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Case report

Oxidized zirconium on ceramic; Catastrophic coupling

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ABSTRACT

Oxidized zirconium (Oxinium™; Smith & Nephew, Memphis, TN, USA) articulated with polyethylene in total hip arthroplasty (THA) appeared to have the potential to reduce wear dramatically. The thermally oxidized metal zirconium surface is transformed into ceramic-like hard surface that is resistant to abrasion. The exposure of soft zirconium metal under hard coverage surface after the damage of oxidized zirconium femoral head has been described. It occurred following joint dislocation or in situ succeeding disengagement of polyethylene liner. We reported three cases of misuse of Oxinium™ (Smith & Nephew, Memphis, TN, USA) heads. These three cases resulted in catastrophic in situ wear and inevitable failure although there was no advice, indication or recommendation for this use from the manufacturer.

1. Introduction

Oxidized zirconium (OxZr) head (Oxinium™; Smith & Nephew, Memphis, TN, USA) articulated with polyethylene in total hip arthroplasty (THA) appeared to have the potential to reduce wear dramatically. Thermally driven oxygen diffusion transforms the metallic (zirconium – 2.5% niobium alloy) surface into a low-friction hard ceramic surface. The metal head with oxidized surface provides superior resistance to abrasion and reduces the risk of brittle fractures [1]. Other recent studies revealed reduced wear properties of oxidized zirconium head on cross-linked polyethylene liner [2,3].

Damage to the OxZr head following joint dislocation [4] or following in situ disengagement of polyethylene liner [5] has been described in the literature. We reported three cases whose bearing couple resulted in catastrophic in situ wear and inevitable failure. All index primary arthroplasties had been performed outside our clinic. They were all examples of misuse of Oxinium™ heads, although there was no advice, indication or recommendation for this use from the manufacturer (Smith & Nephew, Memphis, TN, USA).

1.1. Case 1

A 52-year-old female was admitted with right hip pain and limited movements. Primary total hip arthroplasty was performed for osteoarthritis secondary to acetabular dysplasia 52 months ago. She had no complaints for four years following the index operation. Hip pain started four months prior to her admission to our clinic and increased gradually. The limitation in her right hip movements started after she had "shattering glass sound" when she was leaning forward, which occurred one month before her admission.

She had an antalgic gait pattern. Limited flexion and abduction of her right hip were mainly related to the pain.

Revision of right hip prosthesis was planned due to her complaints, clinical examinations and radiographies (Fig. 1). During her revision, there were synovia colored black, stained heavily with metallosis that radiated proximally through intermuscular interval along the gluteus maximus and medius muscles. Forty-six millimeters cementless, porous coated, hemispheric ceramic Reflection® InterFit acetabular component (Smith & Nephew, Memphis, TN, USA) along with an alumina ceramic liner (Biolox® Forte; CeramTec, Plochingen, Germany) had been used. Ceramic liner was found broken at its corner and +12 mm 28 mm Oxinium™ (Smith & Nephew, Memphis, TN, USA) head had severe deformation (Fig. 2). The femoral component was found stable. All tissues with metallosis were debrided. The cup and the head were revised with 56 mm ceramic Reflection® InterFit acetabular component (Smith & Nephew, Memphis, TN, USA) along with an alumina ceramic liner and 36 mm ceramic head (Biolox® Forte; CeramTec, Plochingen, Germany). Histological examination showed wear debris granulomas with histiocytic reaction and fibrosis.

