Different cup migration in rheumatoid arthritis and arthrosis

A radiographic analysis of 127 uncemented acetabular cups

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We compared retrospectively the radiographic migration profiles of 82 acetabular components in 61 patients having rheumatoid arthritis with those of 45 hips having arthrosis who underwent a standardized technique of cementless arthroplasty with the Zweymüller prosthesis (Alloclassic®). We used a modification of Dickob's technique of digital migration analysis that corrects for magnification errors and horizontal pelvic tilt. The rheumatoid patients were stratified as having oligoarticular, polyarticular, or mutilating arthritis. The overall rate of acetabular loosening in rheumatoid hips after mean 88 (26–117) months was 4%. Loosening was seen only in cases with mutilating arthritis and acetabular protrusion, where the direction of cup migration was also clearly different from that detected in the other types of rheumatoid arthritis and in arthrosis.

The different patterns of cup migration in cementless hip replacement for rheumatoid arthritis, depending on disease severity, is of importance when comparing outcome of total hip arthroplasty in rheumatoid patients.

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Micromotion of cementless implants normally occurs during osseointegration, which can be measured by image analysis. If the threshold of normal setting is exceeded, clinical loosening is likely to occur (Mjöberg 1991, Krismer et al. 1996). Patients undergoing THA for rheumatoid arthritis (RA) have higher rates of clinical loosening of both cemented (Snorrason and Kärrholm 1990) and cementless acetabular components (Hernandez-Vaquero et al. 1996). It has been attributed to the osteopenic periacetabular bone stock (Baldursson et al. 1980, Oettmeier and Babisch 1992) with a greater amount of unmineralized matrix, increased bone turnover and resorptive activity in the acetabular region (Åkesson et al. 1994).

Loosening of cementless threaded cups has been associated with certain types of coxarthrosis (Hernandez-Vaquero et al. 1996). In addition, there are several recent reports emphasizing high failure rates for certain designs of threaded cups (Gouin et al. 1993, Pidhorz et al. 1993, Bruijn et al. 1995, Sweetnam et al. 1995, Yahiro et al. 1995, Garcia-Cimbrelo et al. 1996). However, excellent results of the Zweymüller threaded cup have been reported in arthrosis (Eyb et al. 1993, Delaunay and Kapandji 1996) and RA (Arnold et al. 1998). However, no studies comparing the migration profiles of the same cementless implant in RA and arthrosis have been reported.

We evaluated the migration profile for the Zweymüller cementless, titanium, threaded acetabular cup in patients with uncomplicated arthrosis and compared it with rheumatoid patients, according to the severity of the disease.

Patients and methods

In the Orthopaedic Department of the University Clinic of Vienna, cementless total hip arthroplasty has been performed routinely since 1978 for patients with severe destruction of the hip joint due to rheumatoid arthritis (Arnet 1990). A metal-backed, threaded acetabular cup and titanium femoral stem (Zweymüller System, Alloclassic®) have been used since 1986. This retrospective study reports our experience with this prosthesis in patients with RA between January 1986 and January 1995, with a minimum follow-up of 24 months.

82 hips were operated on in 61 patients (44 women) with a mean age of 53 (20–79) years. The mean follow-up was 88 (26–117) months. Patients who had their first radiograph of the pelvis later than 3 months postoperatively were excluded. A minimum of 2 radiographs (1 postoperatively and 1 at follow-up) which allowed correct identification of the landmarks of interest were necessary. Preoperative assessment of functional score (Harris 1969) was performed. The radiographic staging (Larsen et al. 1977) revealed a late stage (IV or V) in all patients with RA. The onset of the disease was defined when the diagnosis led to the first administration of disease-modifying drugs and was compared in the 3 groups to avoid comparison of different stages of the same disease. According to their severity of disease, 3 subgroups of patients were defined: oligoarticular RA (less than 6 joints affected), polyarticular RA (6 or more joints affected), and mutilating RA (inflammatory acetabular protrusion, progressive joint destruction within 5 years (Table).

