

Pigmented Villonodular Synovitis

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Abstract

Pigmented villonodular synovitis is a proliferative condition of the synovium. Monoarticular involvement, the most common process, occurs in two forms: localized and diffuse. The localized form is characterized by focal involvement of the synovium, with either nodular or pedunculated masses; the diffuse form affects virtually the entire synovium. The localized form has an excellent prognosis and a low recurrence rate when managed surgically. The more common diffuse form has a reported recurrence rate of up to 46%. Although the condition can present in any joint, the knee is the most commonly affected site. Pigmented villonodular synovitis is often aggressive, with marked extra-articular extension. Open synovectomy is the standard method of management. Arthroscopic synovectomy, which has gained popularity, has several advantages over the open technique, but it is associated with higher recurrence rates in diffuse pigmented villonodular synovitis. Synovectomy by any approach, however, may prevent secondary osteoarthritis and subsequent joint arthroplasty. Radiation-induced synovectomy has shown mixed results. Combined surgical and nonsurgical approaches may be necessary, and in some patients, total joint arthroplasty may be the only effective treatment.

Pigmented villonodular synovitis (PVNS) is a condition of the synovial membrane that is characterized by the presence of inflammation and hemosiderin deposition in the synovium. On the microscopic level, it is identified by the characteristic presence of lipid-laden macrophages, multinucleated giant cells, hemosiderin deposition, and stromal and fibroblast cell proliferation¹ (Figure 1).

PVNS was likely first described in 1852 and was originally thought to be a neoplastic process² because of its unrelenting growth pattern, capacity to erode surrounding bone and joint tissue, and high recurrence rate after resection. In 1941, howev-

er, Jaffe et al³ presented the pathologic entity as a synovitis, thereby shifting the focus from a neoplastic process to an inflammatory one. Although PVNS exhibits neither cellular atypia nor abnormal mitotic activity, recent observations of cytogenetic abnormalities demonstrate that its pathogenesis remains unresolved.¹

The surgeon must understand the etiology and pathogenesis of PVNS as well as its clinical presentation and diagnosis. The two forms of PVNS that are distinguished in the literature are diffuse (DPVNS) and localized (LPVNS). Although often described as discrete entities, these two presentations of PVNS are like-

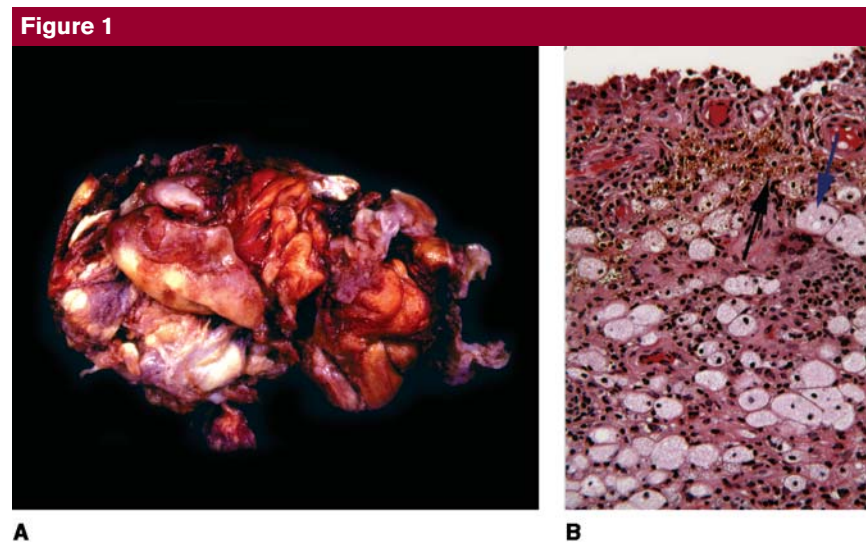
ly two extremes on the spectrum of one disease process. Management options for PVNS include radiation-induced, arthroscopic, and open synovectomy.

Etiology

The etiology of PVNS is still largely unknown. Some suggest that it occurs as a result of trauma and subsequent recurrent local hemorrhage to the affected joint. Support for this theory comes from the observation that patients with hemophilia have progressive erosive arthropathies. Hemophiliac patients also develop a lobular synovitis with extensive hemosiderin deposition, similar to that seen in PVNS. Furthermore, injection of colloidal iron into the joint produces histologic changes that are very similar to PVNS.⁴ Hemophiliac synovial pathology differs from PVNS, however, in that it lacks lipid-laden histiocytes and giant cells, which are considered classic indications of PVNS. Studies that produced similar histologic findings to PVNS by injecting iron or blood into the joint were not able to reproduce the classic lipid-laden histiocytes and giant cells.⁴ Most series report a history of trauma in fewer than one third of patients.^{1,5} For these reasons, the theory of repeated trauma and hemarthrosis as an explanation for PVNS has fallen out of favor.

