Technical Note

Associated Anterior Cruciate Ligament and Fibular Collateral Ligament Reconstruction With Single Femoral Tunnel and Asymmetric Hamstring Tendon Graft

Alejandro Espejo-Baena, M.D., Carlos Molano-Bernardino, M.D., Alejandro Espejo-Reina, M.D., M.Sc., María Josefa Espejo-Reina, M.D., and Jaime Dalla Rosa-Nogales, M.D.

Abstract: A technique for associated anterior cruciate ligament and fibular collateral ligament reconstruction is shown, using a single hamstring tendon graft, which is prepared asymmetrically, leaving one-third of the length with a single diameter and two-thirds with a double diameter. A single femoral tunnel is created, using an interference screw for fixation and isolation of the grafts. A suspension device is used for tibial fixation, allowing for length adjustment according to the graft's length. The objective of this Technical Note is to provide the orthopaedic surgeon with a resource for anterior cruciate ligament and fibular collateral ligament reconstruction even with short grafts, saving bone stock and avoiding the need for allografts.

Surgical reconstruction of the anterior cruciate ligament (ACL) is a popular procedure that in some cases must be associated with fibular collateral ligament (FCL) reconstruction.

Unrecognized FCL laxity is an accepted cause of ACL reconstruction failure.[1,2] In ACL reconstructed knees, sequential cutting biomechanical studies have demonstrated that injury to the FCL increases the load in an ACL graft with no further increase after the cuts to the popliteofibular ligament (PFL) and popliteus tendon (PT).[3] Careful preoperative assessment and planning of isolated ACL reconstructions may detect these cases and show an indication for the combined procedure.

Another clinical situation that requires a combination of ACL and FCL reconstruction is the surgical treatment of multiligament instability of the knee. This procedure also includes reconstruction of the posterior cruciate ligament (PCL) and posterolateral corner and medial stabilization.[4-6] This very complex procedure requires extensive use of allografts, either in addition to autografts or as the only source of grafting.[6] There are 3 primary posterolateral static stabilizers: the FCL, PFL, and PT.[7] Anatomic and biomechanical studies suggest that the FCL is the most important anatomic structure.[3,8-11] These studies have found that the FCL by itself resists varus forces as well as external rotation forces.[8,10]

Up to now, the combined reconstruction of the ACL and FCL requires at least 2 tunnels in the lateral femoral condyle and 2 grafts,[12] with greater donor site morbidity and greater need to use allografts compared with isolated ACL reconstruction. More advanced reconstructions go up to 3 tunnels in complete posterolateral corner with PT reconstruction[6,13] and even 4 if the surgeon decides to do a double-bundle ACL reconstruction.

A surgical technique for the combined anatomic reconstruction of the ACL and FCL with a hamstring

From the Hospital Vithas Parque San Antonio (A.E-B., A.E-R., J.D.R-N.); and Clínica Espejo (A.E-B., A.E-R.), Málaga; Hospital Vithas Nisa Sevilla-Aljarafe (C.M-B.), Castilleja de la Cuesta, Seville; and Hospital Comarcal de Antequera (M.J.E-R.), Antequera, Málaga, Spain.

The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received February 6, 2018; accepted March 28, 2018.

Address correspondence to Alejandro Espejo-Reina, M.D., M.Sc., Clínica Espejo, Paseo Reding 9, 1° C. 29016, Málaga, Spain. E-mail: espejoreina@clinicadoctorespejo.com

2212-6287/18178
https://doi.org/10.1016/j.eats.2018.03.018

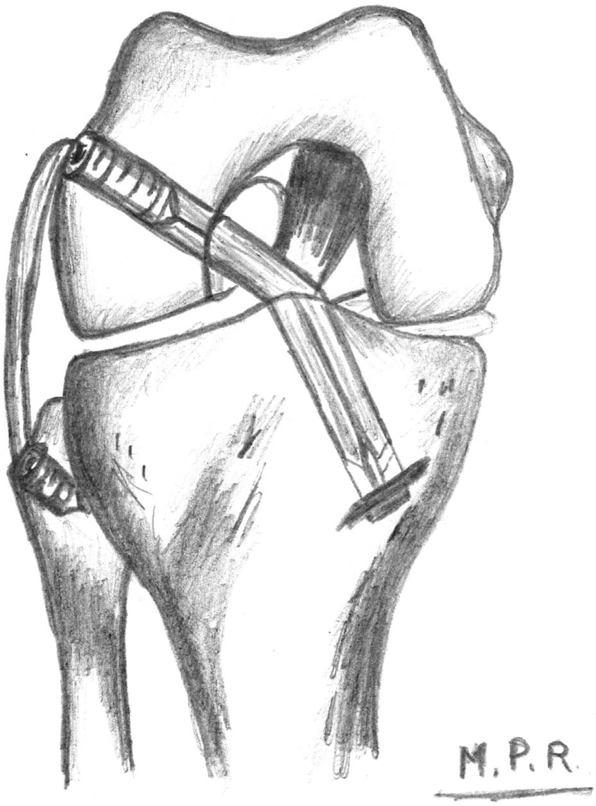

Fig 1. The technique on a right knee. A suspension device attached to its G-Lok XL expansion device is used for tibial fixation, and an interference screw is employed for the femoral one. The remnant of the graft is used for the fibular collateral ligament reconstruction, which is fixed to the fibular head with a smaller interference screw.

