Case Report

Distal Leg Wear Debris Mass from a Rotating Hinged Knee Prosthesis

Panayiotis J. Papagelopoulos, MD, DSc, Andreas F. Mavrogenis, MD, Athanassios E. Karamitros, MD, Konstantinos A. Zahos, MD, George Nomikos, MD, and Panayotis N. Soucacos, MD, FACS

Abstract: An 18-year-old woman presented with a gradually increasing distal leg mass 8 years after wide resection for an osteosarcoma and reconstruction of the proximal left tibia with a rotating hinged knee megaprosthesis. Open biopsy of the distal leg mass showed necrobiotic tissue, metallosis, fibroblasts, osteoblasts, histiocytes, and multinucleated giant cells. The patient underwent debridement of the distal leg mass, metallosis, and wear debris surrounding the tibial component, followed by revision of the destructed polyethylene-bearing components. At the latest follow-up, 4 years after the revision surgery, the patient is alive and tumor-free, asymptomatic, and has no clinical or imaging evidence of wear and metallosis.

Key words: osteosarcoma, polyethylene wear, wear debris, metallosis, giant cell granuloma, knee megaprosthesi.

Orthopedic implant wear particles are well-known factors related to local macrophage reaction, osteolysis, and implant loosening after total knee and hip arthroplasty [1-7]. Patients with prosthetic joint loosening initially experience pain, swelling, and instability. As the joint effusion and intraarticular pressure increases, synovial fluid with wear particles extends to the surrounding tissues. Clinically significant masses related to wear debris have been found around the hip [8]. Granulomatous reaction and the formation of a granulomatous tissue mass are usually uncommon around the knee [6].

In this article, a case of a total knee megaprosthesi polyethylene wear in a patient previously operated on for an osteosarcoma of the left proximal tibia is presented. The granulomatous reaction, the wear debris mass mimicking local recurrence of the tumor, and the extensive metallosis in the soft tissues surrounding the tibial prosthesis are outlined.

Case Report

In 1993, an 18-year-old woman underwent wide resection for a proximal left tibia osteosarcoma and reconstruction of the knee joint with a knee megaprosthesi. The operation was uncomplicated. The patient had neoadjuvant chemotherapy. Histologic examination of the excised specimen showed complete removal of the tumor with clear surgical
margins. There was a 98% tumor necrosis. Postoperative chemotherapy has been administered. A year later, the patient had signs and symptoms of late infection. The knee implant has been removed, and an antibiotic-loaded bone cement spacer was inserted. After a period of 12 months, the cement spacer was removed, and a knee megaprosthes (SMILES rotating knee hinge, Stanmore Implants Worldwide Ltd, Middlesex, UK) has been inserted.

Seven years after the insertion of the megaprosthes, the patient was admitted to the authors’ institution because of a gradually increasing mass at the left distal leg (Fig. 1). Plain radiographs showed cortical osteolysis of the distal femur and soft tissue mass at the junction of prosthesis to distal tibia (Fig. 2A-C). Technetium Tc 99m–human polyclonal immunoglobulin G bone scan showed increased radioisotope uptake at the left knee and distal leg (Fig. 2D). Routine laboratory

Fig. 1. A and B, Photographs of the mass of the left distal leg.

Fig. 2. A–C, Preoperative plain radiographs showed cortical osteolysis of the distal femur and a soft tissue mass at the junction of prosthesis to distal tibia. D, 99mTc-HIG bone scan showed increased radioisotope uptake at the left knee and distal leg.
investigation, including white blood cell, erythrocyte sedimentation rate, and C-reactive protein, was within normal limits.

Open biopsy was performed. On cutting open of the mass, there was black fluid containing thick, darkish amorphous metallic debris and fragments of broken polyethylene. Histologic examination of the excised specimen showed necrobiotic tissue, wear debris and metallic particles, fibroblasts, osteoblasts, histiocytes, and multinucleated giant cells. Nucleous atypia and mitotic features were not observed (Fig. 3). Gram stain was negative. Cultures were negative for infection.

