Technical Note

Hybrid Ankle Reconstruction of Lateral Ligaments

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Abstract: Open anatomic reconstruction of the lateral ligament (AntiRoLL) of the ankle with a gracilis Y graft and the inside-out technique are commonly used and have evolved to minimally invasive surgery, including arthroscopic AntiRoLL (A-AntiRoLL) and percutaneous AntiRoLL procedures. A-AntiRoLL allows assessment and treatment of intra-articular pathologies of the ankle concurrently with stabilization. However, the A-AntiRoLL technique is technically demanding, especially in the process of calcaneofibular ligament reconstruction under subtalar arthroscopy. In contrast, the percutaneous AntiRoLL procedure is a simple concept that does not require the skill of an experienced arthroscopist but requires an extra skin incision to assess and treat intra-articular pathologies of the ankle. This study describes the application of a minimally invasive anatomic reconstruction technique—hybrid AntiRoLL—for chronic instability of the ankle that does not require advanced arthroscopic technique to assess and treat intra-articular pathology simultaneously.

Recently, arthroscopic and percutaneous ankle stabilization techniques have become popular because they are minimally invasive surgery and allow faster recovery than an open technique.[1] They are categorized into repair techniques using residual ligaments as repair materials[2-9] and reconstruction techniques using tendon transplants.[10-14] An anatomic reconstruction technique is indicated if the residual ligament is deteriorated or if there is no ligament fiber.[15] Open anatomic reconstruction of the lateral ligament (AntiRoLL) of the ankle with a gracilis Y graft and the inside-out technique are commonly used[16] and have evolved to minimally invasive surgery, including arthroscopic AntiRoLL (A-AntiRoLL)[14] and percutaneous AntiRoLL (Perc-AntiRoLL) procedures.[10,11] A-AntiRoLL allows assessment and treatment of

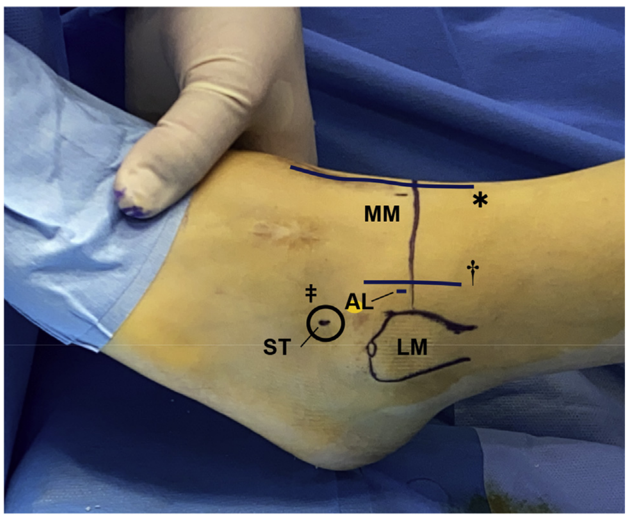

Fig 1. Anatomic landmarks. The patient is in the supine position. The asterisk indicates the lateral border of the tibialis anterior tendon; single dagger, lateral border of the peroneus tertius tendon; and double dagger, sinus tarsi. (AL, anterolateral portal; LM, lateral malleolus; MM, medial midline portal; ST, subtalar portal.)

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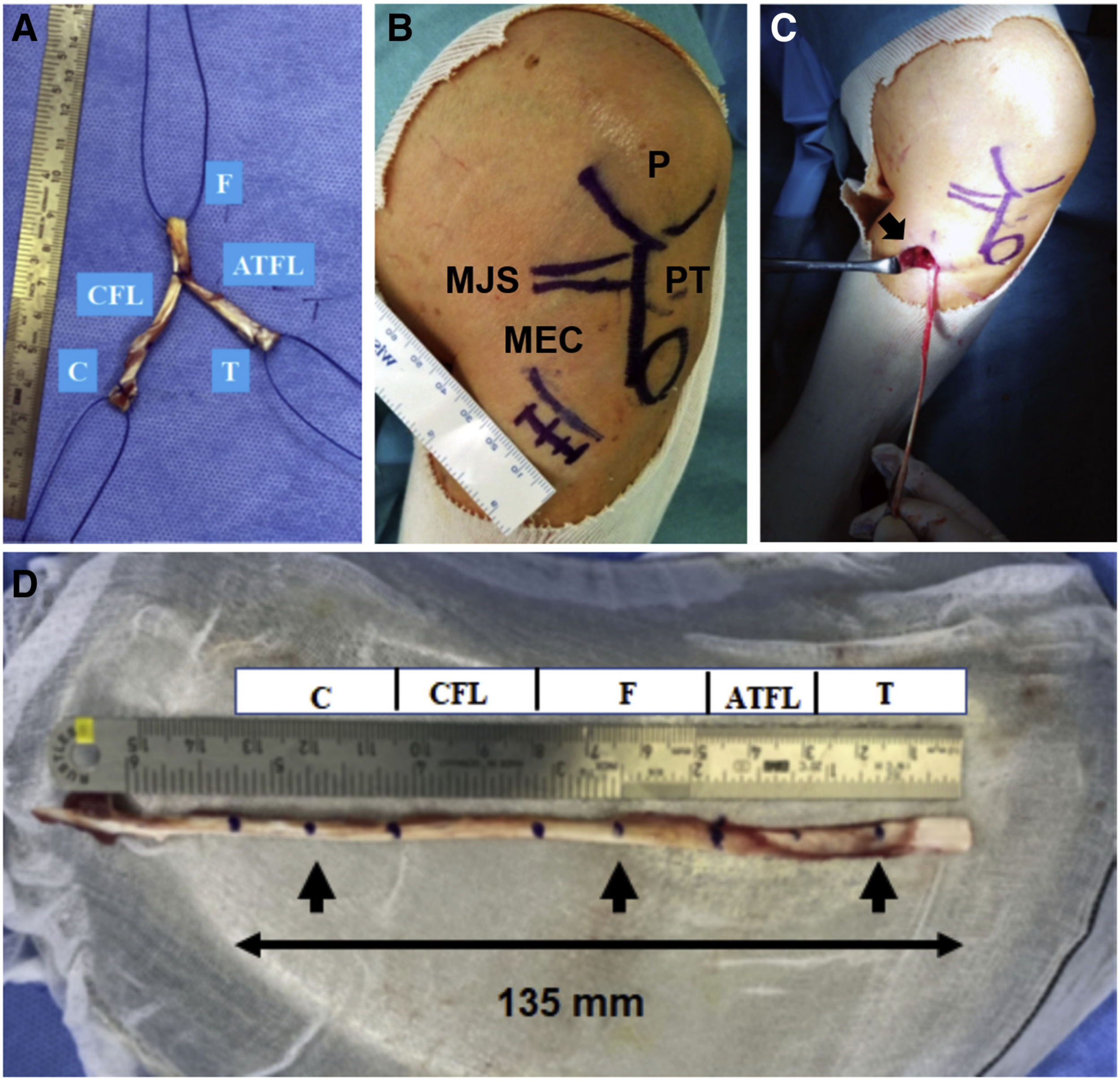

