Arthroscopy-Assisted Closed Reduction and Percutaneous Nail Fixation of Unstable Ankle Fractures: Description of a Minimally Invasive Procedure

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Abstract: When one is surgically managing an unstable ankle fracture, anatomic reduction of the syndesmosis is typically accomplished using an open surgical approach. We propose an arthroscopically assisted technique that restores normal anatomy while using a percutaneously placed intramedullary nail to fix the fibula. The patient is positioned supine, and the ankle is placed under traction by use of a tensor bandage. Standard anteromedial and anterolateral arthroscopy portals are used. The joint is examined for bony, ligamentous, and chondral injury. Lateral malleolus fracture reduction is accomplished with pointed reduction forceps to apply traction and rotation to the tip of the distal fibula fragment. A retrograde fibular intramedullary nail (Acumed, Hillsboro, OR) is inserted under fluoroscopic guidance. Arthroscopy is then used to guide the reduction of the fibula and rotation of the fibula with placement of the arthroscope in the lateral gutter. Syndesmosis screws are placed once the fracture and syndesmosis reductions are confirmed through both fluoroscopy and arthroscopy.

After open reduction—internal fixation of the unstable ankle fracture, wound-related complications have been shown to be associated with worsened functional outcomes.[1] Diabetic and elderly populations tend to be particularly susceptible.[2] Percutaneous ankle fracture reduction systems such as the Acumed fibula rod (Acumed, Hillsboro, OR) have therefore become attractive for their avoidance of large incisions.[3] In emphasizing minimal invasiveness, however, the Acumed system relies on fluoroscopic guidance rather than open visualization for reduction of the syndesmosis. Multiple recent studies have shown that in place of open visualization, reliance on intraoperative fluoroscopy alone for reduction of the syndesmosis is prone to malreduction.[4-6] This has also been shown to subject the patient to worsened functional outcomes[6] and, sometimes, the need for revision surgery.[7] As an alternative to both open visualization and fluoroscopy, ankle arthroscopy has been found to provide a viable means of guiding anatomic syndesmosis reduction.[8]

We present a technique that combines percutaneous nail fixation of the fibula with arthroscopy to adequately reduce the syndesmosis while minimizing soft-tissue damage in fracture fixation (Tables 1-3).

The bone graft substitute used in this presentation is not available for use within the United States. Within Canada, the bone graft substitute is available for ankle fusions and is therefore being used in an off-label manner for fractures.

Technique

A demonstration of our technique is provided in Video 1. The patient is positioned supine on a deflatable beanbag with the hip on the operative side elevated to allow the patient's toes to be pointing toward the ceiling. The heel of the patient reaches the end of the operative table. A thigh tourniquet is applied to avoid compressing the leg muscles and interfering with ankle

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Table 1. Benefits of Arthroscopy-Assisted Ankle Fracture Reduction and Fibular Nail Fixation

Minimization of surgical wound size and soft-tissue trauma
Direct visualization of syndesmotic reduction
Enhanced ability to identify and treat osteochondral injury
Removal of torn capsule and ligaments potentially causing impingement
Potential improvement of outcome
Reduced postoperative length of stay
Reduced postoperative pain
Reduced postoperative wound complications

arthroscopy access. The use of a thigh tourniquet is not essential and can be avoided in the setting of a patient with a vascular abnormality. The leg, ankle, and foot are prepared by sterile technique, and if the tourniquet is used, an Esmarch bandage is applied before inflation.

The ankle is first examined arthroscopically. For joint distraction, we tie a tensor bandage around both the ankle and the surgeon's waist. Anteromedial and anterolateral portals are established. These are placed about the soft spots on the medial and lateral ankle, respectively. If needed, an additional portal can be placed posterior to the medial malleolus. A 2.9-mm, 30° arthroscope is inserted. Joint irrigation is supplied by gravity flow. A shaver is introduced to allow for hematoma evacuation and drainage of irrigation (Fig 1). The distal tibia and talar dome are inspected for osteochondral injury. The medial and posterior malleoli are examined for fracture. The deltoid ligament is examined for rupture. The distal fibula is examined for visualization of the fracture, as well as the fibula's relation to the distal tibia for reduction of the syndesmosis (Fig 2).

Table 2. Technical Pearls

The patient is positioned supine with the hip on the operative side elevated over a deflatable beanbag.
Tourniquet placement about the thigh prevents leg muscle tension from interfering with joint distraction and fracture reduction.
A 2.9-mm, 30° arthroscope is used to view the ankle with a high-flow cannula to remove blood clot.
Distraction of the ankle joint is applied using a tensor bandage tied around both the ankle and the surgeon's waist.
Joint irrigation is supplied by gravity flow to minimize the risk of excess extravasation.
Inserting the longest and widest nail possible provides better varus and valgus control of the fibular fracture reduction.
Ensuring that the nail enters the fibula at its tip enhances control of translation in both the coronal and sagittal planes.
Dorsiflexion of the ankle helps to relax the anterior talofibular ligament during placement of the locking screw, thus preventing internal rotation and anterior translation of the distal fibular fragment.
Leaving the first syndesmosis screw proud allows for correction after reassessment by both arthroscopic and fluoroscopic examination.
External rotation of the distal screws allows correct placement of the syndesmosis fixation.
Large reduction forceps are helpful in percutaneous control of the fracture fragments and reduction of the syndesmosis.

Table 3. Pitfalls

Failure to correctly position the patient on the table into internal rotation of the hip will prevent access to the fibula.
Use of a low-flow cannula will prevent flushing out of the blood and clot and prevent visualization.
The starting point for the nail needs to be correctly positioned because a malreduction will occur if it is incorrectly located.
The distal locking screws need to be placed in 10° to 20° of external rotation so that the syndesmosis screws correctly engage the tibia.
The nail may become engaged in a proud position in a patient with a small fibular canal.
The distal end must be pulled down to ensure that the fracture is held out to length.
Insertion of the arthroscope between the talus and tibia during syndesmosis fixation may cause plantar flexion of the ankle and malreduction of the syndesmosis; instead, the lateral gutter should be visualized through the arthroscope.

The arthroscopic instruments are then removed from the joint, and the tensor band traction is released. Pointed forceps are used to percutaneously reduce the distal fibula fragment under fluoroscopy (Fig 3). A miniature C-arm is used. Standard protocol for insertion of an Acumed fibular nail is then followed. The fibular canal is reamed over a K-wire and then manually reamed. Augment synthetic bone graft (Biomimetics, Franklin, TN) can be inserted into the canal before fibular nail insertion for patients with limited bone healing potential. The fibular nail is then inserted by use of its guide attachment (Fig 4). Using the longest and widest nail possible allows for better varus and valgus control in fracture reduction. Ensuring that the nail enters the fibula at its tip enhances control of translation in both the coronal and sagittal planes. Restoration of fibular alignment is confirmed on fluoroscopy.

Once the surgeon is satisfied with reduction, locking screws are placed into the distal fragment through the fibular nail. Distraction is then used to bring the fibula out to length, and the length can be confirmed with either arthroscopy or fluoroscopy. Before transfixing

Fig 1. Distraction of the ankle is provided through a tensor bandage wrapped around both the ankle and the surgeon's waist. Typical anterolateral and anteromedial portals are used to examine the joint.

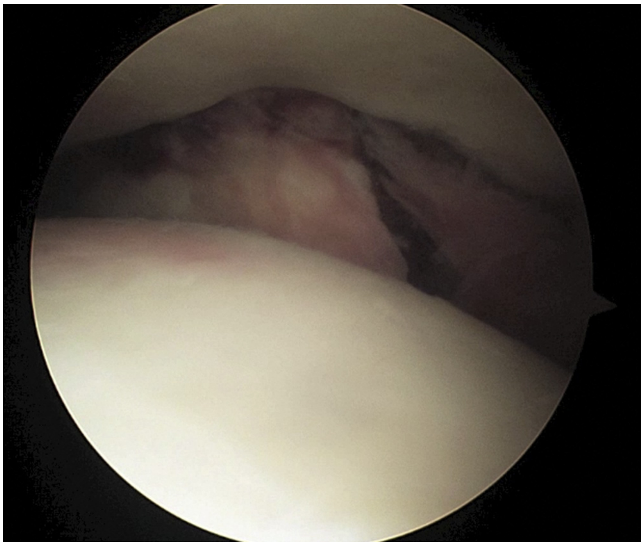

Fig 2. Arthroscopic examination of the joint allows visualization of the syndesmotic joint through the reduction of the fibula in the incisura of the tibia.

