Acetabular revision surgery with impacted bone allografts and cemented cups in patients younger than 55 years

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Abstract This article summarises a clinical and radiographical analysis of 30 acetabular revisions in patients younger than 55 years old, performed with impaction bone grafting and cemented cups. Preoperative Merle D'Aubigne and Postel functional score was an average 7 points. At a mean follow-up of 86.5 months (range 34–228) functional score averaged 16.3 points. Radiolucent lines with no clinical impact were observed in 7% of DeLee and Charnley acetabular zones evaluated. Massive radiological migration, consistent with clinical failure, was observed in two cups. Three patients underwent re-revision surgery (10%): two due to infection and one due to mechanical failure. Reconstruction survival rate was 89% (CI 95% 71.9–96.4) overall, and 96% (CI 95% 82.6–99.3) ruling out cases of infection. Impacted bone allograft constitutes one of the reconstructive techniques of choice in acetabular revision surgery of young patients. Restoration of bone stock is essential in this group of patients due to the possibility of future revisions.

Résumé Nous avons analysé cliniquement et radiographiquement 30 révisions acétabulaires chez des patients jeunes âgés de moins de 55 ans, révision réalisée avec une greffe impactée et une cup cimentée. Le score pré-opératoire de Postel Merle d'Aubigné était en moyenne à 7 points. Après un suivi moyen de 86,5 mois (de 34 à 228 mois) le score post-opératoire de Postel Merle d'Aubigné était en moyenne à 16,3 points. Des liserés sans traduction clinique ont été observés dans 7% des cas et analysés selon DeLee et Charnley. Une migration massive radiographique avec un

échec clinique a été observé dans deux cas. 3 patients ont nécessité une nouvelle révision (10%), 2 pour infection et 1 pour échec clinique. Le taux de survie de cette reconstruction a été de 89% (intervalle de confiance 95% 71.9–96.4) et de 96% (intervalle de confiance 95% 82.6–99.3) pour les cas d'infection. L'allogreffe impactée constitue une technique de choix pour la reconstruction lors d'une révision acétabulaire chez des patients jeunes. La restauration du stock osseux est essentielle dans ce groupe de patients et permet d'anticiper de futures révisions.

Introduction

The outcome of primary total hip arthroplasty (THA) in young patients compares less favourably with that of older patients [3, 19, 22]. Thus, the need for complex revision operations in this group of patients is not uncommon.

Among different techniques that could be used in these cases [6, 8, 20, 23], bone impaction grafting appears to be an attractive option for biological reconstruction of bone defects [2].

Slooff et al. in 1979 were the first to use impaction bone grafting in hip revision operations. They reported favourable results at short, intermediate, and long term follow-up [15, 17, 18, 21]. They also reported satisfactory results in a group of young patients who underwent primary and revision operations with acetabular bone loss [16, 19]. Oakes and Cabanela considered it an appealing technique especially for young patients because of its potential to restore bone stock [12]. However, the results of acetabular impaction grafting for revision surgery in young patients are scarce in the literature.

The purpose of this study is to analyse the clinical and radiographic results of a series of patients younger than 55

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years old who underwent aseptic acetabular revision surgery with impacted bone allografts and a cemented cup.

Material and methods

From March 1987 through May 2003, 30 aseptic hip revision operations in 27 patients (three bilateral reconstructions) younger than 55 years at the time of surgery were performed in a single institution. Reconstructions were performed using the impacted bone allograft technique in all cases. None of the patients (20 women and 7 men) was lost to follow-up. Age at surgery was a mean 44.7 years (range 31–54). Preoperative Merle D'Aubigne and Postel functional score [5] was an average 2.4 points for pain, 2.1 points for gait, and 2.5 points for mobility. Seventeen reconstructions were performed on the right side and 13 on the left side. Operations were performed by four surgeons, although one of them (FP) was present at all the cases. Acetabular bone stock defects were present in all the patients. In order to classify them according to the American Academy of Orthopaedic Surgeons' classification system (AAOS) [4], we compared preoperative and postoperative radiographs, as well as intraoperative confirmation from surgical reports. We describe nine cavitary bone defects and 21 combined (cavitary and segmental) bone defects.

