Reconstruction of Chronic Ankle Instability With Hamstring Autograft

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Abstract: There are varied techniques in the literature for operative treatment of chronic ankle instability. Historically, ankle instability has been treated through direct repair, using imbrication of attenuated tissues. However, direct repair often is not a suitable option for patients with chronic instability that has developed as a result of generalized ligamentous laxity, failed previous stabilization, or paucity of competent local tissue. For these patients, reconstruction of the lateral ligaments is indicated and has been performed using various types of grafts, including semitendinosus grafts, gracilis grafts, peroneal grafts, plantaris grafts, and extensor digitorum longus grafts. We advocate using a hamstring autograft, either gracilis or semitendinosus, depending on the size of the patient's tendons, to operatively reconstruct the lateral ligaments in patients with chronic ankle instability.

Key Words: ankle instability, lateral ligament reconstruction, hamstring autograft

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HISTORICAL PERSPECTIVE

Ankle sprains are among the most common sports injuries and occur at a rate of ~2 million per year in the United States.[1,2] It has been reported that up to 85% of people recover from an ankle sprain within 3 years without operative intervention.[1] Of patients treated nonoperatively, up to 34% of people will resprain their ankle within the 3-year period following an initial sprain.[1] Repeated and severe injury to the ankle can lead to chronic ankle instability, which has been reported to develop in up to 40% of patients.[3]

There are 3 ligaments that make up the lateral ligament complex, the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL). The ATFL, which is the most frequently injured, prevents both inversion and anterior displacement of the talus. The PTFL, which is the least frequently injured, restrains internal rotation and inversion. The CFL functions to limit the supination of the ankle.[1] Tears of both the ATFL and CFL can lead to chronic ankle instability, and chances of developing instability are increased as the number of ankle sprains someone experiences increases.[4] When left untreated, chronic ankle instability may ultimately lead to arthritis of the ankle.[1] In cases with recurrent ankle sprains and persistent symptoms with conservative treatment, surgery is considered.[5]

Operative intervention for lateral ankle instability varies, and there are over 50 different procedures that have described in the literature, including different types of repairs and reconstructions of the lateral ligaments.[6] Historically, both anatomic repairs and nonanatomic repairs have been performed. It is now commonly accepted that anatomic procedures, where the ligaments are directly repaired, have shown better outcomes than nonanatomic repairs. Nonanatomic procedures, which can be quite invasive, often limit postoperative range of motion of the ankle joint in patients and can lead to osteoarthritis and restriction in subtalar motion and donor morbidity.[1,5,7–9] The most successful primary repair is the Brostrom procedure with the Gould modification, which involves direct suturing of damaged ligaments with augmentation using the inferior extensor retinaculum.[1,10] This procedure has consistently led to good results both in the short-term and long-term.[11]

Despite high success rates of the modified Brostrom procedure, primary repairs have been reported to fail in up to 10.8% of patients with no prior indication of ligamentous laxity and failure rates are even higher in patients predisposed to chronic instability by confounding factors.[12] Patients with generalized ligamentous laxity or an underlying deformity, a history of previous failed repair, or a lack of competent soft tissue are not good candidates for a primary repair. These patients, along with high demand athletes, may be indicated for an anatomic ligament reconstruction using either an allograft or an autograft to augment the existing tissue.[1,5,7,9,13,14] There have been a number of different types of grafts used, including semitendinosus grafts, gracilis grafts, periosteal flaps, extensor digitorum longus grafts, plantaris grafts, and peroneal grafts.[1,2,5,7,8,13,15,16] Currently, there is a lack of consensus on which type of graft is best.