autograft that uses only 1 femoral tunnel and only 1 grafting is presented, reducing donor site morbidity, surgical time, complexity of surgical technique, and operating room setup requirements (Fig 1). Because this technique uses routine ACL reconstruction instrumentation, it also allows us to address intraoperative findings of lateral instability of the knee that were previously unrecognized.

Surgical Technique

Patient Positioning

The patient is given a regional or general anesthetic and positioned supine. An ischemia cuff is used, and the limb is supported by a leg holder with the knee placed in 90° of flexion.

Arthroscopic Exploration

A central transtendinous portal is generally used by the authors for cruciate ligament reconstruction (Table 1). The ACL damage is identified, and any associated injuries are treated with the aid of an anteromedial portal (if necessary, an additional anterolateral portal can be used). The increase of the lateral tibiofemoral gap is checked applying varus stress (Video 1); it is also important to address the integrity of the PT (Fig 2). Meanwhile, ACL remnants are removed, and the medial wall of the lateral femoral condyle is prepared using a radiofrequency probe and a resector.

Graft Harvesting and Preparation

A 3-cm oblique skin incision is made anteromedially to the anterior tibial tuberosity to harvest the semitendinosus and gracilis tendons and to create the tibial tunnels. The tendons are harvested with a standard tendon stripper. Both tendons are prepared on an auxiliary table. The ends of the graft are prepared separately with traction threads; this allows the surgeon

Table 1. Step-by-Step Details of the Technique

Patient Positioning
- Supine with limb in a leg holder at 90° of flexion.
- General or regional anesthetic.
- Transtendinous and anteromedial portals.

Graft Harvesting and Preparation
- Semitendinosus and gracilis autologous tendons.
- A 15-mm loop G-Lok device is used (a longer loop can be used if a short graft or a long tunnel are measured).
- Both ends are knotted independently in an asymmetrical manner with traction threads, leaving one end of the graft with a double diameter (anterior cruciate ligament graft) and the other end (approximately one-third of the length of the graft) with a single diameter (FCL diameter).

Intra-articular Preparation
- Remnant cleaning.
- Footprint of anterior cruciate ligament identification.

Tunnels
- Outside-in direction.
- Same diameter as the doubled graft.
- An 80° opening for the femoral tunnel and 55° for the tibial tunnel.

Graft Passage and Fixation
- Craniocaudal direction from the lateral cortex of the femur.
- Transtendinous portal used for vision, anteromedial for graft passage.
- Traction threads are recovered through the tibial tunnel, and the graft is pulled until the suspension device comes out of the tibial tunnel.
- The expansion piece is fixed to the suspension device, and the traction threads of the graft are pulled until the construct is attached to the anterior cortex of the tibia.
- Femoral fixation with a bioabsorbable screw 1 mm wider than the graft and the tunnel.

FCL
- A 2-cm incision posterior to the fibular head is performed to protect the peroneal nerve.
- Anatomic location of FCL fibular insertion is approached through a 1-cm incision.
- A guide pin is inserted in that spot, in the anterior-posterior direction, and a tunnel is created with a drill bit of the same diameter as the single end of the graft.
- The single diameter remnant of the graft is passed percutaneously under the fascia lata to the distal approach performed for FCL fibular insertion.
- The graft is inserted through the tunnel and is fixed with a bioabsorbable screw 1 mm wider than the graft and the tunnel.

FCL, fibular collateral ligament.

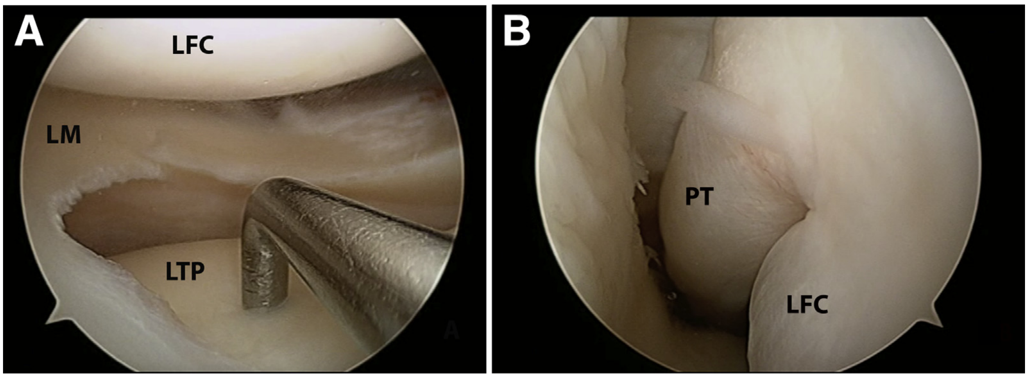

Fig 2. Arthroscopic examination of the right knee (arthroscope through the central portal, probe via the anteromedial one). (A) An increase of the tibiofemoral gap is found on the lateral compartment. (B) Exploration of the popliteus tendon in the lateral recess, which is intact. (LFC, lateral femoral condyle; LM, lateral meniscus; LTP, lateral tibial plateau; PT, popliteus tendon.)

