Technical Note

Cam Impingement of the Knee: Arthroscopic Correction of Posteromedial Tibiofemoral Incongruence

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Abstract: One of the anatomic variations observable within the knee joint is a reduction in the posterior curvature of the femoral metaphysis proximal to the medial femoral condyle. This curvature is usually concave enough to fit the posterior horn of the medial meniscus (PHMM) during full knee flexion. A reduction in curvature may result in posteromedial tibiofemoral incongruence, a condition characterized by compression of the PHMM in full knee flexion, similar to cam incongruence in the hip joint. Clinical symptoms may occur in deep knee flexion, and progressive degeneration of the PHMM can be observed if this position is not prohibited. For patients in whom activity modification and conservative treatment have failed, surgery may be indicated. We describe arthroscopic treatment allowing for final intraoperative confirmation of the clinical indication for posteromedial tibiofemoral incongruence correction, as well as allowing for the least possible, yet sufficient, amount of correction.

Both the medial meniscus (MM) and lateral meniscus are known to translate posteriorly as the knee is progressively flexed.[1] During this motion, the posterior horn of the MM (PHMM) fits within the curvature of the femoral metaphysis proximal to the posteromedial part of the medial femoral condyle (MFC). Under physiological conditions, this part of the femoral metaphysis is concave (Fig 1A) and the space for the PHMM may be seen during the diagnostic part of arthroscopic procedures during full knee flexion.[2,3]

Posteromedial tibiofemoral incongruence (PMTFI) was defined by Suganuma et al.[2] as "impingement on the medial meniscus at full flexion in knee joints without instability or osteoarthritic change." Owing to the similarity to cam-type femoroacetabular impingement (FAI) of the hip, PMTFI was called "cam impingement" of the knee by Suganuma et al. PMTFI was reported to cause PHMM lesions,[2-5] similarly to labral tears caused by cam-type FAI. These lesions are associated with compression of soft tissues caused by bony incongruence: In the case of the hip, this occurs at the femoral head–neck junction; in the case of the knee, this occurs at the femoral metaphysis proximal to the posteromedial part of the MFC (Fig 1B).[2-5] Radiologically, PMTFI has been described as a reduction in the angle between the posterior part of the MFC and the medial tibial plateau (posterior open angle [POA]).[2,3] Such a reduction in the POA describes an insufficiently concave shape of the metaphysis proximal to the posteromedial part of the MFC, which leads to compression and subluxation of PHMM during full flexion of the knee joint, ultimately causing its degeneration (Fig 1B).[2,3] Conservative treatment of PMTFI involving avoidance of end-range knee flexion has been proposed for patients who do not necessarily have to constantly flex the knee during their

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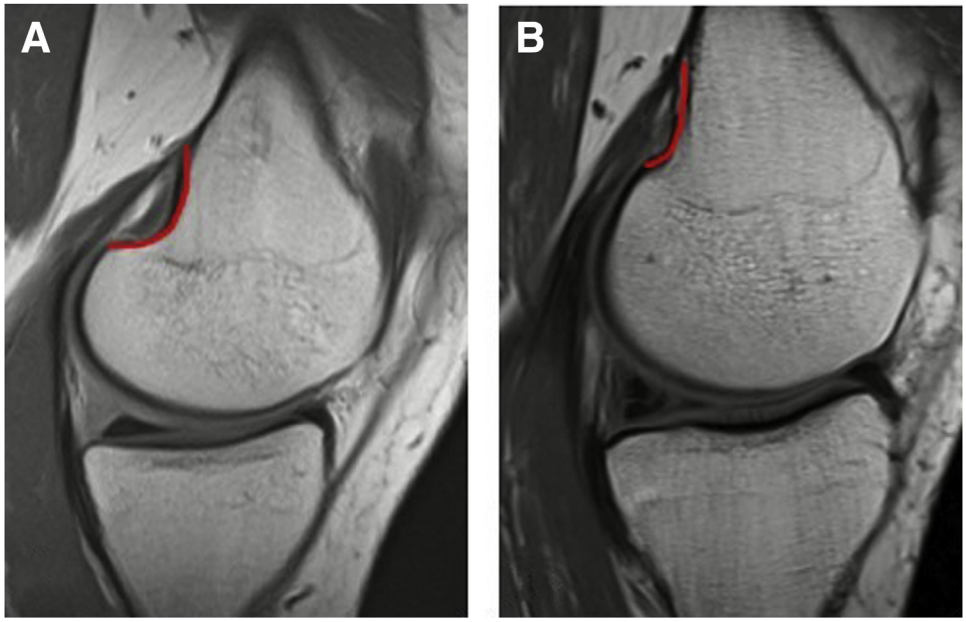

