

Severe Metallosis after Tumor Mega-Prosthesis: Revise or Retain? - A Case Series

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Learning Point of the Article:

Pain, deformity, or stiffness following mega-prosthesis reconstruction in the presence of normal inflammatory markers may indicate metallosis arising from various mechanisms; early recognition of both metallosis and its underlying cause can help avoid extensive revision surgery.

Abstract

Introduction: Tumor mega-prostheses are widely used for limb salvage following resection of bone tumors. Although infection and aseptic loosening are the most common causes of failure, metallosis secondary to structural failure is uncommon and may mimic other complications. We describe a case series of two cases of severe metallosis following tumor mega-prosthesis reconstruction.

Case Report: The first case involved a 34-year-old man who presented with valgus deformity, pain, and restricted knee motion 3 years after proximal tibial reconstruction for a giant cell tumor. Inflammatory markers were normal, and radiographs showed no loosening or implant breakage. Surgical exploration revealed extensive metallosis caused by polyethylene bushing failure of the hinge mechanism. Radical debridement and isolated bushing exchange restored alignment and function while preserving well-fixed components. A second case involved a 24-year-old man with pain in the leg 2 years after distal tibial replacement for osteosarcoma. Radiographs demonstrated osteolysis and stem loosening. However, markers of inflammation were within normal limits. This scenario raised concerns of possible infection or a structural failure. Intraoperatively, severe metallosis with implant loosening was identified. Extensive debridement and revision reconstruction with a longer cemented stem were performed.

Conclusion: Metallosis is a rare but potentially devastating complication of tumor mega-prostheses reconstruction. Polyethylene bushing failure and implant loosening can result in metal-on-metal articulation and extensive tissue damage. Early recognition, exclusion of infection, and timely surgical intervention may permit limited revision and prevent catastrophic implant failure.

Keywords: Tumor prosthesis, metallosis, hinge knee prosthesis, polyethylene bushing failure, limb salvage, mega-prosthesis revision.

Introduction

Lower limb reconstruction with tumor mega-prosthesis is an accepted treatment worldwide for tumors involving the distal femur, proximal tibia, and distal tibia. However, there is a high risk of complications. The literature says loosening and infection are the two most common causes of failure. Furthermore, there is a higher failure rate in the proximal tibial reconstruction

prosthesis compared to that of the femur [1].

The failure modes of a tumor prosthesis can be categorized into mechanical and non-mechanical types. Mechanical failures include periprosthetic fractures, soft-tissue failures such as wound dehiscence and extensor mechanism failure, and structural failures like aseptic loosening and component failure. Non-mechanical failures are typically related to hematoma

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Figure 1: Knee radiograph showing valgus deformity.

formation and infection, with infection being the most common cause [2].

The overall incidence of revision procedures for any cause has been reported in the literature to be as high as 28% at 5 years and 32% at 8 years [3]. Whereas causes of mechanical failure, such as aseptic loosening, warrants complete revision of the prosthesis, structural failure of implants may or may not require a total revision of the prosthesis for instance breakage of the prosthesis requires a total revision of the prosthesis. However, there are less common causes of structural failures, such as polyetheretherketone (PEEK) failure and polyethylene bushing wear, which seldom demand a total revision of the prosthesis. The PEEK and bushing are important components of the hinge, as the locking mechanism relies completely on them [3].

Although structural failures account for around 16% [4], hinge failure rates are reported to be around 1–7% in various studies [3].

Aseptic loosening of the hinge

knee tumor prosthesis usually presents with pain and swelling of the limb, with difficulty in bearing weight. Structural failure may present with a wide variety of symptoms such as pain, reduced range of motion, dislocated knee, deformity at the knee, and so on. Metallosis after joint arthroplasty is a rare occurrence that may lead to chronic inflammatory synovitis, progressive osteolysis, aseptic loosening, and eventual implant failure [5].

We herein present two cases of severe metallosis after tumor mega-prosthesis surgery.