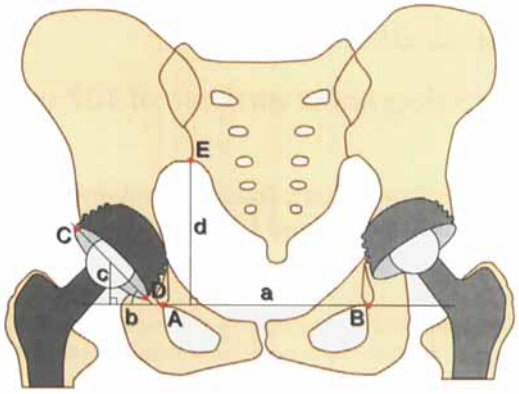
The arthrosis group comprised 45 arthroplasties with the same implant for uncomplicated arthrosis in 40 patients (21 men). The selection of these patients was random. Patients who were operated on because of hip dysplasia or who had any kind of acetabular reconstructions were excluded. The mean age was 62 (21–79) years and the mean follow-up was 98 (67–128) months. Clinical and radiographic examinations were performed postoperatively 6 and 12 months after surgery and annually thereafter.

Radiographic analysis

Migration of the acetabular component was assessed from radiographs obtained at routine postoperative reviews. The radiographs were digitized using a CCD 3 videocamera (Sony™ 3CCD Color Video Camera-DXC-930P, Sony Corporation, Japan) and ICON-TELEMAX Software™ (Macintosh Teleradiology System Vers 2.0, Icon Medical Systems, Inc., Campbell, CA, USA). The image analysis was performed on a Macintosh™ Power-PC, a 20-inch high resolution screen with a screen matrix of 1024 x 768 pixels using NIH™ image analysis software (NIH-Image, Vers. 154 by Wayne Rasband, National Institutes of Health, USA). Digital postprocessing was avoided.

To correct for differing magnifications of the radiographs, the analysis software was calibrated by comparison of the known, true diameter of the head of the prosthesis and the projected diameter for each film. The geometric center of the long axis of the projected ellipse of the socket entrance plane was used to determine the hip-center (Dickob et al. 1994), thus avoiding abberration of the measurement due to polyethylene wear (Sutherland et al. 1982) (Figure 1).

Figure 1. Digitized outline of a pelvis radiograph.



a. Interteardrop distance (basic bone reference line).
b. Horizontal distance from the center of the acetabular component to the ipsilateral teardrop.
c. Vertical distance from the center of the acetabular component perpendicular to the basic bony reference line (a).
d. Perpendicular distance from the lowest point of the sacro-iliac joint (E) to the basic bone reference line.
A. Most caudal point of the ipsilateral teardrop.
B. Most caudal point of the contralateral teardrop.
C. Upper point of the longitudinal axis of the projected ellipse of the socket entrance plane.
D. Lower point of the longitudinal axis of the projected ellipse of the socket entrance plane.

According to Dickob et al. (1994), the bony reference line connecting the most inferior points of the radiographic teardrops (a), the distance from the ipsilateral radiographic teardrop to a perpendicular drawn from the hip-center (b), the perpendicular distance from the bony reference line to the hip center (c), and the inclination angle between the bony reference line and the long axis of the acetabular entrance plane were measured (Figure 1). Horizontal migration was measured as the corrected difference between the value (b) and vertical migration as the corrected difference in value (c) recorded between successive radiographs for each case. Changes in inclination angle were also measured.

Horizontal malpositioning of the pelvis was corrected by measuring the ratio of the inter-teardrop distances (AB) (Figure 1). To correct for vertical tilting of the pelvis in the radiographs, Dickob´s method was modified, using the projected distance from the ipsilateral sacro-iliac joint to the bony reference line as a correction factor. (Dominkus et al: EBRA-Meeting, September, 13th-14th, 1996 Innsbruck, Austria).

