

Blocking Pins Instead of Blocking Screws in the Treatment of Distal Tibial Fractures with Intramedullary Nail

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Abstract

Background: Distal tibial fractures have a high risk of malalignment when treated with intramedullary nails. The use of blocking screws can aid in achieving satisfactory alignment. The aim of this study was to compare the clinical and radiographic outcomes of temporary blocking pins with those of blocking screws for distal tibial fractures.

Methods: From June 2011 through November 2018, a total of 90 patients with distal tibial fractures were enrolled in this prospective randomized controlled study. The patients were randomly received either blocking pins or blocking screws reduction during nailing. After reduction, 5 points at the distal fragment were effectively fixed.

Results: The operating time in the BP group was 73.77 ± 6.25 min, which was significantly shorter than 80.05 ± 8.51 min in the BS group ($P < 0.001$). The time to healing in the BP group was shorter than that in the BS group (18.52 ± 4.57 vs. 21.51 ± 3.17 weeks; $P = 0.001$). The coronal and sagittal plane deformities at any time points were comparable (all $P \geq 0.05$). During the 12-month follow-up period, patients had an average change in the coronal plane of 1.34 degrees in the BP group and 1.00 degrees in the BS group ($P = 0.120$), as well as an average change in the sagittal plane of 1.09 degrees and 0.81 degrees ($P = 0.110$), respectively. Malunion was seen in two patients (5%) in the BP group and one patient (2%) in the BS group ($P \geq 0.05$).

Conclusion: The blocking pins can help achieve satisfactory alignment for distal tibial fractures during nailing. Intramedullary nails without blocking screws can afford adequate stability to maintain the reduction during the healing process when an effective five-point anchoring fixation is achieved.

Introduction

Modern intramedullary nail (IMN) technique is the standard treatment for long bone fractures [1, 2], which can provide favorable reduction and stabilization. However, it is difficult to achieve good reduction if nail does not properly fit in the larger canal of distal diaphyseal and metaphyseal segments [3–5]. In order to achieve a satisfactory reduction, multiple techniques including manual traction, percutaneous clamping, external fixation and temporary unicortical plating have been proposed. The blocking screws (BS), introduced by Kretek [6], attempted to provide improved reduction and stabilization by narrowing the canal available for nail placement and directing nail to the desired position [6–8]. Then, the BS was left in place to maintain the achieved reduction [8–12]. Compared to other methods, the BS could provide a more predictable reduction [6, 13]. As long as the screw is in the correct position, the reduction is generally satisfactory, which is just like an equation. The clinical practices of BS in proximal and distal tibial fractures and distal femur fractures have been well reported [8–11]. Nevertheless, the complications related to the BS might compromise the operative outcomes, including screw breakage, iatrogenic bone splitting, adjacent soft tissue irritation, and higher risk of hardware removal. Wang et al [14] used Kirschner wire instead of BS to treat 9 tibial (proximal or distal) metaphyseal fractures, and obtained the

improved alignment and functional outcomes. Poyanlı et al [15] used temporary K-wires instead of BS to treat 7 distal femoral, 2 proximal tibial, and 4 distal tibial diaphyseal fractures, and 12 of 13 fractures achieved successful alignment and maintain it to fracture union. However, the evidences supporting K-wires in place of BS remain insufficient and it remains a controversy whether it is necessary to retain the BS after achieving the reduction.

We established a protocol of blocking pins (BP) augmented with 5-point anchoring fixation in place of BS in IMN fixation of distal third tibial fractures. The BP is a 3.0 mm diameter steinmann pin, which is used during reduction and removed after fixation of distal inter-locking screws. We designed this prospective randomized controlled trial and the aim was to assess clinical and radiographic outcomes of distal tibial fractures treated following this protocol. We hypothesize that BP can achieve the same reduction and maintain it until the fracture union.

Materials And Methods

This was a prospective study. The protocol and informed consent forms were reviewed and approved by the Institutional Review Board (IRB) of the 3rd Hospital of Hebei Medical University, Shijiazhuang, PR China. All patients participating in this study signed the written informed consent. The study was conducted in accordance with the Declaration of Helsinki.

Patients

From June 2011 through November 2018, a consecutive cohort of patients aged eighteen years or older who had a definite diagnosis of an acute fracture of the distal 1/3 tibia with indications for treatment with IMN were enrolled. Exclusion criteria were as follows: AO/OTA 43 fractures, open fractures, pathological fractures, multiple fractures or preexisting diseases affecting activities of the ipsilateral lower limbs. Based on a sequence number randomly generated by a computer, patients were randomized into the BP group or the BS group. A plaster splint was used as a temporary fixation to reduce swelling in each patient.

