Resultados clínicos a largo plazo de la prótesis total de cadera Furlong H.A.C

25 años del implante pionero en el uso de hidroxiapatita
Ronald Furlong, pionero de la prótesis total de cadera recubierta con hidroxiapatita, nació en Woolwich (Londres, Reino Unido) en 1909. Fue alumno de Rowley Bristow, Director de Ortopedia del londinense Hospital St Thomas. Estudiante brillante, se licenció en cirugía a una edad excepcionalmente temprana.

En 1969 fue nombrado Director del Departamento de Ortopedia del Hospital St Thomas, donde una de sus responsabilidades fue la enseñanza de la cirugía de reemplazo de cadera. Sus dudas acerca de los implantes disponibles en aquel momento le llevaron a estudiar biomecánica, y en 1978 fue galardonado con la Medalla de Pauwels, siendo uno de los cinco poseedores de tal distinción en todo el mundo.

Gracias a sus conocimientos de biomecánica comenzó a diseñar una nueva prótesis, buscando en primer lugar la estabilidad mecánica de la misma. El segundo objetivo era recubrir el implante con un agente bioactivo, que permitiese una fijación fisiológica de larga duración. Su investigación acerca del uso de hidroxiapatita le puso en contacto con el profesor Johannes Osborn, que había escrito un libro y más de 30 artículos sobre la hidroxiapatita y su uso en el tratamiento de las fracturas conminutas abiertas de la mandíbula.

Trabajando en colaboración con una empresa alemana de expertos en tecnología de pulverización de plasma de llama, Furlong y Osborn lograron desarrollar un recubrimiento para la prótesis de cadera. El resultado fue Furlong HAC®, el primer implante revestido con recubrimiento de hidroxiapatita osteoconductor.

La primera prótesis Furlong HAC® fue implantada en septiembre de 1985 y, tras su éxito, en 1988 se fundó la Furlong Research Foundation, para apoyar la investigación científica, la evaluación clínica y la difusión del conocimiento en este campo.

A la vista de los excelentes resultados los cirujanos siguen indicándola hoy en día, convencidos de haber encontrado el buen camino para solucionar la patología coxofemoral con una prótesis segura.
Reemplazo total de cadera primaria con un vástago Furlong de aleación de titanio con recubrimiento completo de hidroxiapatita

Resultados con un seguimiento mínimo de 20 años

Presentamos la extensión del seguimiento (≥ 20 años) de una serie de vástagos femorales recubiertos con hidroxiapatita utilizados en 72 prótesis primarias de cadera (PTC). Los resultados tempranos de esta cohorte ya habían sido publicados previamente. Todos los procedimientos fueron realizados entre 1986 y 1991. La serie incluía a 45 mujeres, 15 hombres y 12 procedimientos bilaterales. Su edad media en el momento de la cirugía era de 60 años (46 a 80) y la duración media del seguimiento ha sido de 22.5 años (20 a 25). En el seguimiento final, la media de la escala de Merle d’Aubigne y Postel fue de 5.5 (4.5 a 6), 3.8 (3.5 a 5) y 3.3 (3.0 a 5.0) para dolor, movilidad y función, respectivamente. El 92% de los pacientes estaban muy satisfechos en el momento del seguimiento final.

Ha habido siete revisiones: seis del componente acetabular por aflojamiento aséptico y otra por aflojamiento acetabulo y del vástago debido a una infección profunda. La supervivencia de esta prótesis a 22.5 años tomando la revisión por cualquier causa como punto final es del 91.7% (intervalo de confianza al 95% de 84 a 99). La supervivencia con aflojamiento aséptico del vástago como punto final fue del 100% (intervalo de confianza al 95% de 90 a 100).

Esta prótesis alivia el dolor en el largo plazo. La supervivencia de este componente es comparable a los mejores resultados en PTC primaria que emplee cualquier método de fijación.
Primary total hip replacement with a Furlong fully hydroxyapatite-coated titanium alloy femoral component

RESULTS AT A MINIMUM FOLLOW-UP OF 20 YEARS

We present the extended follow-up (≥ 20 years) of a series of fully hydroxyapatite-coated femoral components used in 72 primary total hip replacements (THR). Earlier results of this cohort have been previously published. All procedures were performed between 1986 and 1991. The series involved 45 women and 15 men with 12 bilateral procedures. Their mean age at the time of surgery was 60 years (46 to 80) and the mean duration of follow-up was 22.5 years (20 to 25). At final follow-up, the mean Merle d’Aubigné and Postel hip scores were 5.5 (4.5 to 6), 3.8 (3.5 to 5) and 3.3 (3.0 to 5.0) for pain, mobility and function, respectively. Of the patients 92% were very satisfied at the time of final follow-up.

There were seven revisions: six of the acetabular component for aseptic loosening and one of both the stem and the acetabular component for loosening due to deep infection. The survival of this prosthesis at 22.5 years with revision for any reason as the endpoint was 91.7% (95% confidence interval (CI) 84 to 99). Survival with aseptic loosening of the stem as the endpoint was 100% (95% CI 90 to 100).

This prosthesis provides pain relief in the long term. Survival of this component is comparable to the best results for primary THR with any means of fixation.

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Primary uncemented total hip replacement (THR) has become an accepted method of providing pain relief and return to function in patients with symptomatic osteoarthritis (OA) of the hip. Good medium-term results have been reported with the use of partially\(^1\,^2\) as well as fully hydroxyapatite (HA)-coated femoral components at follow-up of up to ten years.\(^3\,^4\)

A recent review identified relatively few long-term survival reports on uncemented femoral components.\(^5\) Only 17 unique studies were found that included a minimum of 50 patients. Two reviews of registry data comparing > 150 patients were found with follow-up periods > 10 years. A total of 16 femoral components were included, both HA- and non-HA coated. Survival rates > 90% were found for these uncemented stems.\(^5\)

This study presents the results at a minimum 20-year follow-up of a previously reported cohort of patients treated with a fully HA-coated femoral component.

Patients and Methods

This prospective study was performed between 1986 and 1991 and includes 72 primary THR performed in 60 patients (45 women and 15 men) using the Furlong femoral component (JRI Ltd, London, United Kingdom). This prosthesis was used in our department for all patients in whom an uncemented THR was required. All procedures were performed by or under the direct supervision of a single surgeon (JANS). No patients were lost to follow-up.

Bilateral procedures were performed in 12 patients (four men, eight women). These were staged procedures in five patients and under the same anaesthetic in seven. The mean age of this cohort was 82.9 years (70 to 100) at the final follow-up. At the time of surgery 11 patients were < 55 years of age (Table I). All patients presented with disabling hip pain.

Surgical technique and prosthesis. All procedures were performed via a Watson Jones approach\(^6\) with the patient in the supine position. Each patient received three doses of prophylactic antibiotics and subsequently were allowed to bear full weight on the first postoperative day.

