Tibial Lengthening Technique

S. Robert Rozbruch, MD

Summary: Lengthening of the tibia with a motorized internal nail is effective and has advantages over the traditional use of external fixation. Since nail entry is through the proximal end of the bone, it is indicated for skeletally mature patients. Principles of leg-lengthening must be followed but the techniques have been modified from those of external fixation. Fibula relationship to the tibia is protected with fibula length stabilization screws. If there is a deformity, then fixator assisted nailing and the use of blocking screws are used to acutely correct the alignment, and then gradual lengthening follows. Judicious use of soft-tissue procedures, such as fasciotomy, gastrocsoleus release, and peroneal nerve decompression are often needed.

Key Words: tibial lengthening—precice nail—internal lengthening nail—distraction osteogenesis magentic nail—limb deformity.

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INDICATIONS AND PREOPERATIVE PLANNING

Tibial lengthening with an intramedullary (IM) nail is indicated for skeletally mature patients with limb length

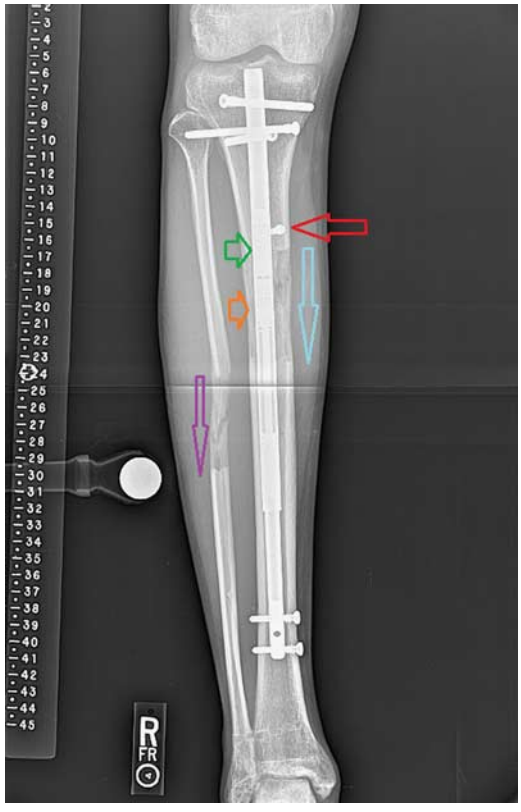

FIGURE 1. Precice nail in tibia after correction of varus and lengthening of 6 cm. Blocking screw (red arrow) controls nail position in proximal segment. Tibial regenerate (light blue arrow) and fibula regenerate (purple arrow) are consolidated. The magnet in the nail (green arrow) is rotated with a remote control and this moves the gears (orange arrow) to elongate the nail.

