Anatomic Fibular Collateral Ligament Reconstruction

Gilbert Moatshe, M.D., Chase S. Dean, M.D., Jorge Chahla, M.D., Raphael Serra Cruz, M.D., and Robert F. LaPrade, M.D., Ph.D.

Abstract: Fibular collateral ligament (FCL) injuries can lead to varus instability of the knee, causing a varus thrust gait and resulting in increased forces on the medial compartment of the knee. In the long term, this can result in meniscal injuries and medial compartment osteoarthritis. Varus instability is also reported to increase forces on the cruciate ligaments, which can lead to overload and failure of these reconstructions in cases of nonrecognized combined injuries. Historically, both repair and reconstruction have been used for grade III injuries to the FCL. However, repair has been reported to lead to a higher reoperation rate. The hereby presented reconstruction technique is used for FCL injuries that do not involve other structures of the posterolateral corner, but can be used in combination with other knee ligament reconstructions including the posterior cruciate ligament, anterior cruciate ligament, and medial collateral ligament. The purpose of this surgical technique article was to describe the biomechanically validated anatomic reconstruction of the FCL using a semitendinosus graft.

The fibular collateral ligament (FCL) is an important stabilizer of the lateral side of the knee through the whole range of motion. Likewise, it resists external rotation near full extension.[1,2]

Injuries to the FCL rarely occur in isolation. They are typically associated with other knee ligament injuries such as the anterior cruciate ligament (ACL), posterior cruciate ligament, other posterolateral corner (PLC) structures, and multiligament knee injuries.[3,4] FCL tears can occur because of direct varus stress, hyperextension, or twisting injuries of the knee.[3]

The current standard of care for isolated grade I and II injuries of the FCL is nonoperative treatment with a brace for 4 to 6 weeks.[5] Animal studies and clinical experience have reported that grade III injuries heal poorly, resulting in knee instability.[6] Persistent varus instability of the knee results in a varus thrust gait with increased forces on the medial compartment of the knee. In the long term, this can result in meniscal injuries and medial compartment osteoarthritis.[3,6] Varus instability due to a deficient FCL has also been shown to increase forces on the ACL and posterior cruciate ligament.[7,8] Therefore, failure to repair and/or reconstruct the FCL at the same time as the cruciate ligament reconstruction can put undue stress on the graft(s) and lead to graft failure.

Historically, both repair and reconstruction have been used for grade III injuries to the FCL. However, repair has been reported to lead to a higher rate of reoperations.[9] Several reconstruction methods have been reported, including different grafts sources such as quadriceps tendon-patella bone[10] and bone–patella tendon–bone.[11] Other groups have reported on augmentation techniques with the biceps femoris tendon,[12] biceps femoris tenodesis,[13] and advancement of the proximal FCL attachment.[14] In recent years, there has been an increased focus on anatomic reconstructions that have been reported to restore the native biomechanics of the knee.[15,16]

The purpose of the surgical technique was to describe the anatomic reconstruction of the FCL with semitendinosus autograft.

Objective Diagnosis

FCL injuries rarely occur in isolation and care must be taken to perform a thorough diagnostic work-up. Clinical examination and stress radiographs are usually used in the diagnosis. Varus stress radiographs have

From the Steadman Philippon Research Institute (G.M., C.S.D., J.C., R.S.C., R.F.L.), Vail, Colorado, U.S.A.; and Department of Orthopedic Surgery Oslo University Hospital (G.M.), Oslo, Norway; The Steadman Clinic (R.F.L.), Vail, Colorado, U.S.A.

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Address correspondence to Robert F. LaPrade, M.D., Ph.D., Steadman Philippon Research Institute, The Steadman Clinic, 181 West Meadow Drive, Suite 400, Vail, CO 81657, U.S.A. E-mail: drlaprade@sprivail.org

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Fig 1. Patient positioning on the operating table. The high placement of the tourniquet and leg holder on the thigh allows great exposure and mobility of the limb during surgery.

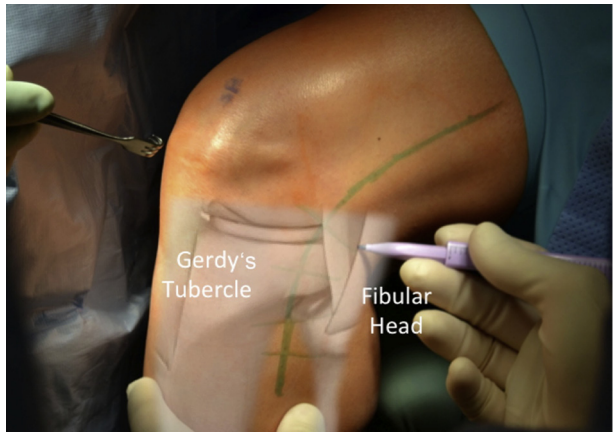

Fig 2. Picture of a left knee showing a superimposed schematic view of the anatomical landmarks and the surgeon's incision outline.

shown good inter- and intraobserver reliability.[17] The diagnostic algorithm used by the senior author (R.F.L.) is as follows: with the knee flexed at 20°, a side-to-side lateral gapping difference of 2.7 to 4.0 mm in varus stress radiographs represents a complete FCL tear, whereas a side-to-side difference greater than 4 mm represents a combined PLC injury. Magnetic resonance imaging is routinely used and is also helpful to identify possible concurrent injuries.

Surgical Technique

Patient Positioning

The patient is placed in supine position with the injured leg in a leg holder (Mizuho OSI, Union City, CA), and the nonsurgical leg is flexed, abducted, and held in an abduction holder (Birkova Product LLC, Gothenburg, NE) (Video 1). A well-padded high-thigh tourniquet is subsequently placed on the upper thigh of the operative leg. The surgical leg is prepped and draped (Fig 1), and the tourniquet is inflated.

Surgical Approach

A lateral hockey stick incision is made to the skin along the iliotibial band and is extended distally between the lateral fibular head and Gerdy's tubercle (Fig 2). A long incision extending proximally is necessary to be able to identify the common peroneal nerve proximally and follow it distally to the fibular head.

Sharp dissection is performed down to the fascia overlying the iliotibial band. Skin flaps with subcutaneous tissue are made anteriorly and posteriorly. The posterior skin flap should have sufficient subcutaneous tissue and vascularity to support wound healing and avoid skin necrosis postoperatively. The common peroneal nerve is then identified, lying posteromedial to the biceps tendon, and a neurolysis is performed (Fig 3). The nerve is then retracted from the surgical field to minimize the risk of injury during the operation.

Once the nerve has been isolated, a 1-cm longitudinal incision is made in the distal aspect of the long head of the biceps femoris tendon, along the fibers of the tendon to access the biceps bursa, where the FCL insertion can be found.[18] A tag stitch is placed in the distal end of the remnant FCL.

The anterior arm of the long head of the biceps femoris tendon is incised longitudinally, and the distal attachment of the FCL is sharply dissected to create room for the reconstruction tunnel on the fibular head. A guide pin is drilled from the FCL attachment on the lateral aspect of the fibular head (8.2 mm posterior to the anterior margin of the fibular head and 28.4 mm