The Furlong femoral component (JRI Ltd) was used in all cases. This is manufactured from a titanium alloy (Ti-6Al-4V). The surface of the body and distal stem are plasma sprayed with a 200 μm-thick layer of hydroxyapatite of high crystallinity. The stem is collared and designed to achieve primary stability via a metaphyseal fit, and has a trunnion with a 12/14 Morse taper. A Furlong UHMWPE acetabular...
A modular 32 mm ceramic femoral head was used in all hips. The femoral component was used in 47 patients (59 hips) and a HA-coated threaded acetabular shell with an ultra-high molecular weight polyethylene (UHMWPE) liner (JRI Ltd) was used in 13 patients (13 hips). A modular 32 mm ceramic femoral head was used in all hips.

Follow-up. Clinical and radiological follow-up was performed at six weeks, 12 weeks, six months and 12 months post-operatively, and annually thereafter. Patients were interviewed, examined, the wound was assessed, and all medical and surgical complications were documented. Specific enquiry was made about anterior thigh pain. Clinical assessment of pain, mobility and function was performed using the Merle d'Aubigné and Postel (MDP) scoring system.7 Patient satisfaction was assessed using a visual analogue scale (VAS), which ranged from 0 (poor satisfaction) to 10 (high satisfaction).

Radiological review. At each visit anteroposterior (AP) and lateral radiographs of the pelvis and operated hip were obtained and reviewed by two separate reviewers (NS, CD). These were examined for changes in the position or orientation of the components as well as for evidence of osseointegration or loosening of the prosthesis.

Signs of loosening included lytic lesions (balloon-shaped lucencies around the prosthesis), migration of the implant (measured as the distance between the shoulder of the implant and the greater trochanter), radiolucent lines (RLL; linear lucencies > 2 mm at the bone–prosthesis interface and occupying > 30% of any Gruen zone9). Solid fixation was indicated by 'spot welding' and trabeculae of cancellous bone extending to the stem as described by Engh, Sychterz and Engh.10

Radiographs were also assessed for signs of heterotopic ossification (HO) and stress shielding of the calcar region of the femur: HO was classified according to the system of Brooker et al,11 and stress shielding was considered to be significant if there was selective bone resorption of the calcar region of the femoral neck.12

Statistical analysis. Statistical significance was set at p < 0.05. Survival analysis was performed using Student’s t-test. The level of significance was set at p < 0.05. Survival analysis was performed using the Kaplan-Meier method with 95% confidence intervals (CI). All analyses were performed using GraphPad software (GraphPad, San Diego, California).

Results

The mean duration of follow-up was 22.5 years (20 to 25). At the last follow-up the mean scores for the pain, mobility and function components of the MDP score were 5.5 (4.5 to 6), 3.8 (3.5 to 5) and 3.3 (3.0 to 5), respectively. Two patients (3.3%) were not satisfied, three (5%) were moderately satisfied and 55 (91.7%) were very satisfied with their result up to the last follow-up. The latter group had a VAS ≥ 8. Clinical improvement was noted at the six-week follow-up and was maintained. All patients reported excellent pain relief at their last review.

The mean MDP scores for pain, function and mobility at ten years were 5.8 (4 to 6), 5.6 (3 to 6) and 5.5 (1 to 6), respectively, and at 17 years they were 5.6 (3 to 6), 5.4 (2 to 6) and 3.8 (0 to 6), respectively. There was no statistically significant difference between the ten- and 17-year MDP scores (p = 0.87). Similarly, there was no significant difference between these parameters between the 17- to 22.5-year follow-up (p = 0.82).

In all, at the final review 17 patients (17 hips) had died: six at 20 years post-operatively, four at 21 years, three at 22 years, three at 23 years and one at 25 years post-operatively. Their deaths were not related to their hip surgery. These patients were all reviewed within a year of their deaths and were therefore included in this study. We reviewed their clinical notes as well as their radiographs and contacted their GPs to determine whether they had any complaints regarding their hips, and none were identified.

A total of seven patients (seven hips) had undergone revision surgery. This involved both components in one patient and the acetabular component alone in six. Loosening of the femoral component occurred in one patient 21 years after their primary procedure associated with deep infection. This was the patient who had both components revised and accounted for the only stem revision in this series. There were no cases of aseptic loosening of the stem in this cohort. At final follow-up one female patient was awaiting revision of the acetabular component but had a well-fixed femoral component in situ. There were no dislocations in this group.

Survival analysis. With revision of the femoral component for any reason as the endpoint, survival at a mean follow-up of 22.5 years was 98% (95% CI 90 to 99). With revision for aseptic loosening as the endpoint survival was 100% (95% CI 90 to 100) (Fig. 1). If we consider the endpoint to be revision for any reason, then survival of the femoral component was 91% (95% CI 88.6 to 98.9) at a mean 22.5 years follow-up (Fig. 2).

Radiological results. There were no cases of subsidence of the femoral components. Radiological evidence of solid stem fixation, including ‘spot weld’ formation12 as well as an osteoblastic reaction at the stem tip, was observed in all radiographs (Fig. 3).
Radiolucent lines were seen in 19 femoral components. Of this group, 16 patients (16 hips) died at a mean of 22.0 years (20 to 23) post-operatively. One of these patients had undergone isolated revision of the acetabular component for wear and loosening two years before death. Specific enquiry of their GPs, family members and review of their notes implied no complaints regarding their hips between their last clinical review and the time of their deaths. Of the three patients who were alive, one had undergone revision of the femoral component for septic loosening and the remaining two lived independently at the time of final follow-up with no expressed concerns about their operated hips.

The radiolucent lines were predominantly present in Gruen zones 2 and 3. They were 1 mm wide and non-progressive over two years (Table II). They were not associated with pain and there were no overt signs of movement of the femoral components.

Focal areas of resorption of the calcar were noted in ten hips (Fig. 3). This feature was associated with signs of good fixation of the metaphyseal segment. These patients had no complaints that might suggest loosening of the implant. On 35 radiographs (48.6%) HO was observed. This was Brooker grade 2 or 3 in 57.1% of cases (Table III).

RLLs were noted around 29 acetabular components (40.3%). These were present in DeLee and Charnley zone 1 (12 hips), zone 2 (five hips) and zones 1 to 3 (15 hips). Five patients (five hips), all of whom had RLLs in acetabular zones 1 to 3, had mild to moderate start-up pain. However, four patients did not wish to have any further surgery because of their age, and one was awaiting acetabular revision at the time of final follow-up.
Complications. There were four calcar fractures that occurred at the time of the original surgery. These were treated with cerclage wires in one hip and conservatively in three hips. All patients with these fractures were mobilised non-weight-bearing with crutches for the first six weeks after their procedure. This included the one patient who developed a deep infection 21 years after surgery, which was successfully treated with a two-stage revision. No patients reported anterior thigh pain.

