Technical Note

Modified Centralization Technique of Tibial Side Capsulodesis for Radial Tear of Incomplete Discoid Lateral Meniscus

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Abstract: An incomplete discoid lateral meniscus is often associated with radial tears, which cause meniscal extrusion and result in poor healing outcomes. Centralization has recently been used as a surgical method to reduce extrusion. However, various repair techniques use single point of fixation sutures exclusively on the femoral side, potentially hindering healing. In this study, a method is devised in which 2 anchor sutures are placed on the tibia and guided out of the capsule from the tibial side of the meniscus, and another anchor is placed distally to tighten the meniscotibial ligament in a plane. This method supports the repaired site against hoop stress by tightening the meniscotibial ligament and is considered a physiological repair because the sutures are confirmed to the tibial side of the meniscus rather than on the femoral side. Furthermore, an inside-out suture of the torn area with a fibrin clot derived from the bone marrow aspirate, rich in tissue-healing components, is also performed.

The discoid lateral meniscus (DLM) is a congenital morphologic variation of the lateral meniscus. The DLM is subdivided into complete and incomplete types according to the degree of meniscal size. A previous report showed that tear patterns differed between complete and incomplete types. A complete DLM tends to have longitudinal and horizontal tears, whereas an incomplete DLM tends to have radial tears.[1] Radial tear is one of the challenging tear types for surgical repair, because the tear line occurs perpendicularly through the circumferential fiber, resulting in disruption of the hoop mechanism.[2,3] Previously, some specific suture techniques were adopted for the radial tear.[4,5] Nevertheless, the healing rate was limited since the tear included the avascular zone and weightbearing compression force made the meniscus peripheral.[5,6] Recently, the centralization technique was used to prevent meniscus extrusion by tying the capsule to the tibial plateau with a suture anchor.[7] The original technique was to place the anchor on the tibial side and tie the thread over the capsule on the femoral side, beside the meniscus. However, the technique may have been insufficient because of overconstrained meniscus tissue and "point-by-point" suture.

The modified centralization technique described in this Technical Note does not pass through the thread over the capsule, on the femoral side beside the meniscus, but stabilizes the meniscotibial ligament using 3 suture anchors to suppress dimensionality. This technique provides strong prevention of meniscus extrusion and reduction of the torn meniscus and is expected to improve the healing rate of radial tears. This report highlights triangular shape stabilization of the meniscotibial ligament using 3 suture anchors. We also describe a bone marrow aspirate (BMA) fibrin clot[8] to enhance biological healing and repair this challenging tear.

Surgical Technique

This technique is indicated for cases with a radial tear in the incomplete DLM. Patients often show tenderness of the lateral joint line, positive McMurray test results, and swelling. Magnetic resonance imaging reveals a

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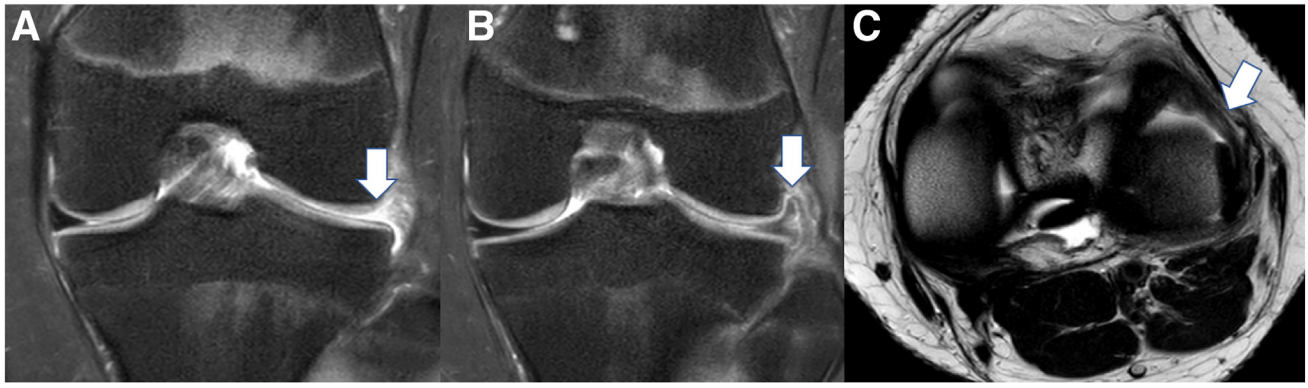

