

Management of Severe Bone Loss in Acetabular Revision Using a Trabecular Metal Shell

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Abstract: We investigated the early results of trabecular metal components in 23 acetabular revisions associated with major bone loss. The mean age was 58.2 years. According to Paprosky's classification, there were 17 type IIIA and 6 type IIIB acetabular defects. Eight chronic pelvic discontinuities were intraoperatively assessed. No additional plating or bone grafting was necessary. The mean postoperative modified Postel-Merle d'Aubigne score was 10.6 points (8-12 points). The mean postoperative position of the center of rotation was 26.3 mm vertically (15-47 mm). The mean inclination was 45.1° (20°-63°). No mechanical failure occurred at a mean follow-up of 35 months (24-50 months). Trabecular metal components appear suitable to achieve primary stability in type III acetabular defect as an alternative to bone graft and cages. **Key words:** total hip arthroplasty, acetabular revision, bone defect, trabecular metal, results.

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Acetabular revision is a challenging procedure, and one of the most challenging aspects of this surgery relates to the management of a major bone loss.

With adequate biologic and mechanical conditions, cementless acetabular components have shown improved medium- and long-term survival over cemented components [1-7]. However, preoperative understanding and determination of acetabular bone loss are essential to achieve a successful reconstruction. Based on the remaining host bone, the surgeon has to evaluate if the required biologic conditions are available and if

primary mechanical stability will allow bone ingrowth for the cementless hemispheric component. The intraoperative decision is made both on the stability of the trial component and the mechanical stability provided by the remaining host bone to the construct.

The senior author previously described a systematic approach based on the severity of bone loss and analyzed the ability of the use of hemispheric cementless porous component in face of failed acetabulum [8]. A type I defect has an undistorted rim with no osteolysis or migration of the component, a type II defect has a distorted intact rim with adequate remaining bone to support a hemispheric cementless implant, and a type III defect has a nonsupportive rim. In type I and II defects, cancellous bone and porous hemispheric acetabula may be used. A cementless acetabular implant is usually suitable in types I and II, and satisfactory outcomes have been shown [1,3,9].

A cementless component may not be adequate in type III defects. Radiographs show superior migration of greater than 2 cm with or without ischial and medial osteolysis. The acetabular rim does not provide sufficient initial stability and

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requires structural allograft to achieve the reconstruction in the proper location. Type III is subdivided in 2 categories.

In type IIIA, durable biologic conditions for bone ingrowth are present with a contact of the component with the remaining host bone more than 40% to 60%. Implantation of a cementless component is possible but requires the use of a structural buttress to provide initial stability, allowing secondary bone growth to occur.

In type IIIB, the migration is superior and medial. Less than 40% host bone is in contact with the component, and the bone ingrowth required for the durable stability of a cementless component is compromised. Therefore, type IIIB defects require the use of a massive allograft fused to the ilium, protected with an acetabular cage, and a cemented polyethylene liner. Other current options include placement of an acetabular component associated with structural bone graft, placement of a large acetabular component, and placement of an acetabular component on host bone in a superior position (a high hip center). Moreover, patients with type IIIB defect are at high risk for occult pelvic discontinuity that may need an additionally posterior reconstruction plate.

The poor clinical outcomes observed with these techniques to face the major acetabular bone loss and the controversial results of structural bone grafting have incited the senior author to explore the use of a trabecular metal acetabular component with augments most of his current type III cases.

Materials and Methods

Material

A group of 23 hips (22 patients) underwent an acetabular revision with the use of tantalum cups and augments for type III defect and was included in a retrospective clinical and radiographic study. Preoperatively, 17 hips were classified as type IIIA and 6 were classified as type IIIB. The mean age at the time of surgery was 58.2 years (range, 34-84 years). There were 16 females and 7 males. Acetabular revision was performed as an isolated procedure in 15 cases (65.2%). The preoperative diagnosis was mainly aseptic loosening (17 hips, 73.9%). On these, 11 acetabular components were cemented (5 metal-backed, 5 whole polyethylene, and 1 cage) and 6 were cementless, including 2 jumbo cups and 1 high hip center. The mean number of previous surgery on the hip was 2.3. The patients were followed up for a mean period of 35 months (range, 24-50 months) (Figs. 1 and 2).