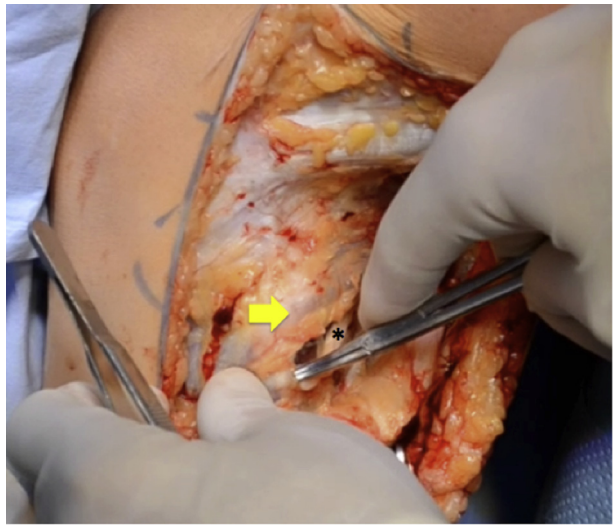

Fig 3. Neurolysis being performed on a left leg after common peroneal nerve identification. Note the relation between the nerve (asterisk) and the tendon of the long head of the biceps femoris (yellow arrow).

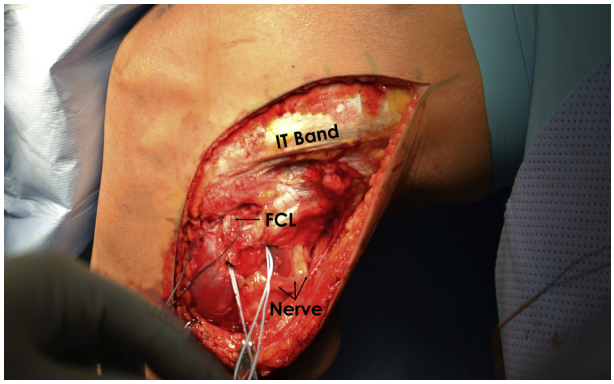

Fig 4. Left knee image showing a passing suture delivered through the fibular tunnel with a loop anterolaterally oriented to facilitate graft passage. The common peroneal nerve can be observed at the bottom right. (FCL, fibular collateral ligament; IT, iliotibial.)

distal to the tip of the fibular styloid process[19]), aimed at the posteromedial downslope of the fibular head, distal to the popliteofibular ligament attachment. Aiming too proximally can damage the attachment of the popliteofibular ligament. A 6-mm reamer (Arthrex, Naples, FL) is used to create a reconstruction tunnel on the fibular head. A passing suture is delivered through the created tunnel with the loop anterolaterally oriented to facilitate graft passage (Fig 4).

Tension is placed on the tag stitch previously sutured on the remnant of the distal FCL, and the femoral attachment can be then identified per visualization and palpation, proximal posteriorly to the lateral epicondyle.[19] A longitudinal incision is then made through the mid-third of the iliotibial band on the lateral aspect of the distal femur, over the lateral epicondyle (Fig 5). In cases where the remnant FCL cannot be found, the proximal FCL attachment is identified

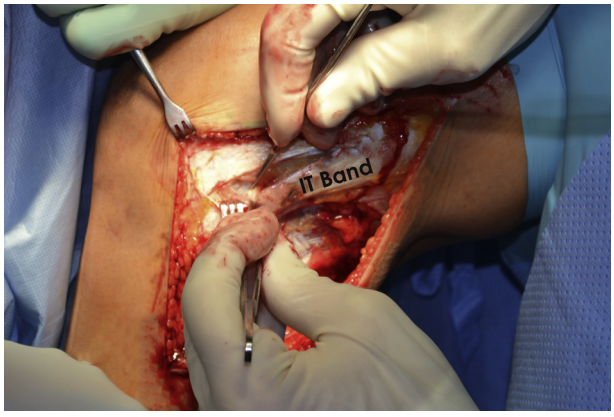

Fig 5. A longitudinal incision is made through the mid-third of the superficial layer of the iliotibial (IT) band on the lateral aspect of the distal femur, over the lateral epicondyle over the previously identified proximal fibular collateral ligament insertion on a left knee.

