Higher failure rate and stem migration of an uncemented femoral component in patients with femoral head osteonecrosis than in patients with osteoarthrosis

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Background Several authors have found poorer outcome after hip replacement for osteonecrosis than after hip replacement for arthrosis. In a retrospective study we evaluated the performance of an uncemented femoral component in patients with osteonecrosis and arthrosis of the hip.

Patients and methods 31 patients operated for osteonecrosis, and 49 patients operated for osteoarthrosis were included. The median follow-up time was 6.1 (2–11) years for the patients with osteonecrosis, and 5.9 (4–8) for the arthrosis patients.

Results Migration analysis performed by the Einzel-Bild-Roentgen Analysis (EBRA) technique revealed a median stem migration of 1.5 (-8.8–0) mm in the patients with osteonecrosis, but only 0.6 (-2.8–0.7) mm in the patients with arthrosis ($p < 0.001$). Survivorship analysis with stem revision as endpoint for failure was 74% (95% CI: 55–94) in the osteonecrosis, and 98% (95% CI: 94–100) in the arthrosis group ($p = 0.01$).

Interpretation We suggest that the higher failure rate and stem migration of uncemented total hip replacement in the patients with osteonecrosis is a consequence of the disease. On the basis of these findings, we recommend close monitoring of the patients with osteonecrosis, which should include migration measurements.

In advanced osteonecrosis with collapsed femoral head and disabling pain, total hip replacement or femoral endoprosthesis remains the treatment of choice (Mont and Hungerford 1995, Hungerford et al. 1998). However, reported outcomes of total hip replacement in the osteonecrosis population have not been as good as in patients with arthrosis. Patients with osteonecrosis tend to be younger and more active than arthrosis patients, which may account for the discrepancy (Cornell et al. 1985, Saito et al. 1989, Brinker et al. 1994, Ortiguera et al. 1999). Alternatively, changes in the bone quality in the proximal femur seen in osteonecrosis may compromise the result (Arlot et al. 1983). For long-term stability of the femoral component, bony integration remains the key requirement. Instability and consequent subsidence may be a sign of aseptic loosening (Engh et al. 1987). However, no correlations between clinical symptoms or patient satisfaction and component loosening were found in a study by Iwase et al. (2002). These authors thus emphasized precise and serial long-term radiographic follow-up as the only satisfactory method for detection of aseptic loosening of total hip arthroplasty. One possible measure of the quality of implant fixation is the rate of migration.

Although total hip replacement in patients with osteonecrosis has been reported to be less durable (Sarmiento et al. 1990, Lieberman et al. 2002), we are not aware of a study that has compared the rate of migration of the same femoral component in patients with osteonecrosis and osteoarthrosis of

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Table 1. Demographic data and results of patients with osteonecrosis and arthrosis of the hip

	Osteonecrosis	Arthrosis	P-value
No. of patients	31	49	
Age (years)	51 (29–75)	63 (34–71)	<0.001
Follow-up (years)	6.1 (2–11)	5.9 (4–8)	0.5
Weight (kg)	76 (52–94)	68 (46–98)	0.04
Stem migration (mm)	1.5 (-8.8–0)	0.6 (-2.6–0)	<0.001
Harris hip score (points)	85 (38–100)	92 (80–100)	0.01

the hip. In this retrospective study, we analyzed the midterm results of uncemented total hip replacement in patients with arthrosis or osteonecrosis of the femoral head by using EBRA-Femoral Component Analysis (EBRA-FCA) in conjunction with the clinical data.

Figure 1. The uncemented total hip replacement device with a straight, collarless stem made of a titanium-aluminium-vanadium alloy (Ti-6Al-4Va), with an additional coating of hydroxyapatite in the proximal two-thirds, which was combined with spherical press-fit cup (Ti-6Al-4Va), a polyethylene liner and a ceramic head.

Patients and methods

From 1990 to 2000, 41 consecutive patients with advanced osteonecrosis (Ficat stage III and IV) (Ficat 1985) received uncemented total hip replacements at our institution. We used 5 prosthetic devices during this time. However, 31 of these patients (35 hips) were operated with the same uncemented stem design (Austria Hip System, Logimed) during this period, and were included in the study. These patients were compared with a control group of 49 consecutive patients (58 hips) who underwent total joint replacement for arthrosis using the same prosthesis with a comparable midterm follow-up interval. For inclusion in this retrospective study, the patients with arthrosis of the hip had to be aged 19–70 years. In patients with both hips operated, only the hip that was operated on firstly was included in the study.

