Intramedullary Nailing With Angle Stable Locking Technique of an Intra-articular Distal Tibial Fracture and an Extra-articular Distal Tibial Shaft Fracture

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Summary: Distal tibial fractures can be treated successfully with a plate or an intramedullary nail (IMN). Because semiextended tibial nailing has increased in popularity and nail design has evolved, more distal tibia fractures are being treated with an IMN. Evolution of distal interlocking technology with “angle stable” screws has improved fixation in the treatment of far distal tibia fractures in more osteoporotic patients. This report details the use of a suprapatellar tibial IMN with angle stable locking screws in the treatment of an open distal tibial fracture with intra-articular extension in a 67-year-old man who fell off a ladder.

Key Words: metaphyseal distal tibial fractures, distal tibial fracture, intramedullary nail, intramedullary nail of distal tibia, angle locking screw

INTRODUCTION

Metaphyseal distal tibial fractures (<5 cm from the articular surface) can be treated successfully with a plate or an intramedullary nail (IMN). As nail design and techniques have improved, intramedullary nailing of far distal tibia fractures has been shown to be a safe and effective treatment method that is increasing in popularity.1–4 The benefits of nailing distal tibia fractures include the application of a load-sharing device, which may allow earlier weight-bearing, with limited soft tissue disruption. Although early concerns for malalignment with IMN limited its use in more distal fracture, recent evidence demonstrates improved radiographic outcomes when nailing in a semiextended position.5

Evolution of distal locking technology has allowed for use of intramedullary nailing in treatment of more distal fractures in more osteoporotic patients, increasing the trend of “extreme” nailing. Proponents of this technique report high union rates, earlier weight-bearing, and less soft tissue dissection when compared with modern plating techniques. We report a case of an open distal metaphyseal tibia fracture with intra-articular involvement treated with an IMN and fibular plating. Appropriate patient selection and technique can result in excellent radiographic and clinical outcomes when using a suprapatellar insertion with “angle stable” screws.

CASE REPORT

Case 1

Patient Information

A 67-year-old man with a history of diabetes mellitus presented as a transfer after a fall off a ladder with immediate onset of pain, deformity, and bleeding of the left leg. On examination, the patient was neurovascularly intact in the left leg with an anteromedial wound. Radiographs and computed tomography (CT) scan demonstrated a highly comminuted fracture of the left distal tibia with intra-articular involvement (Fig. 1). Antibiotics were initiated in the emergency department, the limb was irrigated and immobilized, and the patient was consented for debridement and surgical management.

Surgical Technique

After induction of anesthesia, the patient was placed in the supine position with a bump under the left hip. After standard
prepping and draping, a thorough sharp debridement of nonviable tissue was conducted of the anteromedial distal tibial wound. Care was taken to preserve skin and subcutaneous tissues for a tension-free closure. The wound was then irrigated with saline and reassessed to ensure a complete and thorough debridement.

A simple intra-articular split was then repaired using two 2.7 millimeter screws in a lag-by-technique fashion. The author’s preferred technique is to apply these screws with start sites medial and lateral to the neurovascular bundle with end point and trajectory of the screws determined by the fracture pattern. Location of screws below the physeal scar of the distal tibia will allow for distal seating of the IMN. Screw position was confirmed on AP and lateral radiographs (Fig. 2).

Given the patient’s bone quality, displacement pattern, and soft tissue condition, we chose intramedullary nailing as treatment. With the patient’s left knee in a semiextended position, a suprapatellar portal was used to access a starting point for the IMN. Following an appropriate start point and opening reamer, the ball-tip guidewire was advanced just proximal to the comminuted metaphyseal fracture. Closed manipulative reduction techniques were used to obtain appropriate alignment, and the guidewire was inserted into a position just lateral to center of the plafond on an AP view and near the center to posterior center on a lateral view. Particular attention is paid to the alignment in the coronal plane, and emphasis is made on seating of the ball-tip guidewire in an appropriate location lateral to the center of the plafond (60:40). The intramedullary canal was then reamed sequentially, and the IMN was placed (Fig. 3A). In cases such as this with poor bone quality, the author’s preferred technique is to not ream the distal segment and to “pot” the nail into the distal tibia, preserving all distal bone and maximizing stability by impacting the nail into metaphyseal bone.

Alignment and positioning were confirmed on AP and lateral views (Fig. 3B), and 3 distal interlocking bolts were placed using angle stable locking screws (ASLS), along with 2 proximal locking screws. An associated comminuted fibula fracture was plated due to significant comminution and instability (Fig. 4). Postoperative AP and lateral radiographs were obtained demonstrating appropriate alignment of the tibia and fibula with all hardware in acceptable positions (Fig. 5).

**Postoperative Course**

The patient remained non-weight-bearing to the left lower extremity for 6 weeks with an uneventful postoperative course. At 6 weeks, the patient was started on weight-bearing as tolerated.

**FIGURE 1.** Anteroposterior (A) and lateral (B) radiographs of the left ankle illustrating a comminuted tibia fracture with articular extension and associated fibula fracture with confirmation on axial (C) and coronal (D) computed tomography.

**FIGURE 2.** Intraoperative anteroposterior (A) and lateral (B) fluoroscopy illustrating 2.7-mm screw placement.
weeks, the patient was progressed to weight-bearing as tolerated and therapy initiated. At his final 3-month follow-up, the patient was in normal footwear, walking with minimal pain, and had no motor or sensory deficits. Plain films of the left tibia demonstrated an appropriately positioned IMN, anatomic alignment, and abundant callus formation along the tibia (Fig. 6).

Case 2
Patient Information
A 29-year-old man involved in a motorcycle collision presented to our emergency department for evaluation of a traumatic injury to the right lower leg. Initial evaluation revealed a 5-cm open wound over the distal lower leg, with radiographs and CT confirming a type 2 open comminuted fracture of the distal third shaft and associated right comminuted fibula fracture (Fig. 7). Antibiotics were initiated, the leg was irrigated and immobilized, and the patient was consented for debridement and operative management.

Surgical Technique
After induction of anesthesia, the patient was placed in a supine position and a bump was placed under the ipsilateral hip. After prepping and draping, a thorough irrigation followed by a sharp debridement was conducted and tension-free closure of the skin was performed.

New gloves and drapes were applied, and a 3-towel bump was placed under the knee in anticipation of suprapatellar tibial nailing. An entry guidewire was inserted through a suprapatellar approach to obtain a starting point, with special care given to protection of the

FIGURE 3. Intraoperative anteroposterior fluoroscopy illustrating placement of intramedullary nail over the guidewire (A) before impaction into the distal tibia with confirmed appropriate alignment (B).

FIGURE 4. Intraoperative anteroposterior (A, C) and lateral (B, D) fluoroscopy images illustrating appropriate placement of 3 angle stable locking screws with reduction of tibial fracture before (A, B) and after (C, D) fibula fixation.
patellofemoral joint throughout the case. Once positioned appropriately, an entry reamer was used to open the tibial canal before inserting a ball-tip guidewire down to the level of the fracture. Reduction of the fracture was obtained using a point-to-point clamp through percutaneous stab incisions, and the ball-tip guidewire was subsequently advanced beyond the fracture site into the distal tibia (Fig. 8A). Particular attention was paid to seating the ball-tip guidewire in an appropriate location, as discussed in the previous case. Guidewire location was confirmed on fluoroscopy, and sequential reaming of the intramedullary canal was performed, followed by insertion of the IMN (Fig. 8B).

AP and lateral views were used to confirm appropriate alignment and positioning of the nail, and 3 distal interlocking bolts were placed through the angle stable locking holes of the IMN nail, followed by 2 proximal locking screws off the product jig. Given the comminution and instability of the fibula fracture, it was repaired using a 3.0-mm flexible nail. Postoperative AP and lateral radiographs confirmed anatomic alignment of the tibia and fibula with appropriate positioning of all hardware (Fig. 9).

**Postoperative Course**

The patient was allowed to weight-bear immediately with an uneventful postoperative course, and therapy initiated once the wound had healed. Follow-up radiographs of the tibia showed an appropriately positioned IMN with maintained alignment and abundant callus formation along the tibia at 3 months and union at final, 1-year follow-up (Fig. 10). At the final follow-up, the patient was in normal footwear, walking without pain, and back to work without restrictions.

**DISCUSSION**

Intramedullary nailing of distal tibia fractures has increased in popularity. Implant selection should be driven by patient, injury, and surgeon factors. We present 2 cases of an open intra-articular distal tibia fracture treated successfully with a nail. In these cases, selection of an intramedullary implant was made considering the patient’s age, comorbidities, open wound, and fracture pattern. Important surgeon factors include familiarity with the implant and availability of a system that provides adequate fixation to hold the fracture reduced to union. Although controversy remains regarding the most effective method for management of metaphyseal distal tibial fractures, both nailing and plating of these injuries possess important advantages and disadvantages to consider when selecting a treatment method.2,6–9

Intramedullary nailing of distal tibia fractures has been shown to result in similar rates of fracture union when compared with plating.2,3,6,10 Advantages of intramedullary nailing include its ability to act as a “load-sharing” device and superior performance in biomechanical testing with a greater load to failure and stiffness compared with plating.4 Intramedullary implants also result in minimal devascularization and violation of soft tissues, limiting the risk of postoperative skin complications and infection.5–8,11 Regardless of treatment selection, consideration of soft tissues about the lower leg is critical to an optimal outcome. Traditional methods of open

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**FIGURE 5.** Postoperative anteroposterior (A) and lateral (B) radiographs showing an intramedullary nail and fibular plate maintaining reduction and proper alignment of a treated distal tibial and associated fibula fracture.