Abnormal local metabolic activity also has been suggested as an inciting event for the inflammation seen in PVNS,⁶ but it has been an inconsistent finding. Research studies have failed to reproduce the entity of PVNS by altering the local metabolic environment.⁷

There is still some support in the literature to suggest that PVNS is a neoplastic process. The presence of trisomy 7 and clonal DNA rearrangements have been reported by several authors.⁸⁻¹⁰ There also have been rare reports of malignant transformation and metastasis in patients initially diagnosed with PVNS.^{9,11}



A, Gross photomicrograph of diffuse, nodular pigmented villonodular synovitis lesion removed as part of a complete synovectomy. Note the fibroadipose appearance and nodularity as well as the brownish discoloration representing hemosiderin deposition. **B**, Low-power (x10) hematoxylin-and-eosin stain of a pigmented villonodular synovitis lesion. Note the multinucleated giant cells, hemosiderin deposition (black arrow), and lipid-laden macrophages (blue arrow).

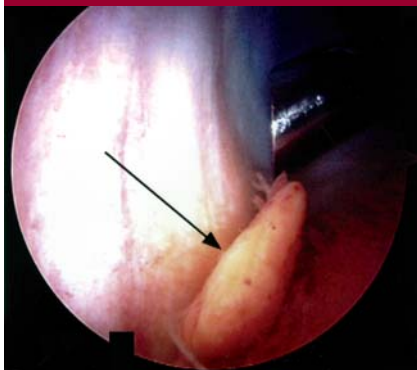
Bertoni et al⁹ characterized eight patients with malignant PVNS; the mortality rate was 50%. In three patients, the original lesion showed classic PVNS histology. Abnormal histologic characteristics were present in all of the lesions identified as malignant PVNS.

Despite the findings of reported cases of malignant PVNS and the presence of DNA aneuploidy, there is also evidence against PVNS being a neoplastic process. Oehler et al¹² found in their analysis of cell populations in PVNS strong support for its being a chronic inflammatory process. Their findings were based on the presence of a cell marker for inflammation within a heterogeneous population of mononuclear cells.¹² They also postulated that the presence of excessive amounts of iron in the lesion stimulated synoviocytes and fibroblasts to take on macrophage-like characteristics. This may explain why it was thought that the cells in PVNS were of a homogeneous and perhaps neoplastic origin. Currently, there are

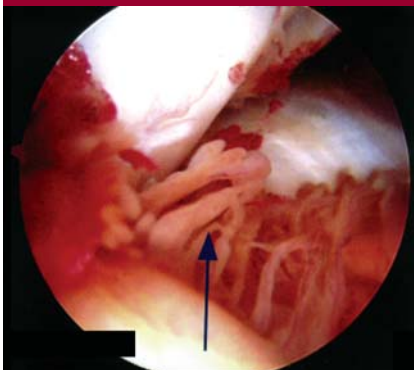
no conclusive data to substantiate the etiology of PVNS as either an oncologic or an inflammatory process.

Pathophysiology and Natural History

Histologically, LPVNS and DPVNS are similar; however, they differ in their clinical presentation, prognosis, and response to treatment. The localized form of the disease is characterized by a pedunculated, lobular lesion localized to one area of the synovium (Figure 2). In the knee, LPVNS lesions occur most commonly in the anterior compartment. Flandry and Hughston² reported that most of these lesions arise at the meniscocapsular junction. Numerous case series support this assertion.¹³⁻¹⁵ The synovium in the region of the anterior horn of the medial meniscus is the most common site of involvement. Patients with lesions in this location often present with signs and symptoms suspicious of meniscal pathology. Additionally, involvement of the in-

Figure 2

Arthroscopic view of localized pigmented villonodular lesion (arrow) before resection. Note the pedunculated appearance of this discrete lesion.

Figure 3

Arthroscopic image of diffuse pigmented villonodular synovitis (arrow). Note the villous nature and diffuse synovial involvement.

frapatellar fat pad, suprapatellar pouch, intercondylar notch, anterior horn of the lateral meniscus, and the medial and lateral recesses of the knee have been reported.¹³⁻¹⁸ Because of its localized nature, LPVNS has a favorable prognosis.