At the final follow-up a peri-prosthetic fracture was noted in an asymptomatic male patient (Fig. 4) who, on enquiry, had no history of trauma or pain. The femoral stem was well fixed radiologically and there were no clinical signs of pain or impaired mobility. The time and cause of this injury remains uncertain.

Discussion
Our results represent those of a non-designer surgeon series. They suggest that HA-coated fixation remains reliable and predictable in the long term, even as the patient ages and the corticomedullary ratio of the femur increases.14 The fact that HA is soluble in vivo and possibly delaminates does not seem to affect long-term survival.15

Good long-term results of primary THR using fully HA-coated titanium stems have been reported in young as well as older age groups.3,16-22 Similar results have been reported when these stems are used in the revision setting.21 Previous reports of the Furlong femoral component in primary THR have been encouraging, with survival rates of 100% and 97.4% at ten and 17 years, respectively.3,22 In this now extended series, survivorship of the remaining femoral components with aseptic loosening as the endpoint at a mean 22.5-year follow-up is 100% (Fig. 1). If all revisions including those for the acetabulum and revision for infection are considered to be failures, then survivorship is 91%.

The mobility and functional components of the MDP score show a gradual deterioration from ten to 22.5 years, whereas the pain score shows that pain relief continues to be sustained. We believe this reflects an age-related decrease in general function and mobility. This change was not statistically significant at any of the three measured time points up to a mean of 22.5 years. It is likely that the lack of pain contributed to the high levels of satisfaction reported by 96.7% of this cohort.

All femoral stems showed signs of stable fixation (Fig. 3). Although focal areas of bone resorption were noted in the calcar region immediately adjacent to the collar in ten patients (Fig. 3), this did not correspond to pain or decreased function. This may possibly relate to localised stress shielding of the calcar region immediately adjacent to the collar after full bonding of the bone to implant had occurred. RLLs were noted around acetabular components in 29 patients (29 hips), which in 52% involved zones 1 to 3.

High early revision rates for uncemented primary THR are thought by some to be due predominantly to peri-prosthetic fractures occurring during stem insertion.23 Our patients experienced four such fractures but recovered without sequelae. Merle et al5 alluded to the paucity of true long-term results for uncemented stems. They found good to excellent results with these components at a minimum of 15 years, and suggested that this technique of fixation is reliable and should become a standard treatment option in appropriate patients.

The 2010 report of the Swedish Hip Registry found no significant differences between cemented and uncemented fixation regarding the risk of revision, irrespective of cause.23 Data from the ninth report of the United Kingdom National Joint Registry24 suggest that the use of uncemented components is increasing but is associated with a higher revision rate for uncemented components in the first ten years. The lowest revision rates up to this point have been found for cemented components. Between four and eight years the revision rates for uncemented components with the ceramic-on-polyethylene bearing couple have been the lowest of all combinations of uncemented components. Data from the Swedish registry demonstrates that after the nine- to ten-year period the failure rate for cemented components surpasses that for uncemented components.

There are several limitations to this study. The sample size is small, as the number of patients who remained alive has decreased. No pre-operative MDP scores were recorded. However, our database provides an accurate record of scores from the time of surgery, and the VAS was consistently used as a patient-reported tool to augment our clinical data.
Our cohort reported significant improvements in pain, mobility and function in their early post-operative phase that has been maintained at the ten-, 17- and now 22.5-year follow-up. There were no cases of aseptic loosening of the femoral component. These results are comparable to the best long-term outcomes in terms of both survival of the component and maintained clinical results for primary THR with any means of fixation of the femoral component.20,23,25-27

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

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References

Uso de componentes femorales recubiertos de hidroxiapatita en pacientes jóvenes con seguimientos de entre 16 y 19 años

Actualización de una publicación anterior

En 2004 describimos los resultados prospectivos a diez años de 38 reemplazos de cadera empleando el vástago femoral recubierto de hidroxiapatita Furlong en 35 pacientes con menos de 50 años de edad. Ahora hemos revisado las 35 arthroplastias supervivientes en 33 pacientes con una media de 16 años (10.3 a 19.9). La edad media de los pacientes supervivientes en el momento de la operación era de 41.3 años (26.0 a 49.0). De estos, ocho han sufrido la revisión de su componente acetabular por aflojamiento aséptico. Ninguno de los componentes femorales ha sufrido revisión por aflojamiento aséptico, siendo su tasa de supervivencia del 100% a 16 años (intervalo de confianza al 95% de 89% a 100%).

El vástago recubierto de hidroxiapatita Furlong ofrece un comportamiento excelente en supervivencia a largo plazo en pacientes jóvenes y activos.
Hydroxyapatite-ceramic-coated femoral components in young patients followed-up for 16 to 19 years

AN UPDATE OF A PREVIOUS REPORT

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In 2004 we described the ten-year prospective results of 38 total hip replacements using the Furlong hydroxyapatite-ceramic-coated femoral component in 35 patients <50 years old. We have now reviewed the surviving 35 arthroplasties in 33 patients at a mean of 16 years (10.3 to 19.9). The mean age of the surviving patients at the time of operation was 41.3 years (26.0 to 49.0). Of these, eight have undergone revision of their acetabular component for aseptic loosening. None of the femoral components has had revision for aseptic loosening giving a survival rate of 100% at 16 years (95% confidence interval 89% to 100%). The Furlong hydroxyapatite-ceramic-coated femoral component gives excellent long-term survival in young and active patients.

Previous studies have shown that cemented total hip replacement (THR) is a successful procedure in elderly and low-demand patients, but the failure rate is higher in young and active patients.1-3 Long-term failure of cemented THR components is usually due to aseptic loosening caused by wear debris stimulating the formation of osteoclasts and subsequent osteolysis. Hydroxyapatite-ceramic (HAC)-coated implants facilitate a biological bond between the implant and bone producing a sealing effect.4

In November 2004 we described the results at ten years of the use of the HAC-coated Furlong implant (Joint Replacement Instrumentation (JRI), London, United Kingdom) which showed no evidence of aseptic loosening.5 We have now reviewed the same series at a mean of 16 years (10.3 to 19.9).

Patients and Methods

Between December 1988 and October 1997, 38 THRs in 33 patients (22 men, 11 women) with a mean age of 42 years (22 to 49) were performed by the senior author (AJE) or under his direct supervision using the Hardinge approach.6 All these patients were recalled for further follow-up and clinical and radiological evaluation. The series has been described in detail previously5 (Table I).

The principal diagnosis was osteoarthritis in 19 hips (50%), developmental dysplasia of the hip (DDH) in ten (26%), post-traumatic arthritis in three (8%), Perthes’ disease in two (5%), slipped upper femoral epiphysis (SUFE) in one (3%), rheumatoid arthritis in one (3%) and Still’s disease in two (5%) (Table I).

