Fractures of the Proximal Third of the Tibial Shaft Treated With Intramedullary Nails and Blocking Screws

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Objectives: To describe the technique and results of using blocking screws and intramedullary nails to treat patients with fractures of the proximal third of the tibial shaft.

Design: Prospective.

Setting: Level I trauma centers.

Patients: Twelve consecutive patients treated with intramedullary nailing and blocking screws for fractures of the proximal third of the tibial shaft.

Intervention: Patients were treated with intramedullary nails and blocking screws.

Main Outcome Measure: The alignment of fractures was determined using standard anteroposterior and lateral radiographs after surgery and at each follow-up examination. One patient was lost to follow-up. All other patients were followed at regular intervals until union or establishment of a nonunion. Changes in alignment and complications were noted.

Results: 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.

Conclusions: Blocking screws are effective to help obtain and maintain alignment of fractures of the proximal third of the tibial shaft treated with intramedullary nails.

Key Words: Tibia fracture, Proximal, Alignment, Blocking screws, Intramedullary nails

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INTRODUCTION

Intramedullary nailing is the standard treatment for most patients with fractures of the tibial shaft.[3,4,6,7,19,20] Patients with fractures of the proximal third of the tibial shaft treated with intramedullary nails have a high incidence of angular malalignment. Valgus and apex anterior malalignment and anterior displacement of the proximal fragment are the most common deformities.[2,5,8,10,17,18]

To obtain a reliably satisfactory reduction of fractures of the proximal third of the tibia, the nail must be aligned with the central axis of the proximal and distal tibial fracture fragments. To accomplish this, several technical modifications to standard intramedullary nailing technique have been proposed, including the use of a proximal starting point for nail entry,[10,11] a lateral starting point for nail entry,[8,17] a neutral insertion angle in the coronal and sagittal planes,[5,8,10,11,17] a femoral distractor,[5] nailing with the knee in a flexed position combined with interlocking in extended position,[5] a patellar tendon-splitting approach,[8] and lateral subluxation of the patella with the knee in a semiextended position.[18] Blocking screws placed within the proximal fragment also have been used to help maintain the nail within the central axis of this fragment. The narrow isthmus serves to maintain the nail centered within the distal fragment. Krettek et al[13] have described the use of such blocking screws to supplement intramedullary fixation of proximal and distal tibia fractures and distal femur fractures.

The goal of this study was to describe our technique of using blocking screws in conjunction with intramedullary nails to obtain and maintain alignment of fractures of the proximal third of the tibial shaft and to review our results with this technique.

MATERIALS AND METHODS

Inclusion Criteria

Between August 1998 and January 1999, twelve consecutive patients with twelve extraarticular fractures of the proximal third of the tibial shaft, that is, between the tibial tubercle and ten centimeters distal to the tubercle, were treated with intramedullary nails and blocking screws.

Patient Characteristics

Eleven of the patients were men and one was a woman. The mean and median ages were forty-seven and forty-five years (range 18 to 80 years), respectively. The mechanisms of injury included motor vehicle accident (n = 5), pedestrian struck by a motor vehicle (n = 4), fall (n = 1), stress fracture (n = 1), and pathologic fracture (n = 1). When classified according to Winquist et al,[21] there were four Type I, one Type II, six Type III, and one Type IV comminutions. When classified according to the Orthopaedic Trauma Association,[1] there were four 42A, seven 42B, and one 42C Type fractures. There were six closed and six open fractures. According to the grading system of Gustilo and Anderson,[9] there were four Grade IIIA and two Grade IIIB open fractures.

Four patients had been previously treated with intramedullary tibial nailing for proximal tibia fractures and were thought to be unacceptably aligned when they were examined at our institutions. One patient was seen one day after initial treatment and had 10 degrees of valgus angulation (Fig. 1A to D). Another patient was examined six weeks after initial treatment and had 30 degrees of varus angulation. Two patients had established nonunions that were also malaligned. One of these patients was initially treated for a stress fracture with two antegrade placed Enders nails. She had a nonunion with 32 degrees of apex anterior angulation and 5 degrees of valgus. The other patient had a pathologic fracture treated with a reamed intramedullary nail that led to a nonunion with 15 degrees of apex anterior angulation.

Implant Characteristics

The Titanium Tibial nail (Synthes USA, Paoli, PA, USA) was used in six patients. The Russell-Taylor Tibial Nail (Smith & Nephew Richards, Inc., Memphis, TN, USA) in five patients, and the AIM Titanium Tibial nail (DePuy ACE, Warsaw, IN, USA) was used in one patient. Nails were inserted without reaming in seven patients and with reaming in five. Blocking screws were standard interlocking screws or 3.5-millimeter cortical screws.

Surgical Technique

Patients were positioned supine on a radiolucent fracture table. A tourniquet was applied to the proximal thigh. The limb was prepared and draped in the standard sterile fashion. Open fractures were irrigated and debrided. Blocking screws were placed freehand through percutaneous wounds into the distal portion of the proximal fracture fragment before nail insertion. The orientation and location of these screws depended on preoperative and intraoperative fracture alignment. To limit apex anterior angulation, blocking screws were placed posterior to the central axis of the tibia so that the nail would pass anterior to the blocking screw (Fig. 2). To limit valgus angulation, blocking screws were placed lateral to the central axis of the tibia so the nail would pass medial to the blocking screw (Fig. 3). To limit varus angulation, blocking screws were placed medial to the central axis of the tibia so that the nail would pass lateral to the blocking screw.

A standard medial parapatellar approach was used for nail insertion. The starting point was obtained using an awl with fluoroscopic guidance. A guide wire was placed past the blocking screw(s) and across the fracture, with the knee flexed over a bolster. Longitudinal traction and appropriately directed forces were manually applied to the limb to obtain provisional alignment during passage of the guide wire. Reaming was performed over the guide wire when indicated. When possible, the reamer was pushed past the blocking screw without it spinning to minimize dulling. A tibial nail of the appropriate length and diameter was inserted over the guide wire. The nail was advanced gently past the blocking screw(s). Fluoroscopic images confirmed appropriate alignment of the fracture with passage of the nail beyond the blocking screw(s) and fracture site. If the alignment was still unsatisfactory, the nail was removed and the blocking screw(s) were moved or additional blocking screws were placed. The nails were locked in standard fashion proximally with an outrigger and distally with a freehand method.

Outcome Measures

Patients were followed up prospectively at regular intervals. Anteroposterior and lateral radiographs were obtained postoperatively and at each follow-up visit. Fracture alignment was determined on each of these radiographs by making goniometric measurements as described by Freedman and Johnson.[8] Anteroposterior radiographs were used to determine coronal plane deformity (varus and valgus), and lateral radiographs were used to determine sagittal plane deformity (flexion and extension). Changes in alignment were noted. Malalignment was defined as more than 5 degrees of angular deformity. Nonunion was defined as absence of progressive fracture healing for three consecutive months.

RESULTS

Blocking Screws

A single posterior blocking screw was used in eight patients. A combination of one posterior blocking screw and one lateral blocking screw was used in two patients. Two medial blocking screws were used in one patient, and a single lateral blocking screw was used in one patient (Table 1). Blocking screws were 3.5-millimeter cortical screws in two patients and standard interlocking screws in the other ten patients. In one patient, a 3.5-millimeter blocking screw bent during nail insertion. Thereafter, the stronger interlocking screws were used in all remaining patients. No other bent blocking screws were noted.

Postoperative Fracture Alignment

Eleven of the twelve patients had postoperative fracture angulation that was less than 5 degrees in the coronal and sagittal planes (Table 1). One patient had postoperative malalignment of 6 degrees valgus. A lateral blocking screw to control valgus malalignment was not used in this patient. This patient was one of the two who had an established nonunion and an associated malalignment (32 degrees apex anterior

FIGURE 1. Anteroposterior and lateral views of revision of malreduced fracture using posterior and lateral blocking screws. A,B: Injury. C,D: Initial malreduction after nailing without blocking screws. E,F: After revision nailing with blocking screws. G,H: Fracture healed and alignment maintained at thirty-six weeks of follow-up.