Left untreated, LPVNS continues to cause pain and discomfort, thus limiting activity and function. No studies have examined the long-term outcomes of patients left untreated for LPVNS, likely because LPVNS has a lower recurrence rate and is frequently more easily treated.^{7,19,20} Most authors agree that marginal excision of the lesion results in a good to excellent outcome, especially when treated early. In their review of early literature, Granowitz et al⁷ found only 2 recurrences of 24 reported cases of LPVNS in the knee (8%) versus a reported 30% recurrence rate for DPVNS.⁷

DPVNS is characterized by involvement of most or all of the joint synovium (Figure 3). It is the more common form of PVNS and often presents with global joint findings. Swelling and pain are more pronounced than in LPVNS and usually are poorly localized. DPVNS tends to have a more rapidly destructive course and, as a result, a poorer prognosis. DPVNS also can present with

extra-articular extension, either at the time of primary diagnosis or as recurrent disease. Extra-articular DPVNS can encroach on major neurovascular structures, making surgical excision more challenging and complete excision difficult.²¹ Despite treatment, the recurrence rate for DPVNS is reportedly high. Early reports of recurrence rates after treatment of DPVNS were as high as 46%.²² With careful and thorough surgical excision, however, the recurrence rate has been reported to be as low as 8%.²³

DPVNS can pose a significant problem for the patient, in part because of its high recurrence rate as well as its destructive course. As noted, complete excision is a challenge for the treating surgeon. Early clinical experience proved that the natural history of DPVNS is marked by continued pain, swelling, and decreased range of motion of the affected joint. The continued inflammation and joint erosions that develop lead to articular cartilage destruction and subsequent osteoarthritis. The end result can be the need for total joint arthroplasty. In a series of seven patients with DPVNS of the hip, Gonzalez Della Valle et al²⁴ noted that six patients initially presented with mild symptoms. Within a

period of 4.5 years without treatment, however, all developed severe, debilitating pain and limited ambulation. Two patients in the series had early radiographs demonstrating minimal articular cartilage destruction, but at 4- and 11-year follow-ups, both had developed advanced joint space narrowing and cystic changes in the acetabulum and in the femoral head. Although no radiographic changes were found at 2-year follow-up in one patient who refused treatment after biopsy proved the presence of PVNS, five of the seven patients required a total hip replacement before age 40 years.²⁴

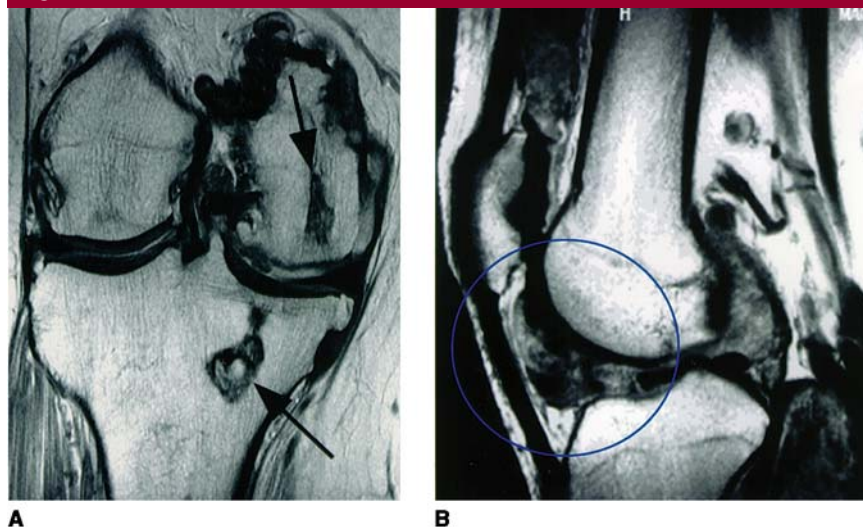
Although a seemingly clear-cut distinction has been made between DPVNS and LPVNS, the two entities exist along a continuum of one disease process. It is important to note, however, that there are patients who present initially with LPVNS who are later found to have more extensive disease involvement.

Clinical Presentation

PVNS is typically a monoarticular process that often involves the large joints. The knee is the most commonly involved joint, but others include the hip, ankle, shoulder, and elbow.⁵ PVNS often appears in the third and fourth decades of life. Historically, this condition was thought to be more common in men, but most recent series show no sex-based predilection.^{1,2,5} The estimated incidence of PVNS is 1.8 per million population.⁵ The clinical course of DPVNS is notable for its slow and insidious onset of pain, swelling, and stiffness in the involved joint. DPVNS frequently has a delayed diagnosis or is misdiagnosed as early osteoarthritis, rheumatoid arthritis, a meniscal tear, or other ligamentous injury. LPVNS also presents with symptoms of pain and swelling, but it more commonly presents with locking, catching, and instability.^{2,5,7} Symptoms are often intermittent in both LPVNS and DPVNS.

Figure 4

T2-weighted sagittal magnetic resonance image of a knee with a localized pigmented villonodular synovitis lesion in the anterior compartment (arrow).

Figure 5

A, T1-weighted coronal magnetic resonance image of diffuse pigmented villonodular synovitis. Note the periarticular erosions on both sides of the joint line (arrows). **B**, Sagittal T1-weighted magnetic resonance image of diffuse pigmented villonodular synovitis. The diffusely thickened synovium can be seen (circle) with spotty low signal areas, representing hemosiderin deposition.