When deciding between using an autograft or an allograft, several factors a surgeon must consider are the benefits and risks of each option. For an autograft to be successful, it is imperative that it can provide a good amount of strength, can mimic the size of the ligaments it is augmenting, and can be easily harvested without leading to a functional deficit in the donor site.[2] Allografts, which are another option, eliminate the risk of introducing any donor-site morbidity, reduce overall OR time, and lead to less postoperative pain. However, many patients prefer autograft in part because allografts are more expensive than autografts and have the added risk of disease transmission and an immune response to the transferred tissue.[17] Furthermore, the cadaveric tissue may be more prone to attenuation and loss of competence.[18] Patients also may experience more febrile days after a procedure with an allograft than an autograft which can hinder their quality of life and delay their ability to return to work postoperatively.[17]

A number of recent papers have reported on cohorts of patients undergoing various reconstructive options. In a 2011 paper, 27 patients (28 ankles) underwent direct repair of the ATFL and CFL with semitendinosus allograft and interference screws. Patients saw significant improvements, with 88% of them reporting being satisfied and an average reduction in talar tilt from 17.8 to 6.7 degrees and anterior drawer from 10 to 4.5 mm.[5] In a 2013 paper, semitendinosus allograft was used

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All patients were enrolled in our ankle instability study which was approved by our institution's Foot and Ankle Registry, which is IRB approved.

M.C.D. is a paid consultant for Extremity Medical and Fast Form, neither of whose products are involved in the current study. The remaining authors declare no conflict of interest.

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FIGURE 1. Preoperative anteroposterior (A) and lateral (B) ankle stress radiographs demonstrating increased talar tilt of 21.5 degrees and anterior drawer of 8.9 mm.

for 28 patients and 25 of 28 reported excellent or good satisfaction.[13] More recently, studies have examined the use of autograft in reconstruction with grafts from various sources, including the hamstrings and peroneus longus tendons. Positive results have been produced patients reporting good to excellent outcomes, no significant differences in radiographic or functional outcomes when compared with allograft reconstruction and, positive decreases in healing time following autograft reconstruction.[2,7,8,15–17]

There remains a lack of consensus about which tendon is best to use when reconstructing the lateral ligaments in a patient with chronic ankle instability. The senior author (M.C.D.) has performed a lateral ligament reconstruction using a hamstring autograft on over 40 patients since 2012. We believe that using a hamstring autograft, either semitendinosus or gracilis, offers patients the best recovery, also minimizes the associated foot morbidity of using a local foot tendon, and reduces the risk of an immune response that may be associated with using an allograft.

INDICATIONS AND CONTRAINDICATIONS

When a patient presents with lateral ankle instability, nonoperative treatment with functional bracing as well physical therapy with a specific focus on balance and peroneal strengthening is typically indicated. Many patients will do well nonoperatively and can return to activities without requiring operative intervention. In patients where conservative treatment does not succeed, 80% to 90% will do well with a traditional technique such as or similar to the Brostrom-Gould repair.[18] There is a subset of patients who may be less than ideal for a Brostom-Gould repair.[1] As previously mentioned, this subset includes high demand athletes, people with generalized ligamentous laxity, patients with a failed previous stabilization procedure and people with severe ankle instability whose talar tilt is >20 degrees and/or anterior drawer is >15 mm on ankle stress radiographs.[1] In addition, concerns about recurrence of instability may lead to augmentation procedures.[1] In our own experience, the senior author (M.C.D.) has found similar subsets of patients are most suited for the described reconstruction procedure.

PREOPERATIVE PLANNING

Patients should be assessed in the office using both a thorough patient history, with focus on history and number of previous ankle sprains, and a physical examination. Stress radiographs with both anteroposterior and lateral stress views should be taken and anterior drawer and talar tilt measurements should be taken (Fig. 1).[14,19] Anterior drawer, which is measured as the shortest distance between the posterior articular surfaces of the tibia to the talus is normally <10 mm or within 3 to 5 mm of the contralateral side.[1,15] Talar tilt, which looks primarily at the CFL, is normally <10 degrees or within 5 degrees of the contralateral side.[1,4] Magnetic resonance imaging can also be helpful to assess the ankle ligaments and to observe other pathology, including osteochondral lesions, presence of loose bodies, and any potential peroneal pathology. Magnetic resonance imaging will often reveal signal within ligaments

FIGURE 2. The incision sites are marked. A 5-cm incision is made over the distal fibula and a small 1-cm incision is shown over the lateral aspect of the calcaneus just below the peroneal tendons.