For each patient, we used the mean of 3 measurements by 2 observers on the same radiograph. Migration over time was calculated according to the EBRA method (Krismer et al. 1995). The comparison of the different groups referred to the mean migration values of the patients in the groups. The preoperative center

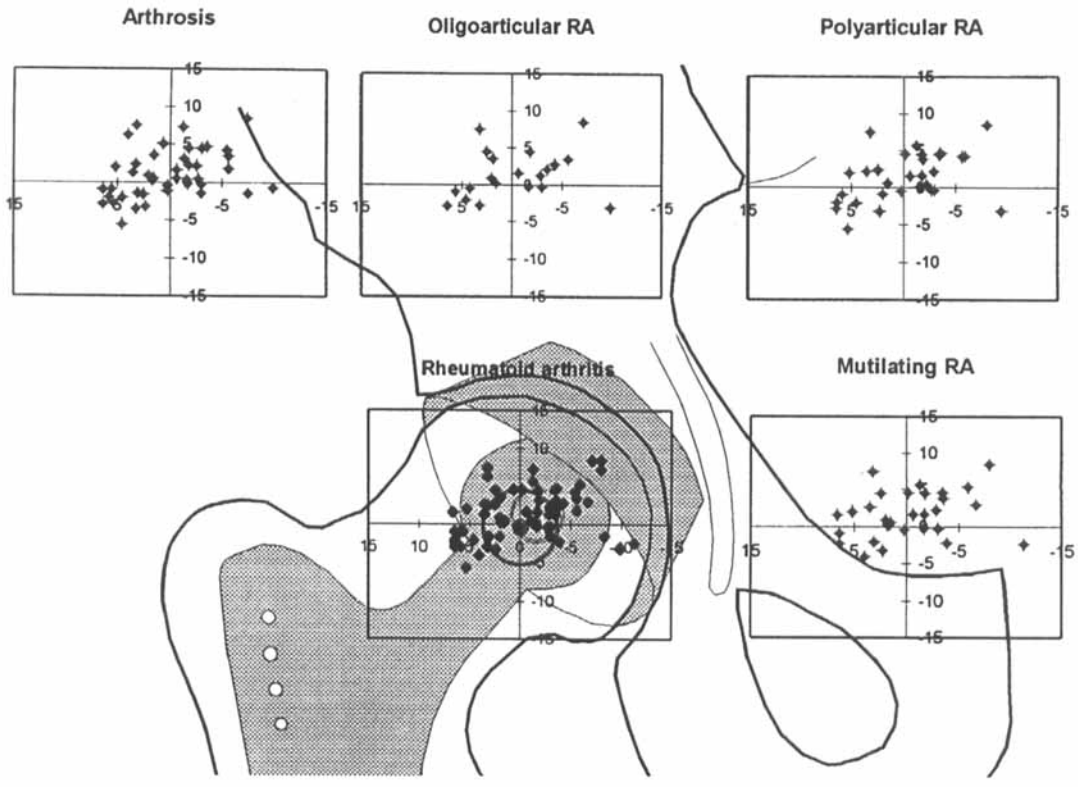


Figure 2. Anatomical position of the acetabular cup compared to the preoperative head center.
X-axis: medial/lateral displacement in millimeters, + = lateral
Y-axis: cranio/caudal displacement in millimeters, + = cranial
The different groups show a similar distribution of the anatomical implantation site. The pelvic outline is schematic and is not scaled to the graphs. Measurements are in mm.

of the femoral head was compared with the center of the acetabular cup at the first postoperative radiograph, to assess the comparability of the implanted cups in the different groups.

We analyzed the accuracy of the method in a cadaver study from 19 repeated radiographs of the same implant, changing the position of the pelvis and the projection center of the tube—1 flat back position, 1 maximum hyperlordosis, 2 horizontal tilt of ± 20° and different center of projection ± 3 cm to the right. The results were compared with an EBRA analysis of the same radiographs (Krismer et al. 1995).

Statistics

Analysis of variance of the overall mean migration per hip over time was performed in the 4 groups (arthrosis, oligoarticular RA, polyarticular RA, mutilating RA). 3 additional comparisons were based on differences between the groups; arthrosis versus all RA; oligoarticular versus polyarticular RA; and oligo- and polyarticular RA versus mutilating RA.

To detect any difference in the time of onset of migration between the 3 RA groups, we performed separate analyses of variance on the mean migration per hip at 6-month intervals. We assessed inter- and intraobserver variability by the standard deviation for the measured inter- and intraobserver differences.

Results

Cadaver study

The measurements of 19 repeated radiographs showed a standard deviation of 0.62 mm in horizontal direction and 0.74 mm in vertical direction.

Using EBRA analysis, 18 radiographs were comparable for measurement of horizontal migration (1 radiograph with a horizontal tilt of 20° to the left was excluded) and 16 radiographs for vertical migration (3 radiographs, which were tilted in vertical direction were excluded). The standard deviations of these comparable radiographs were 0.54 mm for the horizontal and 0.55 mm for the vertical direction. The reproducibility of measurements calculated for known distances was within 0.5 mm for the horizontal vector and 0.66 mm for the vertical vector. The interobserver

Descriptive analysis of the results of horizontal and vertical migration

	Arthrosis	MRA	PRA	ORA
Patients	40	16	25	20
Hips	45	32	30	20
Radiographs	139	160	127	81
Follow-up data	94	128	97	61
Onset of disease, years		6.5	11.3	12.7
Range		3.2–10	6.2–14	5.8–20
Horizontal migration				
Mean (mm)	0.07	–0.93	0.80	0.57
SD (mm)	1.15	0.99	0.87	0.61
Minimum (mm)	–2.52	–2.92	–2.38	–1.02
Maximum (mm)	4.80	2.36	3.26	1.77
Median (mm)	–0.027	–0.95	0.77	0.57
Vertical migration				
Mean (mm)	0.33	0.59	0.69	0.38
SD (mm)	0.63	0.83	1.17	0.57
Minimum (mm)	–0.68	–1.98	–2.86	–1.44
Maximum (mm)	1.98	2.74	6.00	1.75
Median (mm)	0.18	0.66	0.64	0.35

MRA Mutilating rheumatoid arthritis (RA), PRA Polyarticular RA and ORA Oligoarticular RA.
SD Standard deviation

variability (2 observers) over 3 measurements was 0.64 mm, and the intraobserver variability was 0.45 mm. The accuracy of the method on the basis of 2 SD of all radiographs was 1.24 mm in horizontal and 1.48 millimeters in vertical direction.

A comparison of the x- and y-coordinates of the center of the femoral head with the position of the acetabular cup postoperatively revealed no significant difference among the different groups (Figure 2).

Arthrosis group

All patients had a radiographically stable position of the implant. The mean values of each patient after analysis of 94 follow-up radiographs did not exceed the 1.3 mm accuracy threshold of the method in any patient (Table, Figures 3 and 4). The mean Harris hip score was 97 (92–100) points.

Rheumatoid arthritis groups

The mean Harris hip score increased from 36 (15–68) points preoperatively to 89 (65–98) points. The extent of migration in the overall sample of 61 rheumatoid patients was greater than that in the arthrosis group (horizontal migration $p < 0.01$, vertical migation $p = 0.03$). Mean migration values that exceeded the 1.3 mm threshold of accuracy of the method were observed in 3 of 20 hips in the oligoarticular group, in 14 of 30 hips in the polyarticular group, and in 14 of 32 hips in the group with mutilating arthritis.

We observed migration of more than 2 mm in 4/30 hips in the polyarticular group and in 4/32 hips in the mutilating group. No patient in the oligoarticular group had a migration of more than 2 mm.

We found mean migration values of more than 2.6 mm in 3/32 patients in the mutilating arthritis group, 2 of whom had obvious clinical loosening. Migration exceeding the threshold of accuracy in both the horizontal and vertical directions was detected in 1 patient 17 months after surgery and clinical obvious loosening was seen 3 years later. In the second patient, late vertical migration after stable implant ingrowth was detected 5 years after surgery; loosening occurred 4