Fig 1. Magnetic resonance images of a radial tear of the lateral meniscus of the left knee. (A) Coronal image showing diminishing lateral meniscus (white arrow). (B) Slice posterior to A showing an extruded lateral meniscus (white arrow). (C) Axial image showing a radial tear of the lateral meniscus in the anteromedial segment (white arrow).

ghost or white meniscus sign at the tear site and meniscal extrusion at the midbody (Fig 1). The patient is positioned supine with the knee in 90° of flexion. A tourniquet is wrapped around the proximal thigh. Anterolateral and anteromedial portals are created, and the usual arthroscopic observations are performed. The extent of lateral meniscal tears is confirmed (Fig 2). Rasping is simultaneously performed to refresh the torn areas (Fig 3A).

BMA Clot Creation

To prepare the BMA clot, 10 mL of bone marrow is aspirated from the lateral side of the intercondylar notch, anterior to the anterior cruciate ligament, with the knee in the flexed position without a tourniquet and using an 11-gauge bone marrow needle. Aspiration is followed by the "aspirate-rotate-aspirate" technique (Video 1). BMA is subsequently coagulated by gentle shaking in a glass Petri dish. The BMA clot is prepared by shaping to a diameter of approximately 5 mm with a scalpel and strapping it onto an inside-out suture. The standard inside-out approach involves placing a skin incision along the posterior margin of the lateral collateral ligament at an oblique angle starting from the proximal posterior margin to the distal anterior margin. The approach allows subcutaneous exposure of the tibia to tie the modified centralization sutures.

Modified Centralization

When creating the mid-lateral portal, the skin is detached anteriorly from the inside-out skin incision using a retractor to expose the capsule that is then selectively cut using a scalpel. Two JuggerKnot anchors (Biomet) are inserted through the mid-lateral portal to the edge of the tibia, as in standard centralization. Another JuggerKnot anchor is inserted approximately 1 cm distally between the 2 anchors. The 3 anchors are positioned in an upside-down equilateral triangle. The

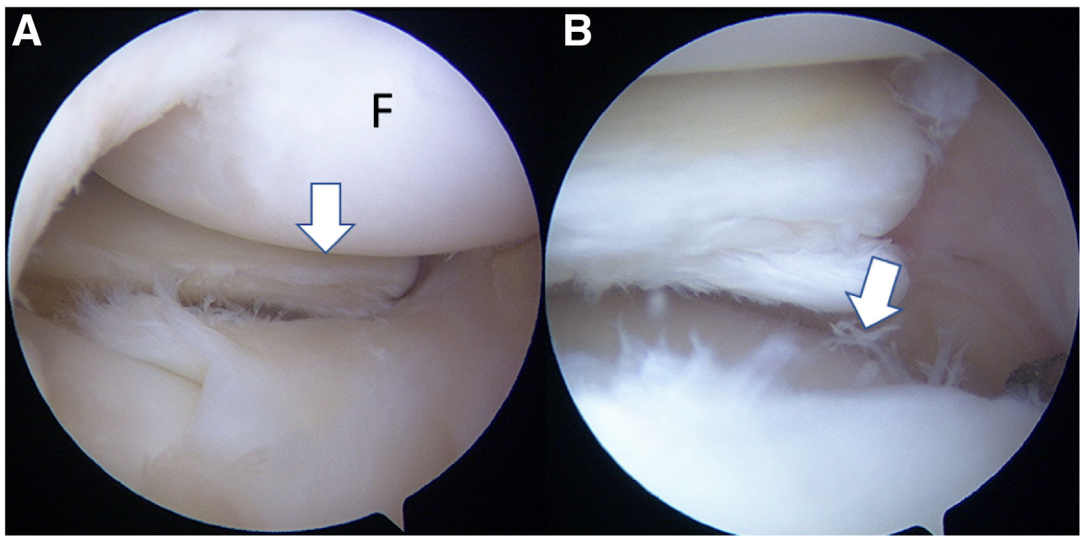

Fig 2. Arthroscopic examination of the left knee from the anteromedial portal with the knee in the figure-4 position. (A) A radial tear of incomplete lateral meniscus reaches from the white zone to the red zone (white arrow). (B) Tibial edge can be seen throughout the tear site (white arrow). (F, femoral condyle.)