Fig 1. Magnetic resonance imaging of right, extended knee joint (sagittal view of medial side of knee). (A) The physiological, concave shape of the metaphysis proximal to the posteromedial part of the medial femoral condyle (proper congruence) is marked (red line). (B) An anatomic variant with insufficient concavity (incongruence) is marked (red line). Signal alterations and deformation of the medial meniscus can be seen, suggesting degenerative structural abnormalities.

daily activities and work. For patients in whom activity modification fails, surgery may be indicated. We describe minimally invasive arthroscopic treatment allowing for final intraoperative confirmation of the clinical indication for PMTFI correction, as well as allowing for the least possible, yet sufficient, amount of correction.

Diagnosis

As the first line of diagnosis, PMTFI is suspected clinically in case of pain or discomfort in the posteromedial part of the knee present in full knee flexion, especially when there is no history of injury. This pain can also be reproduced during the McMurray test, which involves introducing full knee flexion.[6] Radiologically, PMTFI is diagnosed by means of magnetic resonance imaging (MRI) with full flexion of the joint. Subluxation and compression of the MM by the insufficiently concave posteromedial part of the MFC can be observed (Fig 2). In this imaging, the posterior part of the MM is seen not as a triangle but as a quadrangle owing to compression-induced bulging. In cases of degenerative lesions, it may also be fully extruded.[2,3] PMTFI in severe cases with meniscal damage can be diagnosed clinically by a clicking sound appearing during extension after maximal flexion of the knee joint (Video 1). This sound is probably caused by MM subluxation.

Surgical Technique

Indications and Contraindications

The indication for the procedure is subluxation and compression of the PHMM observed on MRI during full knee flexion, associated with clinical symptoms. Final confirmation of the clinical and radiologic indications for PMTFI correction is performed intraoperatively during arthroscopy. Contraindications to the procedure include a technical inability to perform posterior knee arthroscopy (i.e., because of arthrofibrosis or flexion contracture) or active intra-articular inflammation.

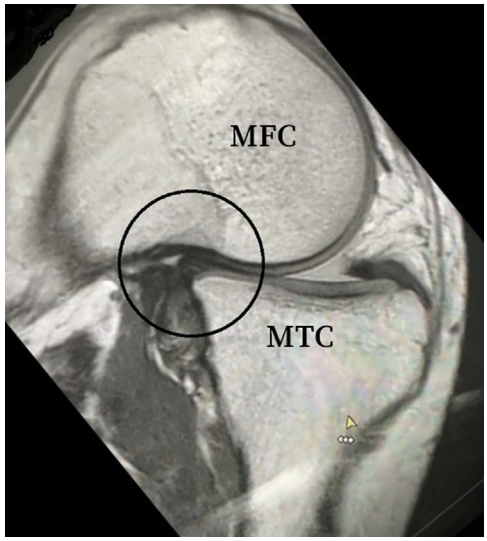

Fig 2. Magnetic resonance imaging of right knee joint in maximal knee flexion (sagittal view of medial side of knee in "sitting MRI" position). The incongruence between the metaphysis proximal to the medial femoral condyle (MFC) and medial tibial condyle (MTC) is marked (black circle). Because of the lack of space, the medial meniscus is compressed. Signal alterations, deformation, and posterior extrusion of the posterior horn of the medial meniscus can be seen, suggesting degenerative structural abnormalities.

