Acetabular Reconstructions with Impaction Bone-Grafting and a Cemented Cup in Patients Younger Than 50 Years of Age

A Concise Follow-up, at 27 to 35 Years, of a Previous Report*

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Abstract: We present an update of 19 acetabular reconstructions, performed with a cemented total hip arthroplasty and impaction bone-grafting, in situ at the time of our previous report. At a mean follow-up of 30 years (range, 27 to 35 years), no additional patients were lost to follow-up. Two patients (3 reconstructions) died for reasons unrelated to the hip surgery. Five reconstructions (5 patients) were revised, 4 for aseptic loosening and 1 for septic loosening, after a mean of 24 years (range, 22 to 27 years), leaving 11 surviving hips (11 patients) that were clinically and radiographically evaluated. Kaplan-Meier survival at 30 years was 0.40 (95% confidence interval [CI], 0.23 to 0.56) for revision for any reason, 0.56 (95% CI, 0.35 to 0.73) for aseptic loosening, and 0.53 (95% CI, 0.33 to 0.69) for radiographic loosening. Competing risk analysis showed that Kaplan-Meier analysis overestimates the revision risk by 18% for revision for any reason and 22% for aseptic loosening. Cemented impaction bone-grafting is a reasonable long-term solution for demanding primary and revision acetabular reconstructions in young patients with acetabular bone defects.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Background

To our knowledge, there are no data available in the literature on the survival of acetabular reconstructions in young patients at ≥30 years after a surgical procedure. As far as we are aware, only a few long-term reports are available, which all describe a considerably shorter duration of follow-up[1-3].

Therefore, we update the long-term outcome of our original cohort of 42 consecutive acetabular reconstructions with impaction bone-grafting using morselized cancellous bone graft and a cemented cup[4,5]. The patient demographic characteristics are given in Table I. We used impaction bone-grafting as a biological technique to reconstruct acetabular defects in these younger patients. This consecutive cohort consisted of 23 primary acetabular reconstructions and 19 revision acetabular reconstructions in 37 patients. The mean patient age was 37 years (range, 20 to 49 years) at the time of the surgical procedure.

Six surgeons were involved in this single-center study. Clinical and radiographic data were collected prospectively. In our original study, the minimum follow-up was 15 years; 1 patient (1 reconstruction) was lost to follow-up and 4 patients (5 reconstructions) had died. Four primary reconstructions were revised and 4 revision reconstructions were re-revised. Kaplan-Meier analysis of acetabular revision for any reason revealed a 20-year survival rate of 0.80 (95% confidence interval [CI], 0.67 to 0.94) (Table II).

The mean follow-up in the next updated study was 23 years (range, 20 to 28 years)[4]. One more patient had died and another 8 acetabular components had to be revised, resulting in a total of 16 re-revisions (7 primary reconstructions and 9 revision reconstructions), leaving 19 surviving reconstructions in 17 patients. The Kaplan-Meier analyses showed a survival of the acetabular component at 25 years of 0.52 (95% CI, 0.35 to 0.72), with the end point as revision for any reason (Table II).

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TABLE I Patient Demographic Characteristics

	Patients	Reconstructions
In series	37 (100%)	42 (100%)
Sex		
Female	22 (59%)	24 (57%)
Male	15 (41%)	18 (43%)
Type of defects according to AAOS classification		
Segmental		1 (2%)
Cavitary		27 (64%)
Combined		14 (33%)
Deaths during follow-up period	7 (19%)	9 (21%)
Lost to follow-up	1 (3%)	1 (2%)
Revisions during follow-up		21 (50%)
Due to septic loosening		3 (7%)
Due to aseptic loosening		12 (29%)
Due to wear		4 (10%)
During stem revision		2 (5%)

The purpose of the present study was to update the clinical and radiographic results of the 19 surviving reconstructions of our previous report after a mean follow-up of 30 years (range, 27 to 35 years) in these young patients.

Methods

In this update, 19 surviving reconstructions in 17 patients were included. This includes 10 primary reconstructions and 9 revision reconstructions in 5 male patients and 12 female patients. All had received the combination of a cemented cup and impaction bone-grafting, which was the only technique used in our department to treat acetabular bone stock loss. A posterior approach was used, and after resection of the femoral head or removal of the failed component, the impaction bone-grafting technique was performed as previously described[4,5]. In short, segmental defects were reconstructed with use of a metal mesh or a solid graft.

