

Revision Total Knee Arthroplasty in a Case of Operated Right Total Knee Arthroplasty with Implant Loosening and Pigmented Villonodular Synovitis

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Learning Point of the Article:

Aseptic loosening is a leading reason for the failure of total knee arthroplasty. This report is expected to encourage surgeons to consider pigmented villonodular synovitis (PVNS) in the differential diagnosis of patients who present with painful swelling after TKA and to recognize PVNS as a possible contributor to implant loosening.

Abstract

Introduction: A 52-year-old male operated elsewhere with the right total knee arthroplasty 5 years ago presented with complaints of pain and swelling in his right knee and difficulty in walking. Radiographs revealed implant loosening with Anderson Orthopedic Research Institute classification type 3 bone defect in the femur and tibia. Right knee effusion was aspirated which was reddish tinged, most likely traumatic; C-reactive protein was within normal limits, and culture and sensitivity showed no growth. The aspirate was not classically bloody or chocolate colored as may be seen in pigmented villonodular synovitis (PVNS).

Case Report: The diagnosis of PVNS was not established preoperatively and occult infection could not be excluded with certainty in a painful, loose total knee arthroplasty (TKA), therefore, a staged revision strategy was selected. The first stage consisted of debridement, implant removal, extensive synovectomy and placement of an antibiotic-loaded cement spacer. Histopathology subsequently confirmed PVNS. Revision TKA was performed 4 weeks later after clinical reassessment and normalization of inflammatory markers. The revision restored alignment and allowed pain-free ambulation.

Conclusion: There were no surgical site complications and no symptoms pointing toward recurrence of PVNS. The SF-12 score, Hospital for Special Surgery Knee Score, Knee Society Score, and Oxford Knee Score for his right knee calculated 1 and ½ years postoperatively showed significant improvement from his pre-operative values.

Keywords: Debridement, implant loosening, cement spacer, pigmented villonodular synovitis, bone defect, Anderson orthopedic research institute classification, revision total knee arthroplasty, metaphyseal sleeve, femoral adapter, stem, TC-3, tibial tray rotating platform.

Introduction

Total knee arthroplasties (TKAs) are becoming increasingly prevalent, resulting in a rise in the frequency of revision TKAs. Revision TKAs are more challenging than primary ones due to the impact of greater bone loss on implant stability. Factors

contributing to bone loss during revision TKAs include inflammation, bacterial infections, stress shielding, osteolysis due to wear and loosening of the original implant, periprosthetic fractures, damage incurred while removing the primary implant, osteonecrosis, bone cysts, and previous fractures of the tibial

Author's Photo Gallery



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Figure 1: (a, b, c) Pre-operative X-rays and (d and e) clinical images of a 52-year-old male with 5 years old operated right total knee arthroplasty.

plateau or femoral condyles [1]. One contributing factor to aseptic loosening that leads to prosthetic failure is pigmented villonodular synovitis (PVNS) [2]. Originally characterized by Chassaignac in 1852 and subsequently detailed by Jaffe et al., in 1941, PVNS is identified as a range of benign neoplastic disorders distinguished by the presence of macrophages filled with hemosiderin, multinucleated giant cells, lipid-rich histiocytes, and inflammatory cell infiltrates within an enlarged synovium. The knee joint is most frequently affected, accounting for as much as 80% of cases, followed by the hip, ankle, and shoulder. It primarily impacts adults in their third to fifth decades of life. Recognized as a benign proliferation of cells, it is categorized into two forms: Localized-type (L-PVNS) and diffuse type (D-PVNS). These variants exhibit differences in their clinical and radiographic features but share similarities in histology, showing histiocyte proliferation and hemosiderin accumulation within the synovial tissue. Due to its gradual appearance and symptom similarities with other joint conditions such as rheumatoid arthritis, juvenile idiopathic arthritis, and synovial cysts, PVNS is often misdiagnosed or diagnosed at a later stage. The typical treatment for this condition involves surgically removing the affected synovium. Even with the implementation of rigorous resection methods, the rates of recurrence are still notable, varying between 18% and 46%, depending on the particular type and extent of the surgery. Additional treatment options are frequently investigated for managing cases of recurring or incompletely resectable PVNS [3]. Future revisions should consider new strategies for improving fixation and preserving native bone stock. In revision TKAs, the use of highly porous metal cones and sleeves has proven to be an effective technique for