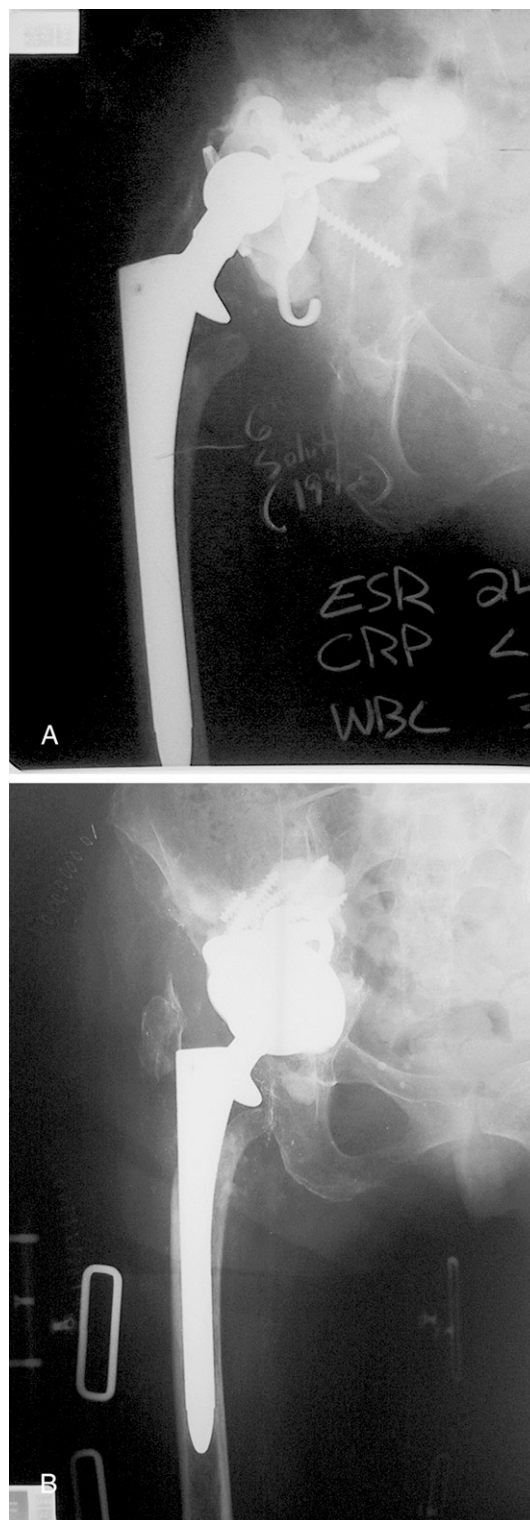
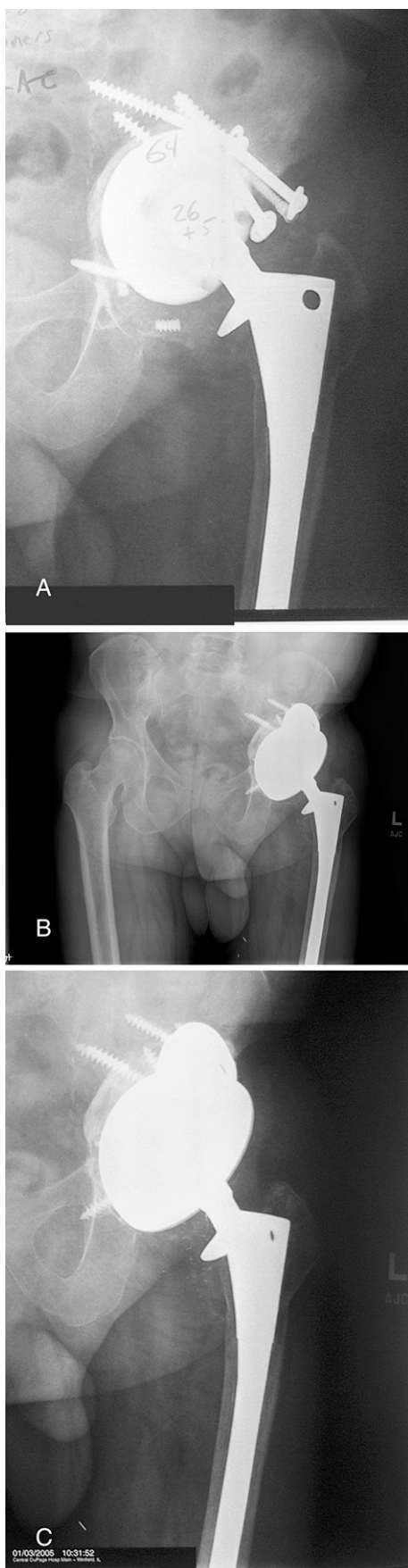


