Impaction bone grafting with reinforcement metallic mesh and cemented cup for the treatment of Paprosky 3B acetabular defects

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Depending on the bone defect, cup revision can be a highly complex operation. Cup loosening, produces cup migration and acetabular bone defects and the size of these bone defects will determine the technique used for acetabular cup revision. Migration of the cup also requires that to obtain a good clinical result, the center of rotation of the hip be reconstructed so the cup is played in the anatomic rotation center of the hip. The acetabular bone stock must be ideal to support the cup. There must be enough medial bone stock and supportive rims to obtain a long-term result.

According to Paprosky, types 1 and 2 bone loss represent a loss of less than 30% of the acetabular surface, type 3A represents a bone loss between 30% and 50%, and type 3B is a defect affecting more 50% of the acetabular surface (1). A hemispherical porous cementless cup supplemented with screws and frequently associated with morselized allografts is currently used in most institutions in revision surgery. This technique show excellent results in cases with a bone defect less than 30% but poor results in cases with a bone defect greater than 50% (2). A major bone defect rarely reproduces the geometry of the implant; in these cases, contact between the cup and the healthy bone is very poor, and osseointegration is not obtained. Fixation similar to that obtained in primary surgery is attainable in the cup is implanted in a vascularized bone bed.

The greatest challenge encountered during acetabular revision is the restoration of bone stock and the reconstruction of the rotation center of the hip. In light of the good results with impacting autografts taken from the femoral head and cement in acetabular protrusio (3), Slooff *et al.* used this technique in revision surgery more than three decades ago (4). These authors proposed converting the uncontained acetabular defect into a contained defect with a flexible mesh. The use of metallic meshes converts segmental defects into cavitary defects, and makes it possible to fill the cavity with impacted morselized allografts. After filling the cavity, the cup is cemented onto the graft.

The Slooff group has repeatedly reported favourable long-term results using impaction bone grafting with cemented technique (4-6). Comba *et al.* (7), using the same technique in 142 hips, reported a re-revision rate of 4.2% after a mean of 4.3 years follow-up. Van Haaren *et al.* (8) reported a 35% risk of re-revision at a considerably shorter follow-up but some cases in their series had a pelvic discontinuity with very severe defects. In the impacting graft technique, open cancellous bone allows rapid revascularisation of the graft, and bone formation proceeds resorption, thus avoiding the loss of mechanical properties of the bone. What is more, the morselized allograft can fill in an irregular bone defect. Garcia-Cimbrelo *et al.* (9) have reported that mid-term results for impacted bone allograft and cemented all-polyethylene cups are more favorable in Paprosky grade 3A than in Paprosky grade 3B hips and that acetabular reconstruction allows anatomic positioning of the cups thereby promoting good final results.

Waddell *et al.* report in a recent interesting paper their American experience in 21 patients with Paprosky 3B acetabular defect who underwent total hip arthroplasty revision using impacting bone grafting (10). After an average follow-up of 47 months, one patient has had radiographic loosening and no symptoms 120 months postoperatively. No patients were revised for a related reason. However radiographic assessment revealed cephalad cup migration of 2.29 mm, and medial migration of 1.57 mm. Authors concluded that impacting bone grafting is a reliable technique for the treatment of Paprosky 3B acetabular defects. It restores bone stock like no other available for addressing these defects (11).

Although we cannot interpret radiographic findings after the use of the impacted bone allograft with cement in an acetabular revision, the cup and graft remodeling are clearly stable (9). Most hips presented uniform radiodensity of the graft and host bone. Histologic studies of cup loosening in humans report bone substitution, but at a slower rate than in animal models (11,12). Although bone graft resorption has been described in areas of substantial weightbearing, it is not common with this technique. Somers *et al.* (13) report the need for the bulk allograft being well fixed to the host pelvis in very large defects when this technique is used. However, different series also report that bulk allografts are at risk of mechanical weakening during the process of creeping substitution, just when a strong buttress is needed (14). The open structure of the cancellous bone graft, associated with cement, permits good vascularization, apposition precedes resorption in the new bone, and bone substitution takes place without mechanical loosening (4). The importance of the presence of radiolucent lines adjacent to acetabular components has already been established in cemented prostheses. Radiolucent lines are quite infrequent in most series (6,7,9). When the cup is in close contact with well-vascularized bone, the stability of the cup is comparable to fixation in primary surgery (11).

