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Case Report

Wear and Deformation of Ceramic Implants in Total Hip Arthroplasty – Case Report

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Abstract:

Introduction: Ceramic-on-ceramic total hip arthroplasty (THA) is recognized for its long-term survivorship, although complications such as squeaking or fractures can occur. We report the first documented case of wear with deformation of a ceramic implant without frank fracture.

Case Presentation: A 72-year-old female, implanted 11 years prior, presented with mechanical pain and squeaking. Radiographs revealed femoral head eccentricity. A single-component revision improved the patient's symptoms. Implant analysis demonstrated abnormal wear and deformation of both the femoral head and the acetabular liner, without fracture.

Discussion: The most likely hypothesis is a third-body effect, secondary to a ceramic fragment detached during initial impaction. This case highlights the importance of a meticulous surgical technique and consideration of individual biomechanics when implanting ceramic-on-ceramic THA.

Key words: total hip arthroplasty; ceramic; deformation; third body

Abbreviation

ALVAL (aseptic lymphocyte-dominated vasculitis-associated lesion), THA (total hip arthroplasties), SOFCOT (French Society of Orthopedic and Traumatological Surgery), CT (Computed Tomography scan), NSAID (Non-steroidal anti-inflammatory drugs).

Introduction

In France, approximately 140,000 primary total hip arthroplasties (THA) were performed in 2013 [1,2]. The incidence was 241 per 100,000 inhabitants/year in 2014. This number continues to rise, with an estimated increase of 41.9 to 114.3% by 2050 [3]. Several bearing couples exist for THA: metal-on-metal, ceramic-on-ceramic, metal-on-polyethylene, and ceramic-on-polyethylene (Appendix 1). Ceramic implants represent about 40% of THA according to the literature, but in the latest French Society of Orthopedic and Traumatological Surgery (SOFCOT) report they account for up to 56% of implants [4,5]. Their high wear resistance [4] may explain this choice. Apart from complications common to all THA, the use of ceramic bearings carries specific risks such as implant fracture and squeaking.

Fractures of ceramic implants are rare events. With the latest generations of ceramics, current studies report fracture rates of 0.1% for the femoral head and 0.2% for the acetabular liner [6]. To our knowledge, the literature only reports cases of ceramic implant fracture, but never cases of wear associated with deformation. We report the case of a patient presenting with wear and deformation of ceramic components without associated fracture, treated at the Emile Gallé Surgical Center, University Hospital of Nancy.

III. Case Presentation

A 72-year-old Caucasian female with no significant past medical history underwent a primary right total hip arthroplasty in 2013 in another center for primary hip arthritis. A posterolateral approach was performed. The implants were as follows: a Selexys acetabular shell (MATHYS®) with a 36 mm ceramic liner, a Twynsys femoral stem (MATHYS®), and a Ceramys 36/-4 mm ceramic femoral head (MATHYS®).

The immediate postoperative course was marked by squeaking. Postoperative radiographs showed a centered femoral head (Figure 1).

Figure 1: Postoperative anteroposterior pelvic and lateral right hip radiographs, 2013

The patient presented 11 years later with gradually worsening mechanical pain that had become disabling, with no triggering event. Hip range of motion was preserved. The surgical scar was non-inflammatory and the patient was afebrile. There was no clinical leg-length discrepancy, and the patient reported persistent squeaking since the immediate postoperative period, with no progression. Laboratory tests showed no inflammatory syndrome. Radiographs % eccentricity with cranial migration of the femoral head compared to the 2013 postoperative images (Figure 2). Wear measurements were obtained by adapting the method of Charnley et al. [4] used for polyethylene bearings, as no validated score exists for ceramic wear measurement on radiographs. CT confirmed cranial migration of the femoral head without clear fracture of the ceramic liner or head, and revealed femoral and acetabular periprosthetic granuloma (Figure 3).

