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A High-Speed Ski Crash Leading to a Unique Synovial Cause for Knee Pain

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ABSTRACT

The presented case involves the evaluation, diagnosis, and management of a 20-year-old male high-level skier who presented with persistent right knee pain following a ski crash. The patient reported hitting his right knee against a tree during the accident, resulting in intermittent swelling and a sensation of a mass within the knee. Despite some initial improvement in the sensation, the pain then became persistent and worsened by activity. Physical examination revealed limited symptoms during gait and functional movements, as well as restricted medial joint line tenderness and a mildly positive McMurray's test on the right knee. Magnetic resonance imaging findings prompted an orthopedic referral, leading to a right knee arthroscopy. The procedure involved resection of nodular synovitis and a diffuse synovectomy, with pathology confirming pigmented villonodular synovitis (PVNS). Despite post-operative complications, including methicillin-resistant *Staphylococcus aureus* bacteremia, ultimately, the patient's recovery was successful with the gradual restoration of pain-free range of motion through physical therapy. Follow-up assessments and magnetic resonance imaging scans indicated sustained improvement and no signs of pigmented villonodular synovitis recurrence.

Introduction

Pigmented villonodular synovitis (PVNS) is a rare giant cell tumor of the synovial joint, synovial bursa, and tendon sheath¹. It can present as either localized to a portion of the synovium, known as localized pigmented villonodular synovitis (LPVNS) or diffuse pigmented villonodular synovitis (DPVNS), however diffuse is more common.¹ The diffuse type is more frequently diagnosed than the localized type and unfortunately carries harder to treat due to its high likelihood of recurrence and its more invasive and destructive nature.²

Annual incidence of PVNS is 1.8 patients per million, with peak ages between 30-40.² Patients typically present with gradual pain, joint effusion and stiffness.³ Those who have an LPVNS lesion frequently present similarly to a torn meniscus because the pedunculated mass most commonly occurs near the anterior horn of the medial meniscus. Whereas DPVNS more frequently mimics osteo or rheumatoid arthritis with diffuse joint pain.⁴ Due to its mimicking nature, it is frequently misdiagnosed at first. If joint aspiration is performed due to the presence of an effusion on examination, the aspirate in PVNS may reveal a bloody, brown-stained fluid.⁴ Advanced imaging with MRI is useful in diagnosing PVNS following physical exam and is the diagnostic imaging of choice.⁵ In DPVNS, MRI will reveal a synovial thickening or poor-defined mass. Whereas, LPVNS will demonstrate, a nodular periarticular or synovial mass. Both may reveal bony erosion of varying extents.⁴

The etiology of PVNS is not fully understood, however it has previously thought to be linked to the presence of repeated local hemorrhage into the joint, such as in hemophilia, or associated with trauma.^{4,5,6} However, trauma has only been found to be present in approximately one-third of patients who are diagnosed with PVNS and all of the characteristic histologic changes seen in PVNS are not reproducible when blood or iron is injected into a joint.^{7,8} Additionally, PVNS has not been seen routinely in patients with hemophilia-associated intra-articular bleeds.⁵ The histologic changes that are seen with PVNS include: lipid-laden macrophages, presence of hemosiderin, multinucleated giant cells and presence of stromal and fibroblast cell proliferation.^{3,6}

Definitive diagnosis and treatment are achieved by surgical resection, with samples sent for pathologic analysis. This can be achieved by open or arthroscopic removal.⁵ The recurrence rate following surgical resection of DPVNS is noted to be as high as 46%, depending on the degree surgical excision that is achieved.⁴ Whereas, LPVNS is more

easily treated and carries a much lower rate of recurrence, 8%.⁶ To date, there are no known long-term consequences if a patient chooses not to undergo resection, however, the presenting symptoms will not improve thus continuing to limit their activities.