Case Reports

Case 1

A 34-year-old male presented to us with the inability to bear weight and valgus deformity at the knee. He had a history of a giant cell tumor in the right proximal tibia, for which he was operated on elsewhere with a hinge knee tumor prosthesis 3 years back. The patient was advised to undergo a total revision of the prosthesis in another hospital due to prosthesis failure. We took a detailed history from the patient. There was no history of trauma, fever, or any other clinical symptoms suggestive of infection. Blood investigations, including the total leukocyte count (TLC), erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP), were within normal limits. His X-ray revealed valgus deformity (Fig. 1).

We examined the patient's knee, and there was an obvious valgus deformity in his right knee. He walked with a valgus thrust. There was no redness, local rise of temperature, or swelling over the knee. The range of motion was restricted terminally as well.

From the history and examination findings, it appeared to us as a



Figure 2: Severe metallosis in the adjacent tissues and broken bushing of the hinge mechanism being taken out.



Figure 3: Post-operative radiograph shows correction of deformity.

case of structural failure of the prosthesis.

We decided to surgically explore the knee. Our pre-operative planning expected us to face two scenarios. First, a change of the hinge mechanism only. This would save the patient from an extensive surgery. The other is a total revision of the prosthesis.

Surgery

After taking valid consent, under combined spinal and epidural anesthesia and all septic conditions, a midline incision and medial para-patellar arthrotomy were done. The prosthesis was exposed, and severe metallosis was found in the adjacent tissues. On further examination, there were no signs of infection or loosening in the femoral or tibial component. The hinge of the prosthesis was then examined in detail, and the bushing was found to be broken (Fig. 2). Hence, we decided to change the polyethylene bushing only. Radical debridement of tissue having metallosis was done, and the bushing was changed. The deformity was corrected, and the range of motion improved significantly compared to the pre-operative condition (Fig. 3) shows

the post-operative radiograph.

The patient ambulated with a walker on the 1st day after surgery. During the course of stay in the hospital, the patient was given intravenous antibiotics, analgesics, anti-inflammatory drugs, physiotherapy, and other supportive treatment.

Case 2

A 24-year-old male presented to us with complaints of persistent weight-bearing pain in the left leg. The patient had a history of osteosarcoma of the left distal tibia for which he underwent limb-salvage surgery with cemented tumor prosthesis reconstruction 2 years before presentation. The post-operative course was initially uneventful. However, over the preceding 2 months, the patient developed progressive pain while walking, which gradually worsened and limited daily activities.

Radiographic evaluation revealed osteolysis and loosening of the cemented stem of the left distal tibia tumor prosthesis, raising concern for mechanical failure and possible infection.

Blood investigations, including TLC, ESR, and CRP, were all within normal limits, which contradicted our differential diagnosis of infection as a cause of loosening.

We decided to explore and revise. Here, we had anticipated two scenarios. First, infection, where we would remove the implant, debride, and put an antibiotic spacer in the first stage, and replace it with a prosthesis at a later stage. Second, aseptic loosening, where we would remove the existing prosthesis and revise with a new prosthesis in a single stage.

Surgery

After taking valid consent, under combined spinal and epidural anesthesia and all aseptic conditions, we operated on the patient.



Figure 4: Metallosis in the periprosthetic tissue and osteolysis in the bone-prosthesis interface, and severe metallosis is visible after removal of the prosthesis.

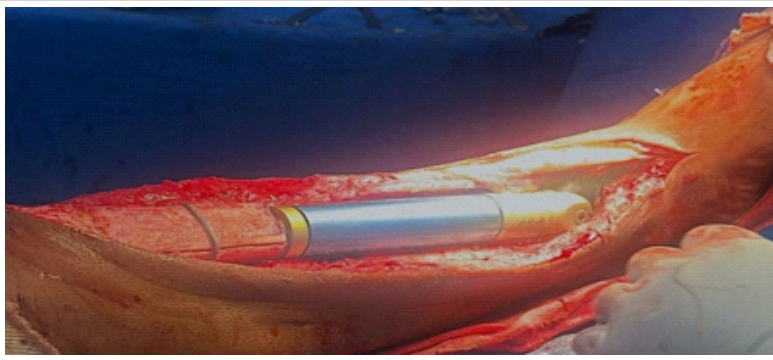


Figure 5: Reconstruction with a cemented distal tibia prosthesis with a longer stem.

