The results at nine to twelve years of the use of a hydroxyapatite-coated femoral stem

Scarlett A. McNally, John A. N. Shepperd, Charles V. Mann, Jonathan P. Walczak

From Conquest Hospital, Hastings, England

We describe the clinical and radiological outcome of 100 consecutive total hip replacements in 86 patients using the JRI Furlong hydroxyapatite-coated femoral component. The follow-up was 100% at a mean of ten years (9.0 to 12.0). All 54 living patients (62 hips) were examined annually. Their mean Merle d'Aubigné score was 5.8/5.6/4.6. A total of 32 patients had died. Their notes at the last annual assessment recorded a similar outcome to that of the living patients. Radiographs showed no radiolucent lines around any femoral component and there were no signs of impending failure. One patient required excision arthroplasty, but the femoral component had been bonded satisfactorily. There have been no other revisions of femoral components. Our findings suggest that the hydroxyapatite coating gives a satisfactory prosthesis-bone interface which is preferable to any other system.

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There is a paucity of long-term follow-up studies of total hip replacement (THR).¹ We describe the ten-year results of a prosthesis with a hydroxyapatite (HA)-coated femoral stem and a collar (Fig. 1).

Patients and Methods

Between February 1986 and February 1989, we performed 100 consecutive THRs in 86 patients using the JRI Furlong HA-coated femoral component (JRI Instrumentation Ltd, London, UK). A 32 mm ceramic head was used and the ultra-high-density polyethylene cup was cemented. The age

range of patients was 45 to 94 years with most aged between 65 and 79 years. The mean follow-up was for ten years (9 to 12). The operation was carried out by one of two surgeons (JANS or trainee under supervision) using a Watson-Jones approach. Bilateral procedures were performed in sequence under the same anaesthetic. Immediate full weight-bearing was encouraged after surgery and patients were discharged as soon as possible.

All patients were then seen at six weeks, three and six months, one year and then annually for a clinical and radiological review.

At each review we noted documented complications, the requirement for revision and the visual analogue scale for pain, assessed the Merle d'Aubigné and Postel (MDP) score for pain, range of movement and function,² and obtained radiographs of the pelvis and hips. On the visual

Fig. 1

Photograph of the prosthesis. The femoral stem is fully coated with HA.

S. A. McNally, BSc, FRCS (Tr & Orth), Specialist Registrar
J. A. N. Shepperd, FRCS, Consultant
C. V. Mann, FRCS, Research Registrar
J. P. Walczak, FRCS Orth, Specialist Registrar
Department of Orthopaedics, Conquest Hospital, The Ridge, Hastings
TN37 7RD, UK.

Correspondence should be sent to Mrs S. A. McNally.

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Table I. Survival analysis of the 100 hips (confidence limits were calculated from the Rothman formula⁵)

Year	Number of patients at start	Failure	Withdrawn	Number at risk	Effective at risk	Annual failure rate (%)	Annual success rate (%)	Stem survival rate (%)	95% CI stem	Cup survival rate (%)	95% CI cup
0 to 1	100	0	3	98.5	99.0	0.0	100.0	100.0	1.0 to 0.94	100.00	1.0 to 0.94
1 to 2	97	1	3	95.5	97.56	1.04	98.95	98.95	0.99 to 0.94	98.95	0.99 to 0.94
2 to 3	93	0	3	91.5	95.54	0.0	100.0	98.95	0.99 to 0.94	98.95	0.99 to 0.94
3 to 4	90	0	4	88.0	93.67	0.0	100.0	98.95	0.99 to 0.94	98.95	0.99 to 0.94
4 to 5	86	0	5	83.5	91.57	0.0	100.0	98.95	0.99 to 0.94	98.95	0.99 to 0.94
5 to 6	81	0	2	82.0	89.95	0.0	100.0	98.95	0.99 to 0.94	98.95	0.99 to 0.94
6 to 7	79	0	2	78.0	88.05	0.0	100.0	98.95	0.99 to 0.94	98.95	0.99 to 0.94
7 to 8	77	0	5	74.5	86.11	0.0	100.0	98.95	0.99 to 0.94	98.95	0.99 to 0.94
8 to 9	72	0	7	68.5	83.79	0.0	100.0	98.95	0.99 to 0.93	98.95	0.99 to 0.93
9 to 10	65	1	4	63.0	81.16	1.58	98.42	98.95	0.99 to 0.93	97.38	0.99 to 0.91
10 to 11	21	1	39	40.5	74.42	2.46	97.54	98.95	0.99 to 0.93	94.98	0.98 to 0.87
11 to 12	20	0	0	20.0	60.66	0.0	100.0	98.95	1.0 to 0.92	94.98	0.98 to 0.86
12 to 13	20	0	20	10.0	43.65	0.0	100.0	98.95	1.0 to 0.89	94.98	0.99 to 0.83

