Technical Note

Arthroscopic Reconstruction of the Anterior Tibiotalar Ligament Using a Free Tendon Graft

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Abstract: Deltoid ligament injuries account for 5.1% to 15.8% of ankle sprains and occur with concomitant lateral ankle sprains. The anterior tibiotalar ligament (ATTL), located within the deep layer of the deltoid ligament complex, connects the talus and the tibia on the medial side of the ankle and controls ankle eversion and rotation. If conservative treatment for chronic medial ankle instability after an ankle sprain fails, ATTL repair or reconstruction might be necessary. Arthroscopic reconstruction techniques of the lateral ankle ligaments recently have been reported. Here, we describe arthroscopic reconstruction of the ATTL using a free tendon graft (ARATTL). This technique is less invasive than other treatments and results in a more stable medial ankle joint.

Introduction (With Video Illustration)

Ankle sprains are the most common sports-related injuries.[1,2] Although the anterior talofibular ligament is the most frequent injury in ankle sprains,[3] epidemiologic surveys indicate that deltoid ligament (DL) injuries account for 5.1%[4] to 15.8%[5] of ankle sprains. The DL is a complex ligament structure spanning from the medial malleolus (MM) of the ankle to the navicular, talus, and calcaneus bones. The DL is divided into superficial and deep layers. The deep layer includes the anterior tibiotalar ligament (ATTL) and the posterior tibiotalar ligament (PTTL).[6] The ATTL can be observed arthroscopically.[7]

There are already several reports of arthroscopic lateral ankle ligament reconstruction for the anterior talofibular ligament,[8-11] calcaneofibular ligament,[12-17] posterior talofibular ligament,[18] and lateral talocalcaneal ligament.[19] Here we describe the arthroscopic reconstruction of the ATTL using a free tendon graft (ARATTL). A summary of the key steps is provided in Table 1, whereas a summary of the technique is provided in Video 1.

Surgical Technique

Step 1: Patient Positioning

This surgery is performed with the patient under general anesthesia and in the supine position. A tourniquet is placed on the proximal thigh and the patient's foot is suspended from the distal edge of the bed. The contralateral leg is slightly lowered to provide a wide working space.[11,16,19]

Step 2: Graft Preparation

The autogenous hamstring tendon is harvested from the pes anserinus and a 1- to 2-strand graft is prepared (Fig 1A). Use of the endoscopic harvest technique is recommended to ensure a smaller scar.[20] An allograft tendon is an alternative. The length is speculated on preoperative magnetic resonance imaging and radiographs. Because ATTL length should be at least 25 mm long, the harvested tendon must be longer than 55 mm to contain a 1-strand bundle or 110 mm long to contain a 2-strand bundle. The 2 ends form a 15-mm-long bundle or loop to facilitate thread attachment for graft delivery. The recommended graft diameter is 4.5 to 5.5 mm (Fig 1B).

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Table 1. Key Surgical Steps, Pearls, and Pitfalls

Key Surgical Steps	Pearls	Pitfalls
Harvest a hamstring tendon	The harvested tendon must usually be longer than 55 mm. The gracilis tendon is usable for ATTL reconstruction. The length is estimated on preoperative images.	A short tendon will prevent graft preparation, especially in cases in which simultaneous reconstruction of the medial and lateral ligaments is performed.
Create the AM portal	The ankle is neutrally positioned. The AM portal is created medially to the anterior tibial tendon.	If the AM portal is positioned too medially, creation of the AAM portal will be difficult.
Create the AAM portal	Before the AAM portal is created, a needle is inserted into the portal site to confirm accessibility to the talar and tibial footprints of the ATTL.	If the AAM portal is created without confirmation by the needle, the AAM portal position will not be suitable for the talar tunnel creation.
Create the talar tunnel	A guidewire is inserted through the AAM portal to drill the talus toward the lateral side of the talus. Intraoperative fluoroscopy is used to confirm guidewire position and direction.	If a guidewire is directed too posteriorly, the lateral cartilage of the trochlea may be damaged. If the tibial tunnel is created without fluoroscopy guidance, the risk of tunnel fracture and malposition may increase.
Create the tibial tunnel	Intraoperative fluoroscopy is used to confirm guidewire position and direction. The angle between guidewire direction and the long axis of the tibia on the lateral view is 20°-40°.	If the tibial tunnel is created without fluoroscopy assistance, the risk of tunnel fracture and malposition may increase.
Dissect the ATTL remnant	The dissection area should be minimal.	If the dissection area is too wide, the PTTL and superficial DL layers may be damaged.
Place the suture anchor in the tibial tunnel	If a drill wire does not reach the opposite cortex, surgeons can insert it from the anterior edge of the tunnel inlet to the posterior and proximal end.	If a drill wire does not reach the opposite cortex, the suture anchor will be positioned within the fibula cancellous bone and the graft fixation strength will be weak.
Fix the graft	If screw insertion into the tibial tunnel is difficult, a smaller screw should be chosen, or suture anchor fixation alone can be considered sufficient.	If the screw is too large for tibial tunnel fixation, tunnel wall fracture will occur.

