POSTERIOR KNEE ARTHROSCOPY: ANATOMY, TECHNIQUE, APPLICATION

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Introduction

The frequency of knee arthroscopy involving the posterior compartments has increased with recent advances in arthroscopic technique and instrumentation. Total arthroscopic synovectomy, arthroscopic repair or reconstruction of the posterior cruciate ligament, all-inside repair of the posterior horn of the meniscus, and removal of loose bodies or tumors posterior to the posterior cruciate ligament all involve arthroscopic visualization of posterior aspects of the knee. Posterior knee arthroscopy is technically complex and requires a detailed knowledge of posterior knee anatomy relevant to the arthroscopist. With pertinent anatomic knowledge and meticulous technique, posterior knee arthroscopy can be safely implemented to provide a broad field of view and increased maneuverability of instruments.

The Popliteal Artery

The popliteal artery is the most anterior structure of the popliteal neurovascular bundle. It courses anteriorly toward the insertion of the posterior cruciate ligament on the tibia and then moves posteriorly. The popliteal artery is closest to the knee joint at the insertion of the posterior cruciate ligament, where it is held near the proximal part of the tibia by the fibrous arch of the soleus. At the joint line, the popliteal artery lies posterior and lateral to the posterior cruciate ligament, adjacent to the posterior septum (Figs. 1-A and 1-B).

Anatomic studies pertinent to an arthroscopist's assessment of posterior knee anatomy at the joint line—i.e., studies done under simulated arthroscopic conditions, including knee flexion and joint distention—are unfortunately rare. Cadaver and radiographic anatomic studies of the posterior aspect of the knee are usually done with the knee in full extension. Anatomic studies done with the knee in flexion have previously focused on posterior knee anatomy pertinent for high tibial osteotomy and total knee replacement—i.e., they have determined the position of the popliteal neurovascular bundle in relation to projected proximal tibial cuts[1-3].

Recently, two magnetic resonance imaging studies of cadavera under simulated arthroscopic conditions (knee flexion and fluid distention) were done to investigate the anatomy of
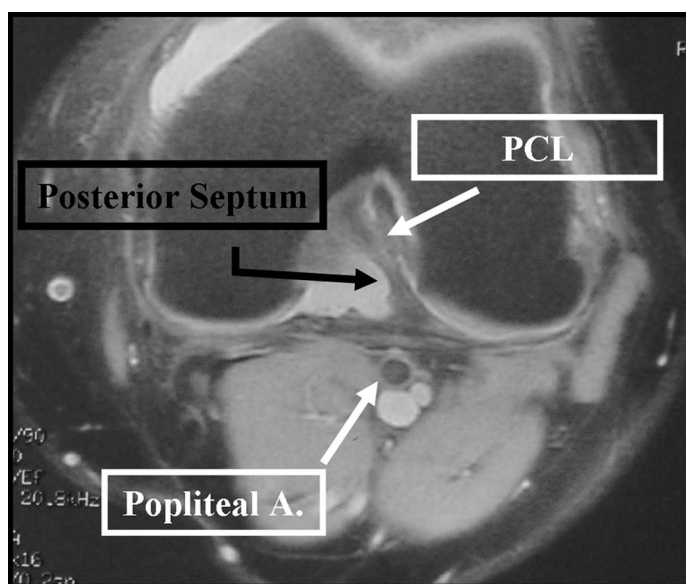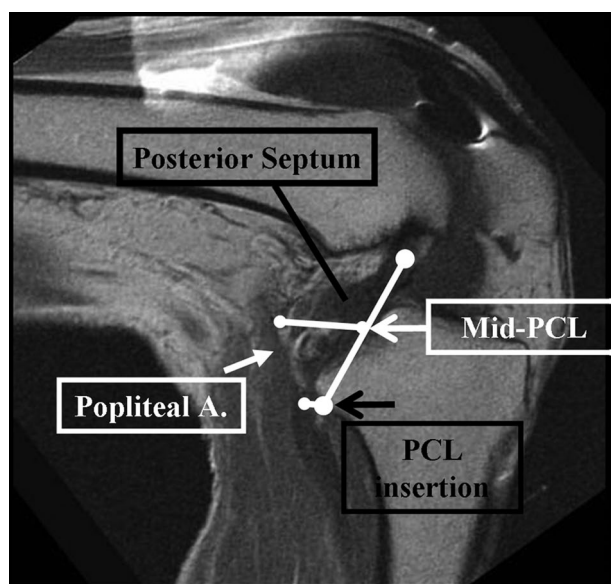

Fig. 1-A

Fig. 1-B

Figs. 1-A and 1-B Magnetic resonance images of the knee, depicting the posterior cruciate ligament (PCL), posterior septum, and popliteal artery. **Fig. 1-A** Axial T2-weighted image with fat saturation. **Fig. 1-B** Sagittal T1-weighted image.
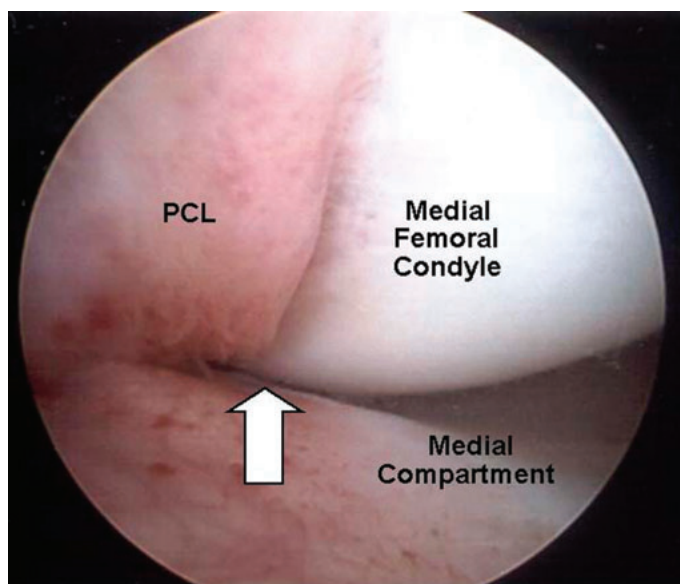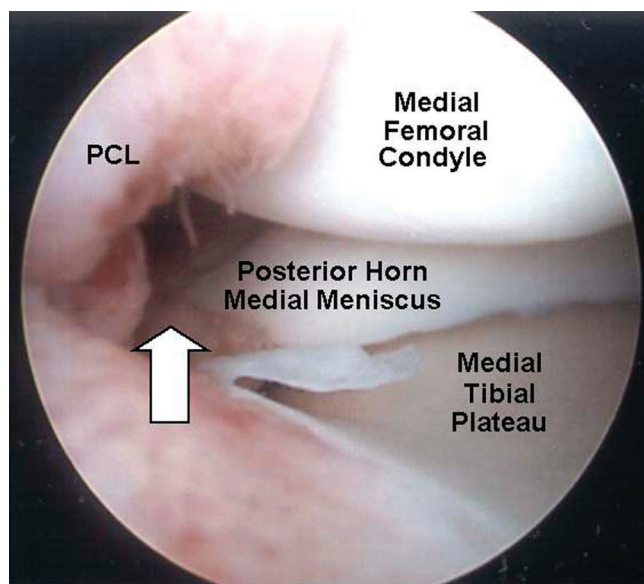
Fig. 2-A

Fig. 2-B

Figs. 2-A and 2-B Transcondylar notch visualization of the posteromedial compartment. (Reprinted, with permission, from: Kramer DE, Frassica FJ, Cosgarea AJ. Total arthroscopic synovectomy for pigmented villonodular synovitis of the knee. Tech Knee Surg. 2004;3:36-45.) **Fig. 2-A** The arthroscope passes into the posteromedial compartment through the interval (white arrow) between the lateral border of the medial femoral condyle and the medial border of the posterior cruciate ligament (PCL) from the anterolateral portal. **Fig. 2-B** With the arthroscope further in the interval (white arrow), it passes the posterior horn of the medial meniscus before entering the posteromedial compartment. PCL = posterior cruciate ligament.

the popliteal artery pertinent to the arthroscopist[4,5]. Matava et al.[5] measured the distance from the insertion of the posterior cruciate ligament on the tibia to the popliteal artery at full extension and at 100° of flexion. In the sagittal plane, the popliteal artery moved farther posteriorly with knee flexion, with its distance from the posterior cruciate insertion changing from 7.6 mm in full extension to 9.9 mm in 100° of flexion. Similarly, in the coronal plane, the popliteal artery moved farther laterally with knee flexion (with the distance changing from 7.2 mm to 9.3 mm). We previously found that, at 90° of knee flexion, the mean sagittal distance from the midpart of the posterior cruciate ligament to the popliteal artery was 29 mm (range, 18 to 55 mm), and the mean sagittal distance from the insertion of the posterior cruciate ligament to the popliteal artery was 10 mm (range, 3 to 16 mm)[4]. Knee flexion does not always guarantee posterior displacement of the popliteal artery, however. In a magnetic resonance imaging study of cadavera (without joint distention), Smith et al.[6] found that two of nine healthy volunteers had anterior displacement of the popliteal vessels with knee flexion.

Transcondylar Notch Visualization
Background

Transcondylar notch visualization, first described by Gillquist and Hagberg in 1976[7], can provide quick and safe visualization of the posterior compartments without the need for posterior accessory portals. It can be used to identify tears of the posterior horn of the meniscus, meniscal root avulsions, and posterior loose bodies. While some authors have

contended that it should be a routine part of all knee arthroscopy procedures[8], transcondylar notch visualization is particularly indicated in patients with a suspected posterior meniscal lesion and those with an anterior cruciate ligament-deficient knee (as a result of the high incidence of tears of the posterior horn of the meniscus in patients with a torn anterior cruciate ligament).

Techniques

The contralateral direct visualization technique for visualization of the posteromedial compartment begins with the arthroscope in the anterolateral portal. The knee is flexed to 90°, and the arthroscope is passed, under direct visualization, through the interval between the lateral border of the medial femoral condyle and the medial border of the posterior cruciate ligament (Figs. 2-A and 2-B). Passage is facilitated by gentle but firm posterior pressure on the arthroscope as a valgus force is applied to the knee and the knee is extended.

The blind technique involves placement of a blunt obturator through the anterolateral portal to palpate the nonarticular anterolateral wall of the medial femoral condyle. The obturator is then slowly advanced posteriorly so that it hugs the lateral border of the medial femoral condyle until it gently pops through the interval between the posterior cruciate ligament and the medial femoral condyle. The obturator is then replaced with the arthroscope to achieve visualization of the posteromedial compartment. Posterolateral transcondylar notch visualization is achieved in an analogous fashion, with the instruments passing in the interval between the lateral border of the anterior

cruciate ligament and the medial border of the lateral femoral condyle while a varus stress is placed on the knee.

Tips

Transcondylar notch visualization may be difficult to achieve in some patients. Ahn and Ha[9] believed that the most important technical tip for a successful transcondylar notch approach is placement of the anterior portal near the corresponding borders of the patellar tendon. This facilitates passage of the instruments through the intercondylar notch interval. The path of the arthroscope through the intercondylar notch can also be enlarged by inserting a round trocar through the interval prior to passage of the arthroscope. Posterior plunging of the instruments during attempted passage through the intercondylar notch interval can be prevented by the surgeon's extended index finger. While the 30° arthroscope is adequate for most situations, the 70° arthroscope can be used to enhance the field of vision when necessary. Finally, another technique involves passage of the arthroscope from the anterolateral portal ipsilaterally through the intercondylar notch interval and into the posterolateral knee compartment. This technique works best for posterolateral visualization in lax knees[10].

Efficacy Data

The safety and efficacy of transcondylar notch visualization have been investigated. Amin et al.[8] performed 150 consecutive knee arthroscopies with the transcondylar notch view and noted that it changed the diagnosis, compared with that based on arthroscopic examinations with standard portals, in 18% of the cases and changed the surgical treatment in 11%. Transcondylar notch views were three times more likely to provide important information when they were used in anterior cruciate ligament-deficient knees[8]. Important information obtained with use of transcondylar notch visualization included revelation of otherwise unseen meniscal tears (45%), a finding of occult loose bodies (33%), and demonstration that a meniscal tear was repairable (10%)[8]. Lubowitz et al.[10] found that posteromedial transcondylar notch visualization revealed loose bodies in 36% of patients with "suspected" loose bodies. Morin and Steadman[11] noted that posteromedial transcondylar notch visualization left a blind spot that involved a mean of 21.5% of the posteromedial meniscosynovial periphery, whereas there was no blind spot with posterolateral transcondylar notch visualization. They attributed this difference to the smaller radius of curvature of the lateral meniscus, the tighter posterior cruciate ligament-medial femoral condyle interval, the increased width of the posterior horn of the medial meniscus, and the larger sagittal diameter of the medial femoral condyle.

Complications

Transcondylar notch visualization is rarely associated with complications. There is a potential for damage to the cruciate ligaments, cartilage, and posterior neurovascular structures. Visualization may be difficult in knees with arthritic changes in the intercondylar notch. Lubowitz et al.[10] performed 100 consecutive knee arthroscopies with transcondylar notch views and found that posterolateral visualization was achieved in 100% of the procedures (and in 93% on the first try) with a 4% rate of mild iatrogenic cartilage damage. Posteromedial visualization was achieved in 97% of the procedures (82% on the first try) with a 28% rate of mild iatrogenic cartilage damage and 3% rates of moderate and severe damage. Instrument breakage occurred with the direct visualization technique only, especially when the anterolateral portal was placed too far laterally.

Posterior Accessory Portals

Background

A posteromedial or posterolateral accessory portal is necessary when transcondylar notch visualization is inadequate or when it is necessary to place instruments into the posterior compartments. Some authors have advocated creation of a posteromedial accessory portal when there is a high suspicion of a tear of the posterior horn of the medial meniscus (especially in an anterior cruciate ligament-deficient knee) and no tear is visualized with standard techniques[12,13]. Posterolateral accessory portals are less commonly employed, as transcondylar notch views usually provide visualization of the entire lateral meniscus[11]. The posterolateral accessory portal is indicated when there is high suspicion of a tear of the posterior horn of the lateral meniscus that is not seen on transcondylar notch views or when instrumentation is necessary in the posterolateral knee compartment.

Technique

Posteromedial Accessory Portal

Creation of the posteromedial accessory portal has been described in several reports[9,14,15]. The knee is kept in 90° of flexion to move the sartorial branch of the saphenous nerve posteriorly. The arthroscope is placed in the posteromedial compartment with transcondylar notch visualization and is advanced as far medially as possible. The long saphenous vein may be identified by transillumination. Fluid outflow is closed to distend the knee joint and allow easy palpation of the medial wall of the posteromedial compartment. The soft spot between the medial collateral ligament, the medial head of the gastrocnemius, and the tendon of the semimembranosus is palpated[15]. The posteromedial portal is localized with a spinal needle at this soft spot just above the joint line (Fig. 3-A). The sartorial branch of the saphenous nerve runs with the long saphenous vein and should lie approximately 10 mm posterior to the portal. A superficial longitudinal skin incision is made, and a hemostat is used to bluntly dissect through subcutaneous tissue and penetrate the joint capsule (Fig. 3-B). A plastic cannula can be inserted into the portal to allow easier instrument passage (Fig. 3-C).

Posterolateral Accessory Portal

With the knee flexed to 90°, the arthroscope is placed in the posterolateral compartment with use of the transcondylar notch view. Outflow is closed to distend the knee joint and allow easy palpation of the lateral wall of the posterolateral knee compartment. The soft spot between the lateral collateral liga-
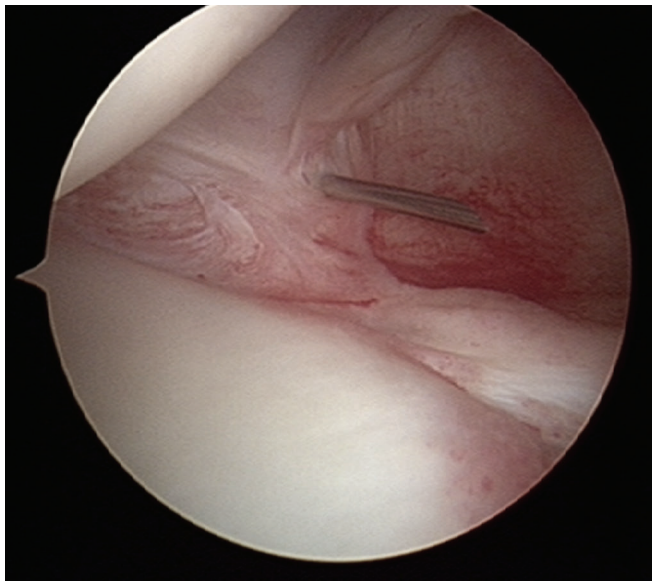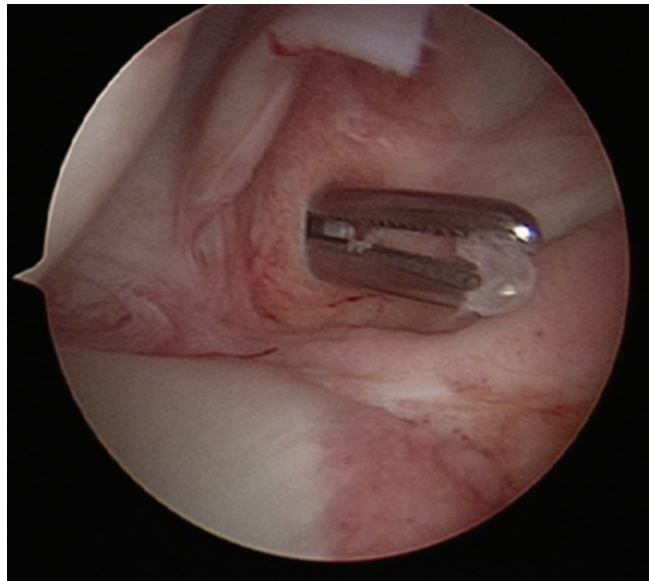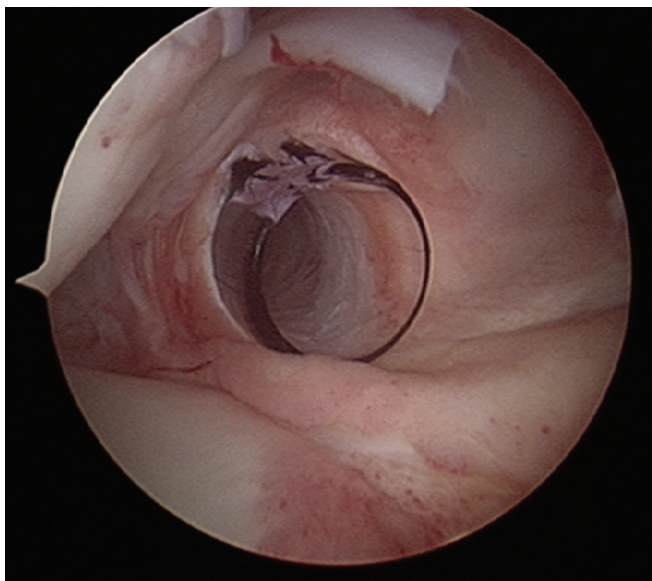
Fig. 3-A

Fig. 3-B

Fig. 3-C

Figs. 3-A, 3-B, and 3-C Establishment of the posteromedial portal. (Reprinted, with permission, from: Kramer DE, Frassica FJ, Cosgarea AJ. Total arthroscopic synovectomy for pigmented villonodular synovitis of the knee. Tech Knee Surg. 2004;3:36-45.) **Fig. 3-A** Localization of the portal site with a spinal needle under direct visualization. **Fig. 3-B** A hemostat bluntly dissects through the posteromedial aspect of the capsule. **Fig. 3-C** The plastic cannula is inserted to establish the portal.

ment, the lateral head of the gastrocnemius, and the posterolateral tibial plateau is felt. The posterolateral accessory portal is then localized with a spinal needle just above the joint line. The entry site is just posterior to the lateral collateral ligament, anterior and superior to the biceps femoris. A superficial longitudinal incision through skin is followed by blunt dissection with a hemostat through subcutaneous tissue to penetrate the knee capsule. A plastic cannula is then inserted through the portal to allow easier instrument passage.

Tips
If a leg-holder is employed, it should be kept proximal enough to allow the saphenous nerve and the common peroneal nerve

to fall posteriorly[15]. Structures surrounding the portals, including the distal part of the femur, proximal part of the tibia, collateral ligaments, and gastrocnemius and hamstring tendons, may be marked on the skin preoperatively, before the anatomy becomes distorted[15]. During portal creation, the knee should always be kept in 90° of flexion with continuous joint lavage under pressure[15]. The portal should not be placed too far anteriorly so that instruments placed through the accessory portals are never oriented in an anterior-to-posterior direction toward the popliteal neurovascular bundle[15]. The 30° and 70° arthroscopes can be used interchangeably to maximize visualization. Lastly, the surgeon should be aware that extracapsular fluid extravasation may occur with the use of accessory portals.

POSTERIOR KNEE ARTHROSCOPY:
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Efficacy Data

Many believe that the posterior horn of the medial meniscus is the greatest source of diagnostic errors in standard arthroscopy[12,13]. The posteromedial accessory portal allows improved visualization of the critical posterosuperior meniscosynovial junction[13]. Tolin and Sapega[13] found that the addition of a posteromedial accessory portal decreased the mean blind zone of the posterior horn of the medial meniscus from 21% to 8.4%. Gold et al.[12] evaluated the frequency of use of posteromedial portals in 400 knee arthroscopies and found that, when employed, the posteromedial portal showed treatable lesions 65% of the time. Most of these lesions were tears of the posterior horn of the medial meniscus, 63% of which were not visible with routine arthroscopic views[12].

Complications

The most common complication of posteromedial portal placement is injury to the sartorial branch of the saphenous nerve. The saphenous nerve exits the adductor canal, where it divides into an infrapatellar branch and a sartorial branch (Fig. 4). The sartorial branch descends inferiorly just posterior to the long saphenous vein. The anatomy of the sartorial branch has been investigated in cadaver and magnetic resonance imaging studies with the knee in extension (not under simulated arthroscopic conditions)[16,17]. The sartorial branch pierces the fascia between the sartorius and gracilis approximately 33 mm posterior and distal to the medial femoral epicondyle[16], anywhere from 37 mm proximal to 30 mm distal to the joint line[17]. Dunaway et al.[17] found that, at the joint line, the nerve was a mean 16 mm (range, 1 to 37 mm) posterior to the anterior border of the sartorius. Since the nerve was never anterior to the sartorius even in knee extension, they concluded that posteromedial dissection anterior to the sartorius is safe.

Gold et al.[12] reported one saphenous nerve injury after the establishment of seventy-eight posteromedial portals, whereas Ogilvie-Harris et al.[15] reported three saphenous nerve injuries after the establishment of 179 posteromedial portals. Injury can lead to saphenous neuritis, which presents as pain and dysesthesia in the distribution of the saphenous nerve. The hallmark physical finding is tenderness to light palpation along the course of the nerve[18]. The diagnosis can be confirmed with a nerve block at the adductor canal, 7.3 cm proximal and 9.8 cm medial to the superior pole of the patella[18].

