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LETTER

Long Term Survivorship of a Severely Notched Femoral Stem after Replacing the Fractured Ceramic head with a Cobalt-Chromium Head

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Abstract:

Background:

Although ceramic head fracture occurs infrequently today, in the event of a fracture, the resulting revision surgery can prove very challenging, since the ceramic particles lodge into the surrounding soft tissue and can cause rapid implant failure

Case Presentation:

A case of long term survivorship of a severed notched femoral stem after replacing the fractured femoral head with a cobalt-chromium one is reported in a 40-year old woman with hip dysplasia who underwent an uncomplicated total hip arthroplasty. The incident of ceramic femoral head fracture occurred 14 months postoperatively without reporting any significant trauma. Intraoperative findings at revision were a multifragmented femoral head and a damaged polyethylene insert along with diffuse metallosis and excessive wear of the cone of the stem. Both the stem and the acetabular component were stable. After removal of ceramic fragments, metallotic tissue excision and careful lavage of the joint, the inlay was replaced by a similar one and a cobalt-chromium femoral head was placed to the existing notched taper of the firmly incorporated stem. At the 13th year follow up examination, the patient had no pain, used no walking aids, and had normal activity with no signs of wearing or loosening in the plain x-rays.

Conclusion:

Despite current recommendations of using ceramic femoral heads in cases of fracture or to revise the severely damaged stems we were able to provide a long term survivorship up to 13 years postoperatively of a cobalt-chromium femoral head applied to a severe damaged stem.

Keywords: Ceramic Head Fracture, Hip Arthroplasty, Long Term Survivorship, Metallic Head, Notched Stem, Revision Surgery.

INTRODUCTION

The optimal type of bearing for hip arthroplasty remains a matter of debate. Ceramic-on-polyethylene bearings are frequently used in younger and more active patients to reduce wear and increase biocompatibility [1]. Nevertheless, their excellent tribological properties i.e. hard scratch-resistant surface, corrosion resistance and biocompatibility, are altered by their lower elasticity and plasticity in comparison to metals carrying the potential risk of sudden material failure [2, 3]. Although ceramic head fracture occur infrequently today, in such cases the revision surgery can prove very challenging, since the ceramic particles are embedded into the surrounding tissues leading to rapid implant failure if not adequately removed [4, 5]. No common strategy exists regarding the type of the revised head. Particularly, massive metallosis and early stem loosening have been addressed after replacement of the fractured ceramic head with a

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stainless steel one [6, 7], whereas the necessity for revision of the stem remains controversial, especially when it has visible damage. In 2006 we published a case report in Eur J Orthop Surg Traumatol journal [8] regarding a 40 year-old female patient who presented with a fractured ceramic femoral head 16 months after the index total hip arthroplasty (THA). The fractured head was replaced by a cobalt-chromium one without revision of the severely notched stem. We were able to re-examine her 13 years after the revision operation and she still has normal activity, no pain and full range of motion at her hip joint. Special concerns had been provided by both reviewers during manuscript editing regarding our decision to keep the severely damaged stem in place without revising it. Our decision to leave it in place was based on the potential risk for further complications by the extensile approach and the subsequent necessary wide opening of the femoral bone. Finally, the patient did well and we think that this worth publishing.