Surgical Technique

Under general anesthesia or epidural anesthesia, patients were placed on a radiolucent table in a supine position. The lateral malleolus fracture was plated when it was less than 6cm from the fibula tip. If any, accompanying posterior malleolus fracture was reduced in a closed manner, and fixated with annulated screws, prior to nailing [16]. A trans-patellar tendon approach was used with the knee in a flexed position. Percutaneous manipulation was performed to obtain and maintain an approximate reduction. A guidewire was introduced into the fracture site prior to reaming. A 3.0 mm smooth Steinmann pin was used as a BP. "Concave side" principle [6] and "Acute angle" principle [13] were followed to reduce the lateral displacement and angular displacement respectively. The location of BP is 6.0-7.0 mm from the center of the canal, approximately one-third of the canal diameter in the AP view, and 2.0 cm from the fracture line [13]. If necessary, a second pin was inserted from the medial to lateral direction to correct

deformity in the sagittal plane, namely, bi-planar modifier. The ball-tipped guidewire was then inserted at the correct side. The critical techniques included the central placement of the ball-tipped guidewire in the distal fragment and reaching a subchondral level, approximately 5.0 mm from the articular surface. The nail was inserted to a subchondral level after sequential reaming. The position of BP could be corrected until a satisfactory reduction was achieved. Thereafter, the proximal end of the nail was locked with two cross static locking screws, and the distal end of the IMN was locked with two parallel transverse interlocking screws. In the BP group, the pin was removed after fixation of distal interlocking screws. Alternatively, the pin was replaced with a screw in the BS group. All procedures were performed under fluoroscopic control.

We categorized fractures into two types according to the positional relationship of the main fragments. Type 1 is defined as a fracture that the dominant deformity is lateral displacement and the angle between the proximal and distal axis is less than 20° in the AP view. The majority of this type fractures are AO type A fractures. Type 2 is a type of fracture that the dominant deformity is angulation with the angle between the proximal and distal axis being above 20° in the AP view. The majority of this type fractures are AO type B and type C fractures. For type 1 fracture, we followed the “acute angle” principle, proposed by Hannah et al [13] to place the BP or screw in the acute angle of the metaphyseal (distal) segment. For type 2 fracture, we followed the “concave side” principle, advocated by Krettek et al [6], to place the BP or BS in the concave side of the metaphyseal (distal) segment. Special emphasis should be placed on achieving adequate visualization of each process on the distal segments in both planes until fixation of distal interlocking screws.

All the operations were performed by three senior trauma surgeons specialized in IMN.

The parameters including age, sex, smoking, diabetes, injury characteristics, articular involvement, AO/OTA classification, interval from initial injury to surgery, intraoperative blood loss, number of BP or BS, and operating time were recorded among BP and BS group (**Table 1**).

Postoperative management

The same postoperative protocol was used in all patients. After 24 h of the operation, patients were advised to begin an early, active, full range of motion of the ankle and knee joints within the limits of their comfort. Gradually, weight-bearing was permitted based on the signs of fracture callus visualized on postoperative radiographs. Standard anteroposterior and lateral radiographs were taken every month until fracture healing, then taken every three months to evaluate potential complications.

Outcomes Evaluation

Fracture union was defined as full weight-bearing without pain and bridging callus of 3 or 4 cortices on x-rays. Failure to achieve this at 6 months was defined as delayed union, and failure to achieve this at 9 months was defined as nonunion [17]. Coronal and sagittal alignments were evaluated using technique described by Freedman and Johnson [18]. Varus and recurvatum angulation were expressed as negative

values, and valgus and antecurvatum as positive values. Satisfactory reduction and alignment is defined as less than 5° angulation in both planes. Leg length and rotational angulation were not measured. The quality of fracture reduction, fracture union time, alignment at 6 and 12 months and loss of reduction at 12 months were recorded. Unplanned secondary surgery and complications (including wound dehiscence, infection, soft tissue irritation, and malunion/delayed union/nonunion) were recorded. The American Orthopaedic Foot and Ankle Society (AOFAS) scoring system [19] was used to evaluate the functional outcome at the last follow-up examination (≥ 12 months).

Statistical Analysis

The data were analyzed with the use of SPSS software 25.0 (SPSS, IBM, Armonk, NY, USA). The continuous data were expressed as mean and standard deviation or median and range, and were evaluated using Student-*t* test or Mann Whitney U test. Categorical data were expressed as number and percentage, and were evaluated using Chi-square test or Fisher exact test. P values less than 0.05 were considered to represent a significant difference.