analogue scale zero represented no pain and 10 the worst possible pain. The AP radiographs were analysed by two authors independently who were blinded to the clinical result. They noted radiolucencies around the cemented acetabulum in zones 1, 2 and 3 of DeLee and Charnley³ and their size in millimetres, radiolucencies around the stem, the distance between the collar and remaining calcar femorale, the presence or absence of an osteoblastic reaction at the tip suggesting bone ingrowth on to the HA-coated stem and the presence and size of a distinct

‘pedestal’ or ‘shelf’ at the tip of the femoral prosthesis.

A survival analysis was constructed using a life table (Table I), with the effective number at risk and confidence intervals calculated.^{4,5} Survivorship was defined as either not awaiting revision or having had a revision and with a MDP pain score of 5 or 6.

Results

Because of our generally static population, we were able to trace every living patient, including those who had moved out of the area. There was no loss to follow-up. We reviewed the notes of deceased patients of whom all except one had been seen for clinical review within one year of death.

Complications. In 11 hips there was a minor peroperative fracture, usually described as ‘yawning of the anterior femoral cortex’. In one case a wire was used, but in the others the prosthesis was inserted as originally planned. If structural strength was in doubt, the patient was not allowed to bear weight for six weeks. Subsequent radiography showed no adverse consequences. At ten years it was not possible to detect evidence of a previous fracture.

There were three acetabular revisions. In two patients the stem was sound and was left intact. In the remaining patient, who had multiple injuries, both the stem and cup were removed for presumed sepsis after a late hip replacement for acetabular fracture.

In one patient an ipsilateral supracondylar nail became infected and both the femoral and acetabular components were removed. Infection was not proved. The femoral component was firmly bonded and difficult to remove. The retrieved implant is shown in Figure 2. Five years later this patient had a new hip replacement. Her MDP scores of 6.3.2 are included in the analysis of the data. There were no other cases of infection.

Dislocation occurred in one patient, three months after

Fig. 2

Detail of the stem removed from a hip in the series. Cancellous bone is seen firmly adherent to the implant.

Fig. 3a

Fig. 3b

Radiographs showing a) a femoral fracture which occurred following an injury four years after arthroplasty, and b) union of the fracture after conservative management with no detrimental effects four years later.

insertion of the prosthesis and was treated by closed manipulation under anaesthesia.

Two patients sustained fractures of the femur around the stem after falls. One occurred at four years and one at six years after the original procedure. Both were managed conservatively. Subsequent radiographs showed the fractures to be united, with no untoward features pertaining to the total hip replacement. At review four years after fracture there was secure femoral fixation (Fig. 3).

Clinical results. Nine to 12 years after their THR 54 patients (62 hips) were still alive and all were seen for clinical review. One with a visual analogue pain score of 4 had spinal stenosis and reported constant pain in both legs. In 37 hips the score for pain was zero. Figure 4 gives a scattergram of all visual analogue scores. The mean rating for each patient was 1.2 ± 0.612 . No patient complained of anterior thigh pain.

Using the MDP score,²² 49 hips had a score of 6 for pain

(Fig. 5a). The patient with a score of 4 had revision of the cup after this assessment. The MDP scores for range of movement are shown in Figure 5b. The hip with a score of 3 was removed with subsequent conversion to a second total hip replacement. Figure 5c shows the MDP scores for function which correlate with age and comorbidity. The mean age was 77 years with 14 of 53 patients aged over 85 years. Nine are still working and 28 regularly undertake strenuous activities.

Of the deceased patients, none had been waiting for a revision. Their MDP scores were similar to those of living patients.

