THE FURLONG HYDROXYAPATITE-COATED TOTAL HIP REPLACEMENT IN PATIENTS UNDER AGE 51 A 6-YEAR FOLLOW-UP STUDY

G. LOUPASIS, E. W. MORRIS, I. D. HYDE

Forty-five Furlong hydroxyapatite-coated total hip replacements were reviewed at an average of 71 months (46-89) after surgery. Patient's average age at surgery was 46 years (31-50). The average Harris hip score at the time of final review was 89, and 38 hips (84%) had no pain (28) or only slight pain (10). Three hips were revised, none for aseptic loosening. Two cups were loose. The remainder of the cups and all the stems were radiographically stable with positive evidence of bone ingrowth and no signs of impending failure. One cup showed definite wear of the polyethylene liner. Focal progressive osteolytic lesions occurred in the calcar region in 3 stable hips (7%).

To date the Furlong hydroxyapatite-coated implant has produced encouraging results in this group of young patients, although longer follow-up is needed to determine its durability.

Key words : HA-coated total hip replacement ; aseptic loosening ; young patients.

Mots-clés : prothèse totale de hanche ; hydroxyapatite ; patients jeunes.

INTRODUCTION

When young adults request treatment for severe disabling hip disease, tremendous demands are placed on the orthopaedic surgeon to relieve pain, restore normal function and ensure longevity of the implant. The option of prosthetic replacement represents a great challenge for the orthopaedic surgeon. Based on the poor results of some early series, many authors have advised against the use of cemented fixation in young patients (5, 6, 10, 30). Alternative modes of fixation for total hip prostheses have been introduced. Recently, hydroxyapatite (HA) has been applied to cementless implants in the hope of enhancing their fixation and the early clinical and radiographic results have been promising (4, 7, 14). We report our 6-year results of Furlong HA-coated THR in a group of young patients.

PATIENTS AND METHODS

Between June 1988 and August 1992, 47 Furlong HA-coated total hip replacements were performed in 42 patients younger than 51 years old in our department.

One patient died from unrelated causes within 2 years of surgery with a well functioning hip at the latest follow-up, and 1 patient had been lost to follow-up. The results of the study were therefore based on 45 total hip replacements in 40 patients. The preoperative data of the patients are shown in Table I.

A lateral Hardinge approach was used in 37 cases and a posterior approach in 8 cases. All the patients received 3 doses of prophylactic antibiotics (cephalosporin). Postoperatively the patients were routinely mobilised at 48 hours and kept partial weight bearing on crutches for 6 weeks.

The Furlong HA-coated implant (Joint Replacement Instrumentation, London) was used in all patients. Both components are fully coated with hydroxyapatite, which is produced by plasma spraying technique, and have a core made of Ti-6Al-4V alloy. The HA-coating has an average thickness of 200 μm and a bonding

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Table I. — Preoperative data

No. of patients	40
Male	17
Female	23
Mean age (yrs)	46 (range 31-50)
No. of hips	45
Right	19
Left	16
Bilateral	5
Follow-up (months)	71 (range 46-89)
Indication for arthroplasty *	
Osteoarthritis	22 (49)
Dysplasia	5 (11)
Osteonecrosis	4 (9)
Perthes	4 (9)
Rheumatoid arthritis	3 (7)
Post-traumatic	3 (7)
Miscellaneous	4

* The values are given as the number of hips with the percentage in parentheses.

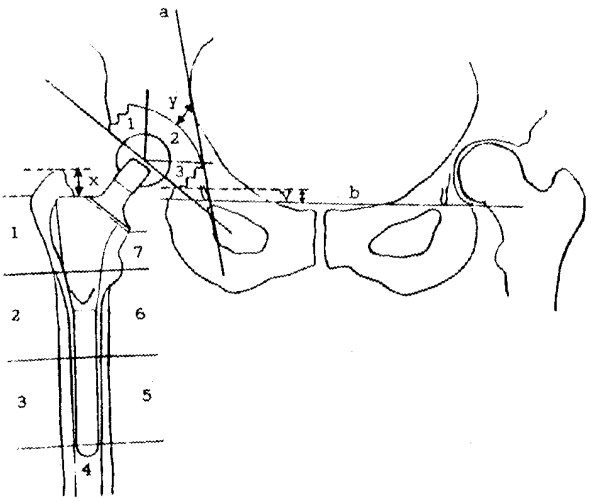

Fig. 1. — Drawing of measurements on the AP radiographs. a = Kohlers' line ; b = interteardrop line ; x = vertical migration of the femoral component ; y = medial migration of the acetabular component ; v = superior migration of the acetabular component.