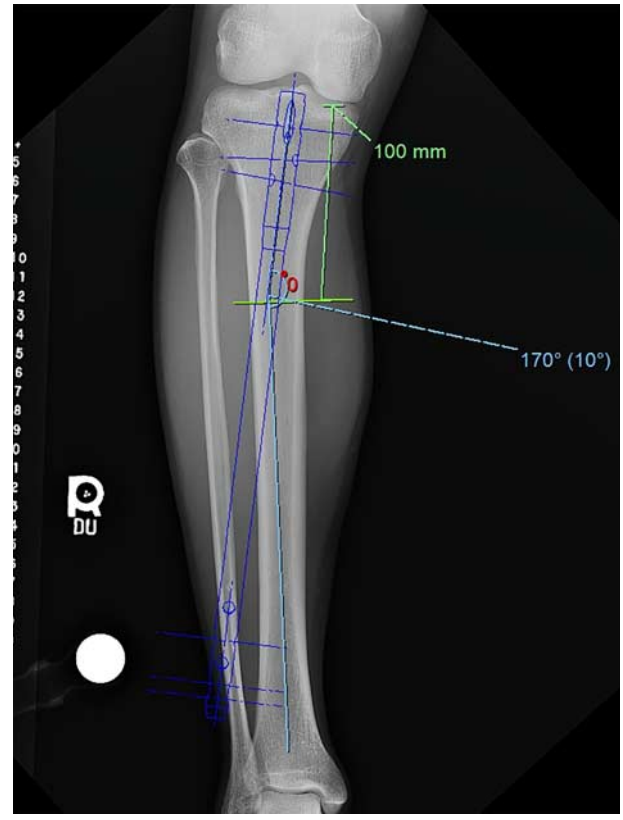

FIGURE 2. Preoperative planning for Figure 1 which shows 10 degrees varus deformity with apex located 100 mm from the joint. Anticipated position of the nail in the proximal segment and blocking screw (red circle) in the concavity of the deformity to achieve realignment.

From the Hospital for Special Surgery, Weill Cornell Medical College, Cornell University, New York, NY.

S.R.R.: Nuvasive, Smith and Nephew, Stryker, Orthospin.

For reprint requests, or additional information and guidance on the techniques described in the article, please contact S. Robert Rozbruch, MD, at rozbruchsr@hss.edu or by mail at Hospital for Special Surgery, Weill Cornell Medical College, Cornell University, 535 East 70th Street, New York, NY 10021. You may inquire whether the author(s) will agree to phone conferences and/or visits regarding these techniques.