Case History

A 20-year-old male high-level skier presented for evaluation of persistent right knee pain following a ski crash 11 months prior. Since the crash, he noted periodic swelling and a sensation of a floating mass in his knee. The pain, concentrated in the posterior aspect of his right knee, worsened with activity but improved with rest. There was no radiation of pain, numbness in the lower extremity, or fever present. His medical history included a Fontan procedure due to congenital heart disease, but no previous knee issues.

PHYSICAL EXAM

His gait was non antalgic. He was able to toe walk, heel walk, and squat without difficulty. Both knees showed full range of motion without restriction. Tests for knee stability, including the anterior and posterior drawer tests, Lachman's test, and apprehension test, were negative for both knees. However, McMurray's test did cause some mild discomfort on his right knee, specifically in the medial area. The medial joint line on the right knee was tender to palpation. There was no noted valgus or varus laxity. Strength and sensation testing were both normal for bilateral lower extremities.

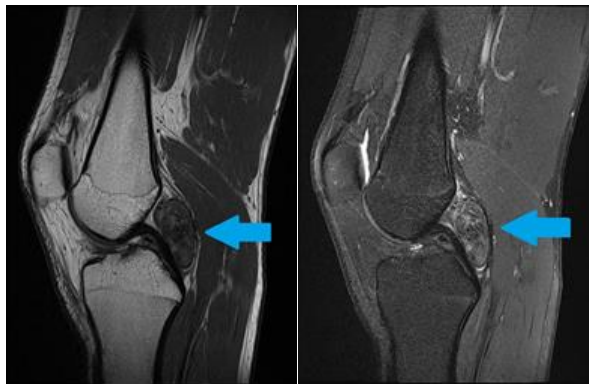
PATIENT COURSE

X-ray was obtained in office, which showed no abnormalities. Following the office visit, MRI was obtained due to concern for meniscal tear, revealing a large intra-articular soft tissue mass within the posterior intercondylar notch directly abutting the posterior lateral aspect of the medial femoral condyle and multiple foci of low signal intensity on fluid sensitive sequences.

The patient was referred to orthopedic surgery for further management based on MRI results. Subsequently, a right knee arthroscopy was advised and performed. Resection of the nodular synovitis and a diffuse synovectomy across all compartments was successfully achieved. The pathology report definitively identified significant synovial proliferation and inflammation characterized by the presence of giant cells, consistent with LPVNS. Despite a post-operative course complicated by methicillin-resistant *Staphylococcus aureus* bacteremia, it's noteworthy that knee aspiration revealed no indications of joint seeding. The post-operative complication

necessitated hospitalization and a 14-day course of antibiotic treatment.

In the follow-up phase, the patient's progress was assessed at the 2, 6, and 12-week marks post-surgery, revealing tangible improvements in both pain levels and the range of motion of the right knee. Subsequent MRI scans exhibited no signs of PVNS recurrence. Around 2 weeks post-surgery, the initiation of physical therapy was deemed appropriate. This aspect of the patient's recovery involved completing a total of 14 physical therapy sessions, culminating in the successful resumption of normal activities.



Left Image: MRI Left Knee Sagittal Proton Density Image

Right Image: MRI Left Knee Sagittal T2 Fat Saturated Image

Blue arrow points to a large intra-articular soft tissue mass within the posterior intercondylar notch directly abutting the posterior lateral aspect of the medial femoral condyle. Multiple foci of low signal intensity on fluid sensitive sequences.

Discussion

The case of this 20-year-old male with persistent right knee pain following a ski crash highlights the significance of a comprehensive approach to diagnosis and management, particularly in the context of an unusual underlying condition like PVNS. The delayed seeking of medical attention after the ski crash may have contributed to the progression this patient's PVNS. Although symptoms did not begin until after the ski crash, and no other correlating injuries were found on the MRI to account for his symptoms, it is unknown at this time if trauma can be considered the inciting cause of his PVNS.^{4,5,6} Other case reports have demonstrated the occurrence of PVNS in the post-traumatic state as well, highlighting the continued need for cases and research to discover the true etiology of the condition to better understand this condition.^{10,11}

