

## Fracture of a Ceramic Femoral Head after a Revision Operation

A CASE REPORT\*

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Since the introduction of the low-friction hip arthroplasty by Charnley, there have been numerous attempts to improve the wear characteristics of metal on polyethylene. Boutin, in 1970, introduced the first ceramic total hip replacement. Ceramic components have been shown to have better wear characteristics than stainless-steel and metal-alloy components because of their hard, scratch-resistant surface; hydrophilic surface properties (wettability); corrosion resistance; and excellent biocompatibility<sup>3,13</sup>. As wear debris is one of the major factors responsible for failure of a total hip arthroplasty, the use of a ceramic femoral head for a revision operation is very appealing<sup>4,5,18</sup>. It is not uncommon to find wear of the acetabular component with osteolysis and a well fixed femoral stem. The use of a ceramic femoral head for a revision may be justified in that situation, especially if the patient is young. However, ceramic has a high elastic modulus, which means that it is a brittle material and thus is susceptible to fracture. In the English-language literature, there have been reports of at least eleven instances of a fracture of a ceramic femoral head in patients who had a polyethylene acetabular component<sup>3,12,15,16</sup>. We now report on a patient who had a revision total hip arthroplasty because of extensive polyethylene wear. At the time of the revision, a ceramic femoral head was placed on a well fixed femoral stem. The head subsequently fractured. This is the first report, to our knowledge, of a fracture of a ceramic femoral head occurring after a revision operation.

### Case Report

A sixty-seven-year-old man who weighed ninety-two kilograms and had osteoarthritis was managed with a right total hip arthroplasty with use of an anatomic medullary locking prosthesis (AML; DePuy, Warsaw, Indiana) that was inserted without cement; the procedure was performed at another institution in February 1988. The patient did well clinically until June 1993, when pain developed in the right side of the groin and he noticed a squeak when rising from a seated position. He was seen at our institution in August 1993, at which time radiographs demonstrated a well fixed femoral stem and a porous cup in a good position, with extensive wear of the polyethylene and

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FIG. 1

substantial osteolysis of the acetabulum and the proximal medial portion of the femoral neck (Fig. 1). An arthrogram showed no evidence of loosening, and cultures of material aspirated from the hip were negative.

The patient had a revision arthroplasty in September 1993. The intraoperative findings included diffuse metallosis, a fractured polyethylene component, and a scored femoral head and acetabular shell. Because of the large cavitory defect in the acetabulum, morselized allograft and a reinforcement ring (Ganz; Protek AG, Berne, Switzerland) were utilized for revision of the acetabular component. A fifty-eight-millimeter all-polyethylene cup was inserted, with cement, into the reinforcement ring. The femoral component was found to be

substantial osteolysis of the acetabulum and the proximal medial portion of the femoral neck (Fig. 1). An arthrogram showed no evidence of loosening, and cultures of material aspirated from the hip were negative.



FIG. 2

Postoperative anteroposterior radiograph demonstrating the reinforcement ring, the ceramic femoral head, and the 2.0-millimeter cables that were used to secure the allograft bone struts that had been inserted into the deficiencies in the proximal part of the femur.

solidly fixed. The femoral head was removed, and the trunnion of the intact femoral prosthesis was found to have minimum scoring and no obvious imperfections. Because of the history of extensive polyethylene wear, a twenty-eight-millimeter zirconia ceramic femoral head with a +3-millimeter offset (DePuy) was placed on the taper of the anatomic medullary locking stem (Fig. 2). The head was placed manually with a twisting motion and was gently impacted twice with a femoral head inserter. The postoperative course was uncomplicated, and the patient was able to return to full activity without any discomfort in the hip.

Approximately one year after the revision, the patient heard a pop in the hip, which was followed by the onset of a mild ache. There was no history of trauma to the hip. Radiographs showed the ceramic femoral head to be fractured into multiple fragments (Fig. 3). Metallosis was found along the taper inside the ceramic femoral head as well as diffusely about the pseudocapsule. The acetabular grafts were well healed, and the acetabular and femoral components were well fixed. The ceramic fragments were removed, the area was well irrigated, and a twenty-eight-millimeter cobalt-chromium femoral head with a +5-millimeter offset was placed on the existing femoral stem (Fig. 4). The taper of the femoral component again was inspected, and no obvious imperfections were found. The postoperative course was uncomplicated. At the ten-week follow-up examination, the patient had no pain, used no walking aids, and had resumed normal activity.

