Acetabular revision with impacted grafting and a reinforcement ring

42 patients followed for a mean of 10 years

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ABSTRACT – We analyzed the outcome of 42 cemented cup revisions (40 patients) with morselized bone grafts and a reinforcement ring after median 10 (7–16) years. The acetabular component migrated a mean of 7 (5–8) mm in 5 hips. The migration stopped after 2 years except in 1 hip, the only one revised because of mechanical loosening. 3 other hips were revised because of infection. Among the other 38 hips (36 patients), the Merle d'Aubigné score increased from 9 to 15 points.

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In acetabular THR revision with considerable loss of bone stock, conventional techniques with plain cementation have yielded poor long-term outcome (Kershaw et al. 1991, Iorio et al. 1995, Raut et al. 1995, 1996). Other combinations with cemented cups and bulk grafts, bulk or morselized grafts with bipolar prostheses or bulk and morselized grafts with uncemented cups have all been tried, with varying success (Harris and Penenberg 1987, Wilson et al. 1989, Gates et al. 1990, Jasty and Harris 1990, Mulroy and Harris 1990, Hooten et al. 1994, Marti et al. 1994, Papagelopoulos et al. 1995, Garbuz et al. 1996, Shinar and Harris 1997). Acetabular reconstruction with impacted morselized bone graft and a cemented cup, as described by Slooff et al. (1984) for primary hip replacement in acetabular protrusion, has shown promising early results (Azuma et al. 1994, Schimmel 1995, Slooff et al. 1996) and good long-term outcome having a survival rate of 90% at 12 years (Schreurs et al. 1998). Mechanical studies have suggested a reduction in the stress on the medial wall by using reinforcement rings (Crowninshield et al. 1983). Thus Slooff's technique evolved into a combined technique of cup revision with impacted morselized bone grafts, mostly to build up the resorbed superior or medial wall and the application of an acetabular reinforcement ring which is anchored with screws. Finally, the all-polyethylene cup is cemented into this construct. Results were promising at 3 years's follow-up (Dartee et al. 1988). Other authors have reported less success with aseptic loosening varying from 7% to 24% (Engelbrecht et al. 1990, Berry and Müller 1992, Rosson and Schatzker 1992, Gurtner et al. 1993, Haentjens et al. 1993, Dihlmann et al. 1994, Zehntner and Ganz 1994, Garcia-Cimbrelo et al. 1997, Gill et al. 1998, Pitto et al. 1998, Korovessis et al. 1999). We report here our 10-year results.

Patients and methods

Preoperative data

Between 1980 and 1988, 44 acetabular cup revisions were performed in 42 patients because of aseptic cup loosening, with major deficiency of acetabular bone stock. The loose cups to be revised had been in situ for a mean of 8 (2.5–15) years.

The type of THA at the index operation was a curved Müller (n 20), Wagner double-cup prosthesis (n 13), Furlong (n 5), Geradschaft (n 3), McKeeFarrar (n 2) and Mittelmeier (n 1) stem, in combination with an all-polyethylene cemented cup except for the metal cemented cup in the McKee-Farrar and the uncemented ceramic threaded cup in the Mittelmeier prosthesis.

The initial diagnosis was osteoarthrosis in 33

Figure 1. Case 14. Burch Schneider cage after 13 years.

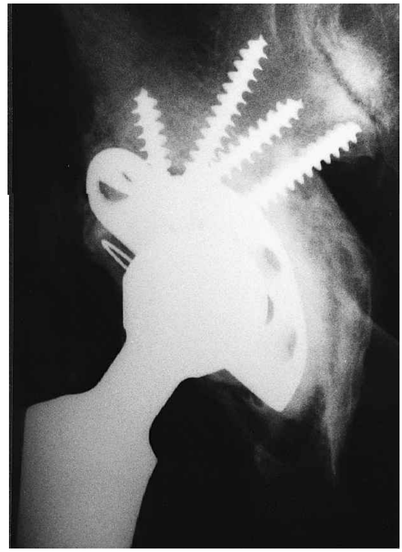

Figure 2. Case 21. Müller cage after 11 years.

hips, rheumatoid arthritis in 7, while 4 hips were diagnosed as secondary osteoarthrosis (1 posttraumatic, 2 epiphysiolysis, 1 congenital dysplasia of the hip).

The mean age at revision was 68 (37–87) years. 10 hips had already been revised once, 2 hips twice and 1 hip three times before. 6 hips were classified as Charnley class A, 30 Charnley class B and 8 Charnley class C (Charnley et al. 1972).