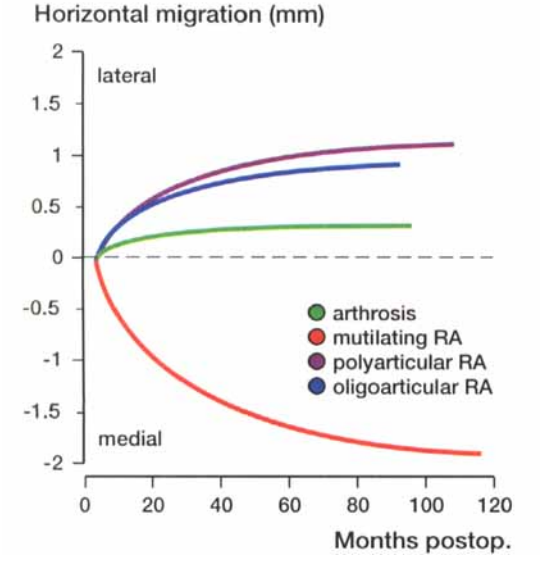


Figure 3. Mean horizontal migration of the acetabular component in the follow-up period (fitted curve).

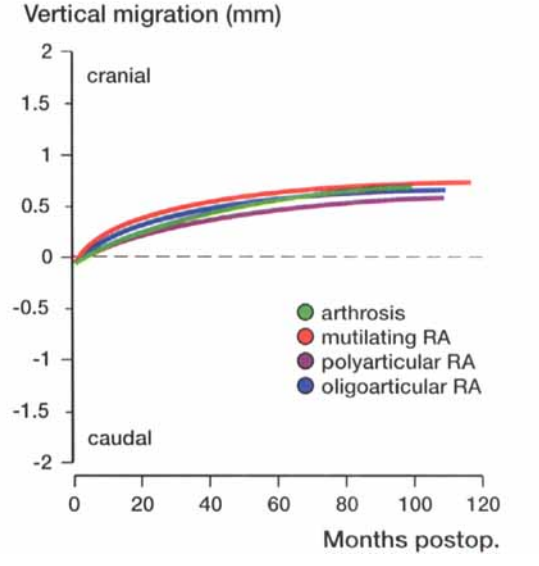
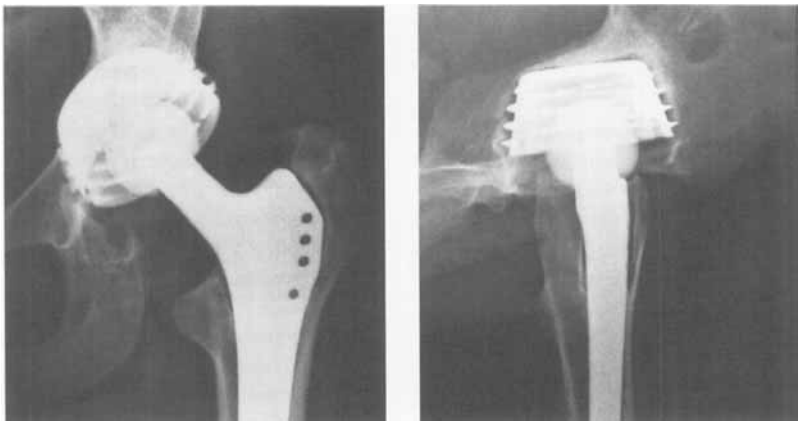


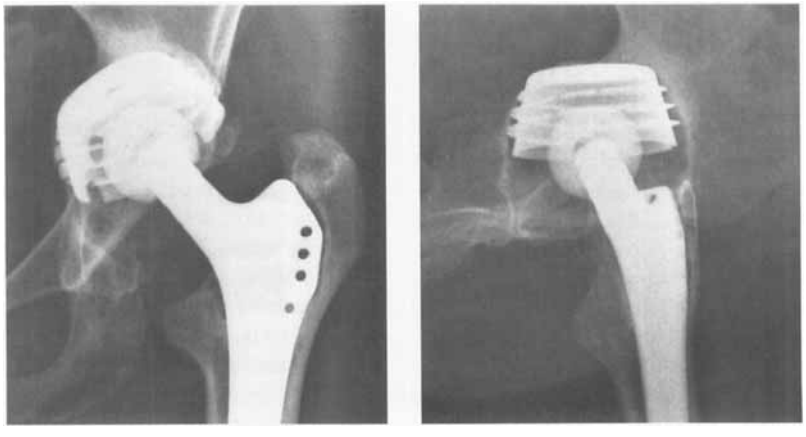
Figure 4. Mean vertical migration of the acetabular component in the follow-up period (fitted curve).