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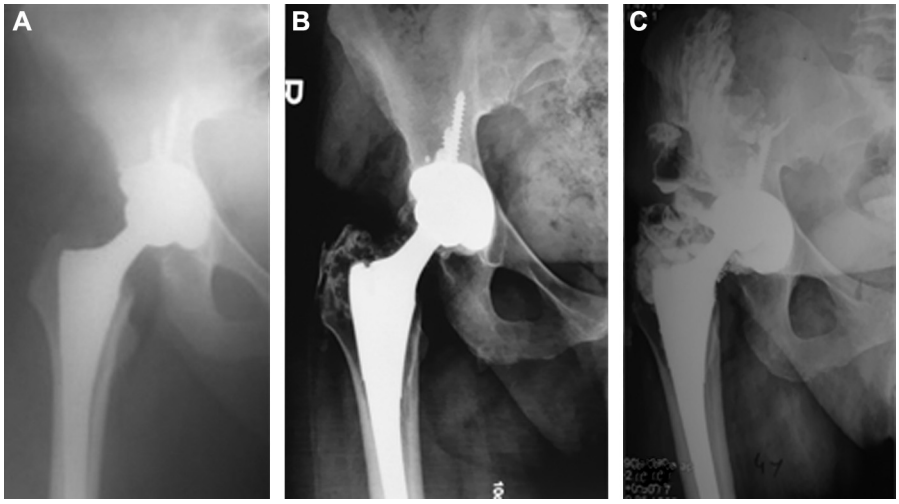

Fig. 1. Plain radiographs showing a 52-year-old female patient who underwent right hip arthroplasty. A. Immediate postoperative after the index operation. B. At her fourth year's follow-up showed early metal debris collection in joint and around greater trochanteric area. C. At 4 year 4 months' follow-up taken in our clinic showed metallosis radiates to proximally through gluteal muscles. Eccentric position of the head in the cup was also observed.

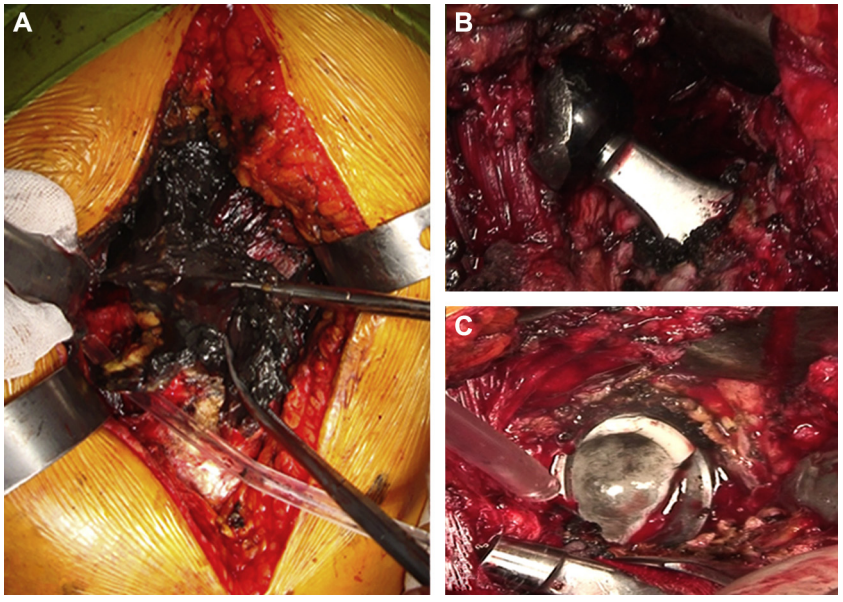

Fig. 2. A. Dark stained metallosis on trochanteric area and distal insertion of gluteus medius muscle. B. Deformed Oxinium™ head. C. Broken ceramic liner. There was no visible corrosion or signs of fretting on femoral head taper.

At 24 months' follow-up, she regained full range of hip movements without any complaints.

1.2. Case 2

A 63-year-old male patient, who underwent left hip arthroplasty for osteoarthritis three years ago, was referred to our clinic with the complaint of his left hip squeaking that lasted the past four months. The squeaking has been getting worse and began disturbing him. He also had pain and limitation of hip movement that started two weeks before admission to our clinic. He did not report any trauma. There was no limping but pain in groin when walking.