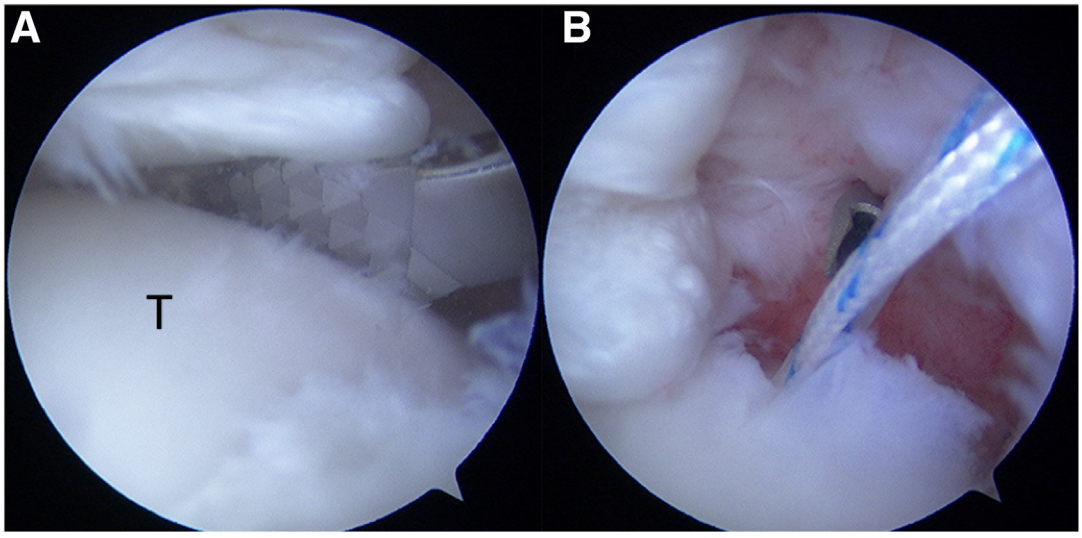

Fig 3. Intra-articular procedure for modified centralization viewed from the anteromedial portal with the left knee in the figure-4 position. (A) Rasping for tibial edge between the lateral margin of the tibia and the meniscotibial ligament. (B) A JuggerKnot anchor (Biomet) is inserted to the edge of the tibia. A Nanopass (Stryker) is introduced through the lateral skin incision site and penetrates the lower side of the capsule to reach the tibial side of the meniscus and retrieve the suture. (T, tibial plateau.)

