Technical Note

Reduction of a Depressed Femoral Lateral Notch at the Time of Lateral Extra-articular Tenodesis

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Abstract: We present a surgical technique to address severe lateral femoral notch depressions using a small extension in the lateral approach for Lemaire extra-articular tenodesis in anterior cruciate ligament reconstruction. Through this approach, the surgeon is able to obtain good exposure of the lateral femoral condyle, with straightforward access for subchondral reduction, without adding any significant morbidity.

The lateral femoral notch sign is a well-recognized radiographic feature that results from the impaction of the posterolateral corner of the tibia on the lateral condyle during the pivot-shift mechanism.[1-3] Despite the presence of this sign in around one-quarter of anterior cruciate ligament (ACL) injuries,[1] little is known about its long-term implications. Nonetheless, it seems to have an association with cartilage degeneration and early osteoarthritis,[3,4] and it appears to be strongly correlated with higher rotatory instability in ACL-injured patients.[5] This bony depression can be fully characterized with magnetic resonance imaging, not only depicting the depth of the lateral notch itself but also showing the extent of bone bruising. In most cases, there is a mirror bone bruise sign involving the lateral femoral notch depression (LFND) and the posterolateral tibial plateau corner (Fig 1). Concerning the depth threshold from which the LFND should be surgically addressed, a clear cutoff point has not been defined in the literature and further research is needed. However, most authors agree that grade II (≥4-mm) lesions must be reduced to prevent additional harm and ensure good long-term outcomes.[1,3,6,7]

Regarding the surgical technique, there are only a few case reports proposing different strategies to address this fracture impaction.[6-8] In this article, we describe an original approach to reduce the LFND through a lateral arthrotomy, taking advantage of the lateral incision used for the modified Lemaire procedure, with little additional morbidity.

Surgical Technique

This technical note presents our surgical technique to address severe LFNDs through the same incision used for modified Lemaire extra-articular tenodesis in ACL reconstruction (Video 1). Pearls and pitfalls of this procedure are described in Table 1.

Patient Positioning and Landmark Placement

The patient is placed in the supine position on the operating table with a lateral support at the level of a padded tourniquet and a foot roll positioned to maintain 90° of knee flexion. The injured leg is prepared and draped with the surgeon's preferred method, similar to

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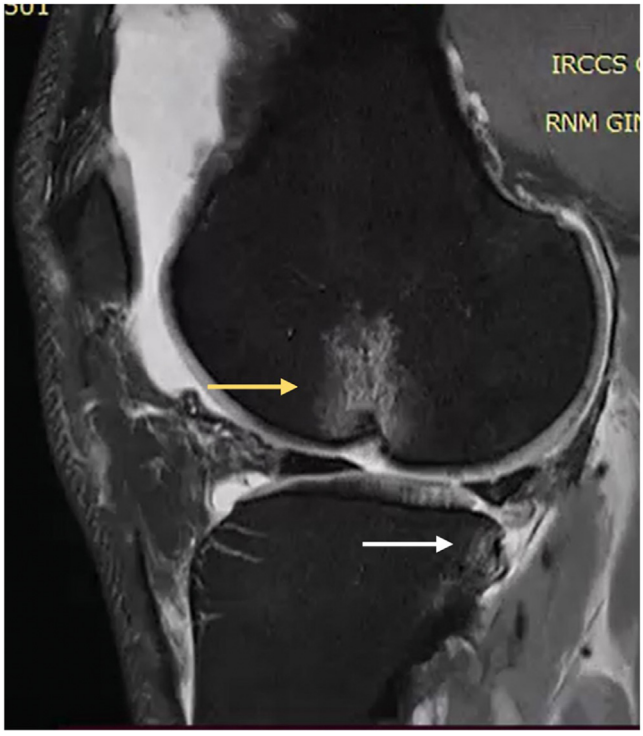

Fig 1. Right knee. Preoperative T2-weighted sagittal magnetic resonance imaging scan showing depression and bone bruise in lateral femoral condyle (yellow arrow) and concomitant bone bruise in posterolateral corner of tibial plateau (white arrow).

any arthroscopic procedure around the knee. Appropriate landmarks are palpated and marked, including the joint line, Gerdy tubercle, and lateral epicondyle (Fig 2).