Deficiencies in the acetabulum were classified according to the AAOS system of D'Antonio et al. (1989) based on the preoperative radiographic appearance on the AP and oblique views, and on the description of deficiencies in the operative reports. 17 were classified as type I segmental deficiencies, 14 as type II cavitary and 13 as type III combined deficiencies. There were no acetabular discontinuities.

Operative technique

In all cases, the anterolateral approach was used, which was increased by trochanteric osteotomy in 7 cases. The femoral stem and cement were removed first in case of stem loosening (36/44). Biopsies were taken for bacterial growth and histology. After removal of the loosened acetabular component, the acetabular bone was meticulously cleared of cement, debris and membranes using small curettes. Tissue samples were taken for bacterial cultures and histology. Morselized allografts were impacted into the acetabulum, until the acetabular reinforcement ring (ARR) fitted perfectly, having its major support from screws in the host bone. The Burch Schneider cage (16) and Müller ARR (26) were used at random according to which one fitted best. The all polyethylene socket was then fixed with gentamicin-loaded bone-cement in the ARR. In the 36 hips also requiring stem revision, we used a cemented Geradschaft stem (32), a cemented Furlong stem (2), a cemented Mittelmeier stem (1) and an uncemented CLS stem (1). All procedures were performed in a conventional operating room. Prophylactic antibiotics and anticoagulants were given routinely.

Postoperative management

The patients were kept in bed for 4 days, after which partial weight bearing was allowed with two crutches until 3 months after operation and full weight bearing thereafter.

Clinical and radiographic assessments

The clinical findings were assessed with the Charnley modification of the D'Aubigné and Postel score (Charnley 1972). We used the criteria in the literature for radiographic failure (Azuma et al. 1994, Hooten et al. 1994, Zehntner and Ganz 1994), noting radiolucencies, migration and tilting of the cup, and breakage of a screw. Migration of the cup or change in its angle of inclination was determined with the M.E. Müller template, comparing the direct postoperative AP radiograph with the radiographs taken at follow-up (Zehntner and Ganz 1994). The X-line of the template was oriented to the distal edge of each teardrop and the vertical line bisected the ipsilateral teardrop. The widths of the radiolucencies at the cement-bone interface in each of the three zones of DeLee and Charnley (1976) were measured. Radiographic failure was defined as migration of more than 5 mm in any direction or as progressive radiolucent lines exceeding 2 mm in all zones. Breakage of screws without continuing migration or change in inclination was not defined as failure.

Results

There were no early complications. 4 patients needed a new revision after a mean of 3.5 (1.8–5) years; in 3 of these, 2 had already been revised once, because of a deep infection. Only 1 had had a positive tissue culture at the time of the first revision operation. This patient developed a fistula after 4.5 years, and needed rerevision after 5.2 years. The fourth case, who had already been revised twice, failed because of aseptic loosening with continuous migration of the ARR at 3.3. years of follow-up.

Clinical data and follow-up

All patients were followed yearly. 2 patients were lost to follow-up, both in the first year. At review in 1997, 7 patients had died, 9–13 years after the last revision. Thus 40 patients (38 women) with 42 acetabular revisions were available for study at mean 10 (6–16) years after revision.

The mean Merle d'Aubigné score increased from 9.2 preoperatively to 15 points at last follow-up. The pain score rose from 3.2 to 5.5 and the mobility score from 3.0 to 5.6 points. Walking ability increased from 3.0 to 4.5 points. As could be expected, there was a negative correlation between Charnley classes B and C and the clinical performance, particularly walking ability ($p < 0.01$).

Radiographic findings

Adequate radiographs of the direct preoperative and postoperative situation and at follow-up were obtained in all patients. Migration of the acetabular component of mean 7 (5–8) mm was present in 5 hips, but only during the first 2 years of follow-up after which it stopped. Therefore they were not recorded as a radiographic failure. In 1 of the 5 hips, the migration continued and led to definite loosening which needed a new revision after 3.3 years. Radiolucent lines of 2 mm or more in one or more zones of DeLee and Charnley were found in 4 hips, but none of them were progressive. In these 4 hips, the clinical results, according to the Merle D'Aubigné score at follow-up, did not differ from that in the group without radiolucensies (15 vs. 14). Breakage of 1 of the screws, with no other signs of radiographic cup loosening, was seen in 2 cases.

Discussion

Several techniques have been described for reconstruction of the acetabulum in cases of cup loosening with massive loss of bone. Revision of the acetabular component with cement alone resulted in high percentages of definite loosening, especially when bone stock was poor and in younger patients (Harris and Penenberg 1987, Iorio et al. 1995, Raut et al. 1995). Even with the use of improved cementing techniques, the results are not very good (Katz et al. 1995, Mulroy and Harris 1990).

