Technical Note

ACL Mucoid Degeneration—Anterior and Posterior Arthroscopic Decompression for Combined Knee Flexion-Extension Deficit

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Abstract: Mucoid degeneration of the ACL (MDACL, ACL ganglion cysts) is a disease involving ACL thickening due to accumulation of mucoid substance and fiber degeneration with possible formation of "ganglions". Clinically, it leads to anteroposterior impingement and painful limitation of knee range of motion due to impingement of the anterior portion of the thickened ACL with the intercondylar notch during knee extension and the thickened posterior part of the ligament with posterior structures of the knee in flexion. Different treatment methods have been described, including total or partial resection of the ACL degenerative fibers. However, these techniques do not allow for ACL preservation and are associated with a risk of postoperative instability. Also, most procedures treat anterior impingement only. Therefore, the aim of this technical note is to present an arthroscopic technique allowing for minimally invasive anteroposterior ACL decompression. The technique is focused on evacuation of the interfibrous mucoid substance, ganglions, and bony decompression, as well as maintenance of ligament integrity. Its greatest advantage is that it is safe and ACL-preserving yet allows for comprehensive treatment of all intra- and extra-ligamentous possible reasons of MDACL origin and promoting good healing conditions.

Introduction

Mucoid degeneration of the anterior cruciate ligament (ACL) (also known as MDACL or ACL ganglion cysts) was first described by Kumar et al. in 1999.[1] It is a knee pathology occurring mostly in middle-aged patients, which leads to painful limitation of knee range of motion, while knee stability is preserved.[2,3] With the progression of the disease, the ACL becomes thicker in a wide spectrum of ranges: from slight degeneration to large cyst formation.[3] This thickening of the ACL results from the accumulation of mucoid substance, containing mucoproteins and glycoprotein in the interfibrous space of the ligament.[3,4] While MDACL is a relatively rare pathology (1.8-9.2%), it may be the root cause of a substantial percentage of intraarticular cysts.[5] Cilengir et al. reported the presence of tibial intraosseus cyst to be one of the best findings to distinguish between MDACL and ACL sprain. In their study, observation of the aforementioned cyst increased more than 40-fold the likelihood that the observed ACL alterations were MDACL rather than ACL sprain.[6]

The pathogenesis of the MDACL is not well known. There are three theories that seem to be the most common: the synovial theory that MDACL is caused by an accumulation of synovial fluid within the ligament, caused by excessive fluid production, and possibly

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The authors report 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 March 3, 2023; accepted April 18, 2023.

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2212-6287/23331
https://doi.org/10.1016/j.eats.2023.04.022

herniation of synovial lining inside the ligament. Also, the synovial cover potentially limits fluid outflow, which results in further ligament fiber degeneration. The post-traumatic theory is that the MDACL may be caused by glycosaminoglycan deposition after a knee injury or as a consequence of repeated microinjuries. The degenerative theory is that the pathology occurs as a result of age-related degeneration of the connective tissue.[7-9] Importantly, these pathogenetic theories may apply to different subgroups of patients: Chudasama et al. classified patients with MDACL into two groups: young, athletic and active patients, whose ACL lesions are connected to microinjuries or bigger trauma, and the older patients with progressive, degenerative ACL lesions, often associated with degenerative meniscal lesions.[10] Also, Lee et al. claimed that the MDACL may be a natural part of a degenerative process.[9] To the present authors' knowledge, the only classification of mucoid degeneration of ligaments was described by Nelissen et al. However, it concerned posterior cruciate ligament (PCL) and was based on a histological degree of collagen fiber irregularity with no clinical or imaging characteristics taken into account.[11]

The origin of pain in MDACL is not well known as well. Kim et al. and Hsu et al. proposed that pain may occur because a widened ACL impinges between the tibiofemoral joint surfaces.[12,13] On the other hand, Rajani et al. suggested that the cause of pain may be a higher tension of a pathologically changed ACL bundle due to mechanical impingement.[14] What is known is that the impingement may include both anterior and posterior portions of the ligament. The anterior portion conflicts with the roof of the intercondylar notch, and the posterior part impinges with posterior structures of the knee, so a painful compression can occur in both parts of the ACL.[12,13]

Clinical Diagnosis

The most common symptom of MDACL is painful limitation of knee range of motion with preserved knee stability.[3,4] In most cases of MDACL, impingement occurs on the thickened and possibly ganglionic posterior part of the ACL, causing pain during deep knee flexion.[3,8] Although an abundant amount of tissue occurs in the anterior part of ACL with similar rate as in the posterior part, clinical limitation of extension is less frequent than flexion.[5]

MRI confirmation of the diagnosis

Clinical suspicion of MDACL requires a confirmation by magnetic resonance imaging (MRI) to evaluate changes occurring and their progression; this examination is a gold standard in MDACL diagnosis.[5] MRI findings demonstrate a "celery stalk" appearance, in