Results

During the study period, a total of 90 patients sustaining a distal tibial fracture were enrolled. Of them, 46 (51%) patients were randomized to the BP group and 44 (49%) to the BS group, with a mean age of 45.6 years and 42.3 years, respectively. During follow-up period, 3 patients, 2 in the BP group and 1 in the BS group were lost, leaving 87 patients for data analysis. The age, gender, side of injury, smoking, diabetes, mechanism of injury, AO/OTA classification, the interval between injury and surgery and follow-up period of patients in both groups were summarized in Table 1, all of which were significantly comparable between the BP and BS group. All patients underwent closed reduction and IMN fixation.

The average intraoperative blood loss was 87.32 mL in the BP group and 96.26 mL in the BS group ($p = 0.126$). The average operating time of the BP group was significantly shorter than that of the BS group (73.77 vs. 80.05 min, $p < 0.001$). Six patients (4 in BP group vs. 2 in BS group, $P = 0.676$) who had concomitant posterior malleolus fractures underwent closed reduction and were treated with percutaneous lag screw fixation before the placement of IMN. Five distal fibula fractures (2 in BP group vs. 3 in BS group, $P = 0.676$) were plated to increase the ankle stability. In the BP group, 41 fractures were reduced with one BP, and 3 fractures with two. In the BS group, 42 fractures were reduced with one BS, and 1 fracture with two ($p = 0.713$). Surgical characteristics were summarized in Table 2.

The average coronal plane deformities immediately after surgery, at 6 months and 12 months after surgery were 1.09 degree, 1.91 degrees, and 2.11 degrees in the BP group, as well as 0.72 degree, 1.19 degrees, and 1.40 degrees in the BS group. The average sagittal plane deformities immediately after surgery, at 6 months and 12 months after surgery were 1.86 degrees, 2.39 degrees, and 2.55 degrees in the BP group, as well as 1.23 degree, 1.63 degrees, and 1.77 degrees in the BS group (all $P \geq 0.05$). During the period from immediately after surgery to postoperative 12-month follow-up, patients had an average change in the coronal plane of 1.34 degrees in the BP group and 1.00 degrees in the BS group ($P = 0.120$),

as well as an average change in the sagittal plane of 1.09 degrees and 0.81 degrees ($P = 0.110$), respectively. There was no significant difference in deformities and angular changes of both coronal and sagittal planes between groups (Table 3).

The average time to healing in the BP group was 18.52 weeks, significantly less than 21.51 weeks in the BS group ($p = 0.001$). Malunion was seen in two patients (5%) in the BP group (one patient had 7° valgus and one had 8° valgus deformity) and one patient (2%) in the BS group (7° valgus deformity) ($p = 1.000$). Delayed union occurred in six patients (3 in the BP group vs. 3 in the BS group) ($p = 1.000$). Two fractures (1 in the BP group vs. 1 in the BS group) healed spontaneously within 7 months without further intervention. Three fractures (1 in the BP group vs. 2 in the BS group) healed following a limb functional brace for two months. Following a bone grafting procedure, the remaining patients in the BP group achieved bone union 3 months later. Two patients underwent removal of BS due to soft tissue irritation ($p = 0.241$). At last follow-up, the average AOFAS score was 82.20 in the BS group and 84.88 in the BP group ($P = 0.126$). Clinical outcomes were summarized in Table 4.

One typical case is shown in Fig. 1.

Discussion

This study investigated the clinical and radiographic outcomes of BP compared to BS in treatment of distal tibial fractures with IMN. The hypothesis of the current study was confirmed that BP could achieve similarly improved reduction and maintain it until the fracture union. There was no significant difference in deformities and angular changes of both coronal and sagittal planes between groups, but the BP group required shorter operating time and fracture union time.

IMN is more acceptable in the treatment of distal tibial fracture due to the minimized soft tissue dissection, protection of extraosseous blood supply, and superiority in axial loading [20, 21]. Some studies have reported that it potentially increased the risk of deformity healing [21–27]. This deformity may originate from an insufficient initial reduction or later loss of reduction. BS can help to achieve satisfactory initial reduction by narrowing the canal available for nail placement [6, 7, 28]. In order to pursue a better result, BP were used to replace BS in this study. Both groups of patients were reduced by BP, and successful reductions were achieved in all fractures without intraoperative adverse events, consistent with other reported results [6, 12]. To achieve a satisfactory reduction, it is important to adhere to the placement principles mentioned in surgical technique, more important to have a standard entry point and a centered end point [29]. Otherwise, there may be eccentric reaming and deformities after nailing.

