RADIOGRAPHY AND HISTOLOGY OF A THREADED ACETABULAR IMPLANT

ONE CASE STUDIED AT TWO YEARS

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Threaded acetabular components are widely used in cementless total hip replacement, despite a poor understanding of the nature of the bone-implant interface. We have examined one case in which the threaded titanium ring appeared to be well incorporated with no discernible radiolucency. Microradiography and histology surprisingly showed that the threads were entirely encapsulated in fibrous tissue. This raises doubt about the relevance of plain radiography to the analysis of the acetabular interface.

The use of threaded acetabular implants in total hip arthroplasty is increasingly popular. The first designs were in the form of a cylinder or truncated cone with relatively coarse threads that required tapping before final insertion. Ceramic, polymeric, and metallic prostheses of this type have been used with varying degrees of success (Lord and Bancel 1983; Endler, Endler and Plenk 1984; Mittelmeier 1984; Morscher 1984). More recent implants are typically manufactured from titanium with a hemispherical profile and smaller, sharp, self-tapping threads. The concept of threaded implants is attractive because they give a tremendous sense of mechanical purchase and stability at operation. The tissue response to threaded implants is, however, poorly understood.

We present a radiographic and histological analysis of the bone-implant interface of a threaded acetabular prosthesis that had been implanted for two years.

CASE REPORT

A 49-year-old Caucasian man with active chronic hepatitis presented with painful loosening of a Mittelmeier prosthesis implanted for osteoarthritis. In February 1985 he had a revision operation with a cobalt-alloy porous-coated femoral component and a threaded acetabular ring of titanium alloy (Mecring, Mecron, Berlin). At operation the socket was carefully reamed to

apparently healthy bone and to a diameter equal to that of the base of the threads of the titanium insert. Secure fixation was obtained, with the impression that the self-tapping threads were cutting well into bone.

Hip function was improved but unfortunately the patient's liver function deteriorated. He lapsed into hepatorenal failure and died in April 1987. Within an hour of death, both proximal femora and the acetabula were removed and fixed in 10% buffered formalin. There was no evidence of infection.

After stripping of soft tissue, anteroposterior and lateral radiographs of the implanted acetabulum were obtained on high-resolution film. Since the lateral radiographs give a better view of the implant threads, these were used for comparison with the earlier clinical radiographs. At one year after implantation these had shown excellent bony filling of the thread grooves both anteriorly and posteriorly (Fig. 1); this was confirmed on the postmortem radiographs (Fig. 2). In general, the radiographic appearance of the interface was excellent in relation to our experience with over 300 threaded acetabular devices. The implant also appeared to be stable within the acetabulum, showing no gross movement on moderate manual compression.

The specimen was then dehydrated in ethanol, defatted in acetone-ether, embedded in polymethylmethacrylate, and sectioned with a low-speed diamond blade (Bobynd and Engh 1984; Engh and Bobynd 1985). The acetabulum containing the implant was bisected in the sagittal plane and two 2 mm sections from the centre of the implant were prepared. Each remaining half of the specimen was then cut at 90° to the original cut and more 2 mm sections produced. Microradiographs were made before further thinning, polishing, and staining with Paragon to provide undecalcified thin sections.

The microradiographs showed much less bone within the grooves of the thread than had been expected from the follow-up and postmortem radiographs (Figs 3 and 4). The thin sections accentuated the absence of

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Fig. 1

Fig. 2

Figure 1. A lateral clinical radiograph taken one year after operation. There appears to be good purchase for the thread and no radiolucency. Figure 2 - Lateral radiograph of retrieved postmortem specimen: the bone-implant interface is typical for this type of implant and suggests good bone retention within the grooves of the thread.

Fig. 3a

Fig. 3b

Figure 3a - Radiograph of a 2 mm thick section prepared in the sagittal plane. The saw cut in the upper left field corresponds to that seen in Figure 2 for the whole specimen. There is little bone within the thread grooves. Figure 3b - Thin section prepared from the slice shown in 3a. The absence of bone-implant contact is even more obvious, showing that even a 2 mm thickness of bone can project a somewhat deceptive radiographic image.

Fig. 4a

Fig. 4b

Fig. 4c

Fig. 4d

Radiographs and sections prepared at 90° (coronal plane) to the section in Figure 3. These show that the fibrous tissue interface was continuous around the circumference of the implant.

bone-implant contact and revealed that the thread grooves were filled by dense fibrous tissue. We did not obtain good detail of the fibrous tissue cells; this is usual with this type of section, but in all sections, calcified tissue was separated at all interfaces from the implant by a minimum of 0.5 to 1 mm. In some regions of the interface the bone closest to the implant showed the convoluted, scalloped edges reminiscent of osteoclastic activity, but again resolution of the cells was insufficient to confirm whether there was active resorption. At the dome of the implant, where the polyethylene liner interfaced with host tissue, we examined for polyethylene wear debris with polarised light but found none.

DISCUSSION

It is very difficult to obtain a clinical radiograph of a threaded implant which will reveal the "real" bone-implant interface within the thread grooves. Often, only the "false" bone-implant interface, the zone outside the thread tips, can be visualised. This case has clearly shown that even if the bone within the grooves can be seen, the bone in front of and behind the threads is superimposed and gives a false impression of both the amount of bone within the grooves and the proximity of bone to the implant. In other words, radiolucent lines and zones are hidden; the illusion of an optimum interface can be created. This does not mean that there is no bone within the grooves of the thread, but it does mean that even an ideal radiograph does not allow a sound assessment of the interface. It also suggests that an implant which shows obvious radiolucency must have a large amount of fibrous tissue at the interface. It is likely that this interpretation extends to all acetabular components, threaded or otherwise. Sophisticated techniques such as tomography or CT scanning could, however, provide a more accurate picture of the interface.

The histological findings suggest that there had been resorption of bone within the grooves and replacement with soft tissue. Bone resorption could be due to one or more factors. These include mechanical and thermal injury during reaming, mechanical instability at the interface, excessive stress concentration, and localised ischaemia due to damage to the microvasculature caused by the sharp threads as the implant is screwed into position. Cyclic changes in the shape of the acetabulum during weight-bearing (Jacob et al. 1976) and the varying structural moduli of the implant and the acetabulum predispose to micromovement at the bone-implant interface.

In our case, despite the fibrous tissue interposition, the implant was grossly immobile within the acetabulum and had given a good clