A Review Paper

Reconstruction of the Failed Acetabular Component Using Cemented Shells and Impaction Grafting in Revision Hip Arthroplasty

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Abstract

Cemented revision techniques have been used with variable success in the reconstruction of the failed acetabular component. Diminished cement–bone interlock secondary to diminished cancellous bone quality and quantity may contribute to the observed high rates of aseptic loosening of this construct in the revision setting. Nevertheless, this technique may still be an option in the elderly patient with limited function or life expectancy.

Impaction bone grafting in conjunction with cemented acetabular cups has been reported to result in good midterm results. The reconstruction is challenging and tedious and requires meticulous execution for success. When performed well, impaction grafting can result in survivorship rates equaling those seen using cementless hemispheric cups with the additional advantage of increasing acetabular bone stock.

Cementing the acetabular component in revision hip surgery has been associated with a high loosening rate. Advances in cementing technique have not reduced this problem. Diminished cancellous bone in the acetabular bed and retention of the subchondral plate may contribute to a weaker mechanical interlock and increased stress concentration at the bone–cement interface, respectively. Large segmental and cavitary defects have been successfully managed with impacted morselized cancellous bone grafting and a cemented cup. Various aspects of this technique, including graft type, size, and compaction technique, are important for graft incorporation. Acetabular reconstruction using impaction grafting is a technically demanding and exacting procedure that, when performed well, can have a high success rate.

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Am J Orthop. 2008;37(10):510-512.

Cemented Revisions

The results of acetabular revision with a cemented cup have been poor. Callaghan and colleagues[1] reported on 146 acetabular revisions performed using a cemented cup at a mean follow-up of 3.6 years. Results were good to excellent in only 66% of the patients. Twenty-nine percent showed progressive radiolucencies, and 9% showed acetabular migration. Definite mechanical failure was noted in 15.8% of hips. Twelve hips (8.6%) were rerevised. Kavanagh and colleagues[2] reported on 166 cemented revision hip arthroplasties followed for a minimum of 2 years. Radiographic evidence of loosening was seen in 20% of acetabular components.

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Advances in cementing technique have not improved the results of acetabular revision with cement. Katz and colleagues[3] reported on 83 cemented revision hip arthroplasties in which a plunger system was used to pressurize the acetabular cement. At the minimum follow-up of 10 years, 16% were revised for aseptic acetabular loosening. Thirty-five percent, including the revised cases, had radiographic acetabular loosening. Ten-year survivorship of the acetabular component was 72% with definite or probable radiographic evidence of loosening as the endpoint.

In the revision setting, the cancellous bony bed of the acetabulum is diminished in quantity and quality, compared with the primary arthroplasty setting. After removal of a primary implant, the remaining acetabular bone is often remodeled to a relatively smooth and sclerotic endosteal surface.[4] Ritter and Thong[5] emphasized that the

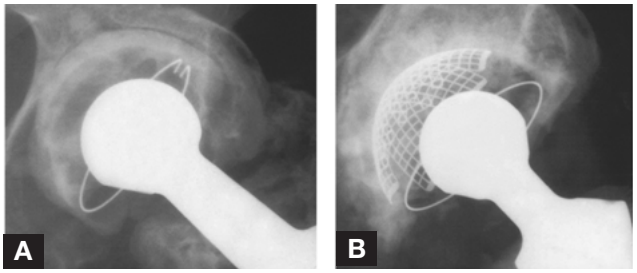

Figure. Acetabular revision using impaction grafting and a cemented cup. **(A)** Preoperative radiograph shows a failed cemented cup. **(B)** Revision of both components with acetabular bone impaction grafting. **(C)** Twenty years after revision, there are no signs of radiographic loosening. During those 20 years, the patient had 2 femoral revisions. Reproduced with permission from Schreurs BW, Bolder SB, Gardeniers JW, Verdonschot N, Slooff TJ, Veth RP. Acetabular revision with impacted morsellised cancellous bone grafting and a cemented cup. A 15- to 20-year follow-up. *J Bone Joint Surg Br.* 2004;86(4):492-497.

key factors in cementing a good socket are exposure of cancellous bone, adequate bony coverage of the cup, and a clean and dry socket; however, even when these conditions are met, it can be difficult to control radiolucency at the bone–cement interface. Sutherland and colleagues[6] showed by finite element analysis that retaining the subchondral plate during cemented acetabular preparation can lead to increased stiffness and high stress concentration at the bone–cement interface. In the revision setting, the mechanical interlock between bone and cement would thus be weaker compared with the primary situation and may contribute to the high incidence of aseptic loosening of cemented revision acetabular components.[7] The poor results associated with cemented acetabular revisions have redirected surgeons to reconstruct the failed acetabular component with uncemented techniques.

