Fracture of ceramic components as a serious failure after total hip replacement with ceramic-on-ceramic bearings

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Introduction
Ceramics have been introduced in total hip arthroplasty for several advantages including minimal friction, low wear, biocompatibility, no ageing problems and no problems related to the systemic increases in serum metal concentrations. In the first generation of ceramic components introduced in the 1970’s the risk of fracture was substantial, reaching up to 13.4 %.1 After introducing the ISO 6474 standard in 1980s, the rate of fracture failure decreased in the last two decades.2 These favorable results have led to the increased use of alumina-on-alumina bearings as an alternative to a conventional metal-on-polyethylene articulation, particularly for young, active patients. Mid-term results for the third generation of ceramic-on-ceramic bearings are encouraging, with rare incidence of component fractures.3-5 It was recently reported, however, that high number of ceramic fractures (1.4% up to 6.1%) occurred in the series of contemporary alumina-on-alumina bearings.6, 7 Such high number of ceramic fractures was associated with repetitive impingement due to extensive anteversion of cup during squatting or cross-leg sitting characteristic for Asian patients.

Materials and methods
From 1997 to 2006, 1228 total hip replacements with ceramic-on-ceramic bearings were implanted at our hospital. Six different designs were used: Anca-fit (Cremascoli, Milan, Italy), Bicon-Plus (Plus Orthopedics, Rotkreuz, Switzerland), SPH (Lima, Italy), Trilogy (Zimmer, Warsaw, USA) and EHS-E (Wright Cremascoli, Toulon Cedex, France) and Duraloc (DePuy, Johnson & Johnson, Leeds, England). Various cementless femoral components were used. Explanted fractured components were examined by means of visual inspection and scanning electron microscopy. Roughness of the components was measured. Tissue samples were taken for histological analysis.

Results and discussion
Fourteen fractures of ceramic components occurred. In three cases femoral head fractured, in seven cases ceramic inlay fractured and in four cases both components fractured. In 7 cases (5 Bicon-Plus and 2 SPH) the ceramic-on-ceramic bearing was sandwich-type (metal shell/polyethylene/ceramic liner), whereas in 7 cases (4 Trilogy, 2 Anca-fit and 1 Duraloc) the bearings consist of metal shell and ceramic liner. In three cases XL skirted heads (Bicon-Plus) were used. Femoral head fractures occurred from 3 days up to 24 months postoperatively, inlay fractures occurred from 15 months to 52 months postoperatively, and the fracture of both components together occurred from 17 to 63 months postoperatively. The average time to fracture was 27 months (range 0.1 to 63). The average age and body mass index of the patients at the time of the primary operation was 58 years (range 45 to 73) and 30.8 (range 24.4 to 38.6, respectively). In ten cases the fractured components were replaced by metal-on-polyethylene bearings, in three cases by ceramic-on-ceramic bearings and in one case by ceramic-on-polyethylene bearings. In two cases the femoral stems were revised too.

In five cases the fractures could be related to the trauma (fall); in two cases the fracture occurred 3 and 12 months, respectively, after the fall. In nine cases the fractures occurred spontaneously without trauma. In two cases the fracture was preceded by occasional sounds (not squeaking) lasting for 5 and 21 months, respectively.

Fractured components were collected in 11 out of fourteen cases, whereas tissue samples were taken in 7 out of fourteen cases. Figure 1 depicts the fragments of a fractured inlay of one of the failures. In all retrieved cases metal marking of varying intensity was observed on the internal surface of the ceramic inlays probably as a consequence of direct contact with the stem taper after head failure. The external surfaces and fractured surfaces of the heads also showed some metal pick-up. Changes in articulating surface roughness were observed as well, resulting from the grinding of fragments. Intensive black staining in the interior and at the rim of the ceramic inlay clearly indicating impingement was observed in four cases.

Histological images were characterized by numerous bright ceramic fragments (Fig. 2). The presence of lymphocytes, which was not evident in metal-on-polyethylene retrievals4,5, was found to be characteristic for collected retrievals. In all seven cases available for histological analysis perivascular (3 cases), diffuse (3 cases) or perivascular and diffuse (1 case) lymphocytic infiltrates were noticed. The gradation was +1 (2 cases), +2 (3 cases) and +3 (2 cases). Necrosis was observed in 4 cases.

Figure 1: Photograph showing the fractured alumina inlay fragments.

Figure 2: Histological image of the periprosthetic tissue of the fractured ceramic inlay given in Fig. 1.

Conclusions
At short-term follow-up of alumina-on-alumina bearings from different manufacturers, fourteen fractures of ceramic components occurred giving an overall fracture rate of 1.14 %. The fracture incidence of this large series of total hip replacements is much higher than expected based on literature data.2,3 This report poses a warning that a catastrophic failure of ceramic components is not a negligible problem and may actually occur more often than predicted also for non-Asian patients, who do not frequently squat or sit in cross-legged position.5,9

References: