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Acetabular reconstruction by impacted cancellous allografts in cementless total hip arthroplasty revision

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Objective: The aim of this study was to evaluate the primary and secondary stability, where 100% or virtually 100% of the uncemented acetabular component contacted with impacted cancellous allografts, focusing especially on the amount of graft used and rim contact.

Methods: Fifteen cases of acetabular reconstruction using impacted cancellous allografts and cementless porous-coated component in which 100% or virtually 100% of the component contacted only with the allograft were reviewed. Mean follow-up was 97.5 (range: 58 to 130) months after revision. The Harris hip score was used to evaluate clinical results. Radiographic evaluations were done using standard anteroposterior views obtained at the final follow-up.

Results: Two patients underwent re-revision. The mean Harris hip score of the remaining 13 patients was 88.3±11.9 (range: 68 to 100) at the final follow-up. Early postoperative radiographs showed mean angle of inclination of 45° (range: 30° to 55°). There was a mean migration of 6.2±7.8 (range: 0 to 29) mm and the migration amount did not differ according to rim contact ($p=0.054$). There was no correlation between migration and amount of graft used ($p>0.05$). There was a significant correlation between migration and follow-up time ($p<0.01$).

Conclusion: Our results imply that 50% host bone contact is not absolutely necessary to form a stable construct while restoring the centre of hip rotation.

Key words: Acetabular component; cancellous allograft; cementless revision.

Total hip arthroplasty is a well-established option with high success rates for patients with diseases of the hip. As a consequence, the prevalence of the procedure has recently increased. Although improved, all implants have a limited life, and bone loss is associated with all of the major causes of failure.[1] With the increasing number of complex revision surgeries, bone loss has become one of the greatest challenges encountered by hip surgeons.

Successful acetabular revision surgery regains hip functions through achieving implant stability and restoring bone stock and the centre of hip rotation.[2,3] Cementless acetabular revision has generally been reported to have good results[4-9] when compared to

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cemented acetabular revision which has been associated with high failure rates.[10,11] Whether with implants, bone grafts, or both, the principle of achieving a mechanically stable construct remains largely unchanged. Cavitary and various combined cavitary and segmental defects can be effectively managed with a nonstructural graft and a hemispherical porous component.[12] If the porous surface of the revision component is not in contact with a minimum of 50% of vascularized stable host bone, it is recommended that reconstruction rings be considered.[13-15]

The minimum host bone contact, or maximum amount of bone graft, which may be tolerated without risk of compromising stability of an uncemented acetabular component has not yet been established with certainty.[16] The purpose of the current study was to evaluate the primary and secondary stability in cases where 100% or virtually 100% of the uncemented acetabular component was contacted with impacted cancellous allografts, focusing especially on the amount of graft used and rim contact.

Patients and methods

Seventy-six consecutive cementless acetabular revisions were performed by the same surgeon between 1998 and 2003. In 16 of these patients, the acetabular components were 100% or virtually 100% in contact with the impacted cancellous allograft. One patient was lost to follow-up at one year. The remaining 15 hips of 15 patients were included in this study. Permission for the study and its publication was obtained from the Local Ethics Committee.

Five (33.3%) of the patients were male and 10 (66.7%) were female with an average age of 52.1 (range: 36 to 73) years. Four (26.7%) of the involved hips were right and eleven (73.3%) were left side. The underlying diseases were primary osteoarthritis in eight patients (53.3%), hip fracture in three (20%), rheumatoid arthritis in one (6.7 %), ankylosing spondylitis in one (6.7%), posttraumatic osteoarthritis in one (6.7%) and low-grade chondrosarcoma in one patient (6.7%). Six patients underwent revision surgery in two stages because of septic failure (40%) and nine patients in one stage because of aseptic failure (60%).