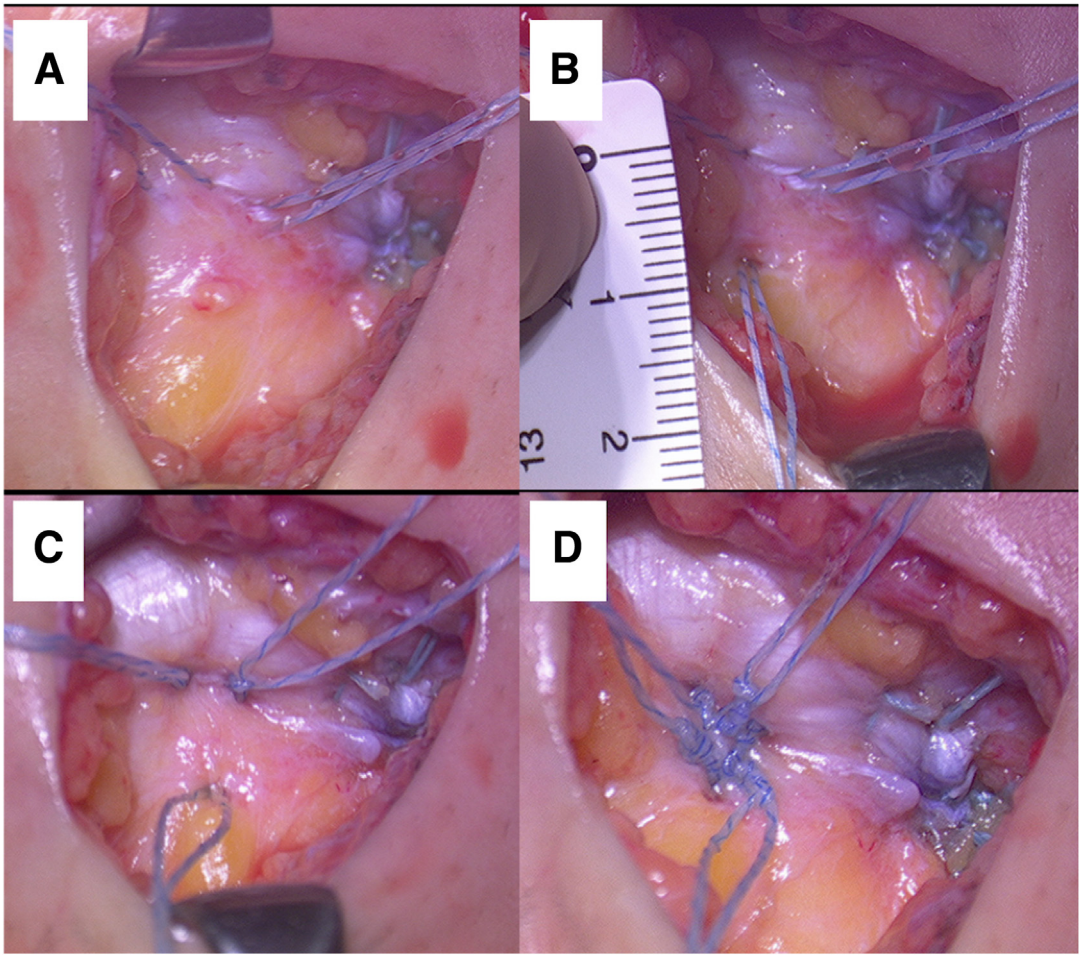

Fig 4. Extra-articular procedure for modified centralization of the left knee in the 90° flexion position. (A) Two pairs of threads from 2 JuggerKnot anchors (Biomet) are led out of the knee joint. (B) Another JuggerKnot anchor is inserted extra-articularly, about 1 cm distally in the middle of the 2 anchors. (C) Each anchor-derived pair is tied. (D) The threads of the adjacent anchors are tied to each other to tighten the capsular ligament (white arrow).

