Percutaneous Drilling for Early-Stage Osteonecrosis About the Ankle

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Introduction

The mid-term clinical, patient-reported, and radiographic outcomes of percutaneous drilling to treat early-stage osteonecrosis (without joint collapse) of the distal part of the tibia or of the talus are promising¹. Atraumatic osteonecrosis is a devastating condition with an unclear pathogenesis^{2,3}. The most prevalent locations of atraumatic osteonecrosis are the femoral head, knee, shoulder, and ankle⁴⁻⁷. At the ankle, lesions are most commonly localized in the distal part of the tibia and/or the talus. The treatment options for osteonecrosis range from joint-preserving procedures (such as core decompression and vascularized and nonvascularized bone-grafting) for lesions that do not include subchondral fracture to non-joint-preserving procedures (such as arthrodesis, talectomy, and ankle arthroplasty) for lesions with a subchondral fracture and subsequent arthritis⁸⁻²¹.

There is a higher prevalence of ankle osteonecrosis in younger patients, in whom joint-preserving techniques are preferable^{4,5}. One such preservation technique, percutaneous drilling, is a variation of core decompression and has been used successfully to prevent disease progression to subchondral fracture. We conducted a study to evaluate the outcome of percutaneous drilling for osteonecrosis about the ankle¹, and we now describe that surgical technique. The indication for the procedure is early-stage osteonecrosis in a patient with symptoms that failed to respond to at least three months of nonoperative management, such as lifestyle and activity modifications, nonsteroidal anti-inflammatory drugs (NSAIDs), and use of braces/orthotics.

The procedure is performed with the following steps.

Step 1: Preoperative Planning for a Lateral Talar Lesion (Figs. 1-A, 1-B, and 2)

Obtain anteroposterior and lateral ankle radiographs as well as magnetic resonance imaging (MRI) studies

of the ankle to evaluate the stage of the osteonecrotic disease.

- Identify talar or tibial involvement according to the modified Ficat and Arlet classification for the ankle¹⁹, which stratifies disease progression into four stages. In Stage I, there is no apparent evidence of the disease on radiographs; however, necrotic changes can be seen on MRI studies. In Stage II, there are cystic and/or osteosclerotic lesions on radiographs with a normal contour of the talus, and no evidence of subchondral fracture. A crescent sign or subchondral collapse are characteristics of Stage-III disease. In end-stage disease (Stage IV), there is narrowing of the cartilage thickness and secondary changes in the distal aspect of the tibia, such as cysts and marginal osteophytes.
- Evaluate the extent of the osteonecrosis according to the method described by Delanois et al.¹⁷, which divides the talar dome into four zones (I through IV) on both coronal and sagittal images and the presence or absence of osteonecrosis in these zones.
- Stage-III lesions with no collapse can still be treated with percutaneous drilling. For Stage-III lesions with collapse and Stage-IV ankle osteonecrosis, consider other treatment modalities such as physical therapy, ankle arthrodesis, ankle arthroplasty, etc.

Step 2: Percutaneous Pin Insertion (Lateral Talar Lesion) (Figs. 3-A and 3-B and Video 1)

Insert a 1.8-mm Steinmann pin or Ilizarov wire percutaneously under biplanar fluoroscopic visualization.

- Use anteroposterior and lateral fluoroscopic views to localize the lesion intraoperatively. These images will be used to identify the safe route for pin insertion.

- The anatomical landmark used for the incision is under the medial malleolus. This is confirmed with intraoperative fluoroscopic imaging.
- Advance a 1.8-mm Steinmann pin or Ilizarov wire from medial to lateral into the talar osteonecrotic lesion as predetermined with the preoperative MRI.
- Use fluoroscopic images in both the lateral and the anteroposterior projection to confirm the pin placement and depth into the necrotic lesion.
- Take care not to penetrate the tibiotalar joint or the joint cartilage. We attempt to avoid cartilage perforation by using preoperative MRI and anteroposterior and lateral radiographs as a surgical map to correlate with intraoperative fluoroscopic images (in both the anteroposterior and the lateral projection) to confirm the correct route of pin insertion.