Diagnosis

Diagnosis of DPVNS or LPVNS is not always obvious clinically. In the series by Flandry et al,¹ only 17% of patients were appropriately diagnosed with PVNS before referral. Various imaging modalities are often necessary to exclude other conditions and narrow the diagnosis. Plain radiographs can be helpful, particularly in the hip, elbow, and ankle. They may show periarticular erosions, with a thin rim of reactive bone. Reciprocal bony lesions on opposite sides of the joint, despite articular preservation, are highly suggestive of PVNS but also can be seen in other conditions. A late finding of joint space narrowing on plain radiograph indicates articular cartilage loss, which can be difficult to distinguish from primary osteoarthritis. The plain radiographic findings may be seen in as few as 30% of patients and in even fewer patients with knee involvement.² The majority of cases have no plain radiographic findings.² Therefore, for PVNS, plain ra-

diography is a nonspecific and insensitive diagnostic tool.

For early diagnosis, synovial fluid aspiration is a commonly reported technique. Brownish-stained bloody fluid is indicative of PVNS. However, this method lacks both specificity and sensitivity. Other conditions often have similar-looking fluid, and the lack of such fluid does not exclude PVNS.²

More recently, magnetic resonance imaging (MRI) has become the modality of choice for diagnosing PVNS.²⁵ MRI is noninvasive and, with newer sequences, can be highly sensitive and specific. It also can be helpful in determining the extent of disease involvement and in distinguishing DPVNS from LPVNS. Typical MRI findings for LPVNS include a periarticular or synovial nodular mass with varying degrees of bone erosion (Figure 4). The high hemosiderin content causes the mass to appear as either a spotty or an extensive low signal on T1- and T2-weighted images.²⁵ Both DPVNS and LPVNS may present with joint effu-

sion. In DPVNS, there is a poorly localized mass or synovial thickening with varying degrees of periarticular erosions (Figure 5). The signal is similar on both T1 and T2 sequences, as in LPVNS. Classically, it is described as “dark on dark” on T1- and T2-weighted images, but early inflammatory lesions with less hemosiderin may have large amounts of bright signal on T2 sequences. Importantly, on fat-suppressed images, the mass is high signal, and hemosiderin deposits cannot be seen. More specific sequences, such as fast field echo, show the hemosiderin deposits clearly.²⁵ Although the lesions often enhance with contrast, this is not diagnostic.²⁵

In 1992, Caluser et al²⁶ reported the first case of thallium Tl-201 uptake in a case of biopsy-proven PVNS. Since then, several case series have reported increased Tl-201 uptake in PVNS. Mackie²⁷ reported six cases of biopsy-proven PVNS showing increased uptake of Tl-201 in both early and delayed images. Tl-201 uptake may prove to be a use-

ful diagnostic modality, particularly in patients in whom there is no clear distinction between recurrent disease and early osteoarthritis. In recurrent disease, MRI findings may be clouded by postoperative changes, making a Tl-201 uptake scan a reasonable alternative.

Management

Because of the differences in disease progression and clinical response, the treatment approaches to LPVNS and DPVNS can vary greatly. The principles behind the management of the two conditions are similar, however. The goal is to eradicate all abnormal synovial tissue, thus removing the source of pain and reducing the risk of joint destruction and recurrence. Patients presenting with recurrent disease often have much more extensive involvement and a poorer likelihood of success. A combination of surgical and nonsurgical approaches may be necessary; in some patients, total joint arthroplasty may be the only effective treatment.

Nonsurgical

The very high recurrence rates and complications associated with the management of PVNS led early investigators to advocate observation until total joint arthroplasty became necessary.²² With advances in surgical technique and good postoperative care, however, postoperative complications and recurrence rates have declined to such a degree that few surgeons today would advocate this approach. Recurrent cases diagnosed on imaging studies but without progressive synovitis may not require repeat synovectomy; therefore, these patients can be treated with watchful waiting.

Radiation Therapy

Radiation has been used for many years as an alternative to surgical synovectomy in patients with synovitis.²⁸⁻³⁰ Its most widely reported use has been in patients with

rheumatoid arthritis, with reported response rates as high as 80% in patients with early disease and without radiographic changes.²⁸ Radiation-induced synovectomy for the treatment of PVNS has evolved, but results have been mixed. As early as 1950, good results were reported with the use of adjuvant external beam radiation for the management of recurrent PVNS.^{29,30} Serious potential complications are associated with external beam radiation, however, including skin reactions, poor wound healing, joint stiffness, and sarcomatous transformation. No significant advantage has been reported to using adjuvant external beam radiation compared with surgical synovectomy alone.³¹ Blanco et al³² reviewed a series of 22 patients treated with low-dose external radiation totaling 2,600 cGy adjuvant to arthroscopic subtotal synovectomy. The authors found a local recurrence rate of 14% as well as a 9% rate of significant posttreatment stiffness. They reported no wound complications. These results are comparable to those recently reported for open total synovectomy.²³