The femoral head was used as autograft, or autogenous bone from the iliac crest was used. In the cases of revision surgical procedures, fresh-frozen, nonirradiated, femoral-head allografts were used, but in the cases of revision surgical procedures performed after a hip resurfacing arthroplasty, reconstructions with use of the femoral head, the iliac crest, or autogenous bone from the iliac crest combined with a femoral allograft were performed. After irrigation, the grafts were impacted and the defect was reconstructed layer by layer using a trial acetabular prosthesis and a mallet. In 16 of these 19 reconstructions, a thin Vitallium wire mesh (Mecron) was used to cover the graft. After pressurization of the bone cement, a 32-mm, all-polyethylene cup was inserted. Eleven of the original 25 Müller cups (Sulzer) and 8 of the original 17 Allopro cups (Sulzer) were reviewed. Further details have been described in our previous reports[4,5].

All patients were prospectively followed clinically and radiographically, annually or biennially, for a minimum of 27 years or until revision or death.

As in our prior publications, acetabular defects were classified according to the classification system of the American Academy of Orthopaedic Surgeons (AAOS) Committee on the Hip[6] (Table I). Anteroposterior and lateral radiographs were reviewed for radiographic evidence of graft incorporation[7], osteolysis and radiolucent line formation[8], heterotopic ossification[9], and linear polyethylene wear[10].

At the time of the latest follow-up, all patients with surviving hip implants were evaluated for clinical and

TABLE II Survival Rates for the 3 End Points After Different Periods of Follow-up

End Point for Survivorship of Acetabular Reconstructions	Kaplan-Meier Analysis*				
	10 Years	15 Years	20 Years	25 Years	30 Years
First publication[5]					
Revision for any reason	0.92 (0.84 to 1.00)	0.83 (0.72 to 0.96)	0.80 (0.67 to 0.94)		
Aseptic loosening	0.97 (0.92 to 1.00)	0.94 (0.87 to 1.00)	0.91 (0.80 to 1.00)		
Radiographic loosening	0.92 (0.84 to 1.00)	0.89 (0.80 to 0.99)			
Second publication[4]					
Revision for any reason		0.84 (0.72 to 0.96)	0.73 (0.58 to 0.87)	0.52 (0.35 to 0.72)	
Aseptic loosening		0.94 (0.87 to 1.00)	0.85 (0.72 to 0.97)	0.77 (0.62 to 0.92)	
Radiographic loosening		0.89 (0.80 to 0.99)	0.71 (0.55 to 0.86)	0.62 (0.44 to 0.80)	
Current update					
Revision for any reason				0.50 (0.32 to 0.65)	0.40 (0.23 to 0.56)
Aseptic loosening				0.70 (0.50 to 0.83)	0.56 (0.35 to 0.73)
Radiographic loosening				0.61 (0.42 to 0.75)	0.53 (0.33 to 0.69)

*The values are given as the estimate, with the 95% CI in parentheses.

TABLE III Radiographic Signs at the Time of Revision in the 21 Patients from the Entire Original Cohort Who Underwent Revision of the Acetabular Reconstruction

