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CASE REPORT

Revision of total knee arthroplasty in a patient with aseptic loosening caused by reaction to polyethylene – Case Report

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Abstract

Total knee arthroplasty (TKA) is an effective surgical procedure commonly performed to treat degenerative knee diseases. The procedure can lead to complications that necessitate revision surgeries, with aseptic loosening standing out as one of the predominant causes of surgical failure. The case is presented of a 56-year-old female patient who underwent TKA due to the primary gonarthrosis in her right knee. The patient experienced aseptic loosening and a periprosthetic fracture associated with osteolysis. The potential factors that may have contributed to the failure of the initial surgery are described. The surgical technique and the quality of the cement mantle are factors that significantly influence the success of the procedure. This study aims to describe how the cementation technique may impact the onset of aseptic loosening. Any irregularities in the formation of the cement mantle should be taken into account, as they may lead to complications such as aseptic loosening.

Key words

total knee arthroplasty, aseptic loosening, cemented knee arthroplasty, revision knee arthroplasty, foreign body reaction

INTRODUCTION

Total knee arthroplasty (TKA) is a surgical procedure with a high survival rate, widely used in the treatment of degenerative knee diseases and significantly improving the patient's quality of life. The increasing life expectancy of patients and improvements in surgical techniques have made this type of procedure a popular treatment option over the last decade. Despite the success of TKA, it should not be forgotten that the procedure may be associated with the occurrence of complications requiring revision TKA [1]. Aseptic loosening remains one of the leading causes of surgical failure. Complications arising within the first 2 years following primary surgery are classified as early complications, which primarily include issues such as infection and instability. Late revisions (more than 2 years after the initial surgery) are most often caused by polyethylene wear and aseptic loosening. Aseptic loosening can be caused by factors including those related to the implant itself, patient characteristics, and surgical techniques. Implant factors concern its structure, method of attachment, and wear debris from cement, metal or polyethylene. Joint malalignment and ligament imbalance are factors related to surgical technique. Patient-related factors usually relate to comorbidities such as osteoporosis or high body mass index [2]. Notably, the techniques used in cementing the implant are critical. Thus, the quality and precision of creating a cement mantle have emerged as potentially modifiable factors that can significantly impact the success of the procedure [3].

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Polyethylene, a component of the fixing cement, remains the cause of most cases of periprosthetic osteolysis associated with a foreign body reaction [4]. Due to the mechanism of material fatigue, polyethylene particles are released into the synovial fluid and induce an immune response. The particles are phagocytosed by macrophages and giant cells, and interleukins (IL-1b, IL-6) and alpha-necrosis tumoral factor induce inflammation and osteoclast activation, which ultimately leads to periprosthetic osteolysis [5]. The correct cementation technique and the use of the appropriate amount of cement allowing for its adequate penetration remain the subject of considerations.

The aim of this study was to determine how the cementation technique and the amount of cement used affected the development of aseptic loosening and periprosthetic fracture associated with osteolysis. We present a case of aseptic loosening following TKA and discuss the potential factors resulting in failure of the initial procedure.

CASE REPORT

In June 2022, a 56-year-old female patient was admitted to the orthopedics department for cemented total knee arthroplasty due to primary gonarthrosis of the right knee joint. The patient reported limited walking ability and pain in the right knee that had been present for several years. A preoperative X-ray of the joint revealed a varus deformity (Fig. 1). In addition to gonarthrosis, the patient was diagnosed with obesity. The patient denied allergies, including drug allergies. Before the procedure, antibiotic prophylaxis (cefazolin) and anticoagulant (enoxaparin) were used. Personalized alignment™ for total knee arthroplasty using the Persona® knee system with quadriceps-sparing approach

was performed. The femoral and tibial components were fixed using antibiotic-loaded bone cement. The procedure was conducted without complications, and the patient was discharged from the hospital in good general condition with a recommendation for further treatment at a rehabilitation clinic. A control X-ray of the operated knee joint showed the correct positioning of the implants (Fig. 2).

Figure 1. X-ray of the right knee joint with visible signs of degeneration

Figure 2. X-ray of the right knee after initial TKA

In November 2022, the patient reported to the orthopedic clinic due to pain in the right knee. The CT scan performed showed loosening and medial positioning of the tibial component of the prosthesis and a comminuted periprosthetic fracture of the medial condyle of the right tibia (Fig. 3). The patient was qualified for revision arthroplasty. During the procedure, inflamed knee joint tissues and excess cement fixing the prosthesis were revealed (Fig. 4).

