher
Orthopedic Surgery, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt,
doctorzaher2017@gmail.com

Ismael Ahmed Yassin
Orthopedic Surgery, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Osama Gaber Abdallah
Orthopedic Surgery, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

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ORIGINAL ARTICLE

Exchange Nailing vs Plate over Nail and Graft in the Management of Non-United Proximal Tibial Fractures after Interlocking Nail Fixation in Proximal Tibial Fractures

Ahmed E. R. Zaher *, Ismael A. Yassin, Osama G. Abdallah

Department of Orthopedic Surgery, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Background: ***Non-united proximal tibial fractures following intramedullary nail (IMN) fixation pose a challenging clinical scenario. The choice between exchange nailing (ERN) and plate fixation as a salvage procedure for these fractures requires careful consideration.***

Aim and Objective: ***To evaluate the surgical outcomes between ERN versus AAP for non-united proximal tibial fractures after fixation by IMN.***

Patients and methods: ***This research included 20 patients with non-united proximal tibial fractures, managed with intramedullary nails, at Al-Azhar University Hospitals. Patients were split into Group A (ERN) and Group B (AAP).***

Results: ***The demographic information revealed no discernible variations in the age, gender distribution, affected side, or length of hospital stay between the two groups. Both groups' non-union was due to comparable reasons. With no statistically substantial variations between the ERN and AAP groups, the union was accomplished in every instance in a mean time of 14.3 ±1.7 weeks. In all groups, postoperative problems, including infection and discomfort, were well handled. According to radiological analyses, the two treatment modalities did not significantly vary in tibial alignment or range of motion.***

Conclusion: ***This study demonstrates that ERN and AAP are effective surgical options for managing non-united proximal tibial fractures following IMN fixation. The choice between ERN and AAP should be based on individual patient factors and surgeon preference, as both approaches can yield favorable results.***

Keywords: NonIntramedullary Nail Fixation; Exchange Nailing; Augmentative Anti-Rotational Plating; Surgical Outcomes; Fracture Healing

1. Introduction

Proximal tibial fractures, occurring at a rate of 10 to 26.7 per 100,000 person-years, often result from high-energy trauma. Surgical interventions, such as intramedullary nails(IMN), plates, and external fixators, are common. IMN is the gold standard for closed fractures but can lead to complications (1.9% to 11.3%) like limb length discrepancy, infection, and nonunion. The development of a nonunion is multifactoria. [1]

Factors contributing to a nonunion's development include the following, listed here with known risk factors.

Fracture and Injury-Related Factors

High-energy fractures with significant comminution

Type of fracture (closed/open), Location and pattern (highly comminuted or butterfly fragments), The extent of soft tissue injury, Extensive soft tissue, and periosteal stripping increase the risk of nonunion. The inner cambium layer of the periosteum contains osteoprogenitor cells that can contribute to fracture healing. Reamed intramedullary nails cause injury to the endosteal blood supply. The periosteal blood supply has been shown to increase following reaming.

Bone loss and fracture gaps (more significant than 3 mm), Lack of cortical continuity, and Infection.[1]

Biology and Patient-Related Factors (Local and Systemic)

Smoking (The most significant risk factor), Nutritional status, Diabetes, Inadequate blood supply, Vitamin D deficiency, Renal insufficiency, Medications (steroids, NSAIDs, opiates, etc.).[1]

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* Corresponding author at: Orthopedic Surgery, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt.
E-mail address: doctorzaher2017@gmail.com (A. E. R. Zaher).

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Surgical-Related Factors as Inadequate Stabilization. [1]

Diagnosis of nonunion can be challenging, with clinical symptoms including pain and tenderness. Radiographic evidence and culture data are essential for accurate diagnosis, particularly for septic cases. Infection should be considered even without typical signs. Management involves a multidisciplinary approach addressing inhibiting factors, systemic therapies, and local surgery.[2] Aseptic nonunion, including hypertrophic and atrophic types, results from various factors and presents diagnostic challenges.[3] Imaging techniques and bacteriology samples help differentiate infected from non-infected nonunion, guiding treatment decisions. [4]

Our study aimed to evaluate the surgical outcomes between exchanging reamed nailing (ERN) versus augmentative anti-rotational plating (AAP) for non-united proximal tibial fractures after fixation by IMN.