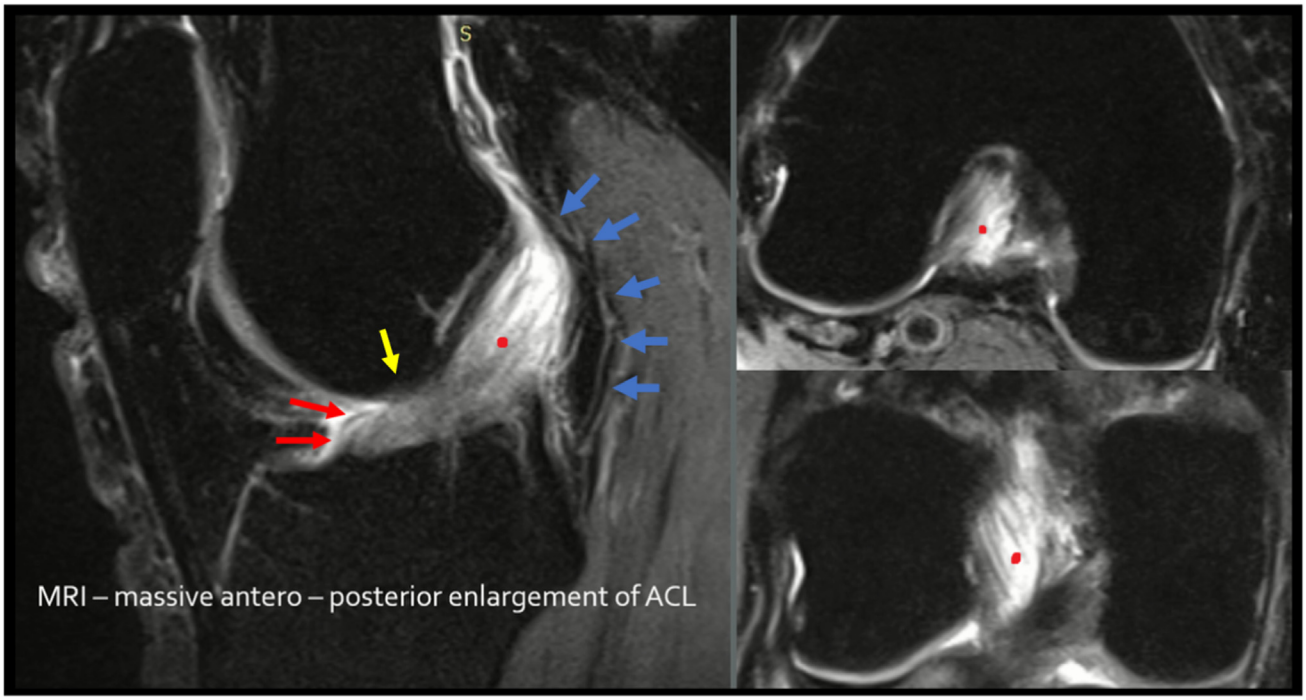

Fig 1. Magnetic resonance imaging of the right knee of a 60-year-old female patient: sagittal, coronal, and axial slices. Degeneration and accumulation of mucoid substance in the interfibrous space of the anterior cruciate ligament (ACL) can be seen (red dot). Posterior part of degenerative ACL seems to tension posterior capsule (blue arrows) and anterior part impinging intercondylar notch (yellow arrow) and protruding to the Hoffa fat pad (red arrows). It can be noticed that most of the mucoid substance is located in the posterior portion of the ACL in this case.

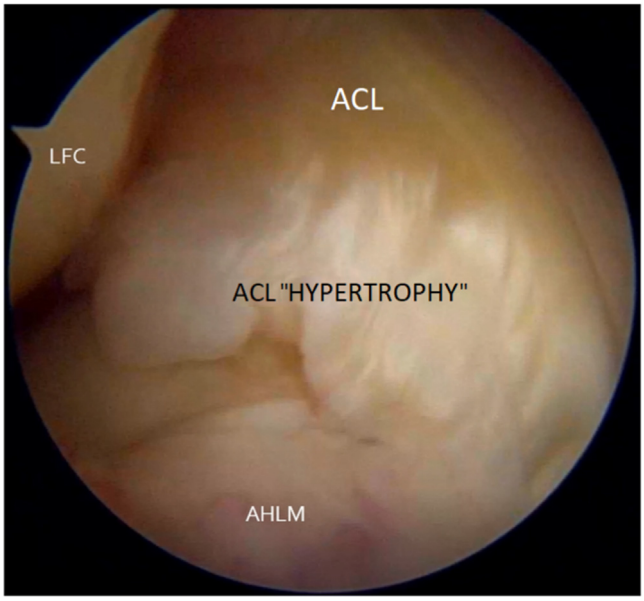

Fig 2. Visualization from the anterolateral portal of the right knee. Arthroscopic confirmation of the mucoid degeneration—anterior cruciate ligament (ACL) "hypertrophy" can be seen. In this case, impingement of ACL with the lateral femoral condyle (LFC) can be seen even in knee flexion. AHLM, anterior horn of the lateral meniscus.

more advanced cases associated with cystic changes and ganglions.[5,7] On MRI imaging, ACL hypertrophy, conflicting with a lateral condyle of the femur can be visible, as well as lighter areas within the ligament fibers. In the later stages of MDACL, the ligament is "hypertrophied" posteriorly, impinging with the posterior structures of the knee (Fig 1, Video 1).[2,15]

Surgical Technique

Patient Positioning and Preparation to the Procedure

The patient is positioned supine, with the operative limb placed in a holder and prepared in a standard way, with use of a nonsterile thigh tourniquet and sterile surgical dressing. Instruments used to perform the procedure are a 30° arthroscope (Arthrex, Naples, FL), switching stick (Arthrex), shaver (ConMed, Utica, NY), bur (ConMed), microfracture awl (ConMed) and radio frequency probe (Arthrocare, Smith & Nephew, London, UK). During the technique, standard portals (anterolateral [AL], anteromedial [AM], medial parapatellar [MP], and posteromedial [PM]) are required.

Arthroscopic Confirmation of MDACL

On primary inspection, differences in the ACL structure can be visualized. Although a healthy ACL has a straight fiber course and fits completely within the intercondylar fossa, in patients with MDACL, the ACL becomes widened, convex, and hypertrophic, and there is impingement with lateral femoral condyle (LFC) and intercondylar notch. While probing it, the surgeon can also visualize the ligament's interfibrous space widening, as it is filled with a mucoid substance (Figs 2 and 3, Video 1).

Procedure

While viewing through the AL portal and working with a shaver and radio frequency probe through the AM portal, the surgeon releases hypertrophied synovium (Fig 4A, Video 1) and a portion of the impinging anterior fibers of the ligament that are in proximity to its tibial insertion (Fig 4B, Video 1). For the next step, the covering synovium is removed from the ligament with a shaver (Fig 5, A and B, Video 1).

Then the number 11 knife blade is inserted through a MP portal and 2—4 longitudinal cuts along the ACL fibers are performed, facilitating the evacuation of interfibrous mucoid substance. The authors would like to emphasize the importance of using an MP instead of an AM or AL portal in this step of the procedure. The angle of decompression allows the surgeon to incise deeply along the ACL fibers with minimal destruction of their continuity (Fig 6 A and B, Video 1).