AAM, accessory anteromedial; AM, anteromedial; ATTL, anterior tibiotalar ligament; DL, deltoid ligament; PTTL, posterior tibiotalar ligament.

Step 3: Portal Placement of Ankle Arthroscopy

Two portals—a conventional anteromedial (AM) portal and an accessory anteromedial (AAM) portal—are created step by step. The ankle is positioned neutrally. The AM portal is created medial to the anterior tibial tendon and slightly proximal to the joint line (Fig 2A).[11,16,18] A 30° 2.7- or 4.0-mm-diameter arthroscope is introduced through the AM portal. The medial gutter is viewed with the ankle neutral or in a slightly dorsi-flexed position.

After a needle is inserted into the portal site to confirm accessibility to both the ATTL talar and tibial footprints, the AAM portal is created. The portal is usually created at approximately 10 to 15 mm anteroinferior to the anterior colliculus of the MM (Fig 2B). A conventional anterolateral portal or the accessory anterolateral portal is created as needed for the treatment of the other lesion, e.g., anterolateral synovitis, osteochondral lesion of the talus, and lateral ligament rupture.

Step 4: Tunnel Creation

The anteromedial synovium and ATTL remnant around the ATTL talar footprint are dissected using a shaver and a radiofrequency probe. A microfracture awl is used to mark the ATTL talar footprint, which is immediately inferior to the articular cartilage of the trochlea,[21] and a 2.4-mm guidewire is inserted through the AAM portal to drill the talus from the ATTL footprint toward the lateral side of the talar neck (Fig 3A). The insertion point should be posteroinferior to the anteromedial corner of the trochlea of the talus.[21] Intraoperative fluoroscopy is used to confirm the guidewire position[22] (Fig 3B). The guidewire is then overdrilled using a drill with the same or a 0.5-mm larger diameter than the graft end to create a 20-mm-deep talar tunnel (Fig 3C).

When the ATTL tibial footprint is not adequately viewed through the AM portal, surgeons can try to dorsiflex the ankle or change to a 70° arthroscope. The ATTL remnant is dissected at the tibial footprint and a