FIGURE 3. A, Bone tunnels are drilled in the calcaneus (25 mm depth), fibula (all the way through), and talus (all the way through). B, A guide wire is shown in the fibula). C, Guide wires are shown in all 3 locations. D, The tunnels are shown.

after injury; however, this does not accurately reflect competence of ligaments.

TECHNIQUE

The patient is placed in a supine position on the operating room table. A tourniquet is placed on the operative thigh and inflated to 250 mm Hg.

Hamstring Autograft Harvest and Preparation

Using a medial approach to the tibia, a 3-cm incision is made at the midway point between the posteromedial border of the tibia and the top of the tibial tubercle. The sartorial fascia is then divided in line with its fibers, exposing both the gracilis and semitendinosus, which are in-between the superficial medical collateral ligament and sartorial fascia. On the basis of the size of the patient's hamstring tendons, the choice is made whether to use gracilis or semitendinosus. In our experience, the diameter of the tendons is between 3.5 to 5.5 mm and, ideally, the graft should have a diameter of 4 mm. Thus, the decision of which tendon to use should be based on the size of the patient's tendons. Metzenbaum scissors are used to remove the adhesions holding the tendons to the medial head of the gastroc and a Linvatec tendon stripper (ConMed, Utica, NY) is used to harvest the tendon. The tendon being used is then brought to a side table for preparation. A ruler is used to remove the muscle

FIGURE 4. Fluoroscopy is used to confirm correct position of the guide wires. This radiograph demonstrates correct positioning of the guide wire in the anterior aspect of the lateral process of the talus.

remnants and then the tendon is attached to a Graft Master (Smith & Nephew, Andover, MA) and prepared to be used for a graft through tubularization with a 0 vicryl suture with a modified Krakow stitch.

This technique for harvesting the hamstring tendon(s) is the same as described in *Techniques in Foot and Ankle Surgery* chapter, "Hamstring reconstruction for chronic achilles pathology." Again, the choice should be made whether to use the gracilis or semitendinosus based on the size of the patient's tendons. In our experience, the graft is usually 22 to 30 cm in length. For ligament reconstruction, typically only 12 to 15 cm are needed, which allows the surgeon to double over some, or all, of the longer grafts. However, it is important to ensure that the graft is not too large as commensurate tunnels in the fibula and talus will be drilled and there needs to be adequate bone to support the tunnels.

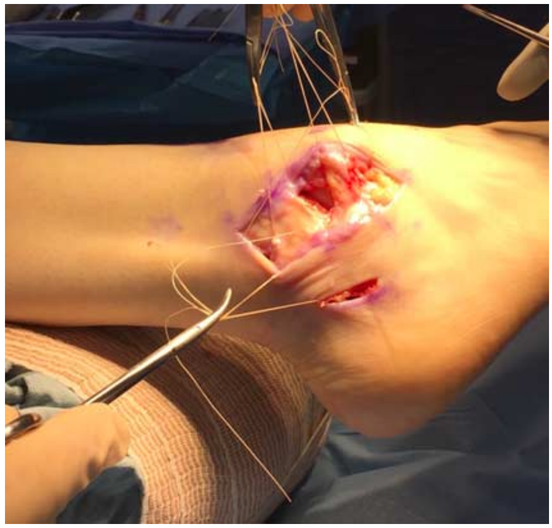

FIGURE 6. Sutures are used for graft shuttling.

Reconstruction of the Lateral Ligaments Using Hamstring Autograft

First, a 5-cm curvilinear incision is made over the distal fibula (Fig. 2). The CFL and ATFL are taken down off of the fibula. Attention is then turned to the peroneals. They are inspected and the protected posteriorly. A small 1-cm incision is then made over the lateral aspect of the calcaneus and a drill hole is placed at the CFL origin site, located just posterior to the fibula and 1 cm from the superior edge of the calcaneus. A bone tunnel is drilled. The diameter of the tunnel should be 0.5 mm greater than the diameter of the prepared graft. Fluoroscopy is used to ensure that the bone tunnel is in the correct position in

