CASE REPORT

Catastrophic Periprosthetic Osteolysis in Total Hip Arthroplasty at 20 Years: A Case Report and Literature Review

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Background: Periprosthetic osteolysis is a serious complication following total hip arthroplasty (THA). However, most orthopedic surgeons only focus on bone loss and hip reconstruction. Thus, it was required to understand the treatment algorithm for periprosthetic osteolysis integrally.

Case Presentation: A 52-year-old Asian male presented with chronic hip pain. A mass appeared on the medial side of the proximal left thigh at more than 20 years after bilateral THA. Radiographs revealed catastrophic periprosthetic osteolysis, especially on the acetabular side. Large amounts of necrotic tissue and bloody fluids were thoroughly debrided during revision THA. A modular hemipelvic prosthesis was used for revision of the left hip. Four years later, the patient presented with right hip pain, where a mass appeared on the medial side of the proximal right thigh. A primary acetabular implant with augment was used for revision of the right hip. Laboratory evaluation of bloody fluid retrieved from surgery revealed elevated levels of inflammatory markers.

Conclusion: Inflammatory responses to polyethylene wear debris can lead to severe bone resorption and aseptic loosening in the long-term following THA. Therefore, in spite of revision THA, interrupting the cascade inflammatory might be the treatment principle for periprosthetic osteolysis.

Key words: Inflammation; Periprosthetic osteolysis; Polyethylene wear; Revision surgery; Total hip arthroplasty

Introduction

The major indications for revision of total hip arthroplasty (THA) include periprosthetic osteolysis, aseptic loosening, hip instability, and periprosthetic infection. The burden of revision surgery continues to increase with the popularity of primary THA.[1] Due to a large number of patients carrying older implant designs with conventional polyethylene, periprosthetic osteolysis has remained a common cause of revision THA.[2] Periprosthetic osteolysis originates from chronic inflammatory responses triggered by implant-derived particulate debris, which cause recruitment of cells, including macrophages, fibroblasts, lymphocytes and osteoclasts. These cells secrete proinflammatory and osteoclastogenic cytokines, exacerbating the inflammatory response.[3] Here we describe a case of catastrophic periprosthetic osteolysis 20 years after bilateral THA, where the composition of the bilateral pelvis including the ilium, pubic branch, and ischial ramus almost disappeared, resulting in a mass on the proximal thigh and hip dysfunction. To our knowledge, this is the first report of catastrophic periprosthetic osteolysis leading to an inflammatory cascade in response to tissue necrosis at an extended time period of 20 years after primary THA. We discuss the clinical findings, appropriate diagnostic workup, and treatment for this unique case. In the workup of a patient with periprosthetic osteolysis, it is important to recognize the possibilities prior

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to catastrophic failure, such as component dislocation or loosening.

The patient was informed that data concerning the case would be submitted for publication, and has provided consent.

Case Presentation

A 52-year-old Asian male with past medical history of ankylosing spondylitis involving bilateral hip, now with bilateral THA, presented with chronic left hip pain. A mass appeared on the medial side of the proximal left thigh and has increased in size. On review of previous medical records, the patient's bilateral THA was performed in 1996 at our hospital, more than 20 years prior to his clinical presentation for hip pain. Operative reports detailed the use of a metal acetabular shell with a 32-mm polyethylene insert (JingHang, China). On the femoral side, JingHang size #4 hip stem was used and paired with a 28-mm femoral head, creating a metal on polyethylene (MoP) construct. On physical examination, he confirmed left hip and groin pain leading to no range of motion of the hip joint. Radiographic imaging of the pelvis showed severe left periprosthetic osteolysis (Paprosky IIIB) (ilium, pubic branch and ischial ramus), as well as displacement of the acetabular shell (Figure 1). After preoperative planning (Figure 2), a revision surgery was conducted through his previous anterolateral incision and posterior approach. On direct visualization of the implant, there was evidence of acetabular shell loosening and extensive dark necrotic tissue (Figure 3). After excision of the associated periprosthetic necrotic tissue, a modular hemipelvic prosthesis was fixed with screws (GPS II, AK Medical, Beijing, China) and a 28-mm metal femoral head (JingHang, China) were used without conducting revision for the femoral stem due to no obvious loosening (Figure 4). The intraoperative bleeding was about 750 mL.