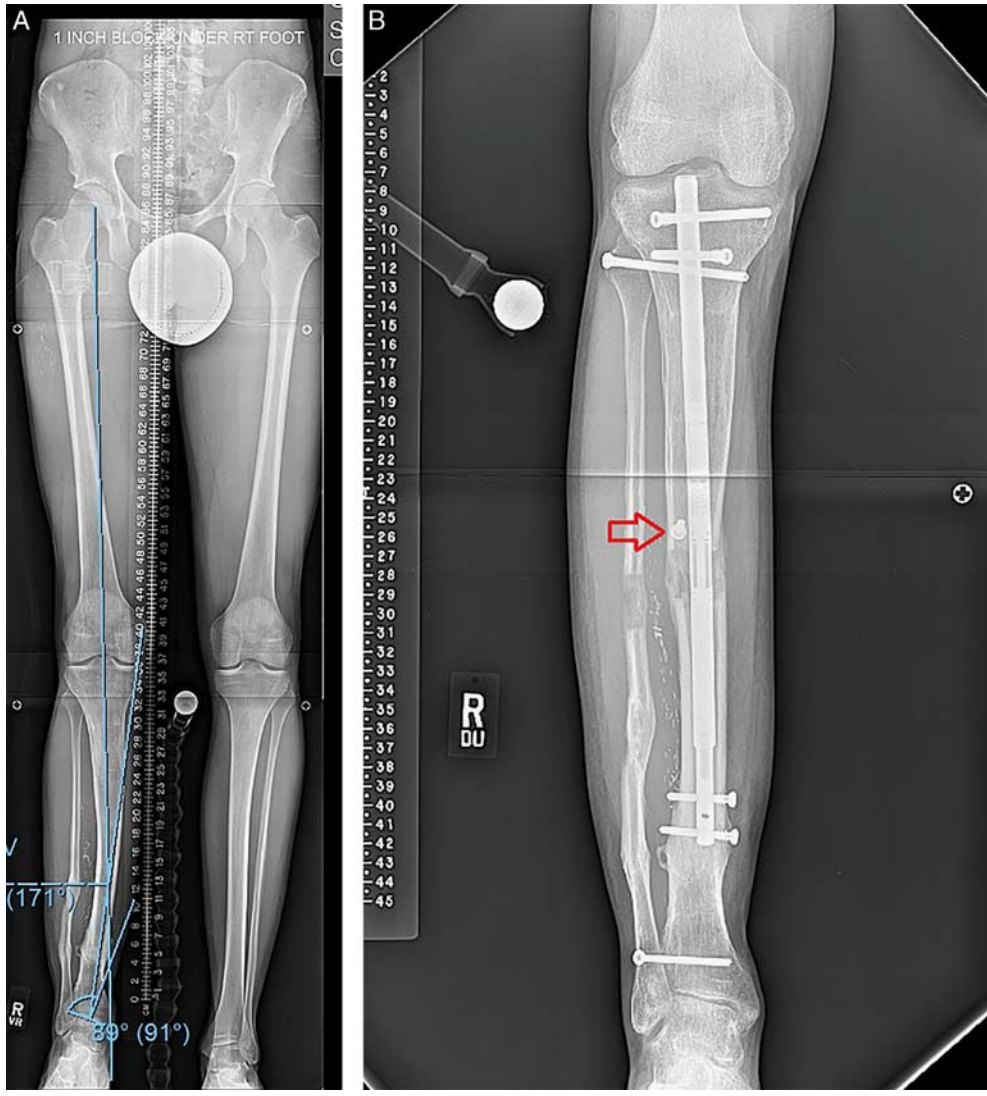

FIGURE 3. A 22-year-old male individual with valgus malunion of 9 degrees and 25 mm shortening. A, Long x-ray shows apex of deformity and optimal location of the osteotomy. B, After correction of alignment and lengthening; blocking screw on the concavity of the deformity (red arrow) was needed to achieve correction since there is mismatch between the canal diameter and the nail at the osteotomy.

discrepancy below the knee who have an open IM canal that is large enough diameter to fit the IM nail. Angular deformity, where the apex of the deformity is located in the zone from the proximal meta-diaphyseal tibia to the mid diaphysis, and rotational deformity can be corrected acutely using this approach. The osteotomy is usually performed 7 to 15 cm from the proximal joint line site (Fig. 1). The nail length is chosen using the shortest nail length analysis aimed to maintain 5 cm of the thick part of nail in the distal segment at the end of distraction (reviewed in chapter one). The entry point of the nail is at the anterior proximal corner of the tibia in the sagittal plane. In the coronal plane, if there is no deformity, the entry is at the proximal end of the anatomic axis line of the tibia. If there is angular deformity, then preoperative anatomic and mechanical axis planning helps to determine the optimal entry point and direction of the nail in the proximal segment as well as the blocking screw (s) location (Fig. 2).

The width of the IM canal is often greater than the diameter of the nail, and the nail will not automatically correct the angular deformity. Furthermore, there are typical deformities that ensue during a tibial lengthening-valgus and apex anterior. Blocking screws can be used to assist with acute deformity correction and prevention of lengthening induced deformities. The blocking screw is typically placed adjacent to the osteotomy site in the concavity of the deformity that is to be prevented or corrected (Fig. 3). In the absence of deformity, the blockings screws are inserted after nail insertion if the width of the IM canal is greater than the nail at the osteotomy site. If there is angular deformity present, blocking screws and a fixator assisted nailing technique are used.

SURGICAL TECHNIQUE

The patient is positioned supine on a radiolucent table with the image intensifier on the opposite side of the surgical