All patients underwent index revision surgery only if erythrocyte sedimentation rates (ESR) and C-reactive protein (CRP) levels were at normal intervals to ascertain the absence of infection. Preoperative iliac and obturator Judet views were obtained in addition to routine anteroposterior radiographs. Defects were classified according to Paprosky et al.'s classification.[13] One hip (6.7%) was Type 2B; two (13.3%) were Type 2C; ten (66.7%) were Type 3A; and two (13.3%) were Type 3B. We identified two groups of cases; acetabular components with rim contact and without rim contact. Evaluation was made by comparison of final follow-up radiographs with early postoperative radiographs. Acetabular components in contact with the impacted morselized allografts were included in the group without rim contact (Table 1).

Table 1. Summary of cases.

Case no.	Paprosky class	Allograft amount	Angle of inclination	Rim contact	Follow-up (months)	Migration (mm)	Final Harris hip score	Re-revision and cause
1	3A	270 cc	30	+	126	0	86	-
2	2B	180 cc	41	+	130	2	76	-
3	3A	60 cc	46	+	120	3	98	-
4	3A	115 cc	31	+	114	0	100	-
5	3A	60 cc	47	+	113	5	97	-
6	3A	270 cc	46	+	111	2	100	-
7	3B	90 cc	52	-	107	5	76	-
8	2C	90 cc	54	-	106	5	53	+ (infection)
9	3A	270 cc	45	-	105	2	88	-
10	2C	60 cc	41	-	104	5	86	-
11	3A	270 cc	43	+	75	0	100	-
12	3A	150 cc	53	+	75	17	60	+ (mechanical)
13	3B	180 cc	42	-	60	5	79	-
14	3A	180 cc	49	-	59	13	73	-
15	3A	60 cc	55	-	58	29	88	-

All revision procedures were done through a posterior approach with patients placed in a lateral decubitus position. Previous implants and all cement were meticulously removed. Samples from at least 3 areas of suspect tissue were taken for analysis of polymorphonuclear leukocytes (PNL) in frozen sections. If the count was less than 5 per high-power field, the revision continued. All soft tissue on the host bone was debrided and curetted and soft tissue was only smoothly curetted at the central part of the acetabulum where the host bone was defective. Sclerotic bone was trimmed with the help of a high-speed burr; if bleeding trabecular bone was not reached, the bone was drilled multiple times with 4.5-mm drills. The wound was thoroughly irrigated with at least 6 liters of pressurized saline. Iodine soaked gauze was placed in the wound and left for 30 minutes, while the clothes of the team and all the surgical instruments were changed and the patient was re-draped. Spongious chips allografts with dimensions of 4-10 millimeters (Tutobone® chips; Tutogen Medical GmbH, Neunkirchen am Brand, Germany) were applied and compacted. Allografts were added until all the defects were filled. A mean of 134.7 (range: 60-270) cc of spongious chips allograft was used. Allografts were compacted with vigorous repetitive impactions taking care to only lock the particles without totally crushing them. Reverse reaming enabled the preparation of the correct size and shape for the component. After evaluating the acetabular preparation with a trial shell, a porous-coated acetabular component (Plasmacup® SC; Aesculap, Tuttlingen, Germany) two to four millimeters larger than the trial component was inserted without cement at adequate anteversion and inclination. The component was tested manually for primary stability then fixed with 2-3 screws through the host bone.

All patients were mobilized with a walker on the first postoperative day. Weight-bearing was prohibited and only toe-touching advised. Partial weight-bearing was permitted after a minimum of 12 weeks, according to radiographic findings. Full weight-bearing was begun 1 year postoperatively with radiographic evidence of complete graft tissue incorporation.

Mean follow-up was 97.5 (range: 58 to 130) months. The Harris hip score was used to evaluate clinical results. Radiographic evaluations were conducted using postoperative radiographs and standard anteroposterior views obtained at the final follow-up. A line drawn between two teardrops was used (if not possible, a line drawn between ischial tuberosities was used) as a reference, and the distance to the inferior pole of the acetabular component was recorded. The difference of that distance between the early postoperative and final follow-up radiographs was accepted as the superior migration. Graft incorporation was defined according to the criteria of Conn et al.[17] using anteroposterior radiographs. Osteolytic lesions were recorded according to the zonal system of DeLee and Charnley.[18]

Results

No neurovascular complication was seen in any patient. No patient experienced dislocation and no superficial or early postoperative infection developed.