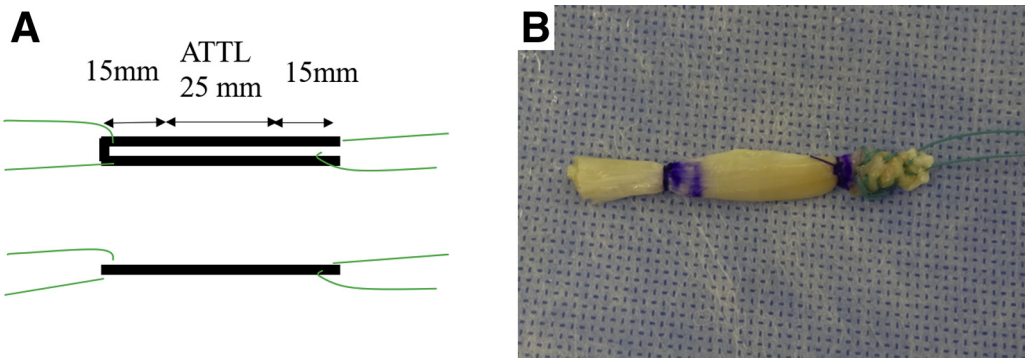

Fig 1. Graft preparation. (A) A hamstring tendon is harvested from the pes anserinus and a 1- to 2-strand graft is prepared. An allograft tendon is an alternative. Required length is estimated on preoperative magnetic resonance imaging and radiographs. Because the ATTL should be at least 25 mm long, the harvested tendon must be longer than 55 mm to contain a 1-strand bundle or 110 mm to contain a 2-strand bundle. The 2 ends form a 15-mm-long bundle or loop to facilitate attachment of the thread for graft delivery. The recommended graft diameter is 4.5 to 5.5 mm. (B) A semitendinosus tendon graft is shown that contains a 1-strand bundle for the ATTL graft. The talar side end of the ATTL graft is sutured using the Krackow method. (Patient 1 is shown.) (ATTL, anterior tibiotalar ligament.)

guidewire is inserted through the AAM portal. Intraoperative fluoroscopy is used to confirm the guidewire position. The insertion point should be on the anterior colliculus of the MM.[23] The angle between guidewire direction and the long axis of the tibia on the lateral view is 20° to 40° (Fig 4A). The guidewire direction is almost on the middle line of the MM on the anteroposterior view (Fig 4B). Viewed from the AM portal, the guidewire is then overdrilled to create a 30-mm-deep tibial tunnel (Fig 4C).

Step 5: Tendon Graft Introduction

Viewed from the AM portal, the surgeon penetrates from the tibial tunnel bottom to the opposite cortex using a 2.9-mm drill wire (Zimmer-Biomet, Warsaw, IN) through the AAM portal. A JuggerKnot Soft Anchor

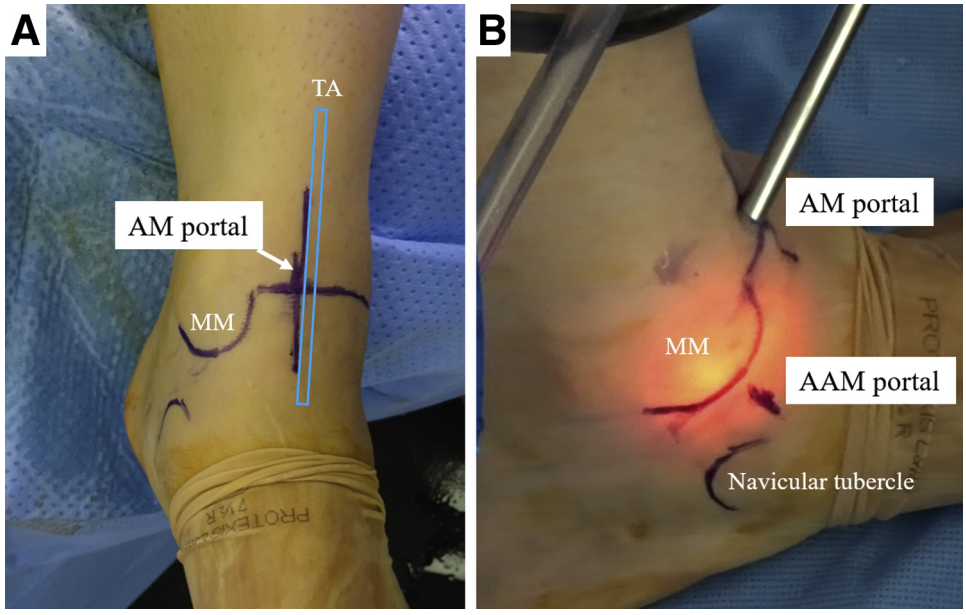

Fig 2. Creation of the AM and AAM portals (left ankle). (A) The ankle is positioned neutrally. The AM portal is created medial to the anterior tibial tendon (blue rectangle) and slightly proximal to the joint line.[11,16,18] A 30° 2.7- or 4.0-mm-diameter arthroscope is introduced through the AM portal. The medial gutter is viewed with the ankle in a neutral or slightly dorsiflexed position. (B) After a needle is inserted into the portal site to confirm accessibility to the ATTL talar and tibial footprints, the AAM portal is created. The portal is usually created approximately 10 to 15 mm anteroinferior to the anterior colliculus of the MM. (Patient 1 is shown in both panels.) (AAM, accessory anteromedial; AM, anteromedial; ATTL, anterior tibiotalar ligament; MM, medial malleolus.)