After 4 years, the patient presented with right hip pain, whereby a mass appeared on the medial side of the proximal right

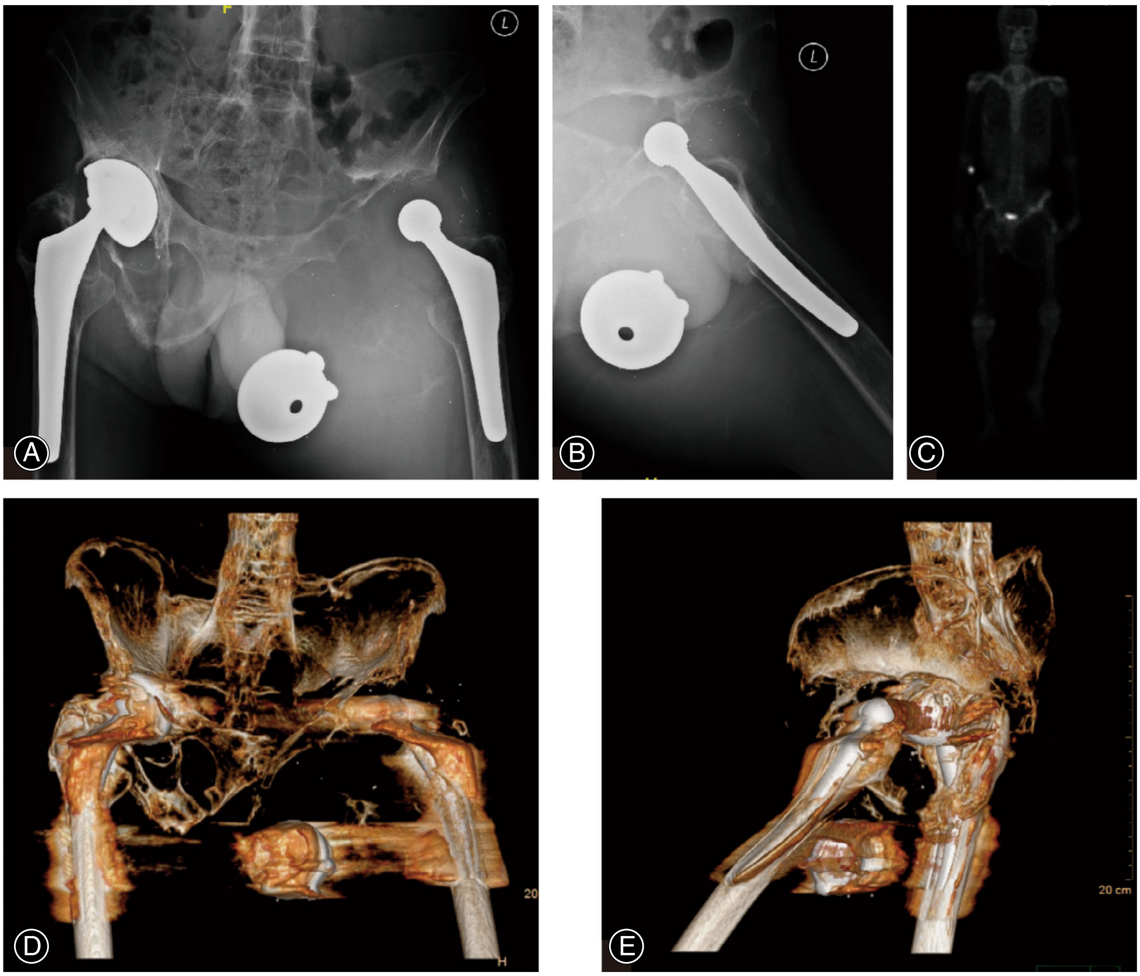

Fig. 1 Preoperative radiograph imaging of the pelvis demonstrating periprosthetic osteolysis of left hip. (A) Anteroposterior (AP) radiograph of the pelvis. (B) Lateral radiograph of the left hip. (C) Bone scintigraphy showing no active bone metabolism. (D) 3D reconstruction of CT scan of the pelvis. (E) 3D reconstruction of CT scan of left hip. CT = computed tomography.

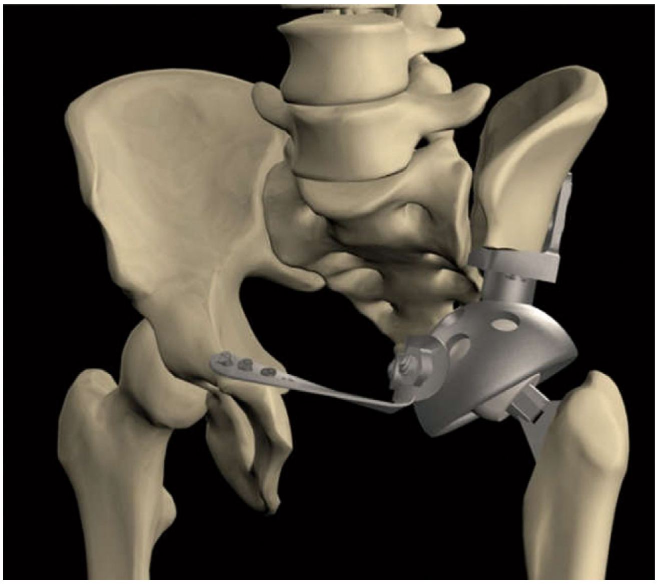

Fig. 2 Preoperative planning for reconstruction of left hip due to severe periprosthetic osteolysis.