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
The graft from the ITB should be taken from its middle third to ensure good access to the lateral femoral condyle.	Reduction of the LFND must be performed prior to ACL reconstruction to prevent any damage to the ACL graft with the tip of the Hohmann retractor placed into the central notch.
The arthrotomy should be performed over the lateral edge of the femoral condyle, previously identified by palpation.	The bone tamps used for the reduction should not be too small in diameter because of the increased risk of breaking through the subchondral plate.
The knee flexion angle must be adjusted until the LFND is exposed through the arthrotomy, between the remaining limbs of the ITB.	Care must be taken when choosing the location of the lateral cortical window to avoid damage to lateral wall attachments such as the popliteus tendon.
The arthrotomy must be carefully closed; a watertight closure must be ensured to prevent fluid extravasation.	

ACL, anterior cruciate ligament; ITB, iliotibial band; LFND, lateral femoral notch depression.

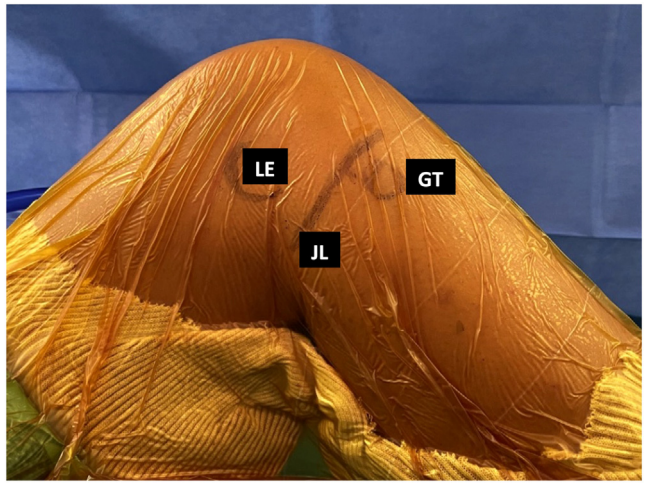

Fig 2. Patient positioning and landmark placement in right knee, lateral view, positioned at 90° of knee flexion. (GT, Gerdy tubercle; JL, joint line; LE, lateral epicondyle.)

Diagnostic Arthroscopy

High anterolateral and anteromedial arthroscopy portals are established. A diagnostic arthroscopy is performed to further characterize the size and shape of the LFND (Fig 3). Any associated meniscal injury is systematically evaluated and treated at this stage.

Lateral Surgical Approach

Preparation for modified Lemaire extra-articular tenodesis is performed prior to ACL reconstruction, as well as reduction of the LFND. An incision centered on the lateral epicondyle, as described for the modified Lemaire procedure,[9] is distally extended to allow a lateral arthrotomy suitable for this technique (Fig 4).

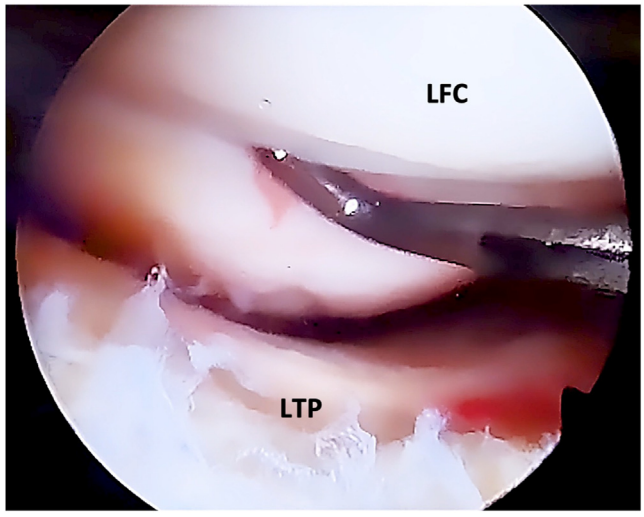

Fig 3. Arthroscopic characterization of lateral femoral notch sign through high anterolateral and anteromedial portals in right knee. (LFC, lateral femoral condyle; LTP, lateral tibial plateau.)