**FIGURE 6.** Anteroposterior (A) and lateral (B) radiographs 3 months postoperatively with maintained alignment and abundant callus formation.
reduction and internal fixation may not be advised in certain clinical scenarios and may be associated with nonunion and soft tissue complications if attention is not paid to the technique.\textsuperscript{11} Reoperation for hardware removal remains a consideration with both IMN and plating.\textsuperscript{6} There are limited data suggesting restoration of ankle motion may also be better in patients treated with IMN versus those receiving a plate.\textsuperscript{10} Some studies have shown a benefit to IMN over plating of all types about time under anesthesia and radiation exposure.\textsuperscript{6,10}

Restoration of alignment when using IMNs for distal metaphyseal tibial fractures is critical and driven by multiple technical considerations during the operation. Location of the nail in the tibial plafond has been shown to affect final alignment. Optimal placement has been shown to be lateral to the center of the talus and plafond on a mortise view of the ankle and just anterior to the center of the plafond on the lateral.\textsuperscript{4} Insertion technique of the IMN has also been demonstrated to be a controllable variable in obtaining proper alignment. A recent series comparing alignment when using an infrapatellar or suprapatellar portal demonstrated incidence of malalignment to be significantly lower with a suprapatellar approach (3.8\%) versus an infrapatellar approach (26.1\%).\textsuperscript{3} These results are similar to the results seen with parapatellar insertion, which has been found to have no difference in incidence of malalignment compared with plating.\textsuperscript{3}

Although achieving anatomic alignment remains critical in obtaining an optimal outcome in these patients, holding alignment to union becomes a factor because the fracture is more distal and the bone quality is poor. Techniques to optimize fixation in this setting include the use of blocking screws to improve nail to canal size discrepancy and use of angle stable locking screws.\textsuperscript{3,7} Angle stable locking screws, such as those used in case 1, decrease the need for cortical contact with the nail to obtain stability. Larger diameters near the screw head compared with conventional screws allow for better contact with the screw hole edges. The expandable sleeve that fits the interlocking hole of the nail improves contact...
between the screw and the nail, providing a “fixed angle” construct in metaphyseal bone.7,12 Newer angle stable locking systems, such as the ones used in case 2, are designed with the expandable sleeve prefabricated within the nail in effort to streamline and simplify obtaining angular stability when nailing distal tibial fractures.

Other important considerations include intra-articular extension that should be reduced and addressed before nail insertion. This provides a stable distal segment into which interlocking screws can be placed and prevents displacement of articular components with seating of the nail. Independent screws should be applied in locations that will not interfere with nail seating or interlocking screw placement. Screws positioned at or below the level of the physeal scar, as shown in this case, are typically safe and allow for unimpeded interlock insertion. Intra-articular fractures with simple patterns that can be held with independent screws are repaired more easily with this approach. Intra-articular involvement with impaction or significant displacement requiring open reduction and plating may not preclude nailing, but identifying patterns that may be difficult to maintain reduction with a nail is critical in optimizing outcome.2,3 By contrast, in patients with baseline poor quality soft tissue (morbid obesity, vasculopathy, significantly friable skin in elderly, and uncontrollable edema) or with significant soft tissue injuries about the ankle, IMN fixation may be preferred over plating because of the ability to limit further disruption of soft tissue in the area of the fracture. These considerations for IMN use should be made on a case-by-case basis.

Potential drawbacks have been detailed in the literature surrounding IMN fixation of metaphyseal distal tibial fractures. Historical concerns regarding alignment with intramedullary nailing of distal fractures seem to be improved with semiextended nailing techniques.5,9 The risk of knee pain after IMN of a tibia fracture has been well-documented in the literature with some series reporting the rates of moderate knee pain in greater than 50% of patients.13–15 Recent literature has demonstrated the rate of hardware removal to be higher in those with IMN fixation compared with the modern minimally invasive plating techniques, with locking screws found to be the most likely source of pain.3,15

CONCLUSIONS

Intramedullary nailing of metaphyseal distal tibial fractures is a useful technique, and recent advancements in implant design allow increasingly distal fractures to be treated with an intramedullary implant. Patient selection and technique are critical factors in obtaining anatomic alignment and sufficient distal fixation when nailing is used for more “extreme” cases.

REFERENCES


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