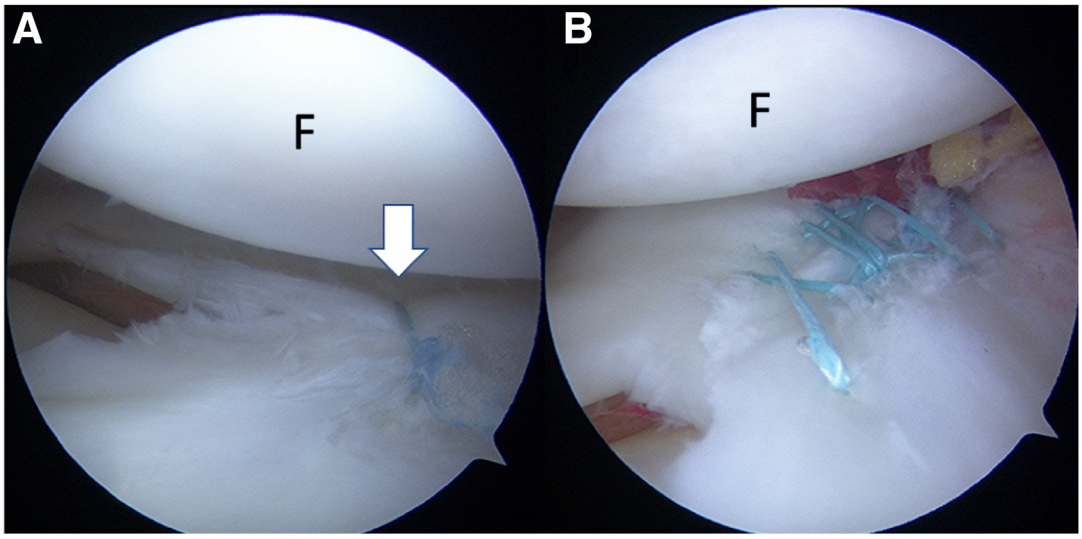

Fig 5. Repair of a radial tear in the left knee observed from the anterolateral (A) and anteromedial (B) portals. The knee is positioned in a figure-4 position. (A) An all-inside suture is applied with an all-inside technique using a 2-0 FiberWire and a knee Scorpion (Arthrex; white arrow). (B) Radial tear site is tied using an inside-out repair with a bone marrow aspirate fibrin clot. (F, femoral condyle.)

JuggerKnot threads inserted into the joint are guided out of the capsule using a Nanopass (Stryker). The Nanopass is inserted just below the meniscus (Fig 3B) and the threads are tied together on the outside of the capsule. First, each anchor-derived pair is tied, following which the threads of adjacent anchors are tied to each other (Fig 4). This method allows loosening of the meniscotibial ligament to be suppressed in the plane (Video 1).

A reduction suture is applied using the all-inside technique with a 2-0 FiberWire and a knee Scorpion (Arthrex) (Fig 5A). The BMA clots are inserted into the tear site using the inside-out technique. The radial tear site is tied using an inside-out repair. The tie-grip suture technique is used to restore the hoop mechanism.[6] Two stay sutures are placed vertically and a transverse suture is placed horizontally (Fig 5B).

The patients are immobilized in a brace for 1 week, followed by 1 week of restricted knee joint range of motion from 0° to 90°. Patients are allowed to bear weight for the first 4 postoperative weeks and then partially for the next 4 weeks. Finally, jogging is permitted 3 months postoperatively, with a return to normal sporting activities at 6 months postoperatively.

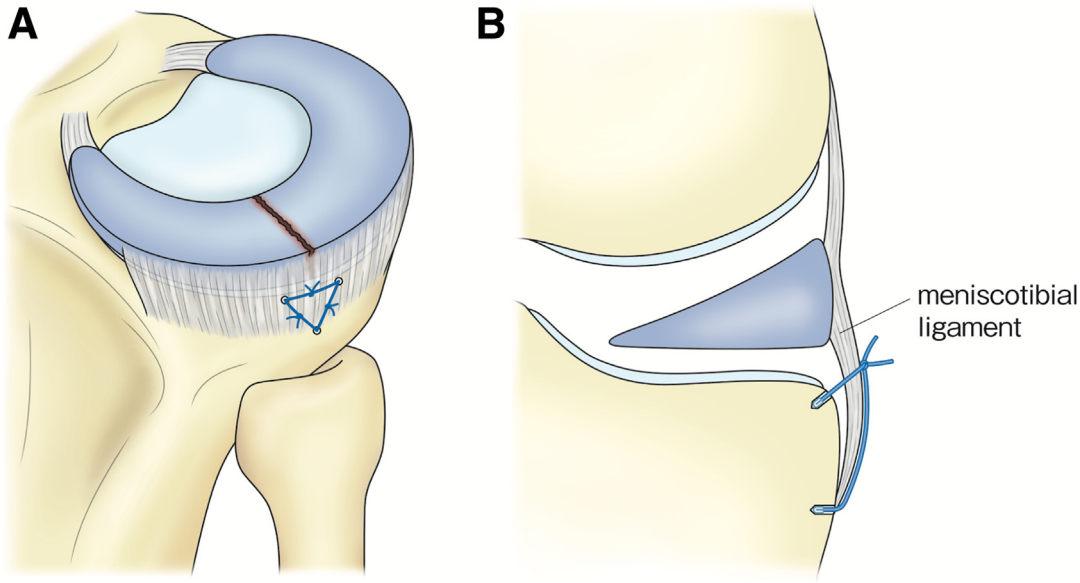

Fig 6. Illustration of the technique. (A) Anchors are positioned to form a triangle. (B) All threads are sutured on the tibial side of the meniscus.

