

CASE REPORT

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Observation of retrieved ceramic-on-ceramic articular surface: a case of revised total hip arthroplasty due to failure of the support ring

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Abstract We report the case of a 63-year-old woman who required revision surgery for ceramic-on-ceramic total hip arthroplasty (THA) due to failure of the support ring. We retrieved the ceramic cup and head, observed it macroscopically and measured it to determine its shape condition (sphere diameter, sphericity, and circularity) and surface condition (surface roughness by scanning electronic microscopy). Although abrasion was not found at the sliding surface of either the cup or head, it was observed at the edges of the cup and at one part of the head. We point out the risk of the edge contact and conclude the possibility of micro-motion between the cup and the head during walking or loading in vivo, and that contact had taken place at such parts.

Key words Ceramic on ceramic · Joint separation · Scanning electronic microscopy (SEM) · Sliding surface · Total hip arthroplasty (THA)

Introduction

Ceramic-on-ceramic total hip arthroplasty (THA) has the advantage of having a low frictional articular surface; using this technique osteolysis by polyethylene particles does not occur and good long-term results are expected. Although a lot of breakage of ceramic components has been reported recently,¹ there are few reports of a retrieved articular surface that is not broken. We report one patient who required revision surgery due to failure of the support ring used in

primary THA and observations of the articular surface of ceramic-on-ceramic THA.

Case report

The patient was a 63-year-old woman with rheumatoid arthritis. In April 1998, using a Ganz ring (Protek, Bern, Switzerland), cemented THA was performed with an alumina-bearing surface (ABS) cup and alumina head manufactured by Kyocera (Kyoto, Japan). The angle of the cup placement was 45° and the postoperative result was satisfactory. However, 7 months after the operation the patient fell, fracturing both sides of the pubic bone and ischium, causing the ring to detach. She was able to walk indoors steadily, and the ceramic cup was fixed with a support ring in a cement well. The angle of the cup placement just after injury was 56°. Thereafter, the cup placement angle gradually became acute and reached 62°, so revision surgery was performed on January 2000, 1 year 2 months after the support ring had become detached (Fig. 1).

For the retrieved cup and head, we (1) made macroscopic observations, (2) measured the sphere diameter, sphericity, and circularity for shape research, and (3) measured the surface roughness (roughness average: Ra) and performed scanning electronic microscopy (SEM) to clarify the surface conditions. We studied a total of six areas of the head for surface condition: the top part, gloss-lost or the matte part, and the equator part (subdivided into four sections by 90°, sections 1–4); and a total of nine areas of the cup: the sphere bottom, the side surface part (subdivided into four sections by 90°, sections 1–4), the four sections of the side surface part subdivided into the end portion (edge), and the central portion, respectively.

Macroscopically, the gloss was lost or appeared as matte in an area of about 10 × 4 mm, 53° from the equator part toward the top of the head. The gloss remained on the cup but a black line was found near the rim.

The diameter of the surface was 28.003 mm and 28.026 mm for the head and the cup, respectively, and the

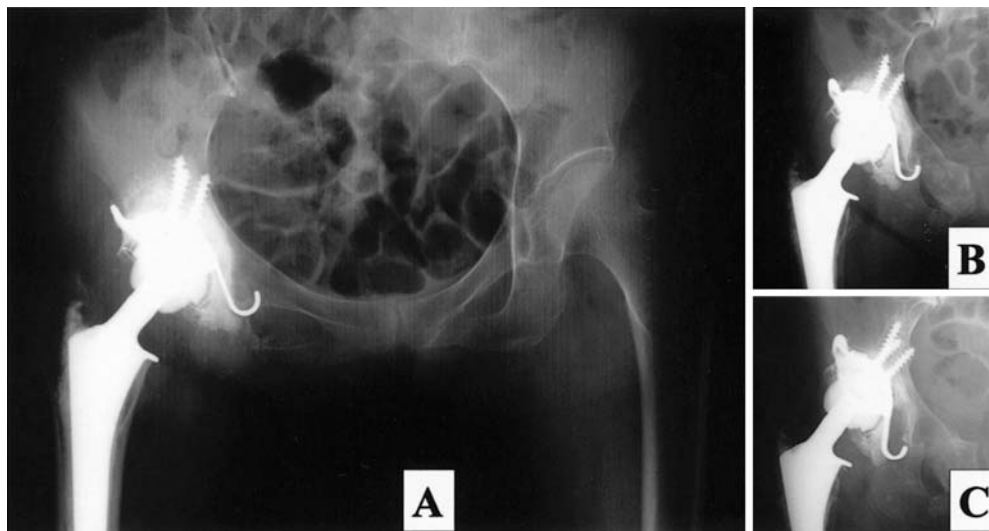
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Fig. 1A–C. Course shown by X-ray films. **A** After primary operation; the angle of the cup placement is 45°. **B** After fracturing, both sides of the pubic bone and ischium cause the hook to come off; the angle of the cup placement is 56°. **C** Before revision surgery; the angle of the cup placement is 62°.



