Systematic Arthroscopic Treatment of Diffuse Pigmented Villonodular Synovitis in the Knee

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Abstract: Pigmented villonodular synovitis (PVNS) is a benign aggressive disease that presents in either a localized (LPVNS) or diffuse (DPVNS) form. Arthroscopic synovectomy is the standard operative treatment for LPVNS, and when used to treat DPVNS, it is usually combined with an open posterior procedure. The purpose of this Technical Note is to report the technique that we have refined to allow for arthroscopic synovectomy as the sole treatment for DPVNS. We describe our technique with the factors we have found to be important to ensure adequate arthroscopic synovectomy, while minimizing risks and complications. The combination of additional portals, the use of multiple different shavers and arthroscopes, and the use of a leg holder all maximize our ability to clear disease.

Pigmented villonodular synovitis (PVNS, also termed tenosynovial giant cell tumor) is a rare synovial proliferative disease characterized histologically by the presence of inflammation, hemosiderin deposition, multinucleate giant cells, and lipid-laden macrophages.[1,2] PVNS is a benign aggressive disease that presents in either a localized (LPVNS) or diffuse (DPVNS) form. If left untreated, it can progress to severe degenerative changes and osteoarthritis.[3]

DPVNS is most commonly located in the knee and is characterized by diffuse synovial involvement, without the pedunculated areas of disease seen in LPVNC. The accepted mainstay of treatment for DPVNS is surgical excision and total synovectomy to treat symptomatic disease and prevent progression of degenerative changes.[3] Controversy remains over the optimal surgical technique for total synovectomy, particularly in the knee. Open, arthroscopic, and combined techniques have been described.[4-7] The optimal procedure should limit morbidity, while limiting recurrence. Open synovectomy is associated with increased hospital stay and prolonged rehabilitation; however, achieving the same synovectomy arthroscopically is technically demanding.[4,5] It may be difficult to achieve complete excision arthroscopically, particularly in the posteromedial and posterolateral compartments, but once accessed, PVNS is easily removed with the shaver as it peels away from the synovium. However, as DPVNS may be adherent to bone and involve any area of the knee, including submeniscal and intercruciate deposits, complete removal of disease is challenging without risking significant damage to other structures.

Mollen et al.[6] published a systematic review showing recurrence rates of 37.8% for arthroscopic synovectomy for the treatment of DPVNS and 13.9% combined with open posterior synovectomy. Occasionally, the disease extends posteriorly through the capsule, making arthroscopic resection dangerous and necessitating an open posterior approach to ensure complete synovectomy. The review showed that, for most surgeons, the decision of whether to treat DPVNS with arthroscopic synovectomy is made on a case-by-case basis. The role of adjuvant external beam radiotherapy is controversial, and did not show any reduction in recurrence rates after a combined synovectomy.[6,7]

Our technique for arthroscopic excision of DPVNS of the knee is described in this Technical Note (Video 1). This procedure may be combined with an open

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posterior synovectomy in certain instances, but allows sufficient access and removal of disease in the most cases. Our aim is to describe techniques that have evolved over time in our cohort and technical pearls that allow for adequate excision of disease while minimizing complications and risk (Table 1).

Surgical Technique

Step 1: Patient Positioning and Setup

After the induction of general anesthesia, bilateral examination of the knees is performed. The patient is positioned to allow unrestricted access to the anterior and posterior aspects of the knee, room for instrument manipulation, and the ability to change the flexion angle throughout the case (Fig 1). We achieve this by using a leg holder (ACUFEX, Smith & Nephew, Andover, MA), with the end of the bed removed, positioned as proximal as possible to maximize posterior access and possible flexion. A well-padded high tourniquet is used with exsanguination of the limb before inflation. The contralateral leg is positioned in a lithotomy boot with the hip abducted and knee flexed less than 90°.