Fig. 1. Anteroposterior view of a 79-year-old woman's right hip with an aseptic cup loosening anteriorly 4 times revised. A, On the preoperative x-ray, the acetabular osteolysis is type IIIA according to Paprosky's classification. The presence of a pelvic discontinuity was not assessed preoperatively. B, Postoperative x-ray at 34 months of follow-up with osseointegration of both tantalum-made cup and superomedial augment.



Surgical Technique

Acetabular components made from porous tantalum were used in this study (trabecular metal; Zimmer, Warsaw, Ind). The trabecular metal modular cup is an elliptical multiholed porous tantalum press-fit cup with a cross-linked polyethylene liner locked in the socket. The trabecular metal revision shell is an elliptical 2-piece design fixed by screws to the ilium with a cross-linked polyethylene cemented into the metal shell. The tantalum acetabular augment shape similar to a partial hemisphere comes in 3 thicknesses (10, 20, and 30 mm) and 6 sizes to match the acetabular component sizes, allowing for fit both the bone defect and the outer diameter of the acetabular component.

All the surgeries were performed by one surgeon with a posterior approach, patients in lateral decubitus position. The approach could include an extended trochanteric osteotomy performed in case of cement removal around a revised stem. The components and the fibrous tissues were removed, and the acetabular bone loss and remaining bone stock were analyzed. The presence of an acute or chronic pelvic discontinuity was also assessed. Finally, an intraoperative infection evaluation including cell count and frozen sections was done.

The acetabulum was sequentially reamed with a progressive increase of 1 mm in the desired location to find the dimension of the cavity until 2 points of fixation were found and the dimension of the cavity assessed. The goal of the reaming was to shape the oval acetabulum to a hemisphere constrained by anterior and posterior walls. The reaming could sacrifice in some cases a portion of anterior column to create this hemisphere. However, care was taken to avoid any damage to the posterior column.

The acetabular cup trial was realized as one size above the reaming, which reproduces in our experience the mechanical stability encountered with the final trabecular metal component that has an inherent 2-mm press-fit. The final goal was to achieve a correct coronal inclination and anteversion of the cup and maximize the contact of the whole construct with the remaining pelvic bone. The trial implants can have full, partial, or no inherent stability. With full inherent stability, the

Fig. 2. Anteroposterior view of a 51-year-old man's left hip with a jumbo cup aseptic loosening (outer diameter, 64 mm). A, On the preoperative x-ray, the acetabular osteolysis is type IIIB according to Paprosky's classification. B, Immediate postoperative anteroposterior view of the pelvis. C, Postoperative x-ray at 26 months of follow-up with osseointegration of both cup and augment.

trial had some press-fit, but the surgeon is able to push on the rim of the trial without displacing the trial, and a trial reduction can be performed without displacing the trial component. With partial inherent stability, the position of the trial is maintained while the trial inserter is removed, and the trial can be removed by the fingers or moved when the surgeon pushed on the edge. The cup position will not be maintained if a trial reduction is attempted. Finally, no inherent stability implies that support of the trial component by host bone is inadequate to maintain placement of the trial in the desired location once the trial inserter is removed. In the present study, all the trials had partial or no inherent stability.