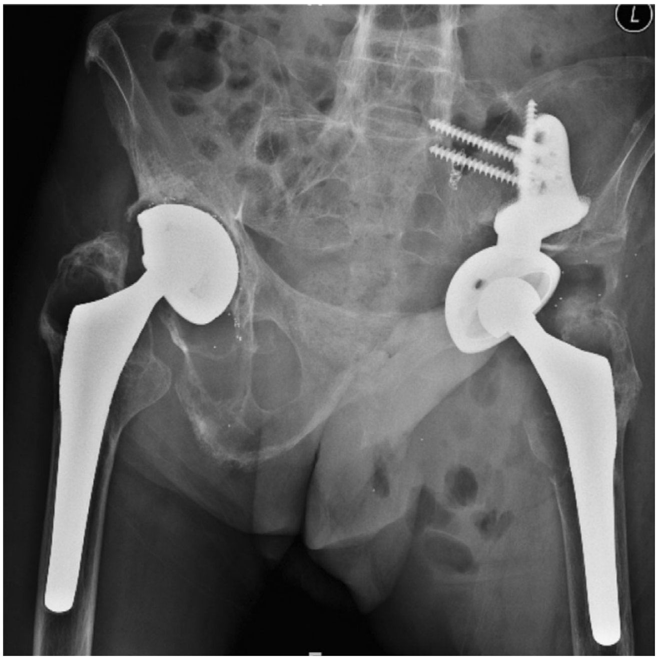

Fig. 4 Anteroposterior radiograph after left revision THA.

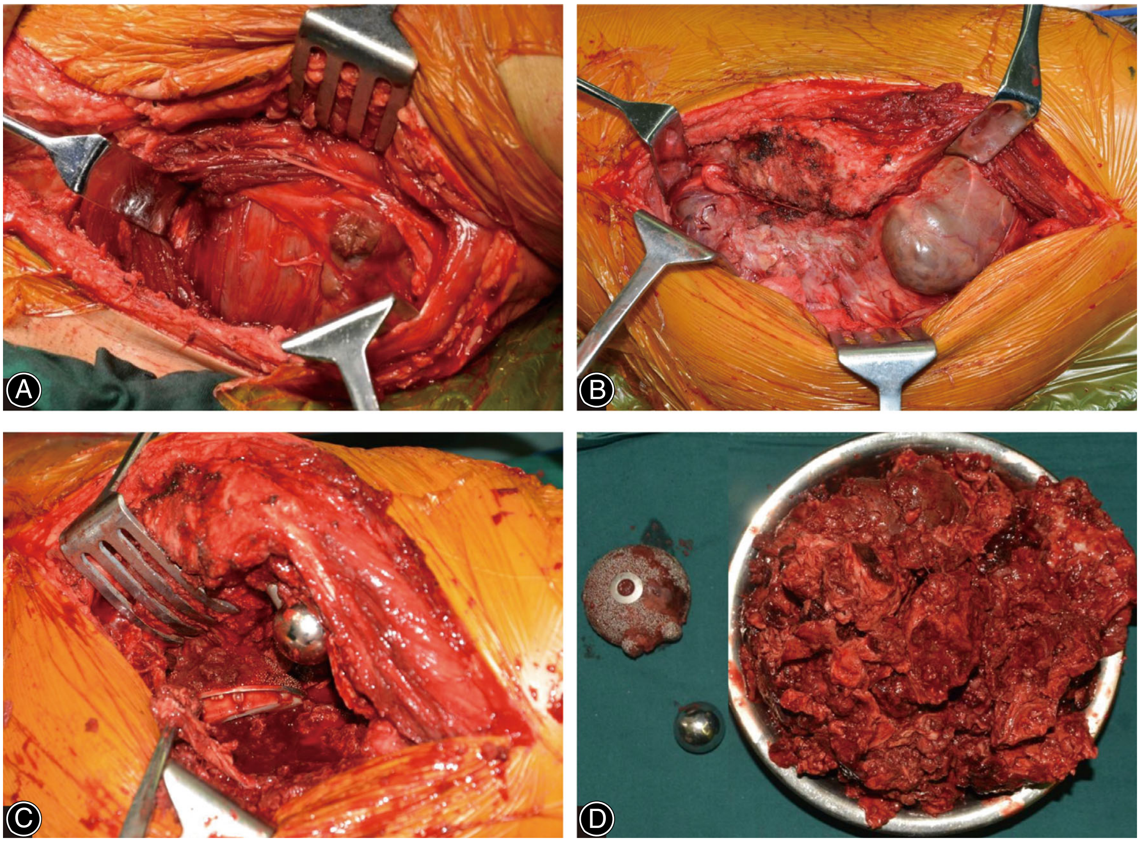

Fig. 3 Intraoperative gross examination of the surgical field with loosing acetabular shell and necrosis tissue. (A) Anterolateral incision to probe mass appeared on the medial side of the left hip. (B) Exposure of large amounts of necrotic tissue inside the mass *via* posterior approach. (C) Displaced acetabular shell in surgical field. (D) Large amounts of necrotic tissue and removed metal femoral head and acetabular shell.

