Radiological and Clinical Outcomes of Metaphyseal Tibial Fracture Fixation Using Intramedullary Nails with Supplementary Poller Screws: A Prospective Case Series

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ABSTRACT

Background:
The use of intramedullary nails for tibial shaft fractures has become increasingly popular and is now regarded as the standard of care. However, fixing diaphyseo-metaphyseal tibial fractures with intramedullary nails presents challenges due to the natural discrepancy between the diameters of the bone in this region and the implant. To address this issue and expand the application of intramedullary nails to this specific area of the tibia, many surgeons have adopted the use of blocking screws.

Methods:
A case series involving 20 patients with diaphyseo-metaphyseal closed tibial fractures were treated using intramedullary nails supplemented with blocking screws. The patients were monitored for final alignment, union rate, and the incidence of complications.

Results:
Union was achieved in all patients, with an average duration of 20 weeks (range: 16-24 weeks). Post-operative fracture alignment was satisfactory in all cases, although three patients exhibited minor coronal plane angulation that was deemed non-significant. The fractures maintained their post-operative alignment until union. Regarding complications related to the blocking screws, one patient (5%) developed a new fracture line at the site of blocking screw placement, which was successfully managed with delayed weight-bearing and the application of a back slab for two weeks. Other complications, unrelated to the blocking screw, occurred in one case (5%), where the patient developed a deep infection.

Conclusion:
Blocking screws can effectively and safely extend the application of mechanically superior intramedullary nails to the metaphyseal region of the tibia.

Introduction

The tibia is a commonly fractured long bone, largely due to its subcutaneous location, which makes it more susceptible to trauma [1]. Intramedullary nailing has become the standard treatment for diaphyseal and selected metaphyseal fractures of long bones. This method preserves the muscle envelope around the fracture and maintains extra-osseous blood supply to the bone, offering the advantage of load-sharing. Additionally, it allows for early rehabilitation, including muscle strengthening, and often permits early partial weight-bearing[2].

Although intramedullary nailing is the preferred treatment for diaphyseal tibial fractures, its use in fractures located at the proximal and distal metaphysis is associated with a higher rate of complications, often due to difficulties in achieving successful reduction and proper alignment [3].

Displaced extra-articular fractures can be challenging to reduce, often leading to residual varus or valgus malalignment. The small size of the distal fragment can further complicate the process by making it difficult to both maintain the reduction and achieve adequate distal locking fixation[4].

Malalignment in proximal tibial fractures is often caused by displacing muscular forces and residual instability, with malunion typically resulting in apex anterior and valgus deformities. Various strategies can be employed to address these issues and improve outcomes, including the use of blocking screws, buttress plates, patient positioning adjustments, intraoperative reduction with a two-pin external fixator, and extended parapatellar or supra patellar approaches. However, there is considerable debate regarding the effectiveness of each technique[4][5].

The concept of the poller screw is derived from small metal devices used on roads to block or guide traffic. Similarly, poller screws are employed to reduce the width of the medullary cavity, physically blocking and guiding the nail while simultaneously increasing mechanical stiffness [6,7].

Methods

This prospective study examined 20 patients with tibial fractures who were treated at our institute using intramedullary nails supplemented with blocking screws, from January 2016 to November 2018. All patients were adults with traumatic closed diaphyseal or metaphyseal tibial fractures (proximal or distal). Exclusion criteria included skeletally immature individuals, open fractures, pathological fractures, and articular fractures.

The study cohort comprised 15 males (75%) and 5 females (25%), with a mean age of 36.4 years (SD = 5.6). The mechanisms of injury were motor vehicle accidents in 13 patients, falls from height in 2 patients, and direct trauma in 5 patients **(Table 1).**

Table 1: Distribution of cases according to the mode of trauma.

Mode of trauma	**Frequency**	**Percent**
Motor car accident	13	65%
Fall from height	2	10%
Direct trauma	5	25%

According to the Tschern-Gotzen classification for soft tissue condition, there were 6 patients classified as C0, 8 as C1, and 6 as C2. For patients with soft tissue classifications C1 and C2, surgery was deferred to allow for improvement in the skin condition **(Table 2).**

Table2: Distribution of cases according to Tscherne classification of soft tissue condition.

Tscherne -Gotzen classification	Frequency	Percent
C 0	6	30%
C 1	8	40%
C 2	6	30%

Blocking screws were utilized based on the following indications:

1. To achieve alignment prior to nail insertion in 7 fractures (35%).
2. To maintain alignment or enhance the stability of the bone-implant complex in 13 fractures (65%) **(Table 3).**

Table 3: Distribution of cases according to the purpose of blocking screw insertion.