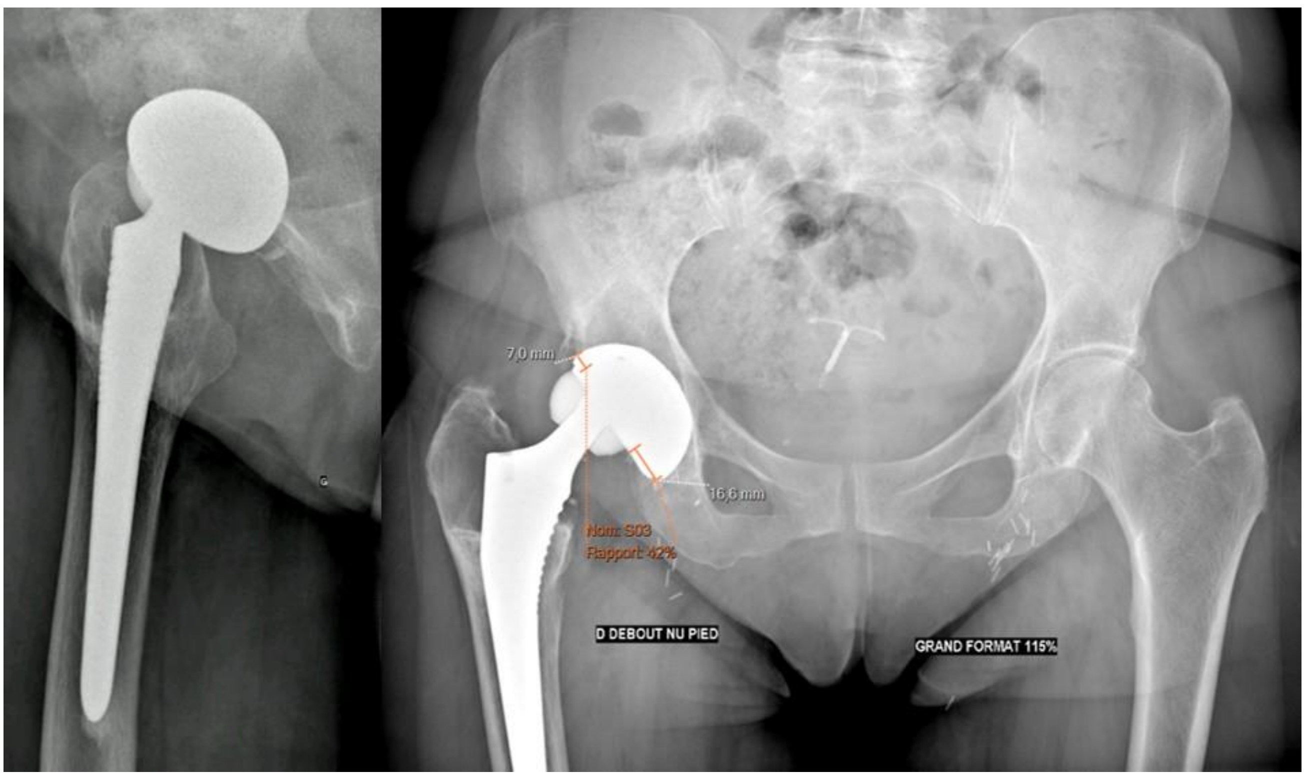

Figure 2 : Anteroposterior pelvic and lateral right hip radiographs, 2024, showing 42% eccentricity of the prosthetic femoral head

Figure 3: Coronal CT scan of the right hip, 2024.

Given the disabling pain and probable implant wear, a one-stage acetabular component and femoral head revision was indicated and performed in July 2024.

Revision surgery took place 11 years after the index procedure under general anesthesia, in left lateral decubitus. The initial posterolateral approach was reused. Intraoperatively, a grayish tissue adherent to the capsule was noted, but no granuloma. A millimetric ceramic fragment was found at the expense of the acetabular liner. Both the ceramic femoral head and acetabular liner were deformed and asymmetric (Figure 4). The metal-back shell was removed without significant bone loss. After removal of the femoral head, the femoral stem showed no signs of wear or loosening and was left in place. A 61 mm diameter HYPE acetabular cup (SERF®) with a HYPE ceramic liner (SERF®) for 36 mm head was implanted after failure to obtain satisfactory stability with an Anexys cup (MATHYS®). A Biolox Option revision ceramic femoral head 36/+5 mm (SERF®) was implanted on the original femoral stem.

