Technical Note

Posteromedial Compartment Arthroscopy of the Knee and Resection of Osteophytes: An Anatomic Perspective on Posteromedial Knee Impingement

Murat Bozkurt, M.D., Ph.D., Yigit Gungor, M.D., Nihal Apaydin, M.D., Ph.D., Georg Feigl, M.D., Ph.D., and Halil Ibrahim Acar, M.D.

Abstract: Posteromedial knee pain is a common clinical problem. It is often accompanied by degenerative changes or tears in the posterior horn of the medial meniscus and/or pain during deep flexion of the knee. In more advanced cases, it is accompanied by the osteophytic formation of a cam lesion that develops gradually in the posterior of the medial condyle of the femur and, with it (or less frequently without it), an osteophytic lesion at the posterior of the tibia (i.e. pincer lesion) occurs. It is believed that resection of the cam lesion may delay the progression of knee osteoarthritis, similarly to repairing the posterior horn of the medial meniscus. In this technical note, we describe a 2-portal technique for resection of cam lesions by posteromedial knee arthroscopy using anatomic landmarks. Using both portals provides better visualization and a better approach.

Posteromedial (PM) knee pain is a frequently encountered problem of patients seen in orthopaedic practice. Generally, the presence of meniscal or cartilage problems has been considered the cause. Suganuma et al.[1] reported that some cases with clinical problems in the posterior of the meniscus developed on the basis of some morphologic problems in the bone. They further stated that treatments to be applied to the meniscus will fail without correcting the underlying bone problems. This pain may be due to a previous trauma or can be experienced without any trauma. In some studies, changes that developed over time

posteromedially in the femur and tibia in patients with medial meniscus posterior tears—especially in untreated cases—have been reported. In these cases, particularly during deep flexion of the knee, a cam osteophyte can develop gradually on the posterior part of the medial condyle of the femur as a first sign. In the progressive stages, together with a cam lesion, or more rarely without it, a pincer deformity can develop in the posterior part of the tibia.[2]

A tear in the posterior horn of the medial meniscus will usually be accompanied by abnormal dynamic mechanical loading, depending on whether the patient is symptomatic or asymptomatic.[3] Abnormal dynamic mechanical loading may further cause repetitive trauma to the medial meniscus and PM soft tissues. Repetitive trauma increases the interaction between the posterior part of the medial femoral condyle and the posterior part of the tibial medial plateau, which will result in pre-osteophytic formations on the bones. These pre-osteophytic formations may not be seen on radiographs in the initial stages. The osteophytes become visible on radiographs if repetitive microtrauma continues over a prolonged period or if an evident trauma occurs.[4,5]

Several studies have reported that the development of arthrosis is inevitable after tears of the medial meniscus posterior horn or in cases of arthroscopic posterior horn subtotal meniscal resection.[6-10] However, the underlying pathophysiological or mechanical mechanisms have not
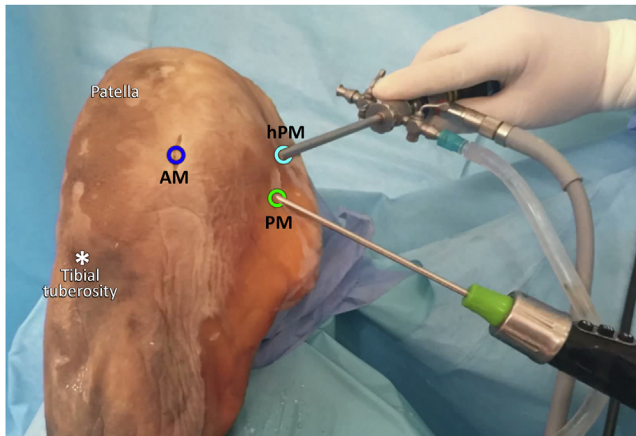
Fig 1. Introduction of 30° arthroscope through high posteromedial portal (hPM) and insertion of arthroscopic instruments through posteromedial portal (PM) in right knee. (AM, anteromedial portal.)

