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Complete polyethylene wear-through and secondary breakage of the expansion cup in a ceramic-polyethylene total hip arthroplasty

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Abstract
Introduction Catastrophic polyethylene failure is an uncommon complication of ceramic-on-polyethylene total hip arthroplasty (THA) because of the favourable tribological characteristics of these implants. We present a case of a 50-year-old woman who formerly underwent bilateral ceramic-on-polyethylene THA with expansion acetabular cups and eleven years later presented with unilateral THA dislocation, secondary to catastrophic polyethylene failure and metal shell fracture.
Case presentation The patient came to our hospital for worsening pain in her left hip and an acute incapacity to bear weight on her left lower limb. Twelve and eleven years earlier she had undergone bilateral ceramic-on-polyethylene THA with acetabular expansion components of identical size on both sides. Radiographically, the left femoral head appeared superiorly dislocated and severe polyethylene wear was detected. The inclination angles of the left and right cups were 60° and 44°, respectively. The patient underwent left acetabular revision, and complete polyethylene wear-through with fracture of a cranial lobe of the expansion metal shell was noted at surgery. One large osteolytic lesion in the roof of the acetabulum and diffuse periarticular metallosis were also present. These findings required the use of a Burch–Schneider reinforcement cage. Two years later the patient is functioning well and has full autonomy in her activities of daily living.
Conclusion The correct inclination of the acetabular component is necessary to prevent accelerated polyethylene wear in THA, even though favourable articular bearing surfaces have been used (e.g., ceramic-on-polyethylene coupling). Should the cup appear well fixed and fairly oriented on follow-up radiographies, the early detection of severe polyethylene wear may permit a revision of only the femoral head and acetabular liner.

Keywords Total hip arthroplasty · Failure · Polyethylene wear · Ceramic · Hip dislocation · Expansion cup

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Introduction

One possible long-term complication of total hip arthroplasty (THA) is breakage of the cementless, metal backed acetabular component. In THAs with metal heads it has been related to catastrophic polyethylene failure with complete wear-through of the polyethylene liner and metal shell [1–3]. The wear rate of acetabular polyethylene in ceramic-on-polyethylene articulations has been reported to be lower than that of metal-on-polyethylene implants in both hip simulator and in clinical studies [4–6]. Despite these favourable tribologic characteristics, catastrophic polyethylene failure and cup breakage have been reported even in THAs with ceramic-polyethylene bearing surfaces [7–9]. No case reports of complete polyethylene failure with

secondary involvement of the metal shell of expansion acetabular cups have been published to date, although breakage of the metal back of such cups has been reported in two case series [10, 11]. To the best of our knowledge, this is the first case of THA dislocation secondary to catastrophic polyethylene failure and metal shell fracture in a patient with bilateral expansion acetabular cups.

Case report

A 50-year-old woman was admitted to our hospital in September, 2006, for worsening of pain in her left hip and acute incapacity to bear weight on her left lower limb. There was no previous trauma or fall, but the patient reported a 6-month history of increasing pain in her left hip. She had undergone bilateral THA of the right hip in February, 1994, and the left in June, 1995, with Spotorno CLS stems, 32 mm. alumina-ceramic femoral heads, and expansion acetabular cups with standard polyethylene liners (Centerpulse, Sulzer/Winterthur, Switzerland) for bilateral steroid-induced avascular necrosis of the femoral head. The size of both original acetabular components was 50 mm. On physical examination, we noted a severe and painful limitation in the range of motion of her left hip, and one and one-half centimetre shortening of the limb. Her calculated body mass index was 27.3. The radiographic examination (Fig. 1) showed correct placement of the right THA, with an inclination of the acetabular component of 44° and a slight cranial migration of the femoral head. Periacetabular osteolytic lesions were also present. In the left hip, the femoral head appeared to be superiorly dislocated; the inclination of the expansion cup was 60°. Although there was no obvious loosening or migration of this component, extensive periprosthetic osteolysis was present. Both femoral stems were correctly placed, but limited and not significant (<2 mm) periprosthetic radiolucent lines were present. She therefore underwent left acetabular revision with a lateral approach. At the time of surgery, we observed that the hip capsule was lined with black tissue. After removal of the ceramic femoral head, which was intact but with dark metallic staining, complete polyethylene wear-through and fracture of a cranial lobe of the metal shell were noted (Fig. 2). No obvious loosening of the cup was present, but a large osteolytic lesion was evident in the roof of the acetabulum. After all the black soft tissue was excised, the acetabular component was revised with a Burch–Schneider reinforcement cage and a cemented acetabular component. The femoral stem was stably fixed and did not require revision. The pathological examination showed extensive and chronic inflammation, with the presence of granulomata, foreign-body giant cells (Fig. 3), necrosis, and fibrin exudation. All intraoperative bacteriological cultures were negative.

Fig. 1 Anteroposterior standard radiograph of the pelvis. Radiographs taken before the revision surgery show correct placement of the right total hip arthroplasty, with an inclination of the acetabular component of 44°. Superior dislocation of the left total hip arthroplasty with an inclination of the expansion cup of 60° and extensive osteolysis of the acetabulum

Fig. 2 Photographs of the damaged components after removal and cleaning. The femoral head shows dark metallic staining. There is complete polyethylene wear-through and fracture of a cranial lobe of the metal shell

At the two-year follow-up, the patient reported that she had returned to her previous level of activity. She walked without support and had complete and painless range of motion in her left hip; the Harris Hip Score was 85. The position of both the acetabular cage and cup were correct and no signs of loosening or migration were observed in the radiographs (Fig. 4).