Fig 2. Constructing anatomic Y graft. The patient is in the supine position. (A) The graft is prepared in an anatomic Y configuration with a 3-looped stem (calcaneal [C], fibular [F], and talar [T]) by doubling the graft to a length of 15 mm at all 3 ends of the Y configuration to facilitate attachment of a "tensioning thread" for graft delivery and tensioning. (B) At the ipsilateral knee joint, the patella (P), patellar tendon (PT), medial joint space (MJS), and medial epicondyle (MEC) are drawn on the patient's skin. (C) The gracilis tendon, with a length of at least 135 mm, is sacrificed using a tendon harvester (arrow). (D) A marking is made every 15 mm from one end. Positions 15, 60, and 120 mm from the end of the tendon (arrows) are the folds that become the insertion parts into the bone tunnels of the talus (T), fibula (F), and calcaneus (C), respectively. (ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament.)

intra-articular pathologies of the ankle concurrently with stabilization.[14] However, this technique is technically demanding, especially in the process of calcaneofibular ligament (CFL) reconstruction under subtalar arthroscopy.[17] In contrast, Perc-AntiRoLL is a simple concept that does not require the skill of an experienced arthroscopist[10] but requires an extra skin incision to assess and treat intra-articular pathologies of the ankle. In this study, we describe the hybrid AntiRoLL technique for anatomic reconstruction of the ankle lateral ligaments, which uses the anatomic Y graft and the inside-out technique.