Nonoperative treatment methods for saphenous neuritis include desensitization therapy, padding, oral or topical analgesics, and tricyclic antidepressants. While these modalities have been investigated in the treatment of reflex sympathetic dystrophy and peripheral neuropathic pain, we know of no published studies documenting their efficacy in the treatment of saphenous neuritis[18]. Romanoff et al.[19] reported an 80% success rate at four months following treatment of saphenous neuritis with serial nerve blocks at the adductor canal in thirty patients. However, poor results were documented by Worth et al.[20], who reported that all of fifteen patients had a failure of nerve block therapy and required surgery, and by Mozes et al.[21], who reported that only twelve of thirty-two patients had success with
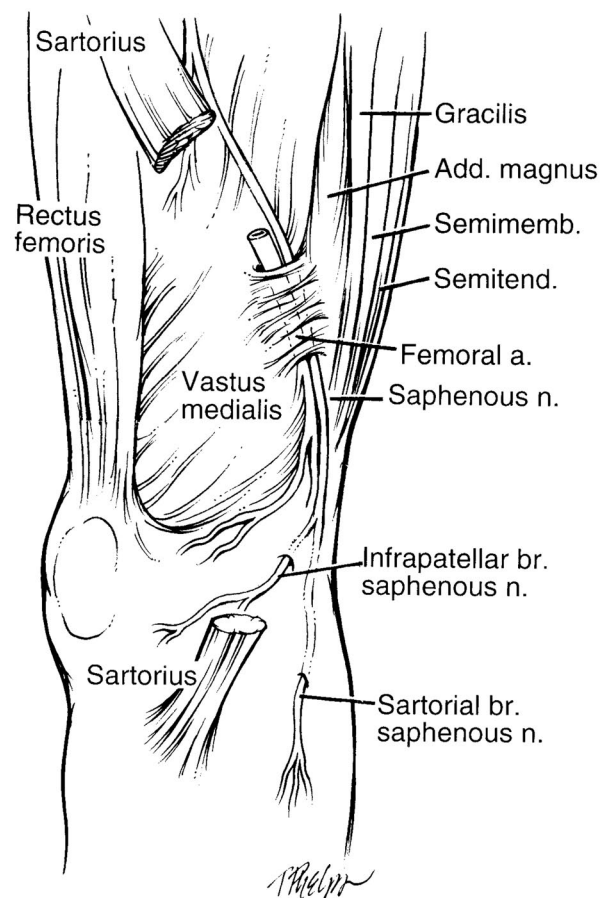

Fig. 4

Anatomy of the saphenous nerve and its branches: the infrapatellar branch and the sartorial branch. (Reprinted, with permission from Sage Publications, from: Kim TK, Savino RM, McFarland EG, Cosgarea AJ. Neurovascular complications of knee arthroscopy. Am J Sports Med. 2002;30:619-29.)

nerve block therapy. Surgical options for treatment of saphenous neuritis include decompression of the adductor canal, neurolysis, neuroma excision, and neurectomy[18]. Worth et al. reported success in four of eight patients in whom saphenous neuritis had been treated with decompression of the adductor canal and in eight of ten in whom it had been treated with neurectomy. In a larger study, Dellon et al.[22] reported an 86% success rate following neurectomy of the infrapatellar branch of the saphenous nerve in sixty-two patients with saphenous neuritis (documented by nerve block) following total knee replacement, trauma, or osteotomy. Of note, neurectomy of multiple nerves was performed in most patients (with a mean of 3.2 nerves resected), which prevented an isolated analysis of saphenous neurectomy in this patient population[22].

The common peroneal nerve is at risk during creation of a posterolateral accessory portal. The common peroneal nerve travels with the tibial portion of the sciatic nerve in the posterior aspect of the thigh. It passes along the medial border of the biceps femoris tendon, lateral to the lateral head of the
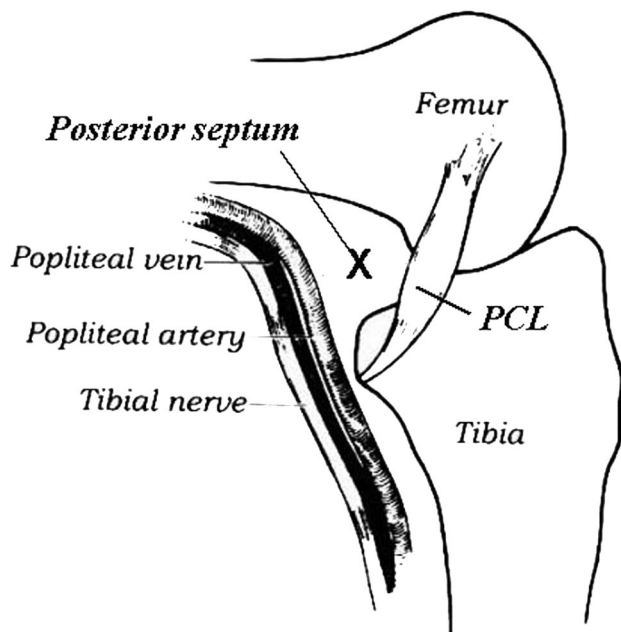
Fig. 5

The posterior septum, a triangular synovial reflection attached to the posterior cruciate ligament anteriorly, the posterior portion of the femoral intercondylar notch superiorly, and the posterior aspect of the capsule posteriorly. Note the posterior displacement of the popliteal vessels with knee flexion. (Reproduced, with modification, from: Matava MJ, Sethi NS, Totty WG. Proximity of the posterior cruciate ligament insertion to the popliteal artery as a function of the knee flexion angle: implications for posterior cruciate ligament reconstruction. Arthroscopy. 2000;16:796-804. Reprinted with permission from the Arthroscopy Association of North America.)

gastrocnemius, and posterolaterally around the head and neck of the fibula, where it divides into the deep and superficial peroneal nerves. Peroneal nerve anatomy is variable, with one study demonstrating that 10% of common peroneal nerves divided into superficial and deep branches just proximal to the knee joint whereas 30% had a cutaneous branch originating approximately 1 cm proximal to the joint line[23].

Complications are rarely associated with the creation of a posterolateral accessory portal. The lateral inferior genicular artery usually runs distal to the portal site, adjacent to the peripheral attachment of the lateral meniscus[15]. The lateral superior genicular artery runs between the lateral head of the gastrocnemius and the posterolateral aspect of the capsule, approximately 3 to 5 mm proximal to the joint line and 2 cm anterior to the portal site[15]. The common peroneal nerve usually runs approximately 15 mm distal to the portal and falls posterior with knee flexion, where it is protected by the biceps femoris tendon[15].

Posterior Transseptal Portal

Background

The posterior septum is a triangle-shaped two-layer synovial reflection that divides the posterior aspect of the knee into posteromedial and posterolateral compartments. It is bounded by the posterior cruciate ligament anteriorly, the posterior portion of the femoral intercondylar notch superiorly, and the posterior aspect of the capsule posteriorly (Fig. 5). The middle genicular vessels perforate the posterior aspect of the capsule parallel to the superior border of the posterior septum at the femoral intercondylar notch. Cadaver studies have shown that there are no important structures at the center of the triangular posterior septum[9].

Recently, Ahn and Ha[9] and Louisia et al.[14] described the creation of a posterior transseptal portal that allows passage of the arthroscope or instruments between the posteromedial and posterolateral compartments (Fig. 6). This transseptal portal provides a large working space and a broader field of view for better instrument maneuverability in the posterior aspect of the knee. This portal can be used to improve visualization of the posterosuperior aspects of the femoral condyles, the posterior portion of the posterior cruciate ligament, the entire periphery of the posterior horn of the meniscus, the posterior meniscofemoral ligament (of Wrisberg), and the posterior aspect of the capsule. Because of the proximity of the popliteal neurovascular bundle, detailed knowledge of posterior knee anatomy and meticulous technique are mandatory for safe implementation of this portal.

The posterior transseptal portal is not indicated for routine knee arthroscopy. However, it has been employed in total arthroscopic synovectomy for pigmented villonodular synovitis of the knee, removal of loose bodies or tumors behind the posterior cruciate ligament, suture fixation of an avulsion of the posterior cruciate ligament from the tibia, all-inside repair of the posterior horn of the meniscus, and arthroscopic reconstruction of the posterior cruciate ligament. Studies have shown that when the posterior transseptal portal
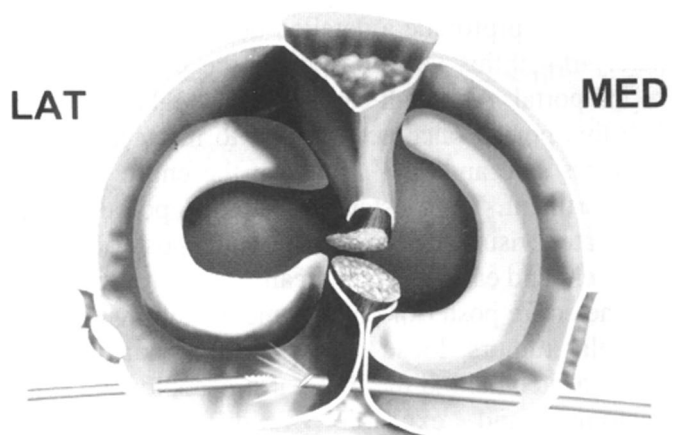