Figure 5. A 22-year-old female patient suffering from mutilating RA, Steinbrocker stage IV.

A. Pre- and postoperative radiograph of the left hip joint with marked preoperative destruction of the femoral head and acetabular protrusion. Cementless total hip arthroplasty, using the Alloclassic®-Zweymüller endoprosthesis, was implanted.



B. A.p. and axial radiograph of the left hip joint in the same patient at 3-year follow-up. Slight tilting and beginning protrusion of the acetabular component. Radiolucent zone at the proximal femur.



C. A.p. and axial radiograph of the left hip joint in the same patient at 7-year follow-up. Marked medial protrusion, tilting and aseptic loosening of the acetabular component.

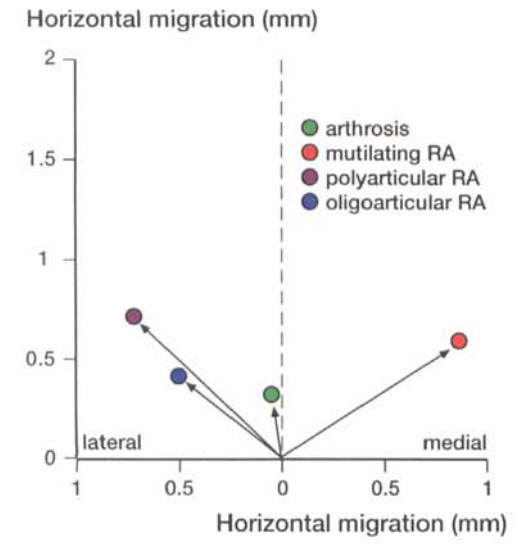


Figure 6. The mean vector of horizontal and vertical migration of the clinical groups is plotted on the x- and y-axes, respectively. In mutilating RA, significant medio-cranial protrusion is obvious.

years later. The third patient developed clinical loosening 6.5 years after surgery, his migration profile exceeded the horizontal threshold 16 months after surgery. Cementless revision of the socket was performed in the first patient (Figure 5), the second underwent cemented revision with a Burch-Schneider device, while the third refused revision.

In the polyarticular arthritis group, 1/30 patients developed marked migration of the acetabular cup, following a traumatic fracture of the superior and inferior pubic rami. Cementless revision of the cup after the fracture had healed resulted in stable fixation of the acetabular component.

Migration vector analysis

The migration vector resulting from horizontal and vertical displacements had a similar craniolateral pattern for each of the arthrosis, oligoarticular, and polyarticular groups in the first 2 years. The mutilating arthritis group differed substantially from the other groups and displayed a tendency to craniomedial migration and the development of acetabular protrusion (Figure 6).

Although the extent of cup migration was significantly greater in the entire sample of rheumatoid patients than that in the arthrosis group, the most striking difference was observed in the horizontal migration of cups in the mutilating group, compared to that in the other rheumatoid groups.

The migration patterns over time differed significantly only for horizontal migration. Considerable changes in horizontal displacement were observed up to 2 years postoperatively, whereas vertical migration and inclination angle did not change significantly over time. The first significant horizontal displacements in cup position were detected at 6–12 months postoperatively.

Discussion

Cementless and cemented hip implants in patients with rheumatoid arthritis have a higher rate of aseptic loosening than in arthrosis, and have been reported as between 19% and 57% (Almby and Hierton 1982, Sutherland et al. 1982, Lack et al. 1986). Loosening occurs predominantly with the acetabular component. A number of factors may contribute to this phenomenon. Stable initial fixation is a prerequisite for successful osseointegration of cementless prostheses, but the periacetabular bone stock in rheumatoid patients is known to be osteopenic with a greater proportion of unmineralized bone (Oettmeier and Babisch, 1992, Önsten et al. 1995). Furthermore, the possibility of ongoing inflammatory resorption of bone around the implant and an adverse effect of protrusio acetabuli (Sutherland et al. 1982) have been implicated in implant loosening. These factors and young age have resulted in a reluctance to use cementless cups in rheumatoid patients.

