We performed a retrospective analysis of the clinical and radiological outcomes of total hip replacement using an uncemented femoral component proximally coated with hydroxyapatite. Of 136 patients, 118 who had undergone 124 primary total hip replacements were available for study. Their mean age was 66.5 years (19 to 90) and the mean follow-up was 5.6 years (4.25 to 7.25). At the final follow-up the mean Harris hip score was 92 (47.7 to 100).

Periprosthetic femoral fractures, which occurred in seven patients (5.6%), were treated by osteosynthesis in six and conservatively in one. We had to revise five femoral components, one because of aseptic loosening, one because of septic loosening and three because of periprosthetic fracture. At the final follow-up there were definite signs of aseptic loosening in two patients.

Radiologically, proximal femoral bone loss in Gruen zones I and VI was evident in 96.8% of hips, while bone hypertrophy in zones III and V was seen in 64.7%. In 24 hips (20.2%) the mean subsidence of the stem was 3.7 mm which occurred within the first 12 postoperative weeks. This indicated poor initial stability, which might have been aggravated by early weight-bearing. The high rate of failure in our study suggests that proximal femoral bone loss affects the long-term survival of the replacement.

One of the benefits of hydroxyapatite (HA) coating is that by enhancing bone ingrowth, even across a gap, it produces long-term cementless fixation. The stress shielding caused by distal fixation is thought to contribute to bone resorption in the proximal femur. The cementless Austria Hip System for total hip replacement (THR), which uses a proximally-coated femoral component, was developed to give initial stability of the implant and enhanced bone ingrowth. Ehall et al published an evaluation of their short-term results in 1992. We now present medium-term clinical and radiological results.

Patients and Methods

Figure 1 shows the combination of components used in all cases. The femoral component was a straight tapered collarless stem of wrought titanium alloy (Ti6Al4V), round distally and oval proximally. The surface of the proximal two-thirds of the stem was corundum-blasted to produce a surface roughness of 55 μm. The surface roughness of the distal third was about 12 μm. Air plasma spray was used to coat the roughened proximal two-thirds with 150 to 200 μm of 98%-pure HA (Ca5(PO4)3OH) with a density of 3.16g/ml and a bonding strength of about 34 Mpa (Osprovit; Ceram Tec, Plochingen, Germany). The femoral components were available in eight sizes, with the distal diameter from 11 to 19 mm and the length from 19 to 23 cm. The stem was designed to be impacted into the cancellous bone of the proximal femur for proximal press-fit and distal splinting.

Between May 1989 and December 1991, we carried out 142 primary THRs on 70 women and 66 men with a mean age of 66.5 years (19 to 90). There were 86 right hips (60.6%) and 56 left (39.4%). The indications for THR were osteoarthritis (OA) in 122 hips (85.9%), developmental dysplasia in seven, avascular necrosis in six, post-traumatic OA in five, rheumatoid arthritis in one and post-Perthes’ OA in one. At a mean follow-up of 5.6 years (4.3 to 7.3), we evaluated 124 THRs (87.3%) undertaken on 118 patients, 13 patients having died and five were lost to follow-up.

Before operation, the required size of the prosthesis was estimated using standard templates. Through a transgluteal approach an osteotomy was performed approximately 10 mm above the lesser trochanter and the femoral canal was reamed using first a 9 mm and then progressively larger reamers, until cortical contact was achieved.
upper femur was then broached to match the proximal dimension of the selected stem, which was then impacted in place.

Perioperatively, all patients received intravenous prophylactic antibiotics and low-dose unfractioned heparin; they received prophylaxis for heterotopic ossification with 150 to 200 mg of diclofenac per day for five days. Mobilisation began two days after operation. Patients were allowed full weight-bearing but advised to use two crutches for at least six weeks and a single crutch or cane for a further four to six weeks. They were reviewed clinically and radiologically, at three, six and 12 months and then annually.