strength of 40 MPa measured in both tension and shear tests (13). Modular femoral heads of 28 mm diameter were used. A threaded acetabular component was used in all cases.

All patients were invited to attend a research clinic for clinical and radiographic assessment. Clinical assessment was done by 1 author (G. L.) according to the modified Harris hip score (100 points total). Patients were asked specifically about the site of pain (thigh, groin or trochanteric area), precipitating factors (weight bearing, prolonged activity) and were asked to give a subjective rating of their operation. Their occupational status was recorded. Standardised anteroposterior (AP) radiographs of the pelvis, centered over the pubis, and lateral radiographs of the operated hip were obtained at the clinic visit for subsequent analysis.

All radiographs were analysed by 2 observers together to avoid inter-observer error. Standard measurements were made on the 6-week postoperative and intermediate radiographs, and compared to the final follow-up films (Fig. 1).

To evaluate the results the following variables were considered for the acetabular component : 1. Position of the cup ; 2. Migration in a superior or medial direction ; 3. Prosthesis-bone radiolucencies in the DeLee-Charnley zones (9) ; 4. Gaps at the implant-bone interface (attributed to failure to achieve intimate bone-prosthesis contact) ; 5. Wear of polyethylene liner.

For the femoral component the following variables were considered : 1. Stem size ; 2. Migration (vertical subsidence) ; 3. Prosthesis-bone radiolucencies in the AP and lateral radiographs (16) ; 4. Adverse calcar remodeling (loss of height, loss of bone density or rounding) ; 5. Increased trabecular bone in the AP radiograph (spotwelds/pedestal) ; 6. Erosive osteolytic lesions ; 7. Diaphyseal canal filling in the AP and lateral radiograph (estimated according to the method of Hedley *et al.* (18)).

All measurements were corrected for magnification using the true diameter of the prosthetic head.

Heterotopic ossification was graded according to the classification of Brooker *et al.* (3).

Radiographic loosening of the acetabular component was defined as the presence of progressive migration (superior, medial or both) of 3 mm or more (26) or a continuous radiolucent line. Radiographic loosening of the femoral component was diagnosed if there was progressive vertical subsidence of 5 mm or more (19).

Clinical and radiographic findings were analysed by the chi-square method with Yates correction and the Student two-tailed t test. Differences were considered significant when $p < 0.05$.

RESULTS

Clinical results

The average Harris Hip Score (HHS) at the final review was 89 (range 31 to 100). Twenty-nine hips were graded excellent (64%), 7 good (16%), 3 fair (7%), and 6 poor (13%). Twenty-eight hips (62%) gave no pain and 10 hips (22%) only slight, occasional pain. Three hips (7%) gave mild pain that slightly limited activity. Three hips (7%) gave moderate pain requiring regular analgesia and modification of activity ; 1 of these had undergone revision surgery for infection, 1 had a radiographically loose cup, and 1 had recurrent dislocations. One hip (2%) with a radiographically loose cup gave severe pain.

Two radiographically stable hips (4%) were associated with activity related anterolateral thigh pain, but the pain was mild.

According to the patients' subjective opinion of the results of surgery, 35 hips (78%) were excellent, 8 (18%) good, 1 (2%) fair, and 1 (2%) poor. The patient's opinion correlated better with the pain score than the overall HHS (correlation coefficient 0.79 compared with 0.71).

Twenty-six of the patients (65%) were able to perform their job and 14 (35%) were retired at the time of the latest follow-up.