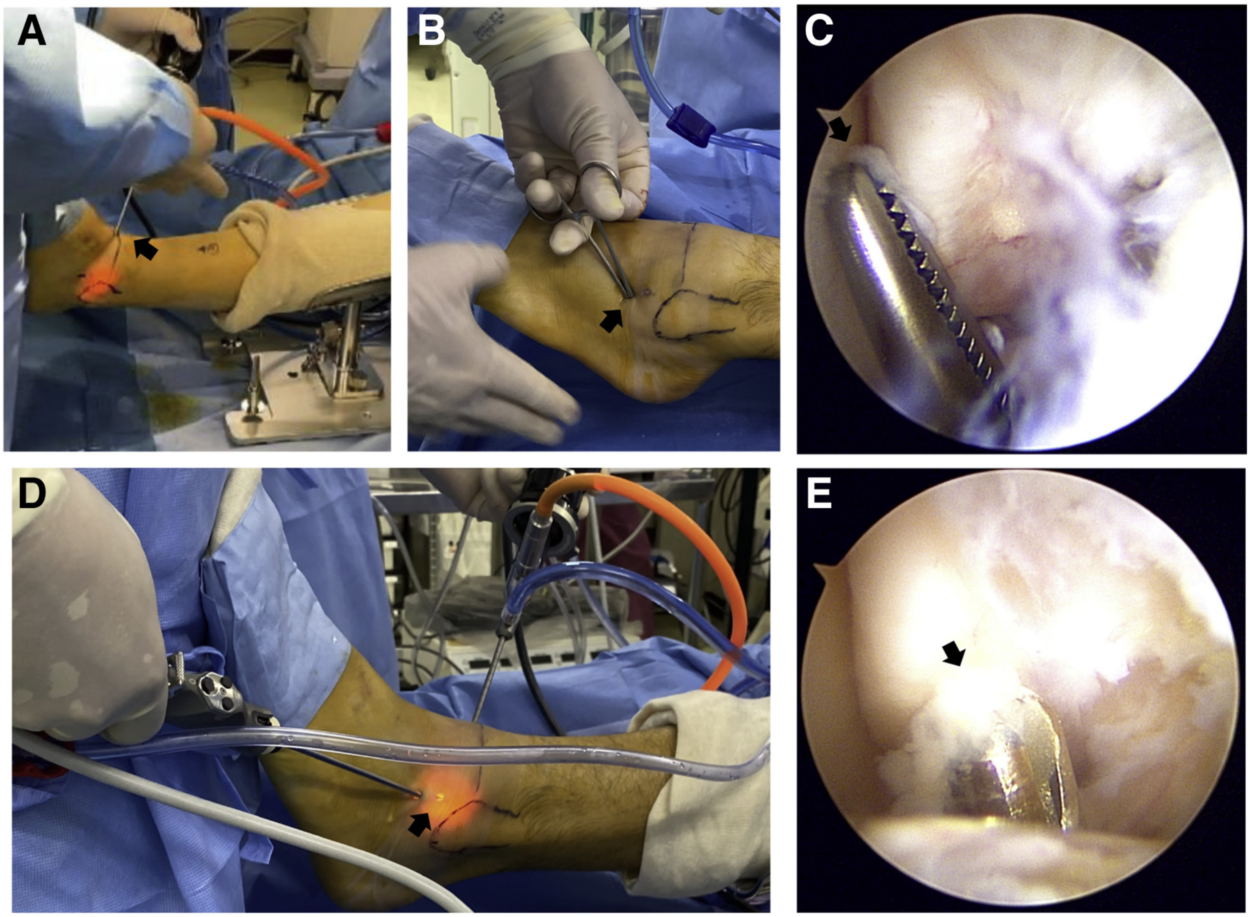

Fig 3. Approach to fibular and talar footprints: anterior arthroscopy of left ankle via medial midline portal with patient in supine position. (A) The arthroscope (2.7 mm in diameter with 30° perspective scope) is inserted through the medial midline portal (arrow), and the arthroscope tip is directed inward and downward to reach the lateral gutter. (B) A direct mosquito Pean instrument is inserted through the subtalar portal (arrow) toward the lateral gutter. (C) It is confirmed arthroscopically that the tip of the mosquito Pean instrument has reached the lateral gutter (arrow). (D) A soft-tissue shaver is inserted through the subtalar portal (arrow). (E) The soft tissue that obstructs the visual field (arrow) is removed.

Technique

Landmark Drawing and Patient Positioning

The patient is positioned supine with a lower leg holder (Video 1). The hybrid AntiRoLL technique uses 2 portals: a medial midline (MM) portal and a subtalar (ST) portal. If the surgeon determines that ankle arthroscopy is necessary, an anterolateral portal is added. Anatomic landmarks should be drawn on the patient's skin before surgery begins (Fig 1).

Constructing Y Graft for AntiRoLL

An autologous gracilis tendon is harvested from the patient's ipsilateral knee with a tendon harvester. The graft is prepared in an anatomic Y configuration with a 3-looped (fibular, talar, and calcaneal) stem (Fig 2A).

An approximately 25-mm skin incision is made 10 mm distal to the medial epicondyle distal end along the gracilis tendon (Fig 2B). Deep tissue is bluntly dissected to identify the gracilis tendon, and a tendon harvester (Tendon Stripper; Smith & Nephew, Andover, MA) is used to sacrifice the gracilis tendon with a length of at least 135 mm (Fig 2C). Positions 15, 60, and 120 mm from the end of the tendon are the folds that become the insertion parts into the bone tunnels of the talus, fibula, and calcaneus, respectively (Fig 2D). The fibula, talus, and calcaneus insertion parts are folded

