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CASE REPORT

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Ceramic femoral head fracture with massive metallosis and severe wear of the cone: a case report and review of the literature

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Abstract A case of a fractured ceramic femoral head without subsequent trauma, 14 months after a primary total hip arthroplasty, in a 40-year-old woman with hip dysplasia is reported. Intraoperative findings were multifragment 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 the 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 22-month follow-up examination, the patient had no pain, used no walking aids and had normal activity.

Keywords Fractured ceramic head · Metallosis · Cone wear · Hip arthroplasty

Fracture de tête fémorale en céramique avec métallose massive

Résumé Nous rapportons un cas de fracture de tête céramique survenue sans notion traumatique 14 mois après une arthroplastie totale de hanche de première intention pour dysplasie chez une jeune femme de 40 ans. L'exploration per-opératoire a mis en évidence une fracture multifragmentaire de la tête, un insert polyéthylène endommagé, une métallose diffuse et une usure du cône métallique. La tige et l'implant acétabulaire étaient stables. Après ablation des fragments de céramique, excision de la métallose, et un lavage soigneux de l'articulation, un insert du même type a été mis en place et une tête métallique placée sur le cône de la tige. Au recul de 22 mois le patient est asymptomatique, marche sans canne et mène une activité normale.

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Mots clés fracture de tête céramique · métallose · usure du cône · arthroplastie de hanche

Introduction

Ceramic femoral heads have gained wide recognition in total hip arthroplasty (THA) since their first use third decades ago. Nevertheless, their excellent tribological properties, i.e. hard scratch-resistant surface, corrosion resistance and excellent biocompatibility, are altered by lower elasticity and plasticity in comparison to metals carrying the potential risk of sudden material failure [8]. The fracture rate has decreased the last years from approximately 1/1,000 to 1/10,000 but fractures are still encountered, especially due to unknown older implants still surviving [26]. Contamination of the joint by particulate ceramic fragments is a well-recognized consequence of fracture [1] but no common strategy for salvage of the involved hip 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 stainless steel one [16], whereas the necessity for revision of the stem remains controversial.

In the case described below, a massive metallosis and severe cone wear were found during the revision operation for a fractured ceramic femoral head.

Case report

In October 2001, a 40-year-old woman of weight 60 kg underwent an uncemented left THA 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 revision 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. The head was placed with a twisting motion and gently impacted twice, with a femoral head inserter. During the sixth and twelfth month evaluation the patient had no symptoms of pain and the hip motion was excellent (Fig. 1). In February 2003, she was referred back to the orthopaedic outpatient office complaining of right groin pain and crepitus, with no history of trauma. Radiographs showed a multiple fragmented ceramic head and significant notching of the cone (Fig.2, arrows).

The patient underwent revision surgery. Intraoperative findings included diffuse metallosis, a pseudocapsule containing black metalloid fluid, excessive wear of the cone that had impacted the damaged polyethylene insert, a multifragmented head and major wear of the insert due to scratching and abrasion from the ceramic fragments, some of which were partially embedded in polyethylene (Fig. 3). The uncemented stem and the acetabular component were not loose. Metallotic tissue was excised, ceramic debris was carefully removed, the area was well irrigated and the polyethylene insert was revised with a similar one. As there were apparent imperfections at the taper of the stem, an effort was made to revise it, which proved impossible, as it was absolutely stable. Actually, during the procedure of removal, a non-displaced fracture at the greater trochanter occurred. A 28 mm small cobalt–chromium femoral head was finally placed at the existing taper whereas non-absorbable transosseous sutures were used for trochanter fixation. Postoperatively, the patient had an uneventful recovery. She was discharged from the hospital 6 days postoperatively. At the 22-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. 4).

Fig. 1 Preoperative plain radiograph showing a dysplastic hip with secondary degenerative osteoarthritis. At 12-month follow-up evaluation, there are no signs of loosening or other implant-related pathology

Discussion

Material scientists improved the properties of alumina ceramics, including the mechanical strength and reliability. Third-generation ceramics are today hot isostatic pressed, laser marked and proof tested with an average fracture rate of Biolox femoral heads reduced from 0.026% for first-generation ceramics (1970s) to 0.004% for third-generation ceramics (1990s) [20]. In the current literature (Medline search 1990–2003) at least 44 ceramic head fractures have been described to date [3–5, 9–19, 21–25]. There is also one large, retrospective, multicenter study reviewing the data retrieved from revision operations for fractured ceramic femoral heads [2] and the recommendations of the SO.F.C.O.T, published in 2003 [6, 7].

While some authors state that the ceramic head failures usually appear during the first months after the operation [5, 13, 24], others have observed that they are more frequent after the first year [12, 14, 16, 21, 25]. In our case the fracture occurred 14 months postoperatively.

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 [9, 11, 17, 19, 24]. However, Nizard et al. [20] found that the ceramic heads in patients less than 50 years of age, 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 [3, 5, 18, 21, 22, 24].