Staged bilateral procedures were performed in four patients and one patient had both hips replaced under the same anaesthetic. Although the Furlong HAC-coated stem was used in all patients the acetabular components varied. The initial 14 hips (37%) received a cemented polyethylene component (JRI) and the remaining 24 had JRI Cancellous Screw Fixation HAC-coated acetabular components with polyethylene liners. Alumina oxide ceramic modular heads were used in 36 hips of which 23 were of 28 mm and 13 of 32 mm in diameter. Cobaltchrome heads were used in two hips, one of 28 mm and one of 32 mm diameter.

The Harris hip score (HHS)7 was completed pre-operatively and at a mean follow-up of 16.0 years (10.3 to 19.9) and the Oxford hip score (OHS),8 University of California Los Angeles (UCLA) activity scale9 and patient satisfaction were also used as outcome measures.

Radiological assessment was carried out by independent observers (NNS, DWC). Anteroposterior (AP) radiographs of the pelvis were assessed for stability and fixation of the femoral component according to the criteria described by Engh, Massin and Suthers.10 Lateral radiographs were also reviewed at the final follow-up. The distribution of osteolysis or radiolucencies was recorded according to the zones of Gruen, McNeice and Amstutz11 using the criteria of Goetz, Smith and Harris.12 The femoral component was considered to be stable if there
was evidence of osseointegration and unstable if there was evidence of migration. Additionally, the leg length was measured directly from the radiographs.

On the AP view osteolysis or radiolucencies around the acetabular component were recorded as described by DeLee and Charnley. The acetabular component was considered to be loose if there was a continuous or progressive radiolucent line at the prosthesis-bone interface or any change in position of the acetabular component. The formation of heterotopic bone was recorded according to the criteria of Brooker et al.

Statistical analysis. The changes in the pre- and post-operative hip scores were compared using the Mann-Whitney U test. A p-value ≤ 0.05 was considered to be significant. Cumulative survival analysis for both components was performed using revision for any reason and revision for aseptic loosening or impending revision as the endpoints, with 95% confidence intervals (CI).

Results
At the time of this review two patients (three hips) had died from unrelated causes. One of these (one hip) had osteoarthritis and the other had Still's disease (2 hips). One patient had moved and was unable to attend, but completed a postal questionnaire. The remaining 34 THRs in 30 patients (19 men, 11 women) from the original series were available for follow-up and radiological study and were included in the statistical analysis. The mean age at operation of these patients was 41.3 years (26.0 to 49.0).

Clinical and radiological findings. The mean pre-operative HHS for the original series was 44 (31 to 55). The mean post-operative HHS at the final review was 89 (78 to 100). For the eight patients who underwent revision of the acetabular component the mean post-operative HHS was 92 (71 to 100) and for the remaining patients it was 86 (78 to 100). This was statistically significant (Mann-Whitney U test, p < 0.001). The mean OHS was 16 (12 to 40) at the ten-year follow-up and 18 (12 to 40) at this latest follow-up which was also statistically significant (Mann-Whitney U test, p < 0.001). The UCLA activity score was 7 or more for 21 patients with a mean of 6 (6 to 9) at the final review.

All the patients were asked at each review about the occurrence of anterior thigh pain. None had experienced this at any stage.
Peri-operative complications were rare. There were no cases of infection or thromboembolism. One patient had a dislocation after 12 years. This patient had a cemented polyethylene acetabular component articulating with a 32 mm ceramic head. Acetabular revision was performed for aseptic loosening and polyethylene wear. There were no peri-operative fractures associated with insertion of the Furlong stem. One late complication occurred in a 27-year-old man with Still's disease with bilateral hip and knee replacements. He fell two years after his second THR and sustained a mid-shaft fracture of the femur at the junction of the femoral components of the hip and knee replacements. This was reduced and fixed by a cable/plate system. At operation it was noted that the femoral component was well bonded. The fracture healed satisfactorily. Despite his extensive surgery he was capable of working as an office clerk and walked with one stick.

From measurements on the AP pelvic radiographs a leg-length discrepancy was found in 14 hips. In six the shortening was between 5 mm and 1 cm and in eight there was lengthening between 5 mm and 12 mm. At the latest review of 12 surviving cemented polyethylene acetabular components, five had required revision because of aseptic loosening associated with polyethylene wear. The mean time from primary surgery to revision was 11 years (9 to 13). Four had a head diameter of 32 mm while the other had a modular head diameter of 28 mm. They were all revised to cancellous screw fixation acetabular components with ceramic-on-ceramic bearing surfaces.

Of 22 HAC-coated cancellous screw fixation acetabular components, three were revised because of aseptic loosening associated with radiolucency in DeLee and Charnley zones 1 and 2. The diameter of the femoral head was 28 mm for these three patients. They were all revised to HAC-coated cancellous screw fixation acetabular components with ceramic inserts. One required additional allograft.

Radiological assessment of the femoral components did not show any radiolucent lines and serial radiographs did not reveal any evidence of subsidence. All were stable with evidence of bonding according to criteria described by Engh et al.\textsuperscript{10} Formation of new bone with a trabecular pattern was seen in relation to all femoral components in all the Gruen zones except zone 7 (Fig. 1). In 11 hips at the level of the calcar...
Resultados clínicos a largo plazo de la prótesis total de cadera Furlong H.A.C

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in Gruen zone 7, an area of bone resorption with rounding of calcar was seen extending distally from 2 mm to 5 mm.

Grade-I heterotopic ossification was observed in 16 hips and grade-II in two. Of these 18 THRs, eight had required revision of the acetabular component.

Survivorship. There were no revisions or impending revisions because of aseptic loosening of the femoral component, giving a cumulative survival of the implant of 100% at 16 years (95% CI 89 to 100) (Table II, Fig. 2). The cumulative survival of all acetabular components was 77% at a follow-up of 16 years. The individual survivorship for cemented polyethylene components was 59% and for uncemented cancellous screw fixation components 86% at the same interval (Table III, Fig. 3).

Discussion

The long-term results of cemented THR in elderly and low-demand patients can be excellent,15-17 but in young and active patients they are variable, although some studies have shown excellent results in this age group.18,19 The Furlong HAC-coated femoral stem was introduced in 1985 with the intention of obtaining a permanent bond between the implant and host bone. This has been substantiated by studies which have shown excellent long-term results in both elderly and young patients, including revisions.5,20-23

The initial report on our series of young patients at a mean follow-up of ten years found 100% survival for the femoral component.5 Extended follow-up of the same group at a mean of 16 years has found no aseptic loosening in any of these implants.

New bone grows into the HA coating on the prosthesis at about the same rate as that of the healing of a fracture. 24 Living bone replaces the HA over time and in these circumstances new bone grows on to the titanium prosthesis without an intervening layer of fibrous tissue.24 The HA-coated component forms a strong bond to the host bone, which is comparable to the strength of the cortical bone itself.25 Radiographs show new trabeculae in the proximity of load-bearing areas of the femoral component indicating that new bone is laid down where it is most needed. Relative osteopenia occurs in areas of stress shielding (Fig. 1). If the geometry of the implant allows new bone to grow into the HA coating in this manner it will create a sealing effect and limit the migration of wear particles around the implant thereby protecting osteolysis induced by these particles.