The following step is anterior bony decompression by an intercondylar notch notchplasty to eliminate the irritation and impingement with the ligament during knee extension. An arthroscopic bur is inserted through the MP portal, which provides the best direction for the

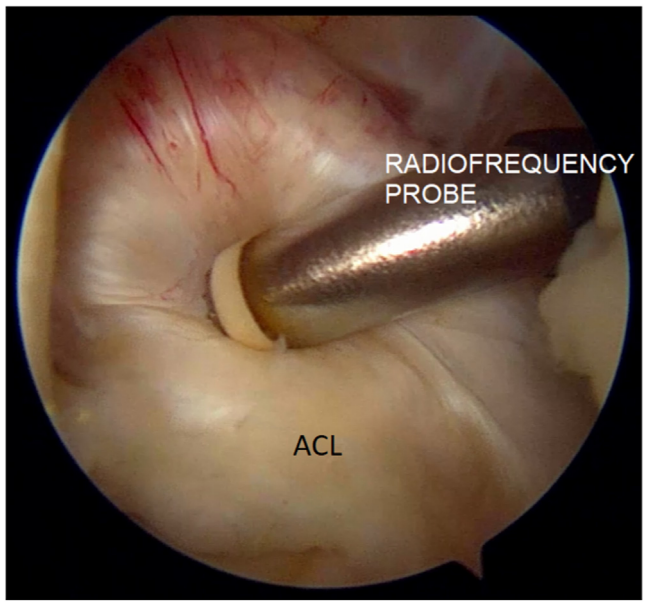

Fig 3. Visualization from the anterolateral portal of the right knee. The radio frequency probe is inserted through the anteromedial portal. Internal enlargement of the anterior cruciate ligament (ACL). While probing the ligament there is an impression of a ligament "filled with liquid". Healthy ligament should be straight, while in the picture, its convex shape is visualized.

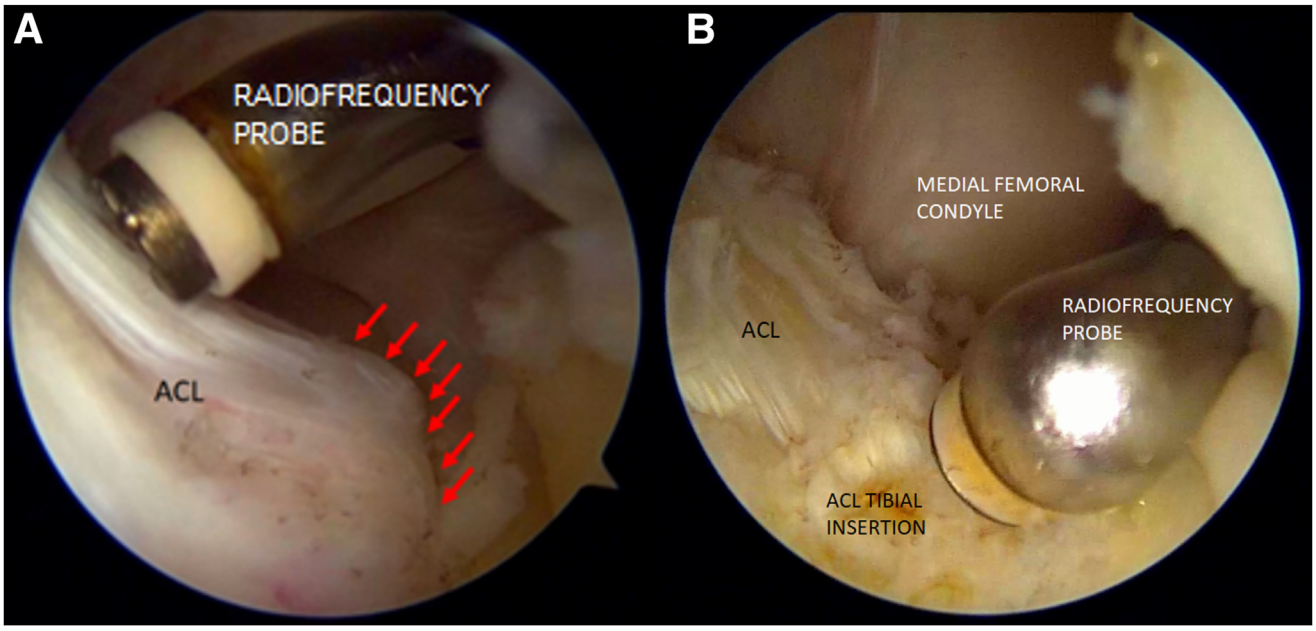

Fig 4. Visualization from the anterolateral portal of the right knee. Radio frequency probe is inserted through the anteromedial portal. (A) Resection of the overgrown synovium from the anterior part of the ligament using a radiofrequency probe. (B) Careful resection of a part of impinging anterior fibers of the anterior cruciate ligament (ACL) in proximity to its tibial insertion (marked with red arrows in A).

tool to reach the roof and both medial and lateral intercondylar notch walls (Fig 7 and Video 1). After decompression, the surgeon checks whether it is possible to perform full knee extension, which confirms that there is no remaining impingement (Fig 8, Video 1).

Subsequently, the surgeon performs a trans-notch maneuver through an AL portal to access the posteromedial recess and creates a PM portal under direct visualization (Fig 9, Video 1). Working instruments—shaver and radio frequency probe—are inserted through the PM portal, and the arthroscope is moved to the MP portal, and again, a trans-notch maneuver is performed. Then, removal of the posterior septum is being performed under direct visual control (Fig 10, Video 1). When most of the septum has been removed, the posterolateral recess starts to be