Case No.	Side*	Defect†	Cup	Follow-up (*yr*)	Reason for Revision	Zones with Radiolucent Lines	Migration	Osteolysis	Radiographic Loosening
3	R	Cavitary	Müller	6.43	Aseptic loosening	1, 2, 3	—	—	Yes
5	L	Cavitary	Müller	19.87	Aseptic loosening	1, 2, 3	—	—	Yes
6	R	Cavitary	Müller	21.32	Wear	—	—	1	No
10	L	Cavitary	Müller	23.17	Wear	1	—	—	No
17	L	Cavitary	Allopro	21.97	Aseptic loosening	—	>5 mm	—	Yes
19	R	Combined	Allopro	14.47	Infection	1, 2, 3	—	—	Yes
20	R	Cavitary	Müller	26.23	Aseptic loosening	—	>5 mm	3	Yes
21	L	Combined	Müller	15.32	Aseptic loosening	—	>5 mm	—	Yes
23	L	Combined	Müller	20.53	Aseptic loosening	1, 2, 3	—	—	Yes
24	L	Cavitary	Allopro	25.40	Aseptic loosening	1, 2, 3	Tilting	—	Yes
26	R	Cavitary	Allopro	20.53	Aseptic loosening	1, 2, 3	>5 mm	—	Yes
27	L	Cavitary	Allopro	22.49	Infection	—	>5 mm	—	Yes
28	L	Cavitary	Müller	3.03	Infection	1, 2, 3	—	—	Yes
30	L	Cavitary	Müller	8.90	Wear	3	—	—	No
32	R	Cavitary	Allopro	18.27	Stem revision	1, 3	—	—	No
34	R	Cavitary	Allopro	18.56	Aseptic loosening	—	>5 mm	—	Yes
36	R	Combined	Müller	21.42	Wear	3	—	3	No
37	L	Combined	Müller	12.33	Stem revision	—	—	—	No
39	L	Combined	Allopro	27.02	Aseptic loosening	3	Tilting	1	Yes
41	L	Combined	Müller	11.65	Aseptic loosening	1, 2, 3	—	—	Yes
42	L	Combined	Allopro	23.53	Aseptic loosening	1, 2, 3	—	—	Yes

*L = left and R = right. †Defect classified according to the AAOS Committee on the Hip.

radiographic review and their Harris hip score and the Oxford Hip Questionnaire Score[11] were again obtained. All patients who died during the follow-up period were followed until their death. Their data, including revisions and radiographic examinations, were included in this report.

Survival analyses were performed for 3 end points: revision of the acetabular component for any reason,

TABLE IV Competing Risk Analysis of Cumulative Proportions of Procedures Revised (1 − KM) Among All Acetabular Reconstructions

	End Point		
	Revision for Any Reason	Aseptic Loosening	Radiographic Loosening
25 years			
1 – KM	0.50 (0.35 to 0.68)	0.30 (0.17 to 0.50)	0.39 (0.25 to 0.58)
Cumulative incidence function	0.44 (0.26 to 0.57)	0.26 (0.10 to 0.39)	0.33 (0.16 to 0.43)
Overestimation	14%	15%	18%
30 years			
1 – KM	0.60 (0.44 to 0.77)	0.44 (0.27 to 0.65)	0.47 (0.31 to 0.67)
Cumulative incidence function	0.51 (0.33 to 0.65)	0.36 (0.17 to 0.51)	0.39 (0.21 to 0.53)
Overestimation	18%	22%	15%

*The values are given as the estimate, with the 95% CI in parentheses.

