Technical Note

Arthroscopic Ligamentum Teres Reconstruction Using Anterior Tibialis Allograft and the Tension-Slide Technique

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Abstract: Once perceived to be a vestigial structure, the ligamentum teres (LT) is now increasingly understood to be critical to providing stability in the adult hip. Surgical treatment with arthroscopic debridement is usually the procedure of choice to treat LT tears. However, reconstruction is a possible alternative in select cases. The authors of a recent systematic review concluded that LT debridement may provide short-term relief of hip pain in patients with partial-thickness tears in whom conservative management has failed whereas reconstruction may be more beneficial in cases of full-thickness tears. This Technical Note describes a method for arthroscopic LT reconstruction using the tension-slide technique to fixate an anterior tibialis tendon allograft to the acetabulum.

Ligamentous laxity, dysplasia, and female sex have been shown to be associated with an increased prevalence of ligamentum teres (LT) tears.[1-3] In patients with borderline dysplasia who underwent arthroscopic labral treatment, femoroacetabular impingement correction, and capsular plication, it was reported that LT tears may indicate advanced instability and portend slightly inferior outcomes compared with a match-controlled group without tears.[1]

We present our arthroscopic LT reconstruction technique with important variations from previous descriptions.[4-6] The technique presented in this article differs in its (1) selection of an anterior tibialis allograft over a semitendinosus alternative, (2) method of sliding the tibialis anterior allograft through the midanterior (MA) portal rather than through the femoral tunnel to reduce the applied pressure against the acetabular fossa, and (3) use of an inside-out docking technique for introduction of the graft into the femoral tunnel. Table 1 presents additional advantages.

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Surgical Technique

Patient Preparation and Positioning

General anesthesia is administered to achieve skeletal relaxation. The patient is placed in the modified supine position on a traction table with an extra-padded post (Fig 1A). Extra padding is provided for the feet as well.

Fluoroscopic Technique

To attain real-time anteroposterior and axial fluoroscopic views simultaneously, dual C-arms are placed as shown in Figure 1B. The dual fluoroscopic visualization allows for better projection of drill trajectories and thus increased accuracy of the final placement of the LT

Table 1. Advantages and Disadvantages

Advantages
No acetabular tunnel is necessary.
The tension-slide technology allows for full graft-to-bone contact with minimal fracture risk.
Use of allograft reduces donor-side morbidity.
An anterior tibialis allograft provides enough graft length for the procedure.
Disadvantages
The intra-articular guide requires an assistant to position it.
The technique is technically demanding.
There are inherent arthroscopic complications.

graft. In addition, this obviates repositioning the C-arm, expediting surgical time.

Initial Portal Placement

Anterolateral, MA, and distal anterolateral accessory portals are created as previously described[1,2] (Fig 1C).

Diagnostic Arthroscopy and Labral Assessment

A systematic diagnostic arthroscopy is performed, assessing the LT, acetabular notch, iliopsoas impingement sign, labral and chondrolabral junction, and acetabular and femoral head cartilage.[3] Indications for LT reconstruction are presented in Table 2.

LT Reconstruction Technique

Graft Preparation. A 7-mm single-stranded anterior tibialis tendon allograft is used for LT reconstruction. Three to 4 Krackow stitches are placed on both ends of the graft with No. 2-0 FiberLoop (Arthrex, Naples, FL) (Fig 2 A and B). The limbs from the initial FiberLoops will be used to pass the allograft from the MA portal through the femoral tunnel. A TightRope (Arthrex) is looped 2 to 3 times around the center of the graft and securely synched. The graft is then folded in half, keeping the TightRope centered (Fig 2 C and D). This doubled-over segment of the graft will be in contact with the acetabular fossa at the end of the procedure.

Femoral Tunnel Drilling. The intra-articular guide is placed into the joint from the MA portal, ensuring that the tip is located at the fovea of the femoral head (Fig 3 A and B). By use of dual-plane fluoroscopy assessment, the trajectory of the drill bit that will be used to create the femoral tunnel is estimated (Fig 3C). An additional lateral 2-cm incision is made to create the femoral transtrochanteric tunnel. During drilling, constant visualization of the exit point of the femoral head should be maintained.

Reaming of the tunnel proceeds as outlined later. For these steps, it is vital that the proper position of all instruments is maintained by the surgical assistant.