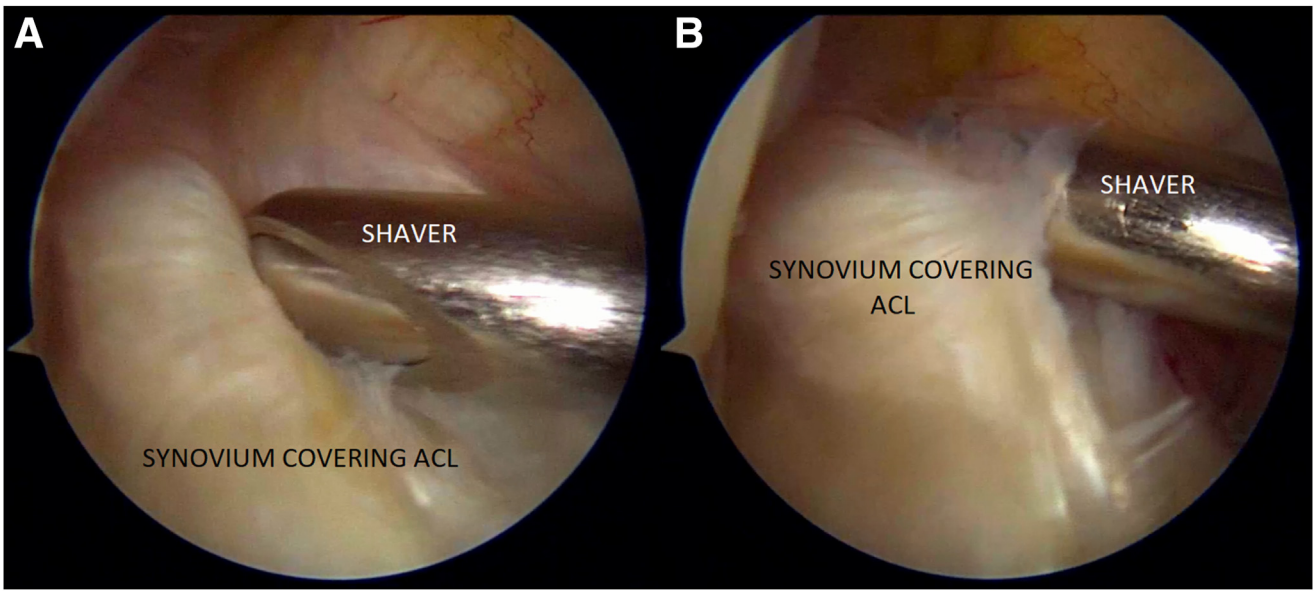

Fig 5. Visualization from the anterolateral portal of the right knee. (A and B). The surgeon uses a shaver inserted through the anteromedial portal, to remove synovium covering anterior cruciate ligament (ACL).

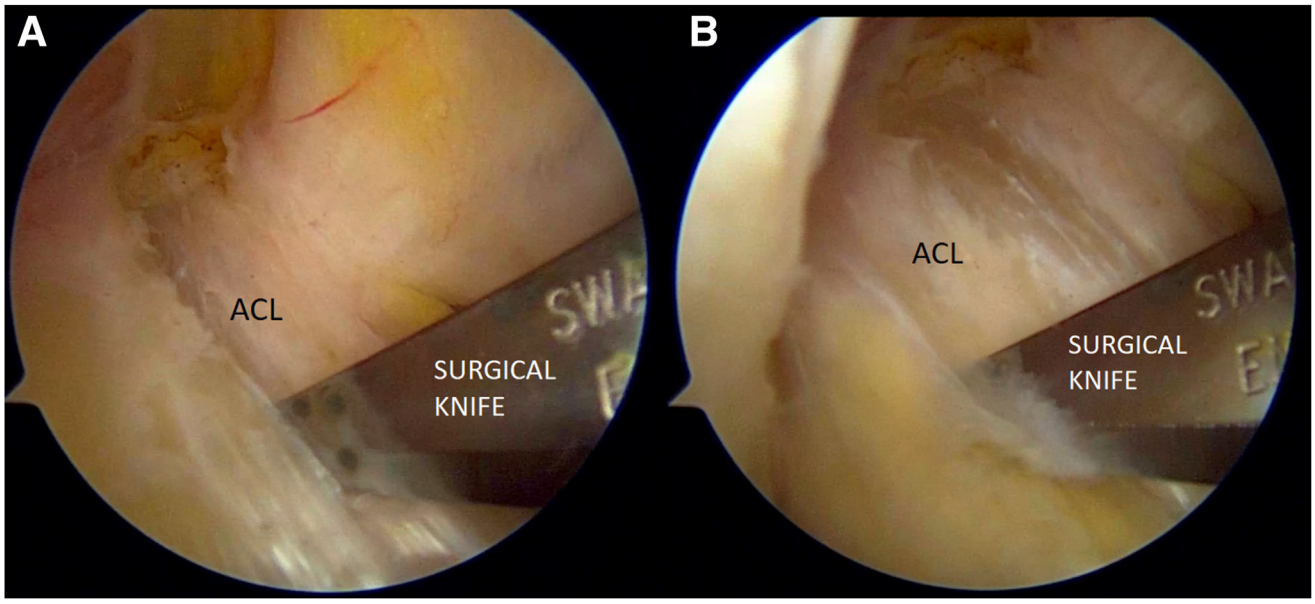

Fig 6. Visualization from the anterolateral portal of the right knee. Surgical knife is inserted through the medial parapatellar portal that allows the surgeon to incise deeply along the anterior cruciate ligament (ACL) fibers with minimal destruction of their continuity.

visualized. Septum removal is the first step of the posterior ACL impingement decompression.

Through the PM portal, the surgeon inserts a switching stick in order to change the position of arthroscope (Fig 11, Video).

As the next step, the camera sheath and scope are inserted over the switching stick through the PM portal.

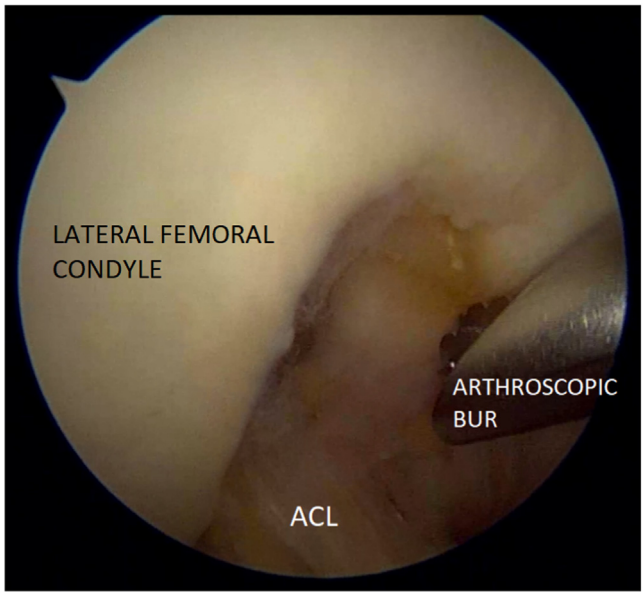

Fig 7. Visualization from the anterolateral portal of the right knee. The surgeon performs a notchplasty, to create more space for the anterior cruciate ligament (ACL). An arthroscopic bur is inserted through the medial parapatellar portal, which provides the best direction for decompression of the roof and both medial and lateral intercondylar notch walls.

A switching stick is inserted through the MP portal, and it touches the posterior cruciate ligament (PCL) from its medial side (Fig 12A, Video 1). Then, the switching stick is changed with a shaver through the MP portal and redirected along the medial border of the ACL fibers between the cruciate ligaments (lateral to the PCL), and the arthroscope is positioned more laterally, closer to the ACL femoral attachment. The remaining portion of the soft tissues covering the femoral attachment of ACL are resected, until direct and unobscured visualization of the ACL posterior "ganglion" is achieved (Fig 12B, Video 1).