Revision of left hip arthroplasty was performed due to his radiographs and clinical complaints. Metallosis with dark black colored synovia was observed around the trochanteric bursa and distally through posterior compartment as expected from his preoperative radiographies (Fig. 3). Eccentric positioned 32 mm Oxinium™ head was found deformed and the articular surface of alumina ceramic liner (Biolox® Forte; CeramTec, Plochingen, Germany) was covered with dark metallic color (Fig. 4). The acetabular component was 54 mm cementless, porous coated, hemispheric ceramic Reflection® InterFit (Smith & Nephew, Memphis, TN, USA) and found to be well fixed to the bone. It was extracted with an extractor and revised with R3® Stiktite coated acetabular component with metal insert. Femoral component was found stable. The 48 mm BirminghamHR® (BHR, Smith & Nephew Inc., Memphis, TN, USA) metal head with +12 mm metal sleeve had to be used to restore the offset (Fig. 3).

Histology revealed soft-tissue granulomas of the wear debris with generalized histiocytic reaction and fibrinosis with granular amorphous necrotic material (Fig. 5).

At 48 months' follow-up, he had no complaints and his Cobalt (Co) and Chromium (Cr) levels were 2.5 μg/L (normal: 0.4 μg/L) and 1.5 ng/mL (normal: < 3.7 ng/mL), respectively.

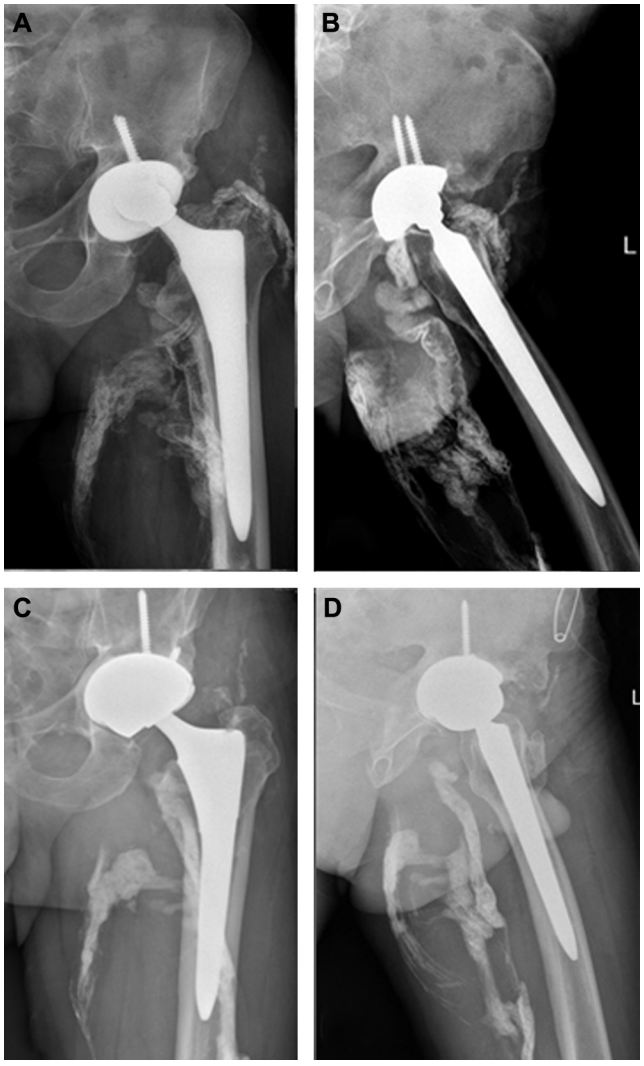

Fig. 3. A 64-year-old male who underwent left hip arthroplasty at his third year's follow-up. Anterior posterior (A) and lateral (B) radiographies showed metallosis radiating distally through posterior compartment and eccentric position of the head. The radiographies at 4 years' follow-up after MOM revision: anterior posterior (C) and lateral (D) view.

1.3. Case 3

A 55-year-old female, who underwent right hip total arthroplasty for acetabular dysplasia seven years ago, was admitted with complaints for her right hip squeaking for four months. For the last month, she also had limited right hip movement with pain and difficulty in walking. The radiographic evaluation of her right hip revealed significant metallosis that infiltrated into bone, especially around the acetabular cup (Fig. 6).