to pass the graft asymmetrically through a suspension device (G-Lok; Stryker, Kalamazoo, MI) attached to its expansion piece (G-Lok XL), resulting in 2 arms: a shorter one, for femoral ACL grafting, and a longer one, which will be further used for lateral collateral ligament reconstruction (Fig 3). The length chosen for the loop of the suspension device is variable, according to the length of the tunnel and the graft (10-15 mm is the length most commonly used, but longer lengths may be needed in case of a shorter graft or a longer tunnel). An additional device of greater length is attached to the standard one to facilitate cortical fixation once the whole length of the tunnel has been created with a diameter identical to that of the graft.

Tunnel Creation

Tunnels for the ACL Graft

Both the femoral and tibial tunnels are created with the aid of an ACL tibial guide (Stryker). This must be adjustable to at least 80° to ensure the correct positioning of the femoral tunnel. Starting with the femoral tunnel, the arthroscope is inserted through the anteromedial portal, and the guide is set at the widest possible angle (the authors usually place the femoral tunnel at 80°) through the central transtendinous portal. If it is possible to identify the bony anatomic landmarks, namely the bifurcate and intercondylar ridges, the said reference points are used to determine and mark the center of the ACL footprint; if not, the center of the tunnel is established approximately halfway along a vertical line drawn parallel to the posterior margin of the lateral femoral condyle and at a distance from the posterior margin of the femoral condyle, from deep to shallow, equal to the radius of the femoral tunnel plus 2.5 mm (e.g., 7 mm for a tunnel 9 mm in diameter). A 1.5-cm incision is made in the lateral femoral epicondyle, and a guide needle is introduced with the aid of the ACL reconstruction guide, entering the joint at the predetermined site. Special attention should be paid to the extra-articular

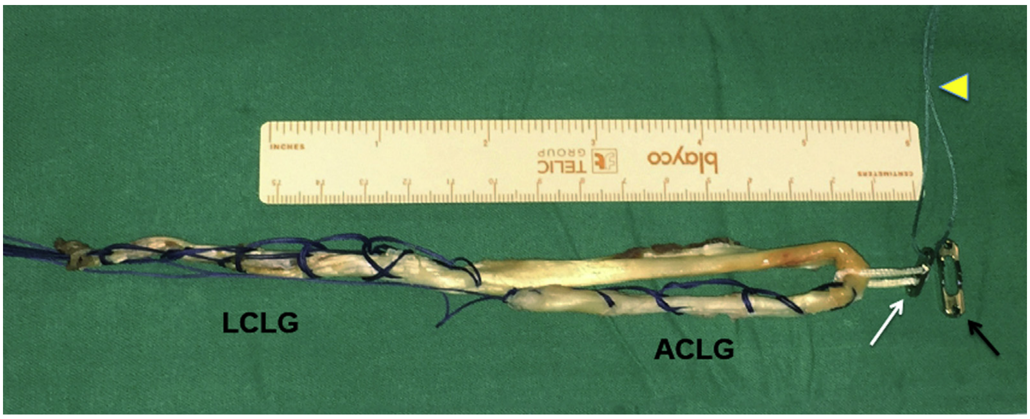

Fig 3. Graft prepared with a single-diameter end for lateral collateral ligament reconstruction and a double-diameter end for anterior cruciate ligament reconstruction. The white arrow shows the G-Lok suspension device, the black arrow shows the expansion piece of the suspension device, and the arrowhead shows the suspension device's traction thread. (ACLG, anterior cruciate ligament graft; LCLG, lateral collateral ligament graft.)

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
• The main advantage of this technique is that a single tunnel is created and a single device is used for femoral fixation, avoiding the risk of confluence. • Anatomic position of both ligaments can be easily achieved because they are performed independently using their original footprints. • The loop's length can be adapted to the length of the graft and tunnel, allowing associated anterior cruciate ligament and fibular collateral ligament reconstruction with a single graft by increasing the length of the loop.	• The tibial fixation device of the anterior cruciate ligament graft must be combined with another expansion device of additional length. • Tunnels are performed in the outside-in direction, so 4 incisions (1 femoral, 1 tibial, and 2 fibular) are needed. • In cases with too short length or breakage of hamstring tendon, an additional graft may be needed.

end of the guide pin for the femoral tunnel, which must be located just proximal and posterior to the lateral epicondyle, on the anatomic femoral insertion of the FCL (Table 2), according to anatomic studies.[14-16]

The tibial tunnel is created by returning the arthroscope to the central portal and introducing the same guide through the anteromedial one, at an angle of 55°. First, a needle is inserted using the guide and positioned at the center of the footprint of the native ACL. Both tunnels are then completed with the aid of a drill bit with a diameter identical to that of the graft.

