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ORIGINAL PAPER

Cemented total hip arthroplasty revisions in patients of eighty years and older

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Abstract
Purpose It is often a difficult decision whether it is safe to perform revision hip surgery in a patient of 80 years and older. Therefore we evaluated the results of cemented revisions in these elderly patients.
Methods Clinical data, radiographs and complications of 49 consecutive cup and/or stem revisions in 48 patients were prospectively collected. The average age of the patients at surgery was 84 years (range, 80–92). We performed Kaplan-Meier (KM) analysis and also a competing risk (CR) analysis because in this series the presence of a competing event (i.e. death) prevents the occurrence of endpoint rerevision.
Results Twenty-nine patients (30 hips) died without rerevision during follow-up and their data was included. The average follow-up of the 16 surviving patients was eight years (range, six to 13). Six re-operations were performed, of which three were re-revisions. Eight-year survivorship was 91.6 % (95 % confidence interval (CI) 76–97 %) for endpoint re-revision for any reason. With the CR analysis we calculated that due to the increasing number of competing events, the KM analysis overestimates the failure rate with 32 % for this endpoint. The average Harris hip score improved from 49 to 74. Mortality within three months after surgery was 6 %. One postoperative fracture occurred and six hips dislocated.
Conclusion Cemented revisions can provide satisfying results in patient of 80 years and older with acceptable survivorship and complication rates.

Keywords Revision total hip arthroplasty · Cemented · Elderly · 80 years and older · Clinical outcome · Complications · Kaplan-Meier survival analysis · Radiographic analysis

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Introduction

When failure of a total hip arthroplasty (THA) occurs in a patient of 80 years or older, it is often a difficult decision whether or not it is safe to perform revision surgery. Revision total hip arthroplasty in the elderly has been shown to have functional outcomes comparable with those in younger patients, but the prevalence of complications has been reported to be higher [1–5]. However, these available studies describe the outcome of revisions performed mainly during the 1990s or earlier [1, 3–5], after an average follow-up of less than five years [2, 4, 5], and with heterogeneous groups of cemented and uncemented components used [1, 2, 5].

The aim of this study was to report the mid-term clinical and radiographic outcome and intra- and postoperative complications of 49 consecutive revision procedures all performed with a third generation cementing technique in 48 patients of 80 years and older.

Materials and methods

Forty-nine consecutive cemented revisions in 48 patients of 80 years and older were performed in our university medical center with high-end intensive care facilities between April 1997 and December 2007. This study was approved by our institutional review board and all data were collected prospectively. Patients in which revision surgery was performed for oncological reasons were excluded.

Thirty-four women and 14 men were included with an average age of 84 years (range, 80–92). The average body mass index was 26 kg/m² (range, 18–44). In 24 operations the patient had an American Society of Anesthesiologists (ASA) grade two and in 25 operations grade three. The main revision indications were aseptic loosening in 27 hips, recurrent dislocation in eight and septic loosening in five. Twenty-seven procedures were on the right side. Revision of only the stem of a THA was performed in eight hips, of only the cup in 13 and revision of both components was performed in 16 hips. Eleven revisions were a conversion of a hemiarthroplasty to a THA with exchange of the stem and one resurfacing prosthesis was converted to a THA; this hip was included in the study as an acetabular revision as the inserted stem was considered a primary component. The 11 cups that were inserted during the conversion of a hemiarthroplasty were also primary components and therefore not analysed. So, in total 30 acetabular and 35 femoral cemented revision components were analysed in this study (see Fig. 1). All individual patient characteristics are presented in Table 1.

All operations were performed through the posterolateral approach by two of the authors (JWMG, BWS). Both are experienced hip revision surgeons. A third generation cementing technique was used in all hips with Surgical Simplex (Stryker Howmedica-Osteonics, Newbury, United Kingdom) antibiotic-loaded bone cement. Impaction bone grafting (IBG) was used to reconstruct bone stock deficiencies in 19 acetabuli and 15 femora. The IBG technique has been described in detail before [6, 7].

The postoperative regimen included administration of systemic antibiotics (three intravenous doses of 1 g of cefazolin) for one day. All patients received anticoagulation therapy for at least six weeks. All five hips with septic loosening were treated with a two-stage procedure, with administration of systemic antibiotics appropriate to the infecting organism for at least six weeks prior to reimplantation.