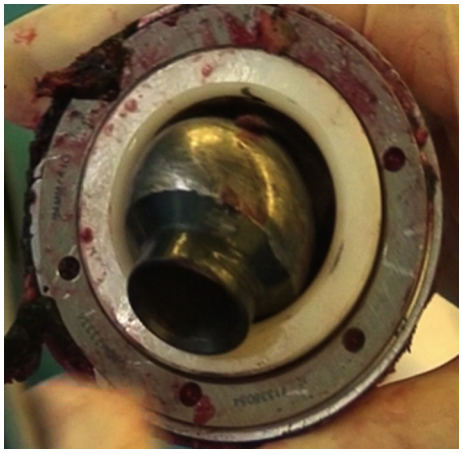

Fig. 4. Extracted cementless, porous coated, hemispheric ceramic Reflection® InterFit component after 3 years from index operation with alumina Biolox® Forte ceramic liner and deformed Oxinium™ head.

Revision of right hip arthroplasty was performed according to her complaints and radiographies. There was dark colored metallosis that covered the synovia of the joint. A 48 mm cementless, porous coated, hemispheric ceramic Reflection® InterFit (Smith & Nephew, Memphis, TN, USA) acetabular component was extracted without an extractor. Metallosis was observed also around the bone of the extracted cup (Fig. 6). The remaining bony acetabulum was stained with dark metallic color but seemed well nourished with the bloody appearance. A 50 mm Reflection® InterFit cementless component with highly cross-linked polyethylene liner was implanted. The femoral stem was found stable. A +16 mm 32 mm OxZr femoral head had to be used to restore the offset and the length leg discrepancy.

Histological examination revealed wear debris granulomas with histiocytic reaction but there was no necrosis.

At 6 months' follow-up, she had full range of hip movements without any complaints.

2. Discussion

The three referred cases are extreme examples of in situ damaged OxZr heads without dislocation or trauma. The main problem in these cases was the misuse of OxZr heads with their ceramicized surface as hard-on-hard bearing couple although there was no advice, indication or recommendation for this use.

The complaints of the patients in the three cases started around three or four months before admission. Squeaking was the first complaint in two cases. However, gradually increasing pain and limitation in the movements of the related hip were the main and

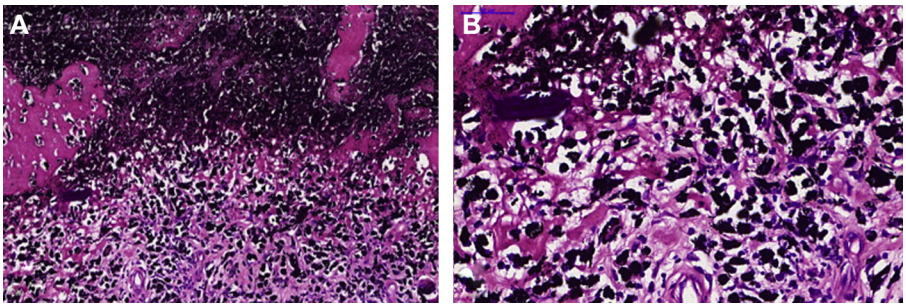

Fig. 5. Histology (in Case 2) revealed soft-tissue wear debris granulomas with generalized histiocytic reaction and granular amorphous necrotic material with fibrinosis. A. 67× H&E. B. 350× H&E.

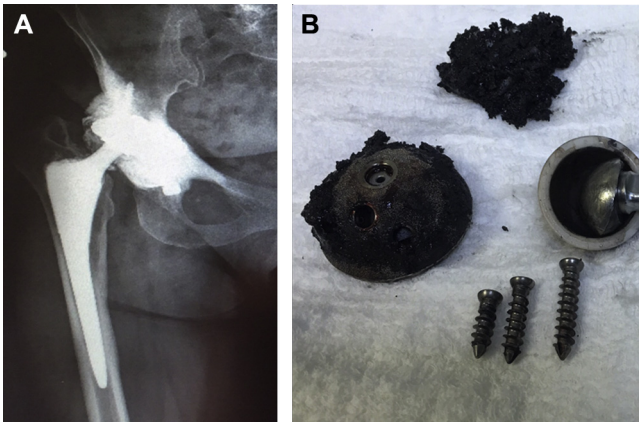

Fig. 6. A 55-year-old female who underwent right total hip arthroplasty seven years ago complained of left hip squeaking for four months. A. At seventh years' AP radiography showing metallosis around cup. B. During revision; extracted cup, ceramic liner and debris bony material.