2. Patients and methods

This prospective cohort study involved twenty patients with non-united proximal tibial fractures fixed with intra-medullary nails. The study was conducted for six months in the outpatient clinic of the Orthopedic Department at Al-Azhar University Hospitals, including Al-Hussin and Al-Sayed Galal Hospital.

The study population met the following criteria: Patients with non-united proximal tibial fractures fixed with intra-medullary nails for clinical evaluation, and Evaluation of the time required for complete healing in both treatment methods. Inclusion criteria are skeletal mature patients with non-united proximal tibial fractures who are free from infections—exclusion criteria patients with pathological fractures, skeletal immaturity, and those presenting with septic nonunion.

After the Institutional Review Board authorized the research, it was conducted with the subjects' full informed permission, acquired in writing.

The included patients were split into two groups:

Group A: The prior IM nail was removed from ten patients via an earlier surgical incision. Then, a reaming procedure was used to prepare the tibial medulla. We selected a new nail based on the size of the tibia. All locking screws were also positioned in a static position. The nonunion spot will not get any further bone transplants.

Group B: The old IM nail, with ten patients, is still there. Over the nonunion location, a fresh incision was created. A compression plate will be used after the tissue between the unconnected ends is adorned until it bleeds. Compression cortical screws were used to treat the fracture with a plate that was the right length. Four cortices were placed at each side of the fracture via almost all critical purchases, close to and passing by the IM nail. In each instance, an autologous cancellous bone graft was taken from the iliac crest and placed over the location of the nonunion after decortication.

All patients were subjected to I. History (Demographic data of studied groups, affected side, hospital stays, causes of nonunion)

II. Preoperative management:

PreoperativeEach patient's preoperative evaluation included a history check, physical examination, and radiological (X-ray and CT) examination.

Sepsis was ruled out at both the fracture site and before the decision to do augmentation plating. All clinical and laboratory evaluations included CBC, ESR, and CRP. There was never throbbing pain, discomfort at night, or pain when the patient was at rest; pain was always tied to the patient's attempt at bearing full weight. At the fracture location, there was no heat or edema. Only when stress levels were within normal limits did tenderness become apparent.

III. Intra-operative Evaluation: Intra-operative blood loss and transfusion and operative time

Surgical technique:

All patients had surgical debridement of all non-viable tissues and bone ends, then canal reaming, revision open reduction and plate, or ERN, and numerous cultures to be obtained from the nonunion site. The administration of antibiotics is based on the sensitivity and findings of the culture. Autologous bone grafting has been advocated as an adjuvant when open therapy is necessary.

A. Exchange Nailing

Reaming was performed with power reamers over the guide wire. Surgeons adhered to a protocol to ensure consistent reaming: 1) Reamed until the first "cortical chatter" (when the reamer contacts the cortical bone). 2) Nail diameter matched the point of "cortical chatter." 3) Reamed 1–1.5 mm more significantly than the chosen nail's diameter after "cortical chatter." The chosen nail was inserted as long as possible without distracting the fracture. All efforts were made to achieve cortical contact without excessive shortening (up to 10 mm). Nail choice and material were at the surgeon's discretion.

B. Plate fixation:

Under spinal anesthesia, the limb and iliac crest were prepared. A small anterolateral incision was made over the fracture site, exposing it with minimal subperiosteal dissection. Bone ends were refreshed, and bone graft-filled defects were present. A narrow DCP with at least two bicortical

screws was applied, with compression at the fracture site after nail dynamization (no dynamization if defect present). Fibular osteotomy was performed for rotational deformity and over-distraction cases. On the second postoperative day, range-of-motion exercises were initiated, and weight-bearing commenced when there were signs of progressive union. Monthly follow-up X-rays were done until healing. Plates were removed if implant-related pain occurred approximately 1.5 years after surgery.

IV. Postoperative Evaluation: Postoperative blood loss, transfusion, postoperative complications, and time to union.

V. Postoperative Follow-Up: After one week of follow-up and evaluation of the wound, two weeks of follow-up, and removing the incision stitches, our patients had follow-up visits every two weeks for the first eight weeks and every two months for the next four months.

Statistical Analysis: IBM's Statistical Package for the Social Sciences (IBM SPSS) version 20 was utilized for data collection, editing, coding, and entry. Quantitative information was given as standard deviations, means, and ranges when their distribution was determined to be parametric; qualitative data were offered as raw numbers and percentages. The chi-square test functioned to compare two paired groups based on qualitative data, and the Fisher exact test was employed in place of the chi-square test whenever the predicted count in any cell was detected to be below five. Paired t-test was used to contrast two groups utilizing quantitative data with a parametric distribution. The margin of error was set at five percent, while the confidence interval was 95%. A p-value of over 0.05 was deemed not significant (NS), whereas a p-value of under 0.05 was regarded as significant (S), as well as a p-value of below 0.001 was deemed highly significant (HS).

3. Results

Demographic data of examined groups were shown in Table 1.

Table 1. Demographic data, affected side, hospital stay and period of follow up of studied groups

	Nail group		Plate group		P value
Gender distribution					
	No	%	No	%	0.15
Males	8	80%	5	50%	
Females	2	20%	5	50%	
Age distribution					
	Mean	SD	Mean	SD	0.08
	46.48	3.9	46.43	3.07	
DM					
	No	%	No	%	0.01
Yes	2	20%	1	10%	
No	8	80%	9	90%	
Smoking					
	No	%	No	%	0.001
Yes	5	50%	6	60%	
No	5	50%	4	40%	
HTN					
	No	%	No	%	0.02
Yes	2	20%	1	1%	
No	8	80%	9	90%	
Affected side					
RT	8	80	9	90	0.05
LT	2	20	1	10	
Hospital stay	5.31	0.8	5.2	0.8	0.1
Period of follow up (months)	6	0.8	5.5	0.68	0.2

Causes of non-union

There were no statical significant differences between both groups regarding the causes of non-union. Figure 1

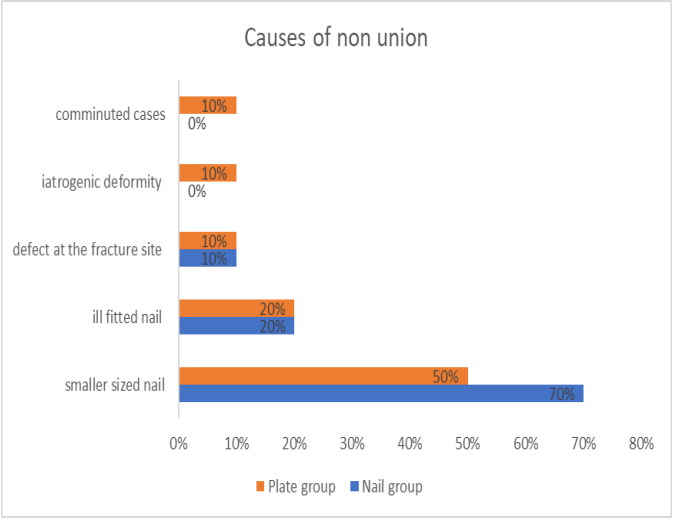


Figure 1: The causes of non-union in the studied groups

Union rate

Union was attained in all cases (100%) within a median time of 14.3±1.7 weeks (range 12 – 17 weeks). In the nail group Union was attained in all cases (100%) within a median time of 14.3±1.7 weeks (range 12 – 17 weeks). In the plate group Union was attained in all cases (100%) within a median time of 14.3±1.7 weeks (range 12 – 17 weeks). There was no statistically substantial variations between both groups. Table 2

Table 2. Union rate in both groups

	Union rate	Nail group	Plate group
Average	14.3	13.5	14.5
Range	12 to 17	12 to 16	12 to 17
SD	1.7	1.360147	4.224926
P value		0.2	

Clinical and radiological follow up and complications:

Clinical follow-up revealed that in the nail group, 30% experienced early postoperative

superficial infections, and 10% had pain necessitating nail removal later, with no disuse muscle atrophy or osteoporosis. In the plate group, 20% had early postoperative superficial infections, 70% reported pain, with no disuse muscle atrophy or osteoporosis. Radiological follow-up showed no substantial variations in tibial alignment between the groups, and there were no statistically substantial variations in coronal or sagittal plane angulation. The average range of motion was similar in both groups, with 133.2 in the nail group and 134.2 in the plate group. Table 3

Table 3. Complications of both studied groups

	Nail group		Plate group		P value
	No	%	No	%	
Superficial Infection	3	30%	2	20%	0.12
Delayed union/nonunion	0	0%	0	0%	-
disuse muscle atrophy	0	0%	0	0%	-
osteoporosis	0	0%	1	10%	-
Pain	1	10%	7	70%	0.5
	Mean	SD	Mean	SD	P value
Malalignment (Sagittal plane)	3.9	2.587	4.222	2.463	0.32
Malalignment (Coronal plane)	3.8	2.315	4.2	2.843	0.21
Range of motion of knee	133.2	15.42	134.2	15.8	0.35

Case presentation:

Case 1: Male patient 35 years old. DM not HTN, smoker with non-united proximal tibia fracture fixed by intramedullary nail. Figure 1

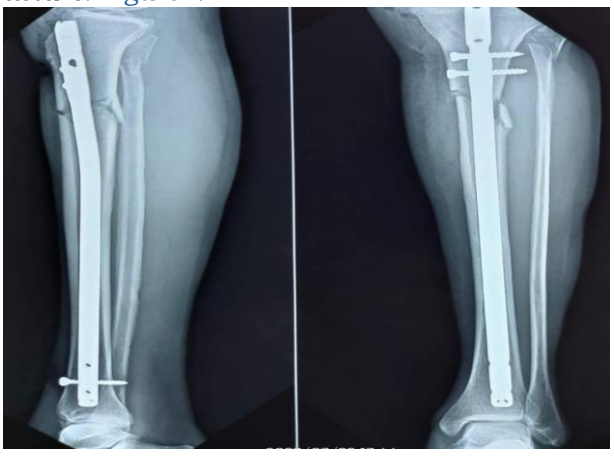
A

B

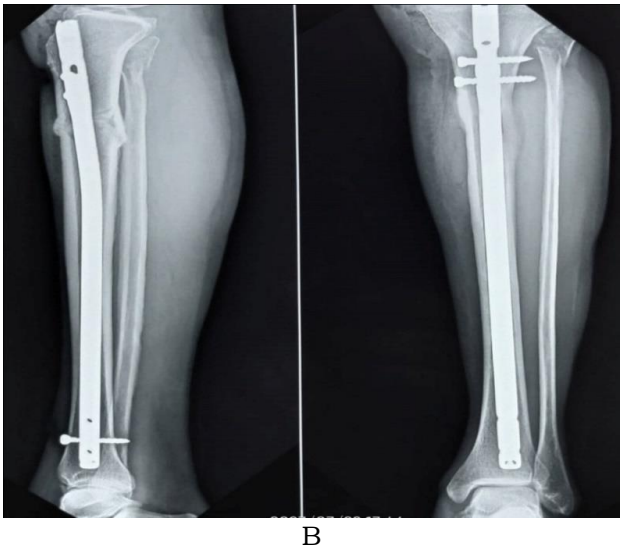
C

Figure1. A) After 6 months X ray showed incomplete healing and patient will follow up. B) Plate over the nail with bone graft for stimulation of healing. C) After 3 months X rays shows healing of the fracture.

Case 2: Male patient 43 years old. Not DM not HTN, smoker with non-united proximal tibia fracture. Figure 2



A



B

Figure 2. A) X-rays shows no healing and we exchange nail with larger diameter nail with reaming of the medullary canal for stimulation of healing. B) After 3 months follow up X ray show healing of the fracture.

4. Discussion

This was a prospective cohort study of 20 patients who presented with non-united tibial fractures (fixed with intra-medullary nails) in the outpatient clinic of the orthopedic department in Al-Azhar University Hospitals (Al-Hussin and Al-Sayed Gala Hospital).