Many factors may be responsible for acetabular cup loosening. A finite-element analysis of a protruded acetabulum has shown that stress on the deficient medial wall varies directly with medial placement of the cup (15). Different authors suggest it is important for good long-term results that deficient acetabulum be corrected to the anatomic position (6,7,9). Theoretically, the location of the center of rotation of the hip affects the load and a higher and more medial position will result in greater loads than a lower placement. In these series, the anatomic rotation center of the hip was improved in all assessed parameters in both Paprosky bone defect grades. However, the change in the approximate femoral head center to center prosthetic femoral head distance is greater for the Paprosky 3B hips, which also had a greater preoperative distance (9).

Waddell *et al.* show that cup migration and bone graft resorption are some of the limitations after acetabular impaction bone grafting in revision surgery when used for large segmental defects (10). Loosening and bone resorption are more frequent in cases with a large segmental defect of the acetabular roof in which a large metal mesh cannot avoid the cranial migration of the femoral head (16). In these cases, porous trabecular metal augments could be used associated with impacting grafting technique (17). The magnitude of this migration probably depends on the grafting technique used, including factors such as the quality of donor bone, size of the bone chips and the surgical technique employed to achieve impaction. Firstly, different types of bone mills were used. The importance of bone chip size is not addressed in most published papers. The true size and location of the bony defect, the quality of the graft, the amount of graft used and the final amount of vital bone facing the implant or the cement are probably all factors with a more or less pronounced influence on cup fixation. Ornstein *et al.* (18), using RSA studies, confirmed similar good clinical results using this surgical technique at mid-term follow-up, although the high migration rates as measured with RSA might be a cause for concern regarding the longevity of this type of cup revision. Mohaddes *et al.* report in a paper also using RSA studied that cemented fixation with bone grafting in acetabular revision surgery results in higher proximal migration (19). Better results for cemented fixation could probably be obtained if bigger graft particles and a more consistent impaction technique had been used. It could also be argued that the increased proximal migration of the cemented acetabular components is due to a different pattern of bone remodelling when cemented fixation is used in conjunction with bone impaction grafting. These hypotheses should most certainly be addressed in future studies (19).

Those of us who practice impacting bone grafting for acetabular defects find that it succeeds in most patients who receive it. However, some studies report failures, including catastrophic ones (8), and the contraindications for this technique need further study. García-Rey *et al.* establishes differences in long-term results according to the type of defect and use of lateral mesh (16). Survivorship analysis at 15 years was 89.1±14 when no mesh was required, 84.9±12 when only medial mesh was required, 79.6±12 whit lateral mesh, and 53.9±22 in cases when both meshes were required (log Rank-Mantel Cox P=0.008). But some points are not clearly defined, and future studies should focus on these. The influence of sex, including sex-related differences in bone quality and/or activity, the relationship of prior surgery (both type and number) on the results of this procedure, and the size of allograft fragments must all be studied further.

Future studies should likewise be large enough to stratify results according to the type and severity of the bone defects being treated. While impacting bone grafting is generally well-behaved, we do need to pay particular attention to those situations in which it does not work well. We must also look for alternatives in those settings, perhaps including porous metal augments. Comparisons between impacting bone grafting and these implants may represent a good topic for future investigations. Clearly, studies will evaluate the results of metallic augments for contained defects, but now we know that impacting bone grafting is a good solution for this problem. What we need to ascertain is whether metallic augments can improve long-term results in 3B/lateral/segmental defects, which are difficult to treat. We also might consider evaluating the combination of porous metal augments with impacting bone grafting. Finally, we must perform more prospective comparative, and ideally, randomized studies examining impacting bone grafting versus metal augments, as well as the results of impacting bone grafting with and without these augments. Longer follow-up is also required to assess potential deterioration of fixation.

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Footnote

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