MINI-SYMPOSIUM: HIP REPLACEMENT

(v) Silent osteolysis associated with an uncemented acetabular component: A monitoring and treatment algorithm

J.H.M. Goosena, R.M. Casteleinc, C.C.P.M. Verheyena,*

aIsala Clinics, Weezenlanden Hospital, P.O. Box 10500, 8011 JW Zwolle, The Netherlands
bUniversity Medical Center Utrecht, P.O. Box 85500, 3508 GA Utrecht, The Netherlands

Summary The rate of polyethylene wear is correlated with the occurrence of osteolysis and the survival of joint prostheses. Several types of metal-backed uncemented acetabular components are associated with a rather high polyethylene wear rate. Silent, asymptomatic cavitation osteolysis can progress into segmental osteolysis that may become manifest and preclude revision procedures. Therefore close monitoring is recommended if silent osteolysis is suspected. A helical CT scan should be performed when signs of osteolysis or evident polyethylene wear are observed on conventional radiographs, or if it concerns a type of metal-backed acetabular component associated with a documented high wear rate. When a cavitation lesion is observed a helical CT scan should be performed yearly and treatment with bisphosphonates is to be considered. In case of segmental osteolysis or progression of a cavitation lesion, extensive debridement of the osteolytic cysts, bone grafting and replacement of the polyethylene liner is the treatment of choice.

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Introduction

Osteolysis, causing component loosening, is considered a main problem in hip arthroplasty. Exposure of particulate materials, including polyethylene and metal, to bone has been cited as an underlying cause of osteolysis in hip arthroplasty.

*Corresponding author. Tel.: +31 38 4244482; fax: +31 38 4243220.
E-mail address: c.c.p.m.verheyen@isala.nl (C.C.P.M. Verheyen).

Wear particles migrate around the prosthesis or cement mantle and cause a local macrophage or sensitivity reaction, leading to the production of osteolytic mediators or local necrosis. The survival of joint prostheses depends to a large extend on factors that influence the rate of polyethylene wear. Another postulated cause of osteolysis is the exposure of periprosthetic bone to joint fluid and joint fluid pressure, causing death of exposed osteocytes. This can be due to early prosthesis migration and also to the shape or position of the acetabular or femoral component. Because metal
on metal hip prostheses show significantly less wear and periprosthetic tissue reaction than metal–polyethylene hip prostheses, it is concluded that all second generation metal implants are to be considered in patients with a long life expectancy.4,7,8

Initially termed cement disease, it is generally accepted that, in most instances, osteolysis is a manifestation of an adverse cellular response to phagocytosable particulate wear and corrosion debris, possibly facilitated by local pressure-induced effects.9 Metal-backed acetabular components were introduced because of findings strongly suggesting a delay of cup loosening and migration by a more efficient stress transfer.10 Clinical studies, however, observed the opposite and concluded a higher wear rate for cemented metal-backed acetabular components than non-metal-backed components in cemented hip arthroplasty.11 Several authors have investigated the effect of implantation time on the wear rate with different results.11–16 Early periprosthetic osteolysis is rarely accompanied by pain or loss of function.17 Acetabular osteolytic defects can be classified as cavitational (a volumetric loss in the bony substance of the acetabulum but with the acetabular rim and medial wall of the hemispheric remaining intact) or segmental (any loss of bone in the supporting rim or medial wall of the acetabulum).18

The dilemma of the way to diagnose and, if observed, how to treat and monitor silent osteolysis is the subject of further discussion.18–23

Monitoring and treatment

Several studies indicated that radiographs largely understate the prevalence and location of osteolysis and CT scans are superior.19,20 Twenty-four per cent of cases of silent osteolysis were missed in 120 uncemented hip prostheses if only radiographs were used for detection compared with CT scans.20

Because the helical CT technique with metal-artefact minimization does not converge, it is a more sensitive method than the conventional CT scan for identifying and quantifying osteolytic lesions.20,22 Puri et al.19 concluded that a CT scan is indicated to confirm the presence of substantial polyethylene wear or the observation of osteolysis on the regular radiographs (Fig. 1) and when a certain acetabular component is associated with excessive wear in the literature.

The question if, how and when to treat silent osteolysis has been the subject of several studies.18,21–23 Patients with cavitational osteolysis may be considered candidates for treatment with bisphosphonates, which inhibit the TNF-alpha release by polyethylene particles causing osteolysis.20,24 Carlsson et al.22 determined the stability of the acetabular component in 100 revision operations and compared their findings with the preoperative radiologic observations. Depending on the classification system, loosening of the acetabular component during the operation was demonstrated in only 6–31 per cent of the hips with radiolucent areas. The authors concluded that the radiographic evaluation of socket stability is troublesome.

For treatment, the following strategies are to be considered:

1. Retention of a well-fixed shell, periacetabular bone grafting and revision of the liner: Retention of the socket with grafting of the periacetabular osteolytic lesion appears to be consistent with satisfactory socket longevity.25 Maloney et al.27 treated 35 patients with osteolytic cysts with bone grafting and replacement of the polyethylene insert. Intraoperatively, all acetabular shells where considered to be stable. After an average follow-up of 3 years all acetabular components seemed to be stable on conventional radiographs, 30 per cent of the osteolytic cysts disappeared radiologically and the other 70 per cent did not show progression. Beaulé et al.25 treated 28 acetabular periprosthetic osteolytic cysts with bone grafting and replacement of the polyethylene insert during a revision operation because of aseptic loosing of the femoral component. Five of the 28 treated acetabular shells had to be replaced at a mean of 6.8 years after the index femoral revision. The authors concluded that revision of a stable uncemented acetabular shell solely because of periacetabular osteolysis is not indicated. Debridement of the osteolytic cysts, bone grafting and replacement of a polyethylene insert of improved quality while the metal shell remains in situ, proved to be a successful treatment (Fig. 2).