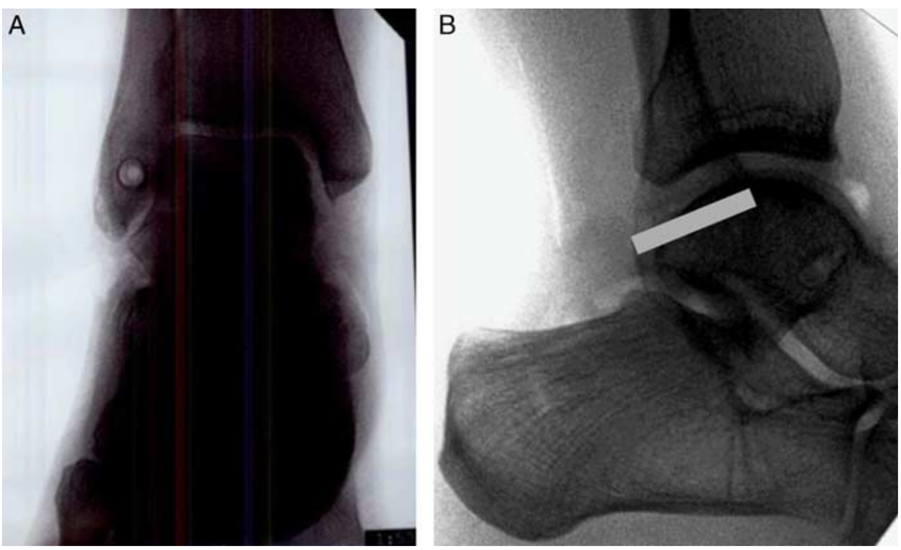

FIGURE 5. Anteroposterior (A) and lateral (B) intraoperative x-rays showing location and the posterior and inferior orientation (indicated by the gray bar) of the fibular drill hole.