O'Sullivan et al²¹ reported 14 cases of refractory and recurrent PVNS, all with extra-articular involvement. Seven of the cases would have required sacrifice of major tendons or neurovascular structures if treated with open surgical synovectomy. All cases received external beam radiation, either alone or as part of preoperative or postoperative treatment. Most of the cases received either 3,000 or 3,500 cGy in 14 or 15 fractions. Of these, 10 had good to excellent results, with only 1 case of persistent disease after treatment. The authors noted that external beam radiation therapy can be highly useful in managing refractory cases of PVNS or in those with extensive extra-articular involvement. In at least two patients who had failed repeated open and arthroscopic surgery, radiation therapy enabled limb amputation to be avoided.²¹

More recently, interest has shifted from external beam radiation to intra-articular radiation synovectomy.³³ Intra-articular radiation therapy has been used in Europe since the 1960s to manage rheumatoid arthritis and has been experimentally extended to the treatment of PVNS. Most reports regard it as an adjuvant treatment modality, but there have been a few case reports of its use alone to treat recurrent disease.^{11,33}

Chin et al¹¹ reported on a series of 30 patients treated with adjuvant intra-articular radiation at a standard dose of 300 mCi (using dysprosium Dy-165) after combined open anterior and posterior synovectomy. They reported a recurrence rate of 17% with radiation, compared with a 0% recurrence rate for open synovectomy alone. These results suggest no advantage to using intra-articular radiation for the treatment of PVNS.²³ However, Chin et al¹¹ noted that 11 patients who had open synovectomy showed residual disease on MRI before intra-articular radiation treatment. Of those 11 patients, only 4 showed residual disease on follow-up MRI after intra-articular radiation therapy.¹¹

Shabat et al³⁴ treated 10 patients with intra-articular yttrium Y-90 at 6 weeks after open partial synovectomy; only 1 had recurrence at mean 6-year follow-up. Although the series is small, these results are comparable with those reported by advocates of open total synovectomy.²³ These more recent studies suggest that intra-articular radiation therapy may be useful in the management of PVNS, particularly in patients with documented postoperative residual disease that is still intra-articular.

One concern associated with the use of intra-articular radiation therapy is radionecrosis of the soft tissues, which may occur when the needle is not appropriately placed.^{33,34} This complication can be avoided with a preinjection arthrogram. Mild febrile and painful reactions, which also can develop posttreatment, are

usually easily treated. There is a theoretic concern for development of postradiation sarcoma and increased risk of other malignancies as a result of total body radiation exposure from spread of the radiocolloid out of the joint. Y-90 has replaced the use of gold Au-198 for intra-articular radiation therapy. Y-90 has only beta emissions, which reduces total body irradiation. Wiss³³ reported a 0.6% inguinal node uptake at 72 hours posttreatment with Y-90. Y-90 also has a short half-life (64 h). Doses reported in the literature range from 4 to 30 mCi for treatment of PVNS, but most reports suggest effective results from doses of about 5 mCi. At low-dose levels, there have been no reported cases of postradiation sarcoma with use of Y-90 in 20 years.

Arthroscopic Treatment of PVNS

Familiarity on the part of most orthopaedic surgeons with arthroscopic techniques has made the use of arthroscopy in the management of PVNS particularly attractive. Arthroscopy has been associated with better functional results and lower rates of postoperative stiffness than have open techniques.¹⁹ Conversely, improper application of this technology has been associated with unacceptable recurrence rates in some instances.³⁵⁻³⁷ Reports of arthroscopic synovectomy for PVNS have been almost exclusively in regard to the knee. Arthroscopic synovectomy in the knee offers excellent visualization of the anterior compartment as well as the medial and lateral recesses. Posterior compartment synovectomy can be performed as well, but it is technically difficult and requires accessory arthroscopic portals and the use of a 70° arthroscopic lens, with which most orthopaedic surgeons are less familiar. Arthroscopic synovectomy for PVNS in other joints, such as the shoulder and ankle, has been described but is uncommon.^{38,39}

Localized PVNS

Arthroscopic partial synovectomy is our preferred surgical option for LPVNS. Limited or partial synovectomy necessitates débridement of the PVNS mass along with a rim of surrounding healthy synovium (Figures 2 and 6). Anterior compartment lesions are addressed via standard anterolateral and anteromedial portals. Alternatively, posterior compartment lesions require posteromedial or posterolateral accessory portals to ensure adequate visualization and access to the entire lesion.