Among the 31 patients with osteonecrosis, there were 12 women. The etiologies were alcohol abuse in 12, corticosteroid medication in 9, idiopathic in 5, posttraumatic osteonecrosis in 4, and sickle-cell-disease in 1 case. In the group with total hip arthroplasty following arthrosis of the hip, there were 49 patients (31 women). At the time of last follow-up, 4 patients (2 patients in each group) had died from causes unrelated to the index hip surgery. The remaining 29 patients in the osteonecrosis group and 47 patients in the osteoarthrosis group could be reached for follow-up examination. Demographic data including number of patients, age, body weight, follow-up interval, and the Harris hip score at the final follow-up are given in Table 1.

A modified anterolateral transgluteal approach was used in all hips (Bauer et al. 1979). The uncemented implant used in all cases was a straight, collarless stem (Ti-6Al-4Va) with a hydroxyapatite coating in the proximal two-thirds combined with a spherical press-fit cup (Ti-6Al-4Va), a polyethylene liner and a ceramic head (Figure 1).

The patients were mobilized with partial weight bearing during the first 6 weeks after the operation. The clinical outcome was rated according to the Harris (1969) hip score. At scheduled postoperative visits, standardized radiographs were obtained which were compared to serial radiographs. Analysis of radiolucent lines (parallel lines of more than 1 mm and 50% of the different regions were considered positive), bone atrophy, hypertrophy, and osteolysis (any scalloping changes around the

Table 2. Radiographical evaluation including femoral bone radiolucency, atrophy, hypertrophy and osteolysis in the seven Gruen zones

	Region 1	2	3	4	5	6	7
Osteonecrosis group (n = 29)							
Radiolucency	29	20	5	25	11	7	18
Atrophy	27	23	0	0	0	8	23
Hypertrophy	0	0	13	8	14	0	3
Osteolysis	5	2	0	0	0	0	3
Arthrosis group (n = 47)							
Radiolucency	40	13	3	20	6	3	13
Atrophy	40	21	0	0	0	4	10
Hypertrophy	0	0	15	17	19	0	4
Osteolysis	5	0	0	0	0	0	1

socket or in the femoral cortex) at the femoral and acetabular site were performed in the Gruen et al. (1979) femoral regions, and the DeLee and Charnley (1976) acetabular regions. The biological fixation of the stem was assessed by a modification of the criteria described by Engh et al. (1990), using the overall score (fixation and stability score) for the degree of adequacy of biological fixation of the stem. Radiographic failure of the stem was defined as a complete radiolucent line or an overall Engh score of less than -10 points.

Anteroposterior radiographs of the hip were digitized using a resolution of 75 dpi. The Einzel-Bild-Roentgen Analysis-Femoral Component Analysis (EBRA-FCA) was utilized for analysis of migration (Biedermann et al. 1999). This method is known to have a specificity of 100% and a sensitivity of 78% compared to RSA for the detection of migration of over 1 mm (Krismer et al. 1995, 1999, Biedermann et al. 1999).

Statistics

Kaplan-Meier survival analysis applying stem revision and mechanical failure as the endpoint were performed with use of the NCSS 2004 statistics package (NCSS, Kaysville, UT, USA). Continuous variables were tested for significance with the Mann-Whitney U-test. Cox regression and multivariate linear regression analysis was done to determine any association between mechanical stem failure, migration and patient-related factors (age, sex, weight and diagnosis). A two-tailed p-value of less than 0.05 was considered to be statistically significant.

Results

Complications

At the latest follow-up visit, 3 patients in the osteonecrosis group complained about thigh pain. In one of these patients a stem subsidence of 2.8 mm, and progressive radiolucent lines were detected. An aseptic stem loosening was presumed and the patient was scheduled for revision operation. In the osteoarthrosis group 1 patient complained of thigh pain, but there were no signs of radiographic stem loosening. There were 3 postoperative hip dislocations. All dislocations were in the osteonecrosis group with alcohol abuse as the underlying disease. In 2 patients a closed reduction was done, and in 1 patient reoperation with change to a longer head and an antiluxation liner was performed. There were no dislocations in the arthrosis group.

3 patients in the osteonecrosis group (2 alcohol-related, 1 corticoid-related) developed a periprosthetic femoral fracture after a trauma. They were reoperated with open reduction and internal fixation followed by revision of the femoral component in 2 of the cases. In 2 patients with osteonecrosis due to alcohol abuse, the polyethylene liner was changed because of excessive wear. The first patient, who was 70 years old at the time of the primary operation, was operated 8 years later. The second patient (40 years old) was reoperated 5 years after implantation. In the osteonecrosis group (2 alcohol-related, 2 corticoid-related, and 1 with sickle-cell disease) 5 patients had femoral component revision for aseptic loosening. 2 patients from the osteoarthrosis group had revision

Table 3. Radiographical evaluation of the acetabular component including radiolucency, atrophy, and osteolysis in the DeLee and Charnley zones

	Region 1	Region 2	Region 3
Osteonecrosis group (n = 29)			
Radiolucency	12	4	7
Atrophy	2	2	2
Osteolysis	1	1	1
Arthrosis group (n = 47)			
Radiolucency	11	4	3
Atrophy	0	2	2
Osteolysis	0	1	0

of the femoral component for aseptic loosening. No acetabular component revision had to be performed in either group.