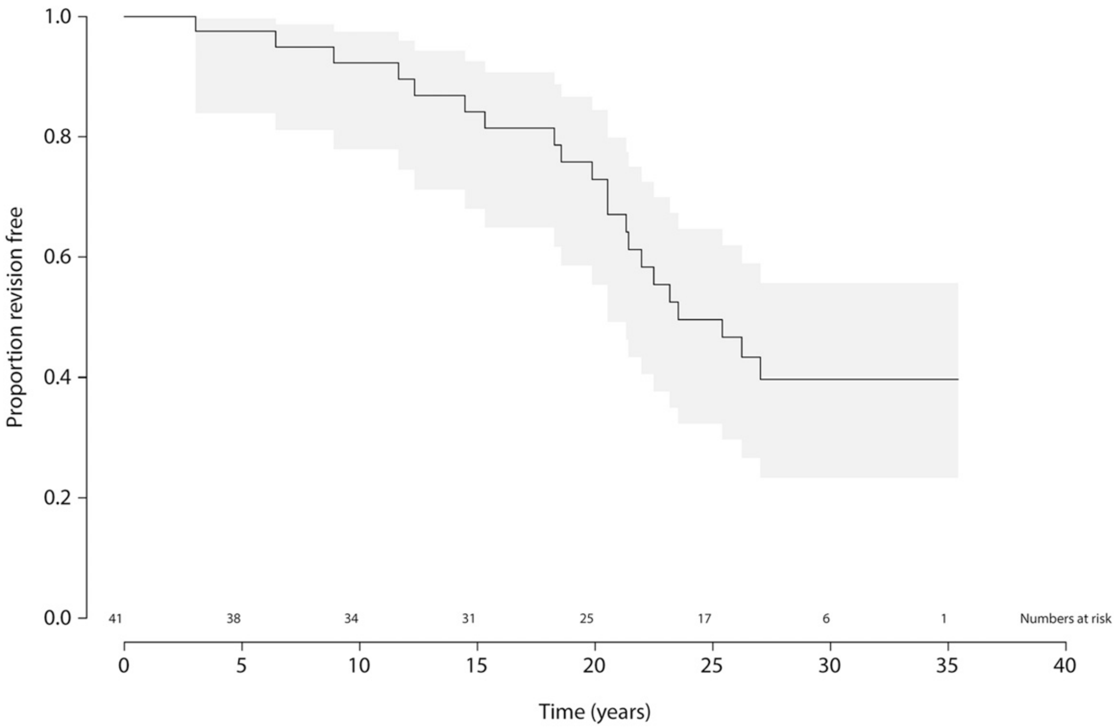

Fig. 1
The Kaplan-Meier survival proportion of the acetabular reconstructions for the end point of revision for any reason.

revision for aseptic loosening, and radiographic failure. The latter was defined as radiolucent lines in all 3 zones defined by DeLee and Charnley[8] or a migration of ≥5 mm in any direction relative to the interteardrop line as seen on the anteroposterior radiograph.

In the presence of a competing risk such as death, the standard Kaplan-Meier method will always overestimate the true revision rate[12-15]. Because of the long-term follow-up and the increasing number of patients who died throughout the study period, we not only calculated Kaplan-Meier survival estimates but also took into account the competing risk of death.

Standard Kaplan-Meier survival analysis was used to estimate the survival percentage for each of the 3 end points. The estimated percentage of procedures revised was calculated as 1 minus the Kaplan-Meier estimate of the survival percentage (1 – KM).

To take into account the competing risk of death, the cumulative incidence function of revisions in the presence of death was used. Analyses were performed for the whole group of reconstructions and were stratified by primary and revision acetabular reconstructions. Log-rank tests were used to test differences between Kaplan-Meier estimates of primary and revision acetabular reconstructions, and Gray (log-rank) tests were used to test differences in cumulative incidence function between groups.

Kaplan-Meier and cumulative incidence function estimates are reported with their 95% CIs. Statistical analyses were performed using R (version 3.2.4; R Foundation) with the packages “rms” and “cmprsk.”[16-18]

Results

Clinical Results

Of the 17 patients (19 reconstructions) who were available for this update report, no patients were lost to follow-up during the current follow-up. Two patients (3 reconstructions) died; none of the deaths was related to the index hip surgical procedure. Five reconstructions in 5 patients were revised after a mean of 24 years (range, 22 to 27 years), leaving 11 surviving hips (11 patients) that were clinically and radiographically evaluated after a mean follow-up period of 30 years (range, 27 to 35 years). All of the patients were able to attend our outpatient clinic for evaluation. The mean Harris hip score of these patients with surviving hips was 88 points (range, 59 to 100 points) and the mean Oxford Hip Questionnaire Score was 20 points (range, 12 to 40 points).

Regarding the entire group of 42 reconstructions in 37 patients, 1 patient (1 reconstruction) has been lost to follow-up prior to the first report and 7 patients (9 reconstructions) have died.

Revisions

Four of 5 revisions presented in this updated review of the acetabular reconstructions were revised for aseptic loosening, which in 1 case occurred a few weeks after a traumatic event. At 22.5 years, 1 additional reconstruction was revised as a result of septic loosening, shown on culture to be due to Staphylococcus. In this update, no additional revisions for wear or osteolysis were performed.