In most modern series, recurrence is rare after limited local treatment of LPVNS lesions.^{13-15,19,36,40} Ogilvie-Harris et al³⁶ reviewed 25 cases of LPVNS and DPVNS managed at their institution with arthroscopic synovectomy. The cohort included five LPVNS lesions managed with excision and partial synovectomy. Partial synovectomy improved pain and function in all five patients and resulted in no case of local recurrence. Kim et al¹⁵ reviewed 11 patients with LPVNS treated with limited arthroscopic partial synovectomy. The authors detected no clinical signs of recurrence at a minimum 2-year follow-up. All of their patients improved symptomatically and were satisfied with surgery. Moskovich and Parisien¹³ evaluated nine arthroscopic partial synovectomies for LPVNS. They detected no evidence of recurrence at an average of 48 months after surgery. They concluded that "the diagnosis of localized pigmented villonodular synovitis is usually made at the time of the arthroscopic surgery, and the opportunity should be taken to treat these lesions definitively during the arthroscopic procedure."¹³

Since 1990, there have been a small number of additional case series and case reports of arthroscopic treatment of LPVNS lesions; none of them has demonstrated evidence of recurrence.^{17-19,35,41,42} Recurrence with local treatment has been reported but is considered rare.⁴⁰ The

Figure 6



Postoperative view of the same patient as in Figure 2, after partial synovectomy for a local pigmented villonodular synovitis lesion removed arthroscopically from the anterior compartment. Complete excision of the lesion, located at the meniscocapsular junction (arrow), was performed. The rest of the synovium remains intact.

application of limited arthroscopic synovectomy has been extended to the shoulder³⁸ and ankle,³⁹ where LPVNS is exceedingly rare, with similar results.

No clinical trials compare open with arthroscopic synovectomy for LPVNS. The few case series in the literature are retrospective and use clinical examination to detect recurrence. No series in the literature have used MRI or arthroscopy to detect subclinical recurrences. However, the functional outcomes and clinical recurrence rates for patients treated with arthroscopic partial synovectomy for LPVNS have been universally favorable.

Diffuse PVNS

Although arthroscopy has gained considerable support as a technique to manage LPVNS, its role in the management of DPVNS remains unclear. DPVNS is considerably more common than LPVNS and has a significantly higher recurrence rate overall. In contrast to LPVNS, in DPVNS the posterior compartment

is typically involved and requires a surgeon who is comfortable with the placement of accessory posterior arthroscopic portals as well as the use of both 30° and 70° angled arthroscopes. Patients with large popliteal masses or extra-articular involvement generally are not candidates for an exclusively arthroscopic approach.^{11,36,37} Patients with intra-articular disease alone may be candidates for arthroscopic synovectomy by an experienced surgeon. Both partial and complete synovectomy have been described for managing this condition, with varying results.

Ogilvie-Harris et al³⁶ were among the first to report on arthroscopic management of DPVNS. They described 20 cases of DPVNS treated solely with arthroscopic synovectomy. Eleven patients were treated with complete synovectomy and nine with partial synovectomy. A thorough anterior synovectomy was performed in the partial group; however, the posterior compartment was not addressed. The patients undergoing complete synovectomy had a significantly ($P = 0.01$) lower risk of recurrence than did the patients undergoing partial synovectomy. The complete synovectomy group had only 1 recurrence out of 11, whereas the partial group had 5 failures out of 9 cases. The authors concluded that a thorough, complete synovectomy is the treatment of choice for DPVNS.

De Ponti et al³⁵ had similar results in their series of 15 DPVNS lesions managed arthroscopically. They detected a markedly higher rate of recurrence and worse clinical outcome in the patients treated with partial synovectomy. Half of the DPVNS patients treated with only anterior synovectomy had recurrence within the first 2 years of treatment. In contrast, in the group treated with complete arthroscopic synovectomy, 80% were symptom free at 2 years.

Zvijac et al¹⁹ performed complete arthroscopic synovectomy on 12 pa-

tients with DPVNS and reported a 14% overall recurrence rate. The two recurrences occurred in the two patients who required revision after a previous failed synovectomy. Average postoperative loss of motion was 6.7°. Only one patient required manipulation after surgery. The authors concluded that complete arthroscopic synovectomy has recurrence rates comparable to those of open techniques and better functional recovery.

Although arthroscopy is a less invasive surgical approach, it is not without potential complications. Chin and Brick³⁷ reviewed 38 cases of failed arthroscopic synovectomies for DPVNS. The patients were initially treated by experienced arthroscopists at tertiary care centers. Only three patients (7.9%) had an MRI diagnosis of PVNS before initial arthroscopy. Most of the patients were diagnosed with PVNS at the time of initial arthroscopy, and a treatment decision was made for synovectomy during the same operation. In this group, follow-up MRI revealed the presence of extra-articular disease in all patients. The authors criticized earlier reports of arthroscopic synovectomy for DPVNS for their inadequate postoperative assessment and lack of postoperative MRI.^{19,36} They speculated that recurrence rates for arthroscopic management of DPVNS could be considerably higher than reported if patients in previous studies were evaluated with objective measures, such as MRI. The authors asserted that patients with extra-articular disease represent a different subset of patients with PVNS and should be treated more aggressively.