Patients were mobilized one or two days after surgery using two crutches and full weight-bearing was immediately allowed. This protocol was adapted when IBG was performed depending on the type and extent of the defect and reconstruction.

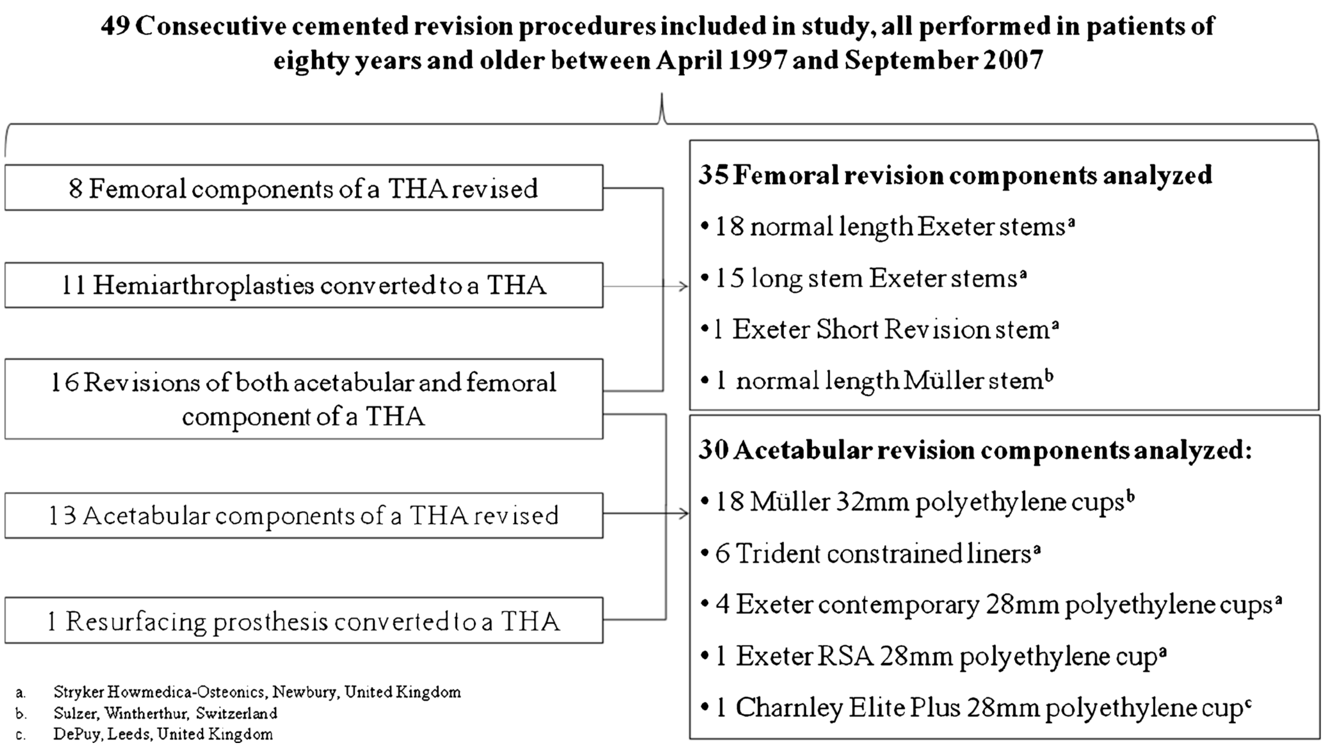


Fig. 1 All acetabular and femoral components analysed in this study

Table 1 Characteristics of the 49 cemented revisions in 48 patients

Patient number	Gender	Age (years)	ASA-grade	Indication	Type of revision	IBG (Y/N)	Follow-up (years)	Died during study (Y/N)	Course (reoperation / rerevision)
1	F	80.4	2	Aseptic loosening	Acetabular component	Y	12.47	Y	
2	F	81.5	3	Aseptic loosening	Acetabular component	N	3.02	Y	
3	F	81.3	2	Aseptic loosening	Acetabular component	Y	9.90	Y	
4	F	83.2	3	Aseptic loosening	Acetabular component	Y	0.67	Y	
5	F	87.1	3	Aseptic loosening	Acetabular component	Y	1.94	Y	
6	F	83.9	3	Aseptic loosening	Acetabular component	Y	2.61	Y	
7	F	90.6	2	Recurrent dislocations	Acetabular component	N	4.94	Y	
8	F	85.6	2	Recurrent dislocations	Acetabular component	N	8.98	N	
9	M	80.7	2	Recurrent dislocations	Acetabular component	N	7.64	N	
10	M	82.5	2	Recurrent dislocations	Acetabular component	N	7.68	N	
11	F	80.9	3	Recurrent dislocations	Acetabular component	N	2.87	N	Rerevision
12	M	82.2	2	Fractured, loose acetabular component	Acetabular component	Y	5.75	Y	Rerevision
13	F	82.3	3	Subluxation + wear acetabular component	Acetabular component	Y	4.85	Y	Reoperation
14	F	83.0	2	Aseptic loosening	Femoral component	Y	5.46	N	
15	M	83.2	3	Aseptic loosening	Femoral component	N	6.00	Y	
16	M	82.2	2	Aseptic loosening	Femoral component	Y	8.20	N	
17	M	85.3	3	Aseptic loosening	Femoral component	N	0.25	Y	
18	F	86.3	2	Aseptic loosening	Femoral component	Y	3.39	Y	
19	F	87.2	3	Recurrent dislocations	Femoral component	N	8.66	N	Reoperation
20	F	82.1	3	Recurrent dislocations	Femoral component	N	6.83	Y	
21	F	84.4	3	Femoral periprosthetic fracture	Femoral component	N	0.00	Y	
22	M	85.0	2	Aseptic loosening	Conversion hemiarthroplasty to THA	N	9.13	Y	
23	F	80.3	2	Septic loosening	Conversion hemiarthroplasty to THA	Y	11.66	Y	