Table 1. Surgical Pearls and Pitfalls

Pearls	Pitfalls
The use of a leg holder allows maximization of access and ability to change the knee flexion angle	Inadequate visualization increases the risk of leaving symptomatic disease and recurrence
Establishing and using multiple portals, including superomedial, superolateral, accessory posteromedial, and accessory posterolateral portals, is needed in most cases	Access can be limited by poor positioning or a low tourniquet/leg holder
Various degrees of flexion and extension improve the ability to debride difficult areas in the posteromedial and posterolateral compartment	Using a single shaver risks inadequate debridement and increases the risk of chondral damage while attempting to debride difficult areas
Visualization through the posterolateral portal and debridement through the notch allows for adequate debridement of pigmented villonodular synovitis (PVNS) in close proximity to the cruciate ligaments	The posterior condyles may prevent extensive debridement if the posterior portals are established too distal and close to the joint line
Regularly cycling between portals, 30° and 70° arthroscopes, and different shavers helps to ensure adequacy of debridement	
It is often necessary to use 3 shavers (4.5 mm, 5.5 mm, and curved) and a system that allows switching from 30° to 70° arthroscopes to visualize and debride all areas	

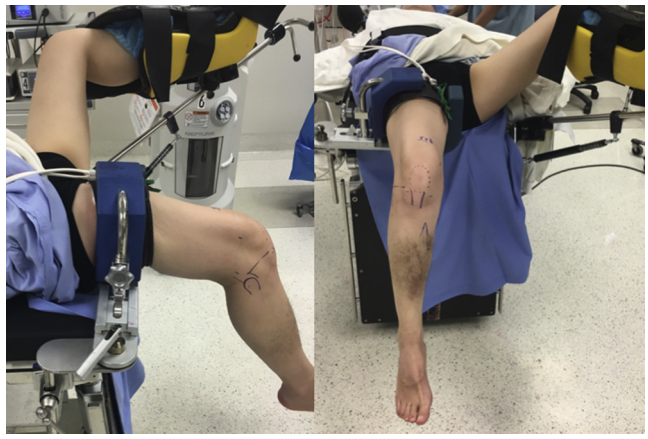

Fig 1. Patient positioning and setup. The patient is supine with the right knee positioned with a high tourniquet and the thigh secured proximally in the leg holder to allow for maximum flexion and freedom of instruments. The contralateral left leg is positioned in a lithotomy boot.

The surface anatomy of the knee and expected portal placements are marked out. Standard anteromedial and anterolateral portals are marked. In addition, superomedial, superolateral, posteromedial, posterolateral, accessory posteromedial, and accessory posterolateral portals are marked out as well (Fig 2).

Step 2: Anterior Synovectomy

Standard anteromedial and anterolateral portals are established using a number 11 blade. Superolateral and superomedial portals are created to function as outflow, viewing, and working portals. In cases where the suprapatellar pouch has been chronically expanded and anterior disease extends far proximally, additional

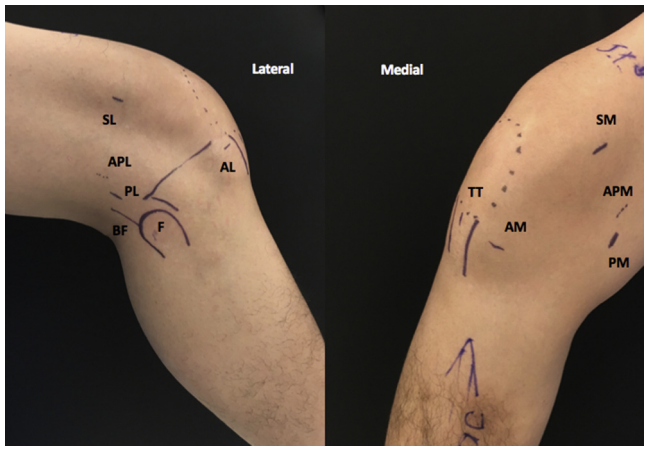

Fig 2. Surface anatomy and portal placements. The surface anatomy and portal placements are marked out for the right knee. View from both the lateral and medial aspect of the right knee is shown. (AL, anterolateral; AM, anteromedial; APL, accessory posterolateral; APM, accessory posteromedial; BF, biceps femoris; F, fibula; PL, posterolateral; PM, posteromedial; SL, superolateral; SM, superomedial; TT, transpatellar tendon.)

Fig 3. Multiple shavers are used to ensure adequacy of debridement (1, DYONICS 4.5-mm Full Radius, Smith & Nephew; 2, DYONICS 5.5-mm INCISOR PLUS Elite, Smith & Nephew; and 3, DYONICS 4.5-mm Curved INCISOR Plus Elite, Smith & Nephew).

proximal portals may be necessary, as disease may extend proximally beyond the reach of standard shavers. A standard diagnostic arthroscopy is then performed using a 30° arthroscope and appropriate biopsy specimens are taken. A systematic anterior synovectomy is then performed starting in the suprapatellar pouch. The medial and lateral gutters are then visualized and synovitis is debrided. It is useful to use the superomedial and superolateral portals as both viewing and working portals to ensure thorough debridement. Occasionally, a central parapatellar vertical portal is made in addition. Cycling instruments between portals ensures that all areas are visualized while being accessed by the shaver. A 70° arthroscope and a curved shaver (DYONICS 4.5-mm Curved INCISOR Plus Elite, Smith & Nephew) are frequently necessary to visualize and debride areas that are difficult to access.