When the trial had partial or no inherent stability, one or more acetabular tantalum augment was necessary to fit the defect and stabilize the trial. The augment could be inserted in many variable locations according to the bone loss pattern. Augments are often placed on the medial aspect of the ilium and are commonly used with the wide base placed laterally and the apex medially in type IIIB and in the opposite way for the type IIIA defect. A reaming of the bone loss was performed line to line according to the augment size to maximize the contact between the bone and the augment. The acetabular augment was then secured by two or three 6.5-mm screws to the pelvis. Portions of the augments may be removed with a metal cutting burr to increase the surface area contact with the acetabular cup. Cancellous bone chips were compacted in the remaining cavitory defect. Acrylic cement was inserted to fill the space between the superior part of the acetabular component and the acetabular augment. The cup was inserted, line to line to the reaming, and was fixed by any 6.5-mm screws as possible. The choice for the trabecular metal revision shell was made in case of need for additional screws, as in pelvic discontinuity. No additional posterior plating was performed in case of pelvic discontinuity, which was stabilized in distraction by the acetabular component. The hip stability was achieved with a modular insert available in standard, 10°, and 20° elevations and large diameter femoral head.

Clinical and Radiographic Evaluation

A modified Merle d'Aubigne and Postel system [10] modified by Charnley [11] was used for the clinical evaluation. The scoring system awards a maximum of 6 points each for pain and walking with a maximum score of 12 points. A score of 11 or 12 points was considered as an excellent result,

10 points as a good result, and 9 or below as a poor result. Presence of complications as infection, nerve palsy, or dislocation has also been recorded.

Radiographic analysis was performed preoperatively, immediately postoperatively, at 3, 6, and 12 months, and at the end of follow-up. These radiographs included an anteroposterior view of the pelvis and anteroposterior and lateral views of the hip. The correction for radiographic magnification was based on the known femoral head diameter.

The preoperative analysis included the analysis of the preoperative location of the hip center, vertically from the interteardrop line and horizontally from the teardrop, and the leg length discrepancy.

The vertical position of the center of rotation from the interteardrop line and the horizontal position of the center of rotation from the teardrop [12], the acetabular cup inclination, and the leg length discrepancy were analyzed postoperatively. The stability of the acetabular component was also analyzed as described by Zicat et al [13] in each of the 3 zones described by DeLee and Charnley [14]. An unstable acetabular component or a revision for aseptic loosening was considered as a failure. The presence of heterotopic ossification was assessed using Brooker's classification [15].

The χ^2 test and Student *t* test were used to make assessment of statistical significance using $P < .05$ as the critical value for α .

Results

The acetabular cementless porous trabecular metal revision shell was used in 19 hips and the modular trabecular metal cup in 4 hips. No relation between the choice of the implant and the preoperative acetabular defect classification was found. Conversely, the choice for the shell was made intraoperatively only in case of need for additional screws or pelvic discontinuities. Eight occult pelvic discontinuities (34.8%) were revealed during the surgery (6 in type IIIA hips and 2 in type IIIB hips), and all had a trabecular metal shell.

Sixteen trabecular metal augments were required in 14 hips (60.9%). Eleven of the 17 type IIIA hips (64.7%) required 1 or 2 augments for 5 of the 6 type IIIB hips (83.3%). Three patients required 2 tantalum augments of which 2 required it both in posterosuperior and anteromedial defects. No augments have been stacked. The mean diameter of the acetabular component was 64.4 mm (52-80 mm). No structural allograft or additional plating was performed. In 3 hips, a morcellized bone graft of the medial wall was associated (1 type IIIA and 2 type IIIB).

Four hips required an extended trochanteric osteotomy to achieve an associated femoral revision, 3 of which to remove the cement of a cemented stem.

The preoperative mean Postel-Merle d'Aubigne modified score was 6.8 points (range, 4-9 points). All the patients had frequent pain with limitations of activities, severe pain, or permanent pain including at rest. Sixteen patients (69.6%) had a limp and needed a cane to walk. Four patients were unable to walk.