been well defined. On the other hand, the intra-articular stabilizing and load absorption effect of the meniscus is very well known and has been described well in previous reports.[9,11] Hence, the development of arthrosis can easily be explained biomechanically as a direct result of abnormal dynamic medial loading.[9,10]

It is important to take precautions before the development of cam and pincer lesions and to start the treatment of a tear in the posterior horn of the medial meniscus as early as possible to prevent the development of arthrosis. Hence, PM arthroscopy seems to be a good alternative among minimally invasive arthroscopic techniques. Its use has not been limited to diagnostic purposes; it has also been used for a number of procedures concerning the PM aspect of the knee, including the repair of meniscal tears and loose body
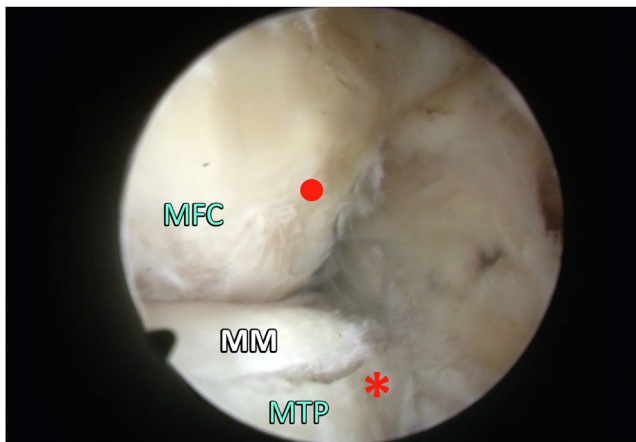

Fig 2. Arthroscopic visualization of medial femoral condyle (MFC) and tibia using 30° arthroscope inserted through high posteromedial (hPM) portal (right knee). The dot and the asterisk indicate the development area of the cam lesion and pincer lesion, respectively. (MM, medial meniscus; MTP, medial tibial plateau.)
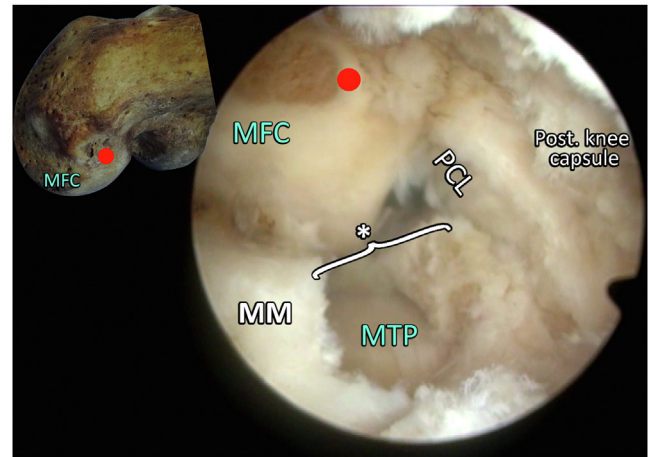

Fig 3. Posteromedial edge of medial femoral condyle (MFC), which was shaved using an arthroscopic burr during deep flexion (right knee). The dot indicates the development area of the cam lesion; the asterisk indicates the shaved tibial plateau posterior edge, which was in contact with the posteromedial femoral condyle. (MM, medial meniscus; MTP, medial tibial plateau; PCL, posterior cruciate ligament; Post, posterior.)

removal.[12-14] However, the use of PM arthroscopy as an early treatment option for the initial stages of osteoarthritis has not been suggested as an alternative in previous reports. Cam and pincer lesions are among the precursor pathologic lesions that induce osteoarthritis in the subsequent stages. Therefore, in this study, we aim to describe an arthroscopic treatment technique for PM knee impingement syndrome, also known as "cam" and "pincer" impingement of the PM part of the knee, in cadavers (Video 1). In doing so, we aim to provide another indication for PM knee arthroscopy and to describe a safe zone for the placement of PM portals based on

Table 1. Pearls and Pitfalls

Pearls
- The PM portal opening should be opened both by visualizing the anterior portals and by using and checking the posterior anatomic landmarks.
- The anatomy of the saphenous nerve and infrapatellar branch must be taken into account when opening the PM and hPM portals.
- Adequate capsule resection in the capsular opening of the PM and hPM portals is important for imaging and the harmonious operation of the working portals.
- Dynamic examination must be performed during arthroscopy. It is strongly recommended to check for impingement with dynamic examination after osteophyte excision.