In all cases, the diagnosis of absence of infection was based on clinical history, radiographic images, macroscopic intraoperative findings, intraoperative frozen section [11], negative deferred cultures, and histopathological studies.

Surgical technique

All operations were performed under epidural hypotensive anaesthesia. Intravenous antibiotic prophylaxis with first-generation cephalosporin was used during anaesthetic induction and the first 24 postoperative hours. Routine prophylaxis for thromboembolic disease was used during the first month after surgery. The transtrochanteric approach was used in 21 cases and the posterolateral approach without trochanteric osteotomy in nine. Wide exposure was required to obtain a complete visualisation of the acetabular limits as well as its bone defects. Neurolisis of the sciatic nerve was not performed in any of the cases. The components and the remaining cement were carefully removed. The transverse ligament or the tear-drop was identified. These landmarks allowed the reconstruction of the centre of rotation in an anatomical position, an essential step to achieve an adequate biomechanical balance of the hip. Interposed soft tissue was carefully removed, avoiding disruption of the medial cortex of the acetabulum. This step was important to obtain an underlying bone free of soft

tissue to permit a close contact between both bones, avoiding early acetabular radiolucencies in postoperative X-rays. Bone allografts were obtained from frozen femoral heads of our own bank following the protocol of the American Association of Tissue Banks for the harvesting and processing of grafts [10]. An average of 2.8 femoral heads were used per case (range 1–6). In 11 cases with cavitary defects combined with severe segmental defects, we used seven metallic meshes and four femoral head structural allografts attached to the iliac bone with screws in addition to contain the impacted grafts.

Routinely 7–10 mm cancellous bone chips were impacted according to the original Slooff technique using specific instruments (Exchange Revision Instruments System, Stryker Howmedica Osteonics, Allendale, NJ, USA and Primary Impaction Grafting Instruments, De Puy Int., Leeds, UK) consisting of impactors of increasing diameter placed in the desired acetabular position and impacted vigorously. The diameter of the last impactor was 4 mm greater than the definitive cup. The impaction should be energetic in order to achieve safe stability of the system. The thickness of the graft layer should be at least 5 mm. It was useful to avoid an excess of medial grafts to prevent a mislocation of the cup. Once the defects were modified to appear hemispherical, the cup test was performed, followed by cement mixing. A wet gauze was placed in the cavity, soaked in epinephrine 1/500,000 or hydrogen peroxide if necessary, to avoid the accumulation of blood between the grafts. Next, the cement was pressurized for 4 s before the cup was set.

Thirty flanged cemented polyethylene cups were used: 8 Osteonics (Stryker Howmedica Osteonics, Allendale, NJ, USA) and 22 Ogee (De Puy, Warsaw, Indiana, USA). Acetabular internal diameter was 22 mm in 25 cases and 28 mm in five cases. Two types of polymethylmethacrylate were used: CMW (De Puy, Warsaw, Indiana, USA) and Simplex (Stryker Howmedica Osteonics, Mahwah, NJ, USA). In only 17 cases was cement combined with antibiotics used.

The rehabilitation protocol was early mobilisation and ambulation using a walker with toe-touch weight-bearing on the operated side during the first 6 weeks. After that, progressive weight-bearing was allowed as tolerated.

Clinical and radiographic follow-up was performed in all cases. For clinical evaluation we applied the Merle D'Aubigne and Postel scoring system [5]. All patients were studied radiographically with A-P and lateral pelvic radiographs. The last radiographs were compared with those done in the immediate postoperative period. To establish allograft incorporation, we followed the radiographic criteria described by Slooff et al. [21]. Therefore, we evaluated graft consolidation, acetabular component migration, and presence of radiolucent lines in the cement-graft

interface. Consolidation was defined as the presence of trabecular bone crossing the graft-host bond. Migration of the acetabular components was determined according to the initial position of the cups using the marking wires relative to the Köhler line and a horizontal line between the tear-drop [9]. The presence of radiolucent lines was described according to DeLee and Charnley's acetabular areas [7]. Cups with continuous radiolucent lines greater than 2 mm thick were considered loose.