The patient underwent open debridement and revision knee surgery. Osteolysis of the distal femur, extensive metallosis and wear debris surrounding the tibial component of the prosthesis, and a large soft tissue granuloma at the prosthesis—distal tibia junction—were observed (Fig. 4A-B). There was polyethylene deformation, including a combination of creep and abrasive wear, burnishing, and predominantly, delamination, distrib-

Fig. 3. A and B, Histologic analysis showing necrobiotic tissue, wear debris, and metallic particles, fibroblasts, osteoblasts, histiocytes, and multinucleated giant cells. Nucleous atypia and mitotic features are not observed.

Fig. 4. A and B, Osteolysis of the distal femur, extensive metallosis, and wear debris surrounding the tibial component of the prosthesis. C and D, Polyethylene deformation, including a combination of creep and abrasive wear, burnishing, and predominantly, delamination, distributed asymmetrically over the medial and lateral joint surfaces. Failed vertical tubular section of the polyethylene tibial bearing component.
uted asymmetrically over the medial and lateral joint surfaces (Fig. 4C-D). Destruction concerned mostly the polyethylene-bearing component secured with bushes into the proximal tibia. The rotating polyethylene-bearing component was not worn as normally expected. However, all polyethylene components were carefully removed and replaced (Fig. 5).

The final diagnosis was osteolysis and soft tissue foreign body reaction caused by polyethylene wear and metallic debris from failure of the proximal tibia polyethylene-bearing component. Walking with arm crutches for a month and quadriceps strengthening exercises were prescribed, and the patient was discharged uneventfully after 8 days of hospitalisation. At the latest follow-up, 4 years after surgery the patient is alive and tumor-free, with a painless knee and no clinical or imaging evidence of wear and metallosis (Fig. 6).

Discussion

In oncologic patients with total knee replacement, any mass needs thorough investigation. First, the orthopedic surgeon must rule out an actual tumor. Imaging evaluation and biopsy are necessary for diagnosis of the exact cause. Differential diagnosis should include a primary or recurrent soft tissue or bone tumor, infection, wear debris, and metallosis-reactive granulomas, as in the current patient, thrombophlebitis, cellulitis, popliteal cyst, and aneurysms [4-6,9,10]. Once the underlying diagnosis is confirmed, the surgeon will deal with the mass and the knee replacement as well.

Several authors have reported the formation of pelvic, thigh, or calf and leg masses related to osteolysis and wear debris in patients with hip and knee joint prostheses [1,4-8,11-27]. Langkamer et al [23] reported an aggressive soft-tissue mass of the thigh after total hip replacement with clinical and radiographic features suggestive of sarcoma. Benevenia et al [24] described a case of pathologic supracondylar fracture of the femur 6 years and 5 months after a porous-coated anatomical total knee replacement arthroplasty (PCA, 9-mm polyethylene insert, Howmedica, Inc, Rutherford, NJ). The fracture occurred through an aggressive expanding soft tissue mass that was a tumor-like lesion secondary to polyethylene wear debris. The lesion was associated with massive osteolysis around the femoral component of the total knee prosthesis. Kane et al reported on a patient with a well-fixed, uncemented femoral component (cobalt-chromium-molybdenum alloy). A large cystic lesion in the distal femur adjacent to the femoral component has been developed 7 years after total knee arthroplasty. This lesion contained fibrotic soft tissue, evidence of a foreign-body giant cell reaction, and a large number of polyethylene particles, but no metal wear debris, infection, or malignancy [26]. Cyst progression in association with wear debris is a rare problem after unicompartmental knee replacement. Hart and Jones [27] reported fracture of the medial tibial plateau 5 years after bilateral unicompartmental knee replacements. A large cyst was found in the lateral femoral condyle, which extended from the
weight-bearing area in the lateral compartment to
the margin of the trochlea. Histology of the lesion
revealed a central degenerate cyst with multiple
particles of polyethylene and cement debris around
its periphery.