Patient Positioning and Preparation

The patient is positioned supine, and a nonsterile thigh tourniquet is used. The operative leg is placed in a leg holder in a manner that allows full intraoperative knee flexion and is prepared and draped in standard fashion. The following instruments should be prepared before the procedure: a standard 30° arthroscope (Smith & Nephew, Watford, England), an ablation probe (Smith & Nephew), straight and curved shavers (ConMed Linvatec, Utica, NY), standard and curved burrs (ConMed Linvatec), and a switching stick.

Preparation for PMTFI Correction Procedure

To perform the knee cam impingement correction procedure, the surgeon needs to make 6 standard portals: anteromedial, anterolateral, medial parapatellar, posteromedial, posterolateral, and trans-septal. After creation of the anterior portals, a medial trans-notch maneuver is performed, and the arthroscope is introduced between the posterior cruciate ligament and the lateral part of the MFC, through the intercondylar fossa.[7] Subsequently, a needle followed by a surgical knife is used to create the posteromedial portal (Fig 3). Then, the scope is transferred to the posteromedial portal. Through the medial parapatellar portal, a shaver is inserted; under visual control from the posteromedial portal, the medial part of the septum is removed, beginning the creation of the trans-septal portal. Initially, this is performed with a straight shaver, but a curved shaver can also be used (Fig 4). Next, through the anteromedial portal, a lateral trans-notch maneuver to the posterolateral side of the knee is performed over the posterior horn of the lateral meniscus to visualize the location for the creation of the posterolateral approach. The posterolateral portal is then localized with a needle followed by a surgical knife (Fig 5). The scope is transferred to the posterolateral portal, and the ablation probe is inserted through the medial parapatellar portal to the posterolateral recess of the knee. The ablation probe is used to remove the lateral part of the septum, finishing the creation of the trans-septal portal (Fig 6).

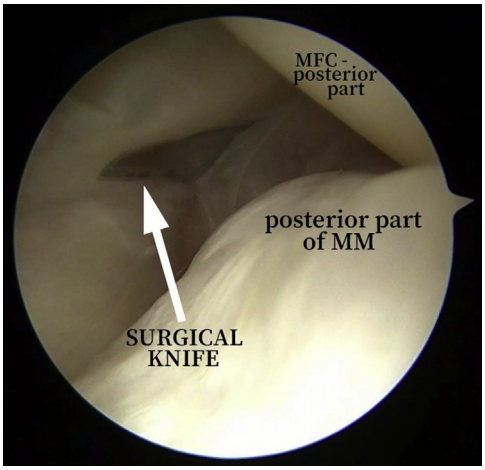

Fig 3. Arthroscopic view of posteromedial recess of right knee via trans-notch maneuver. The surgical knife is used to make the posteromedial portal. The visible structures are the posterior part of the medial femoral condyle (MFC) and the posterior part of the medial meniscus (MM).

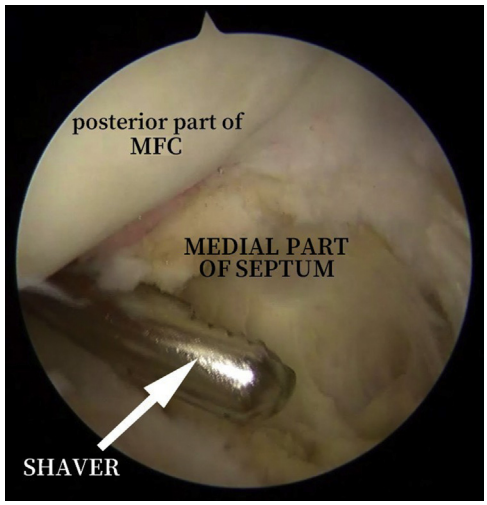

Fig 4. Arthroscopic view of right knee from posteromedial portal. The shaver is inserted through the medial parapatellar portal to remove the medial part of the septum. The visible structures are the posterior part of the medial femoral condyle (MFC) and the knee septum.

Arthroscopic Confirmation of PMTFI Diagnosis

When all necessary portals have been created, final confirmation of PMTFI is established. The posteromedial part of the MFC and PHMM is visualized through the posterolateral and trans-septal portals with the knee flexed to 90°. In the case of proper congruence, the space for the MM in the curvature of the metaphysis proximal to the MFC articular cartilage is visible during both partial and full flexion of the knee (Fig 7). In the case of incongruence, the space for the MM is visible during partial knee flexion, but in maximal flexion, the space closes completely, compressing the PHMM and confirming the diagnosis of PMTFI (Fig 8).