Fig. 6

The transseptal portal is established, and the arthroscope passes freely from the posteromedial compartment to the posterolateral compartment to provide a broader field of view. (Reprinted, with permission from the Arthroscopy Association of North America, from: Ahn JH, Ha CW. Posterior trans-septal portal for arthroscopic surgery of the knee joint. Arthroscopy. 2000;16:774-9.)
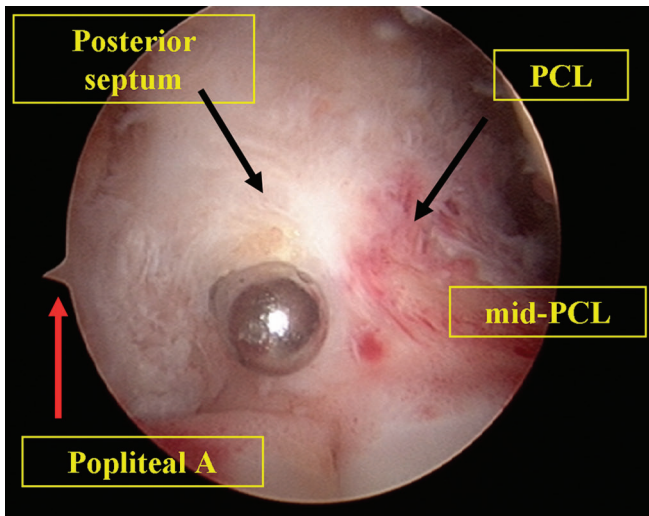
Fig. 7-A

Figs. 7-A, 7-B, and 7-C Establishment of the transseptal portal. (Reprinted, with permission, from: Kramer DE, Frassica FJ, Cosgarea AJ. Total arthroscopic synovectomy for pigmented villonodular synovitis of the knee. Tech Knee Surg. 2004;3:36-45.) **Fig. 7-A** A blunt trocar is used to perforate the posterior septum from the posterolateral portal at the level of the mid-posterior cruciate ligament (PCL), as visualized with the arthroscope in the posteromedial compartment.

is combined with transcondylar notch views posteriorly, the entire posteromedial meniscosynovial junction can be well visualized[9].

Technique

Louisia et al.[14] described the "back and forth" modification of the original technique for creation of the transseptal portal described by Ahn and Ha[9]. The knee is flexed to 90° while the fluid pump maintains continuous joint lavage under pressure to ensure maximum posterior displacement of the popliteal

neurovascular bundle. The posteromedial and posterolateral accessory portals are created, and the 30° arthroscope is placed through the posteromedial accessory portal. A blunt trocar is then passed through the posterolateral accessory portal and is advanced across the posterior edge of the lateral femoral condyle to the posterior septum. The blunt trocar is then used to gently perforate the two layers of reflected synovium that make up the posterior septum. This is done at the level of the midpart of the posterior cruciate ligament, where the mean sagittal distance to the popliteal artery is 29 mm (range, 18 to 55 mm)[4].

Resection of the posterior septum proceeds by the introduction of an oscillating shaver through the posterolateral portal and advancing it toward the posterior septum. The two-layer posterior septum is then resected under direct visualization, beginning where the initial aperture was made at the level of the midpart of the posterior cruciate ligament (Figs. 7-A, 7-B, and 7-C). The shaver must always face anteriorly toward the knee joint and away from the popliteal neurovascular bundle. Resection proceeds, with use of caution, superiorly and inferiorly from the midpart of the posterior cruciate ligament. Superiorly, the middle genicular artery runs parallel to the superior border of the posterior septum. Inferiorly, the popliteal artery moves closer to the posterior cruciate ligament, lying a mean sagittal distance of 10 mm (range, 3 to 16 mm) from the tibial insertion of the posterior cruciate ligament[4]. The amount of posterior septum that must be resected varies depending on the intended use of the transseptal portal.

Complications

The popliteal artery, the most anterior structure of the popliteal neurovascular bundle, is clearly at risk during establishment of the transseptal portal. Risk of injury is greatest during resection of the inferior portion of the posterior septum[14]. To date, no cases of popliteal artery injury during creation of the transseptal portal have been reported, to our knowledge. The middle genic-
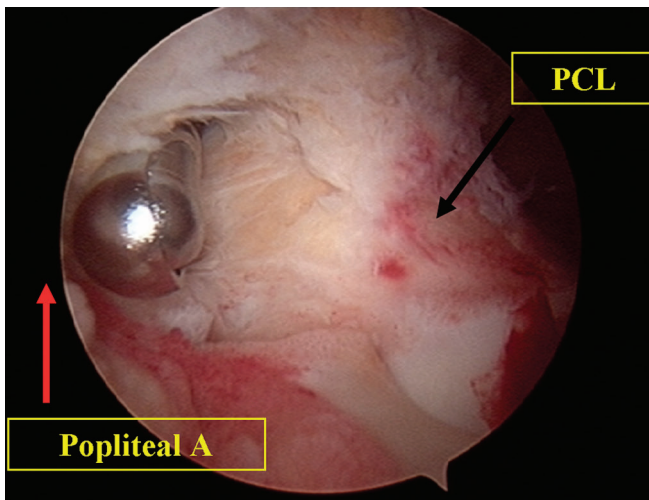

Fig. 7-B

Fig. 7-C

Fig. 7-B An oscillating shaver facing anteriorly is used to resect the posterior septum beginning just posterior to the mid-posterior cruciate ligament (PCL). **Fig. 7-C** The posterior transseptal portal is established, and the posterolateral compartment is visible just beyond the portal.
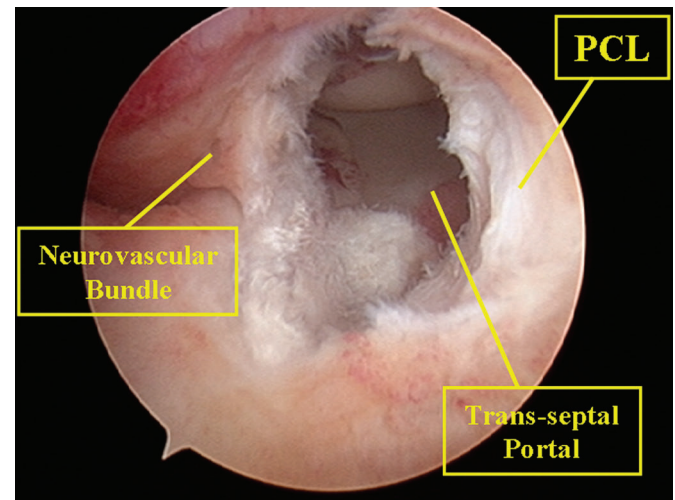
ular artery can be injured when resection of the posterior septum proceeds too far superiorly. Such an injury is treated by immediate arthroscopic coagulation and perhaps placement of an intra-articular drain postoperatively.

Total Arthroscopic Synovectomy for Diffuse Pigmented Villonodular Synovitis of the Knee

Background

Pigmented villonodular synovitis is a rare disease (1.8 cases per million)[24] of synovial proliferation that affects young adults between the ages of twenty and forty years, with an 80% predilection for the knee[25]. It occurs in two growth patterns: localized nodular and diffuse villous. The diffuse villous form is more common (75% of the cases) and involves the entire synovium diffusely, leading to recurrent knee effusions, pain, and stiffness. High recurrence rates (10% to 45%) have been reported following various forms of surgical treatment of diffuse pigmented villonodular synovitis of the knee[26-28], and total synovectomy is currently the treatment of choice. Total arthroscopic synovectomy is technically challenging but is preferred over open synovectomy because of lower operative morbidity, quicker rehabilitation, and easier access to the posterior compartments. Open total synovectomy requires two surgical approaches (anterior and posterior) and has been associated with high rates of arthrofibrosis and wound breakdown[29].

