Favorable Survival of Acetabular Reconstruction With Bone Impaction Grafting in Dysplastic Hips

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Abstract Acetabular bone loss hampers implantation of a total hip arthroplasty in patients with developmental dysplasia of the hip. The bone impaction grafting technique in combination with a cemented total hip can restore the bone stock in these patients, but do these reconstructions yield satisfying long-term results? We used this technique in 28 hips (22 consecutive patients). The degree of dislocation was graded preoperatively as Crowe I in five hips, Crowe II in eight hips, Crowe III in nine hips, and Crowe IV in four hips. We present the long-term results of this bone impaction grafting technique a minimum of 10 years after surgery. Two patients died before the minimum followup of 10 years, leaving 20 patients (26 hips). Two cups were revised, one cup for a sciatic nerve palsy (at 2 years) and the other for aseptic loosening after 12 years. The cumulative survival of the cup with revision for any reason as the end point was 96% at 10 years and 84% at 15 years. There were no femoral revisions during followup. The bone impaction grafting technique in combination with a cemented cup is an effective technique for developmental dysplasia of the hip with favorable long-term results.

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent was obtained.

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Introduction

Developmental dysplasia of the hip (DDH) is a relatively common problem [30]. In patients with symptomatic secondary osteoarthritis one treatment option is to use a THA [4, 9, 15–17, 20, 25, 27, 33, 34, 36, 38, 39]. The problem, however, is how to cope with the acetabular bone stock loss. From a mechanical point of view the anatomy is best restored to normal conditions to obtain stable fixation of the prosthetic components. A variety of surgical techniques have been suggested. Rings or cages [21, 40, 45] and modified cups [2, 5] may be useful in complex reconstructions with massive bone loss and pelvic discontinuity. However, they do not restore the bone deficiency itself and are expensive [24].

A different philosophy is to reconstruct the bone stock loss by bone grafts and use standard implants. One technique is to use structural bulk femoral head bone grafts [27, 32, 44]. A problem observed in longer followups of this technique is resorption of the bone grafts. Another technique to reconstruct the bone loss is to use bone impaction grafting with a cemented cup [46]. Based on our experience with this technique in revisions [41–43], we used this technique in patients with DDH for both anatomical and biological repair. In a previous report of the studied patient cohort, we presented the midterm outcome of this technique at a minimum followup of 5 years; the cumulative cup survival with revision for any reason as the endpoint was 96% both at 5 years and 10 years [1]. However, the true value of any

reconstructing technique can only be documented by long-term outcomes.

We asked how these reconstructions performed by the bone impaction grafting technique and a cemented cup survived at long-term followup. Would the radiographic appearance change over a long-term followup? Was bone graft resorption a problem with this technique and was the anatomical center of rotation indeed reconstructed in all these cases?

Materials and Methods

We retrospectively reviewed 22 patients (28 hips) with DDH in whom we performed reconstruction of the acetabulum with impacted morselized bone grafts in combination with a cemented cup between January 1984 and December 1995. In all cases, the indications for surgery were pain and progressive functional disability. No patients were lost to followup. Two patients died before postoperative year 10, leaving 26 hips in 20 patients available for review with a minimum followup of 10 years. One patient died after 10 years followup. In all three cases, death was unrelated to the hip surgery and at the time of death, no reoperations had been performed. There were 18 women and two men; six patients had bilateral operations. Twelve hips were left and 14 hips were right. Ten patients (14 hips) had previous operations. The average age at operation was 49 years (range, 26–74 years); 14 of 26 (54%) operations were performed in patients younger than 50 years and 23 of 26 (88%) in patients younger than 60 years. The minimum followup of the 20 patients that were clinically available was 10 years (mean, 11.6 years; range, 10–20 years). At final followup we reviewed 19 patients, and one patient was reviewed by an orthopaedic surgeon in another clinic.

According to the Crowe rating [6], the degree of dislocation was Stage I in five hips, Stage II in eight hips, Stage III in nine hips, and Stage IV in four hips. According to the Eftekhari [12] classification, the degree of dislocation was Stage A in seven hips, Stage B in 12 hips, and Stage C in seven hips. Acetabular defects were determined from the preoperative radiographs and the operation record. The bone deficiencies were combined cavitary and segmental defects in all cases, Type 3 defects according to the AAOS classification [7].