Radiographic evaluation and migration analysis (Tables 2 and 3)

According to the radiographic criteria for fixation and stability of the stem, the median overall Engh score was -3 (-26–16) points in the osteonecrosis group, and 21 (-14–26) points in the arthrosis group ($p < 0.001$).

For the migration analysis, 7 hips were excluded since the pictures did not meet set standards for comparability. There were too few pictures in 2 other cases. A complete migration analysis could be performed in 22 of the 29 hips in the osteonecrosis group and in 45 of the 47 hips in the arthrosis group. The median stem migration in the osteonecrosis group was 1.5 (-8.8–0) mm, and in the arthrosis group the median migration was 0.6 (-2.6–0) mm ($p < 0.001$) (Table 1).

Survivorship analysis with stem revision as endpoint for failure was 74% (95% CI 55–94) in the osteonecrosis group, and 98% (CI: 94–100) in the arthrosis group ($p = 0.01$) (Figures 2 and 4). Survival with mechanical failure (radiographic failure and stem revision) was 54% (CI: 31–76) in the osteonecrosis group, and 98% (CI: 94–100) in the arthrosis group ($p < 0.001$) (Figures 3 and 4). Multivariate Cox regression analysis and multivariate linear regression analysis revealed the diagnosis to be the only statistically significant factor for the mechanical failure ($p < 0.01$), revision ($p = 0.05$), and migration of the femoral component ($p < 0.001$).

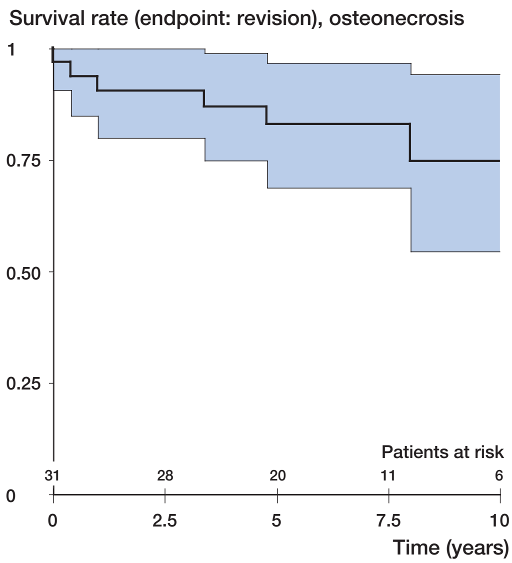

Figure 2. Kaplan-Meier life-table analysis with stem revision (for any reason) as the endpoint. Bold line: survival curve. Thin lines: 95% confidence limits. In the osteonecrosis group, the survival rate of the femoral component was 74% (95% CI: 55–34). The median follow-up time for the patients was 6.1 (2–11) years.

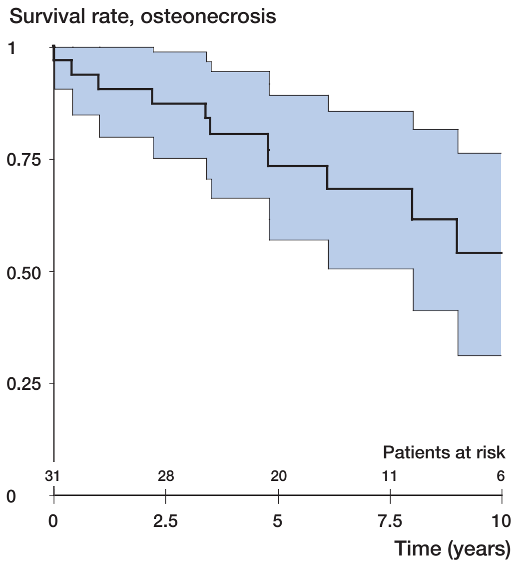

Figure 3. Kaplan-Meier life-table analysis with mechanical failure as the endpoint. Bold line: survival curve. Thin lines: 95% confidence limits. In the osteonecrosis group, the survival rate of the femoral component was 54% (CI: 31–76). The median follow-up time for the patients was 6.1 (2–11) years.