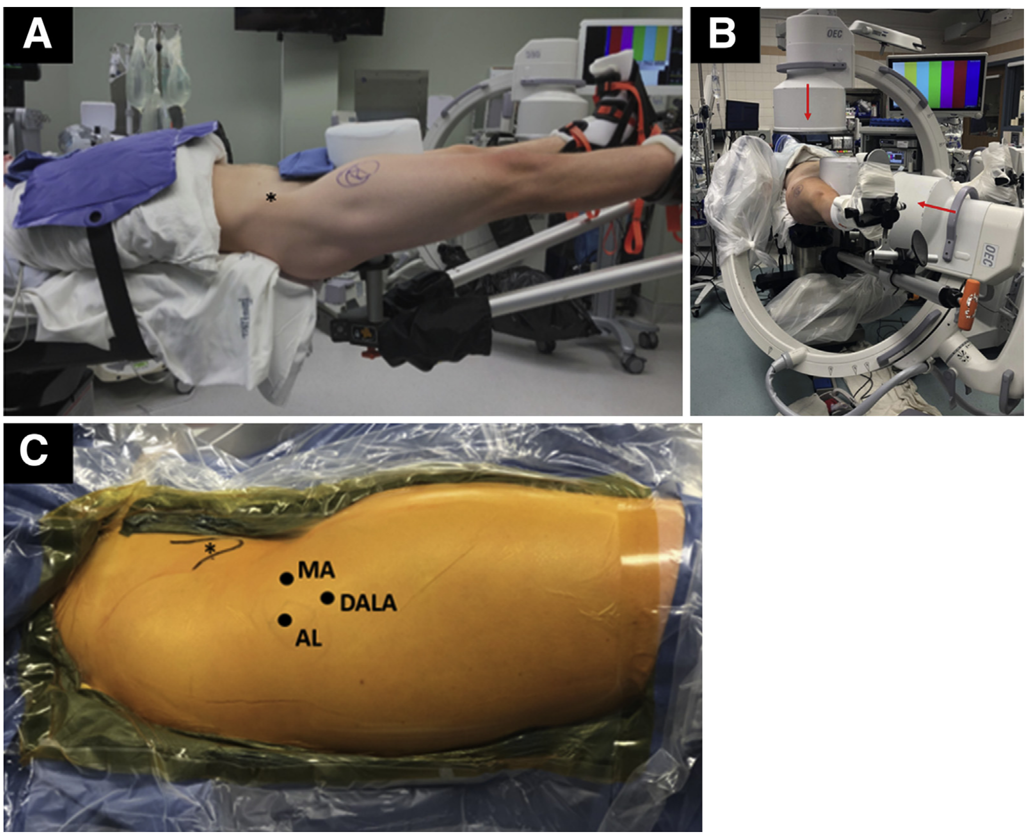

Fig 1. (A) The patient is positioned in the modified supine position. The patient's head is to the right and feet are to the right; the asterisk indicates the anterior inferior iliac spine. (B) Two C-arms (arrows) are used to have the advantages of anteroposterior and axial live views simultaneously in a right hip. (C) Right hip with the patient's head to the left and feet to the right. The 3 portals used are identified: anterolateral (AL), midanterior (MA), and distal anterolateral accessory (DALA). The asterisk indicates the anterior superior iliac spine.

Table 2. Surgical Indications and Contraindications

Indications	
	Complete LT tear and symptoms of microinstability when other causes have already been addressed
Contraindications	
	Osteoarthritis
	True dysplasia in which bony procedures such as PAO are recommended

LT, ligamentum teres; PAO, periacetabular osteotomy.

While the intra-articular guide is held in place, a drill guide is advanced toward the tip of the intra-articular guide. It is critical to constantly assess the drilling trajectory with dual-plane fluoroscopy (Fig 4). Once the drill guide is at the planned point, the fitting reamer (based on the folded allograft diameter) is used to create the tunnel (Fig 5, Video 1).

A FiberStick (Arthrex) loaded with 1 No. 2-0 FiberWire loop (Arthrex) is inserted through the femoral tunnel (Video 1). This loop is retrieved from the MA portal, and the loop is clamped to the external draping. The surgeon should be sure to monitor the suture exiting the femoral incision while retrieving it so that the looped end is not pulled into the joint. The loop will eventually be used to shuttle sutures to pass the graft.

Acetabular Fossa Preparation. The acetabular fossa is prepared with a radiofrequency device, shaver, and burr (Video 1). The radiofrequency device and shaver are used to remove the remaining LT stump. The soft tissue of the acetabulum is cleared, but care should be taken to perform minimal decortication (Video 1). Working through the femoral tunnel may provide for the best angle of attack (Fig 4D).

Acetabular Drilling and Cortical Button Placement for Acetabular Fixation. It is critical to minimize the chance of injuring surrounding structures during this process. As previously described, the surgeon should aim toward the posteroinferior quadrant of the acetabular fossa to avoid hitting the obturator artery and vein.

Internally rotating and abducting the leg can assist in providing better angles. The drill hole in the acetabulum for the graft is created with a 3.2-mm Biceps Button drill pin (Arthrex) under fluoroscopic supervision in both the anteroposterior and axial planes (Fig 6).

For TightRope button placement, the following steps should be performed:

1. The button is passed with the sutures assembled into the intra-articular space from the MA portal.
2. With a grasper from the femoral tunnel, the button is placed with the longitudinal aspect parallel to the grasper and is inserted into the acetabular tunnel.
3. A long switching stick is placed through the femoral tunnel (Fig 6B). While the button's position is held with the grasper, the switching stick is used to push the button into the tunnel. Once in the tunnel, the button is flipped. Fluoroscopy is used to confirm its placement (Fig 6C).