Minimally Invasive Treatment of PMTFI

Under visual control from the posterolateral portal, the conjoint insertion of the joint capsule and medial gastrocnemius tendon is partially detached with the ablation probe (Fig 9). Then, with the use of an arthroscopic burr, the metaphysis proximal to the cartilage on the posteromedial part of the MFC is deepened (Fig 10). To encompass better visualization of all parts of the PMTFI, a switching stick is inserted through the posteromedial portal and the scope is transferred from the posterolateral portal to the

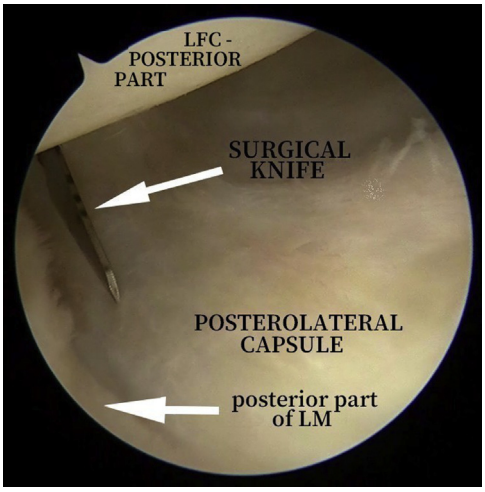

Fig 5. Arthroscopic view of posterolateral recess of right knee from medial parapatellar portal. The surgical knife is used to make the posterolateral portal. The visible structures are the posterior part of the lateral femoral condyle (LFC), the posterolateral capsule of the knee, and the posterior part of the lateral meniscus (LM).

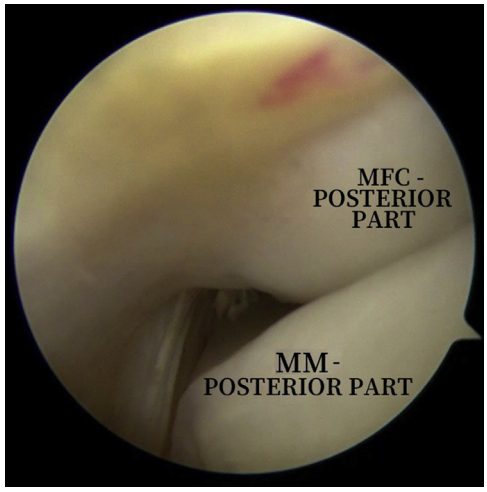

Fig 7. Arthroscopic view of right knee from posterolateral and trans-septal portals. The maximally flexed, right knee joint is visible. In the case of proper congruence, the space for the posterior part of the medial meniscus (MM) is seen as a triangle behind the posterior part of the medial femoral condyle (MFC)

posteromedial portal (Fig 11). With the use of the arthroscopic burr, the most laterally extended part of the impinging bone (near the posterior part of the intercondylar notch) is corrected (Fig 12). Subsequently, the surgeon returns the scope to the posterolateral portal to verify whether there is sufficient free space for the MM during complete knee flexion with no signs of incongruence. The surgeon needs to verify that the proper amount of bone has been removed so that the MM is not compressed (Fig 13). Tips and pearls for the described procedure are summarized in Table 1.

Rehabilitation

During the first 2 postoperative weeks, the patient spends 5 minutes every 2 hours sitting with the knee hyperextended and spends another 5 minutes with the joint gravitationally flexed. After 10 to 14 days, it is possible for a physiotherapist to safely work on the soft tissues (including newly formed scar) with minimal risk of causing additional inflammation. Partial, gradually increased weight bearing as tolerated is recommended for 6 weeks.