Radiographic results

Acetabular component

Forty-three acetabular components were included in the radiographic analysis ; 1 had been revised for infection and 1 for implant failure ; they were therefore excluded.

The average angle of cup inclination was 52° (range 36 to 73). For the cases that were complicated with instability, the cup inclination was 63° compared to 50° in the stable hips ($p = 0.02$).

Progressive superior migration of more than 3 mm in addition to radiolucencies in all 3 DeLee-Charnley zones, were noted in 2 threaded components (4%). These cups were also associated with pain in the groin / trochanteric area and were considered to be loose. No measurable migration or radiolucencies in any zone were seen in the remaining components.

In 37 acetabular components (86%), gaps up to 3 mm in width were noted at the implant-bone interface on the initial postoperative AP films, mainly in zones 1 and 2. At the final follow-up, gaps were not visible or had decreased in 34 cases (92%) ; they had persisted in 1 (2%) and had increased in the 2 loose components. This gap filling appeared on the postoperative radiographs by 3 months and was completed within 2 years. Thereafter no obvious progression was noted.

One acetabular component showed evidence of polyethylene wear with measured loss of thickness of the liner of 4 mm in 5.3 years. There was eccentricity of the femoral head and the cup inclination was 58°.

Femoral component

Forty-four cases were included in the radiographic analysis ; 1 component had been revised for deep postoperative infection and was therefore excluded.

Stem size 10 mm was used in 70% of the cases, size 12 mm in 25% and sizes 14 or 16 mm in 5%. The mean percentage of radiologically determined diaphyseal canal fill was 83% on the AP radiograph and 72% on the lateral.

Calcar remodeling with loss of height, loss of bone density or rounding was observed in 25 hips (57%). The radiological changes seen were not severe and did not appear to progress after 2 years. There was no significant difference in adverse calcar remodeling when diaphyseal canal fill ($p = 0.25$, $p = 0.32$), or stem size 10 mm ($p = 0.3$) and 12 mm ($p = 0.08$) was considered. There were not enough cases with stem size 14 mm or greater to make a valid statistical analysis.

None of the stems showed evidence of measurable migration.

Non-progressive radiolucencies around the femoral component were observed in only 1 case (zones 3, 4, 5 AP, 11, 12 lateral). The case concerned a 48-year-old active patient with bilateral hip replacements who complained of minimal symptoms and no thigh pain. There was no migration of the femoral component and an

increase in trabecular bone around the cone (zones 2, 6) of the prosthesis. This stem was therefore considered stable.

An increase in trabecular bone (spotwelds) was observed in 42 cases (95%). The spotwelds were mainly seen around the cone of the prosthesis (zones 2 and 6), appeared by the 6 month radiograph and did not progress significantly after one year.

Progressive osteolytic lesions (3 to 6 mm) were seen in the calcar region (zone 7) in 3 radiographically stable hips (7%) (Fig. 2). No definite evidence of polyethylene wear was detected in these hips.

Complications

Six cases (14%) were complicated by intraoperative proximal femoral fractures. Five of these were longitudinal fissures and occurred either during broaching or when the stem was inserted. Two fissures necessitated fixation with cerclage wires, and the other 3 did not necessitate intervention. All healed uneventfully and no stem showed evidence of measurable migration in the follow-up. One of the fractures involved the greater trochanter and finally went on to non-union.

Instability developed after the operation in 4 hips (9%) (3 dislocations and 1 symptomatic subluxation). Of the dislocations 2 occurred within 6 weeks of surgery and 1 was delayed. Two hips remained stable after relocation and 1 continued to have recurrent dislocations. The subluxated hip was revised successfully, by changing the standard cup liner to a hooded type and insertion of a longer neck.

One patient developed femoral nerve palsy due to retractor placement, which fully recovered within one year.

One patient developed a deep postoperative infection which was caused by staphylococcus epidermidis and a two stage revision was required.

In one case the metal backing of the acetabular component fractured at 4 years post-surgery requiring revision of the cup. The case concerned an obese 44-year-old lady, who was operated on early in the series and a 41 size cup was inserted. Considering that a 28 mm femoral head was used, both the metallic shell wall thickness and the

Fig. 2a. Progressive focal proximal osteolytic lesion in a 48-year old patient at 6 weeks post operation.