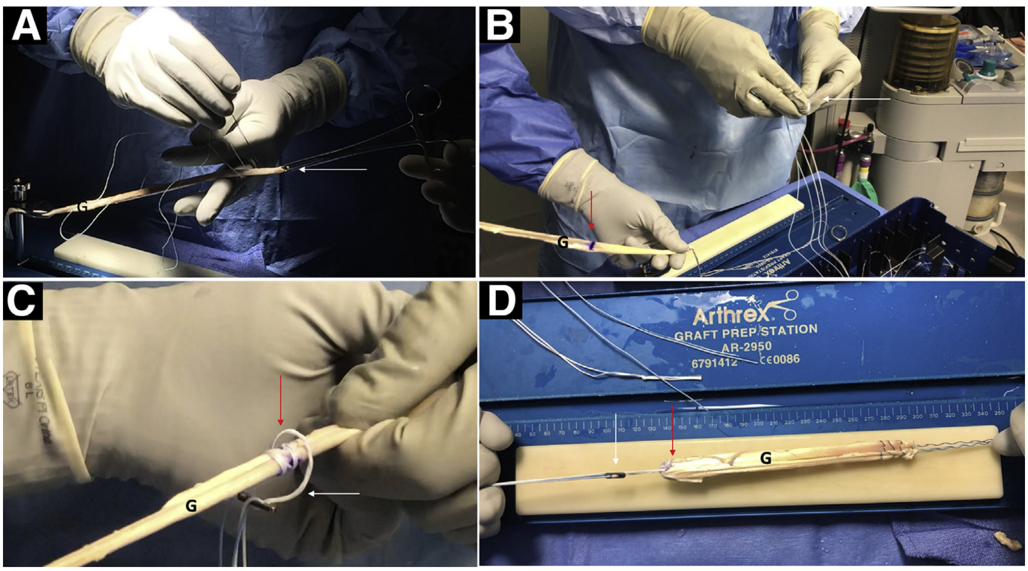

Fig 2. (A) Anterior tibialis allograft (G) is used for reconstruction. Krackow stitches are placed at both ends (arrow) using FiberLoop sutures. (B) The TightRope device is placed through 1 of the ends of the allograft (G) (white arrow). The blue mark (red arrow) identifies the mid part of the allograft. (C) The TightRope device (white arrow) is advanced until the mid portion of the allograft (G) (red arrow). (D) The allograft (G) is folded in half at the midsection (red arrow). The white arrow indicates the TightRope device.