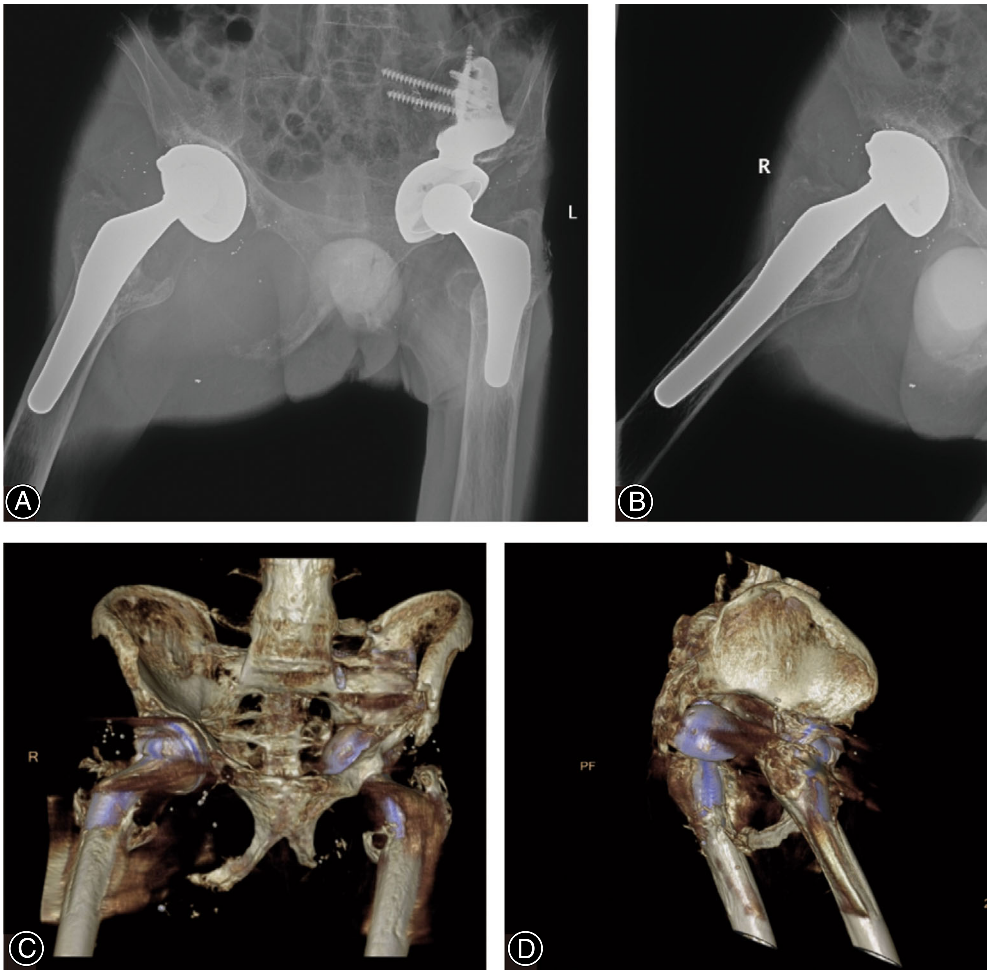

Fig. 5 Preoperative radiograph imaging of the pelvis demonstrating periprosthetic osteolysis of right hip. (A) Anteroposterior (AP) radiograph of the pelvis. (B) Lateral radiograph of the right hip. (C) 3D reconstruction of CT scan of the pelvis. (D) 3D reconstruction of CT scan of right hip. CT = computed tomography.

thigh. Physical examination of the right hip gave similar results as previously with the left hip. Laboratory evaluation revealed elevated levels of inflammatory markers, with C-reactive protein (CRP) at 47.8 mg/L and an erythrocyte sedimentation rate (ESR) of 44 mm/h. Radiographic imaging of the pelvis showed severe right periprosthetic osteolysis (Paprosky IIIB) (Figure 5). Two plans were made during preoperative planning, namely modular hemipelvic prosthesis or primary prosthesis in the acetabular side (Figure 6). A posterolateral approach was utilized, which readily granted access to the implant and necrotic tissue in the right hip. Samples of the periprosthetic necrotic tissue were collected and sent for laboratory examination. Bloody fluid in the surgical field was obtained and sent to the biochemical laboratory for evaluation. A primary acetabular shell, a 32-mm polyethylene insert secured with three cancellous bone screws, a slope augment (ACT, AK Medical, China), and a 28-mm metal femoral head (JingHang, China) were used without femoral side revision (Figure 7). The intraoperative bleeding was about 500 mL. After surgery, patient was instructed to be bedridden and partially weight-bearing on the floor successively.