The mean modified postoperative Postel-Merle d'Aubigne score was 10.6 points (range, 8-12 points). Fourteen patients (60.9%) had an excellent result, 8 (34.8%) a good result, and 1 (4.3%) a poor result. The mean pain score was 5.8 points (range, 3-6 points). Seventeen patients (73.9%) had no pain, and no patients had pain-limiting activities. The mean walking score was 4.8 points (range, 3-6 points). Eleven patients were able to walk without pain or limitation and did not need a cane. Six had an occasional limp without a cane; 7 had a frequent limp with an intermittent need for a cane. No patient was unable to walk. Any correlation was found between the clinical outcomes and the bone loss classification.

Fourteen patients (60.9%) had no limp or walking restriction, 4 (17.4%) had an occasional limp without a need to a cane, and 4 patients (17.4%) had a frequent limp and use a cane for long walks. On these 4 patients, 2 had 4 previous surgeries on the considerate hip with a 3B defect and the other 2 had a 2B acetabular defect. One patient (4.3%) had a permanent limp with the use of a cane. This 66-year-old patient underwent a 2-stage acetabular and stem revision for septic loosening, with a 3B acetabular defect associated to a pelvic discontinuity and a 2A femoral defect of which stem removal required an extended trochanterotomy. No patient was unable to walk.

All the extended trochanterotomy healed. No infections, preoperative fracture, or sciatic nerve palsy occurred. One patient (4.3%) required a reoperation for current dislocation with an insertion of a constrained liner at 23 months from the surgery. No periprosthetic ossification was recorded.

The preoperative mean location of the center of rotation of the hip was vertically 41 mm (range, 20-66 mm) from the interteardrop line and horizontally 39 mm (range, 14-63 mm). The mean leg length discrepancy was 28 mm (range, 1-55 mm), including 4 patients with a preoperative leg length discrepancy below 5 mm. These patients had a bilateral acetabulum failure with migration, and only one of them has undergone a bilateral revision

at the time of the study. The mean postoperative location of the prosthetic head center was 26.3 mm vertically (range, 15-47 mm) and 40.5 mm (23-55 mm) horizontally. The mean acetabular component inclination was 45.1° (range, 20° to 63°). The mean postoperative leg length discrepancy was 8.3 mm (range, 0-38 mm).

No mechanical failure, screw breakage, loosening, or migration has been noticed during the time of the study. Two patients had a nonevolutive radiolucent line below 1 mm present on the immediate postoperative radiograph and at the end of follow-up without clinical implication (1 on zone 2 and 1 on zone 3). No patients required a revision at the time of follow-up.

Discussion

Acetabular revision remains a major consideration with the increasing life span of patients living with total hip arthroplasties and indicating surgery at younger ages. Cementless components have shown satisfactory outcomes over cemented reconstruction and have become the treatment of choice of several authors in acetabular revision [1-7].

However, aseptic loosening in long-time asymptomatic patients often leads to management of major bone loss at the time of revision. Biologic potential for bone ingrowth (including intimate contact between the component and the host bone) and appropriate mechanical condition motion (<40 to 50 μ m) are usually available in types I and II defects. Conversely, type III acetabula are not supportive because of the bone loss and the frequent presence of an occult pelvic discontinuity.

In type IIIA, the migration is superior and lateral, and Kohler line is not violated. The contact of the cementless cup with host bone should occur more than 40% to 60% of the surface area. The trial component will have partial inherent mechanical stability, but the structural allograft is necessary to support the implant. A cementless component associated with a bulk graft allows bone stock restoration for potential further revision and has shown adequate medium-term outcomes [16,17]. Nevertheless, graft resorption may occur with a high rate of loosening [18-20].

With type IIIB defect, the migration is superior and medial, and there is less than 40% of available host bone. The Kohler line is violated, and there is a high risk of pelvic discontinuity [21]. In this setting, the use of a cementless hemispheric component with bulk allograft is compromised.

