THE JOURNAL OF BONE & JOINT SURGERY (Br)

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 previously[5] (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. Cobalt-chrome 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 scale[9] 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 Amstutz[11] using the criteria of Goetz, Smith and Harris.[12] The femoral component was considered to be stable if there

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doi:10.1302/0301-620X.91B7.22311 $2.00

J Bone Joint Surg [Br] 2009;91-B:865-9.
Received 16 January 2009; Accepted after revision 27 February 2009

Table I. The indications for total hip replacement and the distribution of implants in the original series of 33 patients (38 hips)[5]

Diagnoses		**Implants**	
Osteoarthritis	19	HAC* Furlong stem	38
Developmental dysplasia	10		
Post-traumatic arthritis	3	**Acetabular components**	
Perthes' disease	2	Cemented polyethylene	14
Slipped upper femoral epiphysis	1	JRI cancellous screw fixation HAC-coated with polyethylene liners	24
Rheumatoid arthritis	1		
Still's disease	2	**Modular heads**	
		Alumina ceramic	36
		28 mm diameter	23
		32 mm diameter	13
		Cobalt chrome	2
		28 mm diameter	1
		32 mm diameter	1

* HAC, hydroxyapatite-ceramic

Fig. 1

Radiograph showing the Furlong hydroxyapatite-ceramic-coated hip replacement with the Gruen zones.[11] Increased formation of bone is seen in zones 2 to 6 and rounding of the calcar under the collar in zone 7.

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.[13] 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.[14]

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[5] 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).[5] 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[5] 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.

Table II. The cumulative survival for the Furlong stem

Years since operation	Number at start	Failure	Withdrawn	Number at risk	Effective number at risk	Cumulative survival rate (%)	95% lower	95% upper
0 to 1	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
1 to 2	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
2 to 3	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
3 to 4	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
4 to 5	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
5 to 6	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
6 to 7	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
7 to 8	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
8 to 9	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
9 to 10	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
10 to 11	34	0	0	34.0	34.0000	1.0000	0.8985	1.0000
11 to 12	34	0	1	33.5	33.9578	1.0000	0.8984	1.0000
12 to 13	33	0	5	30.5	33.6642	1.0000	0.8976	1.0000
13 to 14	28	0	6	25.0	32.8510	1.0000	0.8953	1.0000
14 to 15	22	0	6	19.0	31.3284	1.0000	0.8908	1.0000
15 to 16	16	0	1	15.5	29.1884	1.0000	0.8837	1.0000
16 to 17	15	0	5	12.5	26.5726	1.0000	0.8737	1.0000
17 to 18	10	0	2	9.0	23.2130	1.0000	0.8580	1.0000
18 to 19	8	0	7	4.5	17.8784	1.0000	0.8231	1.0000
19 to 20	1	0	1	0.5	5.3389	1.0000	0.5815	1.0000

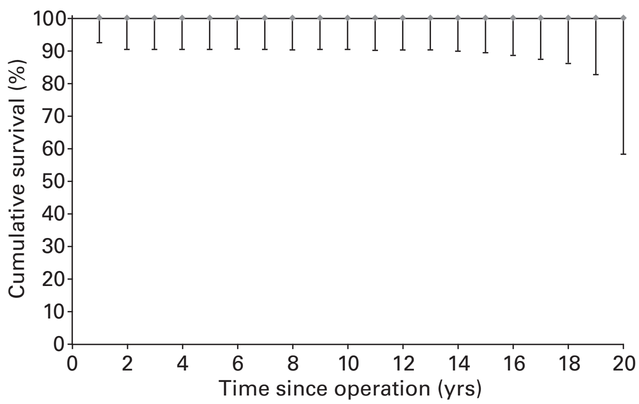

Fig. 2

The cumulative survival curve for the Furlong femoral component with the 95% confidence interval shown.

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.[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

Table III. The cumulative survival table with revision of any acetabular component as the endpoint

Years since operation	Number at start	Failure	Withdrawn	Number at risk	Effective number at risk	Cumulative survival rate (%)	95% lower	95% upper
0 to 1	26	0	0	26.0	26.0000	1.0000	0.8713	1.0000
1 to 2	26	0	0	26.0	26.0000	1.0000	0.8713	1.0000
2 to 3	26	0	0	26.0	26.0000	1.0000	0.8713	1.0000
3 to 4	26	0	0	26.0	26.0000	1.0000	0.8713	1.0000
4 to 5	26	0	0	26.0	26.0000	1.0000	0.8713	1.0000
5 to 6	26	0	0	26.0	26.0000	1.0000	0.8713	1.0000
6 to 7	26	0	0	26.0	26.0000	1.0000	0.8713	1.0000
7 to 8	26	1	1	25.5	25.9364	0.9608	0.8097	0.9930
8 to 9	27	1	1	26.5	25.9979	0.9245	0.7605	0.9793
9 to 10	28	3	3	26.5	26.0472	0.8199	0.6350	0.9225
10 to 11	31	3	3	29.5	26.3273	0.7365	0.5463	0.8664
11 to 12	34	0	1	33.5	26.8056	0.7365	0.5481	0.8656
12 to 13	33	0	5	30.5	27.0577	0.7365	0.5490	0.8652
13 to 14	28	0	6	25.0	26.8996	0.7365	0.5484	0.8654
14 to 15	22	0	6	19.0	26.1741	0.7365	0.5457	0.8667
15 to 16	16	0	1	15.5	25.0359	0.7365	0.5413	0.8688
16 to 17	15	0	5	12.5	23.4127	0.7365	0.5344	0.8719
17 to 18	10	0	2	9.0	21.0282	0.7365	0.5230	0.8769
18 to 19	8	0	7	4.5	16.7207	0.7365	0.4968	0.8878
19 to 20	1	0	1	0.5	5.2473	0.7365	0.3332	0.9399

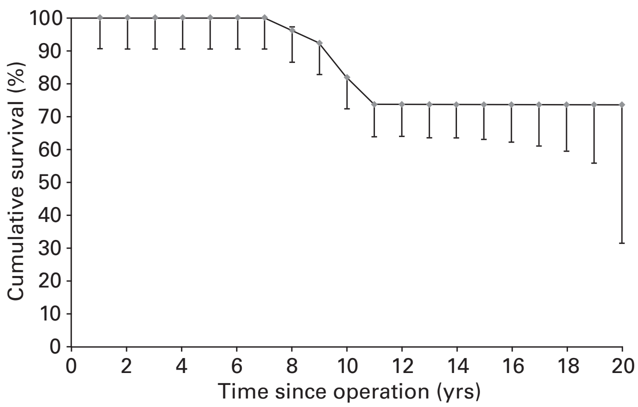

Fig. 3

The cumulative survival curve with revision of any acetabular component as the endpoint with the 95% confidence interval shown.

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 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 acetabular 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 al[27] 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 component[28] 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 prosthesis 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 .

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