The poor survivorship of the polyethylene acetabular components in our series may have been due to a variety of

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<td>0.3332</td>
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Fig. 3

The cumulative survival curve with revision of any acetabular component as the endpoint with the 95% confidence interval shown.
factors such as an abducted position of the component, the use of polyethylene which had to be sterilised in air and the use of heads of 32 mm diameter which is a known risk factor for polyethylene wear. Despite the fact that the HAC Furlong femoral components were exposed to the same particle load associated with acetalubar failure there was no case of aseptic loosening and any bone loss was limited to Gruen zone 7 without compromising fixation. We observed bone loss of between 2 mm and 5 mm in 11 patients just beneath the collar of the femoral component which we believe was due to stress shielding. We think that the collar of the Furlong stem helps to provide early mechanical stability until host bone has bonded to the HA coating. The stress-shielding effect of the collar was never seen to produce progressive lysis.

Concerns have been expressed about the migration of HA particles into the joint space resulting in third-body wear.26 Bauer et al27 compared the surface roughness of the femoral head and polyethylene in HA- and porous-coated, and cemented THRs. The HA hips had the best surface characteristics and they were unable to detect HA particles within polyethylene.

In this series of young patients we did not see the crack microfracture phenomenon around any femoral component28 and no patient reported pain in the anterior thigh. Such pain is thought to occur in the presence of movement of the femoral component and has been described with other implants with an incidence of between 4% and 22%.10,29-31 The absence of this problem in our series is probably due to the good initial mechanical stability provided by the geometry of the prosthesi[s] until permanent fixation is provided by bone integration. It may also be related to the modulus of elasticity of the titanium implant and to the bonding of the bone throughout its length.23,32 At a mean follow-up of 16 years the Furlong HAC-coated femoral component gives excellent fixation in young and active patients.

The authors wish to thank R. Knight for her help with the project and K. Grayson (Statistics by Design) for her help with the statistics. No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

Resultados a largo plazo de un vástago femoral recubierto de hidroxiapatita en reemplazos totales de cadera

Estudio con seguimientos de entre 15 y 21 años

Entre 1986 y 1991 implantamos de modo consecutivo 331 vástagos Furlong recubiertos de hidroxiapatita para el reemplazo total de cadera de 291 pacientes. Se empleó una prótesis acetabular cementada en 217 caderas y un componente recubierto de hidroxiapatita en 114. Describimos la supervivencia a largo plazo tanto clínica como radiológica del componente femoral con un seguimiento medio de 17.5 años (15 a 21). Sólo dos pacientes (0.68%) fueron perdidos durante el seguimiento. Tomando la revisión del componente femoral por cualquier causa como el punto final, la supervivencia a una media de 17 años fue del 97.4% (intervalo de confianza al 95% de 94.1 a 99.5), y tomando la revisión por aflojamiento aséptico como punto final, ésta fue del 100%. La supervivencia a un máximo de 21 años, tomando la revisión del componente femoral por cualquier motivo como punto final, fue del 97.4% (intervalo de confianza al 95% de 81.0 a 99.5). Estos resultados superan a los mejores obtenidos a largo plazo con componentes femorales cementados o no cementados en el reemplazo total de cadera.
Long-term results of a hydroxyapatite-coated femoral component in total hip replacement
A 15- TO 21-YEAR FOLLOW-UP STUDY

Between 1986 and 1991 we implanted 331 consecutive Furlong hydroxyapatite-coated femoral components of a total hip replacement in 291 patients. A cemented acetabular prosthesis was used in 217 hips and a hydroxyapatite-coated component in 114. We describe the long-term clinical and radiological survival of the femoral component at a mean follow-up of 17.5 years (15 to 21). Only two patients (0.68%) were lost to follow-up. With revision of the femoral component for any reason as the endpoint, the survival at a mean of 17 years was 97.4% (95% confidence interval 94.1 to 99.5), and with revision for aseptic loosening as the endpoint it was 100%. The survival at a maximum of 21 years with revision of the femoral component for any reason as the endpoint was 97.4% (95% confidence interval 81.0 or 99.5). These results compare favourably with the best long-term results of cemented or uncemented femoral components used in total hip replacement.

Patients and Methods
Between 1986 and 1991, in Hastings, United Kingdom, we performed 331 total hip replacements (THRs) in 291 patients with a mean age of 71.2 years (31.1 to 89.8). A total of 40 patients had bilateral THRs, 30 under anaesthetic and ten in a staged procedure.

All the patients had a Furlong HA-coated femoral component. A 32 mm modular ceramic head and were allowed to bear weight fully immediately after surgery.

The patients were reviewed clinically and radiologically at 6, 12, 26 and 52 weeks after operation and annually thereafter. Antero-posterior radiographs of the pelvis and lateral radiographs of the hips were taken and the Merle d’Aubigne and Postel hip score was used for the assessment of pain, mobility and function.

The stability and fixation of the femoral component was assessed by two independent observers (SSR, CJ) by a consensus of opinion. The appearance of radiolucencies around the component according to Gruen, McNiece and Amstutz was noted, as was subsidence on serial radiographs, the presence of increased bone density suggesting bony ingrowth, and the appearance of radiolucent lines and pedestal formation at the tip of the stem. An assessment of the radiographs was also made for evidence of stress shielding and of each Gruen zone for osteopenia.

Results
The patients were followed up for a mean of 17.5 years (15 to 21). A total of 184 patients (63.2%; 211 hips) had died by the final follow-up. All had been reviewed within one year of their death and were therefore included in the survival analysis.

Of the remaining 107 patients with 120 THRs, 15 failed to attend the final review and
were contacted via an extended telephone interview. Their results are included in the study. Two hips in two patients (0.68%) were lost to follow-up. One had moved abroad 2.5 years after THR and could not be contacted. The other had a well functioning THR at six years post-operatively and refused further review.

Clinical and radiological. The mean Merle D’Aubigne and Postel\(^3\) score recorded for the 92 patients (105 hips) who attended the latest follow-up was 5.63 (3 to 6) for pain, 5.42 (2 to 6) for mobility and 4.50 (0 to 6) for function.

No patient reported anterior thigh pain at any review. Slight rounding of the femoral calcar under the collar was seen in 43 of 105 hips (41%).

There were no cases of aseptic loosening of the femoral component during the study period. In all cases, the femoral component remained well-fixed with no measured migration at the latest follow-up, with radiological evidence of bonding in the form of spot-weld formation\(^2\) into the stem and a blastic reaction at its tip (Figs 1 and 2). Six patients (1.8%) underwent revision of the femoral component for trauma, sepsis or trunion fretting, at which stage their well-fixed femoral component was removed (Table I).