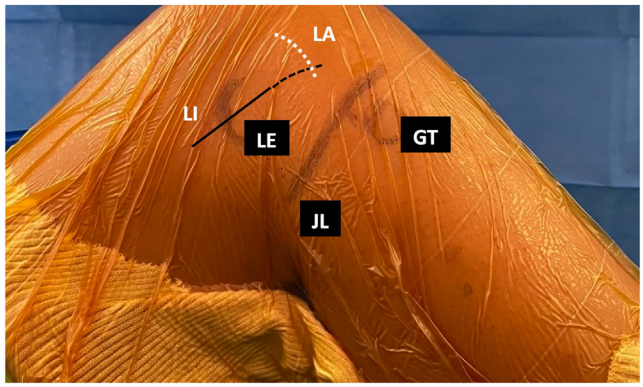

Fig 4. Right knee, lateral view. A lateral incision (LI) centered on the lateral epicondyle (black line), as described for the modified Lemaire procedure, is distally extended (black dashes) to allow a lateral arthrotomy (LA, white dots) suitable for reduction of the lateral femoral notch sign. (GT, Gerdy tubercle; JL, joint line; LE, lateral epicondyle.)

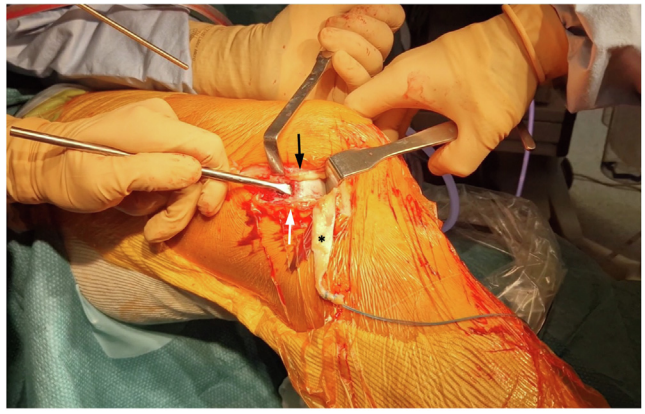

Fig 6. Right knee, lateral view. Exposure of lateral femoral condyle through arthrotomy between upper (black arrow) and lower (white arrow) limbs of remaining iliotibial band. The asterisk indicates the iliotibial band strip for the modified Lemaire procedure.

After a strip of the iliotibial band (ITB) is harvested from its middle third, the graft is whipstitched using a No. 0 suture (Mersilene; Ethicon, Somerville, NJ) and peeled back to the Gerdy tubercle to expose the anterolateral capsule (Fig 5). Between the upper and lower limbs of the remaining ITB, a lateral arthrotomy is performed to reach the lateral femoral condyle (Fig 6). Full exposure of the condyle is achieved by placing the tip of a 90° bent Hohmann retractor into the central notch and adjusting the knee flexion angle until the LFND is exposed (Fig 7).

Reduction Technique

A 10 × 10—mm cortical window, made with a chisel, is taken out of the lateral femoral wall, distally to the lateral epicondyle, and bone tamps, from 6 to 10 mm, are inserted and directed to the depressed femoral condyle lesion (Fig 7). Progressive pounding of the tamps with a mallet is performed until reduction of the plastic deformation of the condyle is achieved (Fig 8). Afterward, the subchondral defect is filled with allograft cancellous bone chips and/or bone substitutes that are impacted under the articular surface, followed by closure of the cortical window with the previously taken cortical bone piece, which is also tamped into the defect. Then, the lateral arthrotomy is closed with a conventional interrupted No. 0 suture (Polysorb; Covidien, Mansfield, MA); care should be taken to ensure that the closure is watertight.