24	M	84.1	3	Aseptic loosening	Conversion hemiarthroplasty to THA	Y	4.30	Y	
25	F	84.7	2	Aseptic loosening	Conversion hemiarthroplasty to THA	Y	4.80	Y	
26	F	83.6	2	Aseptic loosening	Conversion hemiarthroplasty to THA	Y	6.62	N	
27	F	92.8	2	Aseptic loosening	Conversion hemiarthroplasty to THA	N	6.86	N	
28	F	81.6	3	Aseptic loosening	Conversion hemiarthroplasty to THA	Y	4.81	Y	Reoperation
29	F	86.3	3	Protrusio acetabuli	Conversion hemiarthroplasty to THA	Y	10.80	N	
30	F	84.1	2	Subluxation hemiarthroplasty	Conversion hemiarthroplasty to THA	Y	6.57	Y	
31	F	84.1	2	Subluxation hemiarthroplasty	Conversion hemiarthroplasty to THA	Y	8.55	N	
32	F	85.9	3	Protrusio acetabuli	Conversion hemiarthroplasty to THA	N	0.04	Y	
33	F	81.0	3	Septic loosening	THA	N	8.55	Y	
34	M	84.7	2	Septic loosening	THA	N	6.84	N	
35	M	83.0	2	Septic loosening	THA	N	5.72	N	
36	F	83.1	2	Aseptic loosening	THA	Y	8.91	Y	
37	F	81.9	2	Aseptic loosening	THA	Y	11.70	N	
38	M	81.6	3	Aseptic loosening	THA	Y	5.86	Y	
39	F	85.4	3	Aseptic loosening	THA	Y	6.00	Y	

Table 1 (continued)

Patient number	Gender	Age (years)	ASA-grade	Indication	Type of revision	IBG (Y/N)	Follow-up (years)	Died during study (Y/N)	Course (reoperation / rerevision)
40	M	87.3	2	Aseptic loosening	THA	Y	7.82	N	
41	F	86.2	2	Aseptic loosening	THA	Y	0.04	Y	
42	M	81.1	3	Aseptic loosening	THA	Y	1.51	Y	
43	F	83.0	3	Aseptic loosening	THA	N	12.66	N	
44	M	80.8	3	Aseptic loosening	THA	Y	7.47	Y	
45	F	83.0	3	Aseptic loosening	THA	Y	5.53	N	
46	F	81.8	3	Recurrent dislocations	THA	Y	0.80	Y	Rerevision
47	M	88.0	3	Femoral periprosthetic fracture	THA	N	4.05	Y	
48	F	82.6	2	Aseptic loosening + periprosthetic fracture	THA	Y	9.66	Y	
49	F	85.0	3	Septic loosening	Conversion resurfacing arthroplasty to THA	Y	4.34	Y	

F female, *M* male, *ASA* American Society of Anesthesiologists, *THA* total hip arthroplasty, *IBG* impaction bone grafting, *Y* yes, *N* no

Follow-up protocol A standard postoperative follow-up protocol was used, with physical and radiographic examination after six weeks, three months, six months, one year and afterwards on an annual or biennially basis.

Clinical evaluation Clinical evaluation was performed by an independent research assistant using the Harris hip score (HHS: worst score 0, best score 100) [8], the Oxford hip score (OHS; worst score 12, best score 48) [9] and visual analogue scales (VAS) [10]. VAS scores were determined for pain at rest and during physical activity (no pain 0; unbearable pain 100) and for satisfaction (not satisfied at all 0; complete satisfaction 100). All these scores were determined during the postoperative follow-up, and the HHS and OHS were also determined pre-operatively.

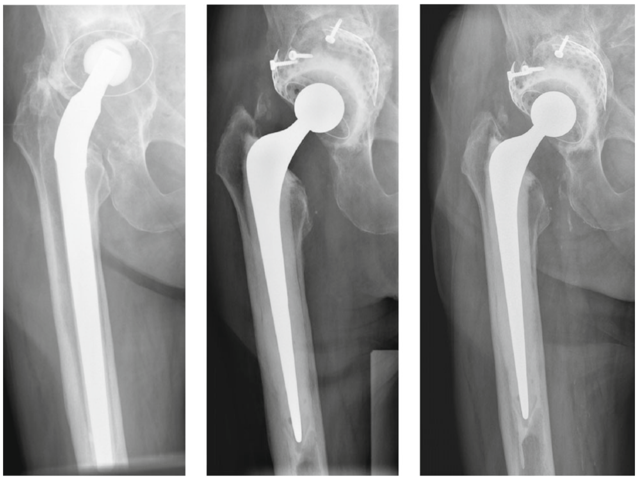
Radiographic evaluation The latest pre-operative and all postoperative anteroposterior radiographs were analysed by three of the authors (MAJTS, SAG, BWS). The pre-operative radiographs were used to determine femoral and acetabular bone stock loss using, respectively, the Endoklinik [11] and American Academy of Orthopaedic Surgeons (AAOS) classifications [12]. The Endoklinik grade was I in 11 hips, II in ten hips, III in 12 hips and IV in two hips. Acetabular bone stock deficiencies AAOS type II were present in six hips and type III were present in 18 hips. Acetabular bone defects were absent in six hips.

All postoperative radiographs were assessed for radiolucent lines according to DeLee & Charnley [13] for the acetabular side and Gruen et al. [14] for the femoral side. When radiolucent lines≥2 mm wide were present in all three acetabular or seven femoral zones, component migration was≥5 mm and/or tilting was≥5 degrees, the component was considered radiographically loose. If bone graft was used, trabecular incorporation was evaluated by the criteria described by Conn et al. [15].

Statistical analysis We calculated the probability of the endpoints rerevision for any reason, re-revision for aseptic loosening and reoperation for any reason in time using the cumulative incidence estimator in a competing risk setting [16, 17]. Accounting for competing risks is necessary because for each endpoint specific competing events can occur, which prevent the occurrence of the endpoint of interest. For the endpoints re-operation for any reason and revision for any reason, we considered the death of the patient as a competing event, as the probability of undergoing a re-operation or a revision for any reason becomes 0 when a patient is deceased. For the endpoint revision for aseptic loosening, we considered both the death of a patient and the revision of the implant for any other reason besides aseptic loosening as competing events, as both events prevent the occurrence of revision for aseptic loosening for that specific implant. In order to allow comparison with the current literature, we have also performed a Kaplan-Meier survival analysis and presented the results as cumulative incidences of the event of interest (i.e. 1 – survival). Additionally, we calculated the amount of bias, which was introduced by the Kaplan-Meier survival analysis by ignoring the presence of the competing risks. All analyses have been performed using the mstate library [18, 19] in R [20].