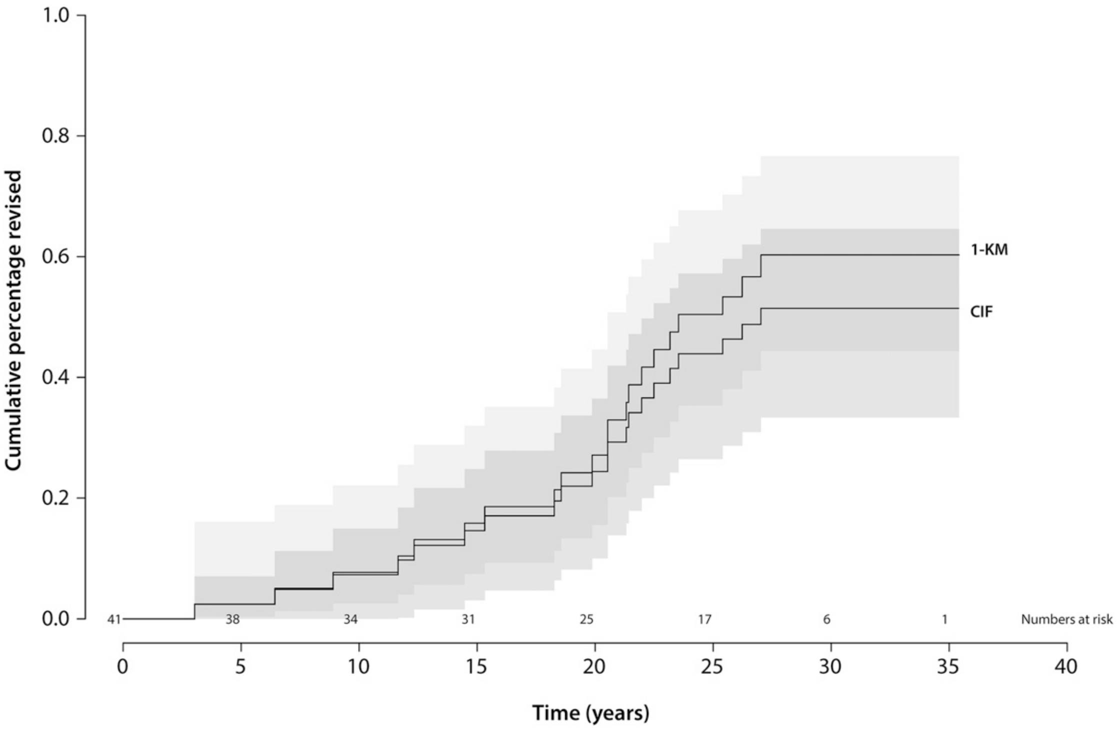

Fig. 2

The cumulative proportion of procedures revised (1 − KM) and the competing risk analysis showing the cumulative incidence function (CIF) for all acetabular reconstructions and their upper and lower 95% CIs with revision of the acetabular component for any reason as the end point.

Revisions in the Entire Original Cohort

Overall, 21 of the 41 acetabular reconstructions in the entire original cohort have been revised for any reason after a minimum follow-up of 27 years. Of these 21 revisions, 12 were performed because of aseptic loosening after a mean follow-up of 19.8 years (range, 6.4 to 27.0 years): 7 originally had a cavitary defect (type-2) and 5 had a combined defect (type-3). Six were primary reconstructions, and 6 were revision reconstructions. Four reconstructions were revised because of wear and osteolysis after a mean follow-up of 18.8 years (range, 8.9 to 23.2 years), showing no intraoperative or radiographic loosening. Three reconstructions were revised because of culture-proven septic loosening after 3, 14.5, and 22.5 years. Another 2 reconstructions had been revised at 12.3 and 18.3 years during a revision of the stem because of persistent instability and matching problems. These 2 reconstructions were both intraoperatively and radiographically well fixed.

Radiographic Results of the Non-Revised Reconstructions

Six of the 11 surviving acetabular reconstructions showed radiolucent lines in 1 or 2 of the Charnley and DeLee zones. All of them were stable and had not shown any progression since the last update in 2011. No osteolysis was seen around these 11 reconstructions. None of the 11 surviving cups showed radiographic loosening. Six reconstructions showed Brooker[9] grade-I periarticular ossifications, 1 showed grade-II ossifications, and 1 showed grade-III ossifications. The mean polyethylene wear for all surviving implants was 2.3 mm (range, 1.2 to 4.2 mm).

We also studied the 9 non-revised reconstructions in the 7 deceased patients. One patient (1 reconstruction) was not able to attend the outpatient clinic in 1 of our previous reports because of dementia over the last years before she died. We used her last available radiograph from 2005. For another 2 deceased patients (3 reconstructions), radiographic data were incomplete. With these limitations, none of the reconstructions was radiographically loose, 2 showed a progressive line in 1 acetabular zone, and 2 showed a nonprogressive radiolucent line in 1 acetabular zone. None showed osteolysis.

