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Structural allograft and primary press-fit cup for severe acetabular deficiency

A minimum 6-year follow-up study

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Abstract Between October 1992 and December 1996, 23 patients with pelvic bone stock deficiency involving major columns underwent revision surgery with a cementless press-fit cup and a structural bone graft. Twenty cases were followed up for a minimum of 6 (average 7.6, range 6–11) years. Three cups were revised: one for aseptic loosening, one for septic loosening, and one for recurrent dislocation. At latest follow-up, the average Merle d'Aubigné hip score improved from 10.9 to 16.2; four hips were rated excellent, seven very good, three good, two fair, and one poor. All cups were stable; the grafts were integrated and anatomy was restored. The Kaplan–Meier cumulative probability of not having revision for loosening at 11 years, predicted a survival rate of 84.4%. We are confident that these results are satisfactory for a very demanding procedure.

Résumé Entre octobre 1992 et décembre 1996, 23 malades avec une perte de substance du bassin atteignant les colonnes du cotyle, ont subi une révision chirurgicale avec une cupule acétabulaire sans ciment et une greffe d'os structurale. Vingt cas ont été suivis pendant un minimum de 6 ans (moyenne 7,6, écart 6–11); Trois cupules ont été révisées, une pour descellement aseptique, un pour descellement septique, et une pour luxation récidivante. Au dernier recul, le score de Merle d'Aubigné s'est, en moyenne, amélioré de 10,9 à 16,2; le résultat a été estimé excellent pour 4 hanches, très bon pour 7, bon pour 3, moyen pour 2, et mauvais pour 1. Toutes les cupules étaient stables, les greffes étaient intégrées et l'anatomie restaurée. Le taux de survie selon Kaplan Meier, en prenant comme élément la révision pour descellement est de 84,4% à 11 ans. Nous considérons ces résultats comme satisfaisants pour une procédure très exigeante.

Introduction

A variety of techniques have been proposed to manage severe loss of pelvic bone stock during revision surgery. Structural bone grafting with cemented or cementless acetabular cups has been considered, in order to re-establish leg length and maintain a sufficient offset. Apart from restoring the anatomy, bone grafting can also make further surgical procedures easier. However, the technique is only reported as being successful when the graft restores a defect of less than 50% of the acetabular bone stock [23] or when it is mechanically supported by reconstruction rings [7, 17]. When bulk grafting was used to restore more than 50% of the acetabular bone stock, a high failure rate was reported [11, 14, 20, 25].

A number of different strategies for surgical revision have been suggested. Jumbo hemispherical cups [22], oblong or bilobed-shaped cups [2, 13], acetabular reinforcement devices and anti-protrusio cages with morselized bone graft [3, 7, 12, 16, 21] have been proposed as viable solutions. However, when the acetabular anatomy is replaced by a metal device, one of the aims of surgical revision, namely restoration of the anatomy, is not fulfilled. Therefore, if further surgery is required, the bone deficiency is still present.

Acetabular reinforcement devices with morselized or bulk grafts seem to be an effective option, but the surgical technique is demanding and cemented cups are required and have shown a sub optimal long-term survival [1, 8, 19]. The aim of this retrospective study was to evaluate the survival of acetabular reconstruction performed with bulk bone grafts and hemispherical press-fit cups.

Materials and methods

Between October 1992 and December 1996, we revised the acetabular cup for aseptic loosening in 23 patients. In all patients, the acetabular defect was at least of type III (AAOS classification) [4] or type III–IV according to Gross [9]. All patients received a bulk bone graft and a hemispherical cementless cup—16 ANCA-Fit hemispherical porous and

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hydroxyapatite-coated cups (Wright Medical Technology), three PCA porous-coated anatomic cups (Howmedica), and one Harris–Galante porous-coated cup (Zimmer) (Table 1). Twenty patients were followed up for an average of 7.6 (6–11) years. Their average age was 66.5 (34–83) years, and there were 16 women and four men. Three patients were lost to follow-up.

Patients had had their previous surgery at an average of 11.7 years before the index operation. At the time of the previous surgery, the acetabular cup was cemented in 12 hips, cementless threaded in six, and cementless press-fit in two (Table 1).

Operative technique

All surgical procedures were performed by the senior hip surgeon (A.T.) through a lateral approach. The bulk allografts were fresh-frozen femoral heads stored at minus 80°C. After the grafts had been thawed, cortical bone and cartilage was removed. Thereafter, the grafts were shaped to have the larger diameter wider than the largest dimension of the bone defect; if necessary, a second graft was added. Then, the grafts were impacted in the acetabular defect (Fig. 1a) and reamed to hold a hemispherical press-fit cup (Fig. 1b). Minor defects were filled by the reamed bone or with supplementary morselized bone graft. Afterward, the cup was impacted in an attempt to achieve direct contact with the host bone in the acetabular weight-bearing area (DeLee and Charnley Zone I) (Fig. 1c). Finally, at least two cup screws were added to improve primary stability (Fig. 1d).

