# 5.6 Revision strategies in total hip arthroplasty with respect to articulation materials

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## Introduction

Revision surgery has become more and more important because of the increased number of total hip arthroplasties performed during the past three decades and their limitation of long-term survival mainly due to polyethylene wear.

The aim of this paper is to present strategies for possible revision scenarios in consideration of different articulating partners.

## Revision strategy for metal/ceramic-on-polyethylene bearings

The main reason for revision of metal- or ceramic-on-polyethylene couplings is increased polyethylene wear, with subsequent osteolysis [1].
The annual wear rate of metal-on-polyethylene is 0.1 – 0.3 mm/y, the rate for ceramic-on-polyethylene is 0.05 – 0.15 mm/y [2]. Therefore, the onset of visible wear and osteolysis in ceramic-on-PE articulations usually occurs later than in metal-on-PE partners.

In case of revision there are no limitations concerning the articulating partners (Fig. 1a, b).

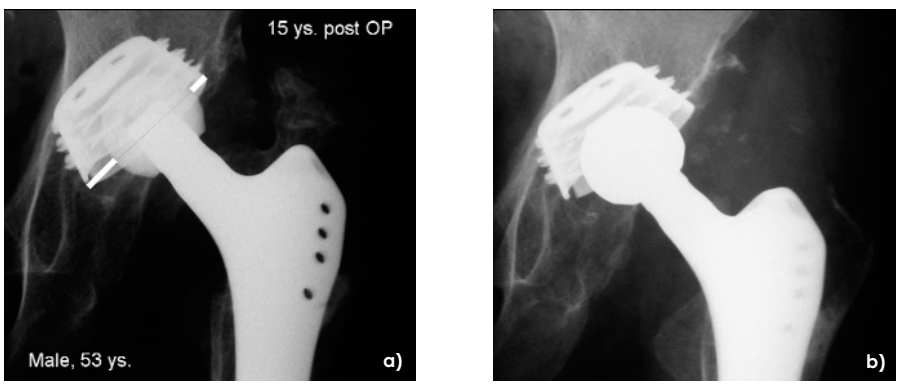


**Figure 1a, b:**
Exchange of polyethylene liner and ceramic head to a metal-on-crosslinked polyethylene bearing due to progressive wear.

## Revision strategy for metal-on-metal bearings

Metal-on-metal bearings have been reintroduced by Weber in 1988 as an alternative to metal/ceramic-on-polyethylene bearings due to improved wear behavior of high carbon implants [3]. However, there are several reports in

literature that show hypersensitivity to metal wear particles leading to early osteolysis and aseptic loosening of components (Fig. 2) [4-6]. Clinical data suggest an association with a delayed hypersensitivity type IV to metal, mainly cobalt. It is still unclear whether the allergy to metal alloys is preexisting preoperatively or the patients became hypersensitive secondary to metal particles. As a consequence, in patients with postoperative persisting or early recurrent, load-dependent thigh pain - with or without radiographic signs of osteolytic lesions - a possible hypersensitivity to metal should be considered.

In case of revision surgery, all bearing couples except metal-on-metal are suggested.

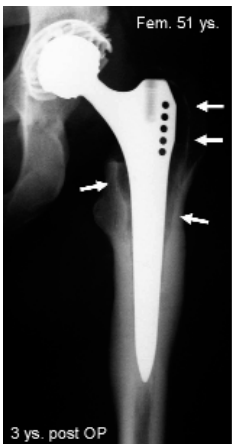


**Figure 2:**
Early osteolysis because of hypersensitivity to metal 3 years postoperatively.

## Revision strategy for ceramic-on-ceramic bearings

As ceramic-on-ceramic bearings produce very few wear debris, revisions mainly are not caused by osteolysis and secondary loosening of the implant. The serious problems of ceramics are fracture of the material f.e. due to impingement or recurrent dislocation.

Alumina ceramic is a very hard and resistent material with excellent wear characteristics. The linear wear rate is very low and described in literature about 0.003 mm/year [7]. Nevertheless the elasticity of the material is also low and does not allow any deformation under load. High punctual stress can lead to fracture. Exact positioning of the cup is necessary to avoid edge loading at the proximal rim of the liner [8].

The revision of ceramic components is not as straightforward as of the other bearing partners and requires certain considerations. Therefore, different failure modes need different treatment scenarios.

*Scenario 1: Acetabular revision*

In many cases it is necessary to remove the ceramic ball head of a well fixed stem either to improve the exposure or to vary the lengh of the neck after the cup revision. It is recommended to perform cup exchange with the original ball head in place as long as possible to protect the taper. A rough removal can damage the surface structure of the taper. If a ceramic head would be used on a

damaged taper once again, high stress concentration can develop leading to a breakage of the ball. For this reason the removal should be done with special tools and under protection of a swab to avoid any scratches on the taper. In principle if the surface structure is macroscopically not damaged a new ceramic head can be used. Only the surgeon is responsible when re-using the taper of a stable stem. Manufacturers state that tapers are never to get re-used with a ceramic ball head because of the danger of damage of the taper during removal which is not in their control. If the surgeon is uncertain or unwilling to take over responsibility, he has to remove the stem which often complicates the surgical procedure.

In the last several years new concepts were developed to solve this problem. Recently, CeramTec offers a metal sleeve that can be put on the original taper to create a smooth surface where a new ceramic ball head can be attached (Fig. 3).