When satisfactory initial reduction is achieved, does the IMN alone provide sufficient mechanical strength to maintain stability without loss of reduction? De Giacomo and Tornetta [17] treated 117 distal tibia fractures with a standard IMN (2 medial-lateral distal interlocking screws), and the malalignment rate was 2%. In their study, no significant loss of reduction (average change of 0.9 degrees in both the coronal and sagittal planes) was observed after surgery, which was consistent with our results. In the present study,

all patients in the BP group were fixed with a standard IMN after reduction, and the average loss of reduction in coronal and sagittal plane at 1 year after surgery was 1.34 and 1.09 degrees, respectively. Collinge et al [30] used percutaneous clamping to reduce tibial fractures and after a satisfactory reduction all fractures were fixed with a traditional IMN. In their study, only one patient had a notable loss of reduction, where alignment changed from anatomic to acceptable. Stedtfeld et al [8] proposed three-point fixation of the short fragment (isthmus, the blocking screw, and the nail tip), which could achieve a good axial alignment when the nail was in the central position. In order to achieve the maximum mechanical strength of the IMN, the five metal-bone contact points at the distal fragment must be effectively fixed (picture 1). Our 5-point anchoring fixation is a strengthened combinational fixation than the simple nail tip fixation(Fig. 1-i), which can maintain the reduction and stability of the IMN. IMN was generally placed to the subchondral level, about 5 mm to the articular surface which is the solidest area of the metaphysis [20]. This is just like the "rooting technique" proposed by Zhu et al [31]. Either of the two transverse interlocking screws fixed two cortices (medial and lateral), constituting the remaining 4 points. The bone surrounding the 2 distal transverse screws must remain intact. The technique of perfect circle can be applied to avoid damaging cortical bone. When these 5 points were properly fixed, the distal fragment would be integrated with the IMN, and there was almost little pendulum between IMN and bone. When modern fluoroscopic techniques are used to allow for visualization through distal locking, 5-point anchoring fixation is easy to achieve. In the BP group, 42 patients achieved effective 5-point anchoring fixation, and the fractures healed in successful alignment without significant loss of reduction.

The process of fracture healing is complex and can be influenced by biological and mechanical factors. Interfragmentary micro-movements should have a certain magnitude and a limiting force, and excessive force will cause delayed union and non-union [32]. Biomechanical studies showed that angular stable IMN can improve stability and reduce interfragmentary movements in treatment of distal tibial fractures [33, 34]. However, this improvement in mechanics had not improved clinical outcomes [35]. The unicortical plate and universal fixator could assist in reduction and increased stability, but was often used as a temporary fixation and removed after nailing[36]. Fibular plate can also assist in reduction and increase mechanical stability in treatment of distal tibial fractures with IMN [37, 38], but it provided no improvement and even slowed fracture union in clinical studies [17, 39]. The above information suggested that blindly increasing stability would not bring benefits to fracture healing, which was also demonstrated in this study. With the persist assistance of BS, the mechanical strength of IMN increased [40]. But the average union time of the BS group (88.5 vs. 97 min, $p < 0.001$) was significantly longer than that of the BP group.

The BP, a 3.0-mm-diameter Steinmann pin, has the following advantages. Firstly, the smooth surface reduces friction and the probability of damage to metal equipment. Secondly, more elastic and proper compromises can be made when the nail is inserted without iatrogenic fracture Thirdly, it is easy to control and adjust the position. Fourthly, direct extraction can shorten the operation time, reduce costs, and avoid the prominent irritation to the adjacent soft tissue. We select a 3.0-mm-diameter Steinmann pin, because the thinner one is too soft and the thicker one is more destructive and prone to producing a new iatrogenic fracture. In this study, the Steinmann pin was used to assist reduction in both groups, and

no intraoperative adverse events occurred. Two patients in the BS group underwent removal of the BS due to soft tissue irritation.

The use of BS is an ideal technique to decrease the incidence of mal-alignment in treatment of tibial fractures with displacement [6]. In this study, satisfactory reduction and radiographic alignment within five degrees were achieved for all patients as shown by immediate postoperative radiographs. The union rates and complications were not different between groups, indicating that the outcomes were not affected by replacing the screw with a pin. Following the removal of the BP during surgery, satisfactory reduction and stability were maintained. There was no statistically significant difference between the two groups in loss of alignment, although 3 patients developed malunion. The reason for 1st malunion in the BP group was that the bone around the distal locking screws was damaged during drilling, and no obvious reasons for the other 2 cases. Therefore, if an effective 5-point fixation cannot be achieved during locking of the distal fragment, surgeons should consider placing BS to increase stability. Two patients underwent removal of BS due to soft tissue irritation although there is no statistical difference in rate of soft tissue irritation. The BP group did not have such a risk, and this difference may be reflected in future large-scale studies.

While this study demonstrates similar results of BP and BS, we only applied this technique on closed, distal third tibial fractures (OTA 42-A1 to C3) fractures. It remains a matter of debate whether OTA 43 fractures should be treated by closed reduction and IMN fixation. Additionally, due to the complexity of fracture healing, this study cannot be simulated by an equivalent biomechanical experiment. Future studies should focus on stability after removal of the BP and the possibility of early weight-bearing with biomechanical studies.