The posterolateral approach was used in all patients. We prepared the acetabulum carefully and reamed it with increasing size of the reamers until a bleeding subchondral bone bed was visible using the acetabular fossa as the anatomic center of the hip. We examined the acetabular floor and walls for any medial or peripheral segmental defects. A metal mesh was used to reconstruct peripheral

segmental defects of the anterior, posterior, and superior walls in 20 hips and was used as reinforcement of the medial wall in six hips. In this way, the acetabular cavity was contained. We reconstructed the anatomy of the hip by creating a new socket at the level of the transverse ligament. In eight cases, a higher hip center was accepted. Bone grafts were morselized with a rongeur from autologous femoral heads in 24 hips and from autologous cancellous bone from the iliac crest in one hip. In one hip, we used combined autografts and allografts from a femoral head obtained from a bone bank. Before inserting the bone grafts, we made multiple drill holes in the host bone for optimal revascularization of the graft. The socket was cleaned with pulse lavage and filled with a substantial layer of graft with a thickness of at least 5 mm. More grafts were needed at the periphery than were needed centrally. The bone grafts were impacted with several sizes of impactors and a hammer starting with the largest possible size and ending with the most suitable cup size. Pressure on the layer of graft was maintained while preparing the bone cement (Genta-Palacos; Merck, Darmstadt, Germany). After inserting and pressurizing the bone cement, we inserted a polyethylene cup and held it in position with a pusher until the cement polymerized [41].

Until 1991, we placed a thin vitallium mesh on the bone grafts after impaction. The bone cement was inserted and perforated through the mesh during pressurizing. In this way, the mesh served as a metal backing for the polyethylene cup to decrease peak stresses at the interface. Because we subsequently believed no positive effect of the metal backing could be expected, we discontinued use of the mesh in the early 1990s. Among the 28 hips in 22 patients, we reconstructed 7 hips (6 patients) with and 21 hips (16 patients) without the thin vitallium mesh on the grafts after impaction.

Postoperative management included systemic antibiotics for 5 days, indomethacin for 5 days as prophylaxis against heterotopic ossification, and anticoagulation for 3 months. Passive movement was started at 24 hours. Walking with partial weight bearing was started at 3 weeks (6 hips, 5 patients) or 6 weeks (22 hips, 17 patients) depending on the thickness of the graft's layer and full weight bearing after 3 months.

We (MPS, JWMG, BWS) used the Harris hip score [23] for clinical evaluation. A preoperative Harris hip score [23] was available for 14 patients. We calculated the score in all other patients from the patient's record at review. Clinical failure was defined as the need for revision of the acetabular cup for any reason.

We performed radiographic followup using anteroposterior and lateral views. All radiographs were assessed by three of the authors (MPS, JWMG, BWS) who made a consensus opinion in the case of disagreement. The

radiographs at latest review were compared with the direct postoperative views and periodically after 6 months, 1 year, 5 years, 10 years, and 15 years followup. Radiolucency was scored in three zones and was regarded as positive if a radiolucent line of more than 2 mm was visible [10]. Migration of the cup was estimated relative to the interteardrop line. A radiographic failure of the cup was defined as migration of 5 mm or more in any direction or radiolucent lines in all three zones. On the femoral side, radiolucency was scored in the zones of Gruen et al. [22] and migration was estimated relative to the tip of the greater trochanter [19].

We used a Kaplan-Meier survival analysis to calculate the cumulative survival of the cups at 10 years and 15 years. Clinical and radiographic results of the patients who had died were included as censored data, because all patients had complete followup in detail yearly.

Results

The cumulative survival of the acetabular cup with revision for any reason as the endpoint was 96% (95% confidence interval, 89%–100%) at 10 years and 85% (95% confidence interval, 65%–100%) at 15 years. The cumulative survival of the cup with the endpoint as aseptic loosening was 100% (95% confidence interval, 87%–100%) at 10 years and 88% (95% confidence interval, 68%–100%) at 15 years (Fig. 1) (Table 1). Two of the 28 cups were revised. One cup was revised because of sciatic nerve palsy after 27 months. A second cup was revised after 12 years followup as a result of aseptic loosening of the cup. None of the stems were revised during followup (Table 2).

The longer followup showed a stable radiographic appearance of the graft and the cup in 26 of the 27 hips,

Fig. 1 Cumulative survival of the cup of 28 consecutive reconstructions is shown. Two patients died before postoperative year 10. All other patients had a followup of more than 10 years. Six patients had a followup more than 15 years.