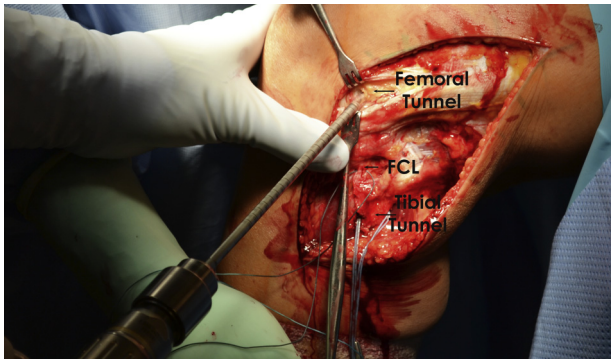

Fig 6. The fibular collateral ligament (FCL) graft is passed into the femoral tunnel (with the help of the passing sutures left in place in the previous step) and fixed with a 7 × 23 mm bio-interference screw.

using the landmarks as described by LaPrade et al.[19] The proximal FCL is dissected from its attachment site and an eyelet-tipped guide pin is aimed anteromedially and approximately 20° to 30° proximally across the femur to avoid damage to the trochlea and potential collision with ACL tunnels in cases of concurrent reconstructions. Dissection in this region should be done carefully to avoid damage to the anterolateral ligament fibers, as its femoral attachment is reported to be 4.7 mm proximal and posterior to the FCL insertion.[20] The eyelet pin is over-reamed with a 6-mm reamer (Arthrex) to 25 mm depth. A 7-mm tap (Arthrex) is used to enlarge the femoral tunnel. A passing suture is then passed through the femoral tunnel.

The semitendinosus tendon is then harvested in the standard fashion, and whip-stitched with No. 2 polyethylene/polyester suture (FiberWire, Arthrex) placed in both ends. The graft end designated to be placed into the femoral tunnel should be whip-stitched for 25 mm. If there are other injuries in the

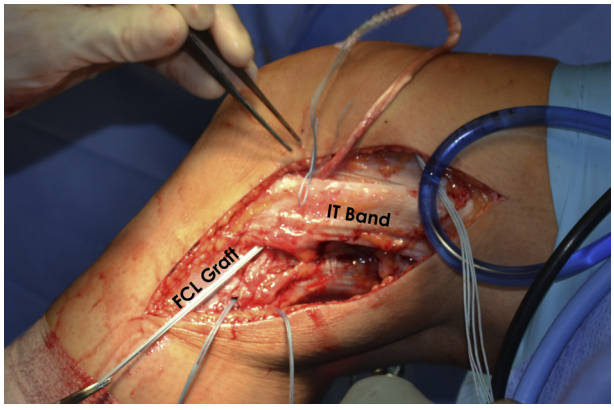

Fig 7. The fibular collateral ligament (FCL) graft is being passed under the superficial layer of the iliotibial (IT) band and will then be passed through the fibular tunnel from lateral to posteromedial with the previously positioned passing sutures on a left knee.

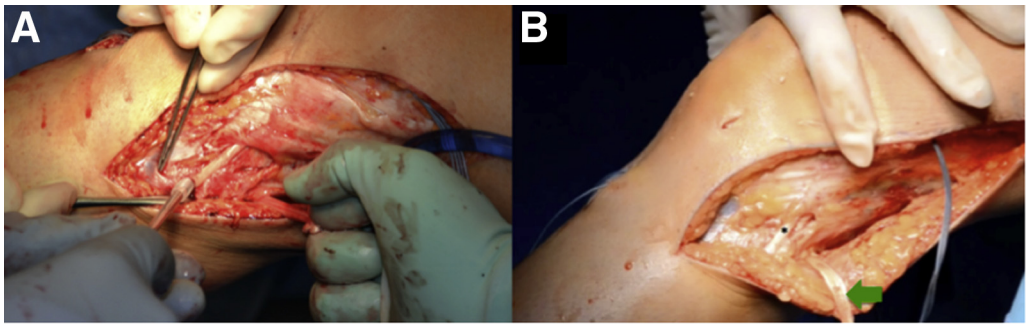

Fig 8. Surgical aspect of a left knee showing (A) graft fixation at 20° of knee flexion with a biointerference screw and (B) the graft (asterisk) in place after fixation. The green arrow indicates the excess graft to be resected after fixation.