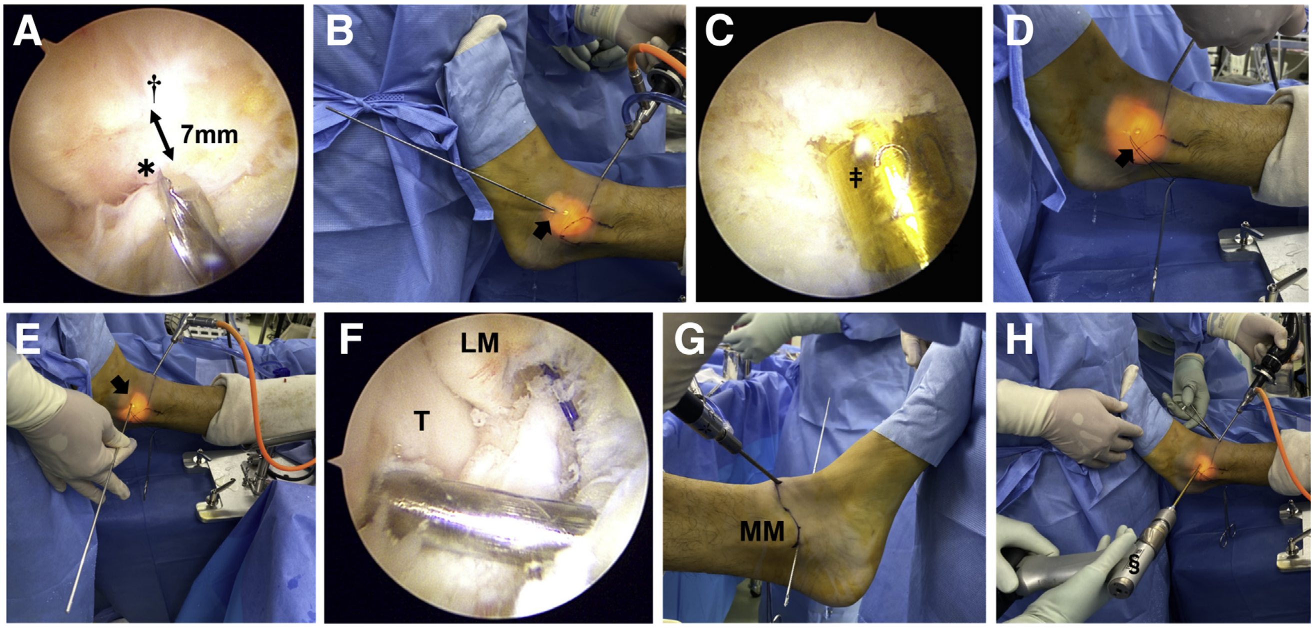

Fig 4. Creation of fibular and talar bone tunnels: anterior arthroscopy of left ankle via medial midline portal with patient in supine position. For creation of the fibular bone tunnel, a guidewire is inserted through the subtalar portal and penetrates the lateral malleolus (asterisk) at approximately 7 mm distal to the attachment of the anterior inferior tibiofibular ligament (single dagger) (A) through the midline of the fibula in the coronal section and at a 30° angle to the long axis of the fibula in the sagittal section to penetrate the posterior cortex of the fibula and skin of the calf (B, arrow). (C) A bone hole measuring 6 mm in diameter and 20 mm in depth is made using a cannulated drill (double dagger). (D) The guidewire is replaced with a passing thread (arrow). For creation of the talar bone tunnel, the guidewire is inserted into the joint through the subtalar portal (E, arrow) and penetrates the footprint center of the talus (F) toward the distal end of the medial malleolus (MM) (G). (H) A bone tunnel measuring 6 mm in diameter and 20 mm in depth is made using a cannulated drill (section sign). (LM, lateral malleolus; T, talus.)

back, and after passing through the guide thread used when guiding the tendon into the bone hole, the folding parts are firmly sutured with No. 2-0 nylon to create a Y-shaped tendon (Fig 2A).

Construction of Bone Tunnels and Insertion of Passing Thread

Fibular and talar bone tunnels are made arthroscopically using the MM portal as a viewing portal and the ST portal as a working portal. The arthroscope (2.7 mm in diameter with 30° perspective scope [LENS Surgical Imaging System; Smith & Nephew]) is inserted through the MM portal. The arthroscope tip is directed inward and downward to reach the lateral gutter (Fig 3A).

To make the ST portal, after confirmation that a 22-gauge straight needle can be inserted at the sinus tarsi up to the base, the needle is removed and a vertical incision of approximately 5 mm is made. A direct mosquito Pean instrument is inserted through the ST portal toward the lateral gutter (Fig 3B), which is confirmed arthroscopically (Fig 3C). A soft-tissue shaver is inserted through the ST portal (Fig 3D) to remove the soft tissue that obstructs the visual field (Fig 3E).

First, the fibular bone tunnel is made. A guidewire is inserted through the ST portal, which penetrates the lateral malleolus at approximately 7 mm distal to the attachment of the anterior inferior tibiofibular ligament (Fig 4A) through the midline of the fibula in the coronal section and at a 30° angle to the long axis of the fibula in the sagittal section (Fig 4B). A guidewire penetrates proximal posteriorly to the posterior cortex of the fibula and skin of the calf. By use of the guidewire as a guide, a bone tunnel measuring 6 mm in diameter and 20 mm in depth is made using a cannulated drill (6.0-mm Endoscopic Drill [Acufex Director ACL System; Smith & Nephew]) (Fig 4C). After both ends of the passing thread are passed through the hole at the guidewire base, the guidewire is replaced by