Discussion

The present case of expansion cup breakage has several peculiarities, including the characteristics of the implant, the unusual radiographic presentation, and its occurrence in

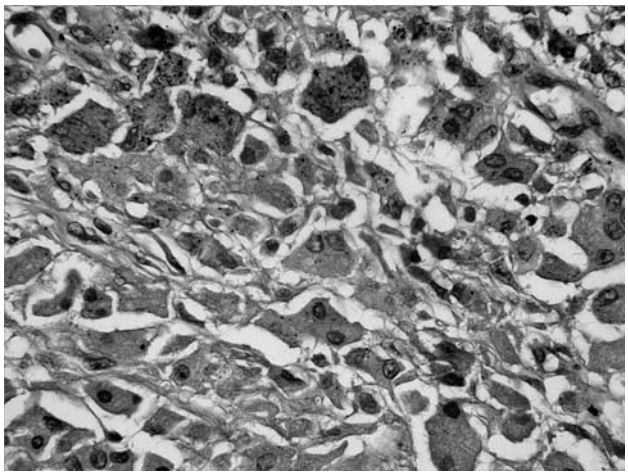

Fig. 3 Histologic section of the soft tissues demonstrating foreign-body giant cells phagocytizing dark metallic particles (hematoxylin and eosin stain; magnification, ×40)

Fig. 4 Anteroposterior standard radiograph of the pelvis obtained 2 years after revision surgery shows correct position of both the acetabular reinforcement cage and cup

a subject in whom an identical prosthesis had been formerly implanted in the contralateral hip. The expansion acetabular component consists of six titanium lobes connected at the pole. Each of these lobes has three rows of antirotation spikes on its convex side. The inner surface is threaded to capture the polyethylene insert. When the insert is screwed in place, the cup expands and mechanical stability is achieved by means of purchase of the sharp antirotation spikes on the bony acetabulum. The metal back is provided with a porous surface to promote bone ingrowth. Since the expansion cup is not rigid, it can match the elasticity of the iliac bone, minimizing the relative movement between the implant and the pelvis. Twelve and eleven years earlier, our patient had received bilateral ceramic-on- polyethylene THA with expansion cups. Eleven years post-surgery, the left acetabular component failed due to excessive polyethylene wear with secondary fracture of the metal shell. To the best of our knowledge, only four cases of catastrophic polyethylene failure in ceramic-on-polyethylene implants have been reported to date [7–9]. Indeed, the tribology of such coupling compares favourably with that of metal-on-polyethylene implants because of its lower wear rate [4–6], even though the reported rates of polyethylene wear in ceramic-on-polyethylene articulations have been highly variable, with a range from 0.03 to 0.34 mm/year [12, 13]. Several correlates of the increased acetabular polyethylene wear have been identified in clinical and laboratory studies, including: the patient's level of activity [14, 16], male gender [14, 15], use of metal rather than a ceramic head [5, 15], femoral head size [16], use of conventional versus highly cross-linked polyethylene [17], polyethylene thinness [1, 18], and the abduction angle of the cup of >45° [15, 19]. In our patient, the formerly implanted right THA served as a natural control; the only difference in risk factors for accelerated polyethylene wear in the left THA was its high angle of inclination. Indeed, an angle of inclination of more than 45° has been shown to increase stress in acetabular polyethylene [19]. For stable fixation, the expansion cup requires full coverage by bone and this likely forced the surgeon performing the former operation to place the cup in a vertical position. The accelerated wear led to complete polyethylene wear-through and direct contact between the ceramic head and the titanium lobe of the acetabular shell, which was weakened and which ultimately fractured. As noted in one previous study [11], fatigue breakage is favoured by the typical structure, elasticity, and thinness of the expansion cup. In the present case, the catastrophic polyethylene wear was also responsible for the development of pelvic osteolysis. The osteolysis that we found in the roof of the acetabulum is a consequence of both the wear of the polyethylene acetabular cup articulating against the hard ceramic femoral head, and the back-side wear of the acetabular liner [20], which in the expansion cup is favoured by the large amount of unsupported polyethylene. There is a large body of evidence on the relationship between wear of the polyethylene and osteolysis [21], and there is a strong relationship between an increase in the penetration rate of the head into the polyethlyene cup and the occurrence of osteolysis. All patients with an average penetration rate of greater than 0.3 mm/year showed radiographic evidence of osteolysis [22].

The clinical presentation of cup breakage in our patient was unusual. Indeed, she presented with a superior dislocation of the femoral head, which made it impossible for her to bear weight on her left lower limb. Even though signs of acetabular polyethylene wear were present on the preoperative radiography in both THAs, breakage of the cup was not suspected and that intraoperative finding was totally unexpected. To our knowledge, only two such cases have been published [8, 23] and this is the first case of THA dislocation secondary to catastrophic polyethylene failure and

metal shell fracture in a patient with bilateral expansion acetabular cups. Breakage of the metal back of the expansion cups has been reported in two case series [10, 11], but it has never been discussed in single case reports.

Conclusion

The present case represents a very rare situation where a ceramic-on-polyethylene THA failed after 11 years due to catastrophic polyethylene wear. This resulted in fatigue breakage of the cup and hip dislocation, severe loss of periacetabular bone, and extensive periarticular metallosis requiring revision surgery with an acetabular reinforcement cage. The controlled comparison with the identical well-functioning contralateral THA highlights the role of the correct inclination of the cup to prevent the accelerated polyethylene wear, even when favourable articular bearing surfaces, such as a ceramic-on-polyethylene coupling, have been used. Even when a cup has been implanted in a vertical position, the early detection of radiologic signs of severe polyethylene wear should suggest that timely replacement of only the femoral head and acetabular liner can prevent the catastrophic outcome that we observed in the present case.

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