Results

At final review, all 16 surviving patients were clinically and radiographically evaluated after an average follow-up



a b c

Fig. 2 Radiographs of a revision in which meshes and impaction bone grafting were used. The patient was 87 years old at time of surgery. **a** Preoperative anteroposterior radiograph of an uncemented total hip arthroplasty with aseptic loosening and extensive bone loss of the acetabulum and femur. **b** Anteroposterior radiograph two months after the revision total hip arthroplasty. First, the extensive acetabular defects were reconstructed with a medial and superolateral rim mesh to create contained defects. After that, acetabular impaction bone grafting was performed with three morselized allograft femoral heads. Because the patient already lost three liters of blood at the time of the surgery and was 88 years old, it was decided to cement the new femoral component without performing impaction bone grafting to replenish the bone stock loss in the femoral cavity. **c** Anteroposterior radiograph after eight years follow-up. The patient is 95 years old. Both the acetabular and femoral component are totally stable, and on the acetabular side complete incorporation of the graft took place

of eight years (range, six to 13). The remaining patients died (29 patients with 30 hips) or had a rerevision (three patients with three hips) during follow-up; data of these patients were evaluated until their latest follow-up. No patients were lost to follow-up.

The average pre-operative HHS was 49 (range, 24–74) and improved to 74 (range, 34–100) at final review. Pre-operative OHS score was 22 (range, 13–29) and improved to 34 (range, 19–48). The average postoperative VAS score in the rest was 5 (range, 0–55), during activity 4 (range, 0–40) and the average VAS score for satisfaction at final review was 76 (range, 15–100).

Intra-operative complications Two intra-operative femoral fractures occurred—one during performance of a transfemoral Wagner osteotomy for removal of a cemented stem and the other during leg rotation when the stability of the reconstruction was tested. Both were successfully treated with plate fixation.

Postoperative mortality Three patients (three hips) died within three months after revision. The first patient (patient (Pt.) 21 in Table 1) had an intra-operative cardiac arrest. She was successfully resuscitated, but died despite adequate treatment on the first postoperative day. The second patient (Pt. 32) developed myocardial infarction intra-operative. Thirteen days postoperative the patient died due to cardiac failure. The third patient (No. 41) died due to an acute cerebrovascular accident two weeks postoperative. Twenty-nine other patients died during follow-up due to reasons not related to the revision surgery.

Re-revisions Three re-revisions were performed. In the first hip (Pt. 11) during the index revision a Trident constrained cup was inserted for dislocations. Unfortunately, three years postoperative a traumatic cup loosening occurred after a fall. During the re-revision a new constrained cup was placed successfully. In the second hip (Pt. 12) another IBG cup re-revision was performed six years postoperative for aseptic loosening.

In the third hip (Pt. 46), in which the index revision was performed for dislocations, five new dislocations occurred within the first ten postoperative months. Therefore the stem was recemented 1.5 cm higher with a cement-in-cement technique. Unfortunately the dislocations continued to occur till the patient died four years later. None of the primary placed components were revised during follow-up.

Re-operations Three other re-operations were performed. In the first hip (Pt. 13) an infection was suspected and debridement was performed 20 days postoperative. The

Table 2 Probability of survival for different periods of follow-up and end points

End point	Five-year survival (95 % CI)	Number	Eight-year survival (95 % CI)	Number	Ten-year survival (95 % CI)	Number
Re-revision for any reason (failures=3)	95.3 % (82–99 %)	30	91.6 % (76–97 %)	13	91.6 % (76–97 %)	5
Re-revision for aseptic loosening (failures=1)	100 %	30	96.2 % (76–99 %)	13	96.2 % (76–99 %)	5
Re-operation any reason (failures=6)	90.8 % (77–96 %)	30	84.3 % (68–93 %)	12	84.3 % (68–93 %)	5

CI confidence interval

intra-operative cultures ultimately were negative. The patient functioned well till she died five years later. In the second hip (Pt. 19) the dislocations, which were the indication for the index femoral revision, continued to occur so it was decided to ream the well-fixed polyethylene cup out of the existing cement mantle and place a Trident constrained cup with a cement-in-cement technique. This successfully prevented further dislocations. In the third hip (Pt. 28) a periprosthetic fracture Vancouver type B1 occurred after a fall 17 months postoperative. The fracture was treated with plate fixation and the patient functioned well until she died almost five years postoperative.

Other postoperative complications No postoperative joint infections occurred. Six hips dislocated, four were successfully treated non-operatively and in two a re-operation was performed as mentioned before. One patient had a postoperative myocardial infarction and three other patients suffered from cardiac decompensation. All were successfully treated. Five patients suffered from a urinary tract infection and two patients developed decubitus. One patient had a pneumonia and one developed a delirium.

Radiographic evaluation In 38 hips the radiographic follow up was complete (78 %), and in 11 hips some radiographs during follow-up were missing (22 %). Nevertheless, we could include these patients in the analysis.

At final review, a radiolucent line was seen around two cups in DeLee zone three. Cranial migration of ≥ 5 mm was observed before re-revision in the two failed cups. In the acetabuli reconstructed with IBG, 39 of the 43 zones showed trabecular incorporation (91 %).

On the femoral side, radiolucent lines were observed around ten stems. These were situated in four hips in one Gruen zone; in three hips in two, in two in three and in one hip in five zones. One stem subsided≥5 mm (23 mm) due to insufficient pressurizing as a result of a distal intra-operative cortical defect with considerable cement leakage. The average subsidence was 2 mm (range, 0–23 mm). In the femora reconstructed with IBG, 76 of the 87 zones showed trabecular incorporation (87 %). See Fig. 2 for a radiographic example.

Survival analysis The KM survivorship at eight years for endpoint rerevision for any reason was 91.6 % (95 % CI 76–97), for rerevision for aseptic loosening 96.2 % (95 % CI 76–99) and for reoperation for any reason 84.3 % (95 % CI 68–93 %). The cumulative KM failure incidences for these endpoints (1–*KM*) were respectively 8.38 %, 3.85 % and 15.72 %. In contrast, when we performed the CR analysis, the cumulative failure incidences for both endpoints were respectively 6.35 %, 2.27 % and 12.48 %. This means that the KM analysis overestimates the failure rate with 32 % ((8.38–6.35)/6.35) for endpoint rerevision for any reason, with 70 % ((3.85–2.27)/2.27)

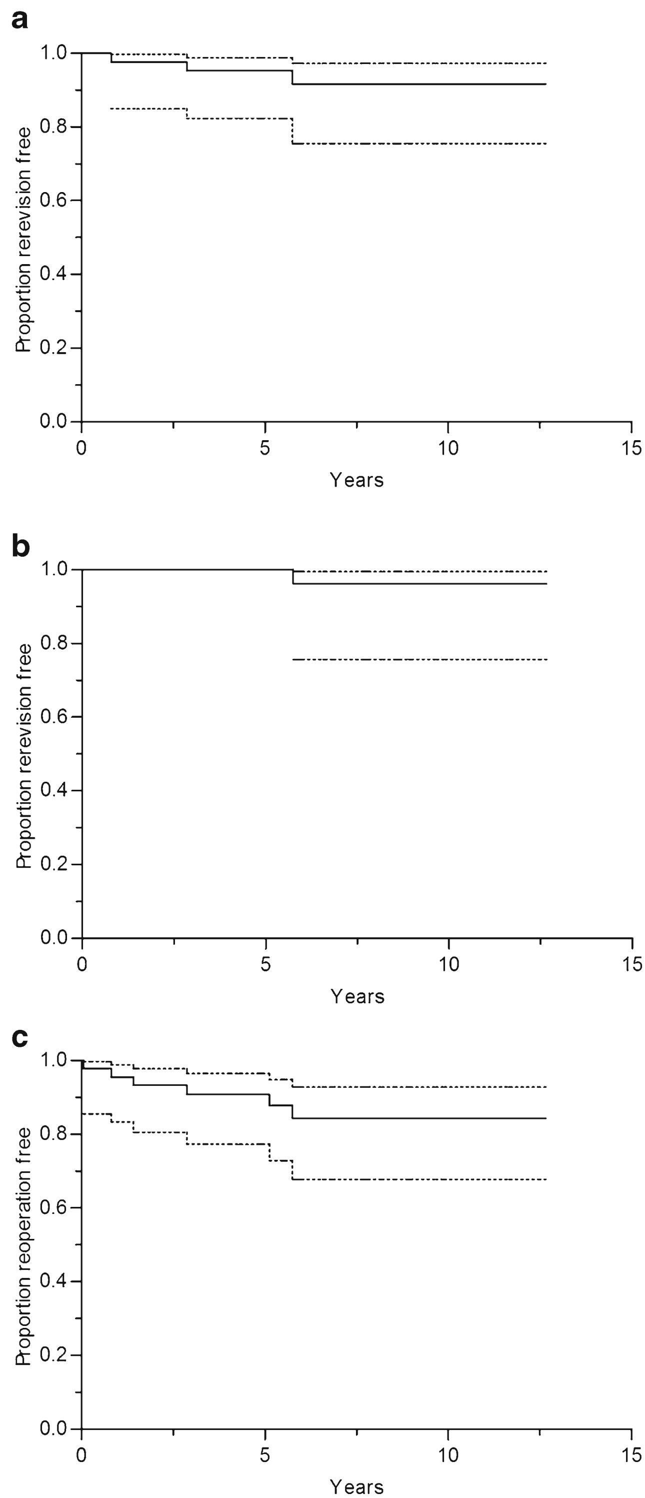
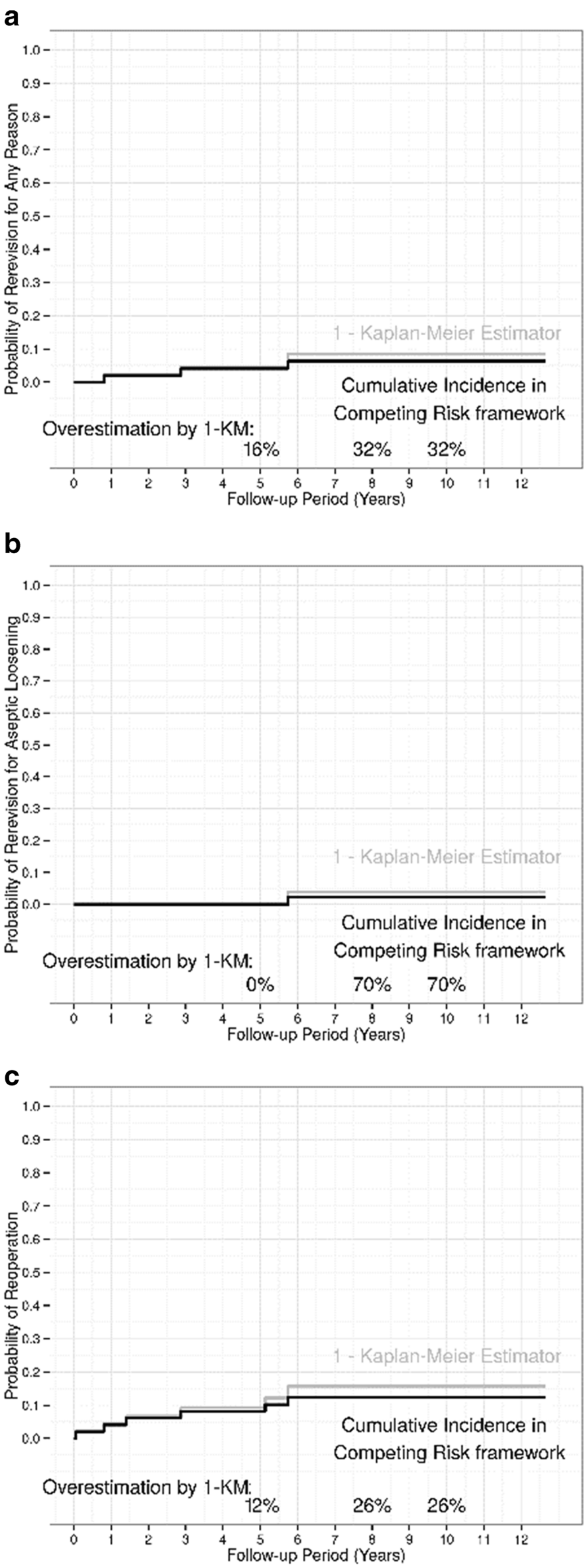


Fig. 3 Kaplan-Meier survival curves showing the probability of revision component survival for endpoints re-revision for any reason (**a**), re-revision for aseptic loosening (**b**) and re-operation for any reason (**c**). The 95 % confidence intervals are included



◀ **Fig. 4** Comparison of the cumulative incidence for endpoint re-revision surgery for any reason (**a**), re-revision for aseptic loosening (**b**) and re-operation for any reason (**c**) calculated with both the Kaplan-Meier estimator and the competing risks method. The discrepancy between the lines represents the bias, which is introduced by erroneous usage of the Kaplan-Meier analysis

for endpoint rerevision for aseptic loosening, and with 26 % ((15.72–12.48)/12.48) for endpoint reoperation for any reason. Survivorship for all endpoints at five and ten years is presented in Table 2, the KM curves are shown in Fig. 3 and overestimation of failure by KM analysis compared to CR analysis is shown in Fig. 4.