Table 1. Cumulative survival after 10 and 15 years followup

End point	Followup	Cumulative survival
Revision for aseptic loosening	10 years	100% (87%–100%)
	15 years	88% (68%–100%)
Revision for any Reason	10 years	96% (89%–100%)
	15 years	85% (65%–100%)

Table 2. Results and revision of the 28 arthroplasties

Variable	Number (Patients)	Results
Acetabular reconstructions from 1984 to 1995	28 (22)	No patients lost to followup
Available with minimum of 10 years followup	26 (20)	Two patients died before postoperative year 10 without reoperation
Revisions	2 (2)	One sciatic nerve release (27 months); one aseptic loosening (12 years). No femoral revisions; no additional radiologic failure

excluding the hip with early revision for sciatic nerve palsy; we observed no resorption of the grafts. There was one radiographic failure with progressive radiolucent lines in all three zones, which led to the only revision for aseptic loosening after 12 years. There were no additional radiographic failures at review. Twenty hips showed a stable radiographic appearance of the acetabulum with uniform and homogeneous density of the graft (Fig. 2). In four hips, a radiolucent line was visible in Zone III. In one hip, the radiolucency was progressive; in three hips, the radiolucent line was stable during followup. In two hips, a radiolucent line was visible in two zones. In both hips, the radiolucency was progressive. Migration of the cup was only seen in the cup that was revised for aseptic loosening; all other cups were stable. On the femoral side, we found a stable appearance without lytic lines in 19 hips. Eight stems had radiolucent lines in one or more Gruen zones. In five of the eight hips, the radiolucency was progressive; in three hips, the radiolucent lines were stable during followup. None of the stems migrated during followup.

Although our aim was to reconstruct the anatomical hip center, hips were reconstructed at the anatomic center in only 20 cases. A higher center of rotation was seen in eight hips (all 1–3 cm above the interteardrop line). Preoperatively, the hips with a high center of rotation were graded as Crowe II (one hip), Crowe III (five hips), and Crowe IV (two hips); and Eftekhari B (two hips) and Eftekhari C (six hips). The average Harris hip score [23] in the eight patients with a high center of rotation did not differ from

Fig. 2A–C A 37-year-old female patient underwent bilateral reconstruction. **(A)** Preoperatively the left hip was graded as Crowe III and Eftekar B and the right hip was graded as Crowe IV and Eftekar C. **(B)** The acetabuli were reconstructed with lateral mesh to support the segmental defect and impacted morselized bone chips. On the femoral side, an Exeter cemented total hip prostheses was implanted. **(C)** The 12-year followup view shows a stable radiographic appearance of both hips.

the hips with an anatomical reconstruction, and all cups had a stable radiographic appearance of the graft.

We had no dislocations or infections during followup. The Harris hip score [23] improved in all patients after surgery. The average score increased from 37 points (range, 9–72) preoperatively to 94 points (range, 70–100) at the previous report after 7.6 years. At current review, the average score had dropped from 94 (range, 70–100) to 81 (range, 42–100). The worst score was seen in a patient in whom we had created an anatomic center of rotation in a previous Crowe III, Eftekar B graded hip. This patient developed a palsy from stretching of the nerve with symptoms arising 4 months after surgery. The patient had a release of the sciatic nerve 15 months after surgery without relief of pain symptoms. After 27 months the well-fixed cup was revised and we created a higher center of rotation to release the tension on the nerve. The patient had a partial relieve of symptoms 1 year after revision surgery, but was not pain free. Except the two cup revisions no other reoperations were performed.

Discussion

The current study suggests favorable long-term results with bone impaction grafting can be obtained in dysplastic hips even after 10 to 15 years, and that in contrast to the reconstructions performed with structural grafts, resorption

of the graft is not seen. It is also remarkable that relative to the earlier report of the same cohort presenting the midterm data [1], no additional revisions were performed, although the average followup increased from 7.6 years to 11.6 years (range, 10–20.2 years).

Our study included a relatively small number of patients. However, the indications are relatively few so large numbers of patients would be difficult to report. Further, the same technique with acetabular bone impaction is also used in acetabular revision with favorable long-term results [41–43]. Five of 26 hips were graded Crowe I and seven of 26 hips were graded as Eftekar A preoperatively. An increasing severity of hip dysplasia is associated with a higher rate of failure of the acetabular component [3, 26, 33]. However, we wanted to report our complete data with this technique in dysplastic hips and because the only revision in this study for aseptic loosening was in a Crowe I/Eftekar A graded hip, these hips were included. No failures were observed in the hips graded Crowe II, III, or IV or Eftekar B or C preoperatively.