ITB Graft Passage

After the femoral attachment of the lateral collateral ligament (LCL) is identified, an incision is made on

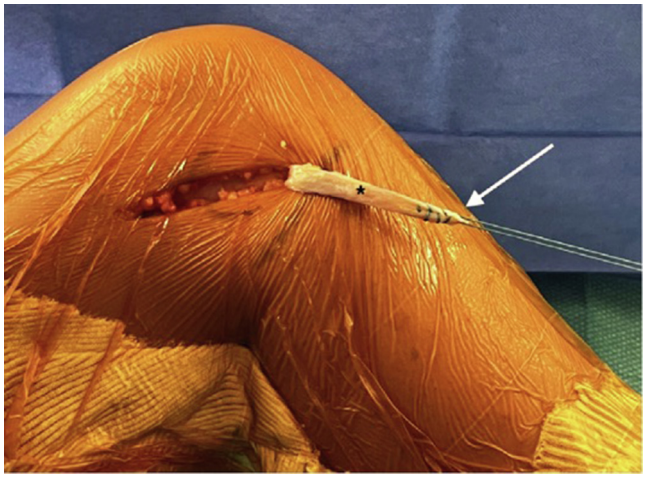

Fig 5. Right knee, lateral view. Iliotibial band graft preparation. A 9-cm strip of the iliotibial band (asterisk) is whipstitched (arrow) and peeled back to the Gerdy tubercle to expose the anterolateral capsule.

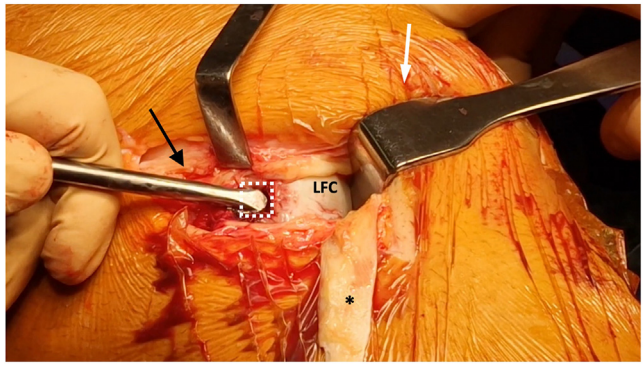

Fig 7. Right knee, lateral view. Full exposure of the lateral femoral condyle (LFC) is achieved by placing the tip of a 90° bent Hohmann retractor (white arrow) into the central notch and adjusting the knee flexion angle until the lesion is exposed. Lateral femoral notch sign reduction is performed through a lateral cortical window (dotted square) with a bone tamp (black arrow). The asterisk indicates the iliotibial band strip for the modified Lemaire procedure.

Fig 8. Right knee. Preoperative (A) and early postoperative (B, C) T2-weighted sagittal magnetic resonance imaging scans showing well-reduced lateral femoral notch sign, with return of condyle to its native curvature.

either side of the LCL and a tunnel is created under it, through which the graft is passed from anterior to posterior. The incisions around the LCL are then closed to prevent fluid extravasation.

Bone–Patellar Tendon–Bone Graft Harvesting and Preparation

A double skin incision, preventing injuries to the infrapatellar branch of the saphenous nerve, is used, as previously described.[10] A proximal incision over the distal pole of the patella is combined with a distal incision located more medially at the level of the tibial tuberosity. The paratenon is identified and divided longitudinally. The middle third of the patellar tendon is then incised using a 10-mm-wide double-bladed scalpel. The bone blocks are harvested using an oscillating saw. Two 2-mm drill holes are placed on the patellar bone block for a figure-of-8 traction suture, and an additional drill hole is made 5 mm from the end of the tibial bone block. First, the tibial bone block is removed and delivered to the proximal incision, after adhesions are released from the patellar tendon; then, finally, the patellar bone block is removed. The tibial block is cut in a trapezoidal shape (11 × 20 mm), and the patellar block, in a triangular fashion (9 × 15 mm). A No. 3 suture (Mersilene) is passed through the 2-mm drill hole in the tibial block. The patellar block is prepared with a No. 3 suture (Mersilene) and a No. 2 suture (Polysorb) in a figure-of-8 shape; then, a knot is positioned at the extremity. This configuration allows this bone block to be pulled during graft passage. The junctions between the tendon and bone are marked with a sterile marker pen.