Pitfalls
- The surgeon should always check the ROM after the excision of osteophytes to verify full flexion and extension.
- There may be limitations in imaging owing to the use of a 30° arthroscope.

hPM, high posteromedial; PM, posteromedial; ROM, range of motion.

Table 2. Advantages and Disadvantages

Advantages
    Adequate visualization of posteromedial aspect of knee
    Effective evaluation of posteromedial capsule of knee and
        posterior root of meniscus
    Arthroscopic minimally invasive surgery
    Early treatment of posteromedial arthrosis of knee
    Quick return of full knee flexion and extension
Disadvantages
    Requirement of experience of posterior knee arthroscopy
    Requirement of special instruments for posterior knee arthroscopy
    Risk to saphenous nerve and infrapatellar branch
    Risk to popliteal artery
    Risk of fluid extravasation and compartment syndrome

standard anatomic landmarks targeting the cam and pincer development area with minimal or no risk of injury to any of the neurovascular structures.

Surgical Technique

Arthroscopy Through 2-Portal Placement Site

Routine arthroscopic examinations of the knee joint in a fresh-frozen cadaveric knee are performed through standard anterolateral and anteromedial portals with the knee joint distended to 50 mm Hg using an arthroscopic infusion pump. Next, a PM portal is created by an experienced orthopaedic surgeon (M.B.) using a transillumination technique with a 30° arthroscope (Tele Pack X LED; Karl Storz Endoskope, Tuttlingen, Germany) that is placed through the intercondylar notch, between the posterior cruciate ligament (PCL) and the medial femoral condyle, via the anterolateral portal. Next, a 21-gauge needle with an outer diameter of 0.81 mm and length of 40 mm (Sterican; B. Braun, Melsungen, Germany) is inserted into the PM compartment, which is located approximately 5 mm above the medial meniscus and just posterior to the medial femoral condyle. After the PM portal is opened and arthroscopic observation is made, bone and soft-tissue landmarks are planned with a skin marker. At this stage, the locations of all anatomic structures are reviewed. Care must be taken to ensure that this opened portal is not too close to the joint, that it will allow observations from the tibial posterior bone plane from above, and that the observation and working portals will work comfortably when considering the other portal to be used. For this reason, attention is paid not only to the points where the portal is opened from the skin but also to the posterior capsule penetrations and the portal positions of the capsule. Next, the high posteromedial (hPM) portal is created 3 cm above and 1 cm proximal to the PM portal.

In the first portal opening, the right point is selected by imaging from the anterior portals. Initially, after the hPM portal is opened, a 30° arthroscope is introduced through the hPM portal and placed into the PM compartment; the instruments are then passed through

the PM portal (Fig 1), and the posterior capsule is resected to allow a better view of the posterior region of the joint and not to exceed 1 cm.

During the arthroscopic examination, the medial meniscus posterior horn and root in the PM compartment, PCL, posterior tibial bone margin, medial gastrocnemius insertion to the medial femoral condyle, and posterior capsule are observed. Next, during a dynamic arthroscopic examination of the knee, the relation between the posterior soft-tissue and bone structures in the knee in deep flexion is observed using the 30° arthroscope through the PM and hPM portals individually (Fig 2).

Arthroscopic Excision of Osteophytes: Cam and Pincer Lesions of Knee

After diagnostic procedures are performed, an examination is conducted to determine which portal is better to take images from and to reach the bony and soft-tissue structures. First, the capsule is debrided with a 5-mm full-radius shaver to widen the surgical field. The capsule is opened from the PM portal with a smiley knife under arthroscopic observation from the hPM portal to allow a better view of the posterior region of the joint and not to exceed 1 cm. Next, by use of a 4.5-mm arthroscopic burr from the PM portal, the PM femoral condyle is shaved, starting from immediately