The other option to reconstruct the bone stock loss by bone grafts and use standard implants is structural bulk femoral head bone grafts. Most surgeons will use a technique with a superolateral structural graft, which yields satisfying early to mid-term results both with cemented and uncemented cup placement [4, 9, 16, 17, 27, 32, 36, 38]. However, long-term experience with acetabular reconstructions with these bulk structural grafts has been

reported with variable results [27, 32, 44]. One study reported high rates of failure in the long term, even in well-functioning patients at 5 to 10 years followup, depending on coverage of the socket by the graft [44]. The other study reports favorable results at 11 years after surgery, although also in this study resorption of the graft is seen. Based on this long-term experience it has been suggested that at least 60% of the cup should be covered by acetabular host bone for noncemented cups [33, 35, 44]. In all cases, when the ilium at the level of the true acetabulum does not achieve 60% coverage or more, alternative surgery should be considered. These alternatives include medialization or cotyloplasty of the acetabulum [26], use of a smaller-sized implant or placement with more inclination [25], placing the cup at a higher hip center [24, 27], the use of rings or cages [21, 40, 45], modular cup designs [2, 5], or cement [34] to improve fixation of the cup. These techniques can be used in primary cases to avoid use of bone grafts, but we believe in the young patient the use of bone grafting is biologically preferable to enhance the bone deficit.

We observed consistent clinical outcomes with stable radiographic appearance of the cup in most reconstructions with bone impaction grafting and without late failure. We believe the difference in our results with impacted morcellized grafts and those with structural grafts is that the latter do not fully incorporate [14, 29]. Bone healing will occur at the interfaces with the host bone, but remnants of necrotic allograft will remain. These can explain the high rates of bone resorption observed in the long-term reports on this technique [25, 27]. The small-fragment grafts used in the bone impaction grafting technique are easier to revascularize from the host bone bed or the surrounding soft tissues [8]. In the long term, this results in a higher amount of incorporation of the grafts which is reflected by the stable long-term clinical outcome [47]. We believe that as long as the defect can be contained adequately with a mesh wire and viable bone bed is available for revascularization, the bone impaction grafting technique can be used. Alternative surgery should be used for massive defects with pelvic dissociation, although it is unlikely that this will be observed in cases with dysplastic hips.

Most reports document good survival of the femoral stem in patients with DDH [16, 33, 36, 38, 39]. We did not use modular stems in this study. Although in patients with DDH, the femoral canal is frequently narrow, we were able to use the normal, commercially available straight stems in this group. Similar to other clinical reports, stem survival was excellent with no failure of the stems during followup.

The bone impaction grafting technique is a safe technique and we had few complications in this study. We recommend performing anatomic reconstructions at the

level of the true acetabulum whenever possible to ensure optimal hip mechanics. However, the sciatic nerve is at risk in hip reconstructions, especially with high dislocations [11, 13, 18, 31, 37]. In this study we had one sciatic nerve palsy in a hip graded Crowe III/Eftekhari B preoperatively and reconstructed at the anatomical center of rotation. Currently we shorten the femur in high dislocations to avoid lengthening the extremity more than 3 cm and to avoid nerve palsies. In eight hips, we chose a higher hip center of rotation to prevent nerve problems. The hips with a high center of rotation showed no signs of failure at followup. This corresponds with findings in the literature that a higher hip center of rotation is not necessarily related to early failure of the reconstruction [28].

The postoperative management in our early patients included bedrest for 3 or 6 weeks. This is not the postoperative regime in our hospital at this time. Now, patients are allowed to walk with partial weight bearing directly after the operation and full weight bearing after 3 months. We only use bedrest for massive reconstructions or in patients who are not able to walk with partial weight bearing.

We observed survival of the cup for aseptic loosening of 100% at 10 years and 88% at 15 years followup. There were no femoral revisions during followup and none of the surviving hips had radiographic failure. This is at least comparable with other reconstruction techniques in a young patient population, with 54% of the patients being younger than 50 years old at the index operation. We conclude the impaction bone grafting technique is an effective and biologically attractive technique to restore bone deficiencies in the acetabulum caused by DDH.

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