OSTEOLYTIC CHANGES IN THE UPPER FEMORAL SHAFT FOLLOWING POROUS-COATED HIP REPLACEMENT

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Ten uncemented total hip replacements were performed in 1975 using an implant in which the cobalt-chrome femoral stem was coated to give a porous surface. In all but one case a high-density polyethylene head was used. The radiological changes in the upper femoral shafts were assessed between three and nine years later. Seven showed extensive stress-relieving changes, loss of calcar, stress fractures at the root of the lesser trochanter with subsequent detachment, and osteoporosis followed by avulsion of the greater trochanter. In these seven patients the lower part of the stem appeared to be soundly embedded, although in only one was there evidence of bony incorporation.

It is suggested that if the fixation of a fully coated implant of this sort remains sound, gross atrophy of the upper femoral shaft develops after five years. This atrophy, associated with an implant which can be removed only at the expense of further bone destruction, presents substantial problems if revision is needed.

The use of porous coating on cobalt implants was first investigated by Hirschhorn and Reynolds (1969) and later by Welsh, Pilliar and Macnab (1971); it was reviewed by Pilliar, Cameron and Macnab in 1975 and again three years later (Cameron, Macnab and Pilliar 1978).

In the experimental animal it seems clear that the sintered coating produces considerable resistance to the subsequent removal of an implant, either because new bone grows within the pores, or because entrapped bone acts as an autogenous graft and fuses with the surrounding bone. (Galante et al. 1971; Cameron, Pilliar and Macnab 1973; Miller et al. 1976; Robertson, Pierre and Chahal 1976; Bobyn et al. 1980a, b). The clinical attractions of this method are clear; if sound fixation with bone by porous coating can be achieved, this would be a satisfactory alternative to the use of cement.

Implants with an irregular outer surface have been used by Judet (1975), Morscher and Mathys (1975), Lord et al. (1978), Lord and Bancel (1983) and Morscher (1984), but the medium-term results have yet to be evaluated. More recently, Engh et al. (1981) and Engh (1983) described the use of implants with coating on the upper two-thirds of the femoral component.

In 1975 10 uncemented total hip replacements were inserted into 9 patients (1 bilateral) in the Joint Replacement Unit at Dorking Hospital. The implant used was identical to the other model in use at that time, except that the outer surface of the femoral component (and in five cases the acetabular component also) was coated along its entire length with sintered cobalt-chrome. The pore size was 100μm. All the implants were inserted without difficulty and there were no postoperative complications. Thereafter, the clinical results and the radiological changes were assessed annually. Five patients were lost to review from death or intercurrent disease, one at three years and four after five years; four survivors were studied over the full nine-year period.
ILLUSTRATIVE CASE HISTORIES

Case 1. In 1975 a 65-year-old man had his hip replaced with a coated prosthesis. He remained symptom-free for five years; radiographs at that time showed well-defined osseous integration of the lower half of the femoral component (Fig. 1). He subsequently died from chronic respiratory failure.

Case 2. A 75-year-old woman had her left osteoarthritic hip replaced with a metal-on-metal prosthesis coated on both the femoral and pelvic components. She remained symptom-free for three years but then developed discomfort in the hip and was able to walk only with the aid of walking sticks. Radiographs showed separation of the greater trochanter and osteoporosis (Fig. 2). Radiographs taken six years after operation showed further resorption of the upper end of the femur and a stress fracture of the pelvic component (Fig. 3).

Case 3. A 57-year-old man had his left hip replaced with a coated prosthesis after failure of an uncoated uncemented model. He remained symptom-free and fully active for five years. Then the hip became painful again. Radiographs showed detachment of the lesser trochanter, calcar resorption, and erosions in the upper third of the femoral shaft. Figure 5—Eight years after operation there were increasing lytic changes.
ter, calcar resorption, and erosions in the upper third of the femoral shaft (Fig. 4). The hip was explored in December 1980. The femoral component proved impossible to extract and the joint was relocated without an exchange procedure. He was mobilised without difficulty and remained symptom-free for three years. Then his pain recurred and radiographs showed increasing lytic changes (Fig. 5). At re-exploration the implant was still soundly embedded and was again impossible to extract. The upper femoral defect was treated by curettage and bone grafting.