ACL Reconstruction Bone Tunnels

Drilling of the femoral tunnel is performed with an outside-in guide (Arthrex, Naples, FL) at the ACL femoral footprint. Progressive drilling is carried out, enabling the position of the femoral tunnel to be rechecked and adjusted as needed until a 10-mm reamer is placed. The lateral aperture of the tunnel is overdrilled to 11 mm for press-fit fixation. Then, the tibial ACL guide (Arthrex) is positioned over the ACL tibial footprint, and progressive reaming is performed.

ACL Graft Passage and Fixation

A No. 2 passing suture (Polysorb) is delivered from the tibial tunnel to the femoral tunnel for antegrade passage of the graft. The sutures from the patellar bone block are inserted into the loop created by the passing suture. Using a straight clamp, the surgeon guides the patellar bone block through the femoral tunnel; then, the traction sutures are pulled to allow passage of the graft. While traction is maintained distally, the tibial bone block is lightly hammered using a bone impactor until press-fit fixation is achieved. Maximal manual tension is then applied to the sutures of the patellar bone block, and the knee is cycled through full flexion and extension several times to ensure the full passage of the graft. Next, the knee is placed in 30° of flexion, and tibial fixation is achieved using an interference screw (FastThread BioComposite Interference Screw; Arthrex). Double fixation of the graft is then performed on the tibial side using the transosseous sutures positioned on the tibial tuberosity. Finally, bone graft is inserted into the graft harvest sites, and the wounds are closed.

ITB Graft Fixation

An insertion point for the Lemaire extra-articular tenodesis that is proximal and posterior to the lateral epicondyle is identified, and a 2.6-mm drill bit is used to allow the insertion of a 2.6-mm knotless suture anchor (2.6-mm Knotless FiberTak Anchor; Arthrex). The whipstitched graft is then taken through a loop from the suture anchor, and the graft is fixed close to extension. The graft is sutured back onto itself using a No. 0 suture (Polysorb), and the remaining ITB is closed

with the same suture, aided by the previous release of its inferior part.

Postoperative Rehabilitation

Postoperative rehabilitation begins with brace-free, toe-touch weight bearing for the first 6 weeks and progressive range-of-motion exercises, with restriction to 0° to 90°, also for 6 weeks, in patients undergoing meniscal repair. Early rehabilitation focuses on maintaining full extension and performing quadriceps activation exercises. Return to sports is allowed at 6 months for noncontact sports and at 8 to 9 months for pivoting contact sports.

Discussion

Despite the lateral femoral notch sign being a relatively frequent feature of ACL injuries, its true clinical relevance has yet to be uncovered. Severe LFNDs (≥4 mm) are already known to be associated with accelerated osteoarthritis progression.[3,4] Furthermore, there is a clear association with the pivot-shift mechanism,[2,3,5] pointing to a role in rotatory instability. Nowadays, the direction of this relation is not fully defined because it could be just a consequence of an exuberant pivot-shift mechanism or, as well, an additional predisposing factor for the maintenance of this rotatory instability. We believe that in severe cases, it could actually have a role as a bone engagement mechanism for the anterolateral subluxation of the tibial plateau, acting similarly to what happens in the shoulder with an off-track Hill-Sachs lesion.

Another important point is that, because LFND is normally associated with ACL injuries with a significant pivot shift,[4] ACL reconstruction, in these cases, will certainly benefit from the lateral extra-articular procedure addressing that rotatory instability. The modified Lemaire procedure[9] is a suitable technique to address severe anterolateral rotatory instability, and because it is an open procedure, there is an opportunity—with little additional morbidity—to directly access the lateral femoral condyle and perform a well-controlled subchondral reduction. Through this approach, it is easier to aim the bone tamps toward the lesion, and because this approach provides a direct lateral view of the condylar curvature, it allows one to reliably evaluate the quality of the reduction to recover the condyle's native shape. In summary, this original technique to reach the lateral femoral condyle through the lateral cortical window used for the modified Lemaire procedure in ACL reconstruction is a safe and practical way to address severe LFNDs.

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