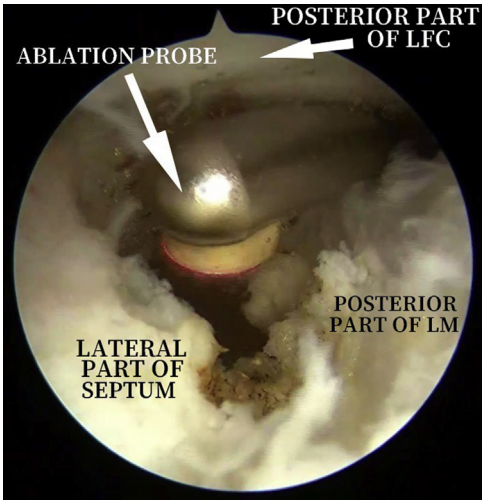

Fig 6. Arthroscopic view of right knee from posterolateral portal. The ablation probe is inserted through the medial parapatellar portal and is used to remove the lateral part of the septum. The visible structures are the posterior part of the lateral femoral condyle (LFC), the lateral part of the septum, and the posterior part of the lateral meniscus (LM).

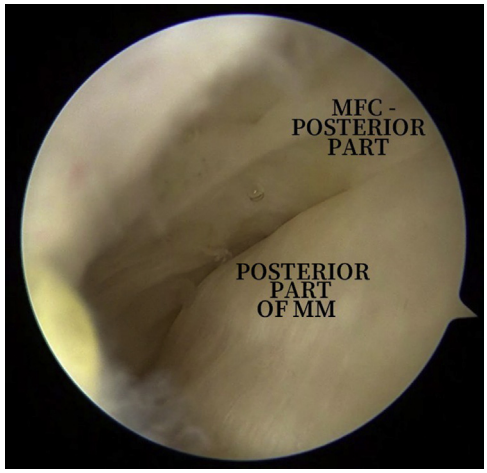

Fig 8. Arthroscopic view of right knee from posterolateral portal. The maximally flexed, right knee joint is visible. In the case of incongruence, the space for the posterior part of the medial meniscus (MM) in full flexion closes completely. (MFC, medial femoral condyle.)

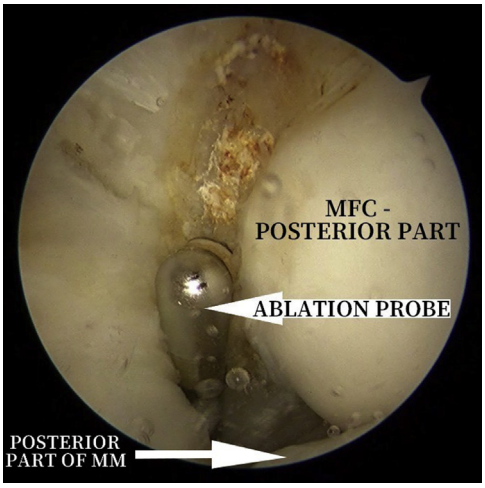

Fig 9. Arthroscopic view of right knee from posterolateral portal. The ablation probe is used to detach capsular fibers that are attached directly proximal to the cartilage on the posterior part of the medial femoral condyle (MFC). (MM, medial meniscus.)

Discussion

The indications for the treatment of posteromedial tibiofemoral impingement are not well developed. Regarding radiographic indications, Suganuma et al.[2] suggested the criterion of a POA less than 3°. The POA is formed by the posterior articular surface of the MFC and the articular surface of the posterior part of the medial tibial plateau, which can be seen on a lateral radiograph during full flexion of the knee. Contrary to the cam deformity of the hip, for which multiple imaging indexes have been developed, the POA is currently the only available radiographic index to guide a surgeon in qualification to correction of PMTFI.[2,4]

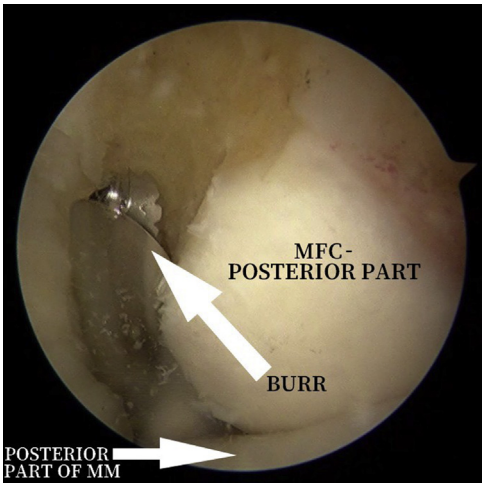

Fig 10. Arthroscopic view of right knee from posterolateral portal. The arthroscopic burr is used to deepen the area proximal to the cartilage margin of the posterior part of the medial femoral condyle (MFC). (MM, medial meniscus.)