In addition to the risk of recurrence, arthroscopic excision carries with it a theoretical risk of joint seeding and portal contamination. Extensive joint involvement and extra-articular spread may result after failed arthroscopic management.^{11,37} Although rare, subcutaneous contamination of an arthroscopic portal

from DPVNS has been reported.⁴³

The ultimate role of arthroscopy in the management of DPVNS is unresolved. Although authors have reported successful use of this technology, proper surgical indications and anatomic considerations have not been defined. Patients with extensive extra-articular involvement and large popliteal fossa masses clearly are not appropriate candidates for arthroscopic synovectomy. Additionally, open procedures should be considered for patients with disease in difficult locations, such as the popliteus tendon sheath, underneath the heads of the gastrocnemius, and within the semimembranosus bursa. Arthroscopic management should be reserved for patients with limited disease in a purely intra-articular location. The extent of preoperative disease must be defined with MRI before performing a definitive resection to identify these problematic areas. If an arthroscopic approach is selected, a complete synovectomy, including the posterior compartments, should be performed to minimize the risk of recurrence.^{19,35,36}

Open Surgical Management

Good success rates have been reported for LPVNS with open resection of the lesion. Johansson et al²⁰ reported no recurrence in 11 patients with LPVNS treated with open surgical excision. Similarly, Byers et al²² reported only two recurrences of 13 cases after resection of lesions. High success rates for LPVNS have been reproduced by others but are similar to results seen with arthroscopic treatment of LPVNS.^{7,13,15,20} Thus, arthroscopic resection is currently recommended for treating LPVNS.

Open arthrotomy and complete synovectomy is the standard surgical treatment for DPVNS.³⁰ In the knee, this is performed through a combined anterior and posterior approach. Our preferred anterior approach is through a midline incision and medial parapatellar arthrotomy.

The incisions must be extensive enough to allow flexion of the knee and lateral inversion of the patella. This approach permits adequate exposure to the anterior aspect of the knee to perform the synovectomy. After the anterior approach is performed, the patient is turned prone for the posterior approach. We prefer to use a "lazy S-shaped" incision posteriorly. The neurovascular bundle is carefully dissected, and both the medial and lateral heads of the gastrocnemius are detached. This should allow full exposure of the posterior joint capsule, in which an H-shaped capsulotomy is performed. The neurovascular bundle is shifted either medially or laterally to gain access to either side of the posterior aspect of the joint. Similarly, extensive open approaches can be performed for other joints afflicted with PVNS; however, because of the rarity of this condition, most series have focused on treatment of PVNS in the knee.

Early series of radical synovectomy in the knee with DPVNS reported excessively high recurrence rates.^{20,23} In 1968, Byers et al²² reported a recurrence rate of 46% after open complete synovectomy. Only 2 of the 15 patients had a complete resolution of symptoms. Johansson et al²⁰ reported a recurrence rate of 33% following complete open synovectomy for DPVNS of the knee. Most of the data regarding treatment and recurrence rates of DPVNS represent small series and are the experiences of one or two surgeons. The recurrence rates in these earlier studies likely represent incomplete excision of the lesion and probably relate to inadequate surgical exposure.

Flandry et al²³ reported a series of 25 knees with biopsy-proven DPVNS; open anterior and posterior complete synovectomy was done, using two anterior parapatellar incisions and one posterior medial incision. The authors reported a recurrence rate of 8% at average follow-up of 58 months. Ninety-two percent of the patients had good to

excellent results with no major postoperative complications. Twenty-four percent of the patients developed postoperative stiffness, however, requiring early postoperative manipulation. These authors reported lower recurrence rates for DPVNS than those of any of the comparable studies of arthroscopic treatment of DPVNS.^{19,35,36}

Chin and Brick³⁷ also noted high failure rates after arthroscopic treatment of DPVNS when adequate preoperative assessment was not done of the extent of disease and extra-articular involvement. Arthroscopic treatment of DPVNS is limited solely to intra-articular disease without excessive disease extent. Despite the historic variability in recurrence rates after open treatment of DPVNS, open surgical synovectomy currently remains the most reliable and consistent method of treating all anatomic variations of DPVNS.