Fig. 2b. — At 2 years, showing small scalloping under the collar.

Fig. 2c. — At 4 years.

polyethylene thickness were inadequate. This complication would probably have been avoided if a 22 mm head or a larger acetabular component had been used.

Two hips (4%) had clinical and radiographic evidence of aseptic loosening of the acetabular component and have been scheduled for revision.

Heterotopic ossification was present in 16 hips (36%) : Brooker grade I in 9 (20%), grade II in 4 (9%), and grade III in 3 (7%).

DISCUSSION

There currently is limited information regarding the short and medium-term performance of cementless prostheses in patients 50 years of age or less. Short and medium-term follow-up studies in young and middle-aged patients, using various designs of contemporary cementless prostheses with porous coatings of cobalt-chrome or titanium, have shown loosening rates for the acetabular components between zero and 6% (12, 19, 25, 27), and for the femoral components between 3% and 10% (8, 11, 20, 25). The results for cementless prostheses have been reported to be more unfavourable in young patients (17, 23). The early reported results of cemented total hip replacement in young patients, in studies with similar duration of follow-up, were not encouraging. Rates of revision for aseptic loosening in these studies have ranged between 9% and 19% and the incidence of impending failure between 13% and 45% (6, 10, 30). Improvements in the cementing technique and the implant design have mainly affected the femoral side, substantially reducing the incidence of femoral loosening from 30% to 40% at 10 years to 3% or less (1, 29). Cementless implants with HA coating have shown loosening rates of less than 1% even in young patients, in studies with short and medium term follow-up (4, 14). At the current 6-year mean follow-up, zero rates of loosening and revision for the femoral component, and 4% symptomatic loosening for the acetabular component are comparable with the lowest loosening rates in published studies of implants inserted either with or without cement in young patients who were followed for similar periods of time.

Eighty per cent of the hips had an excellent or good clinical rating at a mean 6-year follow-up. The average HHS at the last follow-up evaluation was 89. These clinical ratings are not as good as the excellent clinical hip ratings reported by other authors in series of HA-coated implants (4, 14).

Hydroxyapatite coating has been found to decrease subsidence of the femoral stem (33), migration of the cup and number of radiolucent lines (28). Also the presence of HA induces bone ingrowth and increases gap-filling (32). Initial relatively large gaps between bone and cup were filled almost completely by bone in less than 6 months. Most of our cups and all the stems have shown good osseointegration with no evidence of measurable migration (early or late) or progressive radiolucencies (Fig. 3).

Although smooth (non-coated) threaded cups offer strong initial fixation (22), the disappointing short-term results with several types of these cups due to aseptic loosening, have prompted many authors to abandon their use in favour of the porous surfaced hemispherical cups (12, 15, 31). In the present study, the combination of a threaded design with coating of hydroxyapatite showed a very low mechanical failure rate after a maximum of 7.5 years of follow-up. This is in agreement with the results of a recent study with a similar follow-up period, which has reported a survival rate of 99% for the HA-coated threaded cups (14).

The Furlong femoral stem is designed to be proximally fixed by means of a cone (13). A tight diaphyseal fit is unnecessary for initial fixation of the implant. In the present study the mean percentage of radiologically determined diaphyseal canal filling was 83% in the AP radiograph and 72% in the lateral, values which certainly indicate a less than tight diaphyseal fit. The absence of a tight fit distally indicates that a smaller diameter stem can be used (42 stems had size $<$ 13mm), a contributory factor to avoid marked proximal stress shielding, particularly in the stems with excessive porous coating (2). In our series the adverse bone remodeling seems to be contained within acceptable limits.

Progressive erosive osteolytic lesions have been observed with increasing frequency adjacent to stable porous coated femoral and acetabular com-

Fig. 3a. AP radiograph of the HA-coated Furlong THR at 6 weeks post operation in a 49-year-old patient, showing gaps at the cup-bone interface in DeLee-Charnley zones 1 and 2.