Synovial fluid was collected for bacteriological tests, and 5 fragments of the synovial membrane were sent for histopathological examination. The revision surgery was performed without complications, and the control X-ray performed after the procedure did not reveal any abnormalities (Fig. 5). No microbial growth was detected in synovial fluid samples. The result of histopathological examination confirmed the presence of inflammation in the

Figure 3. Computed tomography of the right knee joint showing loosening of the prosthetic elements and a periprosthetic fracture

synovial membrane and described signs of degeneration and an intense granulomatous reaction in the area of the foreign body. Numerous macrophages with diffuse deposits of grayish pigment were visible in the examined tissue.

The morphological features corresponded to degenerative changes related to the reaction to the prosthesis elements. Laboratory tests showed that C-reactive protein and procalcitonin levels did not exceed the norm. The appearance of the tissues and the results of diagnostic tests suggested a diagnosis of tissue inflammation caused by a reaction to polyethylene.

DISCUSSION

In the described case, the patient underwent revision TKA, which was necessary due to poor results of the initial surgery. Scientific research indicates polyethylene wear and associated aseptic loosening as the most common reason for late revision surgery [6]. This process is based on the mechanisms of osteolysis affecting the tissues in contact with the prosthetic components. Bone metabolism is regulated by maintaining a balance between bone formation and osteolysis processes dependent on the system, in which the key role is played by receptor activator for nuclear factor κB (RANK), receptor activator of NF-κB ligand (RANKL) and osteoprotegerin (OPG). RANKL, by binding osteoclastic RANK, is responsible for stimulating bone resorption. OPG inhibits osteolysis by binding RANK. The inflammation that arises in the tissues, triggered by the ingestion of polyethylene particles and prosthetic materials by macrophages, can disrupt the balance in favor of osteoclastic RANKL. The size of the polyethylene particles plays a crucial role in the osteolysis process. Those measuring between 1 and 10 μm are particularly biologically active and evoke more significant inflammatory response. In contrast, particles larger than 10 μm cannot be effectively phagocytosed, resulting in a reduced inflammatory response. A correlation has been demonstrated between the concentration of polyethylene particles in synovial fluid and the advancement of the