Intraoperatively, features consistent with severe metallosis were noted, including dark-stained periprosthetic tissues and evidence of implant loosening (Fig. 4). The procedure involved removal of the failed distal tibia implant, radical debridement of metallic tissues (Fig. 5), and reconstruction with a cemented distal tibia with a longer stem (Fig. 6). Prophylactic encirclage was done to reduce the risk of iatrogenic fracture. Thorough debridement of metallic tissue was performed to reduce inflammatory burden and prevent further soft tissue compromise.

The post-operative course was uneventful. Intravenous antibiotics, analgesics, anti-inflammatory drugs, physiotherapy, and other supportive treatment were continued, and the patient was allowed ambulation on the next day.

Discussion

Metallosis is an uncommon but well-recognized complication of total joint arthroplasty and surgeries involving mega prostheses, resulting from deposition of metallic debris within periprosthetic tissues and leading to chronic inflammatory synovitis, progressive osteolysis, aseptic loosening, and eventual implant failure [5]. Its occurrence in hinge knee tumor prostheses is rare and potentially catastrophic due to the high mechanical demands and constrained design of these implants.

Clinical features include persistent pain, swelling, instability, grinding sensation, deformity, and reduced range of motion [5,6,7,8,9]. As the symptoms are non-specific and mimic infection, it needs to be ruled out. Usually, routine tests such as complete blood count, ESR, and CRP are normal, and culture sensitivity of the joint aspirate is negative, pointing toward the absence of an infection [6,7]. Radiographically, classic hallmarks of metallosis are “cloud sign” – amorphous fluffy

radiodensities in periprosthetic soft tissues – and the “bubble sign” – curvilinear radiodense outlines along the synovium – strongly suggest extensive metallic debris infiltration. The metal-line sign, representing linear radiodensity, further supports the diagnosis [5,6]. Recognition of these signs is crucial, particularly in complex reconstructions where early symptoms may be attributed to mechanical failure alone. Histopathology shows the picture of foreign-body reactions with the presence of fibrosis, histiocytes, and multinucleated giant cells [5,6].

The underlying pathophysiology centers on metal-on-metal articulation. In conventional arthroplasty, polyethylene liner failure is a common initiating event, permitting direct contact between cobalt-chromium femoral and titanium tibial components. Tibial insert dissociation or progressive polyethylene wear can generate significant debris, amplifying the inflammatory cascade. In tumor prostheses with rotating-hinge mechanisms, failure of the polyethylene bushing represents a similar biomechanical breach. Loss of the interposing polyethylene interface converts intended constrained articulation into uncontrolled metal-on-metal contact at the hinge axis, accelerating debris generation under high torsional and axial loads. Historically, other etiologies have been proposed in the literature, including metallic contamination from surgical instruments such as saw blades, where synovial tissue analysis demonstrated predominant iron deposition [7]. Although iron-predominant debris may suggest iatrogenic introduction, most contemporary cases are attributable to implant-derived cobalt-chromium and titanium particles secondary to polyethylene breakdown [5,8]. The dominant metal composition can therefore provide insight into the source of wear, though clinical correlation remains essential.

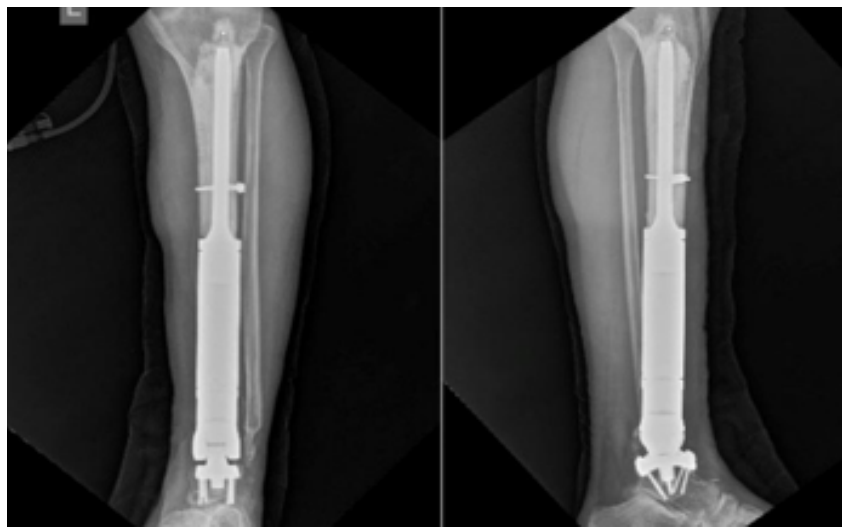


Figure 6: Post-operative radiograph shows revision of prosthesis with a long cemented stem.

