B. Stoeckl · E. Brabec · S. Wanner · M. Krismer ·
R. Biedermann

Radiographic evaluation of the Duraloc cup after 4 years

Received: 4 September 2004 / Accepted: 6 September 2004 / Published online: 14 October 2004
© Springer-Verlag 2004

Abstract We implanted 71 metal-backed, porous-coated, hemispheric, press-fit Duraloc-100 cups in 68 consecutive patients. In 61 patients, the femoral stem was a cementless Spotorno and in ten a cemented Lubinus SP II. A 28-mm BioloX ceramic head was used with both stems. After an average follow-up of 4 (3.7–5.9) years, we examined 67 hips. Radiolucencies were described in three zones according to DeLee and Charnley, and migration was measured on serial radiographs using the computer-assisted EBRA method. Total migration of more than 1 mm within the first 2 years occurred in 22/62 cups. Nine cups showed more than 1.5 mm total migration within the first 2 years and more than 2 mm within the whole period. The presence of post-operative radiolucencies correlated significantly with a total migration value of more than 2 mm within the first 2 years ($p=0.02$). Post-operative radiolucencies in zone 1 correlated with a total migration value of more than 2 mm within the first 2 years ($p=0.027$) and more than 2.5 mm within the whole period ($p=0.051$). These correlation values might reflect the quality of operative technique, particularly reaming, and implant selection.

Résumé Nous avons implanté 71 cupules métal-back hémisphérique press-fit, revêtement poreux, Duraloc-100 chez 68 malades consécutifs. Pour 61 malades la tige fémorale était une Spotorno sans ciment et, pour dix, un tige cimenté Lubinus SP II. Un tête céramique BioloX 28 mm a été utilisée avec les deux tiges. Après une moyenne de suivi de 4 ans (3.7–5.9) nous avons examiné 67 hanches. Les liserés radiologiques ont été décrits dans les trois zones de DeLee et Charnley, et la migration a été mesurée sur des radiographies sérielles en utilisant la méthode EBRA assistée par ordinateur. Une migration

totale de plus de 1 mm dans les deux premières années s'est produites dans 22/62 cupules. Neuf cupules avaient une migration totale de plus de 1.5 mm dans les deux premières années et de plus de 2 mm dans la période entière. La présence de liserés radiologiques postopératoires était corrélé avec une migration de plus de 2 mm dans les deux premières années ($p=0.02$). Les liserés radiologiques postopératoires en zone 1 correspondaient avec une valeur de migration de plus de 2 mm dans les deux premières années ($p=0.027$) et de plus de 2,5 mm dans la période entière ($p=0.051$). Ces valeurs peuvent refléter la qualité de la technique opératoire, en particulier le fraisage, et la sélection de l'implant.

Introduction

The importance of post-operative radiolucencies around press-fit acetabular cups is a controversial topic [3, 12]. Objective radiomorphological assessment is difficult because the appearance of radiolucencies depends on the projection of the cup. Radiolucency is, therefore, not a reliable indicator for cup loosening [3, 16]. In contrast, progressive cup migration is a predictive indicator for the later occurrence of loosening [5, 7, 9].

In the present study, we investigated the appearance of radiolucencies and their correlation with cup migration during the first 4 years after implantation of the Duraloc-100 cup.

Patients and methods

Between December 1993 and September 1995, we implanted 71 Duraloc "100-Series" cups (DePuy, Warsaw, IN, USA) in 68 consecutive patients (40 men, 28 women) with an average age of 55.5 years (range 33.9–68.0). In 59 hips, the primary diagnosis was osteoarthritis.