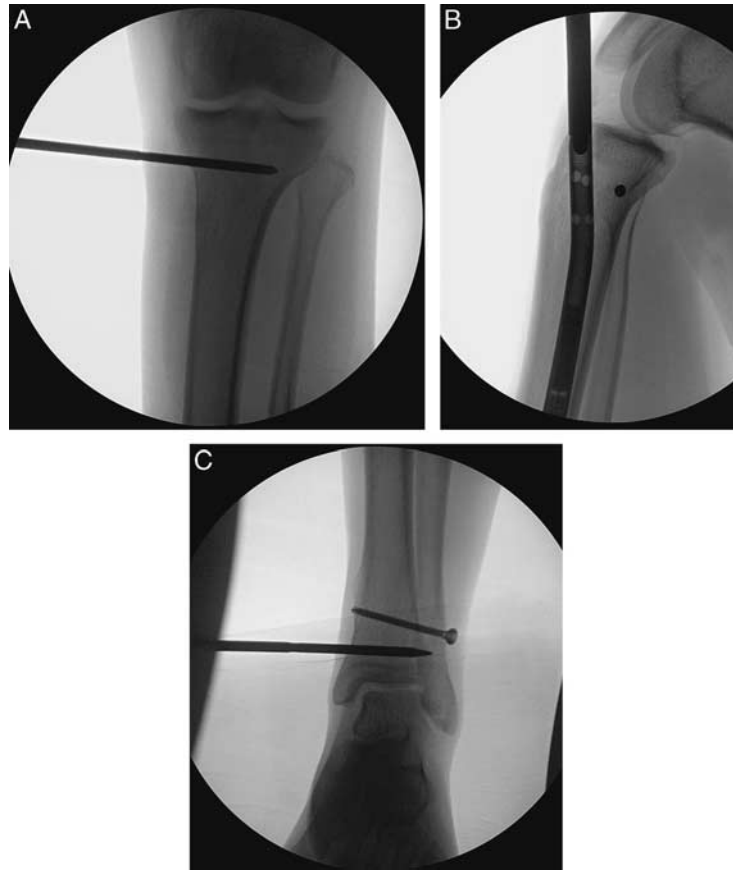

FIGURE 4. External fixator pins placed to mark rotation before osteotomy and maintain stability of limb after osteotomy. A, Proximal pin inserted from medial side and is orthogonal to the proximal segment. B, Proximal pin is posterior to the path of the nail. C, Distal pin is orthogonal to the distal segment and is beyond the fibula length stabilization screw and the anticipated position of the nail.

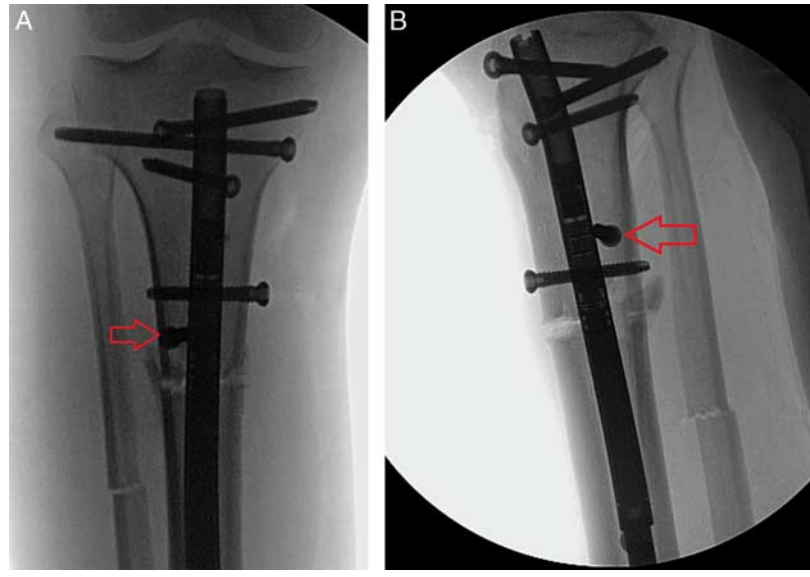

FIGURE 5. Precice nail inserted for lengthening without deformity correction. Blocking screws are needed to prevent typical deformities that may occur during lengthening since there is mismatch between the canal diameter and the IM nail at the osteotomy site. A, Lateral blocking screw (red arrow) to prevent valgus. B, Posterior blocking screw (red arrow) to prevent flexion. IM indicates intramedullary.

extremity. A 2 cm incision is made just lateral to the anterior crest of the tibia at the planned osteotomy location. The periosteum is elevated and multiple drill holes are made with a sharp drill bit (I prefer 4.8 mm) in a multiplanar transverse fashion. There are 2 versions of this technique depending in the clinical circumstance: (1) If there is no deformity or if there is only torsional deformity; (2) If there is angular deformity in the coronal and/or sagittal planes.