knee, they are addressed at this point. Afterwards, the graft is passed into the femoral tunnel and fixed with a 7 × 23 mm biointerference screw (Arthrex) (Fig 6). The graft is pulled laterally with traction to test the fixation on the femur. The graft is then passed under the superficial layer of the iliotibial band and through the fibular tunnel from lateral to posteromedial (Fig 7). With 20° of knee flexion and neutral rotation, a gentle valgus force is applied to the knee and the graft is then fixed to the fibula with a 7 × 23 mm biointerference screw (Arthrex) (Figs 8 and 9) If there is concomitant ACL injury, the ACL graft is then fixed on the tibial side.

Once fixation is complete, the knee is assessed through a complete range of motion and the varus laxity is tested with a varus stress test for comparison with the preoperative state. Pearls and pitfall of this surgical technique are summarized in Table 1.

Rehabilitation

Patients are non-weight-bearing for the first 6 weeks. A brace is used for the same period to protect the knee against varus forces, and to restrict tibial internal and external rotation while the graft is healing. Range of motion and quadriceps strength exercises are initiated

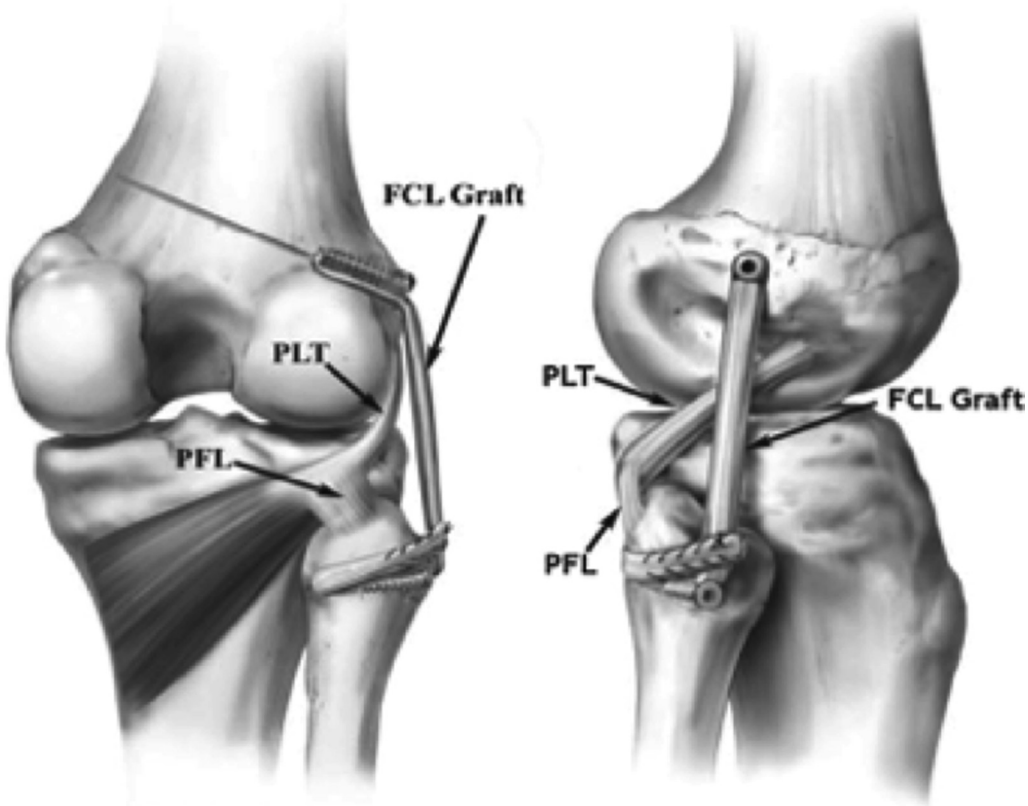

Fig 9. Posterior-anterior and lateral views of an isolated anatomic fibular collateral ligament (FCL) reconstruction using a semitendinosus graft. (PFL, popliteofibular ligament; PLT, popliteus tendon.) (Reproduced with permission from Coobs et al.[15])

