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Migration of uncemented, long-stem femoral components in revision hip arthroplasty

A 2–8 year clinical follow-up of 45 cases and radiostereometric analysis of 13 cases

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We reviewed after 48 (24–90) months the clinical results in 45 cases of revision hip arthroplasties where an uncemented, long-stem femoral prosthesis (BIAS®, Zimmer) had been used. A subgroup of 13 cases was followed with radiostereometric analysis (RSA) for 2 years. 3/45 cases had been rerevised, another 12 had unsatisfactory pain scores. The median Harris score was 69 (26–99). 12/13 stems migrated; 11 subsided 4.1 (0.4–7.9) mm, and 8 migrated posteriorly 2.9 (1.9–9.6) mm.

The poor clinical results and large migrations speak against the use of this prosthesis in revision hip arthroplasty.

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Loosening of the femoral component in cemented revision hip arthroplasty has been reported in 23–44 percent of cases after 4–6 years (Kavanagh et al. 1985, Strömberg et al. 1988, Kershaw et al. 1991). These high failure rates have been attributed to poor cement-bone interdigitation at the smooth endosteal surface of the femur, following cement removal. Various revision prostheses, designed for fixation without cement, have been developed with the aim of bone restoration. Between 1987 and 1992 we used the BIAS® (Zimmer) femoral prosthesis in revision cases with marked femoral endosteal bone loss or in cases with a femoral fracture involving the femoral component.

When evaluating the early results of this prosthesis in revision cases, we examined serial plain radiographs with the aim of measuring subsidence and varus-valgus migration. However, the accuracy of this technique was, indeed, poor due to the poorly defined radiographic landmarks of a femur distorted by a loosened prosthesis and a revision procedure. Therefore, in 1989 we started prospectively to evaluate our prostheses with the aid of radiostereometric analysis (RSA). We report clinical follow-up findings in 45 cases, including RSA in 13 cases.

Patients and methods

During 1987–1992, we performed 260 revision hip arthroplasties with exchange of the femoral component; in 45 of these the BIAS prosthesis was used. There were 43 patients (2 had bilateral revisions); 24 men and 19 women with a median age of 67 (37–91) years and median weight of 75 (52–108) kg. Previously, 14 and 6 hips had been revised once and twice, respectively. The median time from the primary arthroplasty to the present revision was 10 (3–19) years. The index diagnosis was arthrosis in 32 hips (Table 1). All cases had had a cemented femoral component. There was no case of infection; cultures from biopsies were taken at the revision according to the Kamme and Lindberg (1981) technique.

Preoperative femoral bone loss was classified with the 4-grade scale of Gustilo and Pasternak (1988); grade I implies a thinning of the proximal cortices of less than 50 percent, grade II a thinning of more than 50 percent and grade III a posteromedial wall defect involving the lesser trochanter. The circumferential

Table 1. Index diagnosis in the 45 hips revised with a BIAS prosthesis

	n
Arthrosis	32
Segmental collapse secondary to hip fracture	4
Rheumatoid arthritis	3
Childhood disease	3
CDH	2
Avascular necrosis	1

Figure 1. The BIAS prosthesis.

wall is intact for both grades I and II. 9 cases were of grade I, 24 grade II and 12 grade III.

The design of the BIAS prosthesis includes a rectangular shape in its proximal cross-section and a long antecurvated stem that is fluted in the distal part. The core is made of Tivanium® and the proximal body is covered anteriorly and posteriorly with pads of pure titanium mesh with a fiber diameter of 0.25 mm and an average pore size of 0.4 mm. The prosthesis is obtainable in 12 incremental sizes, varying in length from 176 mm to 241 mm, and with exchangeable heads with 3 options for the neck length (Figure 1).

The patients were operated on in a clean air enclosure, using the transtrochanteric and transgluteal approaches in 32 and 13 hips, respectively. The proximal femur was prepared with corresponding rasps for stem size, and the femoral canal was over-reamed by 1–2 mm as compared with the diameter of the chosen femoral component. The prostheses were hammered down gently but, nevertheless, a femoral diaphyseal fracture occurred in 6 cases. These fractures were explored and fixed with cerclage wires. In case 7 (RSA-series) a midshaft femoral osteotomy was performed because of severe femoral bowing. The operative technique did not include instrumented testing of the bone-implant stability. Cancellous chip grafts, either autologous from the iliac crest in 17 cases, or in combination with allograft chips in 6 cases, were introduced into the femoral bone deficiencies during the implantation of the prostheses. Impaction technique was not used.