Conclusion

The blocking pins can help achieve satisfactory alignment for distal tibial fractures during nailing. Intramedullary nails without blocking screws can afford adequate stability to maintain the reduction during the healing process when an effective five-point anchoring fixation is achieved.

Abbreviations

IMN: Intramedullary nail; BS: blocking screw; BP: blocking pin

Declaration

Ethics approval and consent to participate

This study was approved by the Institutional Review Board (IRB) of the 3rd Hospital of Hebei Medical University, Shijiazhuang, PR China. All patients participating in this study signed the written informed consent.

Consent for publication

Written informed consent was obtained from each patients' parents for the publication of this study and the accompanying images.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not in public but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

HTW designed and supervised the study; LJM and SQY searched relevant studies on the subject; SL and PCR analyzed data; XDB and ZHS wrote the manuscript and PCW made manuscript revisions. XDB approved the final version of the manuscript. All authors read and approved the final manuscript.

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Not applicable.

Tables

Table 1. The demographic of the patients in both groups

Parameters	BP Group (n=44)	BS Group (n=43)	Statistics	P-value
Age (years, mean±SD)	42.3±9.3	45.6±10.9	-1.493	0.140
Gender, n (%)			0.092	0.762
Male	30(68.2%)	28(65.1%)		
Female	14(31.8%)	15(34.9%)		
Side of injury, n (%)			0.946	0.331
Left	23(52.3%)	18(41.9%)		
Right	21(47.7%)	25(58.1%)		
Smoker, n (%)	13(29.5%)	9(20.9%)	0.854	0.355
Diabetes, n (%)	5(11.4%)	8(18.6)	0.897	0.344
Injury mechanism, n (%)			2.768	0.597
Falls from standing	19(43.2%)	17(39.5%)		
Fall from height	7(15.9%)	10(23.3%)		
Industrial injury	5(11.4%)	6(14.0%)		
Traffic accident	11(25.0%)	10(23.3%)		
Others	2(4.5%)	0(0%)		
AO/OTA classification, n (%)			9.887	0.195
42A1	18(40.9%)	21(48.8%)		
42A2	10(22.7%)	6(14%)		
42A3	2(4.5%)	2(4.7%)		
42B1	0(0%)	2(4.7%)		
42B2	4(9.1%)	4(9.3%)		
42B3	4(9.1%)	0(0%)		
42C1	2(4.5%)	6(14%)		
42C2	0(0%)	0(0%)		
42C3	4(9.1%)	2(4.7%)		
Time to nail (day, median (IQR))	3(2)	4(3)	-1.160	0.246
Follow-up period (months, mean±SD)	15.95±2.01	16.21±2.54	-0.519	0.605

Table 2. Surgical characteristics

Parameters	BP Group (n=44)	BS Group (n=43)	Statistics	P-value
Operating time(min, mean±SD)	73.77±6.25	80.05±8.51	-3.925	0.000
Intraoperative blood loss (mL, mean±SD)	87.32±19.63	96.26±32.51	-1.548	0.126
Distal fibula plate fixation n (%)	2(4.5%)	3(7%)		0.676
Posterior malleolus screw fixation n (%)	4(9.1%)	2(4.7%)		0.676
Number of blocking pins/screws n (%)				0.713
One BP/BS	41(93.2%)	39(90.7%)		
Two BP/BS	3(6.8%)	4(9.3%)		

Table 3. Fracture alignment

Parameters	BP Group (n=44)	BS Group (n=43)	Statistics	P-value
Coronal plane deformity				
Immediately after surgery (degree, mean±SD)	1.09±1.94	0.72±1.61	-1.288	0.198
6-months after surgery (degree, mean±SD)	1.91±2.67	1.19±2.34	-1.421	0.155
12-months after surgery (degree, mean±SD)	2.11±2.73	1.40±2.32	-1.393	0.164
Sagittal plane deformity				
Immediately after surgery (degree, mean±SD)	1.86±2.08	1.23±2.43	-1.324	0.186
6-months after surgery (degree, mean±SD)	2.39±2.15	1.63±2.59	-1.431	0.152
12-months after surgery (degree, mean±SD)	2.55±2.23	1.77±2.57	-1.490	0.136
Coronal plane-Angular changes (degree, mean±SD)	1.34±0.99	1.00±0.87	-1.553	0.120
Sagittal plane-Angular changes (degree, mean±SD)	1.09±0.77	0.81±0.66	-1.598	0.110