Table I. Details of the revisions of the femoral components

<table>
<thead>
<tr>
<th>Case</th>
<th>Time since THR (yrs)</th>
<th>Indication for revision</th>
<th>Treatment</th>
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<tr>
<td>1</td>
<td>10</td>
<td>Traumatic loosening of both components following road traffic accident</td>
<td>One-stage revision of femoral component</td>
</tr>
<tr>
<td>2</td>
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<td>Late infection following road traffic accident</td>
<td>Two-stage revision of both components</td>
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<tr>
<td>3</td>
<td>13</td>
<td>Loosening of the acetabular component Infection</td>
<td>One-stage revision Two-stage revision of both components</td>
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<tr>
<td>4</td>
<td>1</td>
<td>Acetabular loosening leading to dissociation of ceramic head from trunion</td>
<td>One-stage revision of femoral component and acetabulum</td>
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<td>5</td>
<td>9</td>
<td>Sepsis</td>
<td>Two-stage revision of femoral component</td>
</tr>
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<td>6</td>
<td>8</td>
<td>Peri-prosthetic fracture and loosening</td>
<td>One-stage revision of femoral component</td>
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</tbody>
</table>

*THR, total hip replacement

Fig. 1
Anteroposterior pelvic radiograph showing well-fixed bilateral Furlong hydroxyapatite-coated femoral components and threaded acetabular components, 17 years after total hip replacement.

Fig. 2
Lateral radiograph of the hip showing a well-fixed Furlong hydroxyapatite-coated total hip replacement 17 years after operation.
There were 30 revisions (9.1%) of the acetabular component for infection (3 hips), dislocation (4 hips), aseptic loosening (18 hips) and polyethylene wear (5 hips).

Per-operative fracture. There were 16 (4.8%) per-operative fractures, all of which were iatrogenic fractures of the anterior femoral cortex. In 15 hips (15 patients) a minor per-operative proximal fracture of the femur was identified during implantation of the femoral component, as previously described. All patients with per-operative fractures identified during surgery were mobilised non-weight-bearing for six weeks. In one patient, a cerclage wire was used to stabilise the fracture. All patients with iatrogenic proximal fractures of the femur sustained during insertion of the stem went on to unite satisfactorily, and did not suffer any long-term consequences.

Survival analysis. The life-table survival for the femoral component (including the six revisions) at a mean of 17 years was 97.4% (95% confidence interval (CI) 94.1 to 99.5) and at a maximum of 21 years was 97.4% (95% CI 81.0 to 99.5) (Table II, Fig. 3). Figure 4 shows the worst case scenario, including the two patients lost to follow-up.

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<th>Withdrawn</th>
<th>Number at risk</th>
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<th>95% CI</th>
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* 95% CI, 95% confidence interval

Kaplan Meier survival curve (with 95% confidence intervals) with revision of the femoral component for any reason as the endpoint.

Kaplan Meier survival curve (with 95% confidence intervals) showing the worst case scenario. The two cases lost to follow-up have been included as stem failures.
Discussion

Previous studies on the Furlong HA-coated femoral component have shown excellent medium-term survival when used as a primary or revision implant. Our current series includes the first 100 Furlong HA-coated THRs which were previously reported at a mean of ten years (9 to 12), with a 100% follow-up and a survival of 98.95% at up to 12 years, with no cases of aseptic loosening of the femoral stem. The Furlong HA-coated THR has also successfully been used in younger patients. Singh et al reported the successful use of this implant in patients below the age of 50 years with a 100% survival of the femoral component at a mean of ten years (5.3 to 14.2). Robertson et al had a 95.3% survival of the femoral component at a mean of 8.8 years (5 to 13.8) in patients less than 55 years of age. They did not identify any cases of aseptic loosening of the femoral component.

The Furlong HA-coated THR has provided impressive medium-term results as a revision implant. At a mean follow-up of eight years (5 to 12.4) Trikha et al reported survival of the femoral component of 100% with aseptic loosening as the endpoint, while Raman et al found similarly good results with survival of 95.6% at a mean follow-up of 12 years when revising cemented THRs. In our series of 331 consecutive THRs, survival of the femoral component at a mean of 17 years was 97.4% (95% CI 94.1 to 99.5) and at a maximum of 21 years was 97.4% (95% CI 81.0 to 99.5), with revision for any reason as the endpoint. With aseptic loosening of the femoral component as the endpoint, the survival would be 100%. These figures are similar to those in the literature for the same femoral component.

The length of follow-up achieved in this study is largely attributable to the static elderly population of our region. Only two of the 331 THRs were unaccounted for, thereby reducing the errors in the survival analysis highlighted by Murray, Britton and Bulstrode. The Merle D’Aubigne and Postel hip scoring system for the assessment of pain, mobility and function has been used since the commencement of this study. However, the mobility and function scores achieved at the latest follow-up were influenced by the advancing age of the patients as the follow-up extended. This explains the good mean scores of 5.63 for pain and 5.42 for mobility, but the relatively modest score of 4.50 for function.

The collar on the femoral component prevents early subsidence of the prosthesis after implantation. Once bone has bonded to the prosthesis, its function becomes redundant. This may account for the rounding of the bone under the anterior femoral cortex. Anterior thigh pain has been reported previously with cemented hip prostheses. We would like to thank our research assistants Mrs. K. Goddard, Ms K. Miles and Mrs. D. East for their invaluable efforts over the last 20 years in making this prospective study possible.

References

Resultados de un reemplazo total de cadera recubierto de hidroxiapatita (Furlong)  

Seguimiento de entre 13 y 15 años

Describimos la supervivencia de 134 reemplazos totales de cadera JRI Furlong recubiertos de hidroxiapatita implantados de modo consecutivo. El seguimiento medio fue de 14.2 años (13 a 15).

Los pacientes fueron valorados clinicamente utilizando la escala de Merle d’Aubigne y Postel. Las radiografías fueron evaluadas usando las zonas de Gruen para el vástago y las zonas de DeLee y Charnley para el acetábulo. Signos de movilización, líneas de radiotransparencia, formación de hueso endóstico (soldadura por puntos) y formación en pedestal fueron usados para evaluar la fijación y la estabilidad del vástago de acuerdo con los criterios de Engh. El ángulo del cotilo, migración y radiotransparencia fueron usados para evaluar el aflojamiento del acetábulo. El criterio para el fallo fue la revisión o una necesidad de la misma debido a dolor o aflojamiento. El análisis de supervivencia fue realizado utilizando una tabla vital y la curva de Kaplan-Meier.