Radiological findings. Of the 62 hips of patients still alive, radiographs were available for 61. Eight were visited at home of whom four had radiographs taken within one year and three within two years previously. Radiolucencies around the acetabulum in one or more zones were seen in 22 hips (36%). These occurred at the cement-bone interface and were 0.5 mm (90%) or 1 mm (10%) wide. One hip showed lucencies in all three zones, and was subsequently revised. There was no measurable correlation between the presence of radiolucent lines around the acetabulum and any clinical outcome measure. No radiolucent lines or granulomas were seen around any of the femoral stems in any zone. The mean distance between the collar and the calcar was 2.58 ± 3.3 mm, with 17 hips having no gap. The patient with a distance of 20 mm had had a varus osteotomy for osteoarthritis of the hip. The femoral component was in valgus.

An osteoblastic reaction was seen around the tip of the femoral component in all except one hip, a revision of a failed cemented arthroplasty. In 22 hips this condensed into a shelf with a mean depth of 3.4 ± 2.3 mm (1 to 9). There was no correlation between the depth of the pedestal and the distance between the collar and calcar, suggesting that distal fixation does not lead to stress shielding proximally. In deceased patients the findings were similar.

Using the information from Table I two survivorship curves were constructed, one for the femoral component, and the other for the cemented cup (Fig. 6).

Fig. 4

Scattergram of the visual analogue scores for pain in 62 hips.

Fig. 5a

Fig. 5b

Fig. 5c

MDP scores for the 62 hips of patients still alive showing scores for a) pain, b) range of movement and c) function.

Fig. 6a

Fig. 6b

Survival curves for a) the JRI stem and b) the cemented cup.

Discussion

Our aim was to maintain accurate and detailed follow-up of the first 100 consecutive patients having a THR using one design of a HA-coated femoral component. It is unusual to be able to trace all the patients. In other series those lost to follow-up have been found to have significantly worse outcomes.⁶

Apatite-coated implants can form a chemical fixation with a strength comparable to that of cortical bone itself.⁷ It has been reported that two-thirds of the HA coating is resorbed within 16 weeks of implantation and replaced by bone.⁸ It seems likely that little HA remains after ten years. Patients with non-coated cementless prostheses have a high incidence of thigh pain with 14% reported in some series⁹ and partially-coated femoral implants often show increased

radiolucency in Gruen zone 4.¹⁰ The fully-coated implant which we used gave contrasting observations.

HA has been described as generating 'spot welding' of bone to the prosthesis.¹¹ Several authors have noted the absence of bone lysis around the femoral stem in HA-coated prostheses and have suggested that this layer may impede the access of polyethylene debris to the interface.¹¹

The survivorship of hip prostheses depends on the endpoint used.^{12,13} Britton et al¹² suggested six possible endpoints, with a survival of 80% at ten years for Charnley prostheses if constant pain was taken as one. The rates of failure appeared to increase with time. In younger patients with Stanmore prostheses, the survival to revision at ten years was 90% which decreased to 68% at 15 years.¹⁴

Radiological findings may be useful in predicting loosening in the following five years.¹⁵ Radiolucent lines of 2 mm or more are significant. Stauffer¹⁶ found loosening of the femoral component to be 30% at ten years in Charnley prostheses.

If there is no abnormality on the radiographs after ten years there is a high likelihood of prolonged survival of the implant. Mild resorption of the calcar was considered to be non-progressive and unrelated to loosening.¹⁶ In our patients none of the radiographs showed signs of imminent or potential failure. The absence of distal granulomas or proximal osteopenia may indicate that the bond of the prosthesis to the bone impedes the transport of debris. It also implies that no harm occurred as a result of resorption of HA.

There were 13 cracks in the femur observed in our series; 11 occurred at the time of surgery and two at four and six years after operation and associated with significant trauma. All the fractures were managed conservatively and united uneventfully. A fracture around a cemented arthroplasty is often a serious complication usually requiring major revision.¹⁷ Our findings and those in other series suggest that fractures around a non-cemented stem are often incomplete, minimally displaced, do not compromise stability and do not detract from the clinical results.^{18,19} The HA coating may have improved the chance of union of the fracture.

Our patients showed a rate of survival of 97% for the complete arthroplasty and 99% for the femoral stem which is equal to that of other published series.^{1,20-23}

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