enhancing fixation [1]. At present, titanium metal sleeves are used in revision TKA for addressing significant contained Anderson Orthopedic Research Institute (AORI) type IIA, IIB, or III bone defects. While these sleeves serve a similar purpose to cones, they are designed specifically for each implant, integrated with the stem, and placed as a single unit alongside the entire prosthetic device. Metaphyseal sleeves might provide an additional benefit by acting as a supportive structure for reconstruction when the metaphysis is compromised [4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20].

This report discusses a case involving a 52-year-old man who underwent revision TKA after a right TKA performed 5 years ago with implant loosening and PVNS.

Case Report

A 52-year-old man came with intense pain and swelling in his right knee, along with difficulty walking that required assistance for the past week. He exhibited a varus deformity in his right knee and was ambulating with a lateral thrust while using support. Five years ago, he underwent a right TKA at another facility. He was a known diabetic with a hemoglobin A1c level of 6.5%, and his complete blood counts (CBC), erythrocyte



Figure 2: Intraoperative images (a and b) previous implants with inflamed synovium and synovectomy, and (c) preparation of cement spacer and molding of condyles with cement.

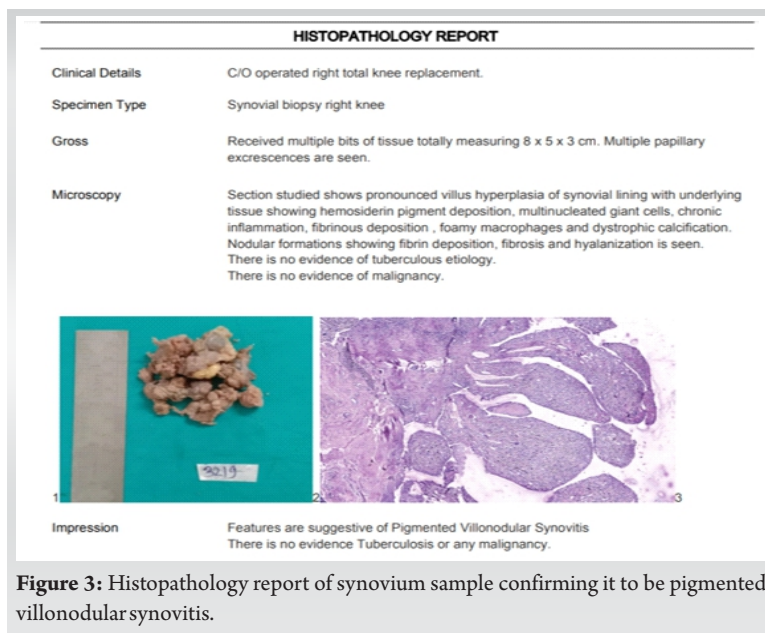


Figure 3: Histopathology report of synovium sample confirming it to be pigmented villonodular synovitis.

sedimentation rate (ESR), and C-reactive protein (CRP) levels were all within normal ranges. Imaging studies showed subsidence of the tibial component, a 12° varus deformity on the Hip-Knee-Ankle (HKA) axis, and loosening of the implant from the earlier operated TKA on the right side (Fig. 1), with an AORI classification type 3 bone defects in both the femur and tibia.

The effusion in the right knee was aspirated, revealing a reddish tinge, likely due to trauma, though it did not exhibit the classic appearance of being bloody or chocolate colored, which is typical for PVNS.

The patient failed to bring any of his earlier reports, including X-rays and discharge summaries. The rationale for the initial surgery and the intraoperative finding was unclear. We acknowledge that the original condition may have been PVNS, which was not identified at that time.