Massive bulk bone grafts also tend to give poor long-term results. Marti et al. (1994) reported an 86% success rate at the 10-year follow-up, with use of small structural autogenous grafts unlike Mulroy and Harris (1990) who reported a 46% aseptic cup loosening due to collapse of small corticocancellous autogenous grafts. Shinar and Harris (1997) found 9/15 failures of large structural allograft-augmented acetabula versus 16/55 failures in large structural autogenous graft-augmented acetabular revisions ($p = 0.03$). Thus it seems that not only the size of the structural graft, but also its nature, has a large influence on its ingrowth and therefore late stability of the acetabular construct (Jasty and Harris 1990, Hooten et al. 1994, Garbuz et al. 1996).

Patient data

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	F	65	CL	2	Mü	16.2	B	2	BS	Y	6	10	N	N
2	F	67	OA	1	Mü	13.2	B	3	Mü	Y	8	13	N	Y i
3	F	77	RA	1	MF	8.5	B	3	BS	Y	8	12	N	N
4	F	61	OA	1	MF	13.5	B	1	BS	Y	12	17	N	N
5	F	71	OA	1	Wa	13.8	A	2	BS	Y	13	16	N	N
6	F	60	RA	1	Mü	13.9	B	3	BS	N	12	15	Y	N
7	F	73	OA	1	Mü	8.2	C	2	Mü	N	10	17	N	N
8	F	67	OA	1	Mü	12.9	B	1	BS	N	11	15	Y	N
9	F	53	OA	4	Wa	12.8	B	2	Mü	Y	11	15	N	N
10	F	67	OA	1	Mü	12.7	A	1	Mü	Y	9	18	N	N
11	M	73	OA	1	Mü	12.6	C	2	BS	N	7	14	N	N
12	F	69	RA	1	Mü	13.2	B	1	BS	N	9	14	N	N
13	F	66	OA	1	Mü	12.8	B	2	Mü	Y	8	13	N	N
14	F	69	OA	1	Mü	13.1	A	3	BS	Y	12	17	N	N
15	F	60	OA	1	Wa	11.9	B	3	BS	Y	9	18	N	N
16	F	87	OA	1	Mü	7.1	C	2	Mü	Y	8	9	N	N
17	F	67	OA	1	Mü	6.8	B	1	BS	Y	11	9	N	N
18	F	65	OA	1	Wa	10.4	B	2	Mü	Y	11	18	N	N
19	F	80	OA	1	Mü	10.3	B	2	BS	Y	9	16	N	N
20	M	75	OA	1	Mü	10.7	C	1	BS	Y	11	15	Y	N
21	F	62	OA	1	Mü	11.1	B	3	Mü	Y	13	17	N	N
22	F	64	OA	2	Wa	10.4	C	1	Mü	Y	8	12	Y	N
23	F	83	OA	2	Wa	6.4	B	1	Mü	Y	9	13	N	N
24	F	63	OA	1	Wa	10.6	A	1	Mü	Y	13	18	N	N
25	F	37	RA	1	Wa	9.2	B	3	BS	Y	10	17	N	N
26	F	64	E	2	Mü	10.8	B	3	BS	Y	9	17	N	N
27	F	51	RA	1	Wa	9.2	B	3	Mü	Y	2	11	N	N
28	F	76	RA	1	Mü	9.4	A	1	Mü	Y	10	13	N	N
29	F	85	OA	2	Fu	9.3	C	1	BS	Y	8	9	N	Y i
30	F	70	PT	2	Mü	8.9	A	3	Mü	Y	7	8	N	Y i
31	F	62	OA	1	Mi	9.3	B	2	Mü	Y	10	12	N	N
32	F	65	E	2	Mü	8.7	B	3	Mü	N	10	15	N	N
33	F	60	OA	3	Wa	8.3	B	2	Mü	Y	10	8	Y	Y al
34	F	62	OA	1	Wa	8.7	B	3	Mü	Y	13	17	N	N
35	F	72	OA	1	Ge	8.4	C	1	Mü	Y	10	12	N	N
36	M	66	OA	1	Fu	6.4	B	2	Mü	Y	10	17	Y	N
37	F	74	OA	2	Ge	9.8	B	1	Mü	Y	13	15	N	N
38	F	82	OA	2	Ge	7.7	C	1	Mü	Y	6	11	N	N
39	F	78	OA	1	Mü	8.3	B	3	Mü	Y	7	13	N	N
40	F	76	OA	1	Fu	6.9	B	2	Mü	Y	12	18	N	N
41	F	45	RA	2	Wa	6.4	B	2	Mü	Y	11	16	N	N
42	F	72	OA	3	Fu	8.3	B	1	Mü	Y	9	16	N	N