Table 1. Pearls and Pitfalls of Anatomic FCL Reconstruction

Pearls	Pitfalls
Leave enough subcutaneous tissue in the posterior skin flap to avoid skin necrosis.	Failure in diagnosing and/or addressing concomitant injuries, especially to the posterolateral corner structures, can lead to overload of the FCL graft and poor outcomes.
Identifying the peroneal nerve during the initial approach and performing a neurolysis prevents injury to this structure.	Aiming too proximal while reaming the fibular tunnel can damage the insertion of the popliteofibular ligament.
Placing a tag stitch in the FCL and pulling it helps identifying the femoral attachment of this ligament.	Careless dissection of the proximal FCL attachment can damage fibers of the anterolateral ligament.
Leaving passing sutures right after creating the tunnels helps with graft passage.	Not attending to the correct orientation of the pin guide for the femoral tunnel can lead to collision with an eventual anterior cruciate ligament reconstruction.
In cases where the FCL cannot be identified, use the anatomical landmarks to locate its femoral attachment.	Not passing the graft underneath the iliotibial band will result in dynamic compression of this structure.
Reaming a 6-mm femoral tunnel and tapping it with a 7-mm tap promotes a better fixation when using a 7-mm graft.	

FCL, fibular collateral ligament.

on postoperative day 1. Range of motion is limited to $<90^\circ$ for the first 2 weeks.

Increased range of motion is allowed after 2 weeks while maintaining the restrictions on external rotation, internal rotation, and varus stress. For isolated FCL reconstruction, patients can return to normal activities after 6 months, with encouragement to use a functional knee brace (Cti, Össur, Foothill Ranch, CA) for physical activities until they are 1 year from the surgery. For combined concurrent knee ligament injuries, 9 months are recommended before return to normal activities.

Discussion

Although several nonanatomic-based FCL reconstructions are used,[10-14] anatomical reconstructions are preferred because this reconstruction technique restores near native knee biomechanics[15,16] and has also been validated to improve patient outcomes.[21,22] The graft is fixed at 20° to 30° because biomechanical studies have shown that these are the angles at which the greatest amount of varus instability is created by sectioning the FCL.[2,7,15] Coobs et al.[15] biomechanically showed that anatomical FCL reconstruction restores varus, external, and internal rotation to near normal stability to knees with isolated FCL injuries. In addition, anatomical FCL reconstruction using a semitendinosus graft at an average 2-year follow-up resulted in improved patient outcomes and near-normal lateral compartment stability in patients with grade III injuries of the FCL. The modified Cincinnati score improved from 28.2 preoperatively to 88.5 postoperatively and the International Knee Documentation Committee subjective outcome score improved from 34.7 preoperatively to 88.1 postoperatively.[21] Another study on anatomic FCL reconstruction showed significant preoperative to postoperative improvements in mean Lysholm and Western Ontario and McMaster Universities Arthritis Index scores, the median SF-12 physical component subscale score and postoperative patient reported outcome scores at an average of 2.7 years postoperatively.[22]

The semitendinosus tendon is preferred because it is long enough to match the length of the FCL, which has shown to be 70 mm on average.[18] The graft is also preferred because of its tensile strength and larger size. Lastly, the semitendinosus tendon is widely used in knee ligament reconstructions and, as a result, harvesting and working with it is familiar to many surgeons.

We recommend our method of anatomical reconstruction of grade III FCL injuries without other concurrent PLC injuries and encourage additional studies by other groups to assess our surgical technique.

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