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 [5, 10, 18]. Piconi et al. [23] investigated a case of fractured ceramic head using a series of non-destructive and destructive controls and found that 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

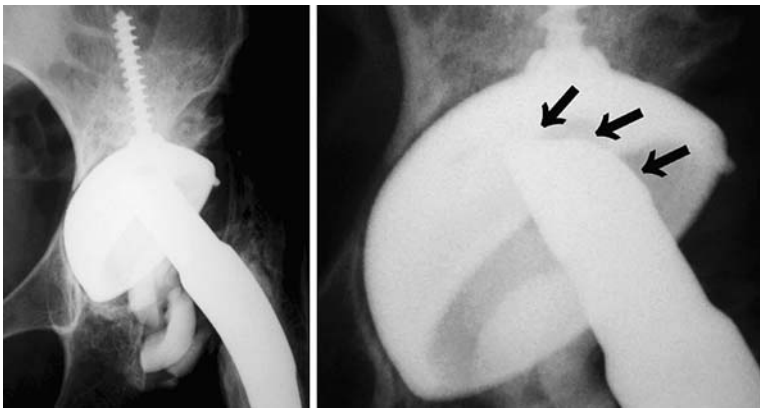

Fig. 2 Fourteen months postoperatively, a multifragment ceramic head failure associated with severe notching of the cone (*arrows*) was detected in plain radiographs

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 factors for failure of a ceramic head seem to be related to the surgical technique, particularly at the time of head implantation [2, 10, 18, 24]. 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 to crack propagation. Entrapment of a foreign body, such as bone chips, between the cone and the ball, may be another contributing factor [11]. 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.

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 [2, 5, 7, 10, 14, 17] even when it appears normal macroscopically, because non-visible ceramic particles may be embedded on 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 [1, 2, 13, 16, 24] but is 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. Hannou-

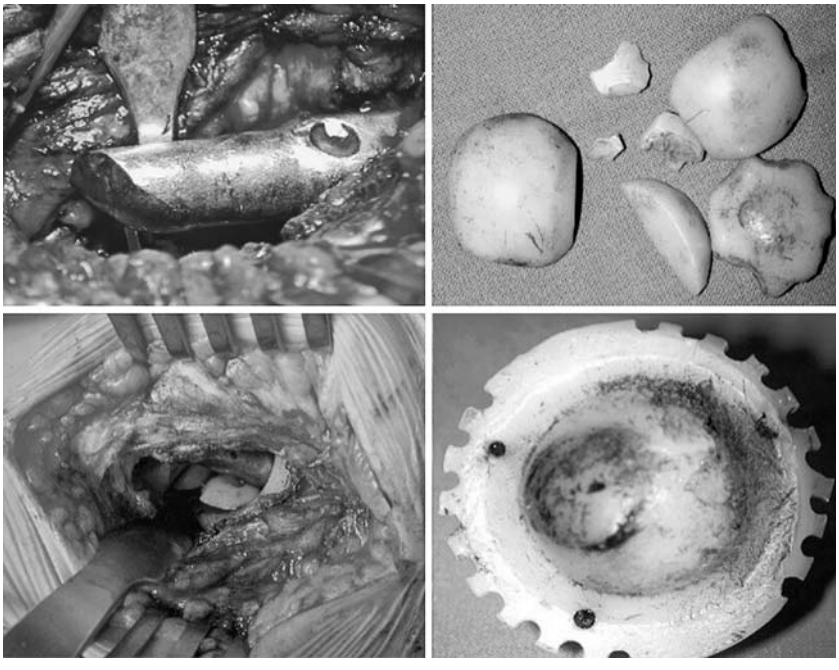

Fig. 3 Intraoperative findings at revision operation showing diffuse metallosis, multifragmented ceramic head, notching of the cone and severe polyethylene insert wear

Fig. 4 Normal plain radiograph of the involved hip 22 months after the revision operation

che 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, which was avoided by a thorough debridement and synovectomy in all cases. When a synovectomy is performed, the principles of tumour surgery would have to be applied, including thorough lavage of the joint and wide borders of resection up to the healthy tissues [16].

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 [1, 5, 13, 15, 18, 21], is no longer recommended as it is considered a cause of diffuse metallosis and loosening [1, 13, 16]. Allain et al. [2] 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%, respectively, when a ceramic and a cobalt–chromium head had been used. The use of a ceramic head for replacement, in order to avoid third body damage of metal, has been proposed by some authors [10], 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 extensile and complex approach was preferred.

The best approach with regard to 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 Allain et al. [2], 25 of 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. [17] do not recommend the 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 [24]. In such cases the use of a cobalt–chrome femoral head is indicated. Our decision to leave the firmly incorporated stem in place, despite the fact that it was severely notched, was based on the potential risk of further complications by the extensile approach and the subsequent necessary wide opening of the femoral bone. A cobalt–chrome head was placed on the existing taper thus minimizing the need for reoperation.

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