The second step of decompression of the posterior impingement is synovium removal and debulking of the "ganglion". The shaver is introduced under the overgrown synovium covering the posterior portion of ACL, facing the surgeon to avoid transection of the ACL fibers. The synovium is meticulously removed similarly to its anterior part, with use of a nonaggressive shaver without serrations (Fig 13A, Video 1). Then, the surgeon rotates the shaver, so that it faces the "ganglion," and very gentle debulking is performed—this usually takes only a few seconds and very little pressure to open the "ganglion", releasing the mucoid substance (Fig 13B and Video 1).

The last step of the posterior part of the decompression is to stimulate healing and blood overflow in the area of the femoral ACL attachment by means of bone marrow stimulation (BMS) performed by a 90° angulated microfracture awl. The surgeon switches the shaver with a 90° angulated microfracture awl and performs BMS (Fig 14, Video 1). Tips and pearls for the described procedure are summarized in Table 1. The follow-up MRI is presented in the Fig 15 and in Video 1.

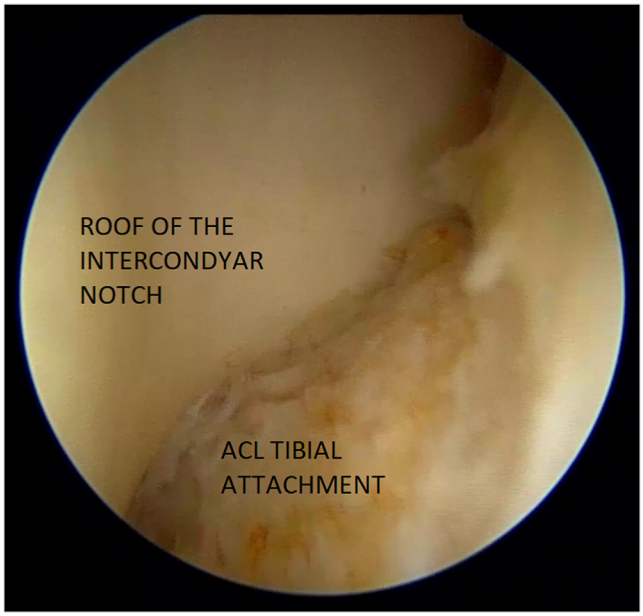

Fig 8. Visualization from the anterolateral portal of the right knee. After the notchplasty, the surgeon verifies that it is possible to perform full knee extension, which confirms that there is no impingement left.

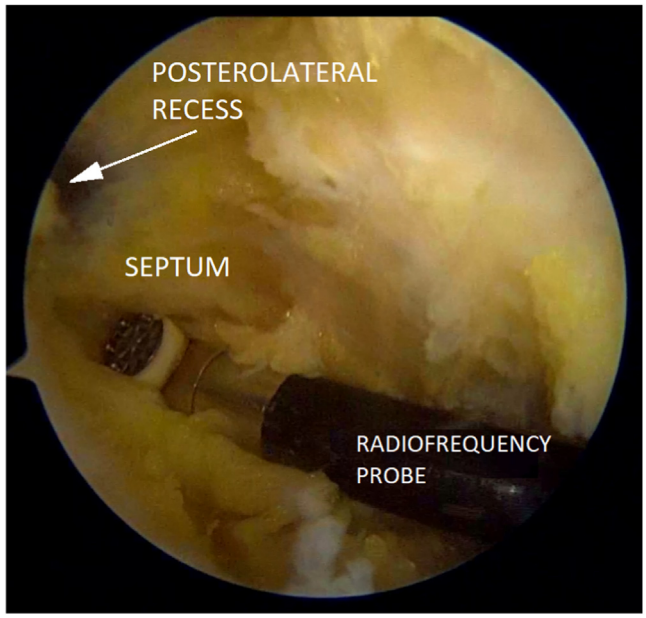

Fig 10. Visualization from the medial parapatellar portal of the right knee after a trans-notch maneuver. A radio frequency probe inserted through the posteromedial portal is used to remove the septum, which is the first part of the posterior anterior cruciate ligament (ACL) impingement decompression. The posterolateral recess starts to be visualized.

Rehabilitation

For the first 2 weeks after surgery, patients spend 5 minutes every hour with a hyperextended knee and 5 minutes with the knee flexed to a minimum of 90°. After about 14 days, physiotherapy treatment on the soft tissues is safe and may be introduced. For 6 weeks postoperatively, gradual weight bearing on crutches is recommended as tolerated (to the limit of pain and gradually up to the full load).

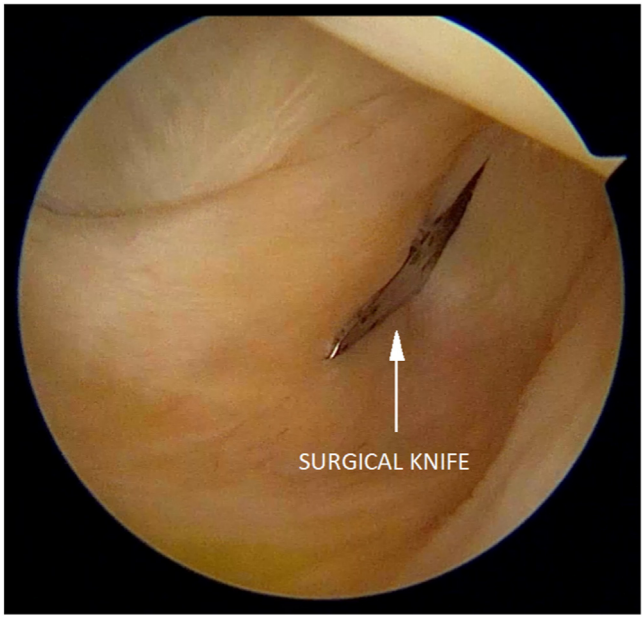

Fig 9. Visualization from the anterolateral portal of the right knee after a trans-notch maneuver. The surgeon creates a posteromedial portal under direct visualization.