Immediate rehabilitation exercises were started in bed on the first post-operative day. During rehabilitation, patients were advised to avoid adduction and forced rotation,

especially externally. Patients were told to use two crutches during walking for at least 45 days. Full weight bearing was usually allowed after a minimum of 4 months when the graft was radiographically integrated.

Clinical and radiographic follow-up

The Merle d'Aubigné and Postel score for pain, range of motion and ability to walk was recorded before and after surgery at each review. Pelvic antero-posterior (AP) and frog-lateral radiographs of the involved hip were taken at 45 days, 3 and 6 months, 1 year, and yearly thereafter. Bone stock loss was evaluated according the AAOS classification [4]; all cases were at least type III. At revision, we also used the classification of Gross [9]; there were 18 cases of type III and two of type IV. Cups were considered definitely unstable when tilted more than 4° on AP radiograph or migrated more than 0.4 cm medially or superiorly [24]. Displacement of the acetabular cup was evaluated radiographically using the system of Pagnano [15]; heterotopic bone formation was graded according to Brooker. Leg-length discrepancy was assessed comparing the distance between the inter-tear-drop line and the tip of the greater trochanter on both sides. Graft integration, resorption, remodelling, or substitution with the host bone was evaluated. The graft was considered “integrated” if bridging trabeculae were present at the host bone-graft interface; considered “remodelled” when resorption was limited to the area of the graft not contiguous to the host bone; and considered “substituted” if it was radiographically impossible to distinguish between graft and host bone. Finally, cup survival was estimated by the Kaplan–Meier method.

Table 1 Demographics and prostheses

Case	Patient	Gender	Age ^a (years)	Side	Cup explanted (survival years)	Cup implanted
1	L.S.	M	63	L	Charnley cem (20)	PCA cluster
2 ^b	S.G.	F	58	L	AnCA threaded ^c (–)	PCA cluster
3 ^b	C.I.	F	63	R	AnCA threaded (7)	PCA cluster
4	P.J.	F	72	L	Charnley cem ^c (–)	Harris–Galante
5	S.A.	F	34	L	Lord threaded (6)	ANCA-FIT
6	G.M.	F	69	R	Charnley cem (8)	ANCA-FIT
7	C.G.	M	36	L	Letournelle–Lagrange (17)	ANCA-FIT
8	G.C.	F	83	R	Godoli threaded (3)	ANCA-FIT
9	G.B.	F	67	R	Charnley cem (15)	ANCA-FIT
10	T.L.	F	73	L	Muller cem (12)	ANCA-FIT
11	M.C.	F	74	L	Muller cem (12)	ANCA-FIT
12	L.E.	F	73	R	Muller cem (21)	ANCA-FIT
13	F.F.	F	73	R	PCA cluster (1.4)	ANCA-FIT
14	C.I.	F	73	R	Muller cem (13)	ANCA-FIT
15	R.A.	F	72	L	Bioceramica cem (3)	ANCA-FIT
16	I.A.	M	72	L	Lord cem (10)	ANCA-FIT
17	G.L.	M	74	R	Lord threaded (25)	ANCA-FIT
18 ^b	S.M.	F	75	R	Charnley cem (19)	ANCA-FIT
19	P.M.	F	63	L	Muller cem ^c (–)	ANCA-FIT
20	P.V.	F	62	R	Lord threaded (8)	ANCA-FIT

^aAge at revision surgery

^bCases in which revision surgery failed

^cPatients were not able to show the clinical files of the previous surgery

Fig. 1 Surgical procedure to restore the acetabular bone stock with structural bone grafts and a hemispherical press fit cup. **a** The acetabular bone defect is restored with press-fitted bulk allografts; **b** the new acetabulum is reamed to hold a press-fit cup; **c** the cup is press

fitted in direct contact with the host bone in the major area of weight-bearing stress (zone I); **d** two screws are added to achieve a better primary stability.

Results

Three acetabular cups were revised. In one, the prosthesis was completely removed 22 months after surgery due to septic loosening. In the second, there was radiographically aseptic loosening of the cup 60 months after surgery, but the bone graft was considered remodelled and osteointegrated. At revision 8 months later, the bone stock was already recovered, and a primary press-fit cup was implanted with no further grafting. At follow-up, the cup was stable and the graft still integrated. Finally, the third revision was due to recurrent dislocation. After 7 years the cup was revised, and at that time the graft was integrated in the host bone. At the latest follow-up the average Merle d'Aubigné hip score had improved from 10.9 preoperatively to 16.2. Four hips were rated excellent, seven very good, three good, two fair, and one poor. In 15 patients, the score for range of motion was 6; gait was normal in 11 patients. According to the system of Pagnano [15], eight cups were in zone 1, four in zone 2, four in zone 3, and four in zone 4. The average lateral displacement from the estimated femoral head centre of rotation was 0.9 cm; the average proximal displacement was 0.54 cm. All cups were considered stable, and 12 were radiographically fully osteointegrated (Fig. 2).