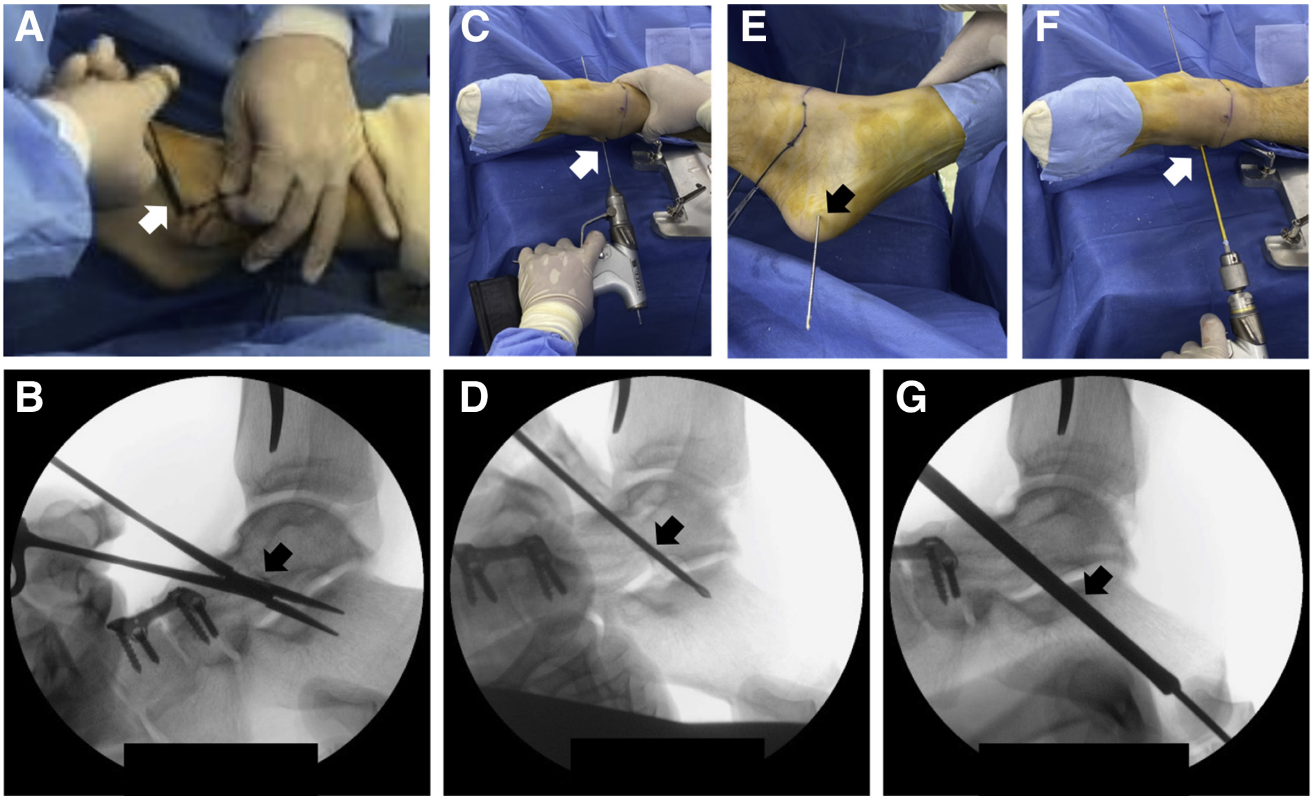

Fig 5. Creation of calcaneal bone tunnel: image intensifier picture of left ankle with patient in supine position. (A, B) Blunt dissection is performed using a mosquito Pean instrument through the subtalar portal toward the posterior talocalcaneal joint passed along the lateral wall of the calcaneus (arrows). The guidewire is inserted through the subtalar portal (C, arrow) and penetrates the calcaneus at approximately 10 mm distal to the surface of the posterior talocalcaneal joint on the perpendicular bisector line of the posterior talocalcaneal joint toward the inferior, medial, and posterior area of the calcaneus under a fluoroscopic lateral view (D, arrow). After the skin of the heel is penetrated (E, arrow), a bone tunnel measuring 6 mm in diameter and 30 mm in depth is made using a cannulated drill (F, G; arrows).

withdrawing it proximally (Fig 4D).

Next, the talar bone tunnel is made. The ankle joint is slightly dorsiflexed, and the talar attachment of the anterior talofibular ligament (ATFL) is observed through the MM portal. The guidewire is inserted into the joint through the ST portal (Fig 4E) and penetrates the footprint center of the talus (Fig 4F) and skin of the medial ankle toward the distal end of the medial malleolus (Fig 4G). Similarly to the creation of a talar bone tunnel, a bone tunnel measuring 6 mm in diameter and 20 mm in depth is made using a cannulated drill (Fig 4H). The guidewire is replaced with the passing thread.

The calcaneal bone tunnel is made under fluoroscopic guidance using the Perc-AntiRoLL technique. Blunt dissection is performed using a mosquito Pean instrument through the ST portal toward the posterior talocalcaneal joint passed along the lateral wall of the calcaneus (Fig 5 A and B). The guidewire is inserted through the ST portal (Fig 5C), which penetrates the calcaneus at approximately 10 mm distal to the surface of the posterior talocalcaneal joint on the perpendicular bisector line of the posterior talocalcaneal joint toward the inferior, medial, and posterior area of the calcaneus under a fluoroscopic lateral view (Fig 5D). After the skin of the heel is penetrated (Fig 5E), a bone tunnel measuring 6 mm in diameter and 30 mm in depth is made using a cannulated drill (Fig 5 F and G). The guidewire is replaced with the passing thread.

Landmarks for Each Bone Tunnel

The fibular obscure tubercle exists between the fibular attachments of the ATFL and the CFL. The anterior inferior tibiofibular ligament is also used as a landmark when creating the fibular bone tunnel (Fig 6). For the talar bone tunnel, part of the residual ligament fiber is attached in most cases, which can be used as the landmark. Otherwise, the anterolateral corner of the talar body is used as the landmark, and the bone