On the acetabular side, an uncemented Harris-Galante socket was used in 22 cases, a cemented Charnley socket in 8 cases and an uncemented, threaded socket (Ceraver) in 1 case. Structural allografts were used in two cases in the acetabulum. The patients were mobilized with crutches immediately postoperatively, without weight bearing during the first 3 months, and followed by partial weight bearing for another 3 months. Bracing was not used.

During 1989 and 1991, in 16 consecutive revisions using the BIAS prosthesis, 5–9 tantalum markers (0.8 mm diameter) were inserted in the proximal femur for subsequent radiostereometric analysis (RSA) with the uniplanar technique (Selvik 1974, Kärrholm 1989). The patients were examined in the supine position within 10 days postoperatively, and then again at 3, 12, and 24 months. Migration of the prosthesis was determined as the displacement of the center of the prosthetic head in relation to the femur. The accuracy of RSA in this application was calculated with 99 percent confidence intervals (Table 2) from one double examination of each hip (Mjöberg 1986). 3 hips were excluded due to improper spacing and/or instability of the markers, leaving 13 hips in the 12 patients comprising the RSA-subgroup (Table 3).

Follow-up was done at a median of 48 (24–90) months with respect to whether the prosthesis was still in situ or not, and whether signs of loosening of the acetabular component were present or not. The Harris (1969) hip score was used for clinical assessment. 1 patient died, but a Harris score was available in the patient's chart, and this patient is also included in the follow-up.

In the RSA-series, prosthetic fill was evaluated from standard postoperative anteroposterior hip radiographs using a digitizing procedure (Analyze®, Biomedical Imaging Resource, Mayo Clinic, Rochester, U.S.A.). Fill was defined as the percentage of the femoral canal surface occupied by the prosthesis, and was evaluated in one upper and one lower region of the prosthesis, delimited by the transition from the smooth to the fluted part of the prosthesis (Figure 1). For technical reasons, the upper region in case 4 (Table 3) could not be evaluated.

Table 2. 99 percent confidence limits for significant motions

Direction	
Proximal-distal	± 0.3 mm
Medial-lateral	± 0.5 mm
Anterior-posterior	± 0.8 mm

Table 3. Data on the subgroup of 13 hips followed by radiostereometry for 2 years

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	64	F	67	OA	11	1	Fx	II	87	66	20	47	–1.5	–6.7	–9.6
2	72	M	108	OA	8	0		II	90	82	40	92	1.6	–4.1	–1.9
3	75	M	84	OA	11	0		I	86	88	40	87	1.1	–0.4	–2.0
4	64	M	100	OA	12	1	Fx	I		83	20	55	0.5	–1.0	1.0
5	67	M	92	OA	10	0		II	74	84	30	60	1.5	–1.9	–2.5
6	67	M	92	OA	9	0		II	77	96	30	60	–0.2	–1.3	1.5
7	79	M	70	OA	13	1		II	87	96	30	62	4.1	–6.0	–6.9
8	76	M	70	OA	14	0		II	76	82	40	80	3.6	–4.9	–3.2
9	73	M	81	OA	10	0		II	73	86	44	97	0.5	–3.1	–0.5
10	71	M	75	OA	5	0		I	76	96	40	71	2.4	–6.0	–2.7
11	67	M	66	RA	9	0		II	88	75	44	83	–2.0	0.0	0.0
12	67	M	75	OA	15	1	Fx	II	80	81	40	74	0.9	–7.9	–8.5
13	59	M	80	HF	19	1		II	67	97	40	76	0.1	0.0	–0.2

A Case number
B Age at revision
C Gender
D Weight, kg
E Index diagnosis
  OA arthrosis
  RA rheumatoid arthritis
  HF hip fracture
F Number of years between the primary arthroplasty and revision
G Number of previous revisions
H Fx peroperative femoral shaft fracture
I Preoperative bone defects according to Gustilo and Pasternak
J Prosthetic fill (percentage) in the upper region
K Prosthetic fill (percentage) in the lower region
L Harris pain score at 24 months
M Harris total score at 24 months
N Migration in mm along the transverse axis
  + medial
  – lateral
O Migration in mm along the longitudinal axis
  + proximal
  – distal
P Migration in mm along the sagittal axis
  + anterior
  – posterior