Two patients (Case nos. 8, 12) underwent re-revision. The first one developed deep infection 8 years after revision and underwent a second revision in two stages. Allografts were found to be incorporated and to have formed a stable base for the second stage of the re-revision. The second patient underwent a second revision 6 years following the index operation due to progressive loosening and migration (Fig. 1). During this revision the grafts were not incorporated to the host bone and there was no vascularization detected microscopically from the allograft specimen taken during surgery. A third patient (Case no. 15) refused re-revision which was recommended on radiological grounds.

Early postoperative radiographs showed a mean angle of inclination of 45° (range: 30° to 55°). Survival

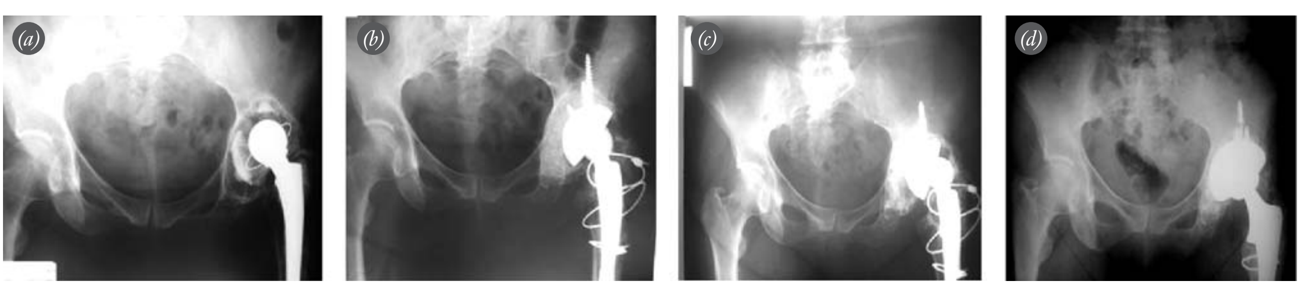

Fig. 1. **(a)** Radiograph showing the loosening and Paprosky Class 3A defect. **(b)** Early postoperative radiograph showing high angle of inclination (53°). **(c)** Failure at the 6th year. **(d)** Radiograph following re-revision performed with a 64-mm cup and no allograft.

rate of implants was 86.6% (2 re-revisions of 15 cases) in a mean of 97.5 (range: 58 to 130) months. The mean Harris hip score of the 13 patients not revised was 88.3±11.9 (range: 68 to 100) at the final follow-up. There was 6.2±7.8 (range: 0-29) mm of mean migration and migration distance did not differ according to rim contact ($p=0.054$). There was no correlation between migration and amount of graft used ($p>0.05$). There was a significant correlation between migration and follow-up time ($p<0.01$).

Discussion

Total hip arthroplasty acetabular component failure is usually associated with acetabular bone defects. These bone stock deficiencies can be managed in several ways. Achieving implant stability and restoration of bone stock and centre of hip rotation are important goals in acetabular revision surgeries.[2] To restore bone stock, bone grafts are almost always used. Autografts are superior to allografts with respect to their incorporation capacity. However, in revision cases, autografts are not always available. Thus, allograft bone is widely used for the restoration of acetabular defects. The allografts used in acetabular reconstruction can be divided into two groups; bulk allografts and morselized allografts. The use of bulk allografts is controversial[2,19] and restricted usually to cases of massive bone loss.[3,12] Despite rare reports of success,[20] filling of bone defects with structural (bulk) allografts may result in early failure due to graft reabsorption and cup loosening.[21-23]

Acetabular components with greater diameter are associated with the removal of more host bone, although with proper technique the host bone is moved (rather than removed) to replace missing bone.[24] Bone stock is actually not restored, thus resulting in bone loss when the component fails.