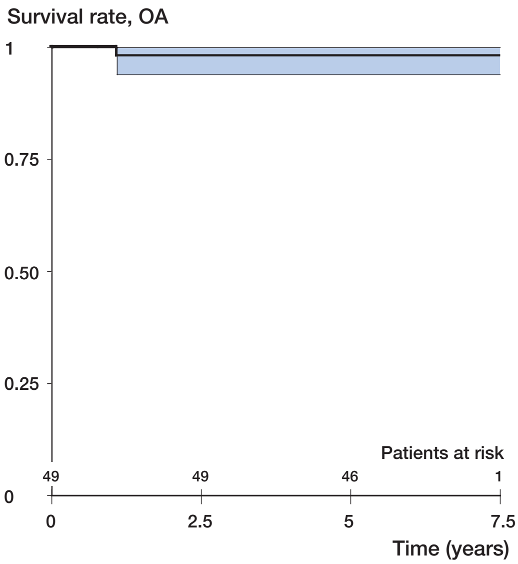

Figure 4. Kaplan-Meier life-table analysis with stem revision for any cause as the endpoint. Bold line: survival curve. Thin lines: 95% confidence limits. In the osteoarthrosis group, the survival rate of the femoral component was 98% (CI: 94–100). The median follow-up time for the patients was 5.9 (4–8) years.

Discussion

Osteonecrosis of the femoral head is said to be the reason for about 10% of primary hip arthroplasties (Hungerford et al. 1998). Usually, this disease occurs in male patients aged less than 50 years, who tend to be more active than patients with arthrosis undergoing total hip replacement. Patients with osteonecrosis of the femoral head are at a higher risk of some specific postoperative complications such as postoperative dislocation (Chiu et al. 1997), which was also observed by us. The periprosthetic femoral fractures in our patients seemed to be related to severe alcoholism.

Two factors are known to strongly influence the outcome of the procedure in patients with osteonecrosis. Survivorship analysis of the Swedish, Danish, and the Finnish hip arthroplasty population showed that the results were disappointing in patients below the age of 55 (Malchau et al. 1993, Lucht 2000, Puolakka et al. 2001). Secondly, higher revision rates after total hip replacement for end-stage osteonecrosis than for patients with arthrosis have been reported (Dorr et al. 1983, Cornell et al. 1985, Saito et al. 1989, Mont and Hungerford 1995, Ortiguera et al. 1999). Modern cementation techniques have improved the results of total hip arthroplasty in patients with osteonecrosis (Kantor et al. 1996, Garino and Steinberg 1997, Ritter et al. 1997). Satisfactory results with uncemented implants encouraged several authors to recommend uncemented implants in these relatively young patients (Lins et al. 1993, Phillips et al. 1994, Piston et al. 1994, Hartley et al. 2000, Xenakis et al. 2001, Capello et al. 2003, Reikeras and Gunderson 2003).

Apart from the age of this patient population, the reason for implant failure may be poor bone quality associated with the underlying diagnosis (Sarmiento et al. 1990, Brinker et al. 1994, Chiu et al. 1997). We support this notion. In a histomorphometric study in 77 adult patients with aseptic osteonecrosis, transiliac bonebiopsy showed a significant reduction in bone volume. The thickness of the osteoid seems to indicate that a systemic bone disease, either osteoporosis or osteomalacia, may co-exist with aseptic osteonecrosis in most patients (Arlot et al. 1983). It is easy to speculate that this deficiency may compromise bony ingrowth of the implant, which could be the reason for early instability and subsequent stem subsidence seen in our patients. These observations are similar to the findings of Mjöberg (1997) who postulated that early loosening of hip prostheses is either a consequence of insufficient initial fixation or early loss of fixation. The most frequent secondary causes of osteoporosis in men are corticosteroid use and alcohol abuse, thus closely following the most commonly associated conditions of the osteonecrosis (Binkley and Krueger 2002). The clinical relevance of the extension of the osteonecrosis in the proximal femur was shown by Saito et al. (1989). Most of the hips with component loosening presented histological evidence of extensive bone necrosis (Saito et al. 1989). Thus, it seems likely that both extension of osteonecrosis and secondary osteoporosis in the osteonecrosis population may influence the bony ingrowth of the prosthetic device.

A reliable method of assessing the stability of the prosthetic device is to measure the migration. Radiostereometric analysis (RSA) has become the golden standard for measuring implant migration (Ornstein et al. 2000), but the EBRA technique, although less accurate, has also proven to be reliable and effective (Krismer et al. 1999). Several studies have demonstrated clearly that early migration can predict implant failure with high accuracy (Kärrholm et al. 1994, Walker et al. 1995, Kobayashi et al. 1997, Biedermann et al. 1999).

The significant difference in the subsidence and survival of the femoral component in the patients with osteonecrosis and arthrosis of the hip supports the notion that the results of total hip replacement are strongly influenced by the osteonecrosis. Our study suggests—but cannot prove—the assumption that the bone around the prosthesis may be influenced by the osteonecrosis. However, this hypothesis should be the subject of further prospective studies including DEXA scan to assess the local bone quality. The increased stem subsidence emphasizes the need for close monitoring in the osteonecrosis patients, which should include accurate migration measurements.

No competing interests declared.

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