Step 3: Establishment of Posterolateral Portals and Posterolateral Synovectomy

The posterolateral compartment is accessed using the modified Gillquist maneuver between the lateral femoral condyle and the anterior cruciate ligament (ACL). The arthroscope is placed through the anterolateral portal independent from the arthroscope sheath. Under direct visualization, the arthroscope sheath (with the introducing trocar) is passed through the anteromedial portal between the lateral femoral condyle and the ACL. The introducer is then removed and the arthroscope placed through the sheath into the posterolateral compartment. A posterolateral portal is then established using an outside-in technique. A spinal needle is used to localize portal placement proximal to the joint line and anterior to the biceps femoris tendon to avoid injury to the common peroneal nerve. The portal should be established proximal enough to ensure adequate freedom of instruments around the posterolateral condyle. A number 15 blade is used to cut the skin only, and then a straight hemostat is introduced to bluntly dissect into the joint under direct visualization (following the trajectory of the spinal needle). Again, a 70° arthroscope and a combination of straight (DYONICS 4.5-mm Full Radius and DYONICS 5.5-mm INCISOR PLUS Elite, Smith & Nephew) and curved shavers are often necessary to ensure adequate debridement (Fig 3).

Varying the degree of flexion and extension at this stage allows the shavers to reach difficult areas, and facilitates adequate debridement of the superior aspect of the posterior compartment (Fig 4). A second accessory posterolateral portal is frequently necessary to ensure a complete synovectomy and debridement.

Next, the shaver is inserted though the anteromedial portal (either between the lateral femoral condyle and the ACL or between the ACL and the posterior cruciate ligament [PCL]) to debride intercruciate disease. It is useful in this situation to view from the posterolateral portal and use the curved shaver.

Step 4: Establishment of Posteromedial Portals and Posteromedial Synovectomy

The posteromedial compartment is accessed using the modified Gillquist maneuver between the medial femoral condyle and the PCL (Fig 5). A posteromedial

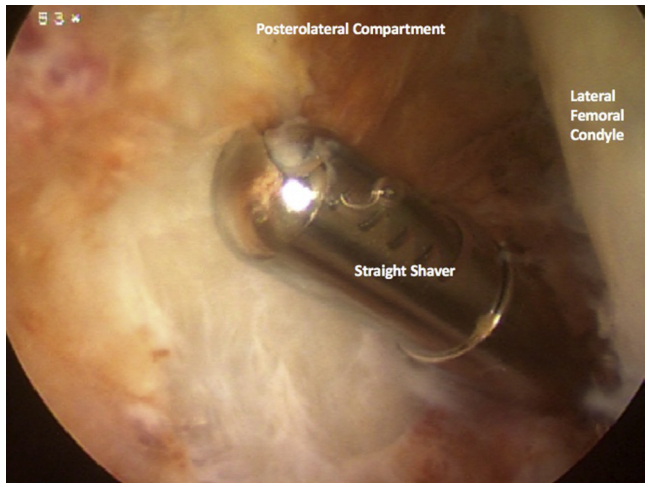

Fig 4. View of the left knee posterolateral compartment through the anteromedial portal via the notch. A straight shaver is used to debride pigmented villonodular synovitis in the posterolateral compartment. Use of multiple shavers is useful to ensure adequate synovectomy. Varying the degree of flexion and extension at this stage allows the shavers to reach difficult areas and facilitates adequate debridement of the superior aspect of the posterior compartment.