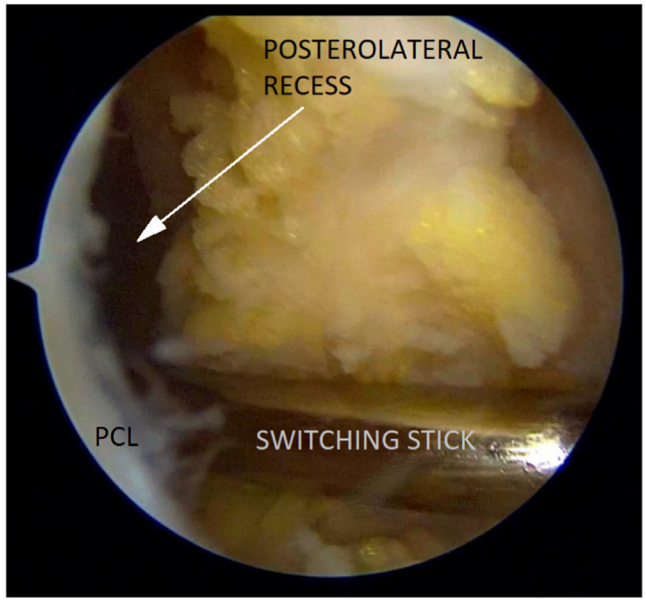

Fig 11. Visualization from the medial parapatellar portal of the right knee after a trans-notch maneuver. The surgeon inserts a switching stick through the posteromedial portal.

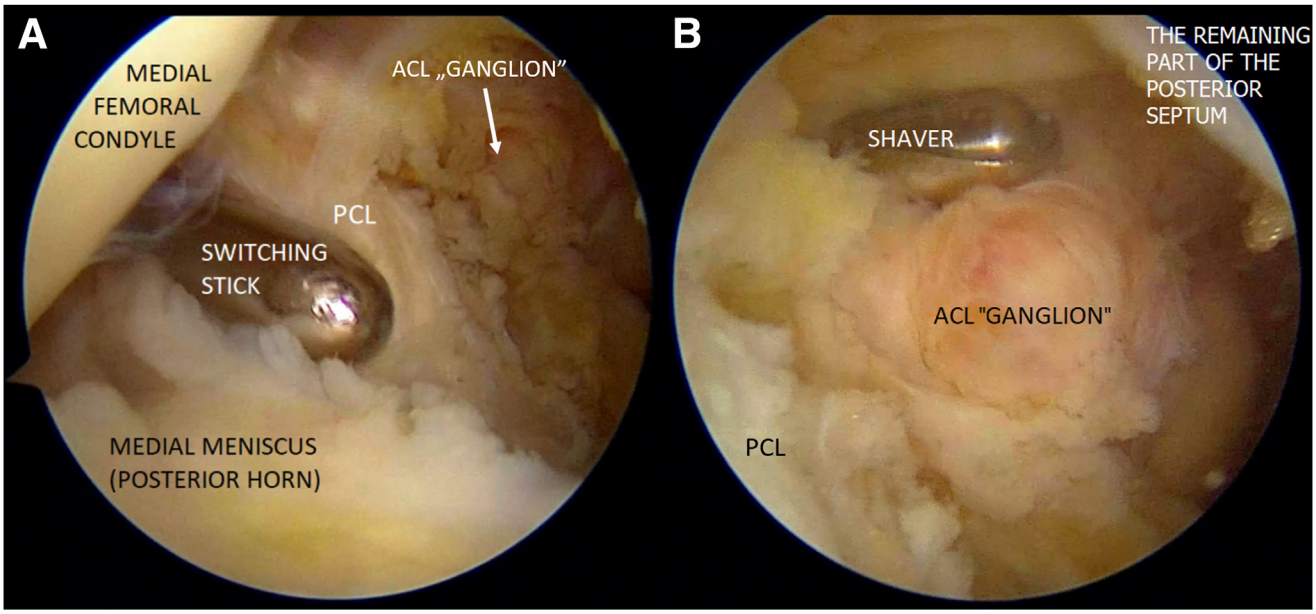

Fig 12. A. Visualization from the posteromedial portal of a right knee. The switching stick is inserted through the medial parapatellar (MP) portal, and it touches the posterior cruciate ligament (PCL) from its medial side. (B). A shaver is inserted through the MP portal and redirected along the medial border of the anterior cruciate ligament (ACL) fibers (between the cruciate ligaments, lateral to the PCL), and the arthroscope is positioned more laterally, closer to the ACL femoral attachment. The remaining portion of the soft tissues covering the femoral attachment of the ACL is resected, until direct and unobscured visualization of the ACL posterior “ganglion” is achieved. The shaver is still over the synovium in this step.

Discussion

It has been well reported that resection of degenerative ACL fibers is a pain-reducing solution; however, ACL reconstruction is often necessary afterward.[2,16] On the other hand, partial resection of the ACL may not be sufficient to reduce pain, while there is a risk of