Case 4. A 74-year-old woman had her left osteoarthritic hip replaced with a coated prosthesis. Nine years after operation she was symptom-free and fully active. Radiographs showed a radiolucent zone around the entire femoral component; the calcar was preserved and there was no osteolysis.

DISCUSSION

Significance of radiological changes. There is little doubt that, in nine of the 10 hips studied, the lower part of the porous coating was capable of inducing secure fixation to bone, although in only one was "radiological ingrowth" clearly visible. Excluding the one example of a stress fracture of the pelvic component, which to date has not yet come to revisional surgery, the radiographic changes in all the other patients suggest that if fixation is sound only in the middle and the lower portions of the femoral component, then massive stress-relieving changes develop in the upper femoral shaft. These radiological changes have not been seen in patients with similar but uncoated implants. The osteoporosis which occurs is sufficiently extreme to permit pathological separation of both the lesser and the greater trochanters; it is slowly followed by loss of function and, to a lesser extent, discomfort.

Although all these implants were coated throughout their length, in none was there any evidence that in the trochanteric region the porous coating was effective in maintaining sound fixation; indeed it was in this area that the most severe osteolytic changes occurred.

There has been considerable controversy over the relative roles played by completely rigid and incompletely rigid fixation of the prosthesis. Perren (1984) asserted that in experiments with screw fixation in dogs, lack of rigidity induced bone resorption. Pilliar and Bratina (1980) have reported that, if micromechanical bonding is adequate, there is less stress transference onto the lateral surface of the implant, and therefore onto the lateral surface of the femur, than if the bonding is inadequate. Pilliar (1983) asserted that with a porous-coated implant, if tissue ingrowth is sufficient, no stress-relieving changes and no remodelling occurred. This has not been the impression gained from our present study. That a rigid intramedullary implant which protected bone from stress produced atrophic changes, was first noticed by Jackson Burrows in 1975. Similarly, Tonino et al. (1976) found that when a rigid steel plate was placed on the surface of the femur the underlying bone became remodelled, the cortex thinned and cavitated and there was an increase in the amount of woven bone. In a similar study fixing fractures with plates, Pilliar et al. (1979) noted the same changes.

Stress distribution in medullary implants with porous surfaces was studied by Anand et al. in 1977. Porous steel coating was found to produce the highest shear stress, and load was transferred over a very short length, increasing stress concentrations; but at the level of bone ingrowth, the bone itself was shielded from stress and remodelling changes occurred. The authors suggested that high modulus materials may not be suitable for porous coatings on medullary implants. However, it may well be that restricting the amount of porous coating on the implant would be as effective as changing to a composite material using a low modulus coating. Clinical implications. From the clinical and radiological study of the patients in this series it would appear that a fully coated implant, when it produces osseous integration, does so in the segment distal to the joint and produces resorptive changes in the peri-articular area. The risk of such an implant sustaining fatigue failure in the course of time must be relatively high. In Case 2 in the present series such fatigue resulted in fracture of the pelvic component. It may be of significance that only one similar fatigue fracture has been seen in over 3000 similar but uncoated pelvic implants. Removal of a coated
implant by conventional methods may be impossible and it seems unlikely that bone grafting, as used in Case 4, will produce anything more than a temporary remission of symptoms.

**Conclusions.** In 1975 10 uncemented total hip replacements were performed using a fully coated cobalt-chrome femoral component. Nine years later radiographs of seven showed firm fixation in the isthmus of the femur, but there were massive stress-relieving changes in the upper femoral shaft with bone resorption and pathological separation of one or both trochanters. These changes were associated with gradual loss of function which, in one patient, necessitated revisional surgery with bone grafting.

The only patient with a satisfactory clinical result at nine years had a radiolucent line around the femoral component on the radiograph, indicating that there had been no osseous integration between the femur and the porous coating.

It is concluded that fixation of a fully porous-coated femoral component by osseous ingrowth will result in massive osteolytic changes in the upper femur.

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**REFERENCES**