While the knee is the most affected joint, with approximately 80% of noted cases occurring here,

other joints can be affected too as noted in prior cases, with ankle, elbow, shoulder and hip being known sites of PVNS as well.^{11,12} Due to the frequency of other injuries affecting these joints such as meniscal tears and ankle sprains, PVNS can be difficult to diagnose when an inciting event occurs that matches with physical exam findings that make more commonly occurring diagnoses seem likely. Obtaining an x-ray is a common first imaging step when presented with a joint complaint. X-ray will demonstrate non-distinct findings such as joint effusion or evidence of a poorly characterized soft tissue mass.¹³ However, they may also demonstrate normal findings such as in our patient. When conditions such as these are not improving with other forms of treatment, such as rehabilitative exercises for an ankle sprain, a further look into causes of joint pain should be undertaken with advanced imaging. The preferred type of imaging to obtain next is MRI as this is the only imaging type that demonstrates the synovium changes as well as the presence of extra-articular extension that is present in DPVNS.¹² This is also an important step for surgical planning to ensure excision of the entire extent of PVNS as the diffuse type has a high rate of recurrence if not fully removed.²

Management of patients with PVNS, is typically surgical with arthroscopic removal of the entire involved synovium.¹² The surgical intervention for our patient with synovectomy proved effective in alleviating symptoms and restoring joint function. As he presented with LPVNS, this proved to be both effective in the short term improvement in symptoms in addition to long term improvement as he did not have any recurrence of symptoms. Fortunately, LPVNS carries a low risk of recurrence in comparison to DPVNS, 22% versus 72%, respectively.¹³ Due to rates of recurrence, some patients under adjuvant therapy following surgical resection with external beam radiation.¹³ While this may help reduce recurrence rates, radiation therapy carries its own risks of complications. While our patient did not experience surgical complications, unfortunately, he did experience bacteremia, adding a layer of complexity to the patient's recovery, necessitating prolonged hospitalization and antibiotic treatment. Majority of patients who are treated with arthroscopic removal are able to undergo surgical removal in an outpatient surgical center and do not necessitate inpatient treatment.

For patients who do not wish to undergo surgical excision, or who are not surgical candidates, treatment options are limited, however, new research has demonstrated that treatment with imatinib may both help with relief of symptoms as

well as controlling progression of joint disease.¹⁴ This is due to the overexpression of colony-stimulating factor-1 (CSF1) in PVNS cells that leads to the tumor progression. Imatinib works by blocking CSF1 reducing the proliferation of cells in PVNS.¹⁴ Unfortunately, those do not undergo surgical excision or other treatments, risk continued joint damage as PVNS is a locally destructive lesion although it is considered to be benign.¹⁵

Confirmation of the diagnosis is accomplished after surgical removal when histopathology testing is able to be performed. Histology reveals hypertrophy of the synovium with irregular protrusions and projections. Nodules containing hemosiderin pigment, scattered multinucleated giant cells and foamy macrophages are also present.¹⁵

Post-surgical restoration of joint function is accomplished via the rehabilitation process with physical therapy eventually culminating in return to pre-surgical activities like skiing. The initiation of physical therapy at an appropriate time, around 2 weeks post-operative, aligns with established protocols for gradual recovery and restoration of functional capacity. Physical therapy should be

ongoing until joint function and range of motion are largely returned to baseline and they are able to return to activities they participated in prior to joint complaint. Our patient required fourteen physical therapy sessions to achieve these goals, highlighting the importance of an individualized approach to rehabilitation, tailored to the patient's progress and needs.

Conclusion

This case highlights how a multidisciplinary approach can be helpful for diagnosing and managing knee pain when clinical presentation is atypical or inconclusive. It highlights the need to consider uncommon conditions like PVNS in the workup of knee pain that is presenting similarly to a meniscal tear such as in this case. Successful outcomes can be achieved through a combination of accurate diagnosis, timely surgical intervention, post-operative care, and tailored physical therapy. This case contributes to the existing literature by providing insights into the evaluation and management of PVNS in a young athlete, offering guidance for clinicians encountering similar presentations.

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