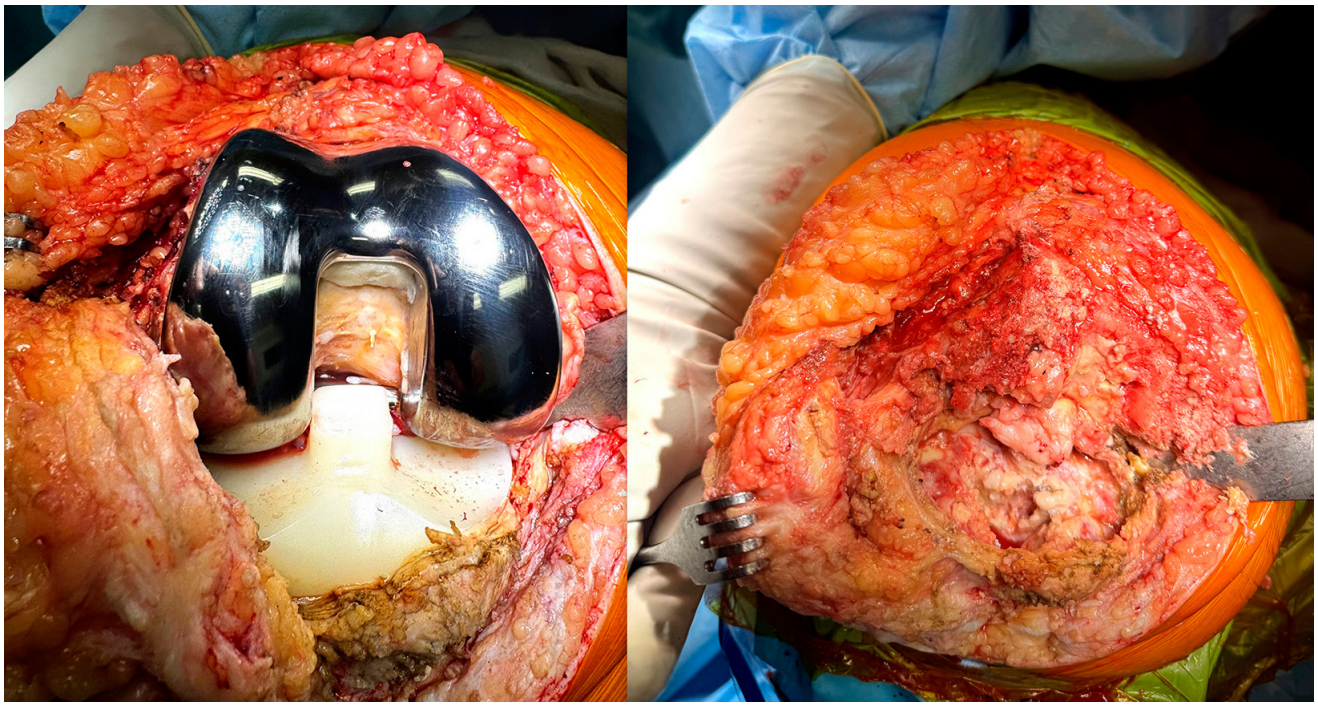

Figure 4. Intraoperative photos of inflamed tissues. Excessive amount of fixation cement visible under the femoral component

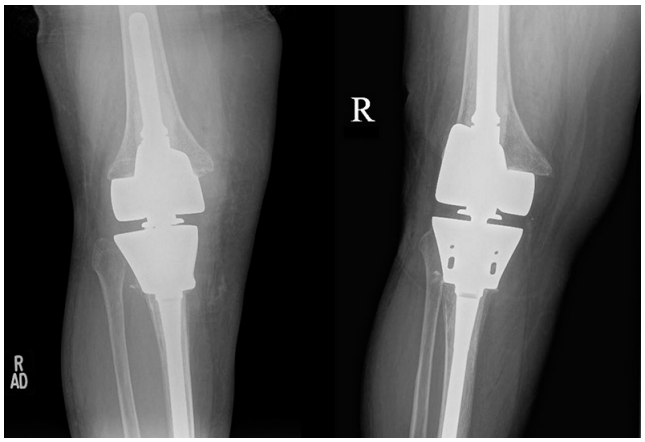

Figure 5. X-ray of the right knee joint after revision surgery. Correct positioning of the prosthetic elements

osteolysis process in the joint surroundings after TKA [5].

Prosthetic failure typically manifests through symptoms like pain, swelling, and limited mobility of the limb. Although the clinical picture is usually suggestive, the presence of late infection should be excluded, and the final diagnosis can be made after a histopathological examination of the tissues. [4]. Untreated osteolysis can lead to periprosthetic fracture and joint instability. Studies suggest that SPECT/CT arthrography is the most accurate method for diagnosing aseptic loosening in TKA. CT and MRI using metal artifact reduction techniques should be considered. X-rays have been described as less sensitive in detecting the earliest stages of aseptic loosening [7].

The surgical technique and obtaining an adequate quality cement mantle are factors that significantly affect the success of the TKA procedure. Research indicates that optimal cement fixation requires its penetration through the trabecular bone, and a minimum cement depth of 2 mm is necessary to involve at least 1 level of trabecular bone. The optimal penetration depth was considered to be 3–4 mm. The use of a larger amount of cement, and therefore greater penetration, may result in thermal damage to the bones [2]. When fixing prosthetic elements, it's essential to follow the correct technique, particularly regarding the optimal timing for mixing and applying the cement. During the preparation of the cement, a polymerization reaction of methyl methacrylate takes place between the powder containing the polymer and the liquid (monomer). Research suggests that the cement should be applied to the prosthetic components and surrounding bone at a specific point – when it no longer adheres to the surgical glove. This critical phase typically lasts between 3 to 7 minutes and depends on factors such as temperature and the speed at which the polymer and monomer are mixed. During the placement of the implant, it is important to remove any excess cement that may leak between the prosthetic components and the bone surface [8].

CONCLUSIONS

In the described case, the primary procedure's failure may have been attributed to an improper cementing technique and an excessive amount of cement revealed in the region of the femoral component during the revision TKA. Research suggests a significant correlation between elevated levels of polyethylene particles in synovial fluid and greater foreign body reaction in tissues. Additionally, there was a notable rise in the level of osteolysis observed in the bones [5]. This leads to the conclusion that cementation technique is a key factor determining the success of the procedure, and irregularities in the formation of the cement mantle should be considered as a potential cause of aseptic loosening.

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