The goal of successful acetabular reconstruction should be the restoration of the centre of rotation to the anatomical position. Although sometimes a high hip centre may be desired, the centre of rotation should be corrected to within 14 mm of the anatomical center of rotation.[3] The degree of defect, reconstructed hip rotation center, as well as the size of the acetabular component, determine the amount of graft to be used.

Morselized spongious allografts, known as “impaction bone grafting”, have been used widely to restore acetabular bone defects since their introduction by Slooff et al.[25] The original technique includes using cement which, while restoring bone stock, has resulted in failure in some cases.[10]

When morselized spongious allografts are used with cages there is lack of biological fixation, so they are most appropriate for very elderly patients.[24] Impaction grafting does not provide immediate biological fixation but does help to achieve good primary fixation from which biological fixation will follow. However, this may take longer than primary cementless total hip arthroplasty. Biological fixation is achieved from clinical and radiological perspective with this technique.

Although it is not recommended that contact with the host bone be less than 50%,[13-15] there are some reports of successful cases with impacted, morselized allografts with cementless components.[16,26,27] Palm et al.[16] used hydroxyapatite-coated components with extensive allograft impaction. They reported a 94% survival rate at 9 years. Ng and Chiu[26] used morselized allografts to restore bone defects in cementless acetabular revisions, and reported no migration at a mean of 58 months. Etienne et al.[27] reported radiographic incorporation of morselized cancellous allografts in 98% of 99 patients at a mean of 7 years follow-up. However, none of these studies provided information about the percentage of host bone contact.

In conformity with the guidelines on weight-bearing, outlined in the literature on the Slooff technique,[25,28] the cases in the current study were only permitted toe-touching until 12th postoperative week. In contrast, Toms et al. stated that unrestricted weight-bearing has no adverse effect on migration.[1] In the light of recent literature,[1] it is now thought that a more suitable approach may be to allow weight-bearing as and when tolerated by the individual patient.

In elderly and very osteoporotic patients with insufficient bone quality, we used larger cups and some high placement so that at least 50% contact of the component to host bone was achieved. Rings and cages were considered only as salvage procedures. The 15 cases comprising the current study were included as the bone quality was considered sufficient to withstand compaction.

In our study, 6 revision surgeries were conducted in two stages due to septic failure and 9 in a single stage for aseptic loosening. However, the two-stage revision might be a more appropriate method, especially for cases where grafts are likely to be used, as it protects against infection.

Of the two re-revisions that were carried out, one resulted from infection and one from aseptic failure due to non-incorporation of the allograft. Several factors may have contributed to this. In the surgical technique, it is essential to obtain sufficient bleeding host bone, to not totally crush the allograft particles and to pay great attention to the angle of inclination. In this study, the postoperative radiographs non-incorporation case (Case no. 12) showed an inclination angle of 53°, which is greater than acceptable. An additional patient, in which the immediate postoperative angle of inclination was 55° (Case no. 15), was recommended to undergo a revision due to aseptic failure at 58 months postoperatively, but declined. Therefore, we are of the opinion that an acceptable angle of inclination could be a strong contributing factor to the durability of the construct. Although there was no possibility of using multi-holed cups in this study, they also contribute to primary stability.

Procedure success is technically dependent. Good results can only be obtained by a solid anchoring of the new component to the acetabulum. Primary stability is achieved by solid anchoring of the component, proper surgical technique and the correct choice of materials. Allograft impaction should be sufficiently tight to ensure a secure fit, the placement of the component must give an acceptable angle of inclination and multi-holed cups with screws of a size 2-4 mm larger than the trial component, should preferably be used. There is no standard for compaction of morselized spongious allograft. If over compacted, the vascularization of the graft will be compromised. If not sufficiently compacted, primary stability cannot be achieved and early migration will occur.

In conclusion, 50% host bone contact is not absolutely necessary to form a stable construct as rim contact may also help to support the acetabular component in the cementless revision of total hip arthroplasty.

Conflicts of Interest: No conflicts declared.

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