### Discussion

Ceramic components have been used for total hip arthroplasty in Europe since the early 1970's, with good results<sup>11,19</sup>. Such components afford a number of theoret-

ical advantages compared with metal-alloy ones. They have been shown to have excellent biocompatibility both in animal studies and in clinical investigations in Europe<sup>6,7,10,20</sup>. Ceramic can be given a very high, scratch-resistant polish. This feature, combined with the wettability and corrosion resistance of the material, allows for low-friction articulations with excellent wear characteristics. A number of studies have demonstrated that the rates of wear for ceramic on ultra-high molecular weight polyethylene are two to twenty times lower than the rates for metal alloy on ultra-high molecular weight polyethylene<sup>8,9,13,17,18</sup>. Ceramic is brittle, which gives it the advantage, compared with ductile materials such as metal, of not being subject to cyclic or fatigue failure. The effective strength of ceramic is a function of the strain rate<sup>2</sup>. This makes it particularly suitable for the repetitive stress in the hip joint.

Historically, alumina has been the ceramic most commonly used for hip replacement. Zirconia was developed in an attempt to increase tensile strength. Zirconia has a much finer grain structure and a lower elastic modulus than alumina; these properties allow zirconia to be polished to a lower surface roughness and they provide the material with increased strength<sup>2,12</sup>. Zirconia may prove to be a better choice for hip replacement; however, there is some controversy with regard to its stability *in vivo*<sup>6,20,21</sup>.



FIG. 3

Anteroposterior radiograph, made approximately one year after the revision total hip arthroplasty, showing the fracture of the ceramic femoral head.



FIG. 4

Anteroposterior radiograph, made after repeat revision with use of a twenty-eight-millimeter cobalt-chromium femoral head.

The disadvantage of ceramic, which is brittle, is its susceptibility to fracture. Because ceramic has a high elastic modulus, it will not plastically deform as metal does. Instead, the formation and propagation of cracks may lead to fracture.

The reported prevalence of fracture of the femoral head is low, especially for hip replacements with ceramic-on-polyethylene articulations. We are aware of eleven instances of a fracture of a ceramic femoral head articulating with polyethylene that have been reported in the English-language literature<sup>3,12,15,16</sup>. The prevalence of this fracture has been higher for ceramic-on-ceramic articulations, especially those in which the ceramic head was manufactured before 1979, when the material was inferior because of its larger grain size and poorer surface finish<sup>7,14,22</sup>. The type of ceramic femoral head that

was used in our patient has had a very good record in the United States; according to information supplied by the manufacturer, our findings represent only the second reported fracture of more than 7589 ceramic heads that have been implanted with cement to date.

Because the effective strength of ceramic is a function of the strain rate and is dependent on the purity of the material, several factors may increase the risk of failure of a ceramic femoral head. Increased weight and activity of the patient may increase the risk of fracture by increasing the load across the joint; however, in some studies, increased activity has not corresponded with an increased rate of fracture<sup>14</sup>. In fact, Nizard et al. found that the ceramic components in patients who were less than fifty years old (and who presumably were more active) had a better rate of survival than those in older patients. A history of trauma was associated with only three of the eleven instances of failure of a ceramic-polyethylene hip replacement that we found in our review of the literature<sup>3,12,15,16</sup>. The trauma involved a minor fall onto the contralateral hip in two patients and onto the ipsilateral hip in one patient. There was no causative event related to the fracture in the remaining eight patients.

Our patient was relatively heavy, which may have been a contributing factor. At the time of the revision, the femoral component was found to be well fixed. We chose to place a ceramic head onto the well fixed stem in light of the history of extensive polyethylene wear. Precise matching of the taper inside the femoral head and the taper of the trunnion of the femoral stem may be important in order to avoid areas of stress concentration. We believe that an unrecognized defect on the existing taper may have contributed to the fracture of the ceramic head. When a ceramic femoral head is used, careful insertion onto a taper with no imperfections may be important to the long-term performance of the ceramic.

We believe that a ceramic head may be a good choice for primary total hip arthroplasty, especially for a young patient. However, the use of a ceramic femoral head on an existing taper at the time of a revision arthroplasty probably should be avoided as minor, unrecognizable flaws on the taper may lead to the formation of cracks in the ceramic with subsequent fracture.

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