If acute correction is planned, prophylactic fasciotomy of the anterior and lateral compartments is performed. The knee is then flexed over a triangle, and a 2.4 mm Steinman pin is placed into the IM canal through the anterior proximal corner of the tibia. A 3 cm incision is made over the pin and the patella tendon is longitudinally split. Alternatively, a suprapatellar tendon approach may be used. A 12 mm cannulated acorn reamer is used to open the canal. In the absence of angular deformity, the guidewire is inserted and sequential reaming is done without use of a tourniquet. Flexible reamers are used to ream the IM canal about 2 mm larger than the diameter of the nail. The IM reamings egress through the drill (vent) holes. Steinmann pins or temporary external fixation pins are placed in the proximal and distal bone segments away from the nail tract to mark rotation (Fig. 4). If there is rotational deformity, the pins are placed with the desired axial plane angular divergence. The osteotomy is completed with an osteotome and then the internal lengthening nail (ILN) is passed across the osteotomy site. The fibula may be left intact at this point to provide leg stability if there is no angular deformity or if there is only torsional deformity that needs to be corrected. Proximal interlocking screws (usually 2) are inserted via the jig and then the jig is removed. Now with the knee in extension, the fibula osteotomy is performed through a lateral approach using the plane between the lateral and posterior compartments. A multiple drill-hole transverse osteotomy technique is used. A 1.8 mm wire is used to the drill holes into the fibula and the osteotomy is completed with an osteotome. Rotation of the bone around the nail confirms a complete osteotomy. Torsional deformity may be corrected at this time as needed. Distal interlocking screws (usually 2) are inserted using a freehand technique. Anterior to posterior blocking screw(s) is/are inserted lateral to the nail if at the osteotomy site there is space between the ILN and the lateral cortex (Fig. 5A). This is to prevent unwanted valgus during lengthening. Medial to lateral blocking screw(s) is/are inserted posterior to the nail if at the osteotomy site, there is space between the ILN and the posterior cortex (Fig. 5B). This is to prevent unwanted flexion during lengthening.

If there is preoperative angular deformity present, the technique is different and utilizes fixator assisted nailing and blocking screw insertion before the osteotomy. The 2 pin external fixator is placed so the pins are outside of the tract of the IM nail. Each pin is placed in the respective segment orthogonal to the axis of that segment. The proximal pin is inserted from the medial side and is posterior to where the nail will be and the distal pin is inserted from the medial side distal to where the nail will be (Fig. 3). This stabilizes the tibia in the corrected position after the osteotomy during the IM canal reaming (Fig. 6). The pins also mark the rotational alignment of each segment so that rotational deformity can be prevented or corrected as needed. In this situation, fibula osteotomy and tibial osteotomy are done and the temporary external fixator is used to hold the tibia in the corrected position before reaming. Furthermore, the entry point and the blocking screws guide the reamer in the desired direction to enable optimal deformity correction (Fig. 7).

FIGURE 6. Two pin external fixator mounted to the medial side of leg maintains stability after osteotomy and correction of deformity during IM canal reaming and nail insertion.

Stabilization of the fibula to the tibia is essential during tibial lengthening. The proximal and distal tibia-fibula relationships are stabilized before lengthening of the tibia. This ensures that the fibula osteotomy will separate and lengthen along with the tibial osteotomy (Fig. 7F). Although cannulated wire technique may be used, solid 4.5 mm are needed. Smaller or cannulated screws are likely to break. Omission of this step would result in proximal migration of the distal fibula and distal migration of the proximal fibula despite a fibula osteotomy. Complications of deformity and contracture of the ankle and knee would ensue if this step were omitted.

If there is bone loss at the ankle and distal tibia, then a bifocal approach may be used. The ankle is reconstructed and the length can be restored at a proximal tibial lengthening site (Fig. 8).

Soft-tissue procedures may be needed. Acute correction of tibial deformity carries a risk of compartment syndrome and nerve injury. Adjuvant procedures of prophylactic fasciotomy and peroneal nerve decompression may be appropriate. Gastrocsoleus recession may be needed to prevent or treat equinus contracture during tibial lengthening of over 4 cm (Tables 1, 2).