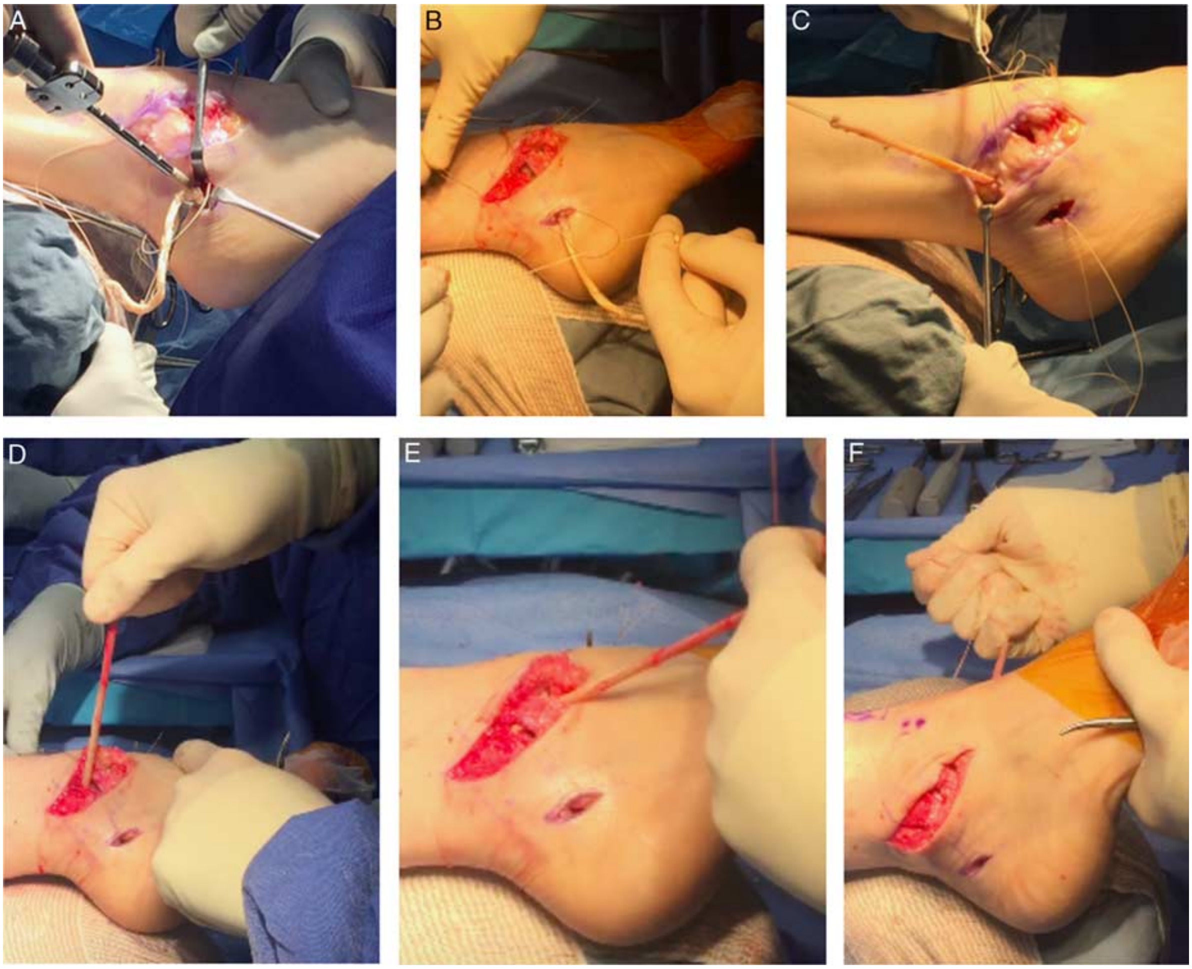

FIGURE 7. A, The hamstring graft is secured in place with a biotenodesis screw. B, The graft is shuttled underneath the peroneal tendons and secured in the calcaneus. The graft is shuttled through the fibula from posterior to anterior (C) and then under the anterior talofibular ligament (D) and out the medial aspect of the talus between the tibialis anterior tendon and posterior tibial tendon (E) and then tensioned (F).

the calcaneal tuberosity at the CFL insertion. Then, another bone tunnel is drilled at the anterior aspect of the lateral process of the talus, at the origin of the ATFL. A third bone tunnel is then drilled anteroposteriorly through the distal fibula by starting at the center of the fibula just inferior to the ankle joint line and aiming posteriorly and inferiorly (Figs. 3–6). Then, the hamstring graft is secured in place in the bone tunnel in the calcaneus using a biotenodesis screw. The screw should be within 0.5 mm of the diameter of the graft to ensure a secure hold. The graft is then shuttled underneath the peroneal tendons and then it is shuttled underneath the ATFL and then out the medial aspect of the talus. Shuttling is performed by placing a Nitinol wire (Arthrex, Naples, FL) with sutures through the tunnel and pulling the Nitinol wire with sutures. Then, pull the sutures with the tendon graft through the tunnel and tension. Next, the ankle is held in maximum posterior translation and eversion. A biotenodesis screw is then placed in the talus and then another biotenodesis screw is placed in the fibula for final tensioning (Figs. 7–9). Translation on the anterior drawer stress test and talar tilt on the varus stress test should now be eliminated (Figs. 10, 11).

The ATFL and CFL are then repaired using 2-0 permanent braided suture and they are augmented with the inferior extensor retinaculum. The superficial subcutaneous tissues are repaired with 3-0 vicryl and the skin is repaired using 3-0 nylon.

RESULTS

Previous literature reports generally positive results following reconstruction with autograft tendons. In a 2013 paper, semitendinosus autograft was used with a minimally invasive technique (2 small knee incisions to harvest the semitendinosus and 4 small incisions of 5 mm each in the ankle at the medial and lateral side of the fibular tip, talar neck, and middle of the calcaneus) on 25 patients. In total, 20 reported excellent results and 5 reported good results. They also report significant improvement on postoperative stress radiographs.[16] A 2017 paper reported using an all arthroscopic anatomic ATFL reconstruction with semitendinosus autografts on 12 patients and also reported good results.[8] In comparing semitendinosus autografts and allografts, a 2014 paper compared 2 cohorts of patients and found that while using a semitendinosus autograft made the operation longer, patients healed in less time than those receiving an allograft. They did not find any significant difference between radiographic outcomes or functional outcomes.[17]