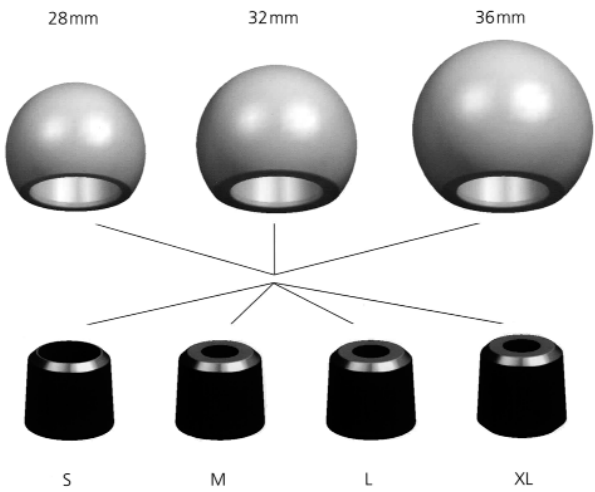


**Figure 3:**
Revision ball heads system by CeramTec.

*Scenario 2: Exchange of the ceramic head for a longer neck size due to dislocation*

Again one is faced with the possible damage of the taper during removal of the original head. This can be solved either by careful removal described above as well as using the ceramic revision ball heads with an inner metal sleeve.

Another problem is the possible limitation of neck length increase for joint stabilization. As the use of ceramic skirted balls is not advisible because of possible impingement leading to fracture, modern ceramic head systems do not exist in the sizes XL or XXL. These issues can limit the ability of ceramic heads for use in revision cases with dislocation. One solution is again the use of the revision ball heads system including an inner metal sleeve allowing longer neck length sizes (Fig. 4).

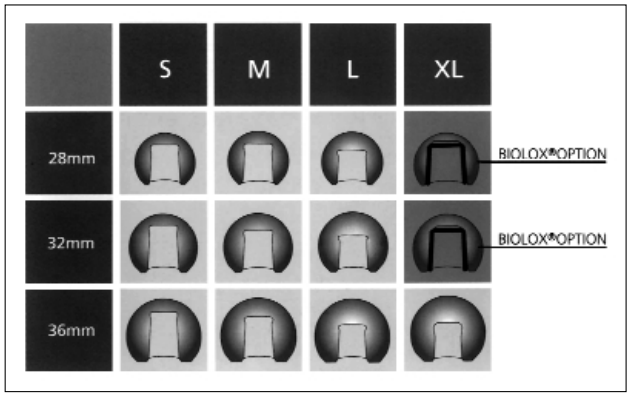


**Figure 4:**
Inner metal sleeves allow ceramic XL neck sizes.

*Scenario 3: Fracture of the ceramic head*

Mostly ceramic component fractures are either caused by a trauma of the patient or are related to dislocation or poor intraoperative handling. In case of fracture many ceramic particles of different sizes can be found during revision. Despite meticulous synovectomy and extensive joint lavage there are always small particles left. This remaining debris is harder than metal and leads to third-body-wear. Therefore it is absolutely necessary to avoid an exchange to a metal head after fracture of a ceramic articulation. Especially if a polyethylene liner is used the small ceramic wear particles get pressed into the soft poly which works like a sandpaper leading soon to massive abrasion of the metal head [9]. The one and only choice of articulation type for revision is renewal of a ceramic wear couple to reduce the risk of third-body-wear.

*Scenario 4: Fracture of the ceramic liner*

This can be caused either by intraoperative rim chipping due to malinsertion by the surgeon or by impingement between the rim of the liner and the taper, especially when skirted balls are used. Again, the one and only choice of articulation type is renewal of a ceramic wear couple to reduce the risk of third-body-wear.

*Prevention of ceramic failure*

To avoid any damage to the ceramic liner during insertion a special suction cup instrument was created [10]. It allows a simple and secure fixation within the titanium shell and can also be used to remove the liner in case of revision (Fig. 5).

It is important to avoid that any tissue gets between the shell and the liner. This could lead to breakage during impaction. The surfaces should be clean and dry. If an all-ceramic inlay with taper fixation is used, just one single blow with the impactor guarantees a secure fixation. Concerning the fixation of the ceramic ball to the taper, the same precaution should be taken.

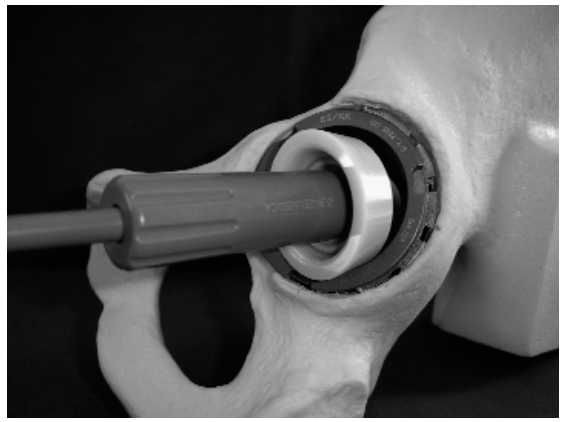

**Figure 5:**
The suction cup instrument.

## Conclusion

Revision of a total hip arthroplasty needs comprehensive knowledge of the characteristics of the articulating materials. A wrong re-implanted wear couple can lead to early re-failure.

Selection of articulation in primary THA can be influenced by possible revision scenarios. Today the new XL-PE, metal-on-metal and ceramic-on-ceramic articulations offer excellent wear behaviors. Concerning the amount of wear, ceramic-on-ceramic seems to be the favourite. Nevertheless, a certain amount of risk for fractures has to be considered.

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