In vitro studies have suggested that macrophages
and other inflammatory cells exposed to wear
particles can produce cytokines leading to bone
resorption [1-3]. Factors influencing implant wear
include patients’ activity, body weight, polyethyl-
ene thickness and quality, polyethylene oxidation
methods of sterilization, implant design, and surgi-
cal alignment and ligamentous balancing of the
prosthesis [1-3,28,29].

The proximal tibial replacement was patient
specific and designed and manufactured by Stan-
more Implants. The replacement comprises of a
proximal tibial shaft with knee replacement. The
SMILES Rotating knee hinge (Stanmore Implants)
was introduced in 1990. The SMILES knee is used
as a custom-made prosthesis either as a total knee
replacement or in conjunction with a massive
endoprosthetic replacement around the knee. The
femoral component fabricated from cobalt chrome
molybdenum alloy has a wide patella surface with
a shallow patella groove to maintain the anatom-
ical tracking. The femoral component is routinely
cemented in situ with a long intramedullary stem
(titanium alloy). The tibial component comprises
4 elements, namely, a short-stemmed tibial com-
ponent (cobalt chrome molybdenum alloy), a
tibial bearing component (ultra–high-molecular-
weight polyethylene), a proximal tibial shaft
(titanium alloy Ti6Al4V) that is coated with
titanium nitride, and an intramedullary stem
fabricated from titanium alloy and coated with
titanium nitride. Both the proximal tibial shaft
and the tibial intramedullary stem are patient-
specific, with respect to the lengths and diameters
of the 2 components. The implant is designed for
each individual patient and the stem length,
diameter, and curvature dimensions are deter-
mixed from special-measurement biplanar radi-
ographs. The short-stemmed tibial component
hinges with the femoral component with an axe
(CoCrMo) that is encased with polyethylene
bushes that are press-fit into the femoral compo-
nent. To prolong the life of the axe bushes, a
hyperextension bumper pad is used as a second-
ary bearing surface. This prevents the metal
tibial and femoral components contacting each
other during hyperextension. The rotational sta-
bility is constrained by beveled superior surface of
the polyethylene component with the conforming
inferior surface of the tibia, as the rotation takes
place there is a gradual motion upward.

In the current patient, a distal tibia mass arose at
the region of a previous wide excision for an
osteosarcoma, mimicking local recurrence of the
tumor. The mass consisted of wear debris and
metallic particles. In addition, extensive metallosis
was observed in the soft tissues around the tibial
prosthesis. Periprosthetic osteolysis and polyethyl-
ene delamination was the cause.

Fig. 6. A and B. Anteroposterior and lateral radiographs 4 years after polyethylene insert exchange surgery.
There are several potential sources of wear debris around joint prostheses. In this case, the most prominent was the tibial secured polyethylene inserts that showed extensive delamination. The extensive polyethylene components damage is difficult to be explained. According to manufacturer, these components were sterilized using cobalt γ- irradiation. The components were sterilized in air and had a maximum shelf life of 1 year. However, it is extremely unlikely that damage, as seen in this case, could have been caused by degradation of the polyethylene due to sterilization in air. If this had been the case, it would be evident because these components would have been made in a batch, and it would be expected that all components of the batch had been through the same processes and, therefore, would undergo the same degradation. This is definitely not the case, there has been extremely few polyethylene components ever returned to the manufacturer. Therefore, it is very difficult to accept that this is a manufacturing/production process–related incident; rather, it is a single episode, and this would then be more likely that the degradation was as a result of a process post production (P Unwin, PhD, personal communication).

The mode of failure in these components looks more like a shattering, as though the polyethylene components had become brittle. It is very difficult to be able to determine if these components have been autoclaved before implantation; this information is not available to the authors. Mechanical and thin section analyses of the polyethylene components could have given an answer for this extensive wear.

The synovial fluid with wear particles drained underneath the fascia and anterior tibial muscles to the anterior compartment of the left leg and progressively enlarged with the accumulation of wear debris and metallic particles. A granulomatous tissue mass formed, mimicking local recurrence of the tumor.

Long-term follow-up evaluation is essential in patients with total joint replacement, for the detection of occult polyethylene wear and early diagnosis of prosthesis loosening. In these cases, revision arthroplasty is mandatory for good knee function.

References