One solution then may be to use a structural allograft with a cemented polyethylene [22]. Type

IIIB acetabular defects treated with large acetabular allograft and cemented acetabular components without a supporting cage bridging the graft have shown poor clinical results [23]. Many authors then began to use reconstruction cages, but the overall mechanical failure rate is between 0% and 15% at midterm follow-up [24-27]. In our experience, 18 of the 45 hips where a cage was used for a type III defect mechanically failed at 2- to 8-year follow-up (9 hips revised for aseptic loosening and an additional 9 hips radiographically loose) [21]. Perka and Ludwig [28] conducted a study on 63 Burch-Schneider rings in 62 patients with segmental or combined defects at a mean follow-up of 5.45 years, and all cases of aseptic loosening occurred in type IIIB defects and defects of the posterior column.

These findings have been since supported by other reports and lead some authors to explore the use of trabecular metal component in type III defects [21,29-31]. In the current study, the trabecular metal components used were cementless hemispheric conventional cups associated with augments. The augments acted as a structural allograft, increasing the contact surface area with the host bone. The construct is then a modular cementless acetabular component allowing the restoration of the hip center without the use of a cage. The early results of the present study were encouraging with a mean modified postoperative Postel-Merle d'Aubigne score of 10.6 points (range, 8-12 points) and no mechanical failure.

The presence of a high number of pelvic discontinuity was a concern in the present study. It has been described that if the hip center has not migrated more than 3 cm above the superior obturator line, the probability of a pelvic discontinuity was minimal [32] and that pelvic discontinuity was rarely encountered in type IIIA acetabular defects [21]. In the current study, the proportion of patient with chronic pelvic discontinuity was relatively high in both type III (35.3% of type IIIA defect and 33% of type IIIB defect) with a mean vertical migration of 23 mm (18-28 mm). All were chronic pelvic discontinuity with a poor healing potential and required the use of the acetabular shell to be stabilized in distraction. Because the initial stability of the whole modular construct was enhanced with distraction, no additional plating was necessary. Therefore, the clinical results of these patients were not different than the general outcome of the whole population studied.

Awaiting longer follow-up, these early results at a mean follow-up of 35 months (range, 24-50 months) are hopeful. Even if the absence of bone stock restoration is emphasized in the present study,

other authors described the use of trabecular metal component with structural allograft [29]. With a careful approach of the problems encountered in the management of acetabular revision with severe bone loss, the use of trabecular metal components seemed adequate to achieve a stable fixation close to the anatomical position without the use of cages in type III defect.

References

1. Della Valle CJ, Berger RA, Rosenberg AG, et al. Cementless acetabular reconstruction in revision total hip arthroplasty. *Clin Orthop Relat Res* 2004;420:96.
2. Leopold SS, Rosenberg AG, Bhatt RD, et al. Cementless acetabular revision. Evaluation at an average of 10.5 years. *Clin Orthop Relat Res* 1999;369:179.
3. Della Valle CJ, Shuaipaj T, Berger RA, et al. Revision of the acetabular component without cement after total hip arthroplasty. A concise follow-up, at fifteen to nineteen years, of a previous report. *J Bone Joint Surg [Am]* 2005;87:1795.
4. Silverton CD, Rosenberg AG, Sheinkop MB, et al. Revision of the acetabular component without cement after total hip arthroplasty. A follow-up note regarding results at seven to eleven years. *J Bone Joint Surg [Am]* 1996;78:1366.
5. Silverton CD, Rosenberg AG, Sheinkop MB, et al. Revision total hip arthroplasty using a cementless acetabular component: technique and results. *Semin Arthroplasty* 1995;6:109.
6. Lachiewicz PF, Poon ED. Revision of a total hip arthroplasty with a Harris-Galante porous-coated acetabular component inserted without cement. A follow-up note on the results at five to twelve years. *J Bone Joint Surg [Am]* 1998;80:980.
7. Tanzer M, Drucker D, Jasty M, et al. Revision of the acetabular component with an uncemented Harris-Galante porous-coated prosthesis. *J Bone Joint Surg [Am]* 1992;74:987.
8. Paprosky WG, Magnus RE. Classification and treatment of the failed acetabulum: a systematic approach. *Contemp Orthop* 1991;22:121.
9. Paprosky WG, Bradford MS, Younger TI. Acetabular reconstruction with massive allograft and cementless prosthesis. *Chir Organi Mov* 1994;79:379.
10. D'Aubigne RM, Postel M. Functional results of hip arthroplasty with acrylic prosthesis. *J Bone Joint Surg [Am]* 1954;36-A:451.
11. Charnley J. *Low friction arthroplasty. Theory and practice.* New York: Springer; 1979.
12. Hirakawa K, Mitsugi N, Koshino T, et al. Effect of acetabular cup position and orientation in cemented total hip arthroplasty. *Clin Orthop Relat Res* 2001;388:135.
13. Zicat B, Engh CA, Gokcen E. Patterns of osteolysis around total hip components inserted with and without cement. *J Bone Joint Surg [Am]* 1995; 77:432.