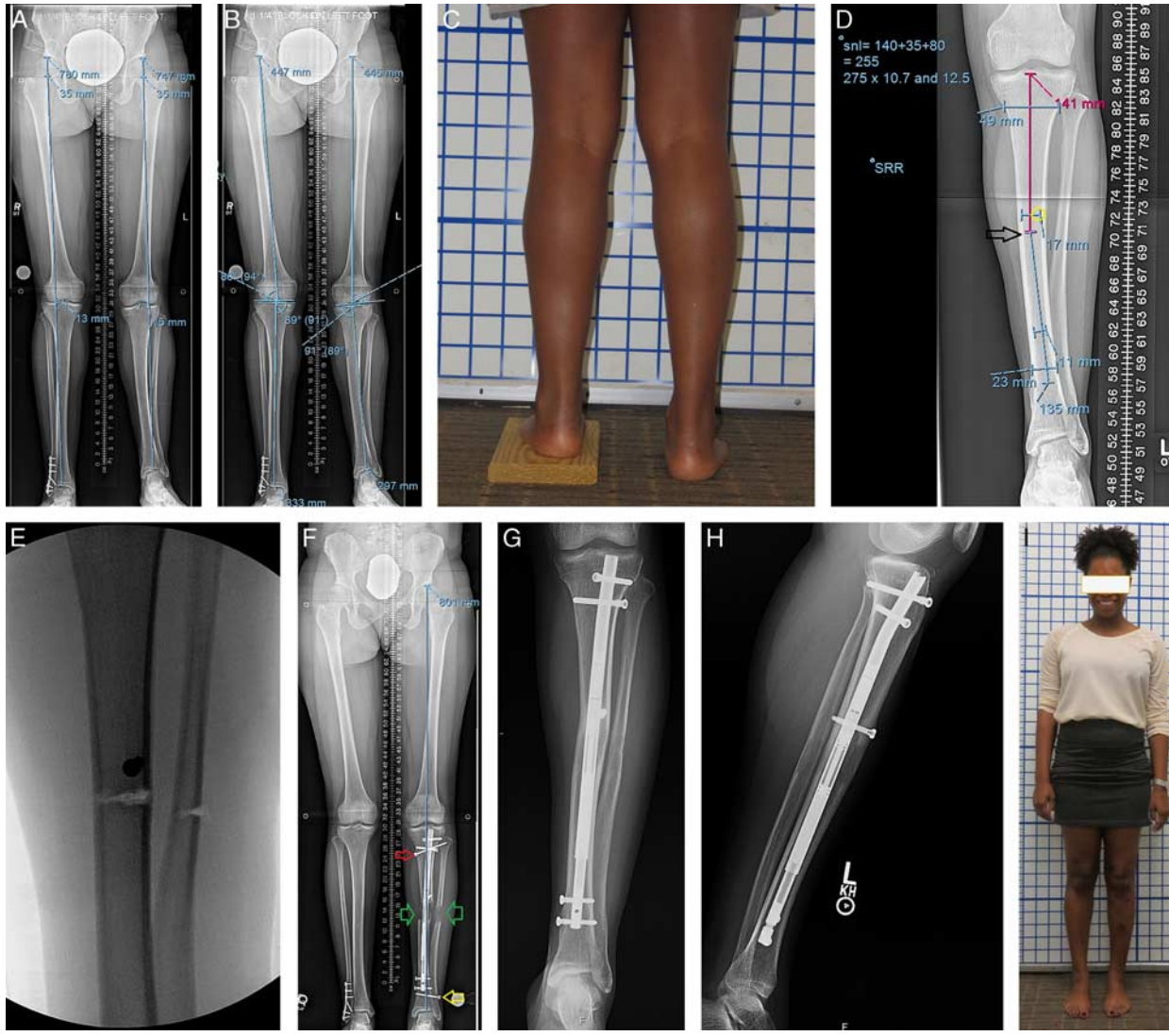

FIGURE 7. A 33-year-old woman with LLD and deformity from congenital etiology. A, Long x-ray shows LLD 33 mm and valgus deformity. B, Tibia has valgus deformity and is source of the LLD. C, Preoperative clinical photo from back showing left leg on 1 inch block. D, Preoperative planning showing apex of deformity and planned osteotomy level (black arrow) 140 mm from the joint. The pink line shows the path of the nail in proximal segment and need for blocking screw (yellow circle) to maintain the trajectory since the canal size of 17 mm will be larger than the nail diameter. The shortest nail length analysis plans for a 275 mm nail to maintain 5 cm of thick nail in the distal segment at end of distraction. E, Intraoperative x-ray with clocking screw in place and after osteotomy and realignment before reaming of the canal. F, Long x-ray after lengthening showing equal leg lengths and correction of valgus alignment. The lateral blocking screw maintained the needed position of the nail in the proximal segment. Proximal (red arrow) and distal (yellow arrow) fibula length stabilization screw maintain fibula position and enable equal distraction of the tibia and fibula (green arrows). G, AP x-ray after full consolidation. Fibula length stabilization screw have been removed. H, Lateral x-ray after full consolidation. I, Clinical photo showing equal leg lengths and normal alignment. AP indicates antero-posterior; LLD, limb length discrepancy.

POSTOPERATIVE REGIMEN

Patients are hospitalized for 2 nights after surgery. Intravenous antibiotics are administered before surgery and for 24 hours after surgery. Prophylaxis for deep venous thrombosis is administered for 2 to 4 weeks depending on the activity level of the patient.

Distraction usually begins on postoperative day 7 at a rate of 0.2 mm 4 times per day. In the case of acute deformity correction, the latency phase may be increased and the distraction rate may be slowed. Knee range of motion is started immediately with a continuous passive motion machine in the recovery room. Partial weight-bearing ambulation based on the diameter of the implanted rod is begun on postoperative day 1. Radiographs are obtained every 2 to 3 weeks and the distraction rate is adjusted accordingly. In most cases, 0.2 mm 3 to 4 times per day works well in the tibia. The most important physiotherapy stretching exercises are knee extension, knee flexion, and ankle dorsiflexion with the knee in extension to stretch the gastrocsoleus complex. Full weight-bearing is allowed when there is bridging bone at 2 to 3 cortices of the regenerate (Tables 1, 2).