Fifteen patients had postoperative leg-length discrepancy. In five patients, it was less than 1 cm; in seven, between 1 and 2 cm; and in three, equal to or greater than 2 cm. High-grade heterotopic bone formations were present in four cases (two grade III and two grade IV), but further surgery was not required. The Kaplan–Meier cumulative probability of not having revision for loosening at 11 years predicted a survival rate of 84% (95% CI 68–100).

Discussion

The management of severe bone-stock deficiency in acetabular cup revision is very demanding. Structural bone grafts are able to biologically restore the anatomy and to assure an effective mechanical support for the acetabular component. The survival of acetabular reconstruction using structural bone grafts and hemispherical press-fit cups seems to be good, in our hands. Nevertheless, in the literature, the employment of structural allografts is controversial. Many authors [11, 14, 18, 20, 25] reporting on bulk grafting advise against this technique. At an average of four years follow-up, Zmolek and Dorr [25] reported superior migration of grafts in four cases and three varus tilts of the cup out of eight acetabular reconstructions with structural allografts.

Fig. 2 X-rays (case 14): preoperative (a), postoperative (b), and at 8 years' follow-up (c) anteroposterior views. At latest follow-up the cup was stable, the graft remodeled, and the anatomy restored.

In spite of the poor survival results of this series, radiographic allograft integration was seen at an average of 11 months. Hooten et al. [11] in 27 cementless revisions reported radiographic instability in 44% at an average of 46 months follow-up, and Kwong et al. [14] reported a failure rate of 47% at 10 years in 28 cemented revisions. Furthermore, Kwong reported an increased rate of graft failure after 5 years. Furthermore, Stiehl et al. [20] reported a 47% revision rate after 83 months' follow-up in 16 hips treated with structural grafts, long pelvic plates and cemented or cementless acetabular cups.

In contrast with these studies, the 84% survival rate at 11 years of our series is very good. The only significant and remarkable difference in comparison with other series is that the structural allografts in our series were never placed in zone I (the area under major stress). Our primary goal was to preserve the structural bone graft from the major weight-bearing stresses. We believe that in order to avoid resorption of the bone graft with subsequent implant failure, a reduced mechanical stress on the graft is essential. Gates [6] reviewed 29 hips treated for protrusio acetabuli with autologous bone grafts and cemented cups at an average of 12.8 years, reporting very good results. He also underlined the basic role of stress for graft survival and suggested that bulk grafting should be avoided in areas of major stresses. Saleh et al. [17] reported a very satisfactory 77% survival rate using a roof-reinforcement ring and a structural graft at a minimum follow-up of 5 years (average 10.5 years) in ten hips with type IV acetabular defect. Kerboul et al. [12] reported a 92% survival in a 13-year retrospective study of 60 acetabular reconstructions (48 type III and 12 type IV according to the AAOS grading) using a bulk allograft, the Kerboul acetabular reinforcement device and an all-polyethylene cemented cup. These very good long-term survivals of bulk allografts were probably due to the shielding effect of the reinforcement devices on the grafts. In other studies [3, 7, 12, 16, 17, 21], the reinforcement devices with bone grafts seem to be a very good surgical solution when restoring severe acetabular bone deficiencies. A larger exposure is required, however, when using a reinforcement device, and the surgical procedure is much more demanding in comparison with the technique we describe. Furthermore, the risk related to the extensive use of screws needed to fix the cage to the pelvis is considerable. In addition, with the bulk-graft-impacting technique, it is possible to employ a hemispherical press-fit cup, which we consider the best option for long-term survival.

Notwithstanding this, there are some limitations and concerns related to the bulk-graft-impacting technique. An efficient bone-banking service is required, and even if low, there is a risk of infection related to the use of allografts. Furthermore, the influence of a displaced centre of rotation on the long-term survival of the implant could be a major concern. In this series, we recorded a lateral displacement from the estimated centre of rotation of 0.9 cm and a proximal displacement of 0.54 cm on average. At mean follow-up of 7.6 years, this cup displacement seems not to influence cup survival rate. This finding is also supported by

Dearborn and Harris [5] who, in 36 acetabular cup revisions, performed with a high hip centre of rotation, reported a survival rate of 94% after an average of 10.4 years.

A postoperative leg-length discrepancy was present in only 15 of our patients, and was greater than 2 cm in only three cases. Considering that 2 cm is the minimum discrepancy needed to raise oxygen consumption on exertion, and to limit walking in elderly patients with substantial cardiopulmonary disease [10], our results are acceptable.

In conclusion, our experience with structural bone grafts and hemispherical press-fit acetabular cups with a survival rate of 84% after 11 years is promising. We believe that the bulk-graft-impacting technique is a viable alternative when reconstructing severe acetabular bone stock deficiencies.

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