Radiographic Results of the Revised Reconstructions

Of the entire original cohort of 21 revised reconstructions, 15 showed definitive radiographic loosening of the cup (Table III). Nine had radiolucent lines in all 3 zones and another 6 had migrated >5 mm. Of the other 6 revised reconstructions, 3 showed radiolucent lines in 1 zone and 1 showed radiolucent lines in 2 zones. Two of them showed osteolysis in 1 zone. The mean polyethylene wear of the revised reconstructions up to the time of the latest follow-up was 2.3 mm (range, 0 to 4.2 mm).

Additional Reoperations and Complications

Since our previous update, 1 additional stem revision was performed in the patients who did not undergo a revision of the acetabular reconstruction. Two other additional stems were revised with a cemented stem at the time of the revision of the acetabular reconstruction.

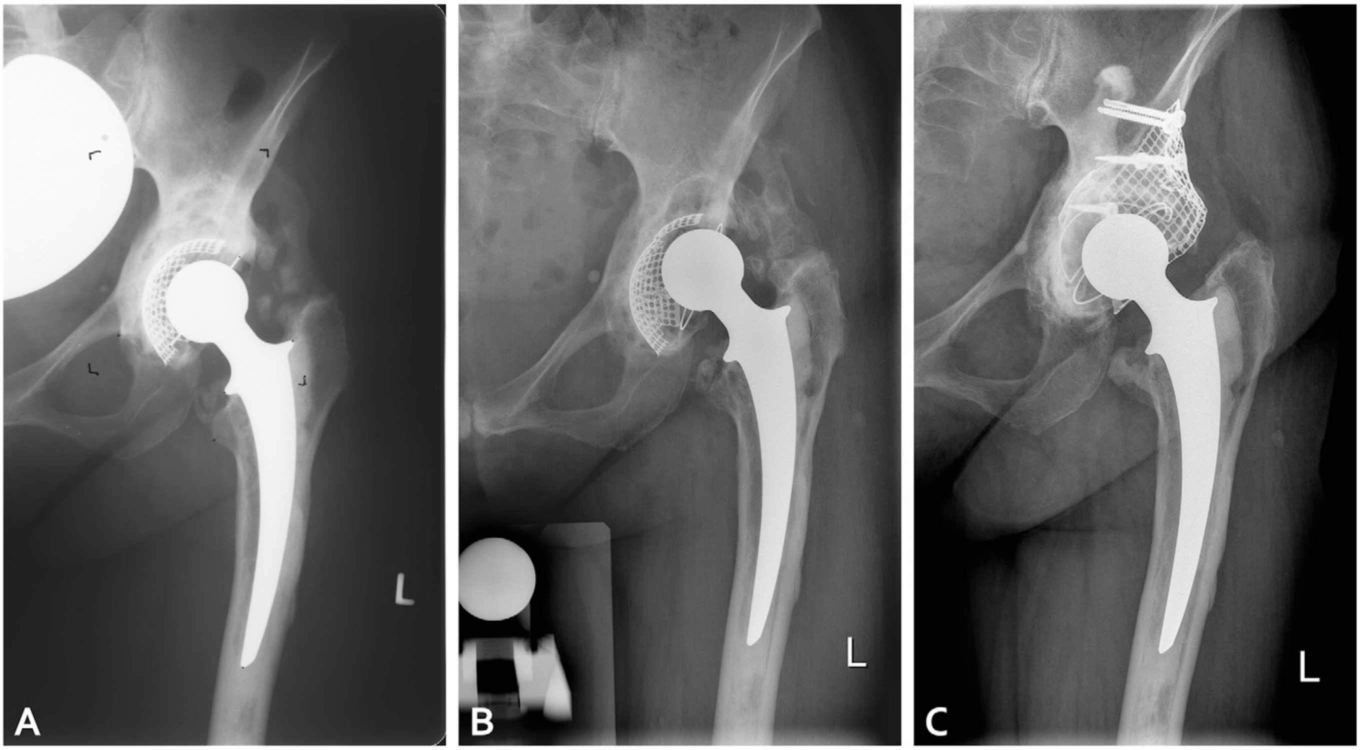

Fig. 3

An example of a female patient who underwent a revision reconstruction at the age of 36 years. At the age of 63 years, her reconstruction was re-revised. **Fig. 3-A** Immediately after the index revision reconstruction in 1985. **Fig. 3-B** Radiograph made before re-revision, showing tilting of the cup in 2011. **Fig. 3-C** The reconstruction that had been re-revised in 2011 was still in situ in 2016.