CASE REPORT

Details of the case have been presented earlier [8] but in brief it is about a 40-year-old woman, weighted 60 Kgr, who underwent an uncemented left total THA in 2001 for secondary degenerative osteoarthritis in a dysplastic hip. All the components had been manufactured by Mathys Medical Ltd., Switzerland, and consisted of a size 14 uncemented stem with 12/14 taper, a 28-mm small ceramic head, a 48 mm expansion shell and a 48/28 polyethylene inlay. The operation was straightforward and carried out according to the manufacturer's instructions. In February 2003, she was referred back to the Orthopaedic outpatient office complaining for right groin pain and crepitus, with no significant history of trauma. Radiographs showed a multiple fragmented ceramic head and significant notching of the cone (Fig. **1a**). The patient underwent revision surgery. Intraoperatively findings included diffuse metallosis, a pseudocapsule containing black metalloid fluid, excessive wear of the cone, a multifragmented head and major wear of the insert (Fig. **1b**). The uncemented stem and the acetabular component were not loose. Metallotic tissue was thoroughly excised, ceramic debris were carefully removed, the area was well irrigated and the polyethylene insert was revised with a similar one. As there were severe notching of the taper of the stem, an effort was made to revise it, but this was proved impossible, as it was absolutely stable. Actually, during the procedure of removal, a non-displaced fracture at the greater trochanter was created. A 28 small cobalt-chromium femoral head was finally placed at the existing taper whereas non-absorbable transosseous sutures were used for greater trochanter fixation. At the 24-month follow-up examination, the patient had no pain, used no walking aids, and had normal activity without any signs of loosening or other implant pathology in plain radiographs (Fig. **1c**). We were able to re-examine her 13 years after the revision operation because of left knee pain and she still had normal activity, no pain and full range of motion at her hip joint. The Harris-Hip score was excellent (95). An x-ray of her hip 13 years after revision had no signs of wearing or other pathology (Fig. **1d**).

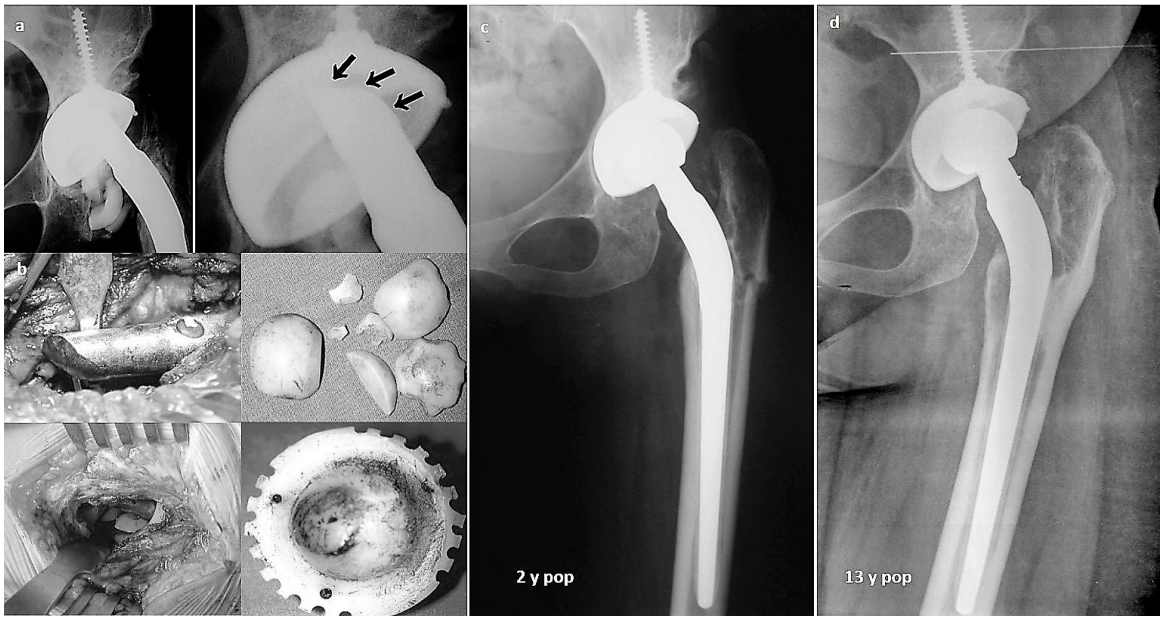

Fig. (1). (**a**). Plain hip x-ray demonstrated multifragment ceramic head failure associated with severe notching of the cone (arrows), (**b**). intraoperative findings at revision operation showing diffuse metallosis, multifragmented ceramic head, notching of the cone and severe polyethylene insert wear, (**c**). follow up x-ray at 2 years and (**d**). final x-ray 13 years after revision operation.

DISCUSSION

Use of ceramic femoral heads has achieved wide recognition for total hip arthroplasty since their first use 30 years ago. Their advantages of biocompatibility and resistance against corrosion contrast with their low plasticity and elasticity, in comparison with metal components, thus giving rise to greater risk of material failure [2, 3]. Newer ceramic materials have been modified to address the issue of potential component failure, and are characterized by a greater fracture toughness and lower wear rate compared to alumina and Biolox or Biolox Forte. However even with the implementation of newer ceramics (i.e. Biolox Delta), the risk of component failures is still present in a small percentage of patients [5, 9, 10], and it represents a catastrophic event, whose results in subsequent revision surgery, might be unpredictable in terms of implant survival and related complications.