angulation and 5 degrees valgus). A single posterior blocking screw was used to help correct the apex anterior deformity. The postoperative fracture alignment was neutral in the sagittal plane and 6 degrees of valgus malalignment. The other patient with a nonunited fracture had 15 degrees apex anterior angulation. A single posterior blocking screw was used. The postoperative fracture alignment was anatomic in both planes. Two patients were seen within six weeks of being treated at other institutions with intramedullary nails for their proximal tibia fractures. One of these patients had 30 degrees of varus angulation. The intramedullary nail was revised using two medial blocking screws. Postoperative angulation was anatomic in both planes. The other patient had 10 degrees of valgus (Fig. 1). The nail was revised using one posterior and one lateral blocking screw. Postoperative fracture alignment was neutral in the sagittal plane and 2 degrees of valgus.

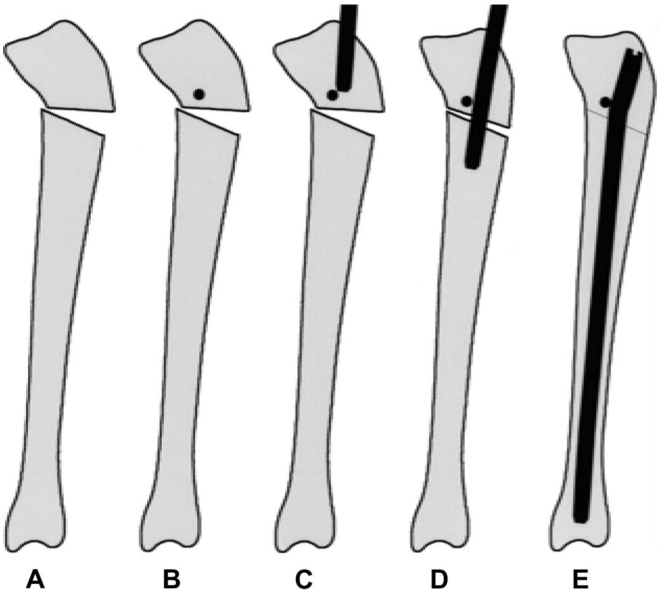

FIGURE 2. Schematic diagram of a posterior blocking screw used to correct apex anterior angulation, lateral view. A, Proximal fracture with apex anterior angulation. B, Blocking screw placed in distal portion of proximal fragment slightly posterior to the longitudinal axis. C, Nail advanced to the blocking screw. Alignment is unchanged. D, Nail advanced past the blocking screw. Alignment is corrected. E. Nail in the final location. The fracture is anatomically reduced.

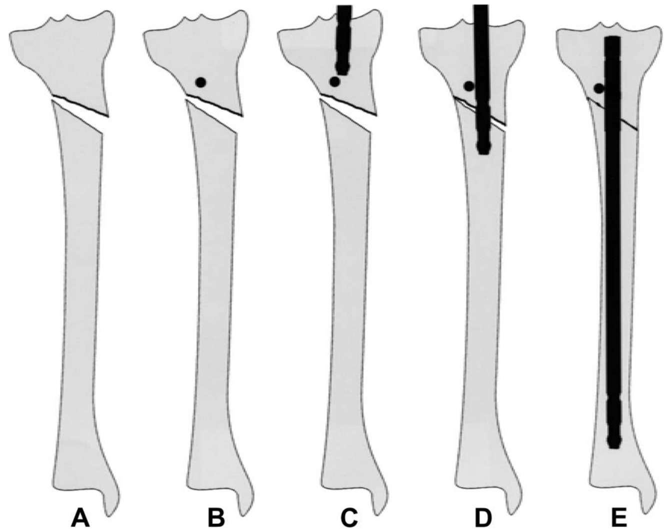

FIGURE 3. Schematic diagram of a lateral blocking screw used to correct valgus angulation, anteroposterior view. A, Proximal fracture with valgus angulation. B, Blocking screw placed in distal portion of proximal fragment slightly lateral to the longitudinal axis. C, Nail advanced to the blocking screw. Alignment is unchanged. D, Nail advanced past the blocking screw. Alignment is corrected. E. Nail in final location. The fracture is anatomically reduced.

Fracture Healing

One patient was lost to follow-up. The other eleven patients were followed to fracture healing or the establishment of a nonunion. The average follow-up was thirty-three weeks (range 19 to 54 weeks). There were two nonunions, and both patients had Grade IIIB open fractures. Despite radiographic evidence of a nonunion, one of these patients refused further operative treatment. The other patient had multiple operative procedures to treat his infected nonunion and eventually healed (Fig. 4).

Alignment at Last Follow-up

One patient was lost to follow-up. Nine patients achieved union and maintained the alignment of their fractures. One patient with a nonunion had maintained fracture alignment at thirty-two weeks of follow-up. 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.

Complications

There were no complications directly related to the use of blocking screws. One patient had osteomyelitis and one patient had a persistent nonunion, as described earlier. One additional patient required removal of proximal interlocking screws because of pain.

DISCUSSION

Fractures of the proximal third of the tibial shaft treated with intramedullary nailing have a high incidence of malalignment. Apex anterior and valgus malalignment and anterior displacement of the proximal fragment are the most common deformities. Factors that may contribute to sagittal plane deformity include the pull of the patellar tendon,[5,17,18] the pull of the anterior compartment muscles,[8] lack of a posterior cortex,[8] the "wedge effect" of the bent nail in the distal fragment,[10] a medial starting point in the area of narrow anteroposterior diameter of the proximal tibia,[5] and a distal starting point for nail insertion.[5] Factors contributing to coronal plane deformity include a medial starting point, a laterally directed nail insertion angle,[5,8,17] and the pull of the lateral compartment muscles.[8] Several technical modifications of standard intramedullary nailing technique have been described to overcome these factors and provide for an anatomic reduction.

Lang et al[17] retrospectively reviewed patients with thirty-two fractures of the proximal third of the tibia treated with intramedullary nails. Twenty-seven fractures had at least 5 degrees of angulation in any plane (84 percent). Valgus malalignment was thought to be related to a medial entry point and a laterally directed nailing insertion angle in the proximal fragment. This was attributed to, in part, the medial para-patellar approach that was used in all but two patients. They suggested that inserting the nail parallel to the anterior cortex could minimize the degree of angulation in the sagittal plane. Based on their findings, the authors subsequently limited the use of intramedullary nailing of proximal tibia fractures at their institution.

Freedman and Johnson[8] retrospectively reviewed 133 fractures of the tibia treated with intramedullary nails. A significantly higher rate of tibial malalignment in fractures of the proximal third versus the middle or distal third was noted. They suggested that proximal third fractures may be better

TABLE 1. Patients' Characteristics, Blocking Screw Location and Number, Postoperative and Final Fracture Alignment

Patient	Age (yr)	OTA*	Wound†	Blocking Screws Location (no. of Screws)	Postoperative Reduction‡	Final Reduction‡
1	75	42A	closed	posterior (1)	valgus 6°5	valgus 10°¶
2	42	42B	IIIA	posterior (1), lateral (1)	valgus 3°	lost to followup
3	47	42B	closed	posterior (1), lateral (1)	valgus 2°	unchanged
4	41	42C	IIIB	posterior (1)	valgus 2°	unchanged
5	40	42B	IIIB	posterior (1)	varus 3°, extension 3°	unchanged
6	53	42B	closed	lateral (1)	valgus 3°	unchanged
7	18	42A	closed	posterior (1)	neutral	unchanged
8	25	42B	IIIA	posterior (1)	neutral	unchanged
9	44	42B	IIIA	posterior (1)	neutral	unchanged
10	46	42B	closed	posterior (1)	neutral	unchanged
11	49	42A	IIIA	posterior (1)	neutral	unchanged
12	80	42A	closed	medial (2)	neutral	unchanged

*Orthopaedic Trauma Association fracture classification (1).
†Open wound grade (9).
‡Reduction measured on immediate postoperative radiographs.
§Reduction measured at the last follow-up examination. One patient lost to follow-up. "Unchanged" is compared with immediate postoperative reduction.
¶Blocking screws not used to control coronal plane deformity.

managed with a neutral to slightly lateral entrance angle for nail insertion. Freedman and Johnson also noted that the lack of a sufficiently long posterior cortex in the proximal fragment is a problem with nailing of proximal third fractures. Fracture alignment at union was not reported.