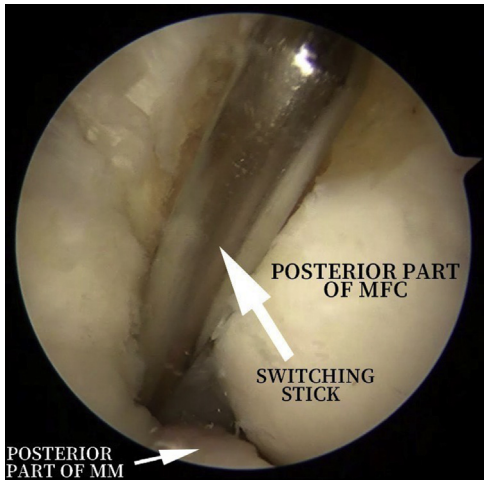

Fig 11. Arthroscopic view of right knee from posterolateral portal. The switching stick is inserted through the posteromedial portal, which is visible above the posterior part of the medial femoral condyle (MFC). (MM, medial meniscus.)

However, because there are no studies assessing the normal values of the POA in the population, this indication remains controversial. In addition, because the POA is measured on radiographs, superimposition of different parts of the metaphysis and MFC may occur. Hence, radiographs do not enable assessment of the PHMM. On the other hand, MRI shows different parts of the metaphysis and MFC without superimposition. If performed in full knee flexion, MRI also allows for assessment of the PHMM, which in cases of PMTFI may

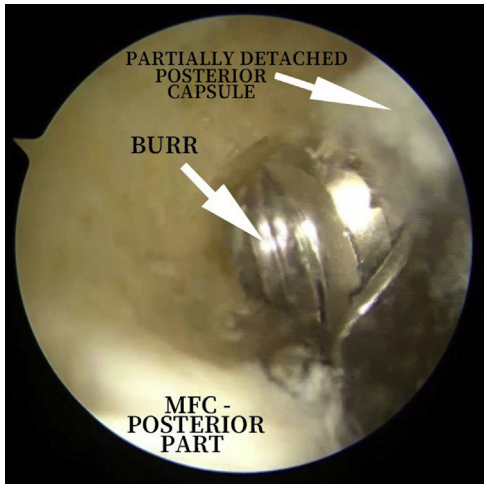

Fig 12. Arthroscopic view of the right knee after changing the view from the posterolateral portal to the posteromedial portal using the switching stick, encompassing better visualization of all parts of the posteromedial tibiofemoral incongruence. With the use of an arthroscopic burr inserted through the posterolateral portal, the most laterally extended part of the metaphysis proximal to the posterior part of the medial femoral condyle (MFC) impingement (near the posterior part of the intercondylar notch) is corrected.

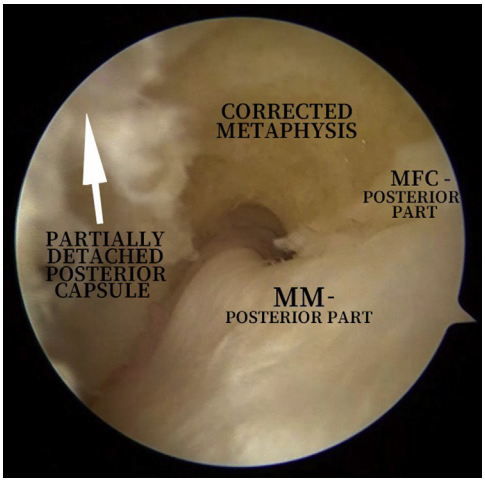

Fig 13. Arthroscopic view of right knee in full flexion from posterolateral portal, confirming successful correction of posteromedial tibiofemoral incongruence. The surgeon verifies whether the proper amount of bone was removed from the metaphysis proximal to the cartilage on the posterior part of the medial femoral condyle (MFC). Proper congruence, represented by a sufficient space for the medial meniscus (MM), is visible.

Table 2. Advantages and Disadvantages of Procedure of Arthroscopic PMTFI Correction

Advantages
The technique allows for final intraoperative confirmation of the clinical indication for PMTFI correction.
The technique allows for the least possible—yet sufficient—amount of PMTFI correction, resulting in a lower risk of fracture than in open surgery.
Partial removal of the conjoint insertion of the joint capsule and medial gastrocnemius tendon is safer than in open surgery owing to better visual control.
The risk of neurovascular injuries is lower than in open surgery.
The risk of infections is lower than in open surgery.
The time of immobilization is shorter than in open surgery.
The risk of PHMM repair failure is potentially decreased.
Disadvantages
The duration of the surgical procedure is longer.
The number of arthroscopic portals is increased.
A trans-septal portal has to be created, with a potential risk of injury to the posterior cruciate ligament in the case of improper technique.
The procedure demands familiarity with arthroscopic posterior knee anatomy.

PHMM, posterior horn of medial meniscus; PMTFI, posteromedial tibiofemoral incongruence.

be seen not as a triangle but as a quadrangle owing to compression-induced bulging. Because of the limited availability of MRI performed in full knee flexion, the diagnostic algorithm proposed earlier is always followed up with the final intraoperative confirmation of the clinical indication for PMTFI correction.

Besides allowing for final intraoperative confirmation, the described technique allows the performance of the least possible, yet sufficient, amount of bone correction. Suganuma et al.[2] described an open surgical technique for the treatment of PMTFI, but in their study, the amount of resection was checked using templates prepared preoperatively: There was no possibility to intraoperatively precisely estimate the effectiveness of bony resection. Unlike in the aforementioned work, during an arthroscopic technique, the surgeon can control the correction intraoperatively, which is very important both to achieve successful treatment and to diminish the potential risk of fracture if too much bone is resected. A recent systematic review by Ebisz et al.[8] concerning posterior knee capsulotomy showed that among 107 operated patients, there were no persistent complications, confirming the safety of procedures performed in this anatomic area. The advantages and disadvantages of the described procedure are summarized in Table 2.

Table 1. Tips and Pearls for Procedure of Arthroscopic PMTFI Correction

The anterolateral portal should be placed high to avoid the tibial eminence during the trans-notch maneuver.
During creation of the posteromedial portal, placement too anteriorly should be avoided. Surprisingly, the convexity of the medial femoral condyle may direct the needle into the popliteal area. Creation of the portal more posteriorly and guidance of the needle in the anterior direction will avoid unwanted bony influence on the needle position.
The portals should be changed as described in this article to achieve the best possible visualization of the impinging parts of the bone.
The surgeon should always confirm the diagnosis of PMTFI by moving the knee into full flexion with direct visualization of the PHMM: Complete closure of its space and its compression are observed.
After PMTFI correction, the surgeon should always assess whether there is sufficient free space for the PHMM during complete knee flexion and no compression can be seen.

PHMM, posterior horn of medial meniscus; PMTFI, posteromedial tibiofemoral incongruence.

Awareness of the importance of PHMM lesions and treatment possibilities has been increasing recently.[9,10] Although it remains to be confirmed in further studies, in cases of PHMM tears associated with PMTFI, repairing the meniscus without correction of bony incongruence may yield unsatisfactory results; similarly, in the hip, FAI is always corrected before the hip joint labrum is repaired.[2,4,5] This philosophy of treatment suggests that aside from the treatment focused on the injured soft-tissue structure (MM or labrum), there is a need to determine the cause (bony incongruence) and to perform its correction. Although severe PMTFI probably causes PHMM lesions on its own, less severe PMTFI has been speculated to be a risk factor for failure of PHMM repair, similarly to a high tibial slope angle in anterior cruciate ligament reconstruction or repair.[2,3,11-14] To conclude, PMTFI may increase the risk of injury to the PHMM owing to its compression

in full knee flexion. The described arthroscopic treatment allows for final intraoperative confirmation of the clinical indication for PMTFI correction and for the least possible, yet sufficient, amount of correction.

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