Open synovectomy for management of DPVNS, however, is not without its associated morbidities. Compared with arthroscopic synovectomy, open synovectomy is associated with a longer hospital stay and longer rehabilitation period.¹⁹ One major criticism of the open technique for PVNS in the knee is postoperative stiffness, which often requires manipulation to avoid long-term decreased range of motion.^{19,36} The rate of postoperative stiffness was 24% in the study by Flandry et al.²³ For this reason, many orthopaedic surgeons advocate less invasive techniques with shorter recovery periods, such as arthroscopic synovectomy.¹⁹

Challenging cases with persistently recurrent disease and involvement of critical anatomic structures may not be adequately treated with open synovectomy alone.²¹ In such cases, adjuvant treatment modalities, such as radiation synovectomy, are reasonable alternatives. Additionally, the lack of experience of the general orthopaedic community with both arthroscopic and radiation

synovectomy could lead to unforeseen complications and higher recurrence rates. Therefore, surgeons who lack advanced expertise in the use of these treatment modalities may better serve the patient by using the more familiar standard open technique or, when indicated, referring cases to more experienced surgeons.

Combined Open and Arthroscopic Approaches

The combination of open and arthroscopic approaches has not been well described in the literature. De Ponti et al³⁵ reported one case in which a popliteal mass was excised via an open posterior approach supplemented with an anterior arthroscopic synovectomy. Ogilvie-Harris et al,³⁶ however, did not believe that patients with popliteal masses were candidates for arthroscopy; therefore, such patients were omitted from their study. Patients with primarily posterior involvement with minimal anterior compartment disease may benefit from anterior arthroscopic synovectomy and open posterior synovectomy. The application of combined approaches for the treatment of DPVNS remains untested, however. Additionally, arthroscopy may have a role in preoperative and postoperative diagnostic biopsies as well as in the treatment of mild residual disease after open or arthroscopic synovectomy.¹¹

Summary

PVNS is very difficult to manage. The goals of treatment are to reduce pain, stiffness, and joint destruction and to increase functional outcomes. Such treatment ultimately should lead to decreased need for joint arthroplasty in young adults afflicted with this condition. Several options are available; the appropriate treatment of each patient must be based on the type of PVNS (ie, local or diffuse), the presence or absence of extra-articular disease, and the level of experience of the surgeon.

MRI should be performed on any person in whom the diagnosis of PVNS is being considered. MRI is helpful in distinguishing between DPVNS and LPVNS as well as in determining the presence of extra-articular involvement. The presence of extra-articular involvement suggests a more aggressive form of DPVNS, which should be managed with an aggressive open surgical approach rather than with arthroscopic surgery.³⁷

LPVNS responds well to arthroscopic resection and can be treated by a moderately experienced arthroscopist with good results. However, LPVNS is the less common form of this condition; the majority of patients present with DPVNS. Moderately extensive intra-articular DPVNS can be managed with total synovectomy when performed by a very experienced arthroscopist, with results equivalent to those of open synovectomy. However, unless a surgeon has a very good understanding of the use of accessory portals and arthroscopic technique in total synovectomy, it is very difficult to treat DPVNS with arthroscopy alone. For the less experienced arthroscopist, open anterior and posterior synovectomy offers better results and lower recurrence rates. In cases of extensive synovial involvement or extra-articular involvement, an open surgical approach is recommended. In the setting of mainly unicompartmental disease, combining a posterior open approach with an anterior arthroscopic approach may be useful. For example, if the majority of disease is located in the posterior compartment of the knee, arthroscopy can be used for a limited anterior synovectomy with an open posterior approach.

The use of adjuvant radiation treatment is still debated. The literature is sparse; however, there may be a limited role for intra-articular radiation treatment or external beam radiation treatment as an adjuvant to surgery. This may especially

be the case for less than a total synovectomy or with recurrent disease. Use of these adjuvants needs to be assessed in the context of surgeon and institutional experience with these agents. More research also is needed regarding the use of radiation treatment of PVNS.

Total joint arthroplasty for persistent recurrent disease or in cases demonstrating end-stage arthritis is a viable option. Unfortunately, there are very few reports on long-term outcomes of patient with PVNS who underwent total joint arthroplasty. Gonzalez Della Valle et al²⁴ reported on four patients with PVNS of the hip who were treated with synovectomy and total hip arthroplasty. All four patients had grade 3 joint involvement on radiograph at the time of treatment. At average follow-up of 13 years, there were no recurrences and there was only one revision for stem loosening, at 10 years. We recommend that joint arthroplasty be strongly considered in the patient with persistent recurrent disease that causes limitation in function and mobility or ongoing pain, despite attempts at treatment with surgery and/or adjuvant radiation therapy. Any patient with significant joint space narrowing along with pain and limited range of motion also should be considered for joint arthroplasty.

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Evidence-based Medicine: There are no level I or II randomized studies reported; reference 28 is a meta-analysis. References are primarily level IV case-controlled series.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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