Tornetta and Collins[18] described the use of the semi-extended position of the knee for intramedullary nailing of fractures of the proximal tibia. Their technique included lateral subluxation of the patella, which required an arthrotomy of the knee. The knee was positioned in 15 degrees of flexion for nail insertion. Immediate postoperative alignment in thirty patients with fractures of the proximal one fourth of the tibia treated with intramedullary nails was reported. The first five patients in this series were treated without using the semiextended knee position, and the average flexion deformity was 8 degrees (range 5 to 15 degrees). The last twentyfive patients were treated using the technique described. None of these patients had more than 5 degrees of flexion deformity. Two of these

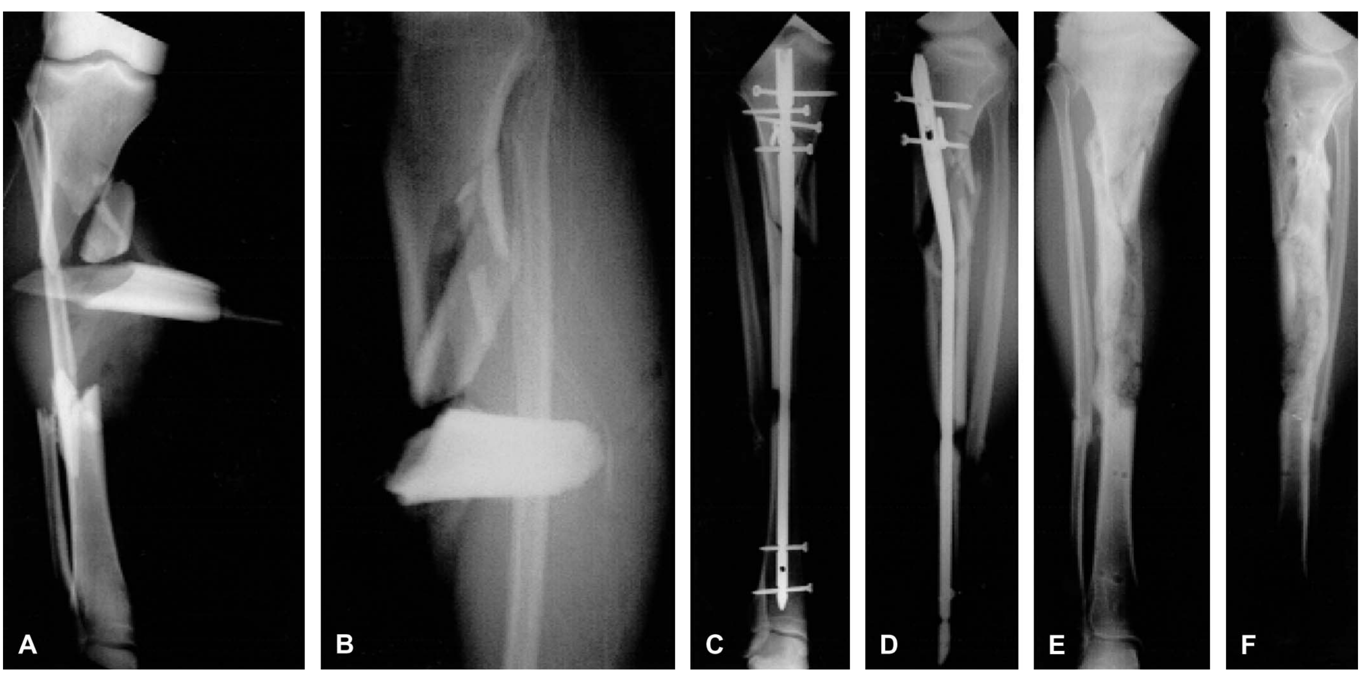

FIGURE 4. Segmental fracture treated with intramedullary nailing with posterior and lateral blocking screws, anteroposterior and lateral views. A,B: Injury. C,D: Immediate postoperative radiographs. E,F: Fracture healed and alignment maintained at forty-one weeks of follow-up.

patients, however, had more than 5 degrees of deformity in the coronal plane and two required an external fixator to augment fixation because of coronal plane instability. Alignment at union was not reported.