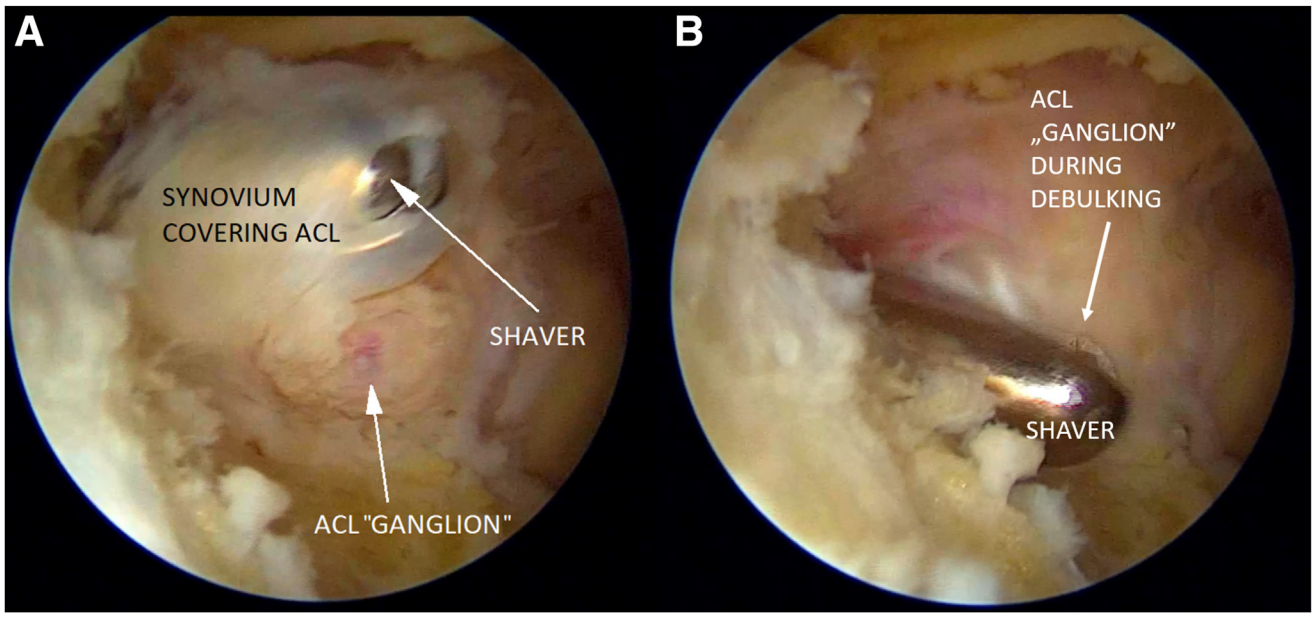

Fig 13. Visualization from the posteromedial portal of a right knee. The second step of decompression of the posterior impingement. (A) A shaver (inserted through the medial parapatellar portal) is positioned under the synovium covering the anterior cruciate ligament (ACL), and the synovial resection is performed. It is important to use a nonaggressive shaver without serrations, facing the surgeon in order to avoid transection of the ACL fibers. (B) Then, the surgeon rotates the shaver so that it faces the “ganglion”, and very gentle debulking is performed—this usually takes only a few seconds and very little pressure to open the “ganglion”, releasing the mucoid substance.

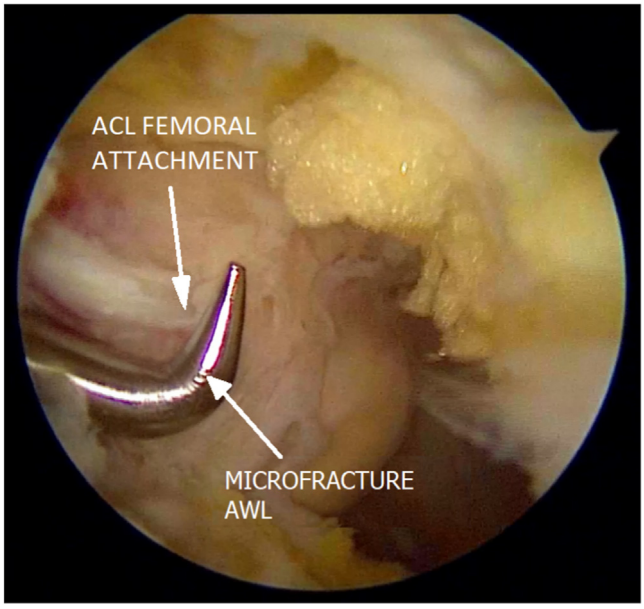

Fig 14. Visualization from the posteromedial portal of the right knee. The surgeon performs bone marrow stimulation (BMS) in the area of the femoral attachment of the anterior cruciate ligament (ACL) using a microfracture awl inserted through the medial parapatellar portal, to stimulate healing and blood overflow.

postoperative instability and a subjective knee "giving way". Such complication is associated with removing too many ACL fibers during decompression.[2,8,14,17] In some of the published techniques, some patients after a planned partial ACL decompression had to undergo ACL reconstruction due to instability.[8,16,18] In addition, in the case series of Kusano et al., 2 out of 4 presented patients had to undergo initial ACL reconstruction due to total resection of ACL during treatment, and the remaining 2 patients sustained a complete tear of the remaining ACL fibers 2 years after the procedure.[2] Therefore, we have presented an arthroscopic technique allowing for a minimally invasive antero-posterior ACL cyst decompression. The technique is focused on evacuation of the interfibrous mucoid substance, ganglion, and bony decompression, as well as enhancement of ligament healing. This technique allows for intraoperative assessment of decompression effectiveness and, if needed, to correct the amount of resected tissue. The procedure allows for minimal fibers resection, so it limits the risk of the knee instability, while being safe for the patient.

Another difference between the presented technique and some of the techniques presented in the literature is that a meticulous resection of overgrown synovium covering both anterior and posterior part of ACL is performed. We believe this step to be important, as accordingly to the "synovial theory," MDACL is caused by an accumulation of synovial fluid within the ligament.[6,7] Besides managing the source of the synovial fluid production, resection of the synovium also opens the "sac," which may contain the synovial fluid within the ligament, limiting its outflow, which results in further ligament fiber degeneration. Therefore, failure to remove the synovium may decrease the chance of successful outcome of the procedure, similarly, as in the treatment of other synovial cysts, i.e., popliteal cysts.[19]

Furthermore, the described technique also limits ligament overgrowth and creates good conditions for tissue healing. This is achieved by 3 means: First, the decompression of the ligament by the means of longitudinal incision sand evacuation of mucoid substance may serve a similar benefit as in Achilles tendinopathy treatment, "stimulating remaining viable cells to initiate cell matrix response and healing," as suggested by Maffulli et al.[20] Second, improved conditions for tissue healing are created by stimulating blood and bone

Table 1. Tips and Pearls for Complete Antero-Posterior Arthroscopic Treatment of Mucoid Degeneration of the ACL With Combined Knee Flexion-Extension Deficit

During the anterior portion of an ACL decompression, remove the covering synovium and perform longitudinal cuts along the ACL fibers (which facilitates the evacuation of the interfibrous mucoid substance). It is important to insert the knife through the medial parapetallar portal instead of an anteromedial or anterolateral portal. This way, the angle of decompression allows the surgeon to cut along the ACL fibers with minimal destruction of fiber continuity.
During notchplasty, insert an arthroscopic bur through medial parapatellar portal to provide the best direction for decompression of the roof and both medial and lateral intercondylar notch walls.
The posterior septum and any remaining soft tissue covering the femoral attachment of the ACL must be meticulously resected to achieve a direct and unobscured visualization of the ACL femoral attachment to facilitate synovium removal, debulking of ganglions and bone marrow stimulation. This resection gives much more free space between femoral attachment of ACL and posterior capsule.
During resection of the posterior part of the synovium covering the ACL, shaver should be inserted below the synovium and faced to the surgeon in order to avoid transection of the ACL fibers. It is important to use nonaggressive shaver without serrations.
Sequential assessment of the decompression effectiveness is mandatory to resect as little of ACL tissue as possible.
Range of motion achieved during the surgery should be symmetric to the contralateral knee.
Although in most cases, combined antero-posterior decompression is a treatment of choice, in some cases, isolated anterior or posterior decompression may be performed.

ACL, anterior cruciate ligament.