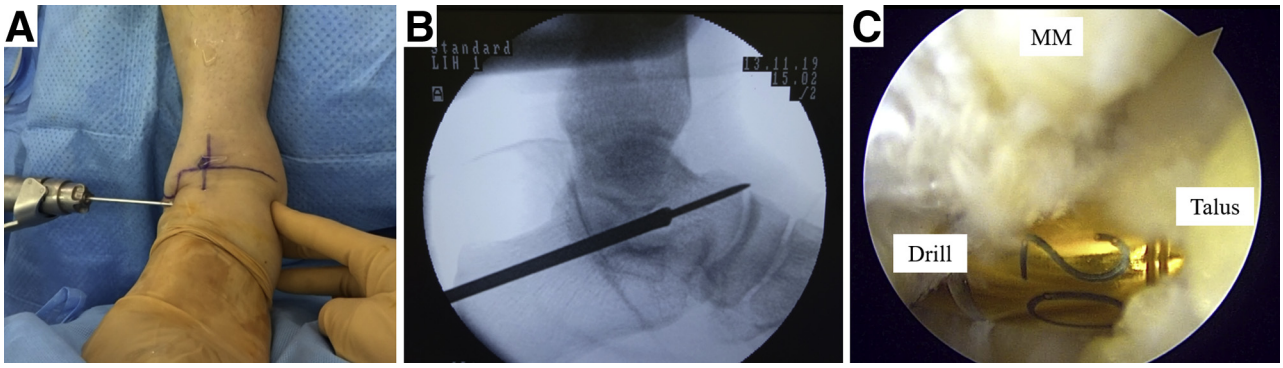

Fig 3. Creation of the talar tunnel (left ankle). (A) The anteromedial synovium and ATTL remnant around the ATTL talar footprint are dissected using a shaver and a radiofrequency probe. A microfracture awl is used to mark the ATTL talar footprint, which is immediately inferior to the articular cartilage of the trochlea,[21] and a 2.4-mm guidewire is inserted through the AAM portal to drill the talus from the ATTL footprint toward the lateral side of the talar neck. (B) The insertion point should be posteroinferior to the anteromedial corner of the trochlea of the talus.[21] Intraoperative fluoroscopy is used to confirm guidewire insertion position[22] by touching with a drill tip. (C) The guidewire is then overdrilled using a drill with the same or a 0.5-mm larger diameter than the graft end to create a 20-mm-deep talar tunnel. (Patient 1 is shown in all panels.) (AAM, accessory anteromedial; ATTL, anterior tibiotalar ligament; MM, medial malleolus.)

2.9 mm (Zimmer-Biomet) is placed at the tibial cortex behind the tibial tunnel (Fig 5A). Next, a 1.6-mm passing pin (Meira Co., Ltd., Nagoya, Japan) is inserted into the talar tunnel through the AAM portal. The pin penetrates the bone and the skin on the opposite side. A looped thread is passed through the eye of the passing pin, which is completely pulled through (Fig 5B). The looped thread in the talar tunnel is connected with the talar graft end. Next, the ATTL graft is introduced from the AAM portal to the talar tunnel by pulling of the looped thread. One strand of the suture anchor thread is sutured to the tibial side end of the graft (Fig 5C), whereas the other strand is pulled to introduce the graft into the tibial tunnel.