The outcome following total arthroscopic synovectomy for treatment of diffuse pigmented villonodular synovitis of the knee is superior to that following partial arthroscopic synovectomy (which does not include evaluation of the posterior compartment). Ogilvie-Harris et al.[30] showed significantly improved results of total arthroscopic synovectomy compared with those of partial arthroscopic synovectomy (p = 0.01). In their series of twenty patients with diffuse pigmented villonodular synovitis of the knee, those who had undergone total arthroscopic synovectomy had a 9% recurrence rate at 3.5 years postoperatively compared with a 56% recurrence rate at 1.8 years postoperatively for those treated with partial arthroscopic synovectomy. Zvijac et al.[28] noted two recurrences in twelve patients following arthroscopic synovectomy for diffuse pigmented villonodular synovitis of the knee. Posterior compartment synovectomy had not been performed in either patient with a recurrence. Finally, Schwartz et al.[27], in a retrospective study of ninety-nine patients with pigmented villonodular synovitis of large joints seen over a period of sixty-seven years, showed that recurrence was significantly associated with treatment with incomplete surgical synovectomy (p < 0.01).

Preoperative Planning

Magnetic resonance imaging of the knee is routinely performed preoperatively to determine whether pigmented villonodular synovitis is nodular or diffuse; whether it is intra-articular or extra-articular, or both; and whether there is disease of the posterior compartment. Nodular disease can be treated with local excision, whereas diffuse disease requires total synovectomy. Extra-articular disease mandates the addition of an open approach. Evidence of posterior compartment disease on magnetic resonance imaging suggests that posterior accessory portals (and possibly the transseptal portal) will be necessary for complete visualization of the posterior compartment. Areas not routinely accessed during arthroscopy, including the infrapatellar fat pad, the synovium posterior to the posterior cruciate ligament, the interval between the cruciate ligaments, and the recess inferior to the popliteus tendon, often contain synovium with pigmented villonodular synovitis. These areas should be visualized with preoperative magnetic resonance imaging to further plan the arthroscopic approach.

Technique

Total arthroscopic synovectomy for pigmented villonodular synovitis of the knee has been previously described[31]. Diagnostic arthroscopy employs standard anterior portals positioned near the borders of the patellar tendon to facilitate transcondylar notch visualization. The anterior synovium, including the anterior fat pad and the region between the cruciate ligaments, is sequentially inspected. The posterior synovium is visualized by means of transcondylar notch views to identify hidden foci of pigmented villonodular synovitis in the posterior meniscosynovial junction and in the synovium behind the posterior cruciate ligament. If posterior compartment disease is noted arthroscopically or with magnetic resonance imaging, posteromedial and posterolateral accessory portals should be established.

Total arthroscopic synovectomy is done under tourniquet control, beginning with the posterior compartments. The arthroscope is placed through the transcondylar notch into the posterior compartment, and the oscillating shaver is placed through the appropriate posterior accessory portal. All abnormal synovial tissue is débrided. Proliferative synovitis and large nodules can obstruct visualization at this stage. It can be difficult to identify all areas of pigmented villonodular synovitis in the synovium on the basis of the macroscopic appearance alone, and the intraoperative synovial appearance must be correlated with the findings on preoperative magnetic resonance imaging to ensure that all areas of pigmented villonodular synovitis are excised.

The indications for establishing a transseptal portal have not been defined. We consider using the transseptal portal when there is extensive posterior compartment disease or when the synovium posterior to the posterior cruciate ligament is involved. In addition to improving visualization of the posterosuperior synovium lining the femoral condyles and the synovial reflection posterior to the posterior cruciate ligament, the transseptal portal provides a broader field of view, which increases instrument maneuverability in the posterior part of the knee.

If the transseptal portal is employed, the arthroscope may be transferred back and forth between both posterior accessory portals, driven through the transseptal portal, or
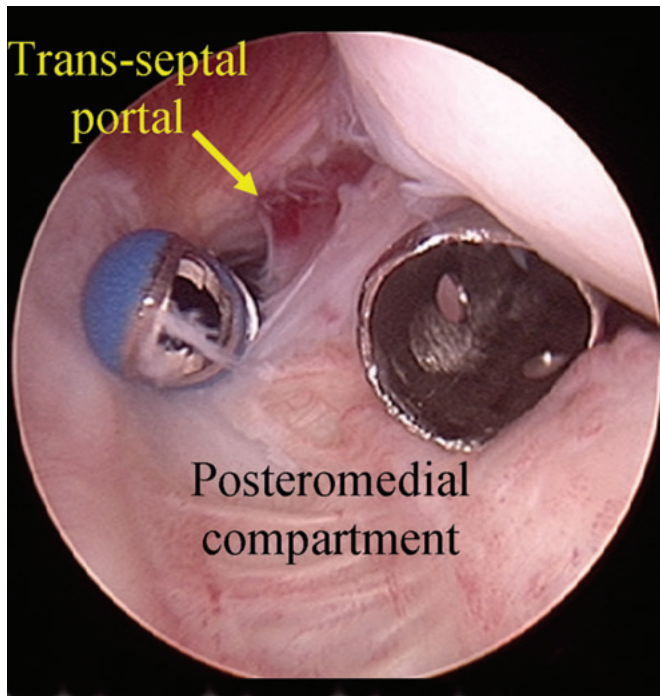
Fig. 8

Use of the transseptal portal in total arthroscopic synovectomy. The arthroscope is in the posteromedial accessory portal, the oscillating shaver has been placed through the transseptal portal, and the sleeve for the arthroscope remains in the medial transcondylar notch position.

placed in the transcondylar notch position to allow visualization of the entire posterior synovium. The oscillating shaver is placed in a posterior accessory portal and may be driven through the transseptal portal (Fig. 8). The entire portion of the posterior septum involved with pigmented villonodular synovitis is resected. The risk of injury to the popliteal artery during posterior compartment synovectomy is greatest during resection of the synovium lining the lateral femoral condyle. This risk is minimized by maintaining continuous joint lavage with the knee in 90° of flexion, by proper posterior-to-anterior orientation of instruments passed through the posterior accessory portals, and by synovial resection under direct visualization, with the shaver pointing anteriorly at all times.

Anterior compartment synovectomy follows. The plastic cannulas in the posterior accessory portals are removed prior to knee extension. Standard anterior portals may be obstructed; a large synovial wad of pigmented villonodular synovitis in the suprapatellar pouch can block the superolateral inflow portal or a large anterior fat pad nodule can obstruct the anteromedial portal. If this occurs, one should consider proceeding with auxiliary suprapatellar, mid-medial, or mid-lateral portals as needed to improve arthroscopic access to specified areas. The risk of hemarthrosis is minimized by achieving hemostasis prior to closure, placing intra-articular drains (if necessary), using thigh-high compression stockings,

applying a knee immobilizer, and maintaining protected weight-bearing for three days postoperatively.

Posterior Knee Arthroscopy for Repair or Reconstruction of the Posterior Cruciate Ligament

Proper visualization of the insertion of the posterior cruciate ligament is important for arthroscopic repair of avulsion fractures involving the posterior cruciate ligament and for reconstructions of the posterior cruciate ligament. Poor visualization can lead to neurovascular injuries, suboptimal repairs, malpositioning of tibial tunnels, and ultimately failure of the ligament reconstruction. Posterior knee arthroscopy techniques can be used to achieve proper visualization of the insertion of the posterior cruciate ligament.

The posterior cruciate ligament inserts on the proximal part of the tibia 10 to 15 mm inferior to the articular surface on the posterior half of the posterior intercondylar fossa[32]. The posterior horn of the medial meniscus inserts on the anterior half of the posterior intercondylar fossa, just anterior to the posterior cruciate ligament[33]. The popliteal artery is closest to the posterior cruciate ligament at the insertion of the posterior cruciate ligament, where it lies a mean of 9.7 mm (range, 3 to 16 mm) posteriorly at 90° of knee flexion[4]. Thus, the popliteal artery is immediately at risk during drilling of the tibial tunnel.

For reconstruction of the posterior cruciate ligament or repair of an avulsion of the posterior cruciate ligament, it is important to expose the entire tibial insertion site of the ligament. This can be done by detaching the posterior aspect of the capsule 10 mm inferior to the joint line with a right-angle rasp. The site of the insertion of the posterior cruciate ligament can then be visualized through a posteromedial accessory portal or a posterior transseptal portal. This aids in safe and proper positioning of the tibial tunnel in a posterior cruciate ligament reconstruction by allowing the hook of the posterior cruciate ligament tibial guide to be placed through the anteromedial portal to the site of the tibial insertion of the ligament under direct visualization.