14. DeLee JG, Charnley J. Radiological demarcation of cemented sockets in total hip replacement. *Clin Orthop Relat Res* 1976;121:20.
15. Brooker AF, Bowerman JW, Robinson RA, et al. Ectopic ossification following total hip replacement. Incidence and a method of classification. *J Bone Joint Surg [Am]* 1973;55:1629.
16. Avci S, Connors N, Petty W. 2- to 10-year follow-up study of acetabular revisions using allograft bone to repair bone defects. *J Arthroplasty* 1998; 13:61.
17. Argenson JN, Paratte S, Flecher X, et al. Impaction grafting for acetabular revision: bringing back the bone. *Orthopedics* 2004;27:967.
18. Jasty M, Harris WH. Salvage total hip reconstruction in patients with major acetabular bone deficiency using structural femoral head allografts. *J Bone Joint Surg [Br]* 1990;72:63.
19. Reikeraas O, Folleraas G, Winge JF. Allografting in uncemented acetabular revision. *Orthopedics* 1998; 21:1191.
20. Hooten Jr JP, Engh Jr CA, Engh CA. Failure of structural acetabular allografts in cementless revision hip arthroplasty. *J Bone Joint Surg [Br]* 1994;76:419.
21. Sporer SM, O'Rourke M, Paprosky WG. The treatment of pelvic discontinuity during acetabular revision. *J Arthroplasty* 2005;20(Suppl 2):79.
22. Garbuz D, Morsi E, Gross AE. Revision of the acetabular component of a total hip arthroplasty with a massive structural allograft. Study with a minimum five-year follow-up. *J Bone Joint Surg [Am]* 1996;78:693.
23. Egli S, Muller C, Ganz R. Revision surgery in pelvic discontinuity: an analysis of seven patients. *Clin Orthop Relat Res* 2002;398:136.
24. Berry DJ. Antiprotrusion cages for acetabular revision. *Clin Orthop Relat Res* 2004;420:106.
25. Wachtl SW, Jung M, Jakob RP, et al. The Burch-Schneider antiprotrusion cage in acetabular revision surgery: a mean follow-up of 12 years. *J Arthroplasty* 2000;15:959.
26. Schatzker J, Wong MK. Acetabular revision. The role of rings and cages. *Clin Orthop Relat Res* 1999;369:187.
27. Berry DJ, Muller ME. Revision arthroplasty using an anti-protrusion cage for massive acetabular bone deficiency. *J Bone Joint Surg [Br]* 1992;74:711.
28. Perka C, Ludwig R. Reconstruction of segmental defects during revision procedures of the acetabulum with the Burch-Schneider anti-protrusion cage. *J Arthroplasty* 2001;16:568.
29. Gross AE, Goodman SB. Rebuilding the skeleton: the intraoperative use of trabecular metal in revision total hip arthroplasty. *J Arthroplasty* 2005;20(4 Suppl 2):91.
30. Gross AE, Goodman S. The current role of structural grafts and cages in revision arthroplasty of the hip. *Clin Orthop Relat Res* 2004;429:193.
31. Nehme A, Lewallen DG, Hanssen AD. Modular porous metal augments for treatment of severe acetabular bone loss during revision hip arthroplasty. *Clin Orthop Relat Res* 2004;429:201.
32. Berry DJ, Lewallen DG, Hanssen AD, et al. Pelvic discontinuity in revision total hip arthroplasty. *J Bone Joint Surg [Am]* 1999;81:1692.