Table 4. clinical outcomes

Parameters	BP Group (n=44)	BS Group (n=43)	Statistics	P-value
AOFAS (mean±SD)	82.20±8.53	84.88±7.62	-1.543	0.126
Time to union (week, mean±SD)	18.52±4.57	21.51±3.17	-3.540	0.001
Complication n (%)	5 (11%)	6 (14%)	0.132	0.716
Malunion	2 (5%)	1 (2%)		1.000
Delayed union	3 (7%)	3 (7%)		1.000
Nonunion	0(0%)	0(0%)		1.000
Softtissue irritation	0 (0%)	2 (5%)		0.241
Unplanned secondary surgery n (%)	1(2.3%)	3(7%)		0.360

Reference

1. Bong MR, Koval KJ, Egol KA: **The history of intramedullary nailing.** *Bull NYU Hosp Jt Dis* 2006, **64**(3-4):94-97.
2. Triantafillou K, Barcak E, Villarreal A, Collinge C, Perez E: **Proper Distal Placement of Tibial Nail Improves Rate of Malalignment for Distal Tibia Fractures.** *Journal of orthopaedic trauma* 2017, **31**(12):e407-e411.
3. Vallier HA, Cureton BA, Patterson BM: **Randomized, prospective comparison of plate versus intramedullary nail fixation for distal tibia shaft fractures.** *Journal of orthopaedic trauma* 2011, **25**(12):736-741.

4. Pairon P, Ossendorf C, Kuhn S, Hofmann A, Rommens PM: **Intramedullary nailing after external fixation of the femur and tibia: a review of advantages and limits.** *Eur J Trauma Emerg Surg* 2015, **41**(1):25-38.
5. Beebe MJ, Morwood M, Serrano R, Quade JH, Auston DA, Watson DT, Sanders RW, Mir HR: **Extreme Nailing: Is It Safe to Allow Immediate Weightbearing After Intramedullary Nail Fixation of Extra-articular Distal Tibial Fractures (OTA/AO 43-A)?** *Journal of orthopaedic trauma* 2019, **33**(8):392-396.
6. Krettek C, Stephan C, Schandelmaier P, Richter M, Pape HC, Miclau T: **The use of Poller screws as blocking screws in stabilising tibial fractures treated with small diameter intramedullary nails.** *The Journal of bone and joint surgery British volume* 1999, **81**(6):963-968.
7. Krettek C, Miclau T, Schandelmaier P, Stephan C, Mohlmann U, Tscherne H: **The mechanical effect of blocking screws ("Poller screws") in stabilizing tibia fractures with short proximal or distal fragments after insertion of small-diameter intramedullary nails.** *Journal of orthopaedic trauma* 1999, **13**(8):550-553.
8. Stedtfeld HW, Mittlmeier T, Landgraf P, Ewert A: **The logic and clinical applications of blocking screws.** *The Journal of bone and joint surgery American volume* 2004, **86-A Suppl 2**:17-25.
9. Ricci WM, O'Boyle M, Borrelli J, Bellabarba C, Sanders R: **Fractures of the proximal third of the tibial shaft treated with intramedullary nails and blocking screws.** *Journal of orthopaedic trauma* 2001, **15**(4):264-270.
10. Ostrum RF, Maurer JP: **Distal third femur fractures treated with retrograde femoral nailing and blocking screws.** *Journal of orthopaedic trauma* 2009, **23**(9):681-684.
11. Ricci WM, Bellabarba C, Evanoff B, Herscovici D, DiPasquale T, Sanders R: **Retrograde versus antegrade nailing of femoral shaft fractures.** *Journal of orthopaedic trauma* 2001, **15**(3):161-169.
12. Moongilpatti Sengodan M, Vaidyanathan S, Karunanandaganapathy S, Subbiah Subramanian S, Rajamani SG: **Distal tibial metaphyseal fractures: does blocking screw extend the indication of intramedullary nailing?** *ISRN Orthop* 2014, **2014**:542623.
13. Hannah A, Aboelmagd T, Yip G, Hull P: **A novel technique for accurate Poller (blocking) screw placement.** *Injury* 2014, **45**(6):1011-1014.
14. Wang Q, Luo JN, Li XB: **Kirschner wire as blocking screws for the treatment of tibial metaphyseal fractures.** *Zhongguo gu shang = China journal of orthopaedics and traumatology* 2014, **27**(12):1040-1042.
15. Poyanli OS, Soylemez MS, Ozkut AT, Esenkaya I, Unal OK, Kilincoglu V: **Use of provisional K wires instead of Poller screws for treatment of diaphyseal fractures of the distal femur and proximal and distal tibia.** *Acta orthopaedica Belgica* 2016, **82**(3):579-585.
16. Mitchell PM, Harms KA, Lee AK, Collinge CA: **Morphology of the Posterior Malleolar Fracture Associated With a Spiral Distal Tibia Fracture.** *Journal of orthopaedic trauma* 2019, **33**(4):185-188.
17. De Giacomo AF, Tornetta P, 3rd: **Alignment After Intramedullary Nailing of Distal Tibia Fractures Without Fibula Fixation.** *Journal of orthopaedic trauma* 2016, **30**(10):561-567.