In 61 hips, we used a cementless Spotorno stem (Sulzer, Bern, Switzerland) and in ten a cemented Lubinus SP II femoral component (Link, Hamburg, Germany). A 28-mm

B. Stoeckl (✉) · E. Brabec · S. Wanner · M. Krismer ·
R. Biedermann
Department of Orthopaedics, Medical University of Innsbruck,
Innsbruck, Austria
e-mail: bernd.stoeckl@uibk.ac.at
Tel.: +43-512-5042691
Fax: +43-512-5042701

Table 1 Cup diameters

Cup diameters in millimetres	48	50	52	54	56	58	60	62	64
Number	0	2	9	17	18	8	8	5	2

Biolog ceramic head (Sulzer, Bern, Switzerland) was used with both femoral stems. We used 18 cups with a diameter of 56 mm and 17 cups with a diameter of 54 mm (Table 1). All operations were performed through a transgluteal approach. We used the 2-mm under-reaming technique for preparation of the acetabulum following the original implantation instruction by DePuy. We used hemispheric reamers manufactured by Sulzer. The position of the component was monitored through the apex hole of the cup. The apex hole was closed using an apex hole plug.

Between November 1998 and April 2000, we conducted the 4-year follow-up. The average follow-up was 4 years (range 3.7–5.9). During this period, one patient died and one moved to an unknown address. Two patients had a telephone interview only whereas 64 patients with 67 hips participated in a follow-up examination.

Standardised anterior-posterior radiographs of the pelvis centred over the symphysis were obtained 3 days after the operation, after 3 months and at each yearly follow-up thereafter. Radiographs were digitised by a film digitiser, VXR-8 (VIDAR-System Co, Herndon, USA), with a resolution of 75 dpi. Cup migration, both vertical and horizontal, was measured on serial radiographs applying the computer-assisted EBRA method [6].

Migration curves could be calculated for 62 of 67 cups with a comparability limit of 3.0 mm (95% confidence interval). Negative horizontal migration values were defined as medial migration. Negative vertical migration (distal migration) up to 1 mm was caused by the limited accuracy of the EBRA measurement method. Total migration was calculated by use of the Pythagorean theorem expressing the length of the vector. We defined loosening as a total migration speed of 0.5 mm per year or more than a total of 2 mm within 4 years [7].

Each cup was evaluated for the presence and progression of broadness of radiolucent lines at the bone-implant interface within the three zones described by DeLee and Charnley [1]. The broadness in millimetres was measured on screen by using the EBRA software.

For statistical analysis, we used the SAS statistical software package (SAS Institute, Inc., Cary, USA). Differences between migration values were calculated by the Wilcoxon rank-sum test. Furthermore, Fisher's exact test, chi-quadrant test and Spearman's correlation coefficient were calculated.

Results

Seventeen cups showed an increase of radiolucencies within 2 and 4 years (cups 1–17, Table 2). In three implants, radiolucencies first appeared after 2 years and remained stable up to 4 years (cups 18–20, Table 2). In

another two cups, post-operative radiolucencies disappeared on the X-rays after 2 years but were visible again after 4 years (cups 21 and 22, Table 2). In two cups, the number of radiolucencies decreased continuously within 4 years (cups 23 and 24, Table 2). In another two cups, the number of radiolucencies decreased within 2 years and remained constant afterwards. Finally, the number of cups with radiolucencies increased from 18 at the 2-year status to 33 at the 4-year status.

Total migration of more than 1 mm within the first 2 years occurred in 22 of 62 cups (35%). Nine of these implants showed more than 1.5 mm within the first 2 years and more than 2 mm total migration within the whole period. These cups were regarded as loose (Fig. 1). The mean total migration rate calculated on 4-year migration curves was 0.88 mm within 2 years and 1.23 mm within 4 years. This is a decrease in migration speed from the second to the fourth year (Fig. 1).