Tunnels for the FCL Graft

The same femoral tunnel created for the ACL graft is employed. A 2-cm incision is made on the posterior aspect of the fibular head. Dissection is carefully performed with the aid of a periosteotome, which is left in place to protect the peroneal nerve when creating the fibular tunnel (Table 3).

After that, a 1-cm incision is made on the anterolateral aspect of the fibular head, over the native insertion of the FCL. A 2.4-cm guide pin is inserted in this spot, in the anteroposterior, craniocaudal, and lateromedial direction, taking special care to protect the peroneal nerve from the pin's tip with the periosteotome. A tunnel of the same diameter of the graft (which has been measured previously) is made over the guide pin with a cannulated drill bit (Fig 4). Once created, a looped suture is left in place to be used as a shuttle afterward (Fig 5).

Graft Pass and Fixation

The graft is introduced from the cranial to caudal direction. The traction threads of the suspension device are inserted into the joint through the ACL femoral tunnel, and they are taken out of the joint through the tibial tunnel; the graft is pulled until it passes through both tunnels.

Once the suspension device has come out of the tibial tunnel, it is fixed to its expansion piece (Fig 6) and is attached to the anterior cortex of the tibia by pulling the traction threads of the graft in the caudocranial direction, which is set in an asymmetrical manner. The short arm (approximately 9 cm long) is used together with the middle part of the long arm for the femoral grafting of the ACL. The longer arm (approximately of double length) will serve as the FCL graft (Fig 7). Tibial fixation is achieved with the suspension device and its expansion piece (G-Lok and G-Lok XL; Fig 8).

Gentle traction of both traction threads is performed until both ends of the graft come out of the femoral cortex. An interference screw (Biosteon; Stryker) of a diameter 1 mm wider than the graft is introduced in an outside-in direction while keeping traction from both ends of the graft, achieving ACL reconstruction (Fig 9).

Table 3. Tips, Pearls, and Pitfalls

Tips and Pearls	Pitfalls
• Although not essential, the authors recommend that the central portal should be used to ensure a clear view of the intercondylar notch. • Once the graft is in place, one should check that the suspension device for tibial fixation is properly supported by the tibial cortex. • Care must be taken to identify the femoral insertion of the fibular collateral ligament (just proximal and posterior to the lateral epicondyle).	• Special care must be taken to protect the peroneal nerve, because its injury can be devastating. • During its passage through the tunnels, the graft may become snagged. To avoid this, the graft should be passed symmetrically, and once passed, one of the ends should be pulled until the other end is at the level of the femoral cortex to provide the longest length to the fibular collateral ligament arm. • In addition, one should check that the graft can be passed with ease through the diameter calibrator. If this is not possible, the authors recommend enlarging the tunnel's diameter by passing the drill bit through the tunnel 1 or 2 more times or by using a drill bit 0.5 mm wider than the graft.

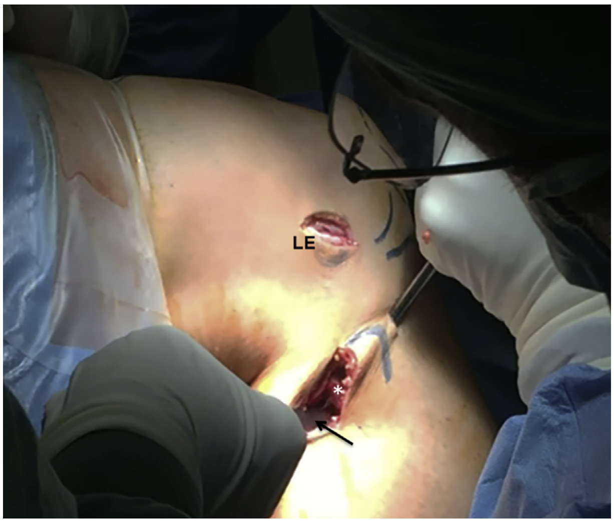

Fig 4. Lateral aspect of the right knee. Fibular tunnel drilling, in the anteroposterior, lateromedial, and craniocaudal direction. The white asterisk shows the fibular head, and the arrow shows the periosteotome protecting the posterior aspect of the fibular head to protect the peroneal nerve. (LE, lateral epicondyle.)