Table 1. Advantages and Limitations of the Procedure

Advantages	Limitations
Physiological support to maintain the structure against hoop stress	Need anchor device
Allows for tightening the meniscotibial ligaments	Need to extend the lateral subcutaneous incision to the distal part of the area
Allows for the reduction of radial tear site	The possibility of reinjury due to the challenging tear pattern
Insertion of BMA clots allows more cytokines that have an advantage in tissue healing into the tear site	Irritation around the suture
Not overconstrained meniscus tissue	

BMA, bone marrow aspirate.

Discussion

The most advantageous aspect of this novel surgical procedure is that the lateral extrusion of the radial tear can be prevented by suppressing the meniscotibial ligament in the triangular plane. The frequently occurring tear patterns in DLMs can differ based on the morphology. Incomplete DLMs have more radial tears, whereas complete DLMs have more horizontal and longitudinal tears.[1] Radial tears disrupt the hoop mechanism of the knee joint by splitting circumferential fibers and are extremely difficult to heal since the torn meniscus dislocates in the direction of spread, especially under weightbearing conditions. A considerable clinical outcome was achieved after inside-out repair for radial tears. About 40% of patients were reported to have failed healing on second-look arthroscopy.[5,6] Radial tears also cause meniscal extrusion, which further increases contact pressure on the articular cartilage. Therefore, various suturing techniques have been developed to treat meniscal tears. On the other hand, in recent years, centralization methods have been developed for reducing extrusion. The original method by Koga et al.[7] in 2012 to suppress the meniscus at a point was recently modified and reported to suppress the meniscus linearly by suturing the suture anchors together.[9-11] These techniques are nonanatomic reduction techniques because suture fixation is performed on the femoral side of the meniscus. Yin et al.[12] reported that the meniscotibial ligament showed circumferentially oriented fibers and was suspected to exist as a potential supporting structure surrounding the meniscus. The present method was further modified to complete suture fixation on the tibial side only and to tighten the meniscotibial ligament in a plane by adding another anchor distally (Fig 6). This repair method is physiological and does not apply excessive force on the meniscus. The main concept of this technique is to tighten meniscotibial ligament loosening, which is directly related to meniscus extrusion.[13] Therefore, a more rigid fixation of the meniscotibial ligament can prevent the meniscus from extruding while simultaneously preventing the radial tear site from spreading further outward. Additional procedures to enhance biological healing are required to achieve higher healing rates. In recent years, BMA has attracted increasing attention as a fluid component rich in cytokines and bone marrow mesenchymal cells, necessary for tissue repair (Hashimoto). The fibrin clot itself is an established adjunctive therapy to promote tissue repair of the meniscus. However, it has been reported that BMA-derived clots are more cytokine rich than peripheral blood-derived clots.[8]

The advantages and limitations, as well as pearls and pitfalls, of our technique are summarized in Tables 1 and 2, respectively.

Table 2. Pearls and Pitfalls of the Procedure

Pearls	Pitfalls
Careful evaluation of meniscus instability for the tear site	Neurovascular structures on the posterior aspect of the knee should be carefully protected
Rasp the edges of the tibia thoroughly to adhere between the bone and meniscotibial ligament	The lateral areas should be thoroughly irrigated to prevent infection because of the presence of sutures and anchors
Insert anchors while the tear is open and before repairing the meniscus	
Fibrin clot threads tie gently	
A reduction suture is performed using a knee Scorpion (Arthrex) before a tie grip suture	

Disclosures

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