A number of authors have also advocated using gracilis to successfully augment the lateral ligaments.[15] Ibrahim and

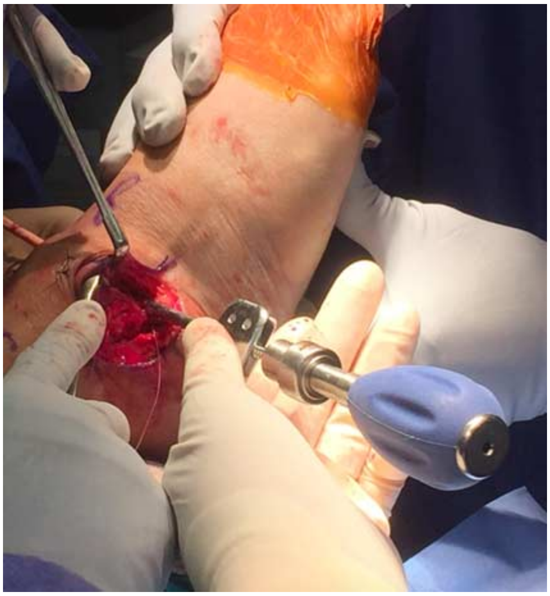

FIGURE 8. The graft is secured in place with a biotenodesis screw in the talus and a third screw is placed in the fibula.

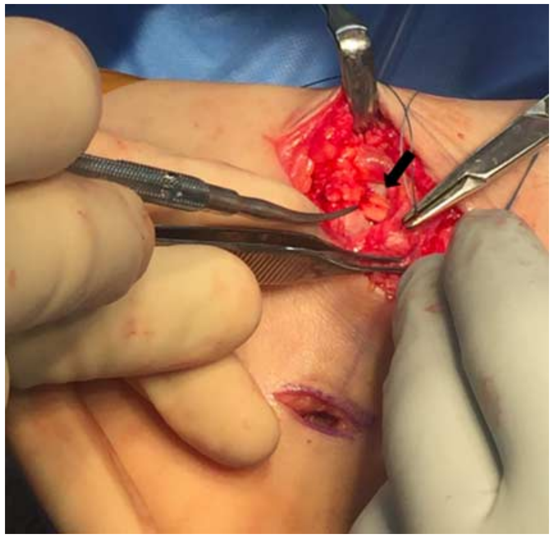

FIGURE 9. The anterior talofibular ligament limb of the graft is shown in place (arrow).

colleagues reported on a series of 16 patients who had the ATFL and CFL repaired with a gracilis graft. In total, 69% of their patients said the surgery led to excellent outcomes and 31% said it led to good outcomes. Range of motion was unaffected after surgery and all radiographic measurements showed significant improvement. Their technique involved dividing a gracilis autograft into 2 equal halves and using 1 for the talar attachment and 1 for the calcaneal attachment.[7]

Aside from hamstring grafts, the peroneus longus has been successfully used to reconstruct the lateral ligaments as an autograft. A 2016 paper used the anterior half of the peroneus longus in 31 patients and reported that this method led to good results and no significant decrease in plantar flexion strength. However, the authors cautioned against using all of peroneus longus because of its important role in eversion and plantar flexion and just used the anterior half of the tendon to avoid a significant functional loss in the ankle. They also reported that in a cadaveric study that the anterior half of the peroneus longus had a similar load to failure as the semitendinosus and about 1.5 times that of the gracilis and thus made it as suitable an option as a hamstring graft.[2]

The senior author (M.C.D.) has been using the described technique to reconstruct the lateral ligaments using hamstring autografts since 2010. Our preliminary results from a study under consideration for publication have been positive, with significant improvements in postoperative talar tilt and anterior drawer in radiographs taken at least 6 months postoperatively, with talar tilt decreasing from an average of 16 to 5 degrees and anterior drawer decreasing from an average of 9 to 6 mm (all changes were statistically significant) in 26 patients who had preoperative and

FIGURE 10. Postoperative anteroposterior (A) and lateral (B) ankle stress radiographs demonstrating a reduced talar tilt of 3.1 degrees and anterior drawer of 6.2 mm.

