

Fixation of cementless acetabular cups

A radiographic 4-8-year study of 102 porous-coated components

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We studied fixation changes over time in 113 porous-coated Howmedica (PCA) cementless acetabular cups inserted in 90 patients 1984-1988. The mean follow-up was 5 years. Radiographic fixation was classified as stable, fibrous-stable, or unstable. 9 cups, 3 in neutral position and 6 vertical, were

revised. At follow-up, 40/75 neutral cups were stable versus 7/27 vertical cups. Most stable cups and two thirds of the unstable cups were clinically good. After the first 2 years, 28/75 neutral cups and 10/27 vertical cups changed their fixation: 12 had improved fixation and 26 had a worse one.

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The cementless porous-coated total hip prosthesis is supposed to achieve fixation by bone ingrowth. Bone remodeling can be considered part of the initial process of bone ingrowth and, in fact, is observed between the first and second postoperative years. Once fixation is achieved by a cementless porous-coated prosthesis, the quality of the fixation is considered stable (Callaghan et al. 1988).

We have studied changes over time in radiographic fixation in Howmedica (PCA) cementless acetabular components with regard to cup position.

Patients and methods

128 PCA cementless total hip arthroplasties were performed at our Department from March 1984 through December 1988. 15 cases with insufficient bone stock of the acetabulum (congenital dislocation of the hip or acetabular protrusion), undersized cups with a gap around their contour greater than 2 mm, and those with incomplete clinical data were excluded from this series. The remaining 113 hips (62 men and 51 women) were analyzed. The average follow-up was 5 (4-8) years. At operation, the average age was 51 (24-71) years, the average weight was 71 (49-97) kg, and the diagnoses were: primary arthrosis (40), necrosis (29), arthrosis secondary to developmental abnormality (16), rheumatoid arthritis (15), post-traumatic arthrosis (12), and tuberculosis (1).

All operations were performed using Hardinge's

(1982) direct lateral approach. A porous-coated anatomic cup (PCA, Howmedica, Rutherford, U.S.A.) was used. The acetabulum was reamed to the size of the cup. The bone cut from the reaming was used as grafts to fill any cysts or voids. Antibiotic and anti-thromboembolic prophylaxis were administered to all patients. Postoperatively, the patients were allowed only toe-touch partial weight bearing on crutches for six weeks, after which full weight bearing was allowed.

The patients were evaluated clinically and radiographically 6 months after surgery and then annually. Pain, function, and range of motion were assessed (Merle d'Aubigné and Postel 1954); the patients were also questioned concerning thigh pain. Clinical failure was defined as revision of the cup and/or pain (Grade 4 or worse). Thigh pain was not considered evidence of clinical acetabular failure, whereas groin and buttock pain were recorded as a sign of clinical failure from an unstable fixation (Pupparo and Engh 1991).

Standard anteroposterior and lateral postoperative and follow-up radiographs of the pelvis were obtained according to a standard protocol. The patients were placed supine with their feet together, and the tube was positioned over the symphysis, one meter from and perpendicular to the table. Variations in magnification were corrected by using the 32 mm head of the femoral component as an internal reference. Each follow-up radiograph was analyzed and compared with the previous views by the same observer (JCA).

Table 1. Mean values of the different parameters assessed in position changes in the acetabular cup: lateral opening (degrees/number of cases), medial migration (mm/number of cases), and vertical migration (mm/number of cases) in neutral and vertical cups

Months	Number of cases			Lateral opening		Medial migration		Vertical migration	
	Neutral	Vertical	Total	Neutral	Vertical	Neutral	Vertical	Neutral	Vertical
0-12	81	32	113	0.13	0.64	0.77	0.46	2.31	1.80
13-24	81	29	110	0.40	1.75	0.29	0.75	0.23	0.25
25-36	75	27	102	1.09	1.57	0.42	1.00	0.31	0.57
37-48	74	24	98	0.18	2.28	0.17	0.13	0.25	0.44
49-60	54	18	72	1.22	1.17	0.05	3.00	1.05	1.00
61-72	40	12	52	2.30	0.80	1.80	0.50	1.30	0.25
73-84	19	7	26	1.25	1.00	1.60	1.00	1.60	0.30
85-96	12	4	16	1.30	-	-	-	-	-

The acetabular opening of the cup was related to a horizontal line through both teardrops, and classified as neutral (35°-55°), horizontal (< 35°), or vertical (> 55°). The radiolucent lines less and more than 2 mm wide and loose beads around the cup were assessed in the three DeLee and Charnley (1976) zones. The periodic radiographic controls included changes in cup position and zonal analysis. Changes in cup positions included: changes in lateral opening of the cup > 5°, vertical migration > 3 mm, measured from the ipsilateral teardrop, and medial migration > 3 mm, measured from the center of the cup to the vertical line through the teardrop (Massin et al. 1989, Johnston et al. 1990). 3 mm of migration and 5° change in the lateral opening angle were the limits of error in the method. The zonal analysis considered radiolucent lines less and more than 2 mm wide, parallel reactive lines, and loose beads.