18. Freedman EL, Johnson EE: **Radiographic analysis of tibial fracture malalignment following intramedullary nailing.** *Clin Orthop Relat Res* 1995(315):25-33.
19. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M: **Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes.** *Foot Ankle Int* 1994, **15**(7):349-353.
20. Talerico M, Ahn J: **Intramedullary Nail Fixation of Distal Tibia Fractures: Tips and Tricks.** *Journal of orthopaedic trauma* 2016, **30** Suppl 4:S7-S11.
21. Hu L, Xiong Y, Mi B, Panayi AC, Zhou W, Liu Y, Liu J, Xue H, Yan C, Abududilibaier A *et al*: **Comparison of intramedullary nailing and plate fixation in distal tibial fractures with metaphyseal damage: a meta-analysis of randomized controlled trials.** *Journal of orthopaedic surgery and research* 2019, **14**(1):30.
22. Ruecker AH, Hoffmann M, Rupprecht ME, Rueger JM: **Distal tibial fractures: intramedullary nailing.** *European Journal of Trauma and Emergency Surgery* 2009, **35**(6):520-526.
23. Seyhan M, Kocaoglu B, Gereli A, Nalbantoglu U, Turkmen M: **Treatment for distal tibial fractures with intramedullary nails and blocking screws.** *European Journal of Orthopaedic Surgery & Traumatology* 2012, **22**(5):395-401.
24. Nork SE, Schwartz AK, Agel J, Holt SK, Schrick JL, Winkquist RA: **Intramedullary nailing of distal metaphyseal tibial fractures.** *The Journal of Bone & Joint Surgery* 2005, **87**(6):1213-1221.
25. Xue X-H, Yan S-G, Cai X-Z, Shi M-M, Lin T: **Intramedullary nailing versus plating for extra-articular distal tibial metaphyseal fracture: a systematic review and meta-analysis.** *Injury* 2014, **45**(4):667-676.
26. Liu XK, Xu WN, Xue QY, Liang QW: **Intramedullary Nailing Versus Minimally Invasive Plate Osteosynthesis for Distal Tibial Fractures: A Systematic Review and Meta-Analysis.** *Orthopaedic surgery* 2019, **11**(6):954-965.
27. Kwok CS, Crossman PT, Loizou CL: **Plate versus nail for distal tibial fractures: a systematic review and meta-analysis.** *Journal of orthopaedic trauma* 2014, **28**(9):542-548.
28. Shahulhameed A, Roberts CS, Ojike NI: **Technique for precise placement of poller screws with intramedullary nailing of metaphyseal fractures of the femur and the tibia.** *Injury* 2011, **42**(2):136-139.
29. Brinkmann E, DiSilvio F, Tripp M, Bernstein M, Summers H, Lack WD: **Distal Nail Target and Alignment of Distal Tibia Fractures.** *Journal of orthopaedic trauma* 2019, **33**(3):137-142.
30. Collinge CA, Beltran MJ, Dollahite HA, Huber FG: **Percutaneous clamping of spiral and oblique fractures of the tibial shaft: a safe and effective reduction aid during intramedullary nailing.** *Journal of orthopaedic trauma* 2015, **29**(6):e208-212.
31. Zhu HB, Wu LG, Fang ZS, Luo CF, Wang QF, Ma YP, Gao H, Fu GH, Hu CT: **[Clinical application of blocking screws and rooting technique in the treatment of distal tibial fracture with interlocking intramedullary nail].** *Zhongguo gu shang = China journal of orthopaedics and traumatology* 2012, **25**(7):569-571.