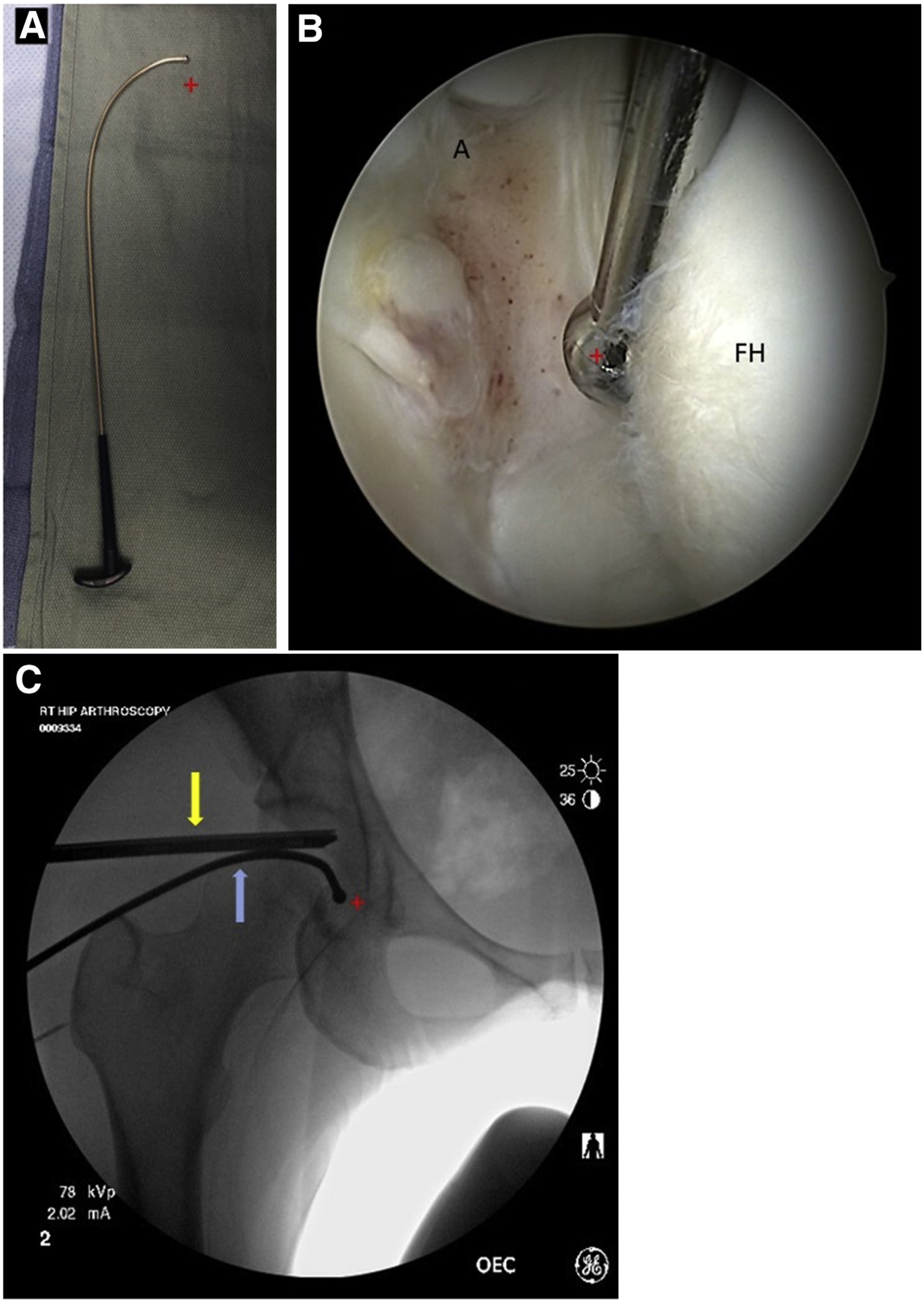

Fig 3. (A) Intra-articular guide for femoral drilling. The red plus sign indicates the tip of the femoral guide. (B) Intra-articular view in a right hip with a 70° arthroscope through the anterolateral portal. The tip of the femoral guide (red plus sign) is placed in the desired position. (A, acetabular fovea; FH, femoral head.) (C) Anteroposterior fluoroscopic view of the same right (RT) hip. The femoral guide (yellow arrow) is introduced through the midanterior portal. The red plus sign indicates the tip of the femoral guide. The 70° arthroscope (blue arrow) is in the anterolateral portal.

Graft Passing. It is important to be aware that in the present technique, the graft is not passed in an anterograde fashion through the femoral tunnel after cortical button deployment. Instead, it is passed from the MA portal to the femoral tunnel in a retrograde manner. The goal is to decrease the risk of acetabular fossa fracture when placing the graft in the femoral tunnel.

With the cortical acetabular button in place, the graft is passed into the joint and then through the transtrochanteric tunnel:

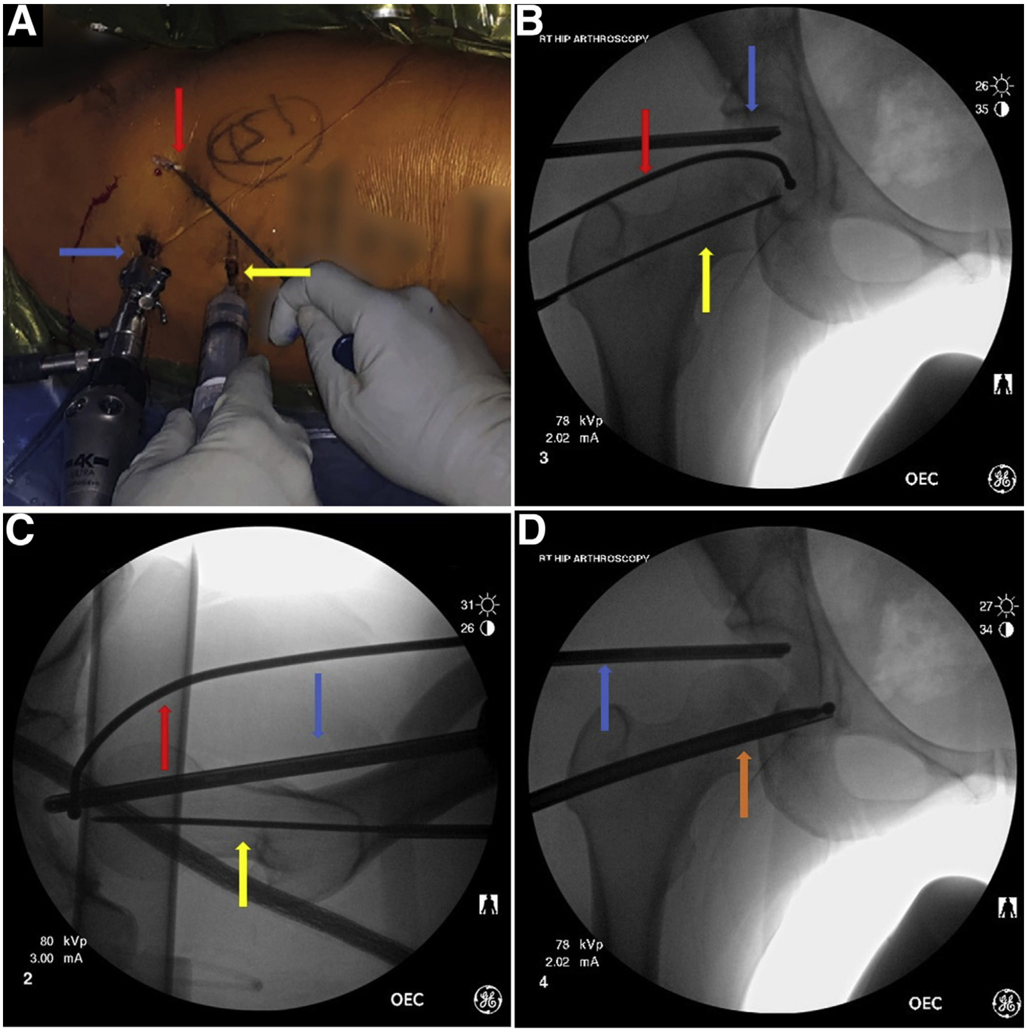

Fig 4. All images pertain to a right (RT) hip. (A) After a lateral 2-cm incision is made to create the trans-trochanteric tunnel, the drill (yellow arrow) is inserted. The intra-articular femoral guide (red arrow) is inserted from the mid-anterior portal. Visualization is achieved from the anterolateral portal (blue arrow). (B) Femoral drilling is achieved from the level of the greater trochanter (yellow arrow). The red arrow indicates the intra-articular guide, and the blue arrow indicates the 70° arthroscope. (C) Figure 4B viewed from the axial plane. (D) Once drilling is completed and the femoral tunnel is reamed, instruments such as a burr (orange arrow) can better access the acetabular fossa. Visualization is maintained from the anterolateral portal (blue arrow).

1. The tension-slide technique is applied by gently pulling on the sutures attached to the button. The graft should slide into the joint and toward the button. The graft is secured with gentle but firm pressure (Fig 2B).
2. The shuttle FiberWire loop is connected to the 4 sutures previously placed at the 2 ends of the graft (Fig 2B).
3. The 4 sutures are retrieved, 2 on each end, and gently pulled to bring the graft through the femoral tunnel in a retrograde manner.

Femoral Fixation. Another distinguishing factor of this technique is the use of hip traction to prevent over-tensioning the graft. While in traction, the leg is positioned to 60° of external rotation and 10° of hyperextension during fixation, which is achieved with a 28-mm PEEK (polyether ether ketone) Delta interference screw (Arthrex).

Postoperative Rehabilitation

The patient is to remain in a brace (X-Act ROM Hip Brace; DJO, Vista, CA) limited to 0° to 90° of flexion for 6 weeks. Use of crutches is encouraged for 6 weeks with restriction to 20 lb of foot-flat weight bearing. Under the supervision of a physiotherapist, active range-of-motion exercise during the first 48 hours with continuous passive motion and/or a static bicycle is recommended. The formal physical therapy protocol should start after the first 6 weeks.