Purpose of blocking screw insertion	Frequency	Percent
Achieve alignment	7	35%
Maintain reduction	13	65%

Screw Specifications and Preoperative Evaluation

All blocking screws used were 4.5 mm cortical screws. Preoperatively, patients underwent clinical examination to assess soft tissue condition and to rule out vascular or neurological injuries. Radiographs of the entire tibia were obtained in both anteroposterior (AP) and lateral views. An above-knee slab was applied until the time of surgery.

Operative Technique

The surgery was performed with the patient in a supine position on a radiolucent fracture table, and a pneumatic tourniquet was applied to the proximal thigh. A trans-patellar tendon approach was utilized for all patients. The entry point for the intramedullary nail was determined under fluoroscopic guidance. A guide wire was placed across the fracture intramedullary with the knee flexed, and manual traction was applied to achieve closed reduction in all cases. Reaming of the medullary canal was conducted over the guide wire using flexible reamers until the appropriate nail size was reached.

Blocking screws were inserted through stab wounds under fluoroscopic guidance. To prevent apex anterior angulation, blocking screws were positioned posterior to the central axis of the tibia, ensuring that the nail passed anterior to the screw. To counteract valgus angulation, screws were placed lateral to the central axis, allowing the nail to pass medial to the screws. To address varus angulation, screws were positioned medial to the central axis, ensuring the nail passed lateral to the screws (**Figure 1).**

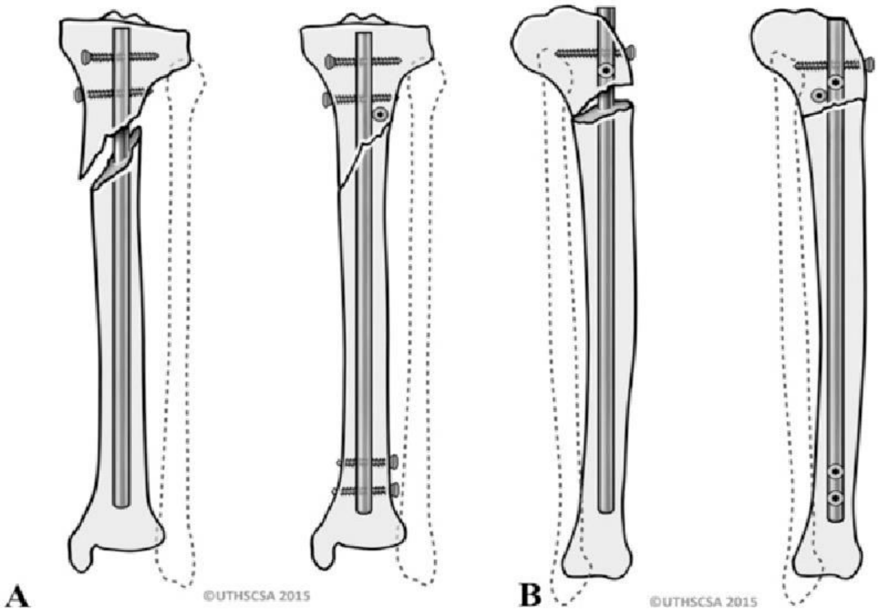

Figure 1: (a) Blocking screw placed anterior to posterior on the lateral side to prevent valgus deformity. (b) Blocking screw placed posteriorly from medial to lateral preventing apex anterior deformity [8].

Once an appropriately sized tibial nail was selected, it was advanced gently over the guide wire past the fracture site. Fluoroscopic images confirmed correct fracture alignment and nail passage through the fracture site. If alignment was unsatisfactory, the nail was temporarily removed, an additional blocking screw was inserted, and the nail was reinserted. When alignment was satisfactory, one or two blocking screws were added while applying manual overcorrection to enhance the stability of the bone-implant complex and maintain alignment. The nails were locked in place proximally and distally using standard aiming devices.

Postoperative Treatment

Isometric exercises were initiated on the first postoperative day. Early active knee and ankle range of motion exercises were encouraged. Partial weight-bearing was allowed starting in the second postoperative week for all patients, with full weight-bearing permitted based on clinical and radiological evidence of adequate fracture union.

Follow-Up

Patients were monitored at 4 to 6-week intervals for clinical and radiological evaluation. The mean follow-up duration was 13 months (SD = 4.2). Radiographs were assessed for fracture alignment and union. Malalignment was defined as angular deformity exceeding 5°, while union was characterized radiographically by bridging cortical bone on at least two cortices and the ability to bear full weight on the extremity free of pain.

Results

All patients achieved fracture union with an average healing time of 20 weeks (range: 16-24 weeks). Delayed union, which was observed at 24 weeks, occurred in one patient due to a deep infection and was managed with suppressive antibiotics until full union was achieved.