The treatment plan was

- Debridement + implant removal + extensive synovectomy + antibiotic-loaded cement spacer in the first stage. This was

chosen because infection could not be excluded with absolute certainty in a painful, loose TKA with extensive synovial inflammation; it was not undertaken because PVNS requires staged revision

- Revision TKA in the second stage after histopathological confirmation of PVNS and clinical reassessment for infection.

An anterior midline incision was made over the right knee after the patient was induced under spinal and epidural anesthesia. A medial parapatellar arthrotomy was performed, revealing inflamed synovial tissue on exposure. The tissue did not appear bloody or chocolate colored, which is typically associated with PVNS. The excised synovial tissue was sent for histopathological evaluation. Loosened implants were identified and removed with an osteotome and hammer, being careful to preserve as much bone stock as possible for the planned revision surgery.

Given the aggressive synovial inflammation and the potential for an infectious cause, the decision was made to place a cement spacer. A synovectomy and thorough debridement of the remaining bone stock and surrounding tissues were completed.

A 5 mL and 10 mL syringe was utilized to prepare the intramedullary section of the cement spacer, which was mixed with gentamicin and vancomycin. The cement was manually shaped for the femoral condyles and the tibial plateau surrounding the inserted intramedullary section of the spacer (Fig. 2). The antibiotic-loaded spacer was used as a precautionary measure because the painful loose TKA and extensive synovial inflammation raised concern for an occult infective process despite normal inflammatory markers and a negative pre-operative aspiration culture. Once the cement had set, a pain relief solution was injected into the quadriceps, and the knee was reduced. The deformity was partially corrected using the cement spacer. Watertight closure of the arthrotomy and the wound was done. After the surgery, the patient was placed on anticoagulants, prophylactic antibiotics, and supplements for duration of 1 month, and was instructed to bear

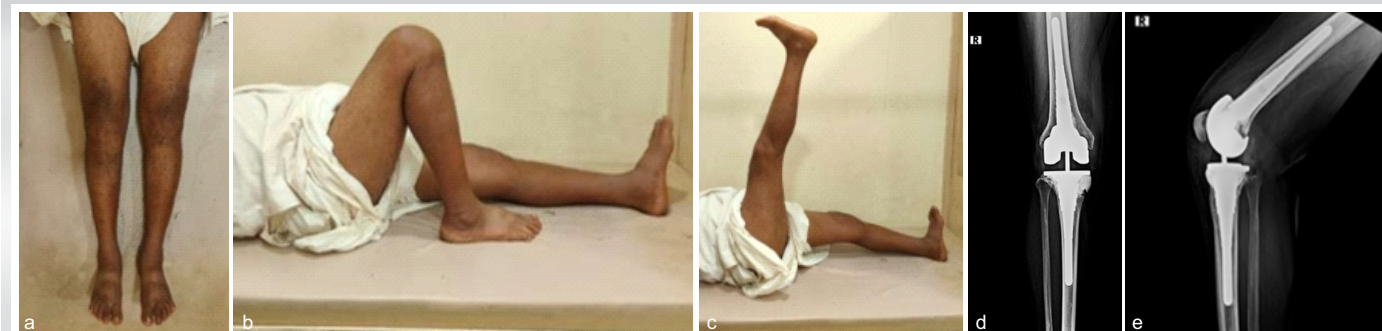


Figure 4: (a, b, c, d, e) 1.5 years follow-up clinical images and X-rays of a 52-year-old male with the right revision total knee arthroplasty.

Table 1: Pre-operative and 1.5 years follow-up post-operative scores of 52-year-old male treated with the right revision total knee arthroplasty

Score	Pre-operative score	Interpretation	Post-operative score	Interpretation
Short form score (SF-12)				
Physical component summary	23.99938	Below average	56.57706	Above average
Mental component summary	19.06444	Below average	60.75781	Above average
Hospital for special surgery knee score	13	Poor	96	Excellent
Knee society score	6	Poor	90	Excellent
Oxford knee score	12	Poor	48	Excellent

weight with assistance. After the initial stage of surgery, the patient experienced a significant reduction in pain. Sutures were removed on the 16th day after surgery.