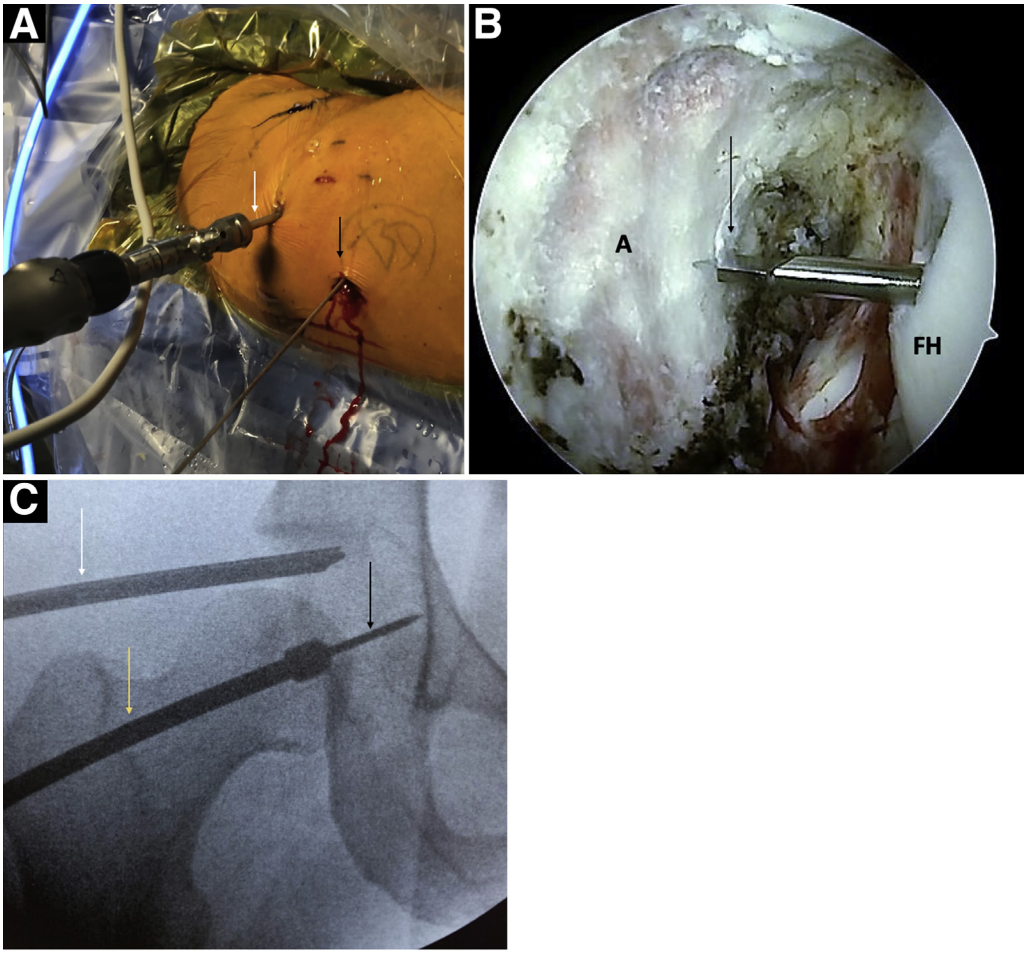

Fig 5. (A) Right hip with the patient's head to the left and feet to the right. The femoral drill guide is placed in its final position through the additional incision (black arrow). A 70° arthroscope remains in the anterolateral portal (white arrow). (B) Intra-articular view in a right hip with the 70° arthroscope from the anterolateral portal, confirming the guidewire position prior to femoral tunnel preparation (black arrow). (A, acetabulum; FH, femoral head.) (C) Anteroposterior fluoroscopic view in a right hip. The appropriately sized reamer is used for the femoral tunnel (yellow arrow) during the reaming process. The black arrow indicates the guidewire, while the 70° arthroscope (white arrow) remains in the anterolateral portal.

Discussion

The purpose of the described technique is to reestablish hip biomechanics and stability by reconstructing a functional LT arthroscopically, using portals that are common to hip arthroscopy. Our contemporary indications and contraindications, pearls and pitfalls, and risks are described in Tables 2-4, respectively.

Botser et al.[7] found a prevalence of LT pathology of 51% in patients who underwent hip arthroscopy for femoroacetabular impingement. LT pathology included partial- and full-thickness tears, osteochondral avulsions, and hypertrophy. Recently, it has been suggested that patients who undergo conversion to total hip arthroplasty after hip arthroscopy may more frequently have complete LT tears in the native joint.[2]

Arthroscopic surgical management with debridement is the workhorse for most LT tears. The authors of a systematic review found that LT debridement is useful for short-term relief of hip pain caused by partial-thickness tears for which conservative management has failed whereas reconstruction may be beneficial for LT tears that have failed to attain relief of symptoms from debridement. Although reconstruction is possible for treating LT tears, the exact indications are still a topic of debate.[8] In addition, because of the rarity of these procedures, studies of the midterm to long-term