joint clearance was 0.0115 mm (11.5 μm), thus it was within the target clearance (5–35 μm) in the ABS system. The sphericity was 2.687 μm at the top part including the matte part of the head, thus exceeding the target value ($\leq 2.0 \mu\text{m}$) in the ABS system. However, the sphericity was 2.689 μm at the side surface of the head, 1.817 μm at the sphere bottom part of the cup, and 1.924 μm at the side surface part of the cup, thus all were within target values. Circularity was 0.11 μm at the equator part of the head and 0.45 μm at a 20° inclination, and thus was within the target circularity value ($\leq 1.0 \mu\text{m}$).

With regard to the surface condition, besides the one part in the matte part of the head that measured 0.09 μm , exceeding the target value ($\leq 0.02 \mu\text{m}$ Ra) in the ABS system, on all other parts of the head and the cup the surface roughness was 0.01 μm and within the target value.

Scanning electronic microscopy observations showed an extremely smooth image at the top part and the equator part of the head at low magnification, while at high magnification the usual void and scratch traces were observed at one part of the equator. No particular trace of damage was found in either of these parts. However, the matte part of the head had a gritty rough surface at low magnification, and at high magnification most of the areas had recesses on the smooth surface and an angular crystal grain image. The crystal grain removal is thought to be due to some kind of contact (Fig. 2). Furthermore, the sphere bottom part and the central portion of the side surface of the cup were extremely smooth at low magnification, while at high magnification voids and scratches were observed but nonetheless had the usual satisfactory sliding surface. Regarding the end portion of the side surface part of the cup (the edge and not the sliding surface), in section 1 of the side surface part, only grain removal and unclear scratches were observed at high magnification. These were thought to be the remains of abrasion traces from manufacture (Fig. 3). However, at the edges of sections 2 and 3 of the side surface, a strip of white was seen at low magnification and at high magnification, intensive grain removal similar to that on the matte part of

the head was observed. As the surface condition matched that of the matte part of the head, we considered that this condition was caused by contact with the matte part of the head (Fig. 4).

Discussion

Boutin² performed ceramic-on-ceramic THA for the first time in 1970, but the results were not stable. Thereafter, survival rate was improved by improvement of the properties of alumina ceramics and precision surfaces,³ but metal-on-polyethylene THA remained the mainstream technique. To avoid osteolysis from polyethylene particles, ceramic-on-ceramic THA attracted attention once again as a possibility. The ABS system of Kyocera uses high-purity alumina with a microcrystalline structure, and thus has a high-precision surface condition. Moreover, in a hip joint simulator, steady abrasion was only 0.02 mm³ per 100 million cycles, and on SEM analysis on the worn surface of alumina, crater-like damage and scratch lines were observed along the articulating direction after a run of 3 million cycles, so satisfactory long-term performance was expected.⁴ However, breakage of ceramic components was reported successively.⁵ On the other hand, there are a few reports of retrieved articular surface without breakage. In the present case, the cup replacement angle became gradually acute due to detachment of the support ring, so we do not suspect damage to the ceramic cup caused by neck impingement or dislocation. We cannot totally deny the possibility that the contact at the edge was produced from detachment of the support ring when the patient fell, but these changes in the retrieved specimen seemed to derive from repetitive contact, so we believe that the injury resulting from a fall was not the sole cause of damage.