In terms of fracture alignment, immediate post-operative radiographs revealed that 17 patients (85%) had fractures that were well-aligned. Two patients (10%) had post-operative varus angulation of less than 5°, and one patient (5%) exhibited post-operative valgus angulation of approximately 3°. Follow-up radiographs confirmed that fracture alignment remained consistent with the immediate post-operative findings.

Complications were classified into those related to blocking screws and those unrelated to blocking screws. Potential complications associated with blocking screws include mechanical instability leading to non-union, new fracture lines at screw insertion sites, nail failure due to drilling-induced damage, screw sinking, and screw breakage. In this study, only one patient (5%) developed a new fracture line at the blocking screw site. This issue was addressed by delaying weight-bearing and applying a back slab for two weeks, after which partial weight-bearing was initiated **(Figure 2).**

Figure 2: (a) Pre-operative x ray showing fracture distal tibia. (b) Immediate post-operative x ray showing a fracture line propagating from the site of blocking screw insertion. (c) Last follow up x ray showing adequate healing of the fracture.

Unrelated complications were observed in one patient (5%), who developed a deep infection resulting in delayed union beyond 24 weeks.

Discussion

Regarding Postoperative alignment:

In our series of metaphyseal-diaphyseal tibial fractures treated with intramedullary nails and Poller screws, seventeen cases achieved good alignment in a neutral position. Postoperatively, two patients exhibited varus angulation of less than 5°, and one patient had valgus angulation of approximately 3°.

These results are consistent with those reported in other studies. For example, Kulkarni et al. documented similar outcomes in a series of 75 tibial fractures treated with intramedullary nailing supplemented by Poller screws [9].

In a study by Gadegone et al., which involved 112 distal tibial fractures (within the distal 6 cm of the tibia), varus angulation was observed in 7 cases (with an angle range of 5°-10°), valgus angulation between 6° and 8° in 12 cases, and recurvatum deformity in 3 cases [10].

Moongilpatti Sengodan et al. reported a mean postoperative varus/valgus alignment of ±1.7°, significantly improved from a mean preoperative varus/valgus alignment of ±10.3°, with alignment maintained until union. Additionally, postoperative procurvatum/recurvatum alignment was ±0.2°, compared to a preoperative average of ±8.0° [11].

Similarly, Shah et al., in their study of 60 tibial fractures, found that 57 cases had less than 5° of valgus or varus deformity, with only three cases showing an 8° valgus deformity[12].

Ahlers and von Issendorff's analysis of 386 tibial fractures revealed that 59% of cases exhibited varus-valgus malalignment of less than 2°, including 32 fractures in the proximal third and 138 fractures (47%) in the distal third[13].

Regarding the fracture healing:

Our results demonstrated that all 20 patients (100%) achieved fracture union, with an average healing time of 20 weeks (ranging from 16 to 24 weeks).

Similarly, in the study by Kulkarni et al. [9], all 75 cases eventually achieved bone union. Healing occurred in 69 cases within approximately 4.2 months, while the remaining cases of non-union were successfully resolved through bone grafting.

Gadegone et al. [11]reported on 120 patients with distal tibial fractures treated with intramedullary nailing, supplemented by two distal interlocking screws and one proximal screw in dynamic mode. In this series, fractures united in an average of 15.4 weeks.

In the study by Sengodan et al. [11], all fractures eventually united within approximately 11.5 weeks.

Similarly, in a series of 60 tibial fractures treated with Poller screws by Shah et al., all fractures eventually united, with healing observed at approximately 5.6 ± 2.3 months postoperatively[12].

Regarding the Postoperative complications:

In our study, one patient developed a new fracture line at the site of the blocking screw placement. In response, we delayed weight-bearing, applied a back slab for two weeks, and then initiated partial weight-bearing. This patient ultimately achieved complete union with maintained alignment.

In the study by Kulkarni et al.[9], postoperative complications included anterior knee joint pain in eight cases and superficial infections in four cases.

Similarly, Sengodan et al. [11](2014) reported a Poller screw-related complication in one case, where a new fracture line appeared during nail insertion after Poller screw placement. Despite this, alignment was achieved and maintained, and the fracture united within eight weeks.

Conclusion

Intramedullary nailing, supplemented with blocking screws, is an effective and reliable method for the fixation of proximal and distal metaphyseal tibial fractures. This approach not only achieves and maintains reduction but also leverages the well-known benefits of intramedullary fixation. However, the procedure requires meticulous preoperative planning, particularly regarding the initial deformity and the optimal placement of blocking screws.

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