Buehler et al[5] described a lateral starting point for nail insertion to maximize the intramedullary canal sagittal diameter at the site of nail insertion. A femoral distractor was used to neutralize the deforming forces of the patellar tendon, and prototype outrigger handles were used to allow the fracture to be nailed in hyperflexion and interlocked in full extension. Nailing in hyperflexion allowed a sagittal plane insertion angle parallel to the anterior cortex of the proximal fragment. Interlocking in full extension allowed final fixation in the position of optimal fracture reduction. Entering the tibia as proximal as possible and remaining directly against the anterior cortex minimized the effective diameter of the nail. Fourteen patients with fractures of the proximal third of the tibia were treated using these techniques. The average anterior displacement was two millimeters (range 0 to 17 millimeters). Coronal plane deformity averaged 2 degrees of valgus (range 2 degrees of varus to 12 degrees of valgus). One patient's fracture fixation was revised three weeks after surgery to correct seventeen millimeters of anterior displacement and 12 degrees of valgus angulation. All patients were followed up for more than six months. There was one nonunion. Angular deformity in the sagittal plane was not reported. The authors concluded that by using techniques that neutralize deforming forces, many fractures of the proximal third of the tibia can successfully be treated with intramedullary nailing.

Krettek et al[13] described the technique of using blocking screws to supplement intramedullary fixation of metaphyseal femur and tibia[14–16] fractures. Results of this technique were described in a prospective report of patients with ten proximal and eleven distal tibia fractures.[16] The average coronal plane deformity was 1 degree (range 5 degrees valgus to 3 degrees varus), and the average sagittal plane deformity was 1.6 degrees (range 6 degrees flexion to 11 degrees extension). The results were not stratified by fracture location. They concluded that blocking screws were useful to control angular deformity when treating metaphyseal tibia fractures with intramedullary nails. In a biomechanical analysis, Krettek et al[12] showed that blocking screws also increase the stability of metaphyseal tibia fractures after intramedullary nailing.

This article describes the use of blocking screws to help obtain and maintain the alignment of fractures of the proximal third of the tibia treated with intramedullary nails. These screws are simple to insert and require no additional equipment. They are useful to control alignment in the sagittal and coronal planes. Twelve consecutive patients who were treated with blocking screws and intramedullary nails for fractures of the proximal third of the tibia were followed up prospectively until fracture union or nonunion. All patients maintained less than 5 degrees of angular deformity in the planes in which blocking screws were used to control alignment. One patient had 6 degrees of postoperative valgus that progressed to 10 degrees at union. A blocking screw was not used to control for valgus in this patient who had a nonunion associated with 32 degrees apex anterior angulation and 5 degrees valgus. However, a posterior blocking screw helped correct the flexion deformity to an anatomic alignment. One patient had a persistent nonunion (open Grade IIIB fracture) but had maintained a satisfactory alignment at the last follow-up examination (thirty-two weeks). Nine patients united without change in fracture alignment. These results compare favorably with other reported technical modifications of standard intramedullary nailing technique.[5,16,19]

One of the limitations of this report was the small sample size of twelve patients. Previous reports of treating fractures of the proximal third of the tibia with intramedullary nails have included similar numbers of patients, ranging from eight to thirty-two.[5,8,11,16–18] This reflects the uncommon incidence of fractures of the proximal third of the tibia, less than 14 percent of all tibial shaft fractures.[8,11] In contrast to most previous reports of patients with this injury,[5,8,11,17,18] this report was prospective, and alignment was maintained when patients were followed until union or establishment of a nonunion.

In conclusion, blocking screws are effective to help obtain and maintain alignment of fractures of the proximal third of the tibial shaft treated with intramedullary nails. The indications for this technique may be extended to other long bone fractures in which angular deformity can complicate intramedullary nail insertion.

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