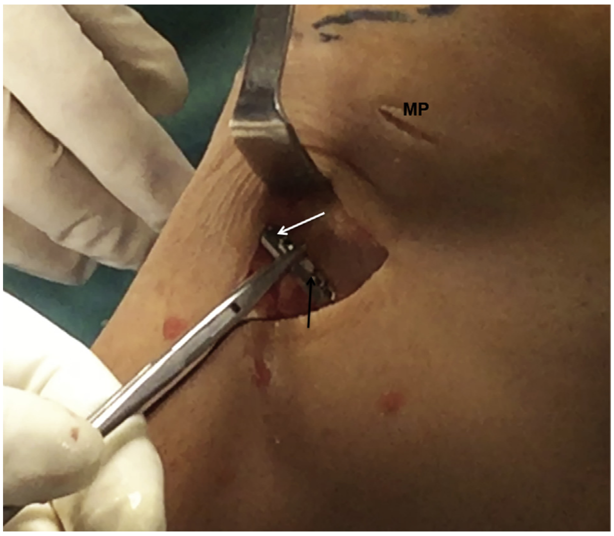

Fig 6. Attachment of the suspension device to its expansion piece. The black arrow shows the suspension device's plate, and the white arrow shows the expansion piece. (MP, medial portal.)

The traction threads are passed percutaneously under the fascia lata, to the anterolateral incision over the fibular head (Fig 10), and they are taken out through this incision. After that, the traction thread of the graft is inserted through the looped shuttle previously set through the fibular head (Fig 11), and it is pulled until the graft passes through the tunnel. Finally, the graft is fixed with an interference screw (Biosteon) of a diameter 1 mm wider than the tunnel, at 30° of knee flexion (Fig 12).

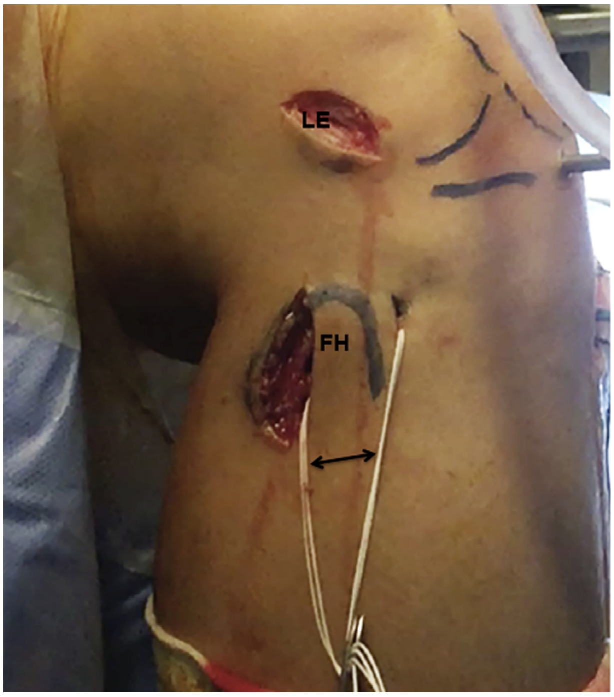

Fig 5. Lateral aspect of the right knee. A looped lace is set through the fibular tunnel to pass the fibular collateral ligament through the tunnel afterward. The arrow shows the traction thread. (FH, fibular head; LE, lateral epicondyle.)

Fig 7. Lateral aspect of the right knee. The long single-diameter end that will serve as the fibular collateral ligament graft is exposed over the skin before being passed under the fascia lata. The black arrow shows the anterolateral incision over the fibular head to create the fibular tunnel, the green arrow shows the extra-articular end of the femoral tunnel, and the blue arrow shows the fibular collateral ligament graft. (FH, fibular head.)

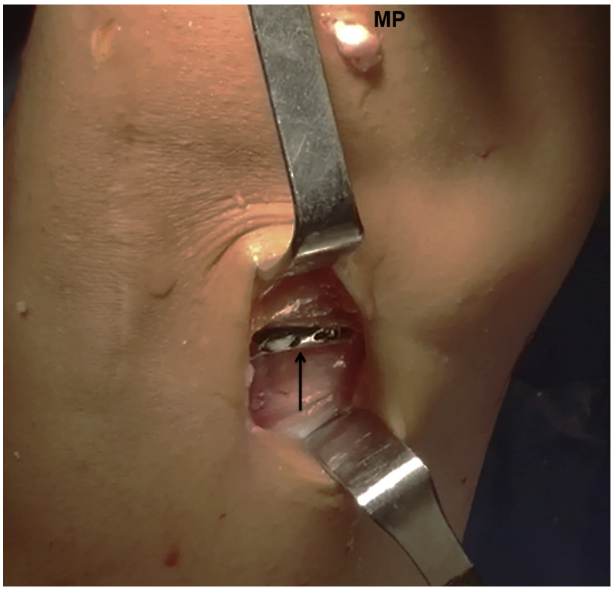

Fig 8. Medial aspect of the right knee. Tibial fixation of the anterior cruciate ligament graft can be seen through the approach made to harvest the autologous hamstring tendon and to drill the tibial tunnel. The arrow shows the suspension device with its expansion piece leaning against the anterior tibial cortex. (MP, medial portal.)