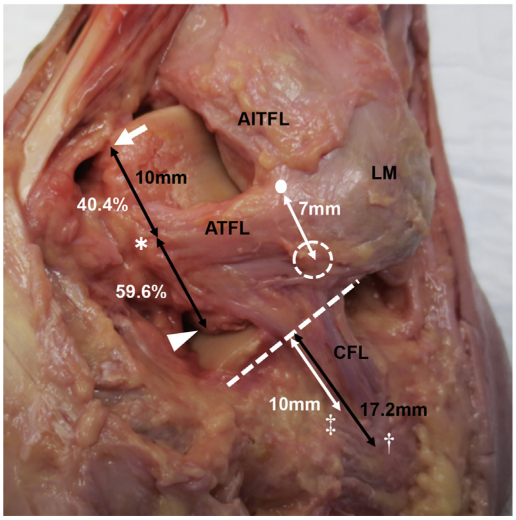

Fig 6. Landmarks for each bone tunnel. The fibular obscure tubercle (dashed white circle) exists between the fibular attachments of the anterior talofibular ligament (ATFL) and the calcaneofibular ligament (CFL). The anterior inferior tibiofibular ligament (AITFL) is used as a landmark to identify the fibular obscure tubercle, located approximately 7 mm distal to the distal end of the fibular attachment (white dot). The center of the footprint of the talar attachment of the ATFL (white asterisk) is located 59.6% distal to the anterolateral corner of the talar body (single-headed white arrow) on the line connecting the anterolateral corner of the talar body and the distal end of the lateral talar process (white arrowhead). In most cases, a part of the residual ligament fiber is attached, so it can be used as the landmark. If the ligament fiber does not remain, the anterolateral corner of the talar body is used as the landmark, and the bone tunnel is made at a position approximately 10 mm distal to the joint surface. On the perpendicular bisector line of the posterior talocalcaneal joint (dashed white line), the footprint center of the calcaneal attachment of the CFL (single dagger) is 17.2 mm distal to the surface of the posterior talocalcaneal joint. The guidewire penetrates the calcaneus at approximately 10 mm distal to the surface of the posterior talocalcaneal joint on the perpendicular bisector line of the posterior talocalcaneal joint (double dagger) to avoid the risk of breaking the peroneus longus and brevis tendons.

tunnel is made approximately 10 mm distal to the joint surface. The footprint center of the calcaneal attachment of the CFL is 17.2 mm distal to the surface of the posterior talocalcaneal joint on the perpendicular bisector line of the posterior talocalcaneal joint (Fig 6).[18] If the calcaneal bone tunnel is made at this point, there is a risk of breaking the peroneus longus and brevis tendons. Accordingly, the guidewire penetrates the calcaneus at approximately 10 mm distal to the surface of the posterior talocalcaneal joint.

Delivery and Fixation of Each Looped Stem of Y Graft to Corresponding Bone Tunnels With Inside-Out Technique

All 3 looped stems of the Y graft are delivered through the ST portal using the inside-out technique. First, an interference screw guide pin is inserted into the fibular bone tunnel through the ST portal under an arthroscopic view (Fig 7 A and B). A tensioning thread is passed through the fibular looped stem of the Y graft into the fibula passing thread loop that exits the ST portal. Then, the other end of the passing thread that exits the posterior aspect of the fibula is pulled through (Fig 7C). This series using the inside-out technique allows delivery of the fibular stem of the Y graft into the fibular bone tunnel. The suture located 15 mm from the end of the Y graft's fibular stem is pulled into the fibular bone tunnel until it is just hidden in the bone tunnel (Fig 7D). A 6-mm-diameter, 20-mm-long cannulated interference screw (Osteotrans Plus Biocomposite Interference Screw; Teijin-Medical Technology, Osaka, Japan) is passed through a guide pin (Fig 7E) and screwed into the fibular bone tunnel until the base of the screw is not visible under the arthroscope (Fig 7F). The guidewire is then pulled out.

Next, the talar stem is introduced into the talar bone tunnel using the same inside-out technique and fixed to the bone tunnel with the ankle in neutral dorsiflexion (Fig 7 G and H). Finally, the calcaneal stem is introduced into the calcaneal bone tunnel using the inside-out technique and fixed to the bone tunnel with the ankle in neutral dorsiflexion. An interference screw is screwed into the calcaneal bone tunnel (Fig 8A) until the base of the narrow part of the driver tip reaches the entrance of the bone tunnel under the fluoroscope (Fig 8B). Once all 3 stems of the anatomic Y graft are fixed, the tensioning threads are removed and the portals are closed using nylon suture.

Postoperative Care

The patient's operative limb is immobilized with an elastic bandage for 2 days. Partial weight bearing is