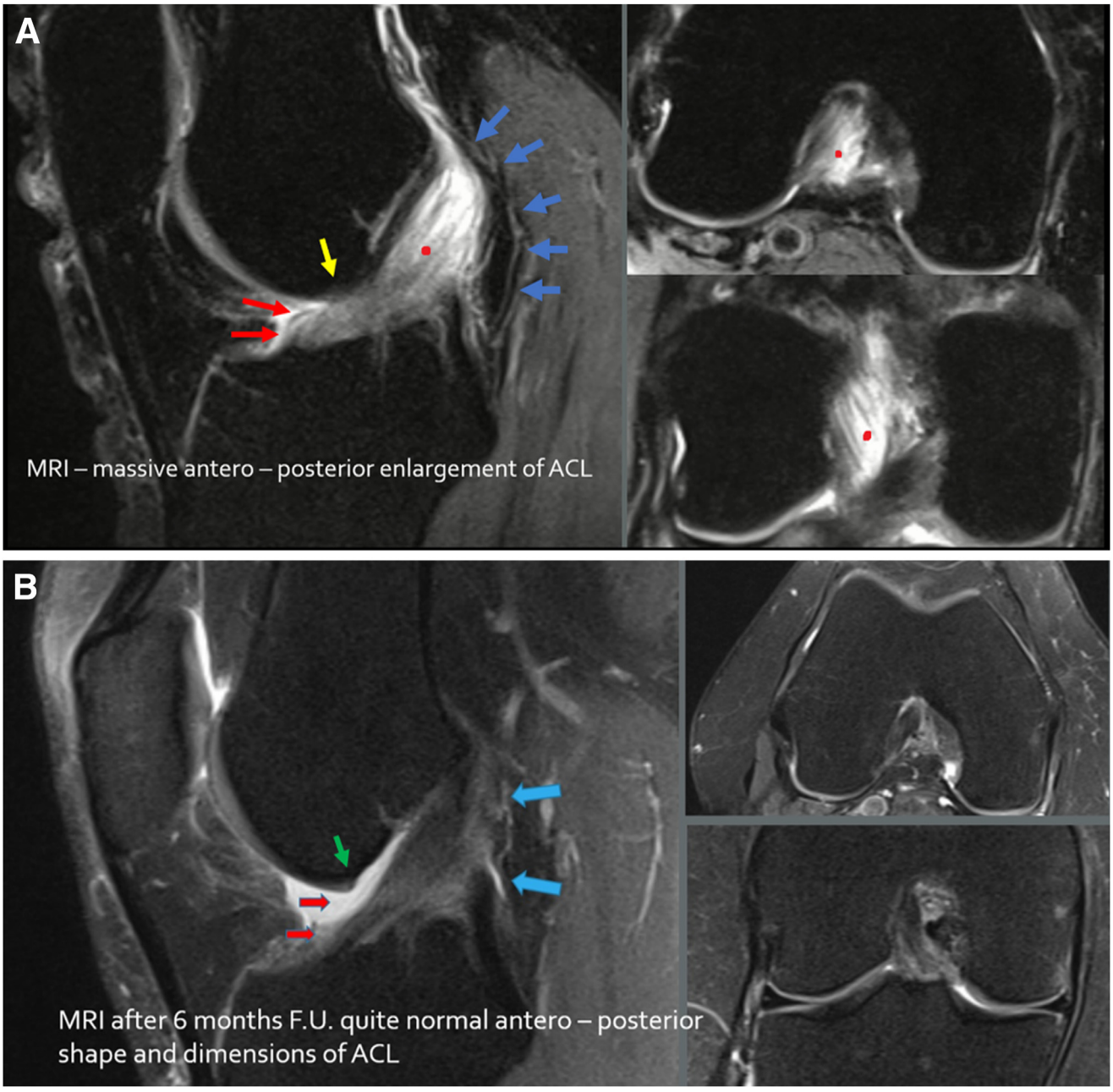

Fig 15. Comparison of the right knee of a 60-year-old female patient preoperative MRI (A) and a magnetic resonance imaging (MRI) performed at 6 months follow-up. (B) Follow-up MRI demonstrated normal dimensions and shape of the anterior cruciate ligament (ACL). There was no anterior impingement (red arrows), and the shape of posterior capsule was restored to normal (blue arrows). Notice the change of intercondylar roof shape after the notchplasty was performed. A, yellow arrow; B, green arrow.

marrow overflow, which is achieved both by performing BMS on the ACL femoral attachment and notchplasty.[21] Third, notchplasty is performed to provide the proper amount of space for ACL healing and to minimize potential friction of thickened ACL with the intercondylar notch.[16] However, this is never performed as an isolated procedure, because the isolated notchplasty does not address the root cause of impingement, which is the accumulation of mucoid substance within the ligament.[3,4]

Impingement due to MDACL may include both the anterior and posterior portions of the ligament.[2,8,16] Therefore, the techniques based on decompressing or resecting only anterior part of the ligament and/or intercondylar notch notchplasty may potentially not be sufficiently effective.[7,8,14] Also, in the presented

Table 2. Advantages and Disadvantages for Complete Antero-posterior Arthroscopic Treatment of Mucoid Degeneration of the ACL With Combined Knee Flexion-Extension Deficit

Advantages	Disadvantages
Limits the risk of postoperative knee instability compared to techniques based on fibers resection	Potential risk of postoperative knee instability
Preservation of natural ACL	Technique demands good knowledge of posterior arthroscopic anatomy of the knee.
Complete technique encompasses both anterior and posterior sources of painful range of motion limitation.	Removal of posterior septum may cause technical difficulties.
Technique covers all intra- and extra- ligamentous suspected reasons of mucoid degeneration of the ACL origin.	
Intraoperative assessment of decompression effectiveness is possible, allowing for correction of the amount of resected tissue, if needed.	
On the basis of the patient's symptoms, in some cases, isolated anterior or posterior decompression may be performed.	
Only basic arthroscopic tools are required.	

technique, the soft tissues covering the femoral attachment of ACL were resected, creating free space for the posterior capsule and potentially decreasing the risk of tensioning the posterior capsule by the "bulky" posterior part of the ACL (Figs 1 and 15, Video 1). Advantages and disadvantages of the technique are summarized in the Table 2.

Conclusions

The presented anteroposterior technique for MDACL treatment is safe and ACL-preserving. It manages the possible source of fluid overproduction by the synovium and promotes good healing conditions by the means of ACL incisions, BMS, and notchplasty.

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