common complaints for all cases. We do not have a clear past medical history of the patients but we think that the necessity of longer neck lengths to restore the offset might have led to the misuse of the bearing couple. Biolox® Forte ceramic heads has limited longer neck options. Oxinium™ head with longer neck might had been thought as an alternative option to a part of hard-on-hard bearing and coupled with ceramic liner.

It was demonstrated that ceramic surface of OxZr head resists roughening, thus enhances superior wear performance of highly cross-linked and non cross-linked ultrahigh-molecular-weight polyethylene. The transformed ceramic-like hard surface has resistance to abrasion [1]. Bourne et al. found that artificially damaged OxZr heads have a tendency to produce valleys when scratched in vitro [6]. Evangelista et al. warned about the possible damage and premature polyethylene wear with the dislocation of the Oxinium™ head. Delamination and cracking occurs on the oxidized surface with grooves under metal substrate. There is also metal transfer from the metal shell to OxZr head. The thin brittle ceramic layer on elastic substrate was unable to resist against high contact stresses and resulted with cracking [7]. Despite the superior wear resistance, the zirconium alloy, under thin hard substrate, is relatively soft when compared with cobalt–chrome alloy and may be deformed by acetabular shell material in the case of dislocation [4]. Gibon et al. also reported OxZr head damage generated by a metal foreign body within polyethylene cup following recurrent dislocation episodes [8]. In another study, the analysis of early retrieved specimens demonstrated clear evidence of surface damage even at the time of reduction of the index THA [9]. In contrast to OxZr heads, there was no visible evidence of cracking on the surface of the alumina ceramic head surface [10]. Metallic transfer onto the ceramic femoral head increases surface roughness and consequently increases the wear rate of the polyethylene liner [11].

Recently, accelerated wear of OxZr head without a trauma or dislocation has been reported in one case. After 10 years, there had been accelerated wear, with femoral and acetabular bone changes as a result of OxZr head and ultrahigh-molecular-weight polyethylene wear during a 6-month period [12]. In our three cases, the deformation of the heads was observed on patients' third, fourth and seventh years of index operations, respectively. Dark stained metallosis radiated proximally, distally and even medially into the bony acetabulum. We did not observe any bony destruction on both acetabular and femoral sides. There were no visible corrosion or signs of fretting observed on femoral tapers (Fig. 2). All femoral components were stable. Histologically, two of our cases showed same wear debris granulomas with histiocytic reaction without necrosis as reported by Tribe et al. [5]. However, a coagulation necrosis in one of our cases was observed in addition to this (Fig. 5). Acetabular component revision was performed in order to change bearing couple. Different bearing couples were used in each revision case. Restoration of the length and the offset with available components in our hands affected our choice for bearings. Now, we have concerns about the complications related to use of the metal on metal and the ceramic on ceramic couples in revisions [13,14]. Clinical and radiographic evaluations were performed at six weeks, three and six months, and one year after surgery and then annually. None of the patients has any problem at their last follow-ups.

3. Conclusion

In conclusion, OxZr on ceramic bearing couple can be named as "hard on hard bearing couple" but different roughness characteristics of each surfaces ended with this catastrophic result. OxZr head has a ceramicized surface but is not a ceramic head. It is manufactured only for using with conventional UHMWPE or cross-link polyethylene. Manufacturer (Smith & Nephew) warns in the instruction for use that it should never be articulated against Biolox® Delta or Forte ceramic liners because of the possible severe wear of bearing surfaces. There are no advice, indication or recommendation for this use from the manufacturer.

Disclosure of interest

The authors declare that they have no competing interest.

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