Step 3: Percutaneous Drilling (Figs. 3-C, 3-D, and 3-E)

Make one, two, or three passes with a 3.2-mm cannulated drill bit over the pin into the lesion(s).

- Make a stab incision along the previously inserted pin for placement of a 3.2-mm cannulated drill bit.
- Advance the 3.2-mm cannulated drill bit over the pin into the lesion(s).
- Make one, two, or three passes depending on the size and location of the lesion. The goal is to drill into the entire area of the lesion(s).
- Take care not to violate the ankle joint. When the joint is violated, backfilling is typically not performed because of concern about intra-articular injection of the bone filler.

Step 4: Backfilling the Bone Tunnel (Optional) (Figs. 3-F and 3-G)

Infiltrate the defect with demineralized bone matrix to backfill the drill track and the deep necrotic bone defect.

- Use a 14-gauge angiocatheter and place it over the 1.8-mm wire.
- Secure the angiocatheter with a hemostat while infiltrating the defect with the demineralized bone matrix (or other synthetic bone substitute according to your preference).
- Infiltrate the defect with the demineralized bone matrix in order to backfill the drill track and the deep necrotic bone defect.

Step 5: Postoperative Management

The patient bears weight as tolerated in a removable short leg rigid boot for the first four weeks and avoids high-impact activities for at least ten months.

- The patient may bear weight as tolerated in a removable short leg rigid boot (or two removable short leg rigid boots if bilateral surgery was performed) for the first four weeks. The patient can remove the boot(s) while at rest and is encouraged to perform range-of-motion exercises of the ankle. An elastic bandage wrap is worn for the first month, and the patient is allowed to bathe three days postoperatively.
- The patient advances to full weight-bearing as tolerated in a supportive shoe after four weeks, or after five or six weeks if he/she underwent a bilateral procedure.
- High-impact activities should be avoided for at least ten months.

Results (Figs. 4-A, 4-B, and 4-C)

In our study, there were significant improvements in the mean American Orthopaedic Foot & Ankle Society (AOFAS) ankle-hindfoot score ($p = 0.001$), University of California Los Angeles (UCLA) activity score ($p = 0.025$), and visual analog scale (VAS) pain score ($p = 0.001$) at a mean of five years (range, two to nine years) postoperatively¹.

Eighty-four (83%) of the ankles did not demonstrate progression of the osteonecrotic lesion (Fig. 5). However, seventeen ankles progressed to a more advanced stage (either from Stage I to II or from Stage II to III or IV), and four of the seventeen progressed to joint collapse.

What to Watch For

Indications (Fig. 6)

- Osteonecrosis of the distal part of the tibia and/or of the talus
- Stage-I or II ankle osteonecrosis
- Symptomatic ankle lesion
- Failure of at least three months of nonoperative management—i.e., lifestyle and activity modifications, NSAIDs, and use of various braces

Contraindications

- Stage-III lesions with collapse and Stage-IV ankle osteonecrosis
- Active infection
- Patient who is too unstable to undergo general anesthesia

- Neuropathy
- Peripheral arterial disease
- Malalignment of the ankle
- Malunion of the distal part of the tibia

Pitfalls & Challenges

- Extreme care must be taken not to penetrate the ankle joint.
- Vascular or nerve injury
- Infection
- Soft-tissue extravasation of the demineralized bone matrix backfiller
- Recurrence or incomplete revascularization

Clinical Comments

- Emphasis should be placed on the early diagnosis of ankle osteonecrosis.
- Patients with asymptomatic early-stage disease should be followed every six to twelve months.
- Symptomatic ankles that have early-stage disease should receive a minimum of three months of nonoperative management.
- Symptomatic ankles with Stage-I or II disease for which nonoperative management has failed may undergo multiple percutaneous drilling procedures.
- Multiple drilling procedures should not be used for patients with late-stage post-collapse (Ficat and Arlet Stage-III or IV) osteonecrosis.
- Since ankle osteonecrosis had a bilateral presentation in the majority of our patients, radiographic evaluation of the contralateral ankle may be very important.
- Osteonecrosis of the distal part of the tibia and

of the talus remains a challenging condition for both the patient and the treating physician.