Material science advancements have sought to mitigate wear-related complications. Conventional polyethylene (CPE), highly cross-linked polyethylene (HXLPE), and Vitamin E-infused polyethylene (VEPE) have all been introduced to improve wear characteristics. However, current evidence does not demonstrate clear superiority of HXLPE or VEPE over CPE in preventing osteolysis or revision, although HXLPE may confer a modest reduction in infection risk [9]. Similarly, ceramic coatings such as titanium nitride aim to reduce metal ion release, yet meta-analyses have shown no consistent clinical advantage or improved long-term survival compared with uncoated implants [9]. These findings underscore that material modification alone cannot eliminate failure if mechanical integrity – such as that of a hinge bushing – is compromised. Metallosis susceptibility is therefore multifactorial and is influenced by implant design, bearing surface characteristics, component positioning, polyethylene wear, corrosion at modular junctions, and patient-specific biomechanical and biological factors that together determine the generation of metallic debris and the subsequent inflammatory response [10,11,12].

Management of severe metallosis requires aggressive surgical intervention. Treatment usually consists of complete synovectomy, extensive debridement of stained and necrotic tissues, removal of all prosthetic components, and revision with long stems, constrained reconstruction, and augments to address bone loss [6,8]. Use of an oxidized zirconium (Oxinium) femoral component was intended to reduce future wear potential, given its improved surface hardness and lower metal ion release compared with traditional cobalt-chromium alloys [5]. In this article, in the first case, we changed the broken bushing only, as there was no osteolysis or loosening of the implant, whereas complete revision of the distal tibia replacement was mandatory in the second case, as osteolysis and loosening had already occurred.

The two cases described here not only represent two different mechanisms leading to metallosis but also highlight the importance of early recognition of bushing wear in hinge knee tumor prostheses. Once polyethylene failure occurs, rapid progression to metallosis can lead to extensive bone loss and soft-tissue destruction, complicating revision surgery.

Conclusion

Metallosis is an uncommon complication after joint arthroplasties and surgeries involving tumor mega-prostheses. It may present many years after implantation with catastrophic bone loss if not identified early. Early recognition is therefore critical. Distinct radiographic signs – such as the cloud and bubble signs – facilitate diagnosis. Prompt revision surgery remains the definitive treatment once extensive debris-related damage has occurred. These cases underscore the importance of vigilant follow-up, particularly in constrained or tumor prostheses subjected to high mechanical stresses. Periodic surveillance enables early detection of polyethylene wear or hinge mechanism compromise, preventing progression to severe osteolysis and technically demanding revision procedures. Severe metallosis secondary to bushing failure in a hinge knee tumor prosthesis can rapidly progress to extensive synovitis, osteolysis, and structural compromise. Importantly, metallosis is most often secondary to polyethylene failure rather than inherent flaws in metal design. Hence, prevention relies more on monitoring wear progression than on newer coatings or alternative polyethylene formulations alone. Vigilant follow-up, careful assessment of new mechanical symptoms, and prompt imaging evaluation are critical in preventing advanced structural compromise. In addition, in early post-arthroplasty synovitis with well-fixed implants and infection excluded, rare causes such as instrument-related metallic debris should also be considered.

Clinical Message

New-onset pain, deformity, or loss of function in patients with tumor mega-prostheses warrants thorough evaluation even when infection markers are normal. Metallosis should be included in the differential diagnosis of painful prostheses with a negative infection workup, as it may result from potentially reversible mechanical failures such as polyethylene bushing or hinge component wear. Careful identification of the underlying cause of prosthetic failure is essential, as not all failed tumor prostheses require complete revision; early diagnosis may permit implant-preserving procedures, reduce surgical morbidity, and improve patient outcomes.

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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