Results of a hydroxyapatite-coated (Furlong) total hip replacement
A 13- to 15-year follow-up

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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, 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 categories3 are shown in Tables I and II.

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-
plher 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>
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<th>Table III. Details of the implants used</th>
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<tr>
<td><strong>Number of hips</strong></td>
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<tr>
<td>Acetabular cup*</td>
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<tr>
<td>Threaded</td>
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<tr>
<td>Surface fixation cup</td>
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<tr>
<td>Femoral head†</td>
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<td>Ceramic</td>
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* all cups had a polyethylene insert
† femoral heads were all 28 mm in size and all femoral stems were fully hydroxyapatite-coated

![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)
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 consid-
ered 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.\textsuperscript{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 inter-
tear drop line.\textsuperscript{8} Rotational change was regarded as signifi-
cant if there was a change of > 3˚ in the angle of the
acetabular component (Fig. 2).

Radiolucent and sclerotic lines at the acetabular and fem-
oral 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.\textsuperscript{6} The formation of
heterotopic ossification was graded according to the
method described by Brooker et al.\textsuperscript{9}

The criteria for failure were either revision or an impend-
ing revision because of pain or loosening.

**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 fol-
low-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-
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With regard to the acetabular component, there was endosteal 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 transient common peroneal nerve palsy. There was one late deep 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 follow-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 functioning 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 femoral components without HA-coating.
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 prostheses. 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

Fig. 4a
Survival curves showing the a) best and b) worst-case scenarios.

Fig. 4b