Posterior Knee Arthroscopy for Meniscal Repair

Posterior knee arthroscopy also provides important visualization for repairs of the posterior horn of the meniscus. Unstable, vertical, peripheral tears of the posterior horn are the best candidates for repair. These tears have been estimated to account for 15% of all meniscal lesions in patients under forty years of age[34,35]. These posterior horn tears can be treated successfully with an all-inside repair technique with the use of posterior knee arthroscopic techniques.

Standard knee arthroscopy performed with transcondylar notch views can aid in the identification of tears of the posterior horn of the meniscus. If a posterior horn tear is suspected but is not visualized with transcondylar views, a posteromedial or posterolateral accessory portal can be established to provide better visualization with an increased ability to probe
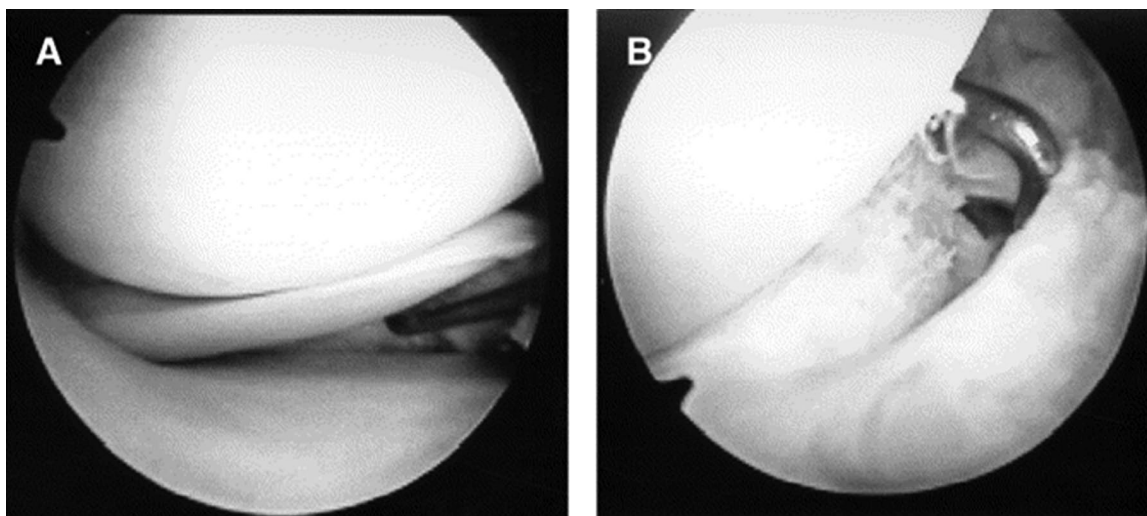
Fig. 9

Use of posterior knee arthroscopy to identify tears of the posterior horn of the meniscus. (Reprinted, with permission from the Arthroscopy Association of North America, from: Ahn JH, Kim SH, Yoo JC, Wang JH. All-inside suture technique using two posteromedial portals in a medial meniscus posterior horn tear. Arthroscopy. 2004;20:101-8.) *A:* On routine views, the posterior horn of the medial meniscus appears intact. *B:* A tear is apparent when it is visualized and probed through the posteromedial portal.

and identify otherwise unseen tears (Fig. 9, *A* and *B*). If a tear is identified and deemed to be repairable, the posteromedial or posterolateral accessory portal is used as the first working portal. The tear is explored with a probe through this portal and may be prepared with a meniscal rasp.

A second posterior working portal can then be created to help perform the subsequent repair. That second portal allows the use of an additional probe, which decreases the likelihood of cartilage damage by the suture hook and helps in the repair of more complex tears such as a double longitudinal tear of the posterior horn[34]. The second portal can be a transseptal portal or a second portal in the same posterior compartment. The transseptal portal can facilitate fragment reduction by providing a portal through which an instrument can hold the central mobile fragment to allow advancement of a suture hook. A second posteromedial accessory portal placed 1 cm above the standard posteromedial portal has also been described for repair of tears of the posterior horn of the medial meniscus[34,36]. Recently, Ahn et al.[36] reported a 97.4% success rate, as demonstrated by second-look arthroscopy, after use of the two-posteromedial-portal technique for repair of the posterior horn of the meniscus in thirty-nine knees.

Complications of Posterior Knee Arthroscopy

The overall incidence of neurovascular injuries from knee arthroscopy ranges from 0.01% to 0.08%[37,38]. These injuries most commonly involve the saphenous nerve, with saphenous nerve injuries occurring in an estimated 7% to 22% of patients undergoing medial meniscal repair[17,39]. Vascular injuries, most of which occur as a result of direct penetration or laceration at the time of surgery, represent 1% of all neurovascular complications[38].

Injury to the popliteal artery is a potentially devastating complication of posterior knee arthroscopy. A detailed knowledge of posterior knee anatomy relevant to the arthroscopist (as discussed earlier) is vital to injury prevention. Popliteal artery injuries range from pseudoaneurysm to acute occlusion to direct laceration. Popliteal artery injuries are rare but have been reported during posterior horn lateral meniscectomy[40-42], arthroscopic reconstruction of the posterior cruciate ligament[43,44], and posterior compartment synovectomy[45]. In 1986, a retrospective survey of procedures performed by members of the Arthroscopy Association of North America identified nine lacerations of the popliteal artery in association with 375,000 knee arthroscopies (a rate of (0.002%)[46]. Most of these injuries occurred during lateral meniscectomy[40,41]. While the popliteal artery is clearly at risk during placement of the transseptal portal, we are not aware of any documented cases of popliteal artery injury during that procedure.

One risk factor for popliteal artery injury is prior procedures involving the posterior compartment. These result in extracapsular scarring, which may cause the popliteal artery to adhere to the posterior aspect of the capsule[45]. Distention of a scarred joint capsule alone can injure popliteal vessels[45]. In addition, extensive posterior compartment synovitis (as is often found in patients with pigmented villonodular synovitis) can limit visualization and increase the risk of popliteal artery injury[45].

Popliteal artery injury during posterior knee arthroscopy can be prevented by judicious use of posterior portals in patients with the above risk factors. Positioning of posterior accessory portals too far anteriorly should be avoided to prevent anterior-to-posterior orientation of the instruments. The oscillating shaver should always face anteriorly during resec-

tion of posterior synovial tissue. Resection in the posterior compartments should proceed under direct visualization only, particularly during resection of the synovium lining the lateral femoral condyle.

   Suspicion of popliteal artery injury mandates immediate vascular surgery consultation[42]. An arteriogram may be obtained by the vascular surgeon to analyze the injury. If there is a high index of suspicion for popliteal artery injury, posterior exploration with the patient prone is indicated. Often the vascular surgeon will utilize an autologous vein bypass graft to restore blood flow to the extremity. Prophylactic fasciotomies of the leg should be considered to prevent compartment syndrome resulting from reperfusion injury[42].

   Pseudoaneurysm of the popliteal artery can be a late sequela of acute laceration. This injury may not be immediately apparent. The treatment of such a pseudoaneurysm involves exploration, resection, and grafting by a vascular surgeon. Pseudoaneurysms have also been reported in genicular arteries following knee arthroscopy[38].

Overview

Posterior knee arthroscopy is technically demanding but, when indicated, it can provide access to the posterior as-

pect of the knee that is superior to that provided by open procedures. Safe and effective implementation requires a detailed knowledge of posterior knee anatomy relevant to the arthroscopist, meticulous technique, familiarity with various portal options, and an awareness of the potential complications. ∎

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References

1. Farrington WJ, Charnley GJ, Harries SR, Fox BM, Sharp R, Hughes PM. The position of the popliteal artery in the arthritic knee. J Arthroplasty. 1999;14:800-2.

2. Ninomiya JT, Dean JC, Goldberg VM. Injury to the popliteal artery and its anatomic location in total knee arthroplasty. J Arthroplasty. 1999;14:803-9.

3. Shetty AA, Tindall AJ, Qureshi F, Divekar M, Fernando KW. The effect of knee flexion on the popliteal artery and its surgical significance. J Bone Joint Surg Br. 2003;85:218-22.

4. Cosgarea AJ, Kramer DE, Bahk MS, Totty WG, Matava MJ. Proximity of the popliteal artery to the PCL during simulated knee arthroscopy: implications for establishing the posterior trans-septal portal. J Knee Surg. 2006;19:181-5.

