Advanced wear of an Oxinium™ femoral head implant following polyethylene liner dislocation

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ABSTRACT

Oxinium™ (Smith & Nephew, Memphis, TN, US) has been used in hip arthroplasty since 2003. The surface coating is hard and provides low wear rates but if this surface coating is damaged, the soft metal core is at risk of accelerated wear. Previous reports have described accelerated wear following intra and postoperative hip dislocation. We report a case of advanced wear of an in situ Oxinium™ femoral head implant following a cracked acetabular liner. The liner had disengaged from the titanium shell, allowing the Oxinium™ head to articulate directly with the shell. The disengaged liner led to dislocation of the Oxinium™ head, with associated pronounced wear of the head and the acetabular cup. The patient had a successful revision procedure. We advise close follow-up of patients with Oxinium™ implants, especially if associated with dislocation and closed reduction.

KEYWORDS

Oxinium™ – Hip arthroplasty – Dislocation – Wear

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A low wear rate is a key element of long-term total hip arthroplasty survival. Ceramic femoral heads have lower wear rates than traditional cobalt-chrome when articulated with a polyethylene acetabular liner but ceramic material is brittle and fracture is a reported failure mechanism.^{1,2}

The Oxinium™ (Smith & Nephew, Memphis, TN, US) surface coating aims to achieve the strength of cobalt-chrome and the wear resistance of ceramic. The surface properties of Oxinium™ are similar to ceramic but the core metal is zirconium alloy, which is softer than cobalt-chrome and can undergo rapid wear if exposed to any articulating metal surface.

Isolated reports in the literature have described damage to the Oxinium™ femoral head and exposure of the soft zirconium metal following joint dislocation and relocation.³ We report a case of an Oxinium™ femoral head undergoing advanced in situ wear and discuss the probable failure mechanism.

Case history

A 60-year-old woman had a Birmingham hip resurfacing revised due to a loose femoral component. She was referred to our institution with continued pain and a large hip effusion. The acetabular component was revised to an uncemented cup (ultra high molecular weight polyethylene liner) and a 36mm Oxinium™ head was placed on the retained,

uncemented Synergy™ stem (Smith & Nephew). Soft tissue histology from the operation revealed an aseptic lymphocytic vasculitis associated lesion (ALVAL).

Figure 1 Preoperative pelvic radiography showing the dislocated and worn Oxinium™ head with the irregular joint opacification of metallosis

Figure 2 Excised tissue that is heavily stained by metallosis but not necrotic

Figure 3 Retrieved polyethylene liner showing severe wear with loose fragments

After three years of painless good function, the patient started to develop squeaking, clunking and instability in the hip. Clinical examination revealed little pain but limited internal rotation. Plain radiography showed eccentric wear of the polyethylene liner, flattening of the superior part of the femoral head, and irregular joint and soft tissue opacification relating to metallosis. Computed tomography and magnetic resonance imaging showed significant metal debris

Figure 4 Retrieved Oxinium™ head showing severe edge wear

Figure 5 Schematic image showing the retrieved head with the area 'P' indicating the predicted original head size, viewed from the front

disease and a large joint effusion. Revision surgery had to be postponed due to episodes of unstable angina thought to be unrelated to her orthopaedic condition. Three months later, she presented with a dislocated hip (Fig 1).

Operative findings were a large, dark brown effusion and a synovium stained heavily with metallosis but with no necrosis (Fig 2). The polyethylene liner was cracked, worn and had disengaged from the shell to lie inferior to the femoral head (Fig 3). Consequently, the Oxinium™ head was articulating on the titanium metal acetabular shell and

had severe edge wear (Fig 4) with corresponding wear on the acetabular shell. Due to the patient's cardiac co-morbidity and well fixed acetabular shell and femoral stem, a polyethylene liner was cemented into the existing but damaged acetabular component and a 32mm ceramic head was placed on to the stem.

Histology revealed soft tissue wear debris granulomas and no tissue necrosis. Volumetric analysis of the head revealed that the volume difference between the retrieved head and the predicted head size was $-2,601.46\text{mm}^3$, indicating significant wear (Fig 5). Two months postoperatively, the patient's Oxford hip score was 42/48 and thorough clinical examination identified no abnormality that suggested zirconium or niobium toxicity. Her blood serum zirconium level was $2,428\text{nmol/l}$. The cobalt and chromium serum levels taken at the same time were $<10\text{nmol/l}$ and 47nmol/l respectively. (The accepted Medicines and Healthcare products Regulatory Authority thresholds are 120nmol/l and 135nmol/l .)

Discussion

Oxinium™ has been used for femoral components in total knee replacement since the 1980s. In 2003 it was introduced as a femoral head in hip arthroplasty surgery and had shown equivalent mid-term results to cobalt-chrome.⁴ Oxinium™ is produced by heating zirconium alloy (97.5% zirconium + 2.5% niobium) in air. The outer $5\mu\text{m}$ of the head is oxidised to form the hard zirconium oxide. Although the outer surface of the alloy achieves over twice the hardness of a cobalt-chrome alloy, the underlying zirconium alloy remains only half as hard as cobalt-chrome. Consequently, if the outer layer is damaged, the deeper soft metal alloy is exposed and can undergo accelerated wear when articulating against another harder metal (in our case titanium).

Kop *et al* retrieved three Oxinium™ femoral heads that had dislocated and were reduced closed.⁵ The authors found extensive damage to the Oxinium™ layer, which had led to exposure of the zirconium alloy. In the presence of failed or repeated closed reductions, the authors recommended Oxinium™ head replacement or regular follow-up appointments.

Our case is an extreme example of a damaged Oxinium™ head. The retrieval analysis showed that fracture of the superior rim of the polyethylene liner had caused the failure of the locking mechanism with the acetabular shell. In turn, this allowed the liner to rotate inferiorly, leaving the Oxinium™ femoral head articulating with the titanium shell. The edge of the shell damaged the superficial oxide layer of the femoral head, exposing the soft zirconium alloy underneath and leading to advanced wear.

One of the interesting points of this case is the patient's relatively mild symptoms given the high level of wear debris in the joint and a serum zirconium concentration of 2428nmol/l . This is 1,000 times greater than in a group of patients with 4.5-year-old Oxinium™ knee implants.⁵ Her

Table 1 Key learning points from this case

- Oxinium™ is an established bearing surface with good mid-term results.
- It tolerates adverse conditions poorly.
- It has a very thin ($5\mu\text{m}$) surface layer with an underlying substrate that is softer than other bearing surfaces.
- Extensive zirconium/niobium alloy debris causes inflammation but not necrosis, as seen with cobalt-chrome.
- Clinically, the zirconium/niobium alloy debris appears to be tolerated well at this extreme level exposure.

range of movement was only limited in internal rotation and her pain remained mild. The reduced pain level compared with a cobalt-chrome metallosis reaction may be due to the absence of tissue necrosis. Zirconium metal debris is obvious macroscopically and causes local tissue inflammation although it is seemingly non-toxic. Histological examination at the second revision showed only wear debris granulomas compared with the ALVAL reaction four years previously.

Conclusions

This case highlights that if the outer surface of the Oxinium™ head is damaged, then rapid destruction of the head can occur. Wear debris from the implant is tolerated relatively well by the patient, causing little pain, and seems to be non-toxic to the surrounding soft tissue (Table 1). We recommend that patients with Oxinium™ femoral heads should be followed up regularly, especially if the implant has dislocated previously, to ensure that any damage to the implant is identified quickly and appropriate steps can be taken before significant wear of the head takes place.

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