We performed 27 THAs using the Kyocera ABS system from October 1998 to June 2000. For all THAs except this case there were no major complications concerning break-

Fig. 2A–D. Scanning electronic microscopy observations (head). **A** Equator 3 (low magnification). Smooth image. **B** Equator 3 (high magnification). Voids and scratches are recognized but no trace of damage is apparent. **C** Matte part (low magnification). Gritty rough surface. **D** Matte part (high magnification). Image of angular crystal grain, and grain removal

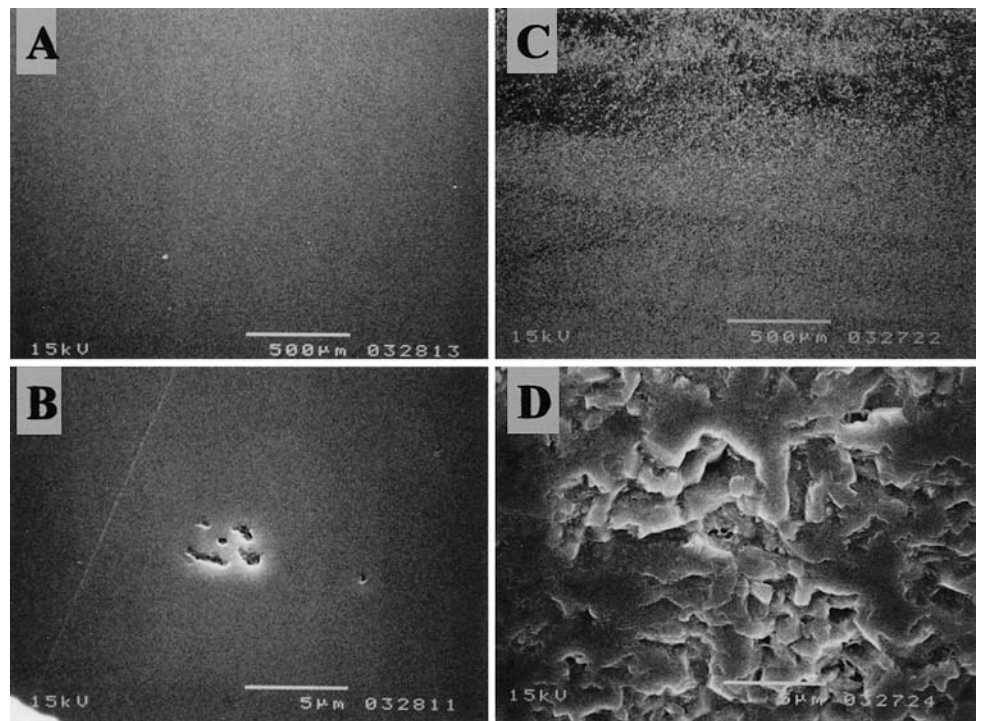
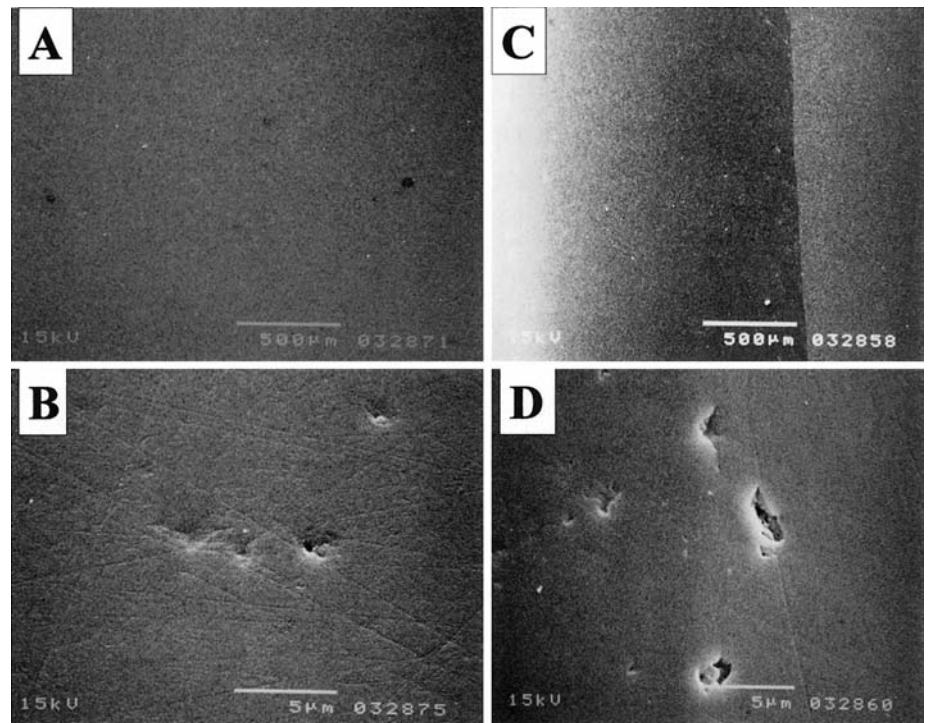