Clinical failure was defined as the need for further acetabular revision surgery, irrespective of the aetiology. Radiographic failure was defined as progression of radiolucent lines in the three acetabular areas, or migration higher than 5 mm.

Statistical analysis was done using the Kaplan–Meier survival method.

Results

The mean follow-up period was 86.5 months (7 years), with a minimum of 34 months and a maximum of 228 months.

Functional results

Postoperative Merle D'Aubigne and Postel score was assessed in the 27 successful reconstructions. For pain, the average was 5.8 points. For gait, the mean score was 5.7 points. For mobility, the mean score was 4.8 points.

Re-revisions

Revision rate was 10% overall (three cases). Only one of the cases was associated with an aseptic failure (3.3%). This was a patient with ankylosing spondylitis in which a

second revision operation had been performed. Acetabular bone defect was classified as type III with a severe segmental bone defect in the medial wall. Failure was clinically diagnosed on the basis of pain and radiographically based on intrapelvic migration during the first 2 months follow-up. A further reconstruction with bone impaction grafting and a Kerboul ring to support the grafts was performed. After 11 months, this reconstruction ring fractured with intrapelvic protusio and iliac deep vein thrombosis. The patient was treated with removal of components and a definitive resection arthroplasty because of bone deficit and multiple failures.

The other two revisions were due to deep infection (6.6%), which was detected at 17 and 50 months respectively. These two patients presented with disabling pain, and one of the acetabular reconstructions showed radiographic migration. Both patients were operated upon early in our hospital before the routine use of the laminar-flow operating room for prosthetic revisions. One of the patients had a history of recurrent dental abscesses. They were treated with prosthetic removal surgery, and one of them was reimplanted at a second operation after specific antibiotic treatment with a favourable result at 76 months of follow-up.

Reconstruction survival rate with the need for revision as the end point was 89% (CI 95% 71.9–96.4). After ruling out the cases of infection, survival rate with a follow-up period of 2–13 years rose to 96% (CI 95% 82.6–99.3). The Kaplan–Meier analysis curve is shown in Fig. 1.

Other complications

One patient presented one episode of dislocation (3.3%). In this patient a Charnley stem with a 22-mm femoral head was implanted through a transtrochanteric approach, and he developed a pseudoarthrosis of the greater trochanter. He

Fig. 1 Survival curve showing the Kaplan–Meier analysis with the need for a further revision concerning the end point

was treated with a closed reduction and further conservative treatment without recurrence of dislocation at latest follow-up.

None of all the patients presented postoperative sciatic nerve symptoms.

Radiographic results

Radiographic aspects of graft incorporation and stable acetabular components were observed in 28 cases. This implies that the host bone and the grafts had a similar bone density, and there was a continuity of trabecular lines and some remodelling of the acetabulum medial cortex (Fig. 2). Acetabular component migration higher than 5 mm was observed in two cases (6.6%). The two cases underwent re-revision, as previously described.

Excluding the two-migrated cups, 6 of 84 (7.1%) DeLee and Charnley areas presented radiolucent lines in the

cement-graft interface. These lines proved to be stable and nonprogressive over time and were not associated with failures or deficiencies in the functional score.

Discussion

Based on our results, we consider that acetabular reconstruction with impacted bone allografts is a valid option for acetabular revisions in young patients. In this series, 30 acetabular reconstructions in patients younger than 55 years of age at the time of surgery were evaluated at a minimum follow-up period of almost 3 years and maximum of 19 years. Reconstruction survival rate was 89% overall and 96% ruling out the cases of infection.