La media total de la escala Merle d’Aubigne y Postel fue de 7.4 antes de la cirugía y de 15.9 durante el seguimiento. Durante el período de estudio 22 pacientes fallecieron y 6 fueron perdidos para el seguimiento. Ninguno de los acetábulos fue revisado. Un vástago fue revisado por una fractura periprotésica tras caída, pero ninguna fue revisada por aflojamiento, arrojando una tasa de supervivencia del 99% a 13 años. Nuestras observaciones sugieren que los resultados a largo plazo de estas prótesis recubiertas con hidroxiapatita son más que satisfactorios.
Results of a hydroxyapatite-coated (Furlong) total hip replacement
A 13- TO 15-YEAR FOLLOW-UP

We describe the survival of 134 consecutive JRI Furlong hydroxyapatite-coated uncemented total hip replacements. The mean follow-up was for 14.2 years (13 to 15).

Patients were assessed clinically, using the Merle d’Aubigné and Postel score. Radiographs were evaluated using Gruen zones for the stem and DeLee and Charnley zones for the cup. Signs of subsidence, radiolucent lines, endosteal bone formation (spot welds) and pedestal formation were used to assess fixation and stability of the stem according to Engh’s criteria. Cup angle, migration and radiolucency were used to assess loosening of the cup. The criteria for failure were revision, or impending revision because of pain or loosening. Survival analysis was performed using a life table and the Kaplan-Meier curve.

The mean total Merle d’Aubigné and Postel score was 7.4 pre-operatively and 15.9 at follow-up. During the study period 22 patients died and six were lost to follow-up. None of the cups was revised. One stem was revised for a periprosthetic fracture following a fall but none was revised for loosening, giving a 99% survival at 13 years. Our findings suggest that the long-term results of these hydroxyapatite-coated prostheses are more than satisfactory.

Previous studies have reported a 100% ten-year survival for the JRI Furlong (Joint Replacement Instrumentation Ltd, London, UK) hydroxyapatite (HA)-coated femoral prosthesis.1 Although the theoretical advantages of an uncemented prosthesis, especially in the younger patient, are becoming more established,2 little long-term data exist on their use in practice. We present a prospective study of the HA-coated uncemented JRI Furlong femoral component.

Patients and Methods
All patients who required a primary total hip replacement under the care of one surgeon (CR) between November 1989 and December 1991 were entered into the study. There were no exclusion criteria. This longitudinal cohort of 116 consecutive patients (134 hips) was followed up prospectively. The mean age of patients was 75 years (26 to 95) with 88 women and 28 men; 66 hips were right-sided, 32 were left-sided and 36 were bilateral (ten simultaneous, eight consecutive). The indications for surgery and the pre-operative Charnley functional categories

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<tr>
<th>Pre-operative diagnoses</th>
<th>Number of hips</th>
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<td>Osteoarthritis</td>
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</tr>
<tr>
<td>Avascular necrosis</td>
<td>3</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>2</td>
</tr>
<tr>
<td>Post-traumatic</td>
<td>1</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>1</td>
</tr>
<tr>
<td>* dysplasia (four hips), slipped upper femoral epiphysis (one hip)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pre-operative Charnley category² for the 116 patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
</tr>
<tr>
<td>Class A, unilateral hip disease only</td>
</tr>
<tr>
<td>Class B, bilateral hip disease only</td>
</tr>
<tr>
<td>Class C, multiple orthopaedic and/or medical problems</td>
</tr>
</tbody>
</table>

The patients were operated upon by the same surgeon (CR) through an anterolateral (Watson-Jones) approach. All had a fully HA-coated JRI stem and either a 28-mm cobalt-chrome or ceramic head. The acetabular component was either an HA-coated threaded or a surface fixation cup (JRI Ltd, London, UK) (Table III). The change to a surface fixation cup during the study was a result of it being readily available and, for the surgeon, technically sim-
pler to use. Ten patients also had a femoral head autograft for acetabular deficiency. Immediate weight-bearing was encouraged post-operatively and all patients received routine antibiotic and deep-vein thrombosis prophylaxis.

The patients were assessed pre-operatively and at six weeks, three months, one, two and five years, and subsequently recalled for clinical and radiological review for this study. The mean follow-up was 14.2 years (13 to 15).

Clinical assessment was performed using Charnley’s modification of the Merle d’Aubigné and Postel scores. In addition to overall pain, range of movement and walking score, we specifically asked about thigh pain.

Standardised anteroposterior (AP) and lateral radiographs were used for radiological assessment. The AP projection was based on the symphysis pubis and was taken at a standard distance of 1 m. The post-operative radiographs were assessed by Gruen zones for the femoral component and DeLee and Charnley zones for the acetabular component.

The fixation and stability of the stem were assessed using Engh’s radiological score for uncemented prostheses. This has two scales, fixation (maximum ten points) and stability (maximum 17 points). The higher the score, the better the fixation and stability. The degree of subsidence was also

### Table III. Details of the implants used

<table>
<thead>
<tr>
<th>Acetabular cup*</th>
<th>Number of hips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threaded</td>
<td>112</td>
</tr>
<tr>
<td>Surface fixation cup</td>
<td>22</td>
</tr>
<tr>
<td>Femoral head†</td>
<td></td>
</tr>
<tr>
<td>Ceramic</td>
<td>88</td>
</tr>
<tr>
<td>Cobalt-chrome</td>
<td>46</td>
</tr>
</tbody>
</table>

* all cups had a polyethylene insert    † femoral heads were all 28 mm in size and all femoral stems were fully hydroxyapatite-coated

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![Annotated radiograph showing the reference line used to measure subsidence and the Gruen zones with the incidence of endosteal bone formation (EBF) or spot welds and reactive lines (RL).](image)

**Fig. 1**
Results

During the study period 22 patients died and six were lost to follow-up. The Merle d’Aubigné and Postel scores improved for all patients, except one who developed Brooker grade IV heterotopic ossification. The mean total score rose from 7.4 (SD 1.5) at pre-operative assessment to 15.9 (SD 1.8) at follow-up with each component of the score showing an improvement (Table IV). No patient complained of thigh pain.

The mean Engh score for fixation and stability was 24.7 (10 for fixation and 14.7 for stability). In 109 stems (81%) there was a pedestal at its tip (Fig. 3). The development of endosteal bone formation in the form of spot welds is shown in Figure 1. There were no reactive lines at the bone-

measured by changes in the vertical distance between the tip of the greater trochanter and the most proximal point on the implant; a change of more than 2 mm was considered to be evidence of subsidence (Fig. 1). Spot welds were defined as the presence of new bone formation bridging the gap between the endosteal surface and the surface of the implant. A bone pedestal was defined as a shelf of endosteal new bone, either partially or completely bridging the intramedullary canal, at the tip of the implant. Calcar remodelling was recorded as hypertrophic, atrophic or indifferent.7

Migration of the acetabular component was defined as significant if there was a > 3 mm linear change (medial, superior or both) in relation to either Kohler’s or the interteardrop line.8 Rotational change was regarded as significant if there was a change of > 3° in the angle of the acetabular component (Fig. 2).

Radiolucent and sclerotic lines at the acetabular and femoral interfaces were also measured. A significant reactive line was classified as a lucency at the bone-implant interface if it was 2 mm wide and occupied at least 50% of any one Gruen or DeLee and Charnley zone.6 The formation of heterotopic ossification was graded according to the method described by Brooker et al.9

The criteria for failure were either revision or an impending revision because of pain or loosening.