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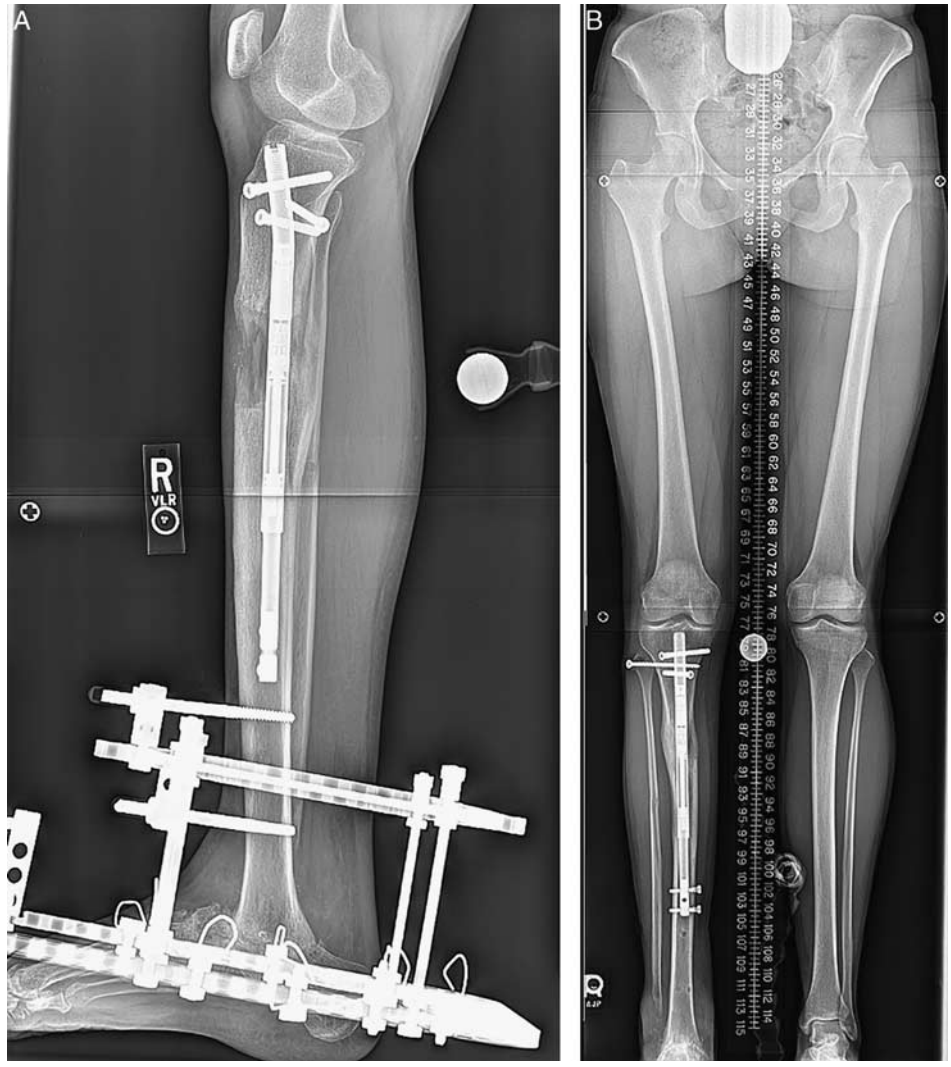

FIGURE 8. A 30-year-old woman had fracture dislocation of the talus and ultimately required a tibia-calcaneal fusion. A, Ankle fusion stabilized with circular fixator and 5 cm lengthening done with IM nail representing a bifocal approach. B, Long x-ray shows equal leg lengths after fusion and lengthening. IM indicates intramedullary.

TABLE 1. Tips for Success

During tibial lengthening, valgus and flexion deformities are prone to occur. Blocking screws lateral and posterior to the nail at the osteotomy site can be used to prevent unwanted deformity
If there is preoperative angular deformity present, the technique utilizes fixator assisted nailing and blocking screw insertion before the osteotomy. The 2 pin external fixator is placed so the pins are outside of the tract of the IM nail
Entry point, trajectory of nail in proximal segment, and location of blocking screws controls the deformity correction
Fibula length stabilization screws should be solid 4-5 mm screws and should be inserted in an oblique direction to enhance the resistance for fibula migration
Multiple drill-hole osteotomy technique is a low energy osteotomy that minimizes thermal necrosis. Multiple drill holes are made in a transverse fashion at the osteotomy level with a new sharp 4.8 mm drill. Then complete the transverse osteotomy with a sharp osteotome
In the absence of angular deformity, the fibula may be left intact for leg stability until after passage of the IM nail across the tibial osteotomy

IM indicates intramedullary.

TABLE 2. Avoiding Pitfalls

Fibula length stabilization screws are needed to ensure that the fibula separates along with the tibia. Omission of this step would lead to proximal migration of the distal fibula and distal migration of the proximal fibula resulting in ankle and knee deformity and contracture
The most important physiotherapy stretching exercise is ankle dorsiflexion with the knee in extension to stretch the gastrocsoleus complex to prevent equinus contracture
With acute correction of deformity, perform fasciotomy to prevent compartment syndrome
With acute correction of large valgus deformity, consider peroneal nerve decompression to prevent stretch injury of nerve
Consider gastrocsoleus recession for lengthening of >4 cm to prevent equinus contracture
Distraction should be slower in the tibia than in the femur. In most adults, distract 0.2 mm, 3-4 times/d. In teenagers, distract 0.2 mm, 4-5 times/d

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