Several reasons have been proposed as risk factors for failure of a ceramic femoral head. Trauma, directly or indirectly, high levels of activity and obesity may hold the risk of breakage by increasing the load across the joint surfaces [11 - 14]. However, Nizard *et al.* [9] found that the ceramic heads in patients less than 50 years old, and therefore presumably more active, had a better rate of survival than those in older patients. In addition, it is likely that extrinsic factors, such as strenuous activity, play a minor role in the occurrence of ceramic fractures, because they will remain below the fatigue limit of the product. This probably explains why fractures usually occur without warning, suddenly and without extra load as in our case [15, 16]. According to a recent systematic review by Traina *et al.* [5] the only factor associated to the risk of ceramic head fracture is the use of short neck 28mm heads as in our case. This was mainly supported by the studies of Callaway *et al.* [17], and Koo *et al.* [18], in which a greater risk of fracture was identified for second and third generation 28mm short-neck ceramic heads in respect. Koo *et al.* [18], particularly, reported 5 head fractures among 367 ceramic-on-ceramic hip prostheses (0,013%) using third generation 28mm heads. All fractured components were short-neck heads and in all cases the fracture involved the circumferential portion of the head near to the edge of the head bore. The authors postulated that using 28mm heads the distance between the corner of the head bore and the outer surface of the ceramic head is smaller in comparison with the medium and long neck designs, thereby facilitating the propagation of cracks. In contrast, in other studies [19, 20] was hypothesized that long neck designs could facilitate head fractures because the increased distance between the edge of the head bore and the outer surface of the head itself that increases the tensile stresses at the taper-bore junction.

Other factors to be taken into account are related to facultative construction errors of the involved materials. Ceramic fractures can be explained by the propagation of subcritical crack growth when submitted to unexpected high load pressure. The presence of cracks is mainly attributed to construction deficits such as pores, scratches and micronotches in the material or at its surface. These imperfections will cause stress concentration on exposure to load [20, 21]. Piconi *et al.* [22] investigated a case of a fractured ceramic head using a series of non-destructive and destructive controls and found that both the poor quality and the manufacture progress of the design were the primary causes of failure. In our case, the damage analysis of the broken ceramic head *(reference PS 2414)* showed that all the required specifications had been fulfilled and no material defects could be detected. No primary metal wear traces were also observed on the cone surfaces. The exact time of fracture initiation was not known and evaluation of contact pattern of the cone was not possible.

The most important risk factor for failure of a ceramic head seem to be related with the surgical technique, particularly at the time of head implantation [4, 21]. Strong impaction of the head on the taper with the hammer and damage of the taper during stem insertion could give rise to stress concentration thus accelerating crack propagation. Entrapment of a foreign body, such as bone chips, between the cone and the ball, may be another contributing factor [23]. Careful handling of the ball, cleaning and drying of the taper before ball insertion and smooth impaction of the ball on the taper are some of the appropriate measurements to avoid crack propagation on ceramic head surface.

Revision surgery for fractured ceramic components can be troublesome, and could be associated to poor results [4, 5]. In fact, it has been speculated that the presence of sharp ceramic fragments retained in the artificial joint space could act as an abrasive paste affecting the performance of the new articular coupling. The operative technique for the treatment of a ceramic head fracture remains controversial and varies among different cases. The most important parameters are polyethylene insert revision, total synovectomy, the type of the exchanged head and the condition of the cone.

Most authors agree to revise the polyethylene insert at the time of revision [4, 12, 17, 21] even when it appears normal macroscopically, because non-visible ceramic particles may be embedded to it, creating a third abrasive component (polyethylene wear debris-alumina particles) at the interface between the cup and the femoral head,

especially when a stainless-steel femoral head is used instead of the fractured ceramic head. In our case major wear of the polyethylene insert was found because the cone of the stem had been articulated with it. Since the acetabular component was intact and quite stable, we simply replaced the damaged insert with a similar one.