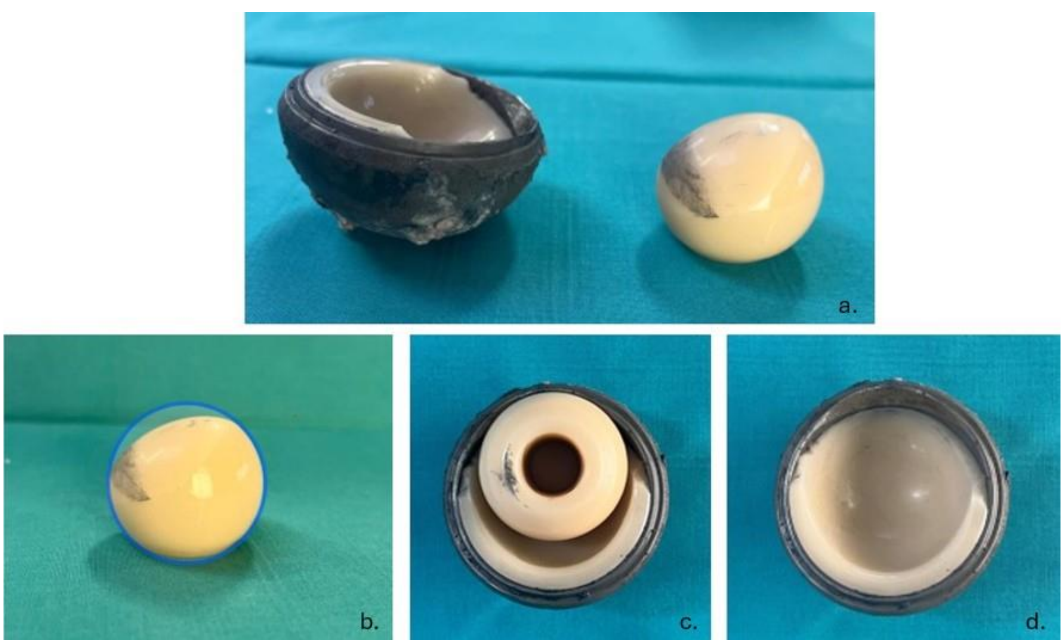

Figure 4. Retrieved worn implants (a)* Acetabular components and ceramic femoral head ; (b)* Wear and loss of sphericity of the ceramic femoral head ; (c)* Ceramic femoral head in situ ; (d)* Wear of the ceramic liner with exposure of the metal-back

Full weight-bearing was allowed immediately postoperatively. At discharge, five days after surgery, the patient reported no squeaking, was pain-free, and was ambulating independently with a single crutch. Postoperative radiographs are shown in Figure 5.

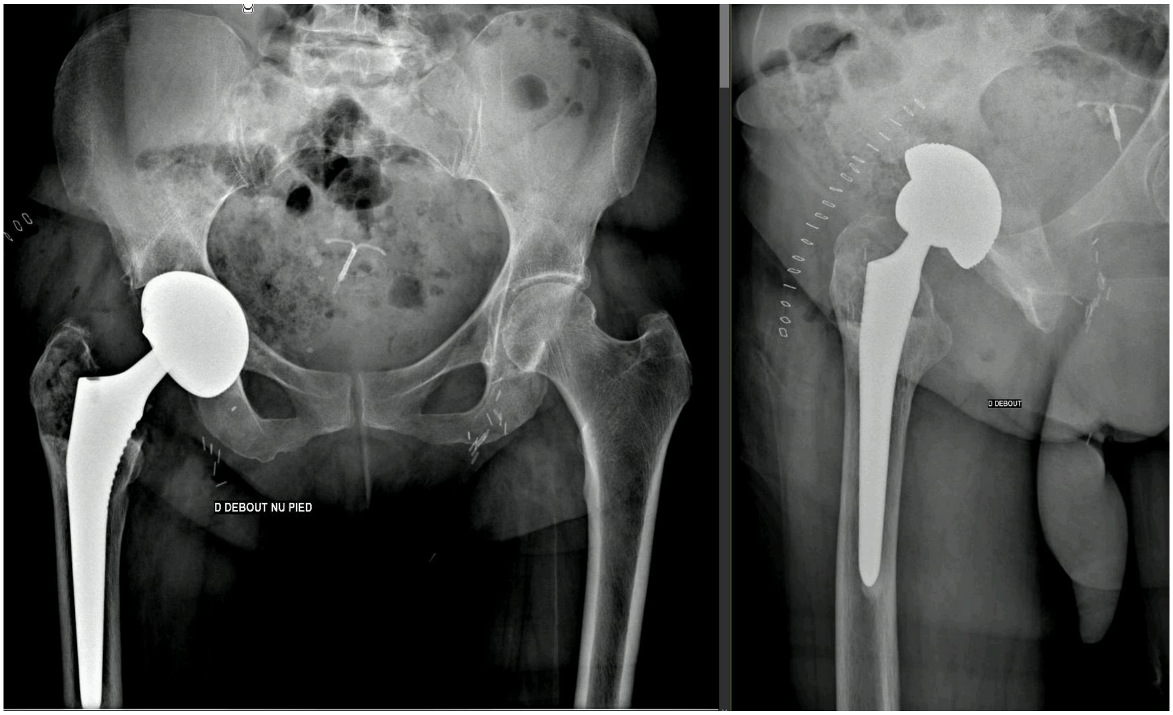

Figure 5. Postoperative anteroposterior pelvic and lateral right hip radiographs, 2024.