Results

So far 3 cases have been re-revised; 1 required excisional arthroplasty after 14 months due to deep infection; 1 was converted to cemented fixation after 28 months, using the very same prosthesis due to distal migration and pain; 1 was replaced after 90 months with a cemented prosthesis and impacted grafts. Another case has been reoperated with lengthening of the neck due to repeated episodes of dislocation. 1 case sustained a femoral shaft fracture involving the tip of the stem at 53 months, and was managed by a plate, leaving the prosthesis in situ. This fracture healed uneventfully.

None of the 42 hips with the femoral prosthesis still in situ at the latest follow-up, showed any signs of acetabular component failure. The median Harris pain score was 33 (10–44) of a possible 44, and the median Harris total score was 69 (26–99). 12 cases had pain scores of less than 30, 18 cases had a total Harris score of less than 70, 17 had scores between 70 and 90, and 7 had scores of 90 or more. The Harris scores in first-time revisions did not differ from those that had earlier been revised one or more times ($p > 0.3$, Mann-Whitney test).

In the RSA-series, 3 stems were stable at 3 months and 1 stem was stable throughout the observation period. In 7 stems, migration progressed between 3 and 12 months, and in 5 between 12 and 24 months.

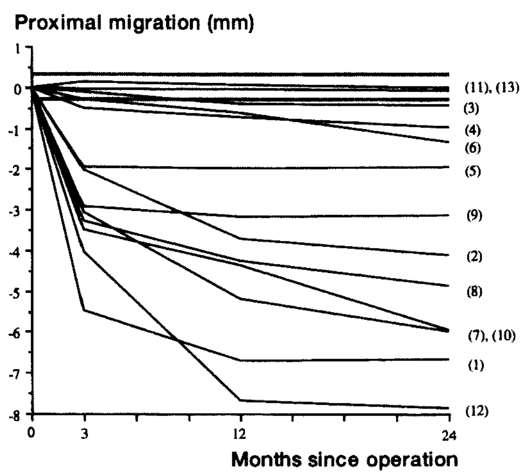

Figure 2. Migration of the prosthetic head along the longitudinal axis. Dashed lines indicate 99 percent limits for significant migration. Figures in brackets refer to hip numbers (Table 3).

For those stems which had migrated significantly along the longitudinal axis, the median distal migration at 3 months (n 9) was 3.1 (0.5–5.5) mm, at 12 months (n 11) 3.7 (0.4–7.7) mm and at 24 months (n 11) 4.1 (0.4–7.9) mm (Figure 2). Significant posterior migration along the sagittal axis at 3 months (n 8) was a median of 1.9 (1.0–2.8) mm, at 12 months (n 9)

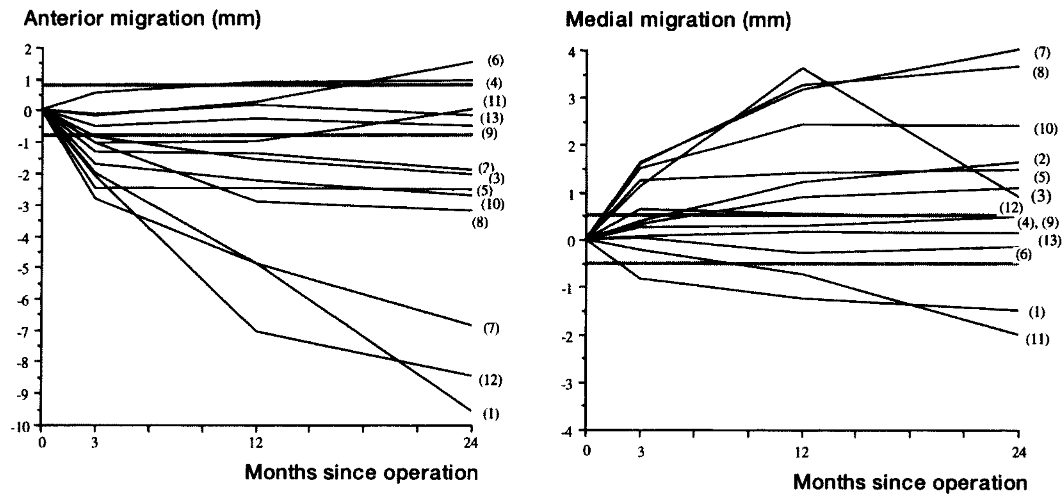

Figure 3. Migration of the prosthetic head along the sagittal axis (A) and along the transverse axis (B). Dashed lines indicate 99 percent limits for significant migration. Figures in brackets refer to hip numbers (Table 3).