For preoperative clinical evaluation we used the Merle d’Aubigné and Postel scoring system. Postoperatively, we used both the Harris hip score (HHS) and the Merle d’Aubigné and Postel assessment. Anteroposterior and frog lateral views of the hip and anteroposterior standing views of the pelvis were obtained for all patients. Radiographs taken postoperatively, at six months and at final follow-up were compared. For each of the seven zones of Gruen, McNeice and Amstutz we recorded endosteal (spot welds) and periosteal bone formations, cortical hypertrophy, radiolucent lines and evidence of a distal pedestal. We measured migration from the tip of the stem to a line through the greater trochanter perpendicular to the long axis of the femur. Subsidence was defined as migration of 2 mm or more, or as progressive subsidence on serial radiographs. Migration of less than 2 mm was considered to be the result of measurement error. Prostheses were considered to be in varus or valgus if the axis of the stem deviated from the axis of the femur by more than 3°. We used the classification of Johannsen et al for periprosthetic femoral fractures. Using a modification of the technique described by Engh et al two independent observers compared bone resorption in the Gruen zones on the postoperative and most recent radiographs. We graded bone loss by the number of zones in which it occurred, labelling it as severe if it was present in all zones, moderate if in four, mild if in two or three, and minimal if in only one. To quantify cortical hypertrophy, we compared the outside diameter of the femoral shaft and the thickness of the prosthesis postoperatively and at final follow-up.

Kaplan-Meier survivorship analysis was undertaken, with removal or definite loosening of the stem as the endpoint. For the statistical analysis we used SPSS 9.0 for Windows (SPSS Inc, Chicago, Illinois) performed on a PC with an Intel II processor and Windows NT 4.0. analysis.

Results

Clinical. At a mean follow-up of 5.6 years, the mean Harris hip score was 92.2 points (47.7 to 100). It was less than 70 points in 11 patients, six of whom experienced thigh pain. Two had previously had a periprosthetic fracture and complained of groin pain and weakness in the leg. In two patients, one with a previous conservatively-treated periprosthetic fracture, the femoral component had loosened. The acetabular component had loosened in another. The overall Merle d’Aubigné and Postel score increased from a preoperative mean of 7.9 points out of a possible 18 (5.2 to 12.4) to 16.7 (15.1 to 18) at follow-up.

Tables I and II give the complications which arose during hospitalisation and afterwards. At follow-up, 12 patients complained of thigh pain, but only six had to take non-steroidal anti-inflammatory drugs.

Further surgery. There were five revisions of the femoral component (4%), three for periprosthetic fracture, one for

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aseptic loosening and one for septic loosening. Periprosthetic fracture occurred in seven hips (5.6%); four patients fell at home, one had a car accident, one fell from a tree and another struck his leg on a bedstead. Of these, six were treated by primary open reduction and internal fixation. Simultaneously, two stems which had loosened were revised. The seventh patient complained of thigh pain several weeks after the injury causing periprosthetic fracture, and revision was required as the femoral component had loosened. Two of the fractures were proximal (type I) and five around the tip of the prosthesis (type II). There were no significant differences in age, gender or weight between the patients who sustained fractures and the others.

Within the first six weeks, we treated two cases of early infection by revision, with debridement and exchange of the polyethylene liner and head but not the metal components. In one of these patients there was septic loosening of the stem two years later.

Radiological. At follow-up the fixation/stability score of Engh et al. was calculated for the remaining 119 arthroplasties. A score of 10 points or more suggested probable osseous ingrowth in 48 hips (40.3%) and a score of 0 to 10 points in 45 (37.8%) indicated possible bone ingrowth. In 18 cases (15.1%) a score of 0 to -10 points suggested a poor result, but with stable fibrous ingrowth, and a score of less than -10 points in eight patients (6.7%) indicated instability of the femoral component. Six of these patients had pain on weight-bearing. The other two had thigh pain and a Harris hip score of less than 70 points; massive distal hypertrophy was evident and both later underwent revision surgery.

The zones of the stem which were coated with HA were I, II, VI and VII. The reactive lines, which were most often seen in zones I and III, are shown in Figure 2. Spot welds, evidence of formation of endosteal bone, were often seen in zones III (44.5%), V (37.8%) and VI (67.2%).

Migration of the stem of more than 2 mm occurred in 29 hips (24.4%). In 24 of these (20.2%) a mean subsidence of 3.7 mm occurred between two and 15 weeks (mean, 10.1) postoperatively. In the others a mean subsidence of 9.2 mm (4 to 15) was noted after periprosthetic fracture, which occurred at a mean of 58 months after surgery.

Bone loss was seen in all cases. This was minimal in eight hips (6.7%), mild in 80 (67.2%), moderate in 27 (22.7%) and severe in four (3.4%). It was seen predominately in proximal zones I (96.8% of hips) and VII (86.6%) and was uncommon in the distal zones, where there was a high rate of cortical hypertrophy (Fig. 3). This occurred in zones III and V in 77 hips (64.7%). At the level of maximum hypertrophy, we found at final radiological follow-up that the mean external diameter of the femoral shaft had increased from 32.2 mm (27 to 42) postoperatively to 36.5 mm. Maximum cortical hypertrophy always occurred in the distal third of the stem at a mean of 5.4 cm (2 to 9) from the tip.