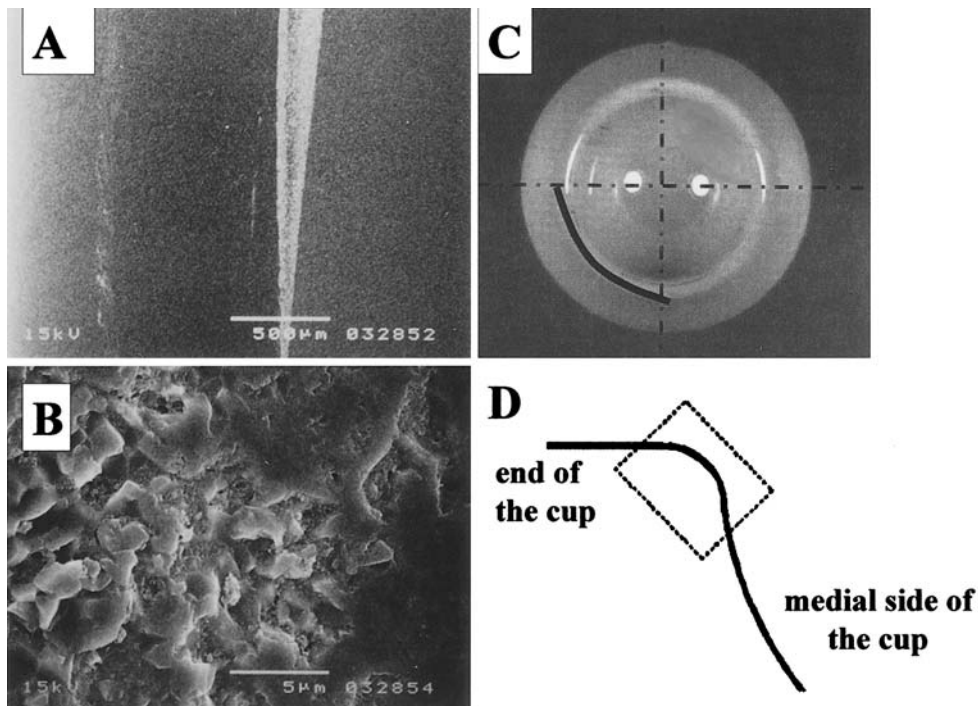
Fig. 3A–D. Scanning electronic microscopy observations (sphere bottom of the cup and end portion of the side surface of the cup, section 1). **A** Sphere bottom (low magnification). Smooth image. **B** Sphere bottom part (high magnification). Voids and scratches are recognized but there is no trace of damage. **C** End portion of section 1 of side surface (low magnification). Streaks thought to be abrasive traces are recognized. **D** End portion of section 1 of the side surface part (high magnification). Grain removal and unclear scratches are recognized



age or revision, and all are working well up to now. Although no dislocation was found in the present case, clear abrasion was recognized at the edges of the cup and not on the sliding surface. Even if we cannot prove when such changes happened, this suggests the possibility that when

the cup is placed at an acute angle, contact is likely to occur at that region. Recently, it has been pointed out that in the hip joint in vivo, there is a possibility that micro-motion⁶ occurs during walking or when a load is placed on it, causing contact not only at the sliding surface where it usually

Fig. 4A–D. Scanning electronic microscopy observations (end portion of the side surface of the cup, section 3). **A** A strip of white is recognized at low magnification. **B** Intensive grain removal is recognized at high magnification. **C** Removed cup. *Dotted line* is the wire-positioning part, *thick solid line* is the damage from section 2 to section 3 of the side surface. **D** Observation field outline of the cup: *dotted line* is the end portion of the side surface



occurs but also at the edges (pistoning⁷). It is not known under what kind of placement conditions this phenomenon occurs, but abrasion and damage to the ceramic may result from intensive contact at the edges, especially in ceramic-on-ceramic THA, therefore measures to deal with such problems must be considered further.

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