2.5 (1.4–7.1) mm and at 24 months (n 8) 2.9 (1.9–9.6) mm (Figure 3A). At 24 months, 2 stems had migrated anteriorly 1.0 and 1.5 mm. One stem changed from a backward migration to neutral between 12 and 24 months. 7 prostheses showed medial migration at 24 months suggesting a varus tilt, whereas 2 stems migrated laterally. Notable was the shift in a lateral direction of 2.7 mm in case 12 between 12 and 24 months implying a gross instability (Figure 3).

The 4 cases with a cortical diaphyseal lesion on the femur (3 fracture cases and 1 osteotomy) subsided to a median of 6.4 mm and migrated posteriorly 7.7 mm, as compared to the 1.9 mm subsidence and 1.9 mm posterior migration in the group with an intact femoral diaphysis.

Distal prosthetic migration in the 13 RSA cases did not correlate with the Harris pain or total scores (p 0.4, Spearman rank correlation).

Prosthetic fill in the 13 RSA cases was a median of 78 percent in the upper region and 84 percent in the lower region (Table 3). Prosthetic fill did not correlate with migration in either the upper ($p > 0.2$) or the lower region ($p > 0.3$, Spearman rank correlation).

Discussion

The clinical results in this series of 45 revisions using the BIAS stem were disappointing; 3 have been re-revised and another 12 had unsatisfactory pain scores, rendering a total failure in one third of the cases after a median of 48 months. In the subgroup of 13 cases followed by RSA, all but one of the stems migrated within the 2 year observation period.

To our knowledge there have been only 2 earlier reports of the BIAS-stem in revision surgery. Gustilo (the designer of the prosthesis) and Pasternak (1988) reported subsidence of 2–11 mm in 11/57 hips followed for 3 years and 4 re-revisions for loosening and an average Harris score of 83. Hussamy and Lachiewicz (1994) reported no re-revisions but subsidence in 13 and unsatisfactory pain scores in 3 of 41 hips followed for 5 years. For other designs of uncemented revision prostheses, loosening and/or re-revisions have been reported in 9–19 percent after 2–8 years (Hedley et al. 1988, Engh et al. 1990, Meding et al. 1994). In comparison, Rubash and Harris (1988) in a series of 43 revisions using second generation cementing techniques followed for 6 years, reported 1 re-revision and 4 loosenings and an average Harris score of 87.

In comparison with 2 earlier RSA-series of cemented revisions using second generation cementing techniques (Snorrason and Kärrholm 1990, Franzén et al. 1992), our uncemented stems had a higher frequency and a greater magnitude of subsidence.

The movements between the prosthesis and bone in our series were probably too large to permit any bone ingrowth. Pilliar et al. (1986) found the limit of motion obstructing bone ingrowth to be 0.1 mm, and Aspenberg et al. (1992) have shown that movements of 0.5 mm at the interface are too large for bone ingrowth to occur. Furthermore, the migratory pattern of our stems, with migrations progressing beyond 3 months, and signs of instability between 1 and 2 years, makes it unlikely that any bone ingrowth has taken place, and that the stems are only partially stabilized by fibrous ingrowth. This is in accordance with the results of a retrieval study by Cook et al. (1991), where only sparse bone ingrowth into porous coated femoral stems in revision cases was registered.

All 3 cases with an intraoperative, diaphyseal fracture below the tip of the prosthesis healed uneventfully, without any dislocation. A similar uneventful course was observed in the one case with a femoral osteotomy. Full intraoperative stability was achieved in all these cases, as in all other cases. Nevertheless, in these four cases both migration and pain were more pronounced.

Our poor results with the BIAS stem could be explained in part by the design of the prosthesis, with its rather flat anteroposterior proximal part that permitted posterior rotation and tilting. We no longer use this prosthesis for uncemented purposes in revision surgery.

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