The main objectives of acetabular reconstruction surgery are to achieve adequate fixation of the new cup, to restore the centre of rotation of the hip, and to recover bone stock loss. Even though the revision of a loose acetabular component can be performed using different techniques [6, 8, 20, 23], acetabular reconstruction with bone impacted grafts is a biological reconstructive method. In 1979, Slooff et al. began using the modified technique of impacted bone allografts and cemented cups in revision surgery. The authors originating the technique reported their results at different follow-up periods of 2 years [21], 5.7 years [17], and 15–20 years [15], with very favourable results.

In this series, the overall re-revision rate was 10%. In two cases (6.6%), failures due to deep infection were observed. As we mentioned before, one of these patients had associated risk factors. However, it is worth pointing out that both patients were operated upon prior to the routine use of the laminar-flow operating room for this type of surgery. Moreover, based on studies conducted at our institution we currently, routinely use graft combined with vancomycin in revision operations. The latter, along with cement loaded with antibiotics, could reduce the rate of infection [11].

Only one of the reconstructions (3.3%) had to be revised for mechanical failure. In that patient, the existing acetabular bone defect (combined with the severe segmental defect on the medial wall) could have been an indication to use some graft supporting device, such as a metal mesh or an acetabular reconstruction ring, which we did not use at that time.

Schreurs et al. [19] reported favourable results using impacted bone allografts for acetabular reconstruction in young patients. It was a series of 41 patients, younger than 50 years old, including 23 patients who underwent complex primary THAs and 18 patients with acetabular revision surgeries. They reported an overall 94% survival rate at a mean follow-up of 13 years without referring their results exclusively for revision cases. The same authors updated the results of their series of patients with a minimal follow-

Fig. 2 **a** A-P X-ray of a female patient with aseptic loosening of a cemented first revision of a THA. **b** Four years after reconstruction the X-rays show a stable reconstruction with the host bone and the grafts with similar bone density

up period of 15 years [16]. Four hips of 19 revisions performed in 18 patients underwent a further revision. Kaplan–Meier analysis revealed a 20-year global survival rate of 80% and 91% excluding septic failures.

Stromberg et al. [23], based on data from the Swedish National Register, reported poor results using cemented components without bone grafts for acetabular revision surgery in patients younger than 55 years old. At a mean of 4 years of follow-up, 21% of the cups required a new revision. At a mean of 10 years follow-up and in spite of modern cemented techniques, 74% underwent further revision surgery. These results could be explained by the fact that deficient interdigitation is achieved between bone cement and a poor host bone.

In our series, massive migration was a radiological sign consistent with clinical failure. It is not clear whether minor migration could be an initial sign of late failure. We did not undertake radiostereometric studies which have been shown to detect minimal displacement [13].

Radiological assessment of consolidation of the graft is difficult and perhaps unreliable. However, incorporation appeared not to be the determinant for a successful outcome based on the histological evidence described in the literature [14]. We used only fresh-frozen morselised bone allograft from our own tissue bank, because it is considered as the “gold standard” for this reconstructive technique [24]. Nevertheless, mid-term results have been reported with favourable outcome in acetabular reconstructions using freeze-dried irradiated and chemically treated allografts [25]. Long-term results with the use of this kind of allograft should be reported in the future.

A possible limitation of our study is the lack of polyethylene wear analysis in a group of active young patients. However, we believe that the reconstruction of acetabular bone defects using impacted bone allografts could restore bone stock in patients in whom future revisions can be expected.

Acetabular reconstruction with impacted bone allografts is a demanding technique requiring access to banked bone. The impaction of grafts of a certain size should be vigorous in order to provide early stability [1].

Even though the reconstruction is stable, the postoperative period should include restricted loading, which in our series was complete for 6 weeks and partial for approximately 6 additional weeks. As in primary surgery, conventional components are used, with consequent reduction in costs. Except for the two septic failures found in our series, only one patient required further revision due to failure of the reconstruction and these were associated with a technical error in the management of the bone defect. Our clinical and radiological medium-term results in young active patients support the use of this reconstructive technique in acetabular revision surgery.

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