A Case number
B Sex
C Age at revision
D OA osteoarthritis
  RA rheumatoid arthritis
  CL congenital luxation
  E epiphysiolysis
  PT posttraumatic
E Number of previous operations
F Primary prosthesis
  Mü Müller
  Wa Wagner
  Fu Furlong
  Mi Mittelmeier
  MF McKeeFarrer
  Ge Geradschaft
G Follow-up in years
H Charnley classification
I AAOS classification
J Type of cage
  Mü Müller
  BS Burch Schneider
K Stem revision
  Y Yes
  N No
L Merle d'Aubigné preoperatively
M Merle d'Aubigné at follow-up
N Radiolucencies
  Y Yes
  N No
O Failure
  Y Yes
  N No
  i infection
  al aseptic loosening

Acetabular reconstruction with impacted morsellized bone graft and a cemented cup was introduced by Slooff et al. (1984). With this technique, survival rates of 87%–94% at long-term follow-up are reported (Azuma et al. 1994, Slooff et al. 1996, Schreurs et al. 1998) but, in his thesis, Schimmel (1995) reported 18% radiographic loosening with the same technique. Medial segmental defects must be closed with a mesh or a thin corticocancellous shell so that the chips can be tightly impacted to obtain a uniform layer. However, in very large peripheral segmental and medial segmental defects, this method has limitations and a reinforcement ring, anchored with screws in host bone, must be used to obtain enough primary stability to place the new acetabular cup in a biomechanically-optimal position.

Interface radiolucent lines are common after socket revision with bone cement alone, and are caused by poor penetration of cement into the sclerotic underlying bone (Iorio et al. 1995, Raut et al. 1996). However, with bone grafts, the interface radiolucency is not seen at the cement-bone interface because of the good penetration of the cement into the morselized bone grafts; the radiolucency is seen at the interface between the host bone and the graft where graft resorption and ingrowth must take place. Graft revitalization starts at the contact area with the host bone and moves through the graft with time. Tägil (2000) showed that impaction reduced bone ingrowth while loading increased remodeling. Larger grafts revitalize slowly (Buma et al. 1992, Slooff et al. 1993, Nelissen et al. 1995, Schimmel 1995, Buma et al. 1996), but even morselized and impacted autografts can remain unremodeled after several years (Tägil 2000). In our series, we observed good radiographic incorporation of the graft without progressive lucencies in 38/42 cases.

Initial migration of the ARR may be caused by insufficiently tight impaction of the morselized graft, in combination with early weight bearing. This can occur especially in the first 6 months after the operation, but migration that continues after that period may be caused by reduced ingrowth and augmented resorption during revitalization of the graft. Such continuous migration, seen in 5 cases, however, stopped within 2 years after operation except in 1 case which had to be revised 3 years after insertion. Progressive lucencies around the screws, an important feature in defining loosening, was seen in no case. In the four cases with no progressive radiolucent lines of 2 mm or more in one or more zones, the clinical results, according to the Merle D'Aubigné score at follow-up, were the same as in those in the group with no radiolucencies (15 vs. 14).

As regards the technical aspect of this technique, it has been suggested to treat isolated peripheral segmental defects or cavitary defects in one or two zones with the Müller ARR and larger defects with the Burch Schneider ARR (Berry and Müller 1992, Rosson and Schatzker 1992, Dihlmann et al. 1994). Gross (1999) classified the bone stock deficiencies as contained (cavitary) or uncontained (segmental). Contained defects were treated by morselized allograft bone with an uncemented cup, if contact could be made with 50% host bone and he reported a 90% success rate in 51 patients at an average follow-up of 7 years. Segmental defects involving between 30% and 50% of the acetabulum were treated with minor collum autografts with a cemented or an uncemented cup; they showed a success rate of 86% at 7 years' follow-up (n 29). Segmental defects involving more than 50% of the acetabulum were treated with major collum allografts which were fixed by cancellous screws and protected by a reconstruction ring; these hips had a success rate of 76% at an average follow-up of 7 years (n 33). In our opinion there is nearly always a combination of a cavitary and a segmental bone defect which makes a clean classification of these bone defects very arbitrary. Therefore we used the Müller ARR and Burch Schneider ARR at random depending on which reconstruction ring fitted best. The only absolute indication for a Burch Schneider ring is pelvic discontinuity. Our long-term results show that this policy of using some type of ARR at all times has been rewarded by allowing the patient to be mobilized very early without adverse effects.

As 3 of our 4 failures had been revised before, our findings confirm the observation that every other revision means a greater risk of a worse outcome.

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