One of these patients also developed a cerebrovascular accident immediately postoperatively and anticoagulation therapy was started immediately. Symptoms including the paresis of the upper and lower extremities resolved fully within days following the start of anticoagulation therapy.

Survivorship Analysis

The Kaplan-Meier survival of the acetabular reconstruction for the different end points is displayed in Table IV. The Kaplan-Meier survival at 30 years for the end point of revision for any reason was 0.40 (95% CI, 0.23 to 0.56) (Fig. 1), so the cumulative proportion of procedures revised (1 − KM) was 0.60 (95% CI, 0.44 to 0.77). The competing risk analysis at 30 years showed that the cumulative incidence function for revision in the presence of death was 0.51 (95% CI, 0.33 to 0.65) (Table IV). Figure 2 shows that the Kaplan-Meier analysis for revision for any reason after a follow-up of 30 years overestimated revision by 18% because the competing risk of death was not taken into account. The Kaplan-Meier survival at 30 years of the end point of revision for aseptic loosening was 0.56 (95% CI, 0.35 to 0.73), resulting in a cumulative failure incidence (1 − KM) of 0.44. The competing risk analysis at 30 years of the end point of revision for aseptic loosening showed a cumulative failure incidence of 0.36 (95% CI, 0.17 to 0.51).

At the time of the latest review, none of the surviving reconstructions showed complete radiographic loosening. A comparison of survival rates of primary and revision reconstructions did not show any significant differences.

Conclusions

This long-term follow-up study has been conducted to study whether impaction bone-grafting can be used to perform a biological repair of acetabular bone defects and hence facilitate future revisions in younger patients. We still use this acetabular bone impaction technique in complex primary and revision surgical procedures.

Compared with our last update, 5 additional revisions have been performed, of which 3 were already reported to be radiographically loose in our last update. However, the results of 70% survival at 25 years and 56% at 30 years for the end point of revision for aseptic loosening are still acceptable[19] as we used the technique in demanding primary total hip arthroplasties and acetabular revisions. As shown in other studies[13,14,20,21], the Kaplan-Meier estimation ignores death as a competing risk, leading to biased estimates of the probability of revision surgical procedures. In our study, we saw an overestimation of 18% for the end point of revision for any reason at the 30-year follow-up. Interestingly, at the time of the current review, none of the surviving implants were radiographically loose, and therefore no accelerated decline of survival is expected in the future. Furthermore, no osteolysis was seen around these reconstructions, supporting the fact that use of this technique in both primary and revision reconstructions can make these reconstructions last for over 30 years. Another advantage of this technique is that in case of failure of the reconstruction, a cemented cup and impaction bone-grafting can again be used to perform a revision or re-revision (Fig. 3). Technically, this can be perfectly performed as the remaining bone stock after reconstruction with impaction bone-grafting can be used to again perform a reconstruction with cement and impaction bone-grafting.

To our knowledge, there have been few reports on acetabular reconstructions in younger patients, all describing a shorter duration of follow-up than what we report in this current study. Kim et al.[2] reported a 15-year Kaplan-Meier survival rate for the revised acetabular components of 93% using revision or radiographic evidence of implant loosening as the end point. Their data are comparable with our outcome at 15 years. Comba et al.[1] reported a 7-year survival of 30 acetabular revisions in patients younger than 55 years of age, performed with impaction bone-grafting and cemented cups, with need for revisions as the end point, of 89% (95% CI, 71.9% to 96.4%). Lee et al.[3] reported the results of 181 mostly uncemented revisions (109 complete revisions), combined if necessary with use of structural and morselized allografts, after a mean follow-up of 11 years in 102 patients who were ≤50 years of age. Twenty-seven patients were lost to follow-up before a minimum follow-up of 2 years. The 25-year survival for the end point of re-revision for any reason was 33%. To the best of our knowledge, no other studies showing a survival of primary and acetabular reconstructions for >25 years are available.

The results support our philosophy that the technique of impaction bone-grafting can be a reasonable long-term solution in young patients with acetabular bone defects. ■

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