The radiographic fixation type was classified according to parameters based on Engh et al.'s (1990a,b) criteria for the femoral component. The types were: 1) stable fixation, with no radiolucencies, no parallel reactive lines, no loose beads, and no changes in cup position, 2) fibrous-stable fixation with parallel reactive lines, no progressive radiolucencies > 2 mm, no increase in loose beads, and no changes in cup position, and 3) unstable fixation, with progressive radiolucencies, loose beads, and changes in cup position. These fixation types were related to the postoperative cup position. Heterotopic bone formation was not classified as failure or loosening.

Early complications included 5 dislocations, all of which needed revision of their cups, either because of vertical position (3 cases) or because of change in implant position (2 cases); one of these was associated with trauma 2 years after the operation. Furthermore, there was 1 case of intraoperative fracture of the lesser trochanter. No deep infection occurred.

Postoperatively, there were 81 neutral cups and 32 vertical cups. We had no horizontal cups in this series.

Clinical failure rate included cases with surgical revision of the cup (including the 5 early dislocations) and/or pain. The overall clinical results in the survival analysis were excellent/good in 85 percent and fair/poor in 15 percent of cases. Mean function, pain rating and motion improved from 3 to 5 after operation, with marginal changes after the first year. Nine prostheses (9 cups and 4 stems) were revised; of these, 3 were neutral cups and 6 were vertical cups.

Kaplan-Meier (1958) survivorship analysis was used to estimate failure rates. The results were assessed by the Pearson chi-square test, the McNemar symmetry test, and the Mantel-Cox test to compare two Kaplan-Meier curves. Values of $P > 0.05$ were not considered significant.

Results

Radiolucent lines < 2 mm remained constant during follow-up in all zones and all groups of cases. Radiolucent lines > 2 mm disappeared after 2-3 years. Parallel reactive lines progressed in zones 1 and 2 (60 percent after 6 years), and remained constant in zone 3. Loosening of beads was progressive with an average of 2 beads per zone after 6 years, and early in zone 3 of vertical cups. Changes in cup position progressed slowly in all the measured parameters; these changes seemed asymptomatic after 7 years (Table 1). Vertical migration > 3 mm was the most frequent parameter in unstable cups (Table 2).

Biological fixation was analyzed in 102 cases with a follow-up longer than 2 years. After 2 years, stable fixation was observed in two thirds of the neutral cups and in one third of the vertical cups, and

Table 2. Changing positional parameters in unstable cups and their clinical relevance

Change in	Unstable cups n 40	Clinical failure n 13
lateral opening (> 5°)	23	7
vertical migration (> 3 mm)	34	6
medial migration (> 3 mm)	24	4

Table 3. Radiographic fixation type in neutral and vertical cups at 2 years post-operation and at the end of follow-up

At 2 years	n	At the end of follow-up		
		Stable	Fibrous-stable	Unstable
Neutral cups				
Stable	48	34	5	9
Fibrous-stable	9	1	3	5
Unstable	18	5	3	10
Total	75	40	11	24
Vertical cups				
Stable	10	5	2	3
Fibrous-stable	3	0	1	2
Unstable	14	2	1	11
Total	27	7	4	16

instability in one fourth of the neutral cups and half of the vertical cups. At the end of the follow-up there was a trend towards instability in all these subsets (Table 3). Good clinical results were observed at the end of follow-up in 61 of the 62 stable cups and in 28 of the 40 unstable cups ($P 0.0003$).

Discussion

Our results confirm radiographic osseointegration in the porous-coated cups in more than half of the neutral cups, but in only a quarter of the vertical cups at 5 years. A proper operative technique with adequate cup placement is strongly recommended to achieve initial osseointegration of the acetabular component. Positioning of a cementless cup is difficult because the acetabulum has a lateral opening greater than 60 degrees: an exact technique is required (Hedley et al. 1987). When the PCA procedure was first practised, the number of vertical cups was higher than when it was well established, and a learning curve was associated with primary cementless PCA total hip prosthesis procedures (Callaghan et al. 1992). In our series the acetabulum was reamed exactly to the size of the cup, but the use of a cup 2 mm or 3 mm larger than the last reamer has been recommended recently

to obtain the optimal initial stability necessary to provide maximum osseointegration of the cup (Curtis et al. 1992).

Osseointegration is desirable because it represents direct contact between bone and implant, without interposed fibrous tissue. Osseointegrated cups also have better clinical results, but not only osseointegrated cups show good clinical results: after 7 years, fibrous-stable fixation is enough to obtain a good clinical result, although with our data, we do not know whether the long-term result with radiographically fibrous-stable cups is as good as with osseointegration (Bobyn et al. 1988). Several authors have stated that the bone-implant interface remodels over time while maintaining stability (Pilliar et al. 1981, Spector 1987). Our results also confirm changes over time in the fixation type that are unrelated to the postoperative cup position, changes that sometimes improve the fixation type (12 percent), and sometimes worsen it (25 percent).

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