Scanning electron microscopy (SEM) findings indicated that polyethylene particles originated from MoP wear (Figure 8). Laboratory evaluation revealed an elevation of inflammatory markers without infection, including TNF-β, IL-6, IL-8 and IL-1β, which initiated a cascade of immune responses (Table 1). Thus, the immune response caused by polyethylene particles is the underlying cause of the occurrence of catastrophic periprosthetic osteolysis. Postoperative radiographic imaging confirmed the initial stability of the right hip prosthesis (Figure 9). After revision THA, the patient underwent two additional procedures for hematoma clearance and exploratory operations due to chronic bleeding in the right hip. Although lower extremity angiography was conducted, there was no active bleeding from iliac vessels. The patient died after 6 months due to hemorrhagic shock caused by coagulation abnormalities and malnutrition.

Discussion

The present study reported a severe catastrophic periprosthetic osteolysis as a serious complication following total hip arthroplasty. Further, we confirmed that polyethylene wear debris induced cascade inflammatory response was

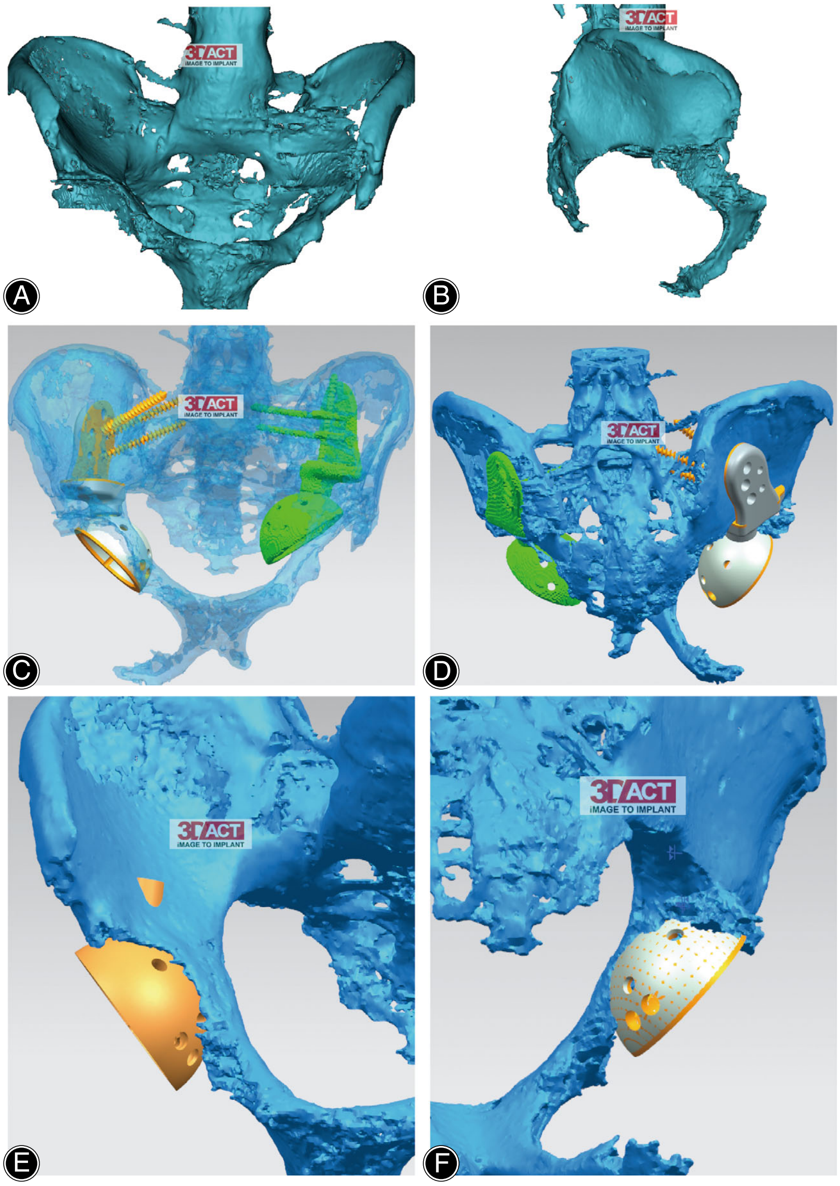

Fig. 6 Preoperative planning for reconstruction of right hip. 3D reconstruction of pelvis by finite element method from frontal view (A) and from lateral view (B). Preoperative planning for reconstruction of right hip based on modular hemipelvic prosthesis from frontal view (C) and from posterior view (D). Preoperative planning for reconstruction of right hip based on primary prosthesis from frontal view (E) and from posterior view (F).

associated with bone resorption and aseptic loosening. The process of this "silent" iatrogenic disease involves both mechanical and biological factors that initiate a local immune response in the periprosthetic tissue that eventually led to implant loosening and failure.[4] Therefore, interrupting the cascade inflammatory might be the treatment principle for periprosthetic osteolysis. Currently, the interventions, including operative and non-operative treatments, were to inhibit osteoclastic bone resorption and to induce bone formation (Table 2).