Diffuse metallosis is mainly reported after revision of a fractured ceramic head onto a metal one [4, 6, 24, 25] but it is also a common finding during the first revision in cases where the stem had made an articulation with the damaged polyethylene [17, 25] as in our case. Hannouche *et al.* [10] in contrast did not observe this complication as many as 20 years after re-implantation, probably because the particular team of surgeons was aware of this potential complication that was avoided by a thorough debridement and synovectomy in all cases. When a synovectomy is performed, the principles of tumor surgery would have to be applied, including thorough lavage of the joint and wide borders of resection up to healthy tissues [6].

More controversies exist about the type of head, which had to be used for replacement of the fractured ceramic head. This particular choice is strongly associated with the condition of the cone of the femoral component. The combination of a metal/polyethylene articular pairing, proposed by various authors in the past [17, 24 - 26] is no longer recommended as it is considered a cause of diffuse metallosis and loosening [4, 6, 24, 25, 27]. Alain *et al.* [4] reported a 47% incidence of repeat revision(s) when a stainless-steel femoral head had been used, whereas the rate was only 17% and 11% when a ceramic or a cobalt-chromium head had been used in correspondence. Lee *et al.* [27] reported recently on 9 third-generation ceramic bearing fractures (6 heads and 3 liners) that were treated with bearing change to Metal on Polyethylene (MoP). Mean follow-up was 4.3 years. During follow-up, 2 of 3 liner-fractured hips and 1 of 6 head-fractured hips showed radiologic signs of metallosis and elevated serum chromium levels. The authors suggested avoidance of MoP in cases of ceramic bearing fractures. In contrast, Sharma *et al.* [28] followed up 8 hips that were revised to MoP articulations using cobalt chromium heads after fracture of ceramic heads. The authors found no revisions or aseptic loosening at a mean 10.5 years follow-up. They emphasized, however, that the key to the long-term success of any revision for a ceramic head fracture is performing a thorough anterior and posterior synovectomy. The use of a ceramic head for replacement, in order to avoid third body damage of metal, have been proposed by some authors [21] even in cases with mild cone wear. In our case, we decided to replace the fragmented head with a cobalt-chromium one because the cone was severely notched and it was impossible to revise the stem unless an extensive and complex approach was utilized.

The best approach regarding the stem cannot be strictly determined based on the existing literature. In cases of loosening the stem must be replaced without second thoughts. According to Alain *et al.* [4], 25 over 105 revised hips had a normal cone, 59 were slightly scratched and 14 had a notched cone. All femoral stems with a notched cone were revised but 17 with a slightly scratched cone were left in place. The authors recommend revision of the stem in all cases with visible damage of the taper and advocate the use of ceramic head for replacement. For the same reasons McLean *et al.* [12] do not recommend use of a ceramic head on the existing cone because minor, unrecognizable flaws on it may lead to the formation of cracks in the ceramic head with subsequent fracture [16]. In such cases the use of a cobalt-chrome femoral head is indicated. A recent review by Hussenbocus *et al.* [29] suggested that stem preservation must only be performed when trunnion corrosion is macroscopically mild (visible but not palpable defects) and when an interference fit can be achieved with the new head. In a study in which retrieved femoral heads assembled onto unimplanted Ti-6Al-4V trunnions were mechanically tested, the authors concluded that the torsional properties of the taper junctions were not significantly influenced by mild or moderate grades of corrosion [30]. Finally, Koo *et al.* [7] reported recently an urgent warning message that neither ceramic nor metallic heads should be implanted on a scratched Morse taper, because it was associated with a high rate of early complications (five hips were revised among the 20 retained stems). According to the authors, abutting a ceramic head on a scratched Morse taper seems to trigger fracture of the revised ceramic head, and abutting a metallic head on a scratched Morse taper seems to induce metallosis. Our decision at that time, to leave the firmly incorporated stem in place, despite the fact that it was severely notched, was based on the potential risk for further complications by the extensile approach and the subsequent necessary wide opening of the femoral bone.

CONCLUSION

In our case the corrosion of the cone was severe, the ceramic head had not been replaced by a new ceramic head but the implants remained stable for 13 years and the patient provided an excellent clinical and radiological outcome.

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