Step 6: Tendon Graft Fixation

The ATTL graft is tensed by pulling the suture anchor thread at the tibial tunnel and the strands are tied (Fig 6A). Subsequently, the graft is fixed with an appropriate diameter 15-mm-long bioabsorbable interference screw in the talar tunnel with the ankle in the 45° to 60° plantar flexion position to avoid restricting postoperative plantar flexion for most patients (Fig 6 B and C). However, maximum plantar flexion position is recommended for patients who require excessive plantar flexion angle, e.g., ballet dancers. If the patient is an athlete and wants to start rehabilitation as early as possible, interference screw fixation is added in the tibial tunnel to provide stronger initial fixation.[24]

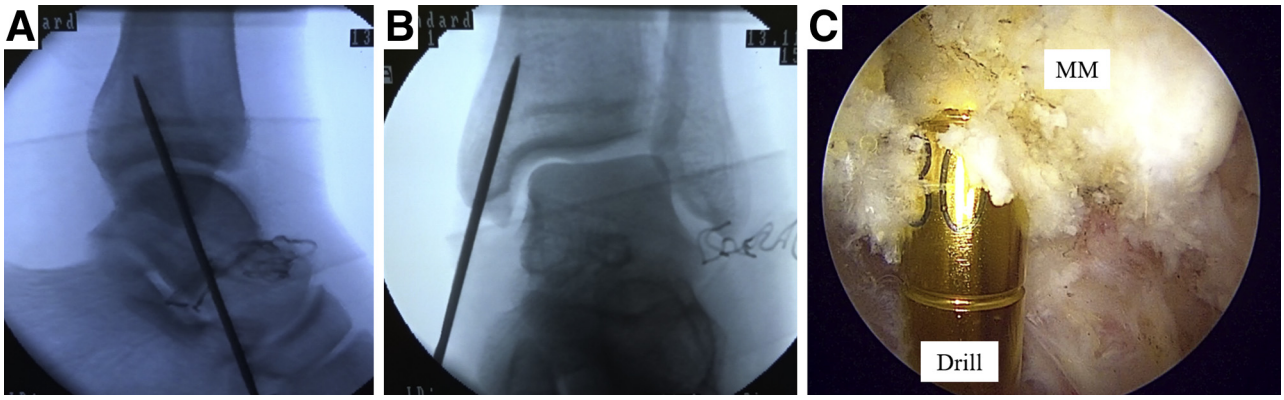

Fig 4. Creation of the tibial tunnel (left ankle). (A) The ATTL remnant is dissected at the tibial footprint. A guidewire is inserted through the AAM portal. Intraoperative fluoroscopy is used to confirm the guidewire position. The insertion point should be on the anterior colliculus of the MM.[23] The angle between the guidewire direction and the long axis of the tibia on the lateral view is 20 to 40°. (B) The guidewire direction is almost on the middle line of the MM in the anteroposterior view. (C1) Viewed from the AM portal, the guidewire is then overdrilled to create a 30-mm-deep tibial tunnel. (Patient 1 is shown in all panels.) (AAM, accessory anteromedial; AM, anteromedial; ATTL, anterior tibiotalar ligament; MM, medial malleolus.)

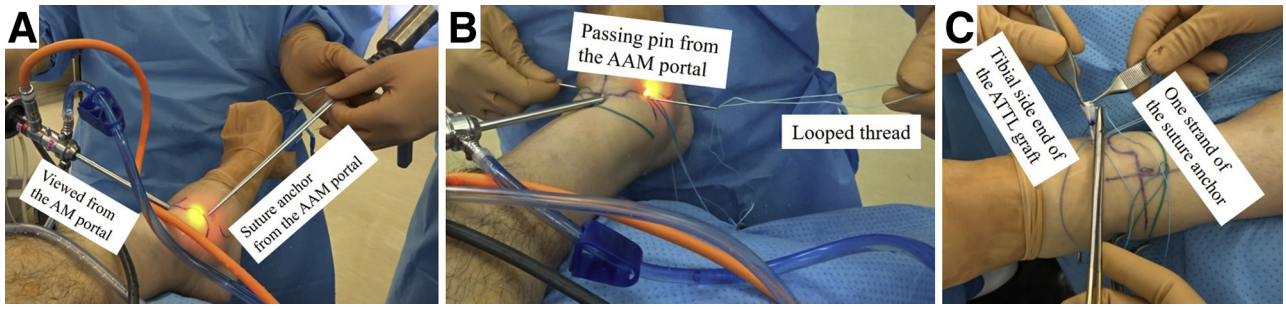

Fig 5. Tendon graft introduction (left ankle). (A) Viewed from the AM portal, the surgeon penetrates from the tibial tunnel bottom to the opposite cortex using a 2.9-mm drill wire (Zimmer-Biomet, Warsaw, IN) through the AAM portal. A JuggerKnot Soft Anchor 2.9 mm (Zimmer-Biomet) is placed at the tibial cortex behind the tibial tunnel. (B) Then, 1.6-mm passing pins (Meira Co., Ltd., Nagoya, Japan) are inserted into the talar tunnel through the AAM portal. The pins penetrate the bone and skin on the opposite side. A looped thread is passed through the eye of each passing pin, which is completely pulled. (C) The looped thread in the talar tunnel is connected to the talar graft end and the ATTL graft is introduced from the AAM portal to the talar tunnel by pulling of the looped thread. One strand of the suture anchor thread is sutured to the tibial side end of the graft, whereas the other strand is pulled to introduce the graft to the tibial tunnel. (Patient 1 is shown in all panels.) (AAM, accessory anteromedial; AM, anteromedial; ATTL, anterior tibiotalar ligament.)

Optional Technique When the Screw Is Not Firmly Fixed or Too Large to Insert

If the screw is not firmly fixed, the screw size is increased or the cancellous bone tips are grafted to the space between the tunnel and the tendon graft.[16,24] If the screw is then too large for tunnel insertion, a smaller screw should be chosen.

Discussion

DL injuries account for 5.1%[4] to 15.8%[5] of ankle sprains and can occur with concomitant lateral ankle sprains.[23,25,26] Single or repeated episodes of ankle sprain cause DL insufficiency and may lead to chronic instability.[27,28] The DL is divided into superficial and deep layers. The deep layer includes the ATTL and PTTL[6,29-31] and prevents eversion of the ankle joint, lateral displacement, and external rotation of the talus.[28,32-34] The ATTL is also known as the deep aTTL,[23] DATL,[21] or DATT.[22] The ATTL originates from the most inferior and anterior areas of the MM and inserts onto the anterosuperior portions of the medial talus body immediately inferior to the articular cartilage of the trochlea.[21]

Patients with chronic external rotation instability of the ankle without severe eversion instability or syndesmosis instability are good candidates for ATTL repair or reconstruction. If severe eversion instability exists, additional treatment of the other DL components, e.g., superficial DL layer or PTTL, should be considered. Although the external rotation stress test applied to the ankle in a neutral position is used to diagnose syndesmosis injury,[35] it is also useful for detecting medial ankle instability. The authors recommend the combination of external rotation stress and anterior drawer stress with the fibula as the central axis of rotation with the ankle in slight plantar flexion because it will diminish the posterolateral ankle instability and make it easy to feel subluxation at the anteromedial ankle.