Bearing Couple	Percentage
Metal-on Metal	1.6%
Ceramic-on-Ceramic	29.4%
Ceramic-on-Polyethylene	27.5%
Metal-on-Polyethylene	40.4%
Cobalt-Chromium/PE	*21.1%*
Stainless steel/PE	*19.3%*

Table 1: Distribution of Bearing Couples in Total Hip Arthroplasty in France (French Society of Orthopaedic and Traumatological Surgery (SOFCOT) 2024) ; PE = Polyethylene.

The MATHYS® (Mathys Ltd Bettlach) materiovigilance report identified organic deposits between the ceramic liner and metal cup. Loss of implant geometry was also noted, resulting in superior edge loading. Multiple liner fractures were observed, some recent with sharp edges and others older with rounded edges. The ceramic femoral head displayed stripe wear, loss of sphericity, and a wear volume estimated at 13.34 mm³.

IV. Discussion

To our knowledge, and after consultation with the manufacturer, no previous reports describe failure with both wear and deformation of a ceramic femoral head.

There are four generations of ceramic materials. Alumina, initially produced by diamond grinding and later by sintering alumina oxide powder, was the first. Zirconia was then developed as a polyphase material with superior strength, giving the ceramic its pinkish color. However, a change in the manufacturing process led to numerous femoral head fractures (9–15% depending on the batch), resulting in market withdrawal in 2001 [4,7,8]. The third and fourth generations are alumina-zirconia composites, stabilized with yttrium and reinforced with strontium platelets to improve stress distribution. The most widely used composite is ZTA ("Zirconia Toughened Alumina"), used in Biolox Delta or fourth-generation ceramics.

Each generation has improved tribological properties, with decreasing wear rates. Alumina-on-alumina bearings have a linear wear rate of approximately 5 microns/year [7], while composite ceramics have wear rates below 2 microns/year [4]. These figures are much lower than those for metal-on-polyethylene (0.1 mm/year) or ceramic-on-polyethylene (<0.1 mm/year) [7].

Clinical consequences of wear include pain, inflammatory tissue reactions to microscopic wear debris leading to granuloma, or ALVAL (aseptic lymphocyte-dominated vasculitis-associated lesion), presenting as solid or cystic pseudotumor, intra- or extra-articular, with histologic diagnosis [9]. These reactions can cause significant bone loss, implant failure, or periprosthetic fracture. Septic, inflammatory, or mechanical loosening may also occur, as with other bearing surfaces.

Ceramic-on-ceramic bearings have their own complications, such as squeaking, reported in 5–20% of THA. The etiology is probably multifactorial [10], with main hypotheses including third-body effect or lubrication failure, sometimes associated with NSAID use.

Such complications may necessitate revision surgery. These revisions should be planned promptly, with appropriate implant availability. Patients should be immobilized in the meantime to limit ceramic debris dispersion in case of fracture. Complete removal of ceramic fragments, extensive synovectomy, and thorough irrigation are required. The same manufacturer's ceramic-on-ceramic coupling should be preferred. If the femoral stem Morse taper is damaged, a revision ceramic head with metallic sleeve should be used. If this is not possible, femoral stem revision is required. Dual mobility cups are contraindicated due to the risk of third-body polyethylene wear from ceramic debris [11–13]. Alternatively, a ceramic-on-polyethylene couple can be chosen in a salvage procedure, according to SOFCOT 2019 recommendations [13].

Several hypotheses may explain the deformation of the ceramic femoral head in this case. The first is direct wear, which seems unlikely, as in vitro wear with this generation of ceramic is <0.1 mm/year [7,14]. The time to implant failure is too short to explain this level of wear. The analysis revealed an annual wear rate of about 1.21 mm/year—over 10 times the usual rate [7,14].

The second hypothesis is a manufacturing defect. However, materiovigilance analysis did not reveal any defect, and review of the manufacturing process by MATHYS® found no deviation from production protocols.

The most probable explanation is third-body wear caused by liner rim fracture during impaction, supported by the materiovigilance findings.

V. Conclusion

Ceramic-on-ceramic THA is highly reliable. However, meticulous technique and respect for implant-specific requirements are critical, particularly during impaction of the Morse taper for the liner and femoral head. Systematic consideration of pelvic morphology during implantation may help reduce complications related to malposition or malimpaction of implants [15].

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Informed Consent: This study was performed in accordance with de ethical standards of the Declaration of Helsinki. The participant provided informed consent for the use of their data. This article complies with the data protection and privacy policy.

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