Table 3. Step-by-step Technique Summary

1. Routine arthroscopic Examinations of the Knee Joint are Performed through Standard Anterolateral and Anteromedial portals.
2. A PM portal is created using a transillumination technique with a 30° arthroscope.
3. A 21-gauge needle with an outer diameter of 0.81 mm and length of 40 mm (Sterican) is inserted into the PM compartment, which is located approximately 5 mm above the medial meniscus and just posterior to the medial femoral condyle.
4. The hPM portal is created 3 cm above and 1 cm proximal to the PM portal.
5. A 30° arthroscope is introduced through the hPM portal and placed into the PM compartment; the instruments are passed through the PM portal.
6. The posterior capsule is resected to allow a better view of the posterior region of the joint.
7. During a dynamic arthroscopic examination of the knee, the relation between the posterior soft-tissue and bone structures in the knee in deep flexion is observed using the 30° arthroscope through the PM and hPM portals individually.
8. The capsule is debrided with a 5-mm full-radius shaver to widen the surgical field.
9. The capsule is opened under arthroscopic observation from the PM portal with a smiley knife.
10. By use of a 4.5-mm arthroscopic burr, the PM femoral condyle is shaved, starting from immediately below the gastrocnemius medial head insertion.
11. The tibial plateau posterior margin in contact with the PM femoral condyle in deep flexion is shaved using the arthroscopic burr.
12. Dynamic examination is repeated during extension and deep flexion.

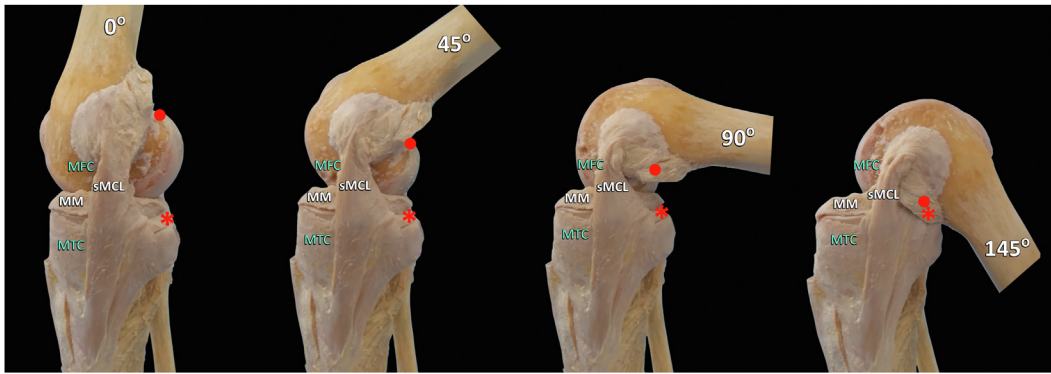hPM, high posteromedial; PM, posteromedial.

Fig 4. Impingement area between femur and tibia illustrated at different flexion angles on medial side of right knee. The dot indicates the development area of the cam lesion; the asterisk indicates the development area of the pincer lesion (right knee). (MFC, medial femoral condyle; MM, medial meniscus; MTP, medial tibial plateau; sMCL, superficial medial collateral ligament.)

below the gastrocnemius medial head insertion. Dynamic examination is repeated during extension and deep flexion of the knee joint. If there is an impingement between the PM femoral condyle and PM tibial plateau, the osteophyte is shaved using the arthroscopic burr until the PM femoral condyle is not in contact with the PM margin of the tibial plateau in deep flexion (Fig 3). With the defined dynamic arthroscopic examination, only osteophytes are excised. Thus, osteophyte resection is performed without disturbing the normal bone curvature. Pearls and pitfalls of the described technique are presented in Table 1, and advantages and disadvantages are listed in Table 2. Table 3 provides a step-by-step technique summary.