Patients' age, gender, pre-operative diagnosis, surgeon and diameter of the cup did not show any correlation to cup migration nor to the extent of radiolucencies. The

Table 2 Appearance and broadness of radiolucencies around cups (zones according to DeLee and Charnley)

Cup number	Radiolucencies (millimetres)								
	Post-operative			After 2 years			After 4 years		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
1	0	1	0	0	1	0	1	1	0
2	0	0	0	0	0	0	0	1	1
3	0	0	0	0	0	0	0.5	0	0.5
4	1	0	0	1	0	0	1	1	0
5	0	0	0	0	0	0	0	1	0
6	0	0	0	0	0	0	0	1	0
7	0	0	0	0	0	0	0.5	0	0
8	0	0	0	0	0	0	0.5	0	0
9	0	0	0	0	0	0	0.5	0	0
10	0	0	0	0	0	0	0.5	0	0
11	0	0	0	0	0	0	0.5	0	0
12	0	0	0	0	0	0	1	0	0
13	0	0	0	0	0	0	1	0	0
14	0	0	0	0	0	0	1	0	0
15	0	0	0	0	0	0	1	0	0
16	0	0	0	0	0	0	1	0	0
17	0	0	0	0	0	0	1	0	0
18	0	0	0	1	1	0	1	1	0
19	0	0	0	1	0	0	1	0	0
20	0	0	0	1	0	0	1	0	0
21	1	0	0	0	0	0	1	0	1
22	1	1	0	0	0	0	1	1	0
23	1	1	1	0	0	1	0.5	0	0
24	1	1	0	0	1	0	1	0	0
25	1	1	0	0	0	1	0	0	0
26	1	0	0	1	0	0	0	0	0
27	2	2	1	0	0	1	0	0	1
28	0	1	0	0	0	0	0	0	0

Fig. 1 Four-year migration curves.

presence of post-operative radiolucencies around the cup correlated significantly with total migration values of more than 2 mm within the first 2 years ($p=0.02$). Especially, the presence of radiolucencies in zone 1 on the immediate post-operative radiographs correlated with total migration values of more than 2 mm within the first 2 years ($p=0.027$) and more than 2.5 mm within the whole period ($p=0.051$).

Discussion

The assessment of radiolucencies around cups is difficult because the projections of the implants may vary. The appearance of radiolucencies near press-fit cups is, therefore, a controversial point in the discussion [3, 12, 18]. It is questionable whether press-fit cups showing progressing or decreasing radiolucency in the course of first 4 years after implantation really are to be considered loose. It is furthermore uncertain as to whether decreasing radiolucency is caused by early migration of the cup into its bone-bearing resulting in secondary stabilisation. Appearance of radiolucencies in the pole area of the cup (zone 2) is considered normal in pole-flattened hemispheric cups [10] during the early post-operative period. Consequently, radiomorphological assessment of appearing radiolucencies caused by different cup projections do not allow a reliable statement on loosening within such short periods as from 4 to 6 years [2, 16].

The decrease in mean migration speed as seen between 2 and 4 years after implantation shows a more positive result for the Duraloc cup than the speed reported after the first 2 years [15]. It remains uncertain as to whether this decrease is a methodological effect caused by the EBRA measurements or if is caused by a secondary stabilisation of the cup. In this case, observation of the individual migration is more revealing, as nine cups showed progressive migration of more than 2 mm within the whole period and thus fulfilled the requirements in the definition of loosening by Krismer et al. [7].

The significant correlation between progressive cup migration and the appearance of radiolucencies reflect the quality of operative technique, particular reaming technique, and the selection of implant in considering the anatomy of the acetabular bone stock [4, 12, 13]. This study has shown that a post-operative gap in zone 1 tends

to result in problems of primary stability. Consequently, the necessary extent of osseointegration for secondary stabilisation of the cup is not obtained. One of three fixation points of the cup, the one at the iliac bone, is missing, which, according to Widmer et al., is indispensable for adequate primary stability [8, 11, 14, 17, 19].

In conclusion, migration values of the Duraloc cup are much better for the whole period of average 4 years than they were after the first 2 years [15]. Nevertheless, nine cups had a migration value over 2 mm within the first 4 years. Especially in zone 1, the presence of radiolucent lines correlates significantly with later progressive migration. Thus, the presence of a gap in zone 1 is an indication of insufficient primary stability, which later on may lead to progressive migration and instability of the porous-coated cups.

References

1. DeLee JG, Charnley J (1976) Radiological demarcation of cemented sockets in total hip replacement. *Clin Orthop* 121:20–32
2. Engh CA, Griffin WL, Marx CL (1990) Cementless acetabular components. *J Bone Joint Surg [Br]* 72:53–59
3. Engh CA, Zettl-Schaffer KF, Kukita Y, Sweet D, Jasty M, Bragdon C (1993) Histological and radiographic assessment of well functioning porous-coated acetabular components. A human postmortem retrieval study. *J Bone Joint Surg [Am]* 75:814–824
4. Herberts P, Malchau H (1997) How outcome studies have changed total hip arthroplasty practices in Sweden. *Clin Orthop* 344:44–60
5. Krismer M, Fischer M, Mayrhofer P, Stoeckl F, Bittner C, Trojer C, Stoeckl B (1994) A prospective study of the migration of two acetabular components. PCA versus RM cups. *Int Orthop* 18:23–28
6. Krismer M, Bauer R, Tschupik J, Mayrhofer P (1995) EBRA: a method to measure migration of acetabular components. *J Biomech* 28:1225–1236
7. Krismer M, Stockl B, Fischer M, Bauer R, Mayrhofer P, Ogon M (1996) Early migration predicts late aseptic failure of hip sockets. *J Bone Joint Surg [Br]* 78:422–426
8. Kwong LM, O'Connor DO, Sedlacek RC, Krushell RJ, Maloney WJ, Harris WH (1994) A quantitative in vitro assessment of fit and screw fixation on the stability of a cementless hemispherical acetabular component. *J Arthroplasty* 9:163–170
9. Mjoberg B (1991) Fixation and loosening of hip prostheses. A review. *Acta Orthop Scand* 62:500–508
10. Morscher E (1993) Principles of acetabular fixation in THR with special reference to the “press-fit cup”. *Acta Orthop Belg* 59(Suppl 1):260–266
11. Ramamurti BS, Orr TE, Bragdon CR, Lowenstein JD, Jasty M, Harris WH (1997) Factors influencing stability at the interface between a porous surface and cancellous bone: a finite element analysis of a canine in vivo micromotion experiment. *J Biomed Mater Res* 36:274–280
12. Schmalzried TP, Wessinger SJ, Hill GE, Harris WH (1994) The Harris-Galante porous acetabular component press-fit without screw fixation. Five-year radiographic analysis of primary cases. *J Arthroplasty* 9:235–242
13. Schmitt D, Bigard O, Bresler F, Mole D, Bernard P (1993) Long-term results of 2 uncemented acetabular cup components in total hip prosthesis. *Int Orthop* 17:357–364
14. Schwartz JT Jr, Engh CA, Forte MR, Kukita Y, Grandia SK (1993) Evaluation of initial surface apposition in porous-coated acetabular components. *Clin Orthop* 293:174–187

15. Stockl B, Sandow M, Krismer M, Biedermann R, Wimmer C, Frischhut B (1999) Migration of the Duraloc cup at two years. *J Bone Joint Surg [Br]* 81:51–53
16. Stocks GW, Freeman MA, Evans SJ (1995) Acetabular cup migration. Prediction of aseptic loosening. *J Bone Joint Surg [Br]* 77:853–861
17. Thanner J (1999) The acetabular component in total hip arthroplasty. Evaluation of different fixation principles. *Acta Orthop Scand Suppl* 286:1–41
18. Weber D, Schaper LA, Pomeroy DL, Badenhausen WE Jr, Curry JI, Smith MW, Suthers KE (2000) Cementless hemispheric acetabular component in total hip replacement. *Int Orthop* 21:130–133
19. Widmer KH, Zurfluh B, Morscher EW (2002) Load transfer and fixation mode of press-fit acetabular sockets. *J Arthroplasty* 17:926–935