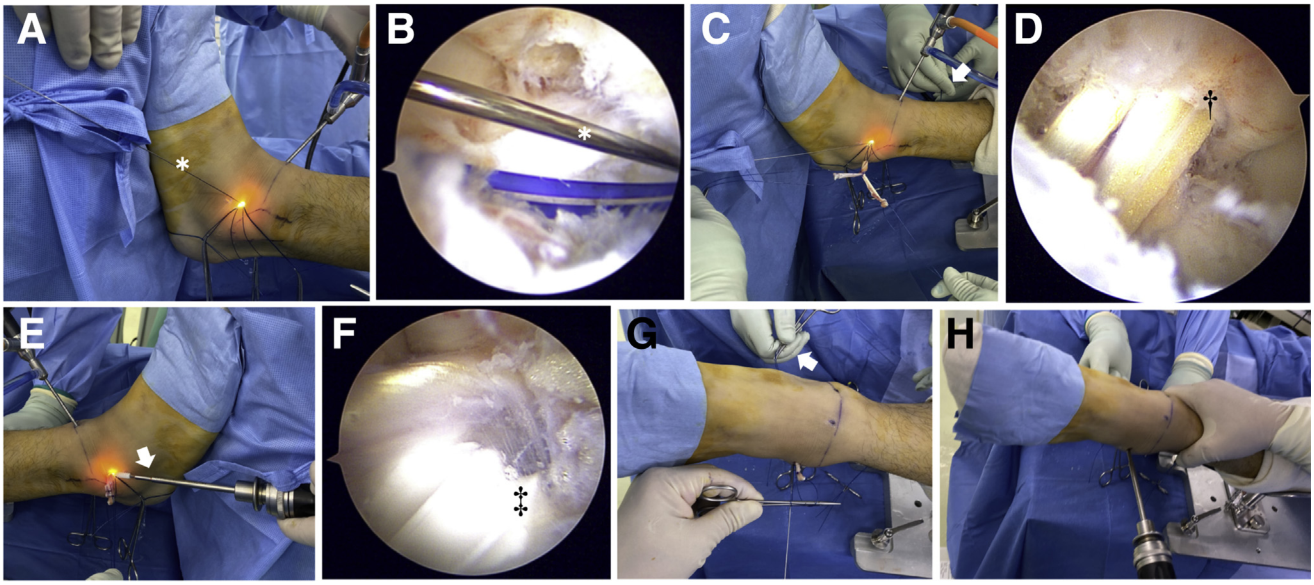

Fig 7. Delivery and fixation of fibular and talar looped stem of Y graft to each bone tunnel with inside-out technique: anterior arthroscopy of left ankle via medial midline portal with patient in supine position. An interference screw guide pin (asterisk) is inserted into the fibular bone tunnel through the subtalar portal (A) under an arthroscopic view (B). (C) A tensioning thread is passed through the fibular looped stem of the Y graft into the fibula passing thread loop that exits the subtalar portal, and then the other end of the passing thread that exits the posterior aspect of the fibula is pulled through (arrow). (D) The suture located 15 mm from the end of the Y graft's fibular stem is pulled into the fibular bone tunnel until it is just hidden in the bone tunnel (single dagger). A 6-mm-diameter, 20-mm-long cannulated interference screw is passed through a guide pin (E, arrow) and screwed into the fibular bone tunnel until the screw base is not visible on arthroscopy (double dagger) (F). Next, we move on to the talar bone tunnel. (G) With the ankle in neutral dorsiflexion, the Y graft is tensioned by pulling the tension thread (arrow). (H) A 6-mm-diameter, 20-mm-long cannulated interference screw is passed through a guide pin and screwed into the talar bone tunnel until the screw base is not visible on arthroscopy.

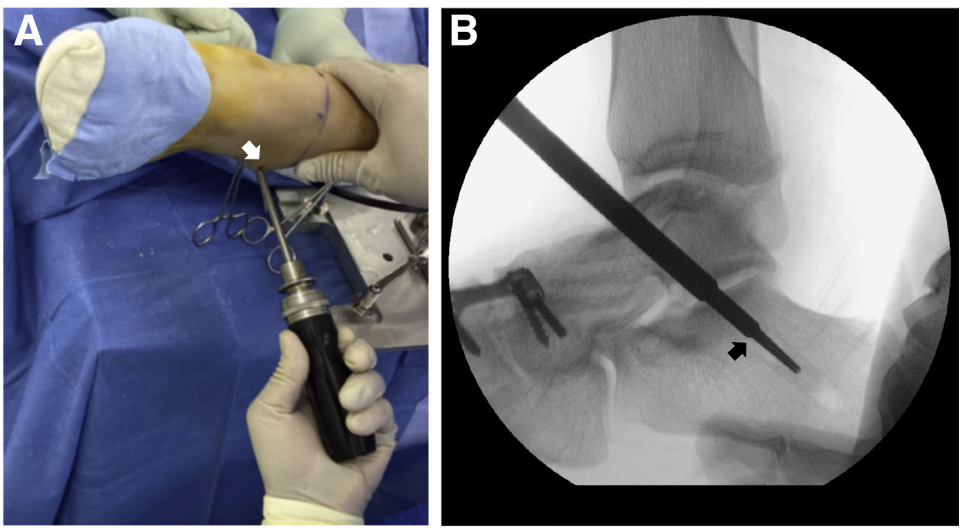

Fig 8. Delivery and fixation of calcaneal looped stem of Y graft to calcaneal bone tunnel with inside-out technique: image intensifier picture of left ankle with patient in supine position. An interference screw guide pin is inserted into the calcaneal bone tunnel through the subtalar portal under fluoroscopic view. After delivery of the calcaneal stem through the subtalar portal and into the calcaneal bone tunnel using the inside-out technique, a 6-mm-diameter, 20-mm-long cannulated interference screw is passed through a guide pin and screwed into the calcaneal bone tunnel (A, arrow) until the base of the narrow part of the driver tip reaches the entrance of the bone tunnel under the fluoroscope (B, arrow).

Table 1. Advantages and Disadvantages

Advantages	
	The technique is a minimally invasive anatomic reconstruction technique.
	Concomitant intra-articular lesions can be treated through the portals simultaneously.
	The procedure is not technically demanding.
Disadvantages	
	It is necessary to master the technique of ankle arthroscopy.
	The postoperative rehabilitation protocol is 2-4 wk behind that after arthroscopic repair.
	The technique is not indicated in skeletally immature patients.

Table 2. Pearls and Pitfalls

Procedure	Pearls	Pitfalls
Constructing Y graft	The folding parts are firmly sutured with No. 2-0 nylon.	If not tightly sutured, the folding parts will break when tensioning the graft.
Placing each bone tunnel	Each bone tunnel is created in the center of the footprint.	If the bone tunnel is created outside the footprint, it will not be anatomic.
Making fibular bone tunnel	The fibular bone tunnel should be made through the midline of the fibula in the coronal section and at a 30° angle to the long axis of the fibula in the sagittal section.	The bone hole wall becomes fragile and there is a risk of fracture if it is not made in the midline of the fibula, and the length of the bone tunnel will be insufficient if it is made at an angle > 30° with respect to the coronal section.
Making talar bone tunnel	The talar bone tunnel should be made toward the distal end of the medial malleolus.	Making the tunnel anteriorly to the distal end of the medial malleolus risks damaging the anterior wall of the talus, and creating the tunnel posteriorly risks damaging the tibial nerve and posterior tibial artery.
Making calcaneal bone tunnel	The calcaneal bone tunnel should be made at approximately 10 mm distal to the surface of the posterior talocalcaneal joint.	Making the tunnel distal to this point risks damaging the peroneal tendon and the sural nerve.

allowed the day after surgery, followed by full weight bearing at 1 week after surgery. Wound inspection and suture removal occur at between 1 and 2 weeks postoperatively.