Discussion

This surgical technique uses a single tunnel in the lateral femoral condyle in an outside-in fashion. The outside-in technique offers the invaluable advantage of choosing both the entry and end point of the tunnel, and so this tunnel goes from the anatomic femoral insertion of the FCL[14-16] to the anatomic femoral insertion of the ACL.[17-19] Therefore, this tunnel requires only 1 graft to satisfy the anatomic requirements of both the ACL and FCL. In addition to this essential feature, the outside-in tunnel offers other advantages: it can be created with the knee in the same position during the entire procedure, avoiding the need for the hyperflexion required when the inside-out technique is used through the anteromedial portal.[20,21] According to Seo et al.,[22] the outside-in technique is valuable because it provides adequate rotational stability.

This technique uses only regular hamstring tendon grafting, including semitendinosus and gracilis tendons. To have a 4-strand construct for the ACL and a 2-strand construct (semitendinosus and gracilis) for the FCL, we folded the 2 tendons at a point located one-third of its entire length instead of half the length. According to Hamner et al.,[23] the 4 strands have a strength of 4,090 N and a stiffness of 776 N/mm, and the 2 strands are estimated to have a strength of 1,897 N. Laprade et al.[24] studied the biomechanical properties of posterolateral structures in 8 cadaver knees and concluded that the ultimate tensile load of the FCL averaged 295 ± 96 N. Therefore, our construct is 6 times stronger than native FCL, and there does not seem to be a reason to worry about mechanical failure.

Fig 9. Lateral aspect of the right knee. Femoral fixation of both the anterior cruciate ligament and the fibular collateral ligament grafts is performed using a single interference screw. The arrow shows the fibular collateral ligament graft. (E, epicondyle.)

Fig 10. Lateral aspect of the right knee. The remnant of the graft, which will serve as the fibular collateral ligament graft, is passed percutaneously under the iliotibial band in the craniocaudal direction to the anterolateral approach over the fibular head. The white arrow shows the fibular collateral ligament graft, and the black arrow shows the tip of the clamp seen through the anterolateral incision over the fibular head carrying the graft's traction thread. (FH, fibular head.)

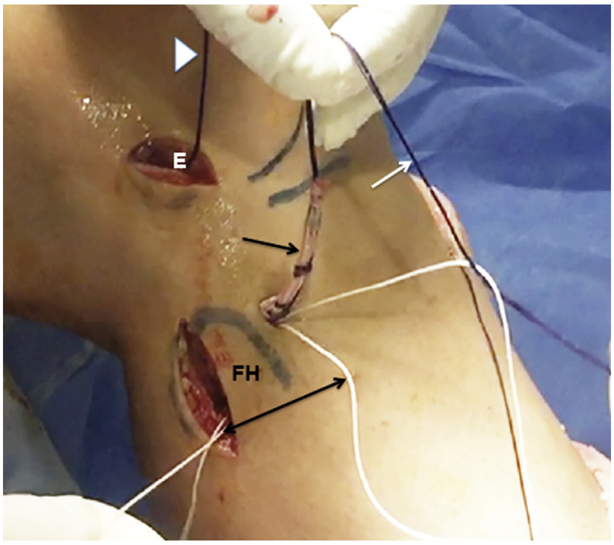

Fig 11. The fibular collateral ligament (FCL) graft's traction thread is passed through the looped lace, which had been previously set through the fibular head. The black arrow shows the FCL graft; the white arrow shows the looped lace to pass the FCL graft through the fibular tunnel; and the arrowhead shows that the traction thread of the short arm of the graft, which served to double the diameter of the anterior cruciate ligament graft, has not been removed yet. (E, epicondyle; FH, fibular head.)

Another advantage of this technique is that only 1 femoral tunnel is employed for both ACL and FCL graft fixation, avoiding the risk of tunnel confluence (especially important in multiligament injuries and revision surgery), as previously stated by Angelini et al.[25]

This technique is proposed by the authors for 2 definite clinical situations. The first one is the association of anterior and lateral instability, which is a recognized cause of ACL reconstruction failure if the lateral stability is not restored.[1,2,26-29]

In a multicenter study including 293 ACL revisions, unrecognized/untreated peripheral laxity was found in up to 3% of cases.[1] In the Danish Registry for Knee Ligament Reconstructions, "other" ligament laxity also accounted for 3% of 1,099 ACL revisions.[29]

LaPrade et al.[3] studied the forces in the ACL graft after sequential sectioning of FCL, PFL, and PT in 8 cadaver knees. They found that forces in the ACL graft increased significantly after sectioning the FCL with no further increase after the other cuts, whereas knee motion in the varus increased progressively after each separated cut. They concluded that grade III posterolateral instability may lead to ACL graft failure.