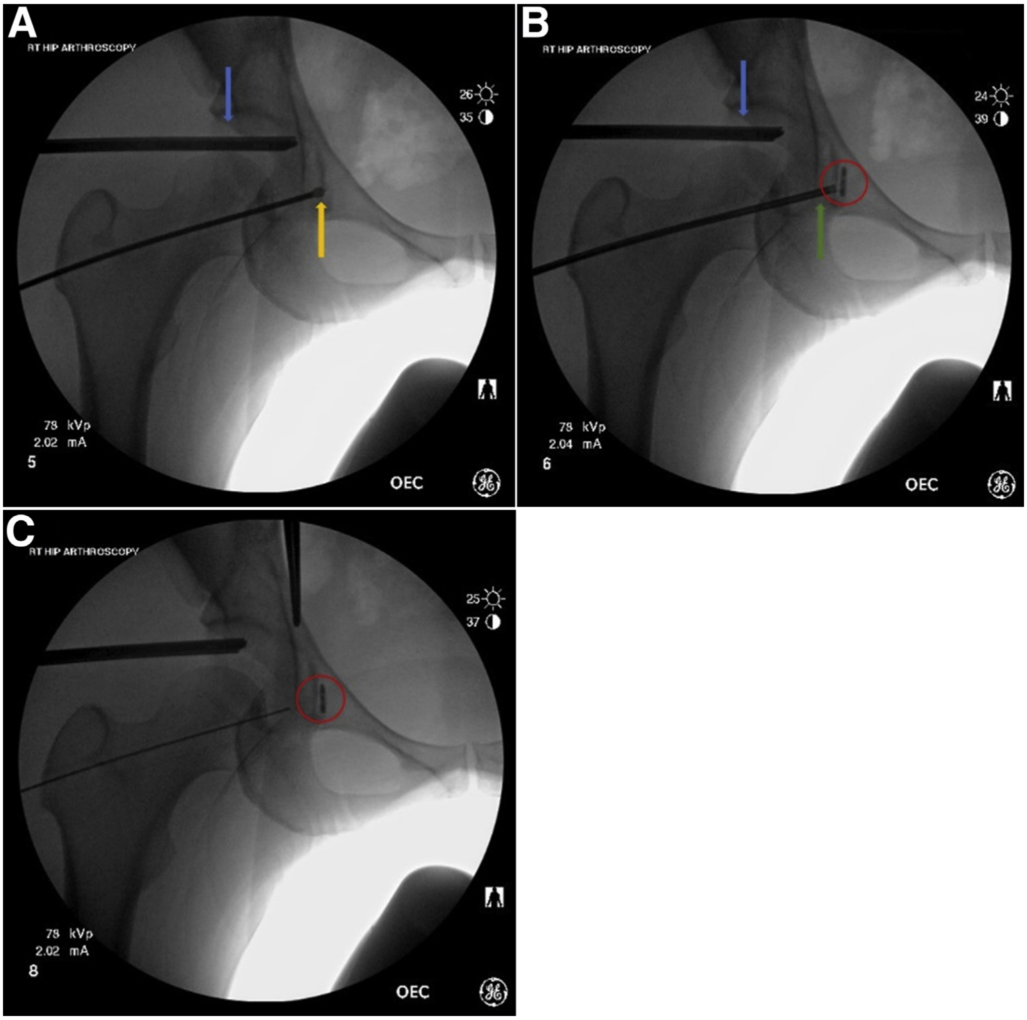

Fig 6. All images correspond to a right (RT) hip. (A) Anteroposterior fluoroscopic image of the hip visualized intraoperatively with the 70° arthroscope (blue arrow). After femoral tunnel reaming, the acetabular fossa is cleared, and the acetabular tunnel is created with a drill bit (orange arrow) introduced through the femoral tunnel. Drilling should be performed under fluoroscopic assessment in both planes to ensure proper placement. (B) The button (red circle) is inserted into the acetabular fossa with the switching stick (green arrow) and flipped. Visualization is maintained from the anterolateral portal (blue arrow). (C) Placement of the button (red circle) is confirmed under fluoroscopy.

Table 3. Pearls and Pitfalls

Pearls
Dual C-arms will save time and make the surgical procedure more efficient.
For better stability, the button should be held with a grasper at the opening of the acetabular drill hole and inserted with a switching stick.
Pitfalls
Length mismatch between femoral tunnel and graft
Over-tightening of graft by fully releasing traction on leg before femoral fixation

Table 4. Risks

Inherent risks associated with hip traction
Possible intra-abdominal extravasation after acetabular drilling
Acetabular fossa fracture
Vascular structures at risk during acetabular drilling