There are few reports in the medical literature of catastrophic periprosthetic osteolysis that originated from progressive, active and inflammatory cascade response to polyethylene wear debris.[13,14] Excessive production of wear by-products induces a foreign body and chronic inflammatory reaction that accelerates periprosthetic bone destruction and inhibits bone formation.[15] Previous case reports were not as severe as the current case.[16] Conventional polyethylene that is gamma irradiated in air generates increased amounts of free radicals, which induce additional wear particles, osteolysis, and eventual component loosening.[17] Periprosthetic osteolysis and aseptic loosening are the leading causes of revision THA in patients with conventional, non-crosslinked polyethylene.[18] In this case, with non-cemented implants, any areas without bony ingrowth could provide access to particle-laden joint fluid and result in periprosthetic osteolysis.[19] The process of osteolysis begins with macrophage-mediated phagocytosis of polyethylene wear debris.[8,20] After ingesting the wear debris, macrophages produce pyrolysis products which result in further release of inflammatory cytokines from other

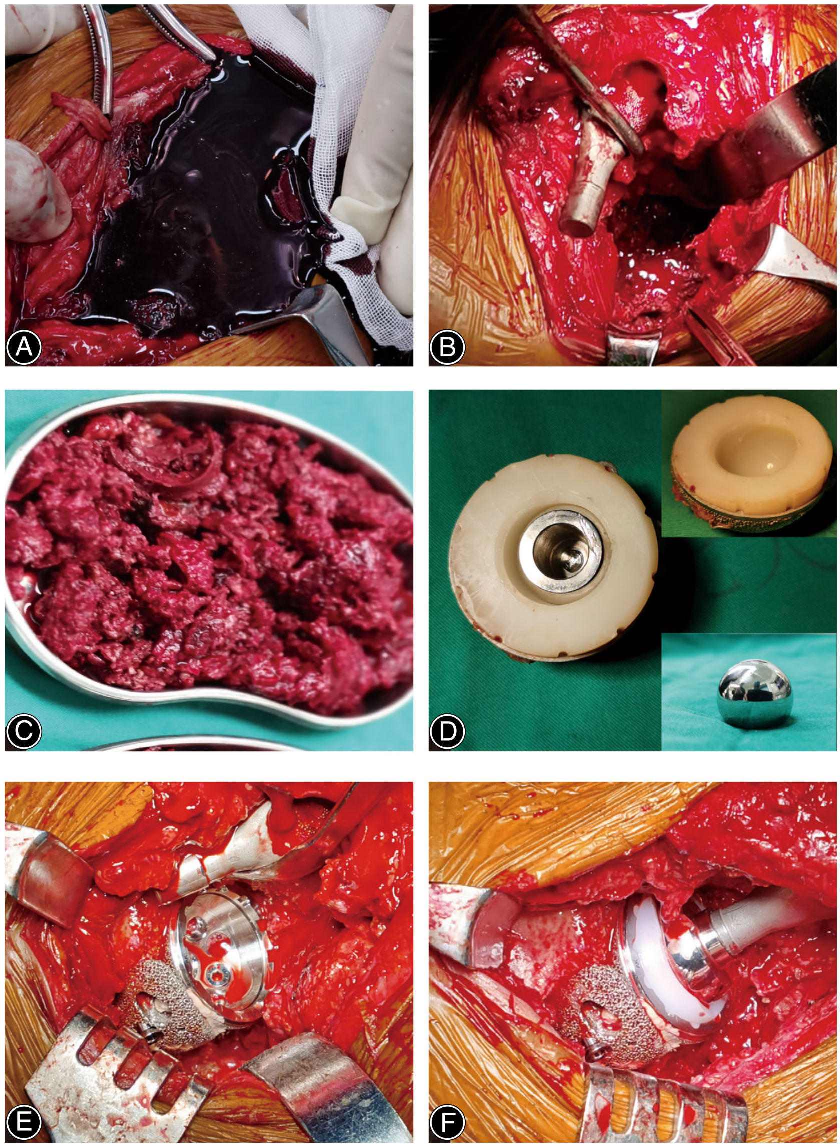

Fig. 7 Intraoperative examination of the surgical field in right revision THA. (A) A large amount of bloody fluid was seen flowing out of deep tissue during the surgery. (B) Remove necrotic tissue completely to expose acetabular side and femoral side. (C) Large amounts of necrotic tissue. (D) Explanted acetabular shell, polyethylenes insert and metal femoral head. (E) Primary acetabular shell, polyethylenes insert secured with three cancellous bone screws, a slope augments were implanted. (F) Hip joint reduction with femoral stem preservation.