Fig. 3b. By 6 years there has been an excellent quality of bone around the implants, with filling of the gaps and endosteal bone apposition in Gruen zones 2 and 6.

ponents (19, 21, 24, 25). With a follow-up as long as 7.5 years, we found proximal femoral osteolytic lesions in 7% of the hips with no evidence of distal osteolysis. It is possible that the presence of circumferential coating of HA, promoting a strong bone-implant fixation, may retard the distal migration of wear particles reducing the incidence of distal osteolysis. Although the level of activity of the patients in the study was not documented, two-third of the patients were employed in a job. An increased incidence of osteolysis, which may lead to late failures, probably will be found with extended follow-up, in this group of young patients with high activity potential and life expectancy of greater than 25 years.

Good implantation technique is essential to avoid complications which may compromise the outcome. We faced complications which were related to the techniques of insertion of the components. Placement of the cup in excessive abduction was significantly associated with an increased incidence of dislocation, and attempts to achieve a tight fit of the stem resulted in a number of intraoperative fractures. It must be emphasized that most of these complications occurred early in the series during the learning curve of the surgeons.

Our six-year mean follow-up of this group of young patients, using the Furlong HA hip, although still relatively short, has shown a satisfactory pain relief and has routinely produced stable implants. We observed an excellent quality of bone around the components, with signs of favourable bone remodeling and with no evidence of impending loosening in the majority of cases. The final verdict on this HA-arthroplasty, inserted in younger population, will need to await a long-term follow-up study.

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SAMENVATTING

G. LOUPASIS, E. W. MORRIS, I. D. HYDE. De hydroxy-apatite-coated Furlong totale heupprothese bij patiënten jonger dan 51 jaar.

Na een gemiddelde follow-up van 71 maanden (46 tot 89) werden 54 furlong hydroxy-apatiet-gecoate totale heupprothesen nagekeken. De gemiddelde leeftijd op moment van de chirurgie was 46 jaar (31 tot 50 jaar). De gemiddelde Harris-score was 89, 38 heupen (84%) had geen pijn (28) of zeer lichte pijn (10). 3 heupen werden gereviseerd, geen enkele voor aseptische loslating. 2 cups waren los. De rest van de cups en al de stems waren radiologisch stabiel met positieve evidentie voor botingroei en zonder tekens van dreigend falen. Bij één cup was er een teken van slijtage van de polyethyleenaflijning. Focale progressieve osteolytische letsels zagen we bij 3 stabiele heupen (7%). Tot op heden hebben de furlong hydroxy-apatiet-gecoate inplanten bemoedigende resultaten opgeleverd in deze groep van jonge patiënten. Langere follow-up is evenwel noodzakelijk.

RÉSUMÉ

G. LOUPASIS, E. W. MORRIS, I. D. HYDE. La prothèse totale de hanche de Furlong à revêtement d'hydroxyapatite : étude clinique avec un recul de 6 ans.

Quarante-cinq prothèses totales de hanche du type Furlong avec revêtement d'hydroxyapatite ont été revues. Le suivi moyen était de 71 mois (46-89) après l'opération. L'âge moyen des patients était de 46 ans (31-50). Le score moyen selon Harris était de 89 lors du dernier contrôle ; 38 hanches (84%), etaient indolores (28 hanches) ou peu douloureuses (10 hanches). Trois hanches ont été reprises mais aucune pour descellement aseptique. Deux cupules presentaient un descellement radiologique aseptique. L'examen radiologique a demontré que les autres cupules et toutes les tiges fémorales étaient stables avec des signes de réhabitation osseuse et sans signes de descellement imminent. Une cupule présentait une usure évidente du polyéthylène. Des lésions ostéolytiques focales ont été observées au niveau du calcar dans trois hanches stables (7%).
A ce jour la prothèse de Furlong à revêtement d'hydroxyapatite a donné des résultats encourageants dans ce groupe de patients jeunes, mais un suivi prolongé sera nécessaire pour savoir si ces résultats se maintiennent avec le temps.