The patients were assessed pre-operatively and at six, one, two and five years, and subsequently antibiotic and deep-vein thrombosis prophylaxis.

for acetabular deficiency. Immediate weight-bearing was encouraged post-operatively and all patients received rou-

pler to use. Ten patients also had a femoral head autograft

† femoral heads were all 28 mm in size and all fem-

* all cups had a polyethylene insert

<table>
<thead>
<tr>
<th>Femoral head†</th>
<th>Acetabular cup*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-chrome</td>
<td>46</td>
</tr>
<tr>
<td>Ceramic</td>
<td>88</td>
</tr>
<tr>
<td>Surface fixation cup</td>
<td>22</td>
</tr>
<tr>
<td>Threaded</td>
<td>112</td>
</tr>
</tbody>
</table>

Table III. Details of the implants used

92%

RL = 0%

EBF = 94%

RL = 0%

EBF = 100%

RL = 0%

EBF = 84%

RL = 0%

EBF = 100%

RL = 0%

EBF = 98%

RL = 0%

EBF = 74%

RL = 0%

EBF = 80%

RL = 0%

EBF = 100%

RL = 0%
RESULTS OF A HYDROXYAPATITE-COATED (FURLONG) TOTAL HIP REPLACEMENT

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stem interface, no changes at the interface and no subsid-
ence or osteolysis in any of the radiographs studied.

With regard to the acetabular component, there was
deoosteal bone formation in DeLee and Charnley zones 1
and 3 in all hips and in and zone 2 in 112 hips (84%,
Fig. 2). No reactive lines were seen in any zone, for any
component. There was no migration in either a vertical or a
horizontal direction and no change in cup angle.

Complications. There were two deep-vein thromboses, one
of which progressed to a fatal pulmonary embolus. There
were also two transient femoral nerve palsies and one tran-
sient common peroneal nerve palsy. There was one late
depth infection with a persistent sinus and one femoral stem
revision for fracture after significant trauma. Five patients
had Brooker grades III and IV heterotopic ossification
(Table V).

Survival analysis. In constructing a survival analysis, we
did not assume that the six patients who were lost to fol-
low-up had similar results to those who were contactable.
Evidence suggests that the former group of patients may
have worse outcomes than the latter. None of the 22
patients (27 hips) who died during the study period were
revised or were awaiting revision. At their last review, two
to six years after surgery, all hips were well fixed and func-
tioning well. We therefore constructed a life table (Fig. 4)
using best and worse case scenarios to account for those
patients who were lost to follow-up.

Discussion

Our series shows a survival rate of 99% at 13 years (95%
confidence interval 94 to 100), equal to other published
series of HA-coated femoral components and superior
to other cementless implants. This is also the case when
using our worst case scenario, accounting for patients who
were lost to follow-up.

Clinical results were very satisfactory with excellent
improvement in the patients’ Merle d’Aubigné and Postel
scores. Deterioration in this score was seen in only one
patient with unknown ankylosing spondylitis and who
developed Brooker grade IV heterotopic ossification.
Another significant feature of our study was the absence of
thigh pain, in contrast with reports of other cementless fem-
oral components without HA-coating.

Table IV. Merle d’Aubigné and Postel clinical scores

<table>
<thead>
<tr>
<th></th>
<th>Mean pre-operative</th>
<th>Mean post-operative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>2.2</td>
<td>5.8</td>
</tr>
<tr>
<td>Mobility</td>
<td>2.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Ability to walk</td>
<td>2.4</td>
<td>5.4</td>
</tr>
<tr>
<td>Total</td>
<td>7.4</td>
<td>15.9</td>
</tr>
</tbody>
</table>

* maximum score is 18 (6 for each category)

Table V. Post-operative complications

<table>
<thead>
<tr>
<th></th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dislocation</td>
<td>2</td>
</tr>
<tr>
<td>Thromboembolic</td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>1</td>
</tr>
<tr>
<td>Deep-vein thrombosis</td>
<td>2</td>
</tr>
<tr>
<td>Infection</td>
<td></td>
</tr>
<tr>
<td>Superficial</td>
<td>3</td>
</tr>
<tr>
<td>Deep (with sinus)</td>
<td>1</td>
</tr>
<tr>
<td>Nerve palsies</td>
<td></td>
</tr>
<tr>
<td>Femoral</td>
<td>2</td>
</tr>
<tr>
<td>Common peroneal</td>
<td>1</td>
</tr>
<tr>
<td>Intra-operative fractures</td>
<td></td>
</tr>
<tr>
<td>Femur - minor (anterior/posterior cortex)</td>
<td>6</td>
</tr>
<tr>
<td>- major (shaft)</td>
<td>2</td>
</tr>
<tr>
<td>Acetabulum (posterior wall)</td>
<td>1</td>
</tr>
<tr>
<td>Brooker grade</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>44</td>
</tr>
<tr>
<td>I</td>
<td>68</td>
</tr>
<tr>
<td>II</td>
<td>17</td>
</tr>
<tr>
<td>III</td>
<td>3</td>
</tr>
<tr>
<td>IV</td>
<td>2</td>
</tr>
</tbody>
</table>

* all transient
† common peroneal palsy followed a deep-vein thrombosis
The mean Engh's radiological score in our series was 24.7, representing excellent stability and fixation, with the presence of spot welds and absence of radiolucent lines. Engh described satisfactory bony ongrowth as a total score of ten points or more. Calcar atrophy, a positive sign of stability, was noted in our study and in that by Engh early in the follow-up and was found to be non-progressive.

Radiological changes around the acetabular components showed evidence of bony ongrowth with no signs of secondary or impending loosening. Gap healing and remodeling of cysts around the acetabulum was also seen. For the ten patients who received a femoral head autograft for acetabular deficiency, all showed incorporation of the graft, as demonstrated by trabecular re-orientation without evidence of significant graft resorption. In our series there was no specific complication related to the implant fixation by HA-coating. The incidence of intraoperative fractures seemed to be related to the experience of the surgeon in using this prosthesis. All the fractures were managed conservatively and united uneventfully without any long-term effect on the stability, fixation, or clinical outcome. HA-coating may even have improved the chance of fracture union. One patient, who had a deep infection with a persistent sinus, surprisingly did not show any evidence of stem loosening. Our incidence of heterotopic ossification was comparable with other reported series. The only prosthetic failure in our series was one periprosthetic femoral fracture. However, during the revision it was noted that the stem was well fixed.

Our study shows a 99% survivorship at 13 to 15 years’ follow-up for total hip arthroplasty using these components, adding long-term evidence to earlier, published series. HA-coating of implants appears to offer a satisfactory solution to fixation. However, a valid concern may be later failure as a consequence of polyethylene wear.

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

References