macrophages, inducing an elevated immune response and bone resorption.[21,22]

The treatment algorithm for treatment algorithm periprosthetic osteolysis needs to consider the patient's symptoms, activity level, and medical co-morbidities.[1] The patient in this case presented with worsening pain, appearance of acetabular shell loosening, and severe bone loss, leading to indications for revision surgery. Complete debridement of the patient's osteolytic lesions was of significant importance, which could inhibit the inflammation by removing reservoirs of cytokines. In a previous study, we reported that modular hemipelvic endoprosthesis, coupled with the use of iliosacral fixation showed stable reconstruction and good functional outcomes for patients with severe acetabular bone loss.[23] Considering left hemipelvic absence in this case, a modular hemipelvic prosthesis was used in the revision of the left hip. After evaluation of acetabular bone loss in the right hip, defects exhibited >60% deficiency of the host acetabular bone stock, and the acetabular rim and columns were completely non-supportive. Hence, a non-cemented acetabular shell was used in conjunction with a modular porous metal augment in the revision of the right hip.[24] After evaluation of the femoral side, the stem was not revised in the left or right hip due to their satisfactory stability.

Risk factors for periprosthetic osteolysis may be related to patient, surgical, and implant aspects. Although highly crosslinked polyethylene and newer implant designs have been used in more recent THA procedures with improved long-term survivorship,[25] other factors such as appropriate polyethylene thickness and proper positioning of components might still contribute to osteolysis after THA.[1] In the diagnosis of osteolysis post-THA and treatment using

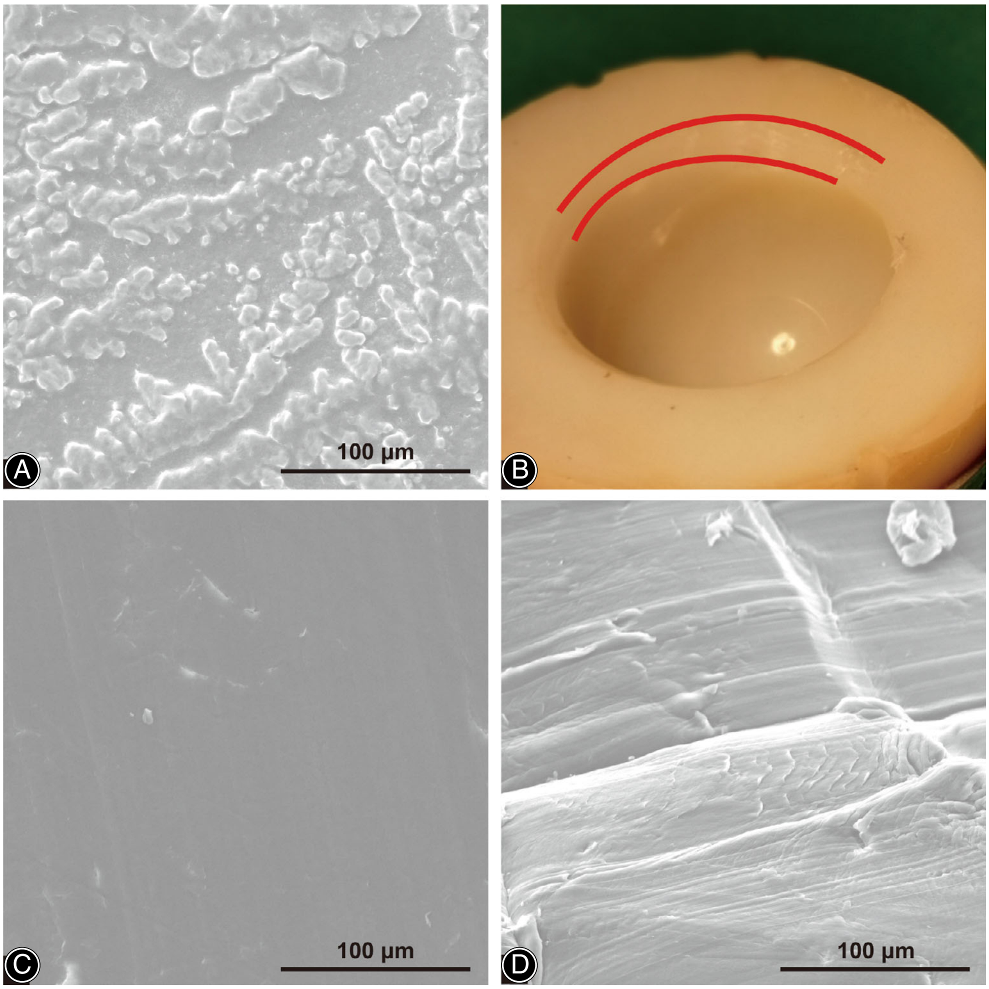

Fig. 8 Polyethylene particles leading to periprosthetic osteolysis. (A) Polyethylene particles were observed under the microscope. (B) Catastrophic wear from polyethylene insert. (C) Normal area of polyethylene insert in SEM imaging. (D) Worn area of polyethylene insert in SEM imaging.