Discussion

Many theories have been proposed in relation to the development of osteoarthrosis in the knee.[14-17] The mechanism in varus knees can be explained on a mechanical basis in most cases. Changes over time in the normal anatomy and biomechanics of the knee, with changes starting in the medial tibiofemoral compartment, represent the early stages of knee osteoarthrosis.[18] Even if nontraumatic cartilage and meniscus changes in the medial compartment of the knee are treated in the early stages, most cases show progression.[19]

In the advanced stages, alignment correction treatment options for alignment changes in the coronal plane of the knee are procedures that are applied to relieve pain and protect the knee from osteoarthrosis. Particularly in studies of the relations of ethnicity and sex with the development of knee osteoarthrosis, the biomechanical relation has been shown to be important. In societies in which knee flexion is often performed as a part of daily activities (e.g. during sitting and prayer actions), nontraumatic meniscus and cartilage lesions frequently develop on the basis of repetitive trauma.

In patients with isolated medial meniscal tears and no evident history of trauma, Habata et al.[20] reported a tendency for varus deformity of the knee, with degeneration of the medial meniscus resulting in a tear. In movements involving repetitive flexion of the knee, as a result of repeated contact between the tibial plateau posterior bone margin and the femoral PM condyle in deep flexion, together with degenerative tears that may occur in the posterior of the medial meniscus, bone lesions that may occur in the PM femoral condyle and the tibial plateau posterior have the appearance of cam and/or pincer lesions, just as in cases of femoroacetabular impingement described in the hip. Such lesions are formed between the medial femoral condyle articular surface and the medial tibial plateau posterior section when the knee joint is in full flexion, and this relation was defined as the posterior open angle by Suganuma et al.[1]

The posterior open angle formed by the articular surface of the medial femoral and tibial condyles was measured on lateral radiographs of knee joints in full
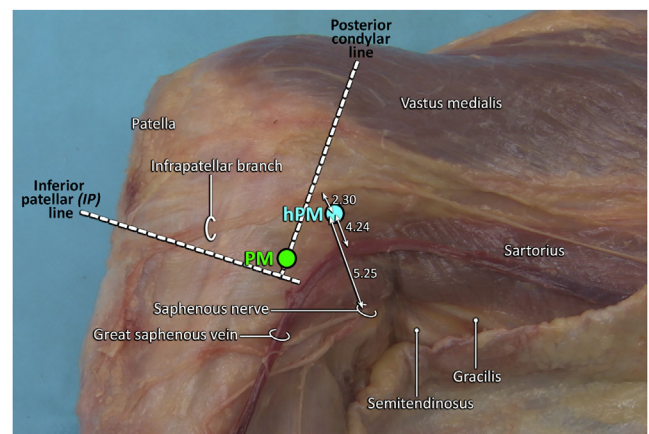

Fig 5. Cadaveric dissection of right knee indicating location of high posteromedial portal according (hPM) to saphenous nerve and its infrapatellar branch (right knee). (PM, posteromedial.)

Table 4. Anatomic Risks of Posteromedial Arthroscopy of Knee

Structure or Condition	Anatomic Risk
Saphenous nerve	The saphenous nerve lies posteroinferior to this hPM point. The closest mean distance between the hPM point and the saphenous nerve is measured as 5.25 cm.
Infrapatellar branch	The closest mean distance between the hPM point and the infrapatellar branch is measured as 2.30 cm.
Popliteal nerve	The popliteal nerve lies approximately 1.2 cm laterally to the septum; as such, the septum is a safe anatomic protective landmark during imaging and working procedures.
Peroneal nerve	There is no significant risk to the peroneal nerve unless the posterolateral portal is used.
Fluid extravasation and compartment syndrome	Particular attention should be paid to fluid passage through the gastrocnemius when the posterior capsule is opened too wide. It is important to control the posterior compartment at the time of surgery.

hPM, high posteromedial.

flexion. It was concluded that the smaller this angle is, the greater the potential for the development of isolated medial meniscal tears will be in populations for whom daily activities include deep flexion. The subsequent abnormality of the bone shape at this site results in incongruence of the PM tibiofemoral joint, thus constituting one of the causes of isolated medial meniscal tears.