5. Matava MJ, Sethi NS, Totty WG. Proximity of the posterior cruciate ligament insertion to the popliteal artery as a function of the knee flexion angle: implications for posterior cruciate ligament reconstruction. Arthroscopy. 2000;16:796-804.

6. Smith PN, Gelinas J, Kennedy K, Thain L, Rorabeck CH, Bourne RB. Popliteal vessels in knee surgery. A magnetic resonance imaging study. Clin Orthop Relat Res. 1999;367:158-64.

7. Gillquist J, Hagberg G. A new modification of the technique of arthroscopy of the knee joint. Acta Chir Scand. 1976;142:123-30.

8. Amin KB, Cosgarea AJ, Kaeding CC. The value of intercondylar notch visualization of the posteromedial and posterolateral compartments during knee arthroscopy. Arthroscopy. 1999;15:813-7.

9. Ahn JH, Ha CW. Posterior trans-septal portal for arthroscopic surgery of the knee joint. Arthroscopy. 2000;16:774-9.

10. Lubowitz JH, Rossi MJ, Baker BS, Guttmann D. Arthroscopic visualization of the posterior compartments of the knee. Arthroscopy. 2004;20:675-80.

11. Morin WD, Steadman JR. Arthroscopic assessment of the posterior compartments of the knee via the intercondylar notch: the arthroscopist's field of view. Arthroscopy. 1993;9:284-90.

12. Gold DL, Schaner PJ, Sapega AA. The posteromedial portal in knee arthroscopy: an analysis of diagnostic and surgical utility. Arthroscopy. 1995;11:139-45.

13. Tolin BS, Sapega AA. Arthroscopic visual field mapping at the periphery of the medial meniscus: a comparison of different portal approaches. Arthroscopy. 1993;9:265-71.

14. Louisia S, Charrois O, Beaufils P. Posterior "back and forth" approach in arthroscopic surgery on the posterior knee compartments. Arthroscopy. 2003; 19:321-5.

15. Ogilvie-Harris DJ, Biggs DJ, Mackay M, Weisleder L. Posterior portals for

arthroscopic surgery of the knee. Arthroscopy. 1994;10:608-13.

16. Arthornthurasook A, Gaew-Im K. The sartorial nerve: its relationship to the medial aspect of the knee. Am J Sports Med. 1990;18:41-2.

17. Dunaway DJ, Steensen RN, Wiand W, Dopirak RM. The sartorial branch of the saphenous nerve: its anatomy at the joint line of the knee. Arthroscopy. 2005;21:547-51.

18. Morganti CM, McFarland EG, Cosgarea AJ. Saphenous neuritis: a poorly understood cause of medial knee pain. J Am Acad Orthop Surg. 2002;10:130-7.

19. Romanoff ME, Cory PC Jr, Kalenak A, Keyser GC, Marshall WK. Saphenous nerve entrapment at the adductor canal. Am J Sports Med. 1989;17:478-81.

20. Worth RM, Kettelkamp DB, Defalque RJ, Duane KU. Saphenous nerve entrapment. A cause of medial knee pain. Am J Sports Med. 1984;12:80-1.

21. Mozes M, Ouaknine G, Nathan H. Saphenous nerve entrapment simulating vascular disorder. Surgery. 1975;77:299-303.

22. Dellon AL, Mont MA, Mullick T, Hungerford DS. Partial denervation for persistent neuroma pain around the knee. Clin Orthop Relat Res. 1996;329:216-22.

23. Deutsch A, Wyzykowski RJ, Victoroff BN. Evaluation of the anatomy of the common peroneal nerve. Defining nerve-at-risk in arthroscopically assisted lateral meniscus repair. Am J Sports Med. 1999;27:10-5.

24. Myers BW, Masi AT. Pigmented villonodular synovitis and tenosynovitis: a clinical epidemiologic study of 166 cases and literature review. Medicine (Baltimore). 1980;59:223-38.

25. McCarthy EF, Frassica FJ. Pathology of bone and joint disorders: with clinical and radiographic correlation. Philadelphia: Saunders; 1998. Diseases of synovial membrane; p 310,311.

26. Klompmaker J, Veth RP, Robinson PH, Molenaar WM, Nielsen HK. Pigmented villonodular synovitis. Arch Orthop Trauma Surg. 1990;109:205-10.

27. Schwartz HS, Unni KK, Pritchard DJ. Pigmented villonodular synovitis. A retrospective review of affected large joints. Clin Orthop Relat Res. 1989;247:243-55.

28. Zvijac JE, Lau AC, Hechtman KS, Uribe JW, Tjin-A-Tsoi EW. Arthroscopic treatment of pigmented villonodular synovitis of the knee. Arthroscopy. 1999;15:613-7.

29. Chin KR, Barr SJ, Winalski C, Zurakowski D, Brick GW. Treatment of advanced primary and recurrent diffuse pigmented villonodular synovitis of the knee. J Bone Joint Surg Am. 2002;84:2192-202.

30. Ogilvie-Harris DJ, McLean J, Zarnett ME. Pigmented villonodular synovitis of the knee. The results of total arthroscopic synovectomy, partial, arthroscopic

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synovectomy, and arthroscopic local excision. J Bone Joint Surg Am. 1992; 74:119-23.

31. Kramer DE, Frassica FJ, Cosgarea AJ. Total arthroscopic synovectomy for pigmented villonodular synovitis of the knee. Tech Knee Surg. 2004;3:36-45.

32. Cosgarea AJ, Jay PR. Posterior cruciate ligament injuries: evaluation and management. J Am Acad Orthop Surg. 2001;9:297-307.

33. Kantaras AT, Johnson DL. The medial meniscal root as a landmark for tibial tunnel position in posterior cruciate ligament reconstruction. Arthroscopy. 2002; 18:99-101.

34. Ahn JH, Kim SH, Yoo JC, Wang JH. All-inside suture technique using two posteromedial portals in a medial meniscus posterior horn tear. Arthroscopy. 2004;20:101-8.

35. Reigel CA, Mulhollan JS, Morgan CD. Arthroscopic all-inside meniscus repair. Clin Sports Med. 1996;15:483-98.

36. Ahn JH, Wang JH, Yoo JC. Arthroscopic all-inside suture repair of medial meniscus lesion in anterior cruciate ligament—deficient knees: results of second-look arthroscopies in 39 cases. Arthroscopy. 2004;20:936-45.

37. Complications of arthroscopy and arthroscopic surgery: results of a national survey. Committee on Complications of Arthroscopy Association of North America. Arthroscopy. 1985;1:214-20.

38. Kim TK, Savino RM, McFarland EG, Cosgarea AJ. Neurovascular compli-

cations of knee arthroscopy. Am J Sports Med. 2002;30:619-29.

39. Mochida H, Kikuchi S. Injury to infrapatellar branch of saphenous nerve in arthroscopic knee surgery. Clin Orthop Relat Res. 1995;320:88-94.

40. Jeffries JT, Gainor BJ, Allen WC, Cikrit D. Injury to the popliteal artery as a complication of arthroscopic surgery. A report of two cases. J Bone Joint Surg Am. 1987;69:783-5.

41. Potter D, Morris-Jones W. Popliteal artery injury complicating arthroscopic meniscectomy. Arthroscopy. 1995;11:723-6.

42. Tawes RL Jr, Etheredge SN, Webb RL, Enloe LJ, Stallone RJ. Popliteal artery injury complicating arthroscopic meniscectomy. Am J Surg. 1988; 156:136-8.

43. Cohen SB, Boyd L, Miller MD. Vascular risk associated with posterior cruciate ligament reconstruction using the arthroscopic transtibial tunnel technique. J Knee Surg. 2004;17:211-3.

44. Wu RW, Hsu CC, Wang CJ. Acute popliteal artery occlusion after arthroscopic posterior cruciate ligament reconstruction. Arthroscopy. 2003;19:889-93.

45. Furie E, Yerys P, Cutcliffe D, Febre E. Risk factors for arthroscopic popliteal artery laceration. Arthroscopy. 1995;11:324-7.

46. Complications in arthroscopy: the knee and other joints. Committee on Complications of the Arthroscopy Association of North America. Arthroscopy. 1986;2:253-8.