- Tibial lesions are less common than talar lesions; however, they are typically found in combination with talar lesions. Percutaneous drilling of tibial lesions is typically performed from a medial approach, which limits the risk of tendon injury and avoids the fibula. Anterior drilling of a tibial lesion can be safely performed when an anterior ankle incision has already been made to address another ankle condition in the same surgical setting.
- Arthroscopic guide instruments can be utilized when a simultaneous ankle arthroscopy is being performed in order to allow accurate percutaneous drilling.
- Backfilling of the percutaneous drill tunnel and necrotic area theoretically increases strength and prevents collapse as the injectable volume fills the tunnel and necrotic area. We have used demineralized bone matrix and other injectable bone-filling agents with success and believe that the fluid pressure of the injection increases extravasation of the filler into the necrotic region and thus provides strength and decreases pain.
- Although there is some degree of cartilage loss with osteonecrosis, percutaneous drilling treats the underlying bone, which is the foundation of the joint, and thus prevents further adjacent cartilage loss.
- Typically, patients experience pain relief within three to six months following percutaneous drilling; if not, repeat drilling may be necessary. Repeat percutaneous drilling is successful in patients who have developed new lesions or if the original percutaneous drilling failed because of inaccurate placement or incomplete revascularization.

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Fig. 1-A

Fig. 1-B

Fig. 1-A Lateral radiograph of the ankle demonstrating cystic and sclerotic (osteonecrotic) changes in the posterior and central parts of the talus. **Fig. 1-B** Anteroposterior radiograph of the ankle demonstrating cystic and sclerotic (osteonecrotic) changes in the lateral half of the talus.

Fig. 2 Preoperative T2-weighted MRI of the talus demonstrating osteonecrotic lesions with adjacent bone marrow edema and no evidence of joint collapse.

Fig. 3-A

Fig. 3-B

Fig. 3-C

Fig. 3-D

Fig. 3-A A 1.8-mm pin is percutaneously placed under fluoroscopic guidance. **Fig. 3-B** A fluoroscopic anteroposterior image is used to confirm placement of the wire into the necrotic lesion without penetration into the ankle joint. **Fig. 3-C** A stab incision is made for placement of the 3.2-mm cannulated drill bit. **Fig. 3-D** The 3.2-mm cannulated drill bit is advanced to the lesion.

Fig. 3-E

Fig. 3-F

Fig. 3-G

Fig. 3-E Biplanar fluoroscopy is utilized to determine the appropriate drilling depth to avoid violation of the ankle joint. **Fig. 3-F** A 14-gauge angiocatheter is placed over the 1.8-mm pin to backfill the drill track and defect. **Fig. 3-G** The angiocatheter is secured with a hemostat while the defect is infiltrated with the demineralized bone matrix.

Fig. 4-A

Fig. 4-B

Fig. 4-C

Figs. 4-A and 4-B Postoperative anteroposterior (**Fig. 4-A**) and lateral (**Fig. 4-B**) radiographs of the ankle made five years following percutaneous drilling, showing no progression of the disease. **Fig. 4-C** Postoperative T2-weighted coronal MRI of the talus, demonstrating a minimal residual cyst with sealed subchondral cysts.

Fig. 5
Summary of the radiographic outcomes at the time of final follow-up in our study¹.

Fig. 6
Summary of our proposed treatment algorithm for early-stage ankle osteonecrosis.