In Meena et al.'s study, Because of the smaller incision formed by closed nailing, patients in the IMN group had considerably shorter hospital stays than those in the PTP group (p \0.05), indicating that IMN has a lower economic impact and healthcare costs on society than PTP. [5]

A fibular osteotomy, in which a 2.5 cm length of fibula is removed, has been used to treat delayed and hypertrophic nonunion by increasing axial tibial loading. However, there has yet to be a consensus on the optimal site for the partial fibulectomy. [6]

Ateschrang et al. revealed that Compared to therapy with exchange reamed intramedullary nailing, plate augmentation of tibial nonunion resulted in faster bone consolidation. [7]

They ascribed such to plate fixation's increased stability and less endosteal perfusion disruption. More stability is provided by the plate's compression action and the screws' blocking effect together than by just the intramedullary locked nail. This characteristic is most evident in fractures of the proximal tibia's metaphyseal-diaphyseal junction, which is broad and shaped like a cone and cannot be treated with an IMN. [8]

The union rate in our series is 100%. It is comparable to others Wu et al. (96%) and Ueng et al. (100%). Union was attained in all cases (100%) within a median time of 14.3±1.7 weeks (range 12 – 17 weeks).

Regarding the clinical follow-up and Complications:

According to several studies, weight-bearing should begin when the patient can tolerate it.[9]

For the same reasons, the period to complete weight-bearing in extra-articular proximal tibial fractures managed by PLP has varied from 6 to 13 weeks.[9]

In Meena et al.'s study, The IMN group needed much less time (18.26 weeks) before full weight-bearing than the PTP group (22.84 weeks), which was only accomplished after the complete radiological union. [5]

We only began full weight-bearing after complete clinical and radiographic fracture union, even if these timeframes are longer than those described in previously published publications.

Regarding the radiological follow-up.

One of the key benefits of the augmentation plate approach is that it enables the nonunion site to be attacked by bone graft insertion, debridement of the fracture site, and increased fixation stability by fracture compression.[10]

That method also has the benefits of being straightforward, affordable, and enabling early patient recovery.

However, this method also has several drawbacks, including the fact that it is more intrusive than ERN and leaves a giant postoperative scar, which might make recovery discomfort worse.

The disruption of the soft-tissue sleeve around the nonunion site disturbs the local periosteal blood flow, which is crucial for fracture healing. Finally, the plate often irritates many people and must be removed later.

In our investigation, to control proximal displacement in cases of exchange nailing, we used reduction plating in one instance, blocking screws{poller screws} in three cases, and universal distractors in two cases.

In other instances, a reduction clamp avoided proximal fragment expansion when driving in the nail.

In all nailing situations, a slightly higher entrance site than that typically utilized for tibial nail insertion was adopted. This adjustment reduced the extent of the proximal fragment by bringing our insertion site closer to the tibia's medullary canal.

Lindvall et al. observed a greater incidence of malunion in the nailing group, although this distinction was not statistically substantial. Apex anterior malreduction occurred in 36% of the patients in the IMN group and 15% of those in the locking plate group. [9]

The high union rates we found in our dataset align with the 91–100% range reported in many published papers. Our findings, however, were better than those reported in research by Lindvell et al., who found that the IMN group's union rates were 77% and the PTP group's union rates were 94%.[9]

The study's limitations include the small patient population, the lack of long-term follow-up to assess how misalignment affects the onset of osteoarthritis of the knee, and the usage of both stainless steel and titanium implants. These may impact infection rates because titanium is more biocompatible than stainless steel and thus less likely to cause a soft-tissue reaction and increase the risk of infection.

4. Conclusion

In conclusion, intramedullary nails and plate augmentation techniques offer effective treatments for proximal tibial fracture nonunion, with no clear advantage regarding various outcomes. Both methods provide crucial rigid fixation to prevent secondary fracture collapse. Augmentation plating excels in

nonunion healing, reduced operative time, and quicker return to activities. Plates are more reliable in specific scenarios like fractures at the proximal metaphyseal-diaphyseal junction and cases with bone defects due to comminution, requiring bone grafting for added stability. Alternatively, exchanging the nail with a larger diameter version, with or without a bone graft, can yield similar results while avoiding future plate removal surgery.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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