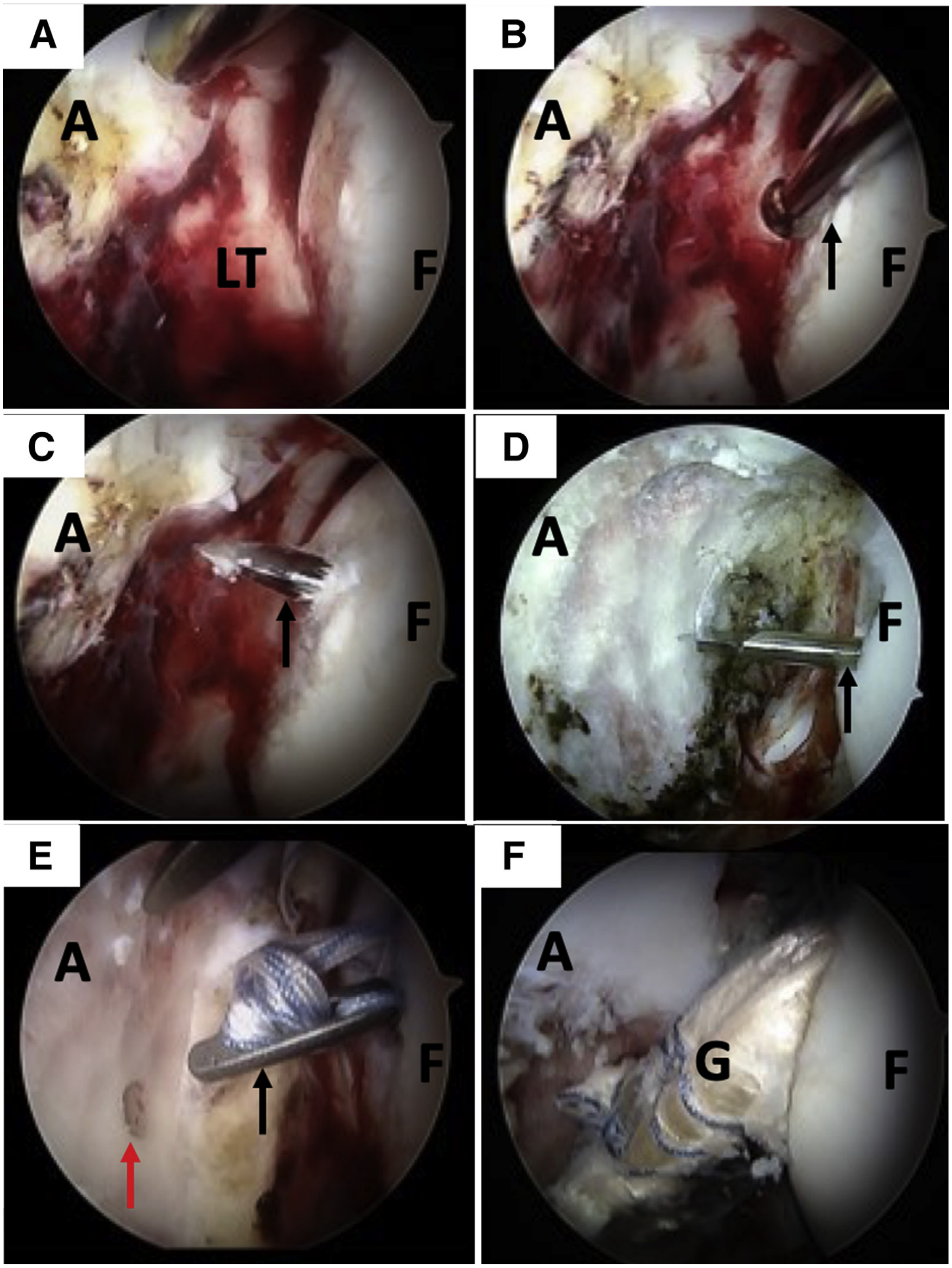

Fig 7. All images correspond to a right hip and show intra-articular views from the anterolateral portal using a 70° arthroscope; the acetabulum (A) and femoral head (F) are marked. (A) A diagnostic arthroscopy is performed, and the complete ligamentum teres tear (LT) can be seen. (B) The ligamentum teres stump has been partially removed, and the intra-articular guide is placed at the level of the fovea of the femoral head (black arrow). (C) The desired femoral point has been reached by the tip of the femoral guide (black arrow). (D) The femoral tunnel is reamed based on the diameter of the anterior tibialis allograft. The acetabular fossa has been prepared, and the 3.2-mm Biceps Button drill pin can be seen exiting through the femoral tunnel and reaching the posteroinferior quadrant of the acetabular fossa (black arrow). (E) The acetabular fossa is drilled (red arrow), and the Biceps Button (black arrow) is in the joint from the anterolateral portal. (F) Final graft construct (G) exiting the femoral head, fixated to the acetabular fossa.

outcomes are needed. Our technique for LT reconstruction offers several advantages such the tension-slide technology and preservation of the acetabular fossa bone stock (Fig 7).

References

1. Chaharbakhshi EO, Perets I, Ashberg L, Mu B, Lenkeit C, Domb BG. Do ligamentum teres tears portend inferior outcomes in patients with borderline dysplasia undergoing hip arthroscopic surgery? A match-controlled study with a minimum 2-year follow-up. *Am J Sports Med* 2017;45:2507-2516.
2. Maldonado DR, Laseter JR, Perets I, et al. The effect of complete tearing of the ligamentum teres in patients undergoing primary hip arthroscopy for femoroacetabular impingement and labral tears: A match-controlled study. *Arthroscopy* 2019;35:80-88.
3. Domb BG, Martin DE, Botser IB. Risk factors for ligamentum teres tears. *Arthroscopy* 2013;29:64-73.
4. Amenabar T, O'Donnell J. Arthroscopic ligamentum teres reconstruction using semitendinosus tendon: Surgical

technique and an unusual outcome. *Arthrosc Tech* 2012;1: e169-e174.
5. Garabekyan T, Chadayammuri V, Pascual-Garrido C, Mei-Dan O. All-arthroscopic ligamentum teres reconstruction with graft fixation at the femoral head-neck junction. *Arthrosc Tech* 2016;5:e143-e147.
6. Lindner D, Sharp KG, Trenga AP, Stone J, Stake CE, Domb BG. Arthroscopic ligamentum teres reconstruction. *Arthrosc Tech* 2013;2:e21-e25.
7. Botser IB, Martin DE, Stout CE, Domb BG. Tears of the ligamentum teres: Prevalence in hip arthroscopy using 2 classification systems. *Am J Sports Med* 2011;39:117-125.
8. de Sa D, Phillips M, Philippon MJ, Letkemann S, Simunovic N, Ayeni OR. Ligamentum teres injuries of the hip: A systematic review examining surgical indications, treatment options, and outcomes. *Arthroscopy* 2014;30: 1634-1641.