Few studies report long-term results of cementless THA in rheumatoid patients, but encouraging results have been reported using both threaded (Hoikka et al. 1987, Krödel and Refior 1988) and hemispherical press-fit cups (Cracchiolo et al. 1992). Our experience with the Zweymüller Alloclassic® conical, threaded cup over more than 11 years has not been associated with the high rates of failure reported with other designs of threaded cups and prompted us to investigate its utility in rheumatoid patients. A previous study (Önsten et al. 1995) found no correlation between the degree of bone mineralization and acetabular implant migration. We have therefore stratified the rheumatoid patients according to the clinical severity of their disease, as defined by the American Rheumatoid Association, without attempting to correlate this with bone morphology.

In our patients undergoing THA with this implant for rheumatoid arthritis, we found a loosening rate of only 4% at a mean follow-up of 7 (2–10) years. While it is true that acetabular component loosening may sometimes become evident 10 years after implantation, migration analysis of components within the first 2 years seems to be an accurate predictor of eventual clinical loosening (Krismer et al. 1996). Although

reviewed retrospectively, our series also identified accurately 3/61 cases of early significant cup migration which went on to develop clinical loosening at an average of 31 (16–59) months. Note that all of these occurred in the 32 patients with mutilating type arthritis.

Most migration analyses show a small amount of displacement of cementless acetabular implants during osseointegration within the first 2 years. Therefore, the results of implant migration analysis should be related to a normative setting profile in uncomplicated arthroplasties. In our analysis, the standard profile of 45 Zweymüller Alloclassic® cups in uncomplicated arthrosis resulted in a cranial vertical displacement of 0.87 mm and a mean horizontal displacement of 0.07 mm laterally. This lateral displacement seen in the arthrosis group and the oligo- and polyarticular rheumatoid groups is a phenomenon not reported in the setting profiles of other cups. This finding was not due to rotatory displacements, as there were no associated changes in cup inclination angle, and may be explained by the particular geometry of the conical, threaded cup.

Although the absolute amount of displacement was significantly greater in patients with oligo- and polyarticular rheumatoid arthritis than in arthrosis, it was interesting to note that the migration of cups did not differ significantly in direction from the arthrosis group. In contrast, the migration in hips with mutilating arthritis was medial horizontal more often and to a larger extent compared to the other groups.

The fact that acetabular protrusion mostly occurred in the mutilating group prompted us to investigate further biomechanical factors that could influence this migration pattern.

The position of the acetabular implant turned out to be of crucial importance. 3/4 acetabular cups in the mutilating group and 2/4 in the polyarticular group that migrated medially for more than 2 mm showed initially a remarkably protruded position of the socket with a very thin medial wall or a partial disruption. However, the analysis of the postoperative cup position revealed medialization in 3 patients of the oligoarticular group and in 2 patients of the arthrosis group, but none of these implants showed loosening or remarkable migration in the further follow-up. It seems that poor bone-stock, in combination with a protruding implant, might influence early implant fixation. These findings emphasize the importance of carefully preserving the medial cortical wall on reaming and using solid bone grafts on the medial wall, which leads to a lateralization of the protruded hip center. However, this technique requires an initial stable implant fixation as well as an adequate circumferential coverage of the socket to provide bony ingrowth of the graft. Another option is the use of cementless revision cups that allow for additional screw fixation to enhance the primary stability.

The EBRA method (Krismer et al. 1995) has proved to be useful for early prediction of implant loosening (Krismer et al. 1996). However, this method presumes comparable radiographs for analysis. The accuracy of Dickob's method of image analysis may be slightly less than the EBRA method (Dickob et al. 1994), but it enables the evaluation of all radiographs by the use of correction factors for magnification and tilting of the pelvis. Moreover, this method is less time-consuming, as it uses only 5 reference points and was therefore chosen for the migration analysis.

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