Discussion

We have described the hybrid AntiRoLL technique for anatomic reconstruction of the ankle lateral ligaments, which uses the anatomic Y graft and the inside-out technique. This is a 3-portal technique, including 2 portals for performing ATFL and CFL reconstruction and 1 portal for approaching intra-articular pathologies. The current hybrid-AntiRoLL technique has the advantages of both the A- and Perc-AntiRoLL techniques. The advantages and disadvantages, as well as the pearls and pitfalls, are described in Tables 1 and 2. In conclusion, hybrid-AntiRoLL is a minimally invasive anatomic reconstruction technique for chronic instability of the ankle that does not require advanced arthroscopic technique to simultaneously assess and treat intra-articular pathologies of the ankle.

References

1. Matsui K, Takao M, Miyamoto W, Matsushita T. Early recovery after arthroscopic repair compared to open repair of the anterior talofibular ligament for lateral instability of the ankle. *Arch Orthop Trauma Surg* 2016;136:93-100.
2. Acevedo JI, Mangone P. Arthroscopic Brostrom technique. *Foot Ankle Int* 2015;36:465-473.
3. Acevedo JI, Mangone P. Ankle instability and arthroscopic lateral ligament repair. *Foot Ankle Clin* 2015;20:59-69.
4. Acevedo JI, Palmer RC, Mangone PG. Arthroscopic treatment of ankle instability: Brostrom. *Foot Ankle Clin* 2018;23:555-570.
5. Guillo S, Odagiri H. All-inside endoscopic Broström-Gould technique. *Arthrosc Tech* 2019;9:e79-e84.
6. Nery C, Raduan F, Del Buono A, Asaumi ID, Cohen M, Maffulli N. Arthroscopic-assisted Broström-Gould for chronic ankle instability: A long-term follow-up. *Am J Sports Med* 2011;39:2381-2388.
7. Takao M, Matsui K, Stone JW, et al. Arthroscopic anterior talofibular ligament repair for lateral instability of the ankle. *Knee Surg Sports Traumatol Arthrosc* 2016;24:1003-1006.
8. Vega J, Malagelada F, Dalmau-Pastor M. Arthroscopic all-inside ATFL and CFL repair is feasible and provides excellent results in patients with chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc* 2020;28:116-123.
9. Vega J, Montesinos E, Malagelada F, Baduell A, Guelfi M, Dalmau-Pastor M. Arthroscopic all-inside anterior talofibular ligament repair with suture augmentation gives excellent results in case of poor ligament tissue remnant quality. *Knee Surg Sports Traumatol Arthrosc* 2020;28:100-107.

10. Glazebrook M, Eid M, Alhadhoud M, Stone J, Matsui K, Takao M. Percutaneous ankle reconstruction of lateral ligaments. *Foot Ankle Clin* 2018;23:581-592.
11. Glazebrook M, Stone J, Matsui K, Guillo S, Takao M; ESSKA-AFAS Ankle Instability Group. Percutaneous ankle reconstruction of lateral ligaments (Perc-Anti RoLL). *Foot Ankle Int* 2016;37:659-664.
12. Guillo S, Takao M, Calder J, et al. Arthroscopic anatomical reconstruction of the lateral ankle ligaments. *Knee Surg Sports Traumatol Arthrosc* 2016;24:998-1002.
13. Michels F, Cordier G, Guillo S, Stockmans F; ESKKA-AFAS Ankle Instability Group. Endoscopic ankle lateral ligament graft anatomic reconstruction. *Foot Ankle Clin* 2016;21:665-680.
14. Takao M, Glazebrook M, Stone J, Guillo S. Ankle arthroscopic reconstruction of lateral ligaments (Ankle Anti-ROLL). *Arthrosc Tech* 2015;4:e595-e600.
15. Karlsson J, Bergsten T, Lansinger O, Peterson L. Reconstruction of the lateral ligaments of the ankle for chronic lateral instability. *J Bone Joint Surg Am* 1988;70:581-588.
16. Takao M, Oae K, Uchio Y, Ochi M, Yamamoto H. Anatomical reconstruction of the lateral ligaments of the ankle with a gracilis autograft: A new technique using an interference fit anchoring system. *Am J Sports Med* 2005;33:814-823.
17. Guillo S, Archbold P, Perera A, Bauer T, Sonnery-Cottet B. Arthroscopic anatomic reconstruction of the lateral ligaments of the ankle with gracilis autograft. *Arthrosc Tech* 2014;3:e593-e598.
18. Matsui K, Oliva XM, Takao M, et al. Bony landmarks available for minimally invasive lateral ankle stabilization surgery: A cadaveric anatomical study. *Knee Surg Sports Traumatol Arthrosc* 2017;25:1916-1924.