Table 1 Immunity and inflammation evaluation of bloody fluid in surgical field

Cytokines	Result (pg/mL)	Reference values
TNF-β	21.54*	≤2.54
IL-8	10725.41*	≤15.71
IL-6	17706.63*	≤11.09
IL-1β	24.30*	≤3.40
IL-17F	<1.00	≤4.66
TNF-α	<1.00	≤4.50
INF-γ	<1.00	≤4.43
IL-22	<1.00	≤3.64
IL-17A	<1.00	≤4.74
IL-12p70	<1.50	≤10.18
IL-10	2.33	≤4.50
IL-5	<1.00	≤4.15
IL-4	<1.50	≤4.19
IL-2	<1.50	≤6.64

* Indicated positive result.

revision THA, it is of prime importance to conduct a thorough evaluation, meticulous radiographic examinations, detailed preoperative planning, adequate implant preparation, and skillful surgical execution.

Availability of data and material

The final dataset will be available from the corresponding author.

Conflict of interest

The authors declare that they have no conflict of interest.

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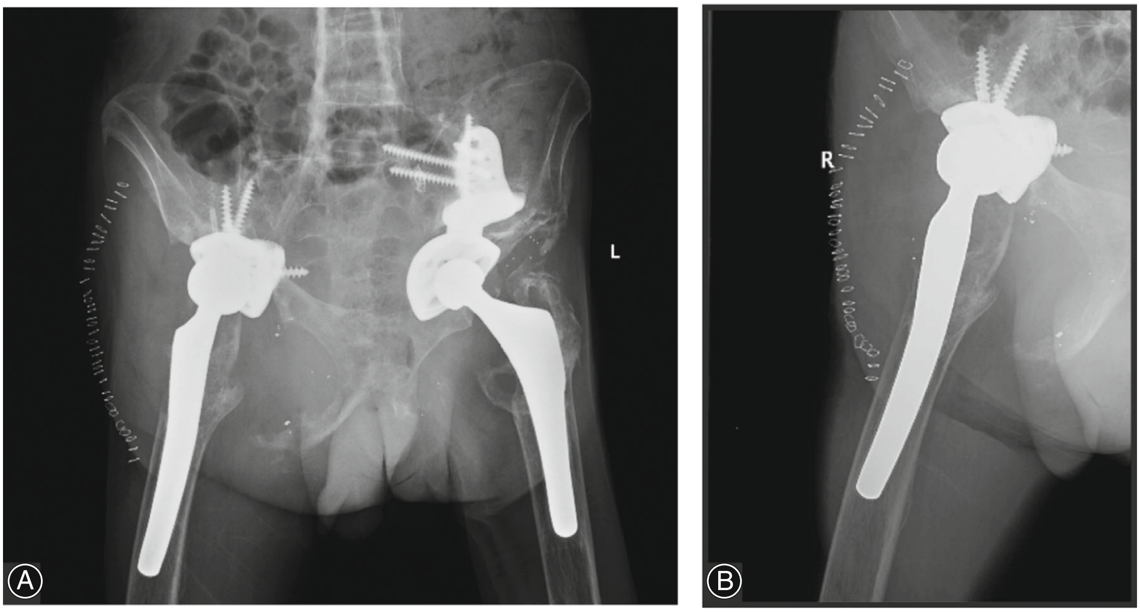

Fig. 9 Anteroposterior (A) and lateral (B) radiograph after right revision THA.

Table 2 Treatments for periprosthetic osteolysis

Intervention	Treatments	Mechanism
Operative treatment	Revision surgery	It is indicated to correct the failing articulation and address prior and ongoing potential bone loss.[5]
Non-operative treatment	Bisphosphonates	These medications do not affect the pro-inflammatory profile of periprosthetic tissues.[6]
	Denosumab	It is a human monoclonal antibody to RANKL that blocks the binding of RANKL to RANK, thereby inhibiting osteoclast activity and function.[7]
	Aimed at specific pro-inflammatory cytokines	It inhibit cytokine pathway that dramatically affect the consequences of injury or other adverse stimuli.[8]
	Targeted to upstream from the inflammatory cytokines	It can interfere with the key proinflammatory transcription factor.[9]
	The 1–34 amino acid portion (1–34) of parathyroid hormone (PTH)	It is an anabolic substance that increases bone formation.[6]
	Recombinant OPG gene therapy	It can inhibit osteolysis.[10]
	Icariin	It can protect osteolysis by promoting osteogenic differentiation of MSCs.[11]
	Cell therapy	Local therapeutic delivery of cells can directly or indirectly affect osteolysis.[12]

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