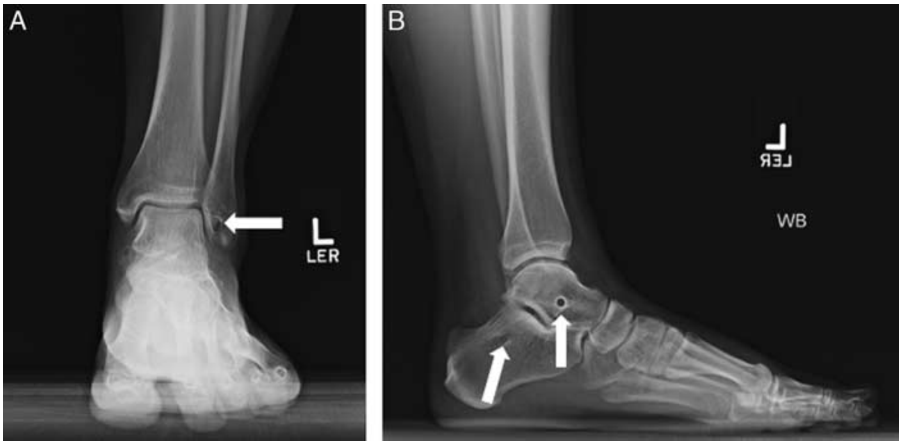

FIGURE 11. Postoperative standard weight-bearing anteroposterior (A) and lateral (B) radiographs. Relevant drill holes in the fibula, talus, and calcaneus are indicated by arrows.

postoperative stress radiographs. Clinical outcomes were assessed using the Visual Analog Pain Scale (VAS) and the Foot and Ankle Outcome Score (FAOS). In 26 patients who completed preoperative and postoperative surveys (at least 1 y postoperatively) between 2012 and 2015, VAS decreased from an average of 5.2 to 2.1 and FAOS Pain, Symptoms, Activities, Sports, and Quality of Life subscales increased from 64 to 82, 58 to 86, 61 to 75, 75 to 92, and 40 to 75, respectively (all changes were statistically significant with $P<0.05$).[20]

COMPLICATIONS

Complications include the risk of postoperative wound infection, possible dysfunction of the superficial peroneal or sural nerves, and donor-site morbidity where the hamstring tendon is harvested. Hardware irritation is another potential complication that can develop after the operation. Historically, cases of nonanatomic reconstruction have led to stiffness and subtalar arthrosis.

Of the patients treated by the senior author (M.C.D.), 4 cases of minor wound edge necrosis, 1 case of sural nerve dysesthesias, 1 case of numbness related to the infrapatellar branch of the saphenous nerve at the hamstring autograft harvest site, and 1 case of DVT at 8 weeks postoperatively have been seen. In addition, 1 patient underwent a second procedure to remove the interference screw at 2 years postoperatively.

POSTOPERATIVE MANAGEMENT

Following the operation, patients remain in a non–weight-bearing splint for 2 weeks. After this period, they are transitioned to a controlled ankle movement walker boot and can begin gentle range of motion activities. They can begin partial weight-bearing in the boot at 4 weeks postoperatively and begin physical therapy at 6 weeks postoperatively where they will progress to full weight-bearing. They can return to limited jogging at 3 months postoperatively and resume all sports and activities at 6 months postoperatively.

POSSIBLE CONCERNS, FUTURE OF THE TECHNIQUE

We believe that using hamstring autograft to reconstruct the lateral ligaments in patients with chronic ankle instability is a successful operative technique that offers a suitable donor tendon without the added costs and risks of immune response associated with using an allograft and without additional foot morbidity that is associated with transfer of a local foot tendon such as the peroneus longus. Hamstring harvest is proven to be safe with minimal morbidity.[21] It is important that continued studies follow outcomes of this procedure for an extended period of time as there is little long-term follow-up currently available. In addition, it is important to continue to weigh the pros and cons of autograft versus allograft to help determine which will be most successful for individual patients.

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