Survivorship analysis predicted a rate of survival of the implant of 88.6% at 87.6 months (Fig. 4).
Discussion

By 1989, when the stem used in this series was introduced, the contribution of HA coating to sound early secondary fixation of implants was well recognised.\textsuperscript{15,16} Furlong and Osborn\textsuperscript{17} reported signs of early fixation in post-mortem histological specimens retrieved days or weeks after implantation. Several investigations established the appropriate thickness of the coating. Osborn,\textsuperscript{18} in a study of HA-coated implants in animals, showed that some resorption of the coating occurred, and more thickly coated implants came to be used in many arthroplasties.\textsuperscript{17,19} In a histomorphometric investigation, however, Wang et al\textsuperscript{20} showed that an HA coating of 50 μm had a higher shear strength than that of 200 μm. The site of failure was at the bone-HA interface during the first four weeks of implantation, the HA coating itself after six weeks, and the HA-titanium alloy interface after eight to 12 weeks.

Lintner et al,\textsuperscript{21} in a histomorphometric analysis of a retrieved prosthesis, demonstrated ‘creeping substitution’, the process during which HA is replaced by new bone. Other histological analyses of retrieved specimens have also shown that HA resorption is progressive.\textsuperscript{22,23} Tonino, Thèrin and Doyle\textsuperscript{24} observed excellent osseointegration in retrieved specimens in which the HA coating had been almost completely lost (Fig. 5).

We stopped using this prosthesis in 1997, but it is still in use elsewhere. Despite its theoretical advantages, we observed a high incidence of proximal bone loss, early migration and periprosthetic fractures. Using an HA-coated Omnifit stem, D’Antonio et al\textsuperscript{25} reported subsidence of the stem in only 8%, but we observed migration in 20.2% within the first 12 weeks. To reduce micromovement, D’Antonio et al\textsuperscript{25} allowed only partial weight-bearing for the first six weeks, while we allowed early full weight-bearing. Geesink and Hoefnagels,\textsuperscript{26} who used the Omnifit stem and allowed full weight-bearing in uncomplicated cases, reported only one case of migration, which was caused by femoral fracture. Their rate of survival at follow-up at six years was 100%. Using a straight tapered collarless stem with a 155 μm HA coating, Røkkum et al\textsuperscript{19} reported no subsidence or loosening. The question of weight-bearing was addressed experimentally by Søballe et al.\textsuperscript{27} Measuring the shear stiffness of HA-coated implants in dogs, they demonstrated that it was three times greater (p < 0.01) in immobilised implants than in those subjected to continuous weight-bearing. Histomorphometric analysis of the HA-coated implants showed that the mean bone ingrowth was 31% in weight-bearing and 58% in immobilised implants (p < 0.02). Søballe et al\textsuperscript{27} observed that a decrease in micromovement resulted in a threefold increase in the shear strength of the anchorage of the implants. We attribute the high incidence of early migration of the stem in our study to a fault in design, but weight-bearing may have compounded the poor initial stability.

Several studies, especially radiostereophotogrammetric analysis, indicate that early subsidence leads to a poor outcome.\textsuperscript{28,29} Kobayashi et al\textsuperscript{30} suggest that a precursor of aseptic loosening is radiological evidence of migration, proximal radiolucent lines and subperiosteal formation of new bone in zone IV. Although none of the stems which migrated early in our patients has yet been revised, it seems that we should expect late aseptic failures.

The high incidence of periprosthetic fractures, with loosening of the component in four of seven, seems to be associated with resorption of bone around the proximal femur. All fractures were types I and II, and all patients had direct trauma to the trochanteric region when falling. The incidence of periprosthetic fractures ranged from 0.1% to 2.5%;\textsuperscript{26,31} in our study it was 5.6%.

It is evident that the prosthesis did not provide adequate initial press-fit stability. Despite HA coating of the proximal two-thirds of the stem, proximal fixation was unsatisfactory. As it failed, stress was transferred to the distal third of the stem. Proximal femoral bone loss was the main reason for the high incidence of periprosthetic fracture.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to this article.

References