Discussion

This study shows that the results of revision total hip arthroplasties performed with a third-generation cementing technique are satisfying in patients of 80 years and older. The five-year Kaplan–Meier survivorship for endpoint re-revision for any reason was 95.2 % (95 % CI 82–99 %) and the ten-year survivorship was 91.6 % (95 % CI 76–97 %). Parvizi et al. showed comparable outcomes for 170 uncemented revisions in a rewarding case-control study with a one year survival rate of 95 % and a five-year survival rate of 92 % [3].

When compared to other studies our re-revision percentage of 6 % is acceptable. Strehle et al. reported a percentage of 5.6 % at an average follow-up of 4.0 years [5], and Parvizi 7.6 % at an average follow-up of 6.8 years [3]. All these re-revision rates are low compared to the 13.5 % in the control group of patients younger than 70 years presented in the case-control study by Parvizi et al. [3]. An explanation for this could be that younger patients have higher activity levels and therefore use their revision prosthesis more intensively, which could lead to earlier failure. In addition to this, older patients have a shorter life expectancy, so it is plausible that death occurs earlier than prosthesis failure. The three months postoperative mortality in our study group was 6 %, which is comparable to the 4.8 % found in the study of Lübbeke et al. [2] and the 5.7 % reported by Strehle et al. [5], while Parzivi reported a three-month mortality of 2.9 %.

The most common postoperative complication in our study was dislocation, which occurred in six hips (12 %). Previous studies have shown before that dislocations occur more often at high ages [2, 4, 5]. However, the study by Parvizi et al. [3] showed less postoperative dislocations in the 170 revisions in octogenerians compared to their younger control group (2.4 % versus 9.4 %). They stated that this could be due to the more frequent use of constrained liners in their elderly group. Also, Lübbeke et al. [2] observed a downward trend in the dislocation rate throughout the years their study was conducted, and they also concluded that this might be related to the introduction of a double-mobility cup in their institution (20.3 % in the first part of the study versus 0 % in the second part). In our institution we started to insert constrained liners for recurrent dislocating hips in 2004. In this present study six constrained liners were placed, all successfully treating the recurrent dislocations.

Pain relief is the main reason in the elderly patients to perform revision of a failed hip arthroplasty [4]. The average post-operative VAS pain scores in our study group were 5 in rest and 4 during activity on a scale of 0 to 100. Despite the fact that we did not have any preoperative VAS scores to compare with, we think it is reasonable to conclude that revision surgery in our study was effective in relieving pain in these elderly patients.

Although the number of patients in our group is not extensive, we think our data are significant. We present a homogenous group of cemented revisions after a mean follow-up of eight years, all our data were collected prospectively and no patients were lost to follow-up.

A limitation of this study is that due to the very high average age of the patients at time of the revision a large number of patients (65 %) was deceased at last review. However, all data of these patients was reviewed until the time of their death and included in this study. We also did not provide a younger control group of cemented revisions.

The Kaplan-Meier analysis is a valid method to estimate component survival when no competing events have occurred. However, it is better to use competing risk analysis whenever competing risks are present, because the use of the KM estimator then will introduce bias [16, 17]. The resulting bias is greater when the "competition" is heavier, i.e. when the hazard of the competing events is larger. In this study, we showed that because of the high number of competing events, the KM analysis overestimates the failure rate with 32 % for endpoint rerevision for any reason and with 26 % for endpoint re-operation for any reason. For endpoint rerevision for aseptic loosening the overestimation is 70 % because there are more competing events (i.e. the re-revisions for other reasons than aseptic failure).

In conclusion, this study shows that cemented total hip arthroplasty can provide satisfying results in patients of 80 years and older with acceptable survival outcomes and complication rates. Nevertheless, revision surgery in this elderly group can be very complex and the patients are in general very fragile. Therefore each patient deserves extensive consideration of all options including non-surgical treatment and, when surgery is necessary, an individual surgical treatment strategy.

Conflict of interest No conflicts of interest are declared.

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