Impaction Bone Grafting With Cement

Bone impaction techniques using a cemented cup can provide a stable reconstruction and restore hip joint mechanics. Unlike cementless techniques—hemispheric cups at the anatomical center of rotation or at a high hip center, extra-large cups, or oblong cups—this procedure can reconstitute major bone loss. Bone-grafting acetabular protrusio secondary to rheumatoid arthritis was first reported in 1975 by Hastings and Parker.[8] Mendes and colleagues[9] later reported on 8 patients who had acetabular protrusion and underwent primary hip arthroplasty with the acetabulum reconstructed using bone chips and mesh. None of the patients required revision at 6-year follow-up, and bone graft incorporation was confirmed by histologic analysis.

The so-called acetabular impaction grafting technique was described by Slooff and colleagues[10] in 1984. The same group later standardized the technique with minor modifications and technique-specific instrumentation.[11-13] The modern technique involves using a flexible stainless-steel mesh to delineate the segmental and peripheral rim defects. Fresh-frozen morselized bone chips are impacted into the acetabulum. On the first layer of chips, additional layers are sequentially impacted until the graft layer is at least 0.5 cm thick. An all-polyethylene cup is then cemented into the graft. Although structural graft is not used, this sequential, tight impaction of large quantities of morselized graft has been shown to provide stability and reconstitute bone stock in large defects in a manner analogous to bulk structural graft[14] (Figure). In a series of 142 acetabular reconstructions, Comba and colleagues[15] reported that they used a mean of 2.4 femoral heads per case.

The success of impaction grafting depends on the biological and mechanical properties of the morselized bone graft used. These properties are influenced by factors such as graft type (cancellous, cortical-cancellous), pretreatment (freeze-dried, fresh-frozen, irradiated), graft particle size and grade (range of sizes), surgical handling (rinsing and compaction), and postoperative rehabilitation. Cancellous allograft is the graft type recommended in the original technique.[16] It was suggested that the trabecular structure of the cancellous bone would allow for more rapid incorporation.[16,17] However, it has also been suggested that cortical-cancellous graft would not weaken as quickly as cancellous graft during the resorption phase and thus may be a better choice. The literature does not include any reports of studies comparing cancellous and cortical-cancellous bone grafts in acetabular impaction grafting.

"Perhaps the most critical part of impaction grafting is compaction, which is performed layer by layer and with vigorous impaction."

The size of the allograft particles are also important for the early stability of the reconstruction. Larger sizes (chips 8-10 mm in diameter) provide the best initial stability[18] and result in more porous and permeable impaction. The porous voids are penetrated by pressurized cement; this may contribute to the initial stability of the construct. If the graft material contains differing sizes of particles, fixation is enhanced. The compacted allograft layers are prone to creep under shear forces. If the pores between larger particles are filled with smaller size particles, the resulting construct will have improved resistance to shear forces. Rinsing significantly improves the shear strength of the graft and may also reduce the immunogenicity of the allograft.[19] Perhaps the most critical part of impaction grafting is compaction, which is performed layer by layer and with vigorous impaction. Degree of impaction is determined by energy applied

with mallet blow and number of cycles.[4] When adequate compaction is not achieved, then early or even intraoperative acetabular failures may result.[20]

Postoperative weight-bearing status after acetabular impaction grafting is controversial. The original recommendation was restricted weight-bearing for 6 to 12 weeks.[15,21] A comparative radiostereometric analysis of cup migration in patients with restricted weight-bearing and weight-bearing as tolerated showed that there was no difference in the final amount of migration of the implants.[22] However, acetabular cups in patients who performed weight-bearing as tolerated settled into their final position faster, and patients were generally more satisfied with their results.

Slooff and colleagues[16] and Schreurs and colleagues[11,14,21] reported good outcomes of acetabular impaction allografting of the same cohort of patients at follow-ups of 2 years, [16] 6 years,[11] 12 years,[14] and 15 to 20 years.[21] In 2004, Schreurs and colleagues[21] reported on 62 acetabular revisions performed using this procedure. Fresh-frozen femoral head allograft was used. Defects included cavitary, segmental, and combined defects. Cup survival was 93% and 79% at 10 and 15 years, respectively, with revision for any reason as the endpoint.[11,21] Harris hip scores increased from 45 points before surgery to 85 points after surgery.[11,21] In a 15-year follow-up of this technique in 42 patients younger than 50, the same authors reported a 20-year survival rate of 80% with acetabular revision for any reason and 91% for aseptic loosening as the endpoint.[23] In their series of 142 acetabular reconstructions evaluated at a mean of 4.3 years, Comba and colleagues[15] reported a survival rate of 95.8% overall (97.9% excluding infections) and emphasized the importance of supporting the graft with a mesh or ring in the presence of severe combined medial segmental acetabular defects.

Summary

Cemented acetabular cups have fared poorly in revision acetabular surgery. Lack of adequate cancellous bone in the revision setting and retention of the subchondral plate may contribute to the relatively high loosening rate. Acetabular reconstruction using impaction bone grafting is an attractive biological revision option that allows restoration of the bone stock. However, the technique is very meticulous and exacting. The surgeon must understand the available graft types and grades. Sequential impaction and cementing technique are critical to the success of this procedure. When performed well, revision acetabular surgery using this technique has outcomes rivaling those seen using uncemented hemispheric shells with the added benefit of restored bone stock.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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