The second scenario that we propose for this technique is the surgical treatment of multiligament instability of the knee and knee dislocations. The incidence of posterolateral corner injuries in multiligament knee instability is very high. In a series by Richter et al.[30] of 89 knee dislocations, the incidence of FCL injury is as high as 59%; the FCL was injured in 38% of cases and both the medial collateral ligament and FCL in 21% of cases (n = 19). The surgical treatment of these injuries requires extensive use of allografts, either in addition to autografts or as the only source of grafting.[6] The series of Stannard et al.,[31] LaPrade et al.,[13] and Levy et al.[32] used allografts in 100% of cases. In a retrospective study of knee dislocations by Cook et al.,[4] 80% of allografts were used for FCL reconstruction. The reason for using allografts in the multiligament surgery setting is twofold: the limited availability of autogenous grafts to fulfill the requirement for 3 or 4 grafts and the need to save time in these complex procedures. Our technique permits us to address both ACL and FCL injuries with hamstring autografts, the harvest of which is a familiar and quick procedure for most knee surgeons. In addition to the biologic advantages of autografts, the time spent in harvesting hamstrings is compensated for by the time that is not spent in the second femoral tunnel for the FCL.

In conclusion, the technique described in this note meets the requirements to address associated anterior and lateral instabilities, avoiding the need for additional grafts and multiple femoral tunnels.

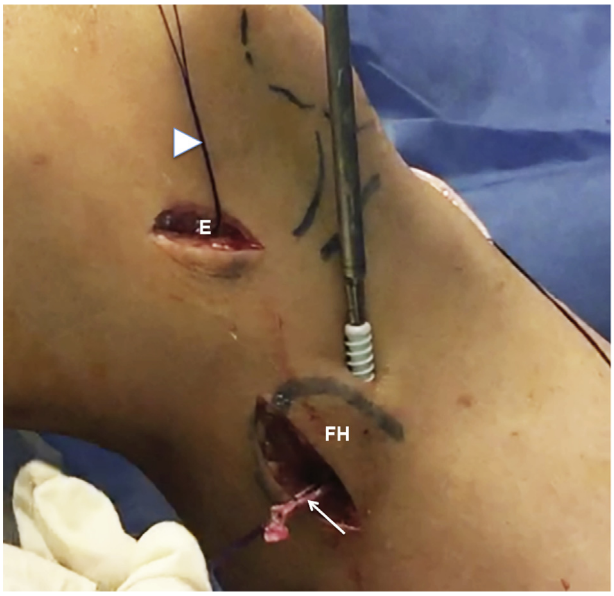

Fig 12. An interference screw 1 mm wider than the diameter of the tunnel. The graft is placed for fibular fixation of the fibular collateral ligament. The arrow shows the remaining graft after being passed through the fibular tunnel; the arrowhead shows that the traction thread of the short arm of the graft, which served to double the diameter of the anterior cruciate ligament graft, has not been removed yet. (E, epicondyle; FH, fibular head.)