Changes in calcified bone lesions, which could occur after repetitive trauma, may represent a mechanical barrier that locks flexion in the advanced stages. Calcified cartilage is not believed to develop through interstitial growth, but changes in thickness have been associated with endochondral ossifications. As a consequence, the subchondral bone thickness and calcified cartilage thin. When noncalcified articular cartilage is incorporated into the calcified area by the advancement of anterior calcification, this is demonstrated by the duplication of the tidemark with subsequent thickening of the calcified zone.[21] Omoumi et al.[22] reported increased cartilage thickness in the non–weight-bearing posterior surface of the medial condyle but not in the lateral condyle when comparing knees with osteoarthritis versus non-osteoarthritic knees. It was also shown that as the Kellgren-Lawrence grading score increased, the cartilage thickness in the posterior surface of the medial condyle also increased.

PM knee impingement from continually performing advanced flexion is associated with lifestyle and ethnicity. Both the morphometric features of the distal femur and proximal tibia and the incomplete anatomic and biomechanical compatibility provide a predisposition. This condition is actually well known in the practice of total knee arthroplasty (TKA). It was reported that the posterior capsule will be tightened when the posterior condyles are prominent, resulting in a smaller extension gap.[23] Bellemans et al.[24] reported that the maximal obtainable flexion in most cases in vivo with a modern PCL-retaining TKA was ultimately determined by impingement of the posterior tibial insert against the femur, and this was exacerbated during flexion as a result of aberrant kinematics with anterior sliding of the femur. It is therefore important

that the posterior condylar offset is restored to allow a greater degree of flexion before impingement develops[24] (Fig 4). When there is impingement of the femur medial condyle with the tibial insert in TKA, the PM part of the femoral condyle is compressed with the tibial plateau posterior bone border and this interaction results in the pincer effect in this area.

In the study by Suganuma et al.,[1] in which a treatment protocol for posteromedial impingement of the knee was described, it was reported that in knee joints with PM tibiofemoral incongruence at full flexion, when decompression of the posterior segment of the medial meniscus was added to the meniscal repair, more room was provided for the accommodation of the medial meniscus, and this improved both knee joint function and the success rate of the repair of isolated medial meniscal tears in patients who habitually performed full knee flexion. Suganuma et al. emphasized that better results were obtained in the group in which medial meniscal repair was applied together with femoral condyle decompression than in the group in which decompression was not applied. In their study, open surgery was applied, whereas in our cadaveric study, the treatment was arthroscopic.

The portals defined for posterior knee arthroscopy were the PM, posterolateral, and septal portals. Particularly in 120° of flexion, there is a high risk of damage to the common peroneal nerve when using the posterolateral portal. Therefore, during both the dynamic arthroscopic examination of PM impingement of the knee and the application of arthroscopic shaving of the femoral PM condyle cam lesion and tibial pincer lesion, there must not be advanced flexion. Due to the vascular and nerve structures in posterior part of the knee joint, portals with safe and clear arthroscopic exposure are required. The hPM portal described here is ideal for the provision of good visualization. The point where the line drawn through the medial epicondyle intersecting the inferior patellar line perpendicularly is determined to be located within this zone and over the joint capsular space. Some anatomical landmarks such as the medial femoral epicondyle and inferior patellar line are

important for the anatomical definition of the posterior joint capsule. Hence, this point is regarded as the ideal point for placing the hPM portal (Fig 5). Anatomic risks of the described technique are presented in Table 4.

Applying a far-medial portal together with a medial portal is an effective method to use in the reconstruction of anatomic anterior cruciate ligaments. However, imaging from a position that is higher than the PM portal and using the instruments from the classic PM portal is a method that can be used for the treatment of PM cam and pincer lesions, as well as posterior meniscal debridement. Points that require great care are the varying dimensions and the capsule cutting and resectioning. It must not be forgotten that in extensive resections, there should be preparations for predicted compartment problems that may develop in the posterior compartment associated with fluid leakage.

In conclusion, in knees that habitually perform advanced flexion, PM knee impingement starting with a medial meniscal lesion may continue with an associated femoral cam and tibial pincer lesion, resulting in a clinical picture of varus osteoarthrosis. In the period when the loss of knee flexion is reversible, it is clear that arthroscopic treatment will both prevent irreversible damage and slow the progression to osteoarthrosis.

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