2. Retention of a well-fixed shell with placement of a cemented liner: Beaulé et al.26 placed 17 cemented polyethylene liners into a well-fixed uncemented shell and had favourable results after a follow-up of 5.1 years. This method is a good alternative for suitable candidates who have a well-fixed cementless socket with an inner diameter that is larger than the outer diameter of the liner. One of the limitations of this technique is the possible relative thinness of the replaced liner, which can interfere with the wear resistance of the polyethylene.26
3. Revision of the acetabular shell: In case of loosening of the acetabular shell because of osteolysis, the acetabulum needs to be reconstructed with bone grafting. If 50 per cent or more of the surface of the acetabular shell contacts with the bone graft, a cemented acetabular component has to be placed. The placement of an uncemented acetabular component is indicated if the contact is less than 50 per cent.21

A proposed algorithm for surveillance and treatment of silent osteolysis is presented in Fig. 3. A wear rate of 0.20 mm per year seems to represent a critical threshold for the development of osteolysis.28 Puolakka et al.16 reviewed 107 metal-backed uncemented acetabular components on polyethylene wear after an average follow-up of 6 years. They observed an average polyethylene wear rate of 0.20 mm per year, which is rather high compared with studies on other polyethylene inserts in uncemented acetabular components.11–16 Because of an unacceptable survival percentage of 65 per cent after a 9-year follow-up the studied type of insert was withdrawn from the market.29

A metal shell containing screw holes correlates with a higher percentage of observed periacetabular osteolysis, while polyethylene particles, caused by back side wear of the polyethylene inserts, are exposed to the periacetabular bone through the screw holes.23 Huk et al.30 observed

Figure 1 (a) A 74-year-old man with an uncemented total hip prosthesis. A hydroxyapatite coated metal shell with an air sterilized polyethylene liner is used. (b) Ten years postoperative an evident polyethylene wear (0.43 mm according to the method of Livermore34). And two osteolytic lesions can be observed (white arrows). (c) On the subsequent helical CT-scan, the lesions are seen in cross-section. (d) Helical CT-scan after bone grafting and liner replacement.
necrosis and granulomatous tissue reactions of the bone accompanied by polyethylene particles situated at the screw holes of the metal shell after an average implantation of 22 months.

A reduction of wear rate by improving the quality of the polyethylene insert is expected to decrease the prevalence of osteolysis. Sterilization methods changed in the mid-1990s from gamma-irradiation in air to predominantly irradiation in inert gas or vacuum packaging. Mechanical in vivo degradation, which is based on an oxidative mechanism, is higher in air than in argon gamma-sterilized UHMWPE acetabular components after implantation because of radical formation in the polyethylene during sterilization in air.31 Kurtz et al.32 observed severe mechanical degradation caused by oxidation in 16 metal-backed air sterilized polyethylene liners after an average follow-up of 11.5 years. Head et al.33 performed a randomized trial of 200 patients in which argon sterilized cups were compared with cups sterilized in air with an average follow-up of 3 years. A wear reduction of 40 per cent was observed in the cups sterilized in argon. Highly cross-linked polyethylene shows an 80–90 per cent wear reduction in hip simulator testing.35 Digas et al.36 compared 32 patients who received a total hip arthroplasty bilaterally with liners of highly cross-linked polyethylene on one side and conventional polyethylene on the other. After a mean follow-up of 2 years the highly cross-linked polyethylene liners showed 31 per cent lower total penetration of the femoral head. The authors concluded that highly cross-linked showed a better wear performance and could increase the implant longevity. Longer follow-up is needed to establish if this new material is associated with less occurrence of osteolysis.

It is to be expected that a better polyethylene quality will decrease the wear rate and the incidence of periprosthetic osteolysis.

Conclusion

A metal-backed acetabular component, poor rotational stability of the polyethylene insert and sterilization in air are factors that seem to correlate with a high polyethylene wear rate causing periprosthetic osteolysis. Early periprosthetic osteolysis is rarely accompanied by pain or loss of function. Timely treatment is indicated to prevent progression of the osteolytic lesions. As long as the metal shell is stable, extensive debridement of the osteolytic cysts, bone grafting and replacement of the polyethylene liner for a superior bearing material, is the treatment of choice for osteolytic lesions. In case of loosening of the acetabular shell, the acetabulum needs to be reconstructed with bone grafting, and an un cemented or cemented acetabular component has to be placed.

Future studies need to concentrate on the improvement of the quality of arthroplasty components in order to minimize the prevalence of osteolysis. Patients treated with a metal-backed acetabular component associated with a high wear rate and a long-term follow-up should be monitored closely on linear wear rate, osteolysis and cup loosening.

Practice points

- A metal-backed acetabular component, poor rotational stability of the polyethylene insert and sterilization in air are factors that seem to correlate with a high polyethylene wear rate causing periprosthetic osteolysis.
- Timely treatment is indicated to prevent progression of the osteolytic lesions.
- In case of a stable metal shell the treatment of choice for osteolytic lesions is extensive...
debridement of the osteolytic cysts, bone grafting and replacement of the polyethylene liner for a superior bearing material.

- In case of loosening of the acetabular shell, the acetabulum needs to be reconstructed with bone grafting and an uncemented or cemented acetabular component has to be placed.

**Research directions**

- Future studies need to concentrate on the improvement of the quality of arthroplasty components in order to minimize the prevalence of osteolysis.

**References**

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