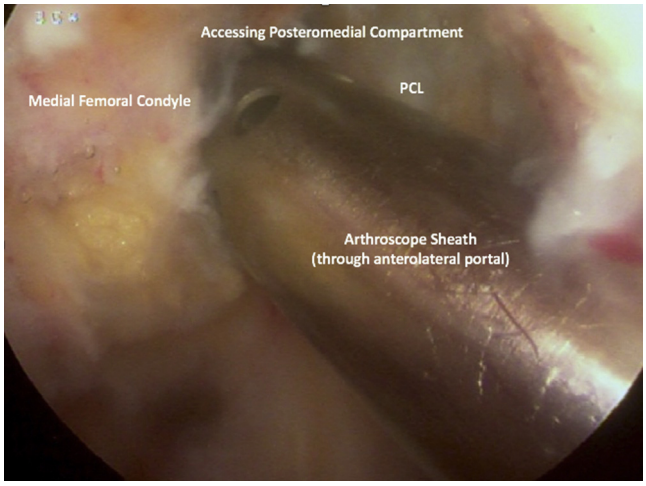

Fig 5. View from the anteromedial portal of the left knee. The posteromedial compartment is accessed by placing the arthroscope through the anteromedial portal independent from the sheath. Under direct visualization, the arthroscope sheath (with the introducing trocar) is passed through the anterolateral portal into the posteromedial compartment. (PCL, posterior cruciate ligament.)

portal is created using an outside-in technique in the same fashion as the posterolateral portal. The portal is positioned posterior to the medial femoral condyle and proximal to the joint line. The saphenous nerve and vein are at risk if the portal is established too posterior. Similar to the posterolateral compartment, an accessory posteromedial portal is often used for both viewing and debridement. It is also helpful to visualize the compartment from the posteromedial portal and work posteriorly through the notch in a similar fashion to the posterolateral compartment. Cycling regularly between the 30° and 70° arthroscopes and the anterolateral and posteromedial portals facilitates adequate synovectomy.

Step 5: Trans-septal Posterior Approach

A trans-septal approach is used to facilitate adequate resection of the PVNS centrally. The posteromedial compartment is viewed through the notch with a 70° arthroscope. The curved shaver (through the posteromedial portal) is then used to work from medial to lateral, staying against the posteromedial femoral condyle under direct vision until it falls through the septum. The septum is perforated at the distal portion just posterior to the PCL and in flexion to maximize distance from the neurovascular bundle. Visualization of both the posterolateral and posteromedial compartments is improved once the septum is perforated.

Discussion

Although controversy remains over the optimal method of surgical excision of DPVNS,[4-7] the technical pearls described above have enabled adequate arthroscopic synovectomy for DPVNS in the most cases, without the need for an additional open posterior synovectomy. The primary advantages of isolated arthroscopic synovectomy for DPVNS are minimizing postoperative stiffness, shorter hospital stay, shorter period of rehabilitation, and fewer wound complications compared with open surgery (Table 2).[4,5]

Positioning the patient using a proximally placed leg holder with a high tourniquet is helpful to ensure optimal visualization and freedom of instruments. We have often found it necessary to use 3 different shavers (Fig 3) to facilitate thorough synovectomy. Access to a system that permits easy switching from a 30° to a 70° arthroscope improves the efficiency of the operation. Accurate portal placement is important to ensure freedom of instruments and adequate visualization. Specifically, inferior portal placement in the posterior portals may result in obstruction of the instruments by the posterior condyles. We also do not hesitate to create additional portals, particularly in the suprapatellar, posteromedial, and posterolateral compartments, to improve both instrumentation and visualization. Varying the degree of flexion and extension of the knee is valuable, particularly when debriding the synovium in close proximity to the posterior condyles.

The main risks of arthroscopic treatment alone involve damage to neurovascular structures when accessing the posterior compartments of the knee. Establishing the posterolateral portal anterior to the biceps femoris tendon is important to ensure safety of the common peroneal nerve. The saphenous nerve and vein are also at risk when creating the posteromedial portal. Although using a trans-septal approach allows for improved visualization in the posteromedial and posterolateral compartments, care must be taken to ensure safety of the neurovascular bundle and PCL when taking down the septum. Residual disease is also a risk and increases the chance of recurrence;

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Arthroscopic excision of diffuse pigmented villonodular synovitis (DPVNS) is associated with decreased hospital stay	Achieving adequate arthroscopic excision of DPVNS is technically challenging
The risk of wound complications is decreased with arthroscopic excision	Disease that extends posteriorly through the capsule cannot be safely accessed arthroscopically. This necessitates an open posterior approach to ensure adequate synovectomy
There is less postoperative stiffness and faster rehabilitation compared with an open or a combined approach	Neurovascular structures are at risk when debriding disease in the posterior compartments

submeniscal and intercruciate disease can be easily missed if not specifically identified and debrided.

Although we recognize that this procedure is technically challenging and may have a steep learning curve, most of our patients opt to undergo this primary procedure, accepting a slightly increased revision rate. We feel that our results can widely be replicated by following the steps in this technical guide.

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