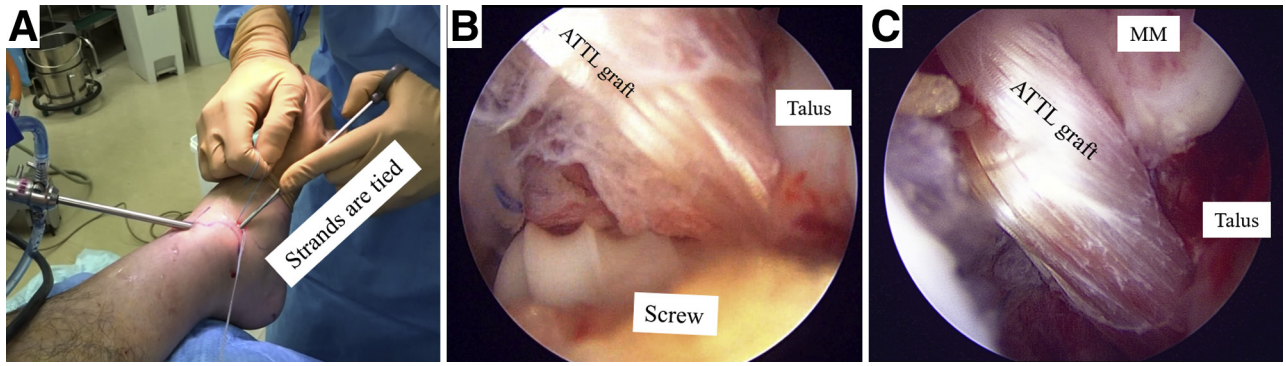

Fig 6. Tendon graft fixation (left ankle). (A) The ATTL graft is tensed by pulling of the suture anchor thread at the tibial tunnel and the strands are tied. (B) Subsequently, the graft is fixed with an appropriate diameter 15-mm-long bioabsorbable interference screw in the talar tunnel with the ankle in the 45 to 60° plantar flexion position to avoid restricted postoperative plantar flexion for most patients. (C) Viewed from the AM portal, the ATTL graft is tensed by plantar flexion or external rotation stress. (Patient 1 is shown in all panels.) (AM, anteromedial; ATTL, anterior tibiotalar ligament; MM, medial malleolus.)

Table 2. Advantages and Disadvantages of Anterior Tibiotalar Ligament Reconstruction

Advantages
Possibly better medial ankle joint stability and long-term clinical results
Less risk of other DL components via the intra-articular approach by arthroscopy
Only one more portal needed over conventional AM portal
Safe and reproducible tunnel creation
Anatomical reconstruction and lower postoperative risk of ROM restriction
Disadvantages
Longer tendon graft needed in cases of simultaneous reconstruction of medial and lateral ligaments
Possible risk of tunnel fracture
Basic arthroscopy skills needed
Need for intraoperative fluoroscopy

AM, anteromedial; DL, deltoid ligament; ROM, range of motion.

The incidence of ATTL is 63.2% (10.0%[29]-93%[21]) according to a recent review.[6] This means that the ATTL remnant does not always exist; therefore, repair is not always possible and reconstruction using a tendon graft is more reliable. Moreover, the repair technique may carry the risk of simultaneous suture of the superficial DL layer and can restrict range of motion.

The open reconstruction technique may require a longer skin incision and carries a greater risk of postoperative skin problems and superficial DL layer damage. Thus, the arthroscopic approach is preferable to avoid those complications because the ATTL is part of the deep DL layer and can be arthroscopically observed.[7] When combined medial and lateral rotational instability is observed in a patient, arthroscopic reconstruction of the ATTL is a less-invasive alternative because it requires only one more portal than the conventional AM portal of arthroscopic surgery.[11,16,19] Although there are already arthroscopic repair techniques of the anterior part of the superficial DL, specifically the tibionavicular ligament,[36,37] ATTL reconstruction is a more direct approach for treating medial instability of the talocrural joint. Moreover, because the existence rate of the tibionavicular ligament is 89.6%,[6] this repair technique is not always possible.

Although 4 studies[21,22,30,38] of a total of 47 ankles reported a pooled mean ATTL length of 12.85 ± 3.2 mm,[6] one reported a mean of 16.1 ± 6.8 mm. It is difficult to determine the exact length on preoperative images. Thus, we recommend that surgeons prepare the ATTL graft to be longer than 25 mm and adjust the length by inducting the graft end deeper into the tibial tunnel. If it is too short, additional operation time will be necessary for re-preparation of a tendon graft.

Some authors reported that the ATTL originates from the tip of the anterior colliculus and anterior part of the intercollicular groove of the MM.[23,27] If the tibial tunnel is created at the intercollicular groove, the PTTL may be damaged. Thus, the tibial tunnel should be created at the anterior colliculus. The talus insertion center is 12.2 mm posteroinferior to the anteromedial corner of the trochlea[21] and 16.6 mm posterior to the proximal point of the talar neck.[22] The medial ankle capsule near the anteromedial corner consists of fatty and synovial tissue.[39] However, a slightly more anterior position[24] in which it is just inferior to the anteromedial corner of the trochlea may be acceptable for the talar tunnel because it seems more effective for controlling anterior drawer stress and external rotation stress. In such cases, a longer graft for the ATTL is recommended. Because the distance between the anteromedial corner of the trochlea and the talonavicular joint cartilage is 7.2 ± 2.3 mm,[39] a tunnel diameter of 4.5 to 5.5 mm is appropriate.

Although the clinical effectiveness of ATTL reconstruction is unknown and should be researched in the future, the authors believe that this technique provides the possible advantages of lower invasiveness and a more stable medial ankle joint. A summary of its advantages and disadvantages is provided in Table 2.

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