The use of cementless expansion acetabular component and an alumina-polyethylene bearing in total hip arthroplasty for osteonecrosis

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We performed 114 consecutive primary total hip arthroplasties with a cementless expansion acetabular component in 101 patients for advanced osteonecrosis of the femoral head. The mean age of the patients at surgery was 51 years (36 to 62) and the mean length of follow-up was 110 months (84 to 129).

The mean pre-operative Harris hip score of 47 points improved to 93 points at final follow-up. The polyethylene liner was exchanged in two hips during this period and one broken acetabular component was revised. The mean linear wear rate of polyethylene was 0.07 mm/year and peri-acetabular osteolysis was seen in two hips (1.9%). Kaplan-Meier analysis indicated that the survival of the acetabular component without revision was 97.8% (95% confidence interval 0.956 to 1.000) at ten years.

Our study has shown that the results of THA with a cementless expansion acetabular component and an alumina-polyethylene bearing surface are good.

The reported results of cemented and cementless total hip arthroplasty (THA) in patients with osteonecrosis of the femoral head depend upon the success of the implants used and the nature of the patients in each cohort. Despite the difficulty of comparing different series, several generalisations can be made. Aseptic loosening of cemented acetabular components has been a problem. The survival of cementless, porous-coated acetabular components implanted by a press-fit technique, with or without multiple screws, has been excellent although wear of polyethylene and periprosthetic osteolysis have still been major problems.1-7

Few investigators have studied the long-term results of THA in patients with osteonecrosis of the femoral head using a cementless elastic expansion acetabular component and an alumina-polyethylene bearing surface. Our aim therefore was to assess the long-term clinical and radiological results of such a THA in patients with osteonecrosis of the femoral head.

Patients and Methods

Between March 1993 and December 1995, we performed 114 consecutive THAs in 69 men (78 hips) and 32 women (36 hips) with advanced osteonecrosis (stage III or stage IV of Ficat8) of the femoral head. Of the 101 patients, four (four hips) died from causes unrelated to their THA before they completed a minimum follow-up of seven years and six (six hips) were lost to follow-up. This left 91 patients (63 men, 28 women, 104 hips) in the study. The mean length of the follow-up was 9.2 years (84 to 129 months). All the operations were performed at one institution by one surgeon (SYK).

The mean age of the patients at the time of their initial operation was 51 years (36 to 62). There were seven patients (eight hips, 7.7%) under 40 years of age, 36 (41 hips, 39.6%) between 40 and 49 years of age, 42 (47 hips, 46.2%) who were aged between 50 and 59 years and six (eight hips, 6.6%) between 60 and 69 years. The mean weight of the patients was 68 kg (50 to 82) and their mean height was 170 cm (155 to 179). The right hip was operated upon in 40 patients and the left in 38 patients. A staged, bilateral procedure was performed in 13 patients, the operations being performed between one and 12 months apart.

The presumed cause of osteonecrosis was alcohol abuse in 57 hips (54.8%), idiopathic in 37 (35.6%), steroid use in seven (6.7%), and previous trauma in three (2.9%); 83 patients (91.2%) undertook either recreational sports or strenuous activity while eight were sedentary or semi-sedentary.

The six segments of the cementless expansion cup (Sulzer, Winterthur, Switzerland) have, on their convex side, nine anchorage tips...
Vertical and horizontal migration was assessed by the bone had bridged the gap in serial follow-up radiographs. The polar gap was considered to have disappeared if the trabecular pattern of the acetabular bone was more than 2 mm wide in both zones I and III, was designated as probably loose.

A cementless stem was considered to be loose when there was progressive subsidence exceeding 3 mm, a change of position, a continuous radiolucent line wider than 2 mm, widening of the canal, or a large pedestal. A cemented stem was considered to be loose if it subsided or changed in position, if it was associated with a fracture of the cement mantle, if there was a radiolucent line at its interface with the cement (debonding), or if the cement mantle itself had subsided. Any stem which was broken or bent was also considered to be loose. The presence of heterotopic bone was assessed according to the technique described by Brooker et al.

Pelvic osteolysis was defined as cystic or scalloped lesions > 2 mm in diameter which had not been present on the immediate post-operative radiograph. The sites of the osteolytic lesions were recorded according to the seven zones described by Gruen, McNeice and Amstutz on the femoral side and the three zones described by DeLee and Charnley on the acetabular side. Lesions were classified as small (< 2 cm in any dimension) or large (≥ 2 cm in any dimension).

Linear wear of the polyethylene liner was measured by the method described by Livermore, Ilstrup and Morrey. A digimatic caliper (Model No CD-15B; Mitutoyo Co, Tokyo, Japan) with an accuracy of 0.01 mm was used. The diameter of the head of the femoral component was taken as the standard for the correction of magnification.

Statistical analysis. The probability of survival of the implant was estimated by the Kaplan-Meier method. Failure was defined as removal of the acetabular metal shell for any reason. Statistical analysis was performed by the use of Student’s two-tailed t-test and a linear regression test. Values for p of less than 0.05 were regarded as significant (version 10; SPSS, Chicago, Illinois).