References

1. Trojani C, Sbihi A, Djian P, et al. Causes for failure of ACL reconstruction and influence of meniscectomies after revision. *Knee Surg Sports Traumatol Arthrosc* 2011;19:196-201.
2. Wright RW, Huston LJ, Spindler KP, et al. Descriptive epidemiology of the Multicenter ACL Revision Study (MARS) Cohort. *Am J Sports Med* 2010;38:1979-1986.
3. LaPrade RF, Resig S, Wentorf F, Lewis JL. The effects of grade III posterolateral knee complex injuries on anterior cruciate ligament graft force. *Am J Sports Med* 1999;27:469-475.
4. Cook S, Ridley TJ, McCarthy MA, et al. Surgical treatment of multiligament knee injuries. *Knee Surg Sports Traumatol Arthrosc* 2015;23:2983-2991.
5. Dwyer T, Whelan D. Anatomical considerations in multiligament knee injury and surgery. *J Knee Surg* 2012;25:263-274.
6. Fanelli GC, Edson CJ. Surgical treatment of combined PCL-ACL medial and lateral side injuries (global laxity): Surgical technique and 2- to 18-year results. *J Knee Surg* 2012;25:307-316.
7. James EW, LaPrade CM, LaPrade RF. Anatomy and biomechanics of the lateral side of the knee and surgical implications. *Sports Med Arthrosc Rev* 2015;23:2-9.
8. LaPrade RF, Tso A, Wentorf FA. Force measurements on the fibular collateral ligament, popliteofibular ligament, and popliteus tendon to applied loads. *Am J Sports Med* 2004;32:1695-1701.
9. Gollehon DL, Torzilli PA, Warren RF. The role of the posterolateral and cruciate ligaments in the stability of the human knee. A biomechanical study. *J Bone Joint Surg Am* 1987;69:233-242.
10. Liu P, Wang J, Zhao F, Xu Y, Xu Y, Ao Y. Anatomic, arthroscopically assisted, mini-open fibular collateral ligament reconstruction: An in vitro biomechanical study. *Am J Sports Med* 2014;42:373-381.
11. Grood ES, Stowers SF, Noyes FR. Limits of movement in the human knee. Effect of sectioning the posterior cruciate ligament and posterolateral structures. *J Bone Joint Surg Am* 1988;70:88-97.
12. Latimer HA, Tibone JE, ElAttrache NS, McMahon PJ. Reconstruction of the lateral collateral ligament of the knee with patellar tendon allograft. Report of a new technique in combined ligament injuries. *Am J Sports Med* 1998;26:656-662.
13. LaPrade RF, Johansen S, Agel J, Risberg MA, Moksnes H, Engebretsen L. Outcomes of an anatomic posterolateral knee reconstruction. *J Bone Joint Surg Am* 2010;92:16-22.
14. Takeda S, Tajima G, Fujino K, et al. Morphology of the femoral insertion of the lateral collateral ligament and popliteus tendon. *Knee Surg Sports Traumatol Arthrosc* 2015;23:3049-3054.
15. Terry GC, LaPrade RF. The posterolateral aspect of the knee. Anatomy and surgical approach. *Am J Sports Med* 1996;24:732-739.
16. LaPrade RF, Ly TV, Wentorf FA, Engebretsen L. The posterolateral attachments of the knee: A qualitative and quantitative morphologic analysis of the fibular collateral ligament, popliteus tendon, popliteofibular ligament, and lateral gastrocnemius tendon. *Am J Sports Med* 2003;31:854-860.
17. Lopez-Vidriero E, Hugh Johnson D. Evolving concepts in tunnel placement. *Sports Med Arthrosc Rev* 2009;17:210-216.
18. Zantop T, Petersen W, Sekiya JK, Musahl V, Fu FH. Anterior cruciate ligament anatomy and function relating to anatomical reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2006;14:982-992.
19. Espejo-Baena A, Espejo-Reina A. Anatomic outside-in anterior cruciate ligament reconstruction using a suspension device for femoral fixation. *Arthrosc Tech* 2014;3:e265-e269.
20. Lubowitz JH. Anteromedial portal technique for the anterior cruciate ligament femoral socket: Pitfalls and solutions. *Arthroscopy* 2009;25:95-101.
21. Breland R, Metzler A, Johnson DL. Indications for 2-incision anterior cruciate ligament surgery. *Orthopedics* 2013;36:708-711.
22. Seo SS, Kim CW, Kim JG, Jin SY. Clinical results comparing transtibial technique and outside in technique in single bundle anterior cruciate ligament reconstruction. *Knee Surg Relat Res* 2013;25:133-140.
23. Hamner DL, Brown CH, Steiner ME, Hecker AT, Hayes WC. Hamstring tendon grafts for reconstruction of the anterior cruciate ligament: Biomechanical evaluation of the use of multiple strands and tensioning techniques. *J Bone Joint Surg Am* 1999;81:549-557.
24. LaPrade RF, Bollom TS, Wentorf FA, Wills NJ, Meister K. Mechanical properties of the posterolateral structures of the knee. *Am J Sports Med* 2005;33:1386-1391.
25. Angelini FJ, Helito CP, Tozi MR, et al. Combined reconstruction of the anterior cruciate ligament and posterolateral corner with a single femoral tunnel. *Arthrosc Tech* 2013;2:e285-e288.
26. Cavaignac E, Tscholl P, Valoroso M, Menetrey J. Revision anterior cruciate ligament reconstruction. In: Randelli P, Dejour D, Van Dijk N, Denti M, Seil R, eds. *Arthroscopy: Basic to advanced*. New York: Springer, 2016;285-306.
27. Harner CD, Giffin JR, Dunteman RC, Annunziata CC, Friedman MJ. Evaluation and treatment of recurrent instability after anterior cruciate ligament reconstruction. *Instr Course Lect* 2001;50:463-474.
28. Lind M. One-stage revision: Danish approach. In: Siebold R, Dejour D, Zaffagnini S, eds. *Anterior cruciate ligament reconstruction: A practical surgical guide*. New York: Springer, 2014;387-406.
29. Lind M, Menhert F, Pedersen AB. Incidence and outcome after revision anterior cruciate ligament reconstruction: Results from the Danish registry for knee ligament reconstructions. *Am J Sports Med* 2012;40:1551-1557.
30. Richter M, Bosch U, Wippermann B, Hofmann A, Krettek C. Comparison of surgical repair or reconstruction of the cruciate ligaments versus nonsurgical treatment in patients with traumatic knee dislocations. *Am J Sports Med* 2002;30:718-727.
31. Stannard JP, Brown SL, Farris RC, McGwin G Jr, Volgas DA. The posterolateral corner of the knee: Repair versus reconstruction. *Am J Sports Med* 2005;33:881-888.
32. Levy BA, Dajani KA, Morgan JA, Shah JP, Dahm DL, Stuart MJ. Repair versus reconstruction of the fibular collateral ligament and posterolateral corner in the multiligament-injured knee. *Am J Sports Med* 2010;38:804-809.