32. Kenwright J, Goodship AE: **Controlled mechanical stimulation in the treatment of tibial fractures.** *Clin Orthop Relat Res* 1989(241):36-47.
33. Horn J, Linke B, Hontzsch D, Gueorguiev B, Schwieger K: **Angle stable interlocking screws improve construct stability of intramedullary nailing of distal tibia fractures: a biomechanical study.** *Injury* 2009, **40**(7):767-771.
34. Gueorguiev B, Ockert B, Schwieger K, Wahnert D, Lawson-Smith M, Windolf M, Stoffel K: **Angular stability potentially permits fewer locking screws compared with conventional locking in intramedullary nailed distal tibia fractures: a biomechanical study.** *Journal of orthopaedic trauma* 2011, **25**(6):340-346.
35. Hontzsch D, Schaser KD, Hofmann GO, Pohlemann T, Hem ES, Rothenbach E, Krettek C, Attal R: **Evaluation of the effectiveness of the angular stable locking system in patients with distal tibial fractures treated with intramedullary nailing: a multicenter randomized controlled trial.** *The Journal of bone and joint surgery American volume* 2014, **96**(22):1889-1897.
36. Meena RC, Meena UK, Gupta GL, Gahlot N, Gaba S: **Intramedullary nailing versus proximal plating in the management of closed extra-articular proximal tibial fracture: a randomized controlled trial.** *J Orthop Traumatol* 2015, **16**(3):203-208.
37. Egol KA, Weisz R, Hiebert R, Tejwani NC, Koval KJ, Sanders RW: **Does fibular plating improve alignment after intramedullary nailing of distal metaphyseal tibia fractures?** *Journal of orthopaedic trauma* 2006, **20**(2):94-103.
38. Nork SE, Schwartz AK, Agel J, Holt SK, Schrick JL, Winkquist RA: **Intramedullary nailing of distal metaphyseal tibial fractures.** *The Journal of bone and joint surgery American volume* 2005, **87**(6):1213-1221.
39. Javdan M, Tahririan MA, Nouri M: **The Role of Fibular Fixation in the Treatment of Combined Distal Tibia and Fibula Fracture: A Randomized, Control Trial.** *Adv Biomed Res* 2017, **6**:48.
40. Abdelazeem H, Abdelazeem A, Al-Dars A, Hegazy M, Abdellatif N: **Triple attack technique for non-union of femoral neck fractures.** *International orthopaedics* 2016, **40**(4):807-812.

Figures

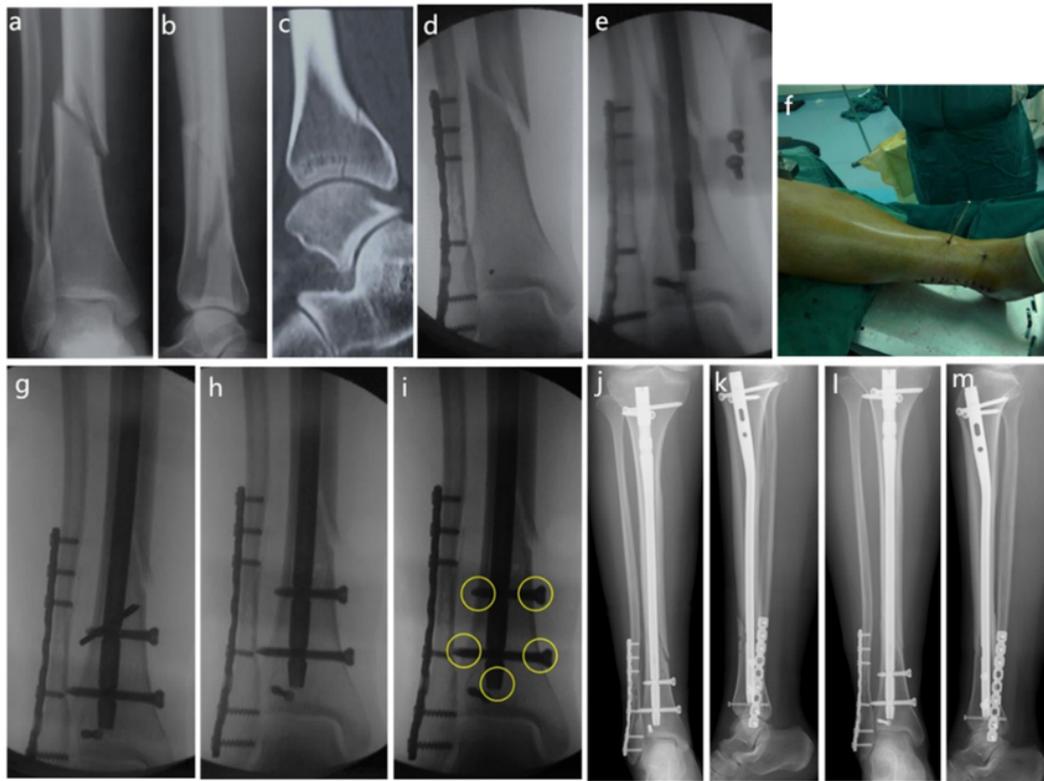


Fig. 1 Preoperative, intra-operative, and postoperative graphs of a patient with distal tibiofibular fractures and a posterior malleolar fracture. **a-c** Preoperative X-ray and CT. **d-e** The fibula and posterior malleolar fractures were fixed. The tibial fracture had a lateral displacement after insertion of the IMN. **f-g** A blocking pin was introduced to achieve a satisfactory reduction. **h-i** The blocking pin was removed after 5-point anchoring fixation. **j-k** Postoperative X-ray. **l-m** The fracture healed at 17 weeks after surgery.

Figure 1

Preoperative, intra-operative, and postoperative graphs of a patient with distal tibiofibular fractures and a posterior malleolar fracture.