**Results**

**Clinical outcome.** One patient (one hip) had a revision of the acetabular component because of aseptic loosening and two (two hips) had an exchange of polyethylene liner because of excessive wear. They were excluded from the detailed clinical analysis. This left 101 hips in 88 patients available for clinical review.

The mean pre-operative Harris hip score was 47 points (15 to 68) which at the most recent follow-up had increased to 93 (83 to 100). Eighty-one hips (80.2%) were rated as excellent, 15 (14.8%) as good and five (5%) as fair.

Before arthroplasty, each patient had pain. This was moderate in 58 patients (65 hips, 64.4%) and severe in 30 (36 hips, 36.5%). By the final follow-up examination 79
patients (89 hips, 88.1%) had no pain and nine (12 hips, 11.9%) had mild pain. Before the operation, 54 patients (60 hips, 59.4%) did not use any aid for walking, 24 (28 hips, 27.7%) used a walking stick, nine (11 hips, 10.9%) a crutch and one (two hips, 2%) two crutches. By the final follow-up examination, no patient used an aid for walking.

Before arthroplasty, every patient had a limp; 53 (59 hips, 58.4%) had a mild limp, 25 (30 hips, 29.7%) a moderate and ten (12 hips, 11.9%) a severe limp. By the final follow-up examination 84 patients (97 hips, 96%) had no limp and the remaining four (four hips, 4%) had a mild limp. The ability to use stairs and public transport, to put on shoes and to cut toenails was markedly improved after surgery.

**Radiological outcome.** For the three hips which required a revision of the acetabular component, the most recent radiograph which was reviewed was that taken immediately before the revision of the metal shell (one hip) and the exchange of the polyethylene liner (two hips). The mean size of cup used was 54 mm (48 to 62) and the mean thickness of the polyethylene liner 10.9 mm (8 to 15). The mean acetabular abduction angle was 42.2˚ (22˚ to 66˚). One acetabular component was radiologically loose and was found to be broken at revision surgery. Gaps in zone 1, where the anchorage tips of the shell had not penetrated the acetabular bone were found in 29 hips (27.9%) on the immediate post-operative radiographs. Most of these gaps (27 of 29 hips, 93.1%) disappeared during the follow-up period. The polar gap in zone II of the acetabulum was found in 56 hips (53.8%) on the immediately post-operative radiographs. Of these 56 gaps, 51 (91%) had disappeared completely on the final follow-up radiographs (Fig. 2). The mean time required for the polar gap to disappear was 50 months (6 to 100). The mean total linear wear of polyethylene was 0.55 mm (0.05 to 2.85) and the mean rate of wear was 0.07 (SD 0.04) mm/year (0.01 to 0.27). Osteolysis was identified adjacent to two (1.9%) acetabular components. One lesion was large and the other small and both were found in zones 2 and 3. No cup was revised because of mechanical problems related to osteolysis. We found more wear in patients with a higher acetabular abduction angle (regression test, p = 0.023). However, we found no significant relationship between wear and weight (regression test, p = 0.24), hip score (regression test, p = 0.29), type of stem (Student’s t-test, p = 0.31), gender (Student’s t-test, p = 0.07), age (regression test, p = 0.12), the thickness of the acetabular polyethylene liner (regression test, p = 0.06) or the degree of anteversion (regression test, p = 0.32).

**Complications, revisions, and survivorship.** Three hips (2.9%) had at least one dislocation. Two were treated successfully by closed reduction and the application of an abduction cast for six weeks. One had five episodes of dislocation. The patient refused further surgery and after three years the hip became stable. One intra-operative periprosthetic fracture of the femur was fixed internally by a plate and screws.

Heterotopic ossification had developed in 12 hips (11.5%) by the time of the final follow-up. Seven had Brooker grade-I, two grade-II, and three grade-III ossification. One symptomatic deep-venous thrombosis was diagnosed by ultrasound and was treated with warfarin. No deep infections occurred and no neurovascular injury was seen. No intra-operative acetabular fractures occurred during the attempt to achieve a press-fit.

Of the 104 hips, 101 (97.1%) had the original acetabular component in place. One loose cup was revised because of a broken metal shell and aseptic loosening (Fig. 3). Histological examination by polarising microscopy of the tissue between each segment of the acetabular component showed scattered, birefringent polyethylene particles with a foreign-body reaction which was suggestive of wear of the polyethylene liner. Exchange of the polyethylene liner was undertaken in two hips because of excessive wear of poly-
ethylene at nine and ten years, respectively, although the metal shells were soundly fixed at the time of the operation. No breakages of the alumina head occurred in this series.

The Kaplan-Meier survival analysis at ten years showed that the acetabular component had a survival rate of 97.8% (95% confidence interval, 0.956 to 1.000) with the removal of the acetabular shell as the end-point.

Discussion

Good results have been described for the use of a cementless expansion acetabular component in a shorter study. However, we believe that our findings represent the first long-term follow-up of a cementless expansion acetabular component, and a 28 mm alumina ceramic-polyethylene bearing surface in the treatment of patients with advanced osteonecrosis of the femoral head. The so-called first-generation cementless cup had some problems in earlier studies. Poorly designed implants, periprosthetic osteolysis, and excessive wear of the polyethylene liner led to an increased rate of loosening. With the development of newer designs and reduced wear coefficients, the use of modern implants has improved the results.