The histopathological analysis of the synovial tissue confirmed the diagnosis of PVNS (Fig. 3). The pathologist ruled out polyethylene debris-induced synovitis using established histopathological criteria. Specifically, polarized light microscopy showed no birefringent polyethylene particles, and no foreign body type granulomatous reaction typical of wear debris related pathology was identified. Instead, the synovium demonstrated a disease specific pattern of diffuse villous and nodular hyperplasia with prominent hemosiderin deposition, foamy macrophages, multinucleated giant cells, fibrin deposition, and fibrosis, which is diagnostic of PVNS.

The patient returned for a follow-up appointment after a month, during which his CBC, ESR, and CRP were retested and found to be within normal limits. He was scheduled for the second stage of revision TKA. The challenges for this surgery were to preserve bone stock, restore flexion and extension balance, preserve joint line, maintain coronal and sagittal plane alignment, maintain optimal ligament stability, maintain adequate bone implant interface reconstruction, and decide the amount of constriction needed.

The patient was prepared for surgery under spinal and epidural anesthesia. An incision was made along the anterior midline of the right knee. A medial parapatellar arthrotomy was performed, with no signs of infectious or inflamed tissues observed during exposure. The knee was subluxated, and the cement spacer was removed utilizing a drill, osteotome, and hammer while preserving as much of the bone stock as possible. A thorough debridement was carried out once more before proceeding with the revision TKA. It was decided to utilize metaphyseal sleeves, a tibial tray rotating platform, TC-3, a femoral stem, a tibial stem, and femoral adapters in the procedure. After thorough preparation, trial implants were inserted, the knee was reduced, and the stability, patellar tracking, range of motion, and ligament integrity were assessed

and found to be satisfactory. The final implants were then placed, and following reduction, stability and integrity were evaluated, confirming satisfactory results. A watertight closure of the arthrotomy and the wound was completed. In the post-operative phase, the patient was prescribed anticoagulants, prophylactic antibiotics, and supplements for 1 month, along with instructions for weight-bearing with assistance.

The deformity in the patient's right knee was successfully corrected through revision right TKA, enabling him to walk without pain after the surgery. There were no complications at the surgical site, and no signs indicating a recurrence of PVNS were present. The SF-12 score, Hospital for Special Surgery Knee Score, Knee Society Score (KSS), and Oxford Knee Score for his right knee, assessed 1½ years post-surgery, demonstrated considerable improvement compared to his pre-operative values. His pre-operative and post-operative knee scores are presented in (Table 1), along with follow-up images in (Fig. 4). The HKA axis of his lower extremity has been corrected to neutral (180°).

Discussion

The failure of TKA can result in significant bone loss around the implant, which may compromise the stability and function of the ligaments. Careful surgical planning and precise identification of defects are essential for the successful execution of revision TKA.

PVNS is known to cause implant loosening through a mix of mechanical stress and bone degeneration due to the growth of abnormal synovial tissue. The PVNS tissue can damage the bone surrounding the implant, weaken the supporting structures, and ultimately result in aseptic loosening. This phenomenon is often observed in the tibial component, where the abnormal tissue can proliferate beneath the implant [21].

In cases of PVNS involving significant joint areas, extensive removal of the synovium is often necessary, which frequently compromises portions of the capsule and ligament structure. In these situations, implants that provide a higher degree of constraint are needed to maintain proper balance. Semi-constrained options, and even hinged systems, have been employed in such cases [2].

The Malefijt et al. [22] group enhanced the understanding of periprosthetic bone defects in the knee by presenting the differentiation between contained and uncontained defects, a concept that remains relevant today. Presently, the AORI classification proposed by Engh and Parks [23] is the most

frequently cited system in the literature, representing a considerable improvement over earlier classifications by integrating aspects such as defect size, location, and soft-tissue involvement.

Hamlin et al. [24] documented four failures among 18 primary arthroplasties with PVNS. Three of these failures were attributed to aseptic loosening, which were addressed through revision arthroplasty, while one failure resulted from two recurrences of PVNS that required an above knee amputation.

Houdek et al. [25] documented that complications led to revisions in 10 out of 48 primary arthroplasties involving PVNS. Recurrence occurred in six patients, who underwent synovectomy and revision arthroplasty in four cases, local excision in one case, and transfemoral amputation in one case. In total, 25 patients faced at least one complication, with the most common being a decreased range of motion in the knee. The average KSS and functional score showed considerable improvement post-surgery ($P < 0.001$).

Chung and Park [21] reported a comparable case of TKA revision due to loosening of the tibial component in a single patient diagnosed with PVNS. A radiolucent lesion was identified beneath the tibial component during the patient's last follow-up assessment before revision surgery. During the revision surgery, there was localized growth of synovial tissue with significant pigmentation observed around the anteromedial area of the tibial component. The tibial component was replaced after excising the abnormal tissues. The polyethylene's articulating surface remained intact. A 5-mm thick medial metal block and an extension stem were utilized in the revision procedure. Histopathological examination of the abnormal tissue showed characteristic features of PVNS.

Certain principles must always be followed when dealing with bone loss during revision TKA. Extreme care must be taken to preserve as much host bone as possible while removing the implant. The treatment strategy will vary based on the remaining bone structure. It is essential to restore the joint line to achieve a stable and well-functioning knee. It is important to use stemmed components to divert stress from the joint line when addressing any periarticular concerns that involve more than a simple prosthetic enhancement. Although this topic has been examined in many studies and reviews, incorporating a stem in TKA, whether for primary or revision surgeries, can improve mechanical stability but may also result in stress shielding along the length of the stem. Both experimental and computational studies suggest that the addition of a stem reduces proximal tibial strain [11,13].

Radiotherapy is an important treatment for PVNS, improving local control rates in both adjuvant therapy and after incomplete

resections. Nevertheless, the primary goal should always be to attain the most complete resection possible. For D-PVNS, it is recommended to deliver a total dose of 36–40 Gy using conventional fractionation (5×1.8 –2.0 Gy/week), while for L-PVNS, lower total doses ranging from 20 to 36 Gy are sufficient. Employing computed tomography-based 3D radiation planning is advisable because the target area in joints must encompass the entire synovial space [26].

It is important to emphasize that a two-stage revision is not routinely indicated for PVNS-associated TKA failure. In the present case, the staged approach was selected because the patient had a painful and grossly loose TKA with extensive synovial inflammation and substantial AORI type III bone loss, while occult periprosthetic joint infection could not be excluded with complete certainty at the time of the first operation. The antibiotic-loaded cement spacer was therefore used as a precautionary measure while obtaining definitive histopathological and microbiological assessment. The subsequent diagnosis of PVNS should not be interpreted as an indication for staged revision in PVNS itself. In patients with confirmed PVNS and no clinical or laboratory suspicion of infection, thorough synovectomy combined with appropriate revision arthroplasty may be performed in a single stage when technically feasible.

Conclusion

A precise and timely diagnosis of PVNS of the knee is essential along with thorough pre-operative imaging and complete surgical excision to reduce the likelihood of recurrence and maintain joint function.

Successfully managing bone defects during TKA revisions is vital for obtaining favorable and lasting results. There are multiple management approaches available, each presenting distinct advantages and disadvantages, and there is no universal remedy for bone failure that applies to every case. Therefore, the decision-making process and the choice of method used should be customized to the patient; still, the procedure should focus on restoring bone stock in individuals, facilitating possible future revisions.

Clinical Message

This report is expected to encourage surgeons to consider pigmented villonodular synovitis (PVNS) in the differential diagnosis of patients who present with painful swelling after TKA and to recognize PVNS as a possible contributor to implant loosening. Importantly, PVNS by itself does not require a two-stage TKA; the staged approach in this case was selected because of the uncertainty surrounding occult infection and the severity of the failed TKA with extensive bone loss.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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