the proximal segment, the surgeon uses ankle dorsiflexion to de-tension the anterior talofibular ligament and prevent internal rotation and anterior translation of the distal fibular fragment. The arthroscope cannot be placed between the tibia and talus during this step but can be placed in the lateral gutter to guide reduction and rotation of the fibula. Once reduced, under fluoroscopic guidance, a single syndesmosis screw is placed across 3 cortices to temporize fixation of the joint. To prevent anterior translation of the fibula, as well as internal rotation of the fibula, we recommend dorsiflexion of the ankle at the time of syndesmosis screw insertion. The screw is left proud through the stab incision for access and adjustment during the remaining steps.

Reduction of the syndesmosis is confirmed by both fluoroscopy and arthroscopy. If adjustment is needed,

Fig 3. Reduction of the fibular fracture is obtained through application of percutaneous reduction forceps both to the distal fibula and across the fracture site. Fracture reduction and restoration of length are observed fluoroscopically. A guidewire is placed up the fibular canal for reaming and eventual placement of the fibular nail.

Fig 4. The fibular nail is inserted with its insertion tool.

the syndesmosis screw is backed out from the tibia. The fibula is then percutaneously manipulated with the pointed reduction forceps, and the screw is re-advanced to fix the syndesmosis in the appropriate reduced position. Once the surgeon is satisfied with the reduction and fixation, a second syndesmosis screw is then inserted.

Final fluoroscopic images are taken. Synthetic bone graft is again placed into the fibular canal as well as the fracture site by use of a pituitary rongeur in cases at risk of delayed bone healing. The number and placement of incisions are shown in Figure 5. The incisions are closed with interrupted nonabsorbable sutures. The ankle is dressed in a bulky sterile dressing with a plaster back slab for prevention of equinus contractures.

Discussion

Management of the unstable ankle fracture in the diabetic or multiply comorbid patient remains a challenge in surgical decision making. Small incisions reduce the chance of wound infection or breakdown but compromise the ability to obtain an anatomic reduction. We have presented a procedure that achieves both goals. The small incisions required to fix an unstable ankle fracture using this technique are significantly less traumatic to the soft tissues than the typical incision used in an open approach. The incorporation of arthroscopy allows the surgeon to directly visualize reduction and soft-tissue

Fig 5. All incisions used in the procedure are stab incisions no greater than 1 cm in length.

and cartilage damage to a degree not achievable when using fluoroscopy alone. This procedure therefore holds promise for minimizing the risk of postoperative soft-tissue complications, particularly in high-risk populations. In turn, a reduction in postoperative wound complications would translate into decreased reoperation rates, shorter hospital stays, and improved economic efficiency.

An additional advantage of arthroscopy is its enhancement of the surgeon's ability to identify and manage osteochondral injury. This allows for increased accuracy in prognosticating the risk of post-traumatic arthritis developing in the patient.

Like any novel procedure, the learning curve for the described technique can be a limiting factor to its incorporation in the operating room. The operative time should be kept to a minimum to reduce the risk of infection, tourniquet-associated injury, and traumatic extravasation of intra-articular irrigation. In our experience we have found that the time it now takes to complete this procedure is closely comparable to the time required to perform a standard open reduction—internal fixation of the same injury. Furthermore, with the use of low-pressure gravity-flow irrigation, we have not encountered any episodes of excess extravasation.

Although fixation of the medial or posterior malleoli was not described in this article, we believe that these too can be addressed arthroscopically with minimal deviation from our protocol.

As we continue to improve on this technique, we have been evaluating each patient with postoperative computed tomography scans to assess the quality of our reductions. We would encourage any surgeon using this procedure to do the same.

Use of this method was first mentioned in a case report in 2012.[9] Since then, we have performed a total of 19 cases using this technique, 14 of which were in patients with diabetes. Our preliminary data suggest that this technique helps minimize the risk of postoperative soft-tissue complications developing and the need for removal of hardware. Similar research comparing open versus arthroscopic ankle fusion has shown that arthroscopy in place of open dissection reduces the length of hospital stay and significantly improves postoperative pain and function.[10] We believe that our procedure holds the potential to show a similar trend. Moving forward, its continued study and development should distinguish its key indications in which it maintains maximal superiority over standard open reduction—internal fixation.

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