The results of cementless threaded acetabular components have been discouraging, with an unacceptable incidence of mechanical failure and a high rate of revision surgery because of migration. The cementless expansion acetabular component which we used is a different design. In our study there was one (1%) revision for aseptic loosening of the acetabular component and a further one (1%) was probably loose. This compares very favourably with the results, after a similar follow-up period, for other cementless acetabular components. The disappearance of the gap between the anchorage tips of the metal shell and the bone which we found post-operatively in zone 1, and the disappearance of the polar gap by remodelling of the bony trabecular pattern produced peripheral fixation and load transfer. We found these remodelling patterns of the periacetabular bone in most of our cases.

Pelvic osteolysis was found in two hips (1.9%) in our study. Although we found no statistical significance between osteolysis and the rate of wear because of the small number of cases, both hips with pelvic osteolysis had a mean wear rate of 0.17 mm/year. The mean, overall wear rate was 0.07 mm/year. The rate of pelvic osteolysis of 1.9% was lower than that seen in the first generation of cementless cups (AML, Depuy, Warsaw, Indiana; PCA, Howmedica, Rutherford, New Jersey; HGP, Zimmer, Warsaw, Indiana) after a similar follow-up period. In the second-generation porous-coated cementless cups, there was an improvement in the fixation, locking mechanism, and design. However, wear of polyethylene and osteolysis remained a concern. There have been many studies on the in vivo wear rates of the metal-on-polyethylene implant with most ranging from 0.1 to 0.2 mm/year. By contrast, there have been few long-term studies on the in vivo wear of the ceramic-on-polyethylene implant. These have demonstrated lower rates than for metal-on-polyethylene implants with a mean of < 0.1 mm/year. Our mean linear wear rate of 0.07 mm/year is similar to earlier reports for ceramic-on-polyethylene wear. Although Sycherz et al found no advantage of a ceramic-on-polyethylene articulation, there are clearly other reports which have found it to be advantageous.

Our demographic data are very different to many other published reports. Our patients were relatively young and had advanced osteonecrosis of the femoral head; 43 (47.3%) were less than 50 years old, 63 (69.2%) were men, and 83 (91.2%) were involved in either recreational sports or strenuous activity. When investigating the results of THA for osteonecrosis in young active patients, the most controversial issue is the durability of the prosthesis compared with that in patients who have undergone THA for osteoarthritis. Using histological analysis, Calder, Pearse and Revell showed that changes extended distal to the lesser trochanter in patients with osteonecrosis. The necrotic nature of the intramedullary canal may account for the higher rates of loosening of the femoral implant. It is not known if osteonecrosis of the femoral head leads to acetabular changes and subsequent poor durability of the implant. However, it is likely that at least some of the problems with the survival of THAs in patients with osteonecrosis can be explained by the demographic details (young and active individuals) and the underlying diagnoses (alcohol abuse, sickle-cell disease, and corticosteroid use) which led to the condition. Recently, Nich et al reported the long-term results of 52 consecutive, cemented or cementless alumina THAs undertaken for osteonecrosis at a mean of 16 years follow-up (11 to 23). Neither osteolysis nor wear was seen. However, 13 (25%) revision procedures were performed in ten patients for aseptic loosening of the acetabular component at a mean of 11.8 years after implantation. Hamadouche et al and Sedel et al showed that acetabular fixation was the weak link in alumina-on-alumina THA and the most common reason for revision. Bizot et al reported excellent results for 11 hybrid alumina THAs using a press-fit metal-backed acetabular component in patients less than 55 years of age and with a follow-up of six to 11 years. They found no acetabular migration and no osteolysis. They suggested that better fixation and a reduction in wear appeared to give better results, compared with a conventional THA undertaken in younger patients.

Although the optimal thickness of the polyethylene is unknown, we could have used a thicker liner because the metal shell was thinner than for other, similar components. For example, the thickness of polyethylene of a 50 mm expansion acetabular component is 8.5 mm but that of an HGP-1 component is 6.2 mm. The minimum thickness of the polyethylene used in our study was 8 mm. However, the cementless expansion acetabular component has several disadvantages. Retroacetabular osteolysis around the stable components suggests that wear particles from the non-articular portion migrate through the space between the
lobes of the shell and the acetabular bone. The acetabular component can also fracture because the shell is elastic and thin. One fracture was found in our series.

Our study shows good results for THA undertaken for osteonecrosis of the femoral head. We believe that the factors responsible for these results are a better design, adequate thickness of polyethylene, the use of a 28 mm alumina-polyethylene bearing surface and the low number of steroid-induced cases of osteonecrosis.

The shortcomings of our study, however, are the relatively short follow-up of 9.2 years and the wide range of age of our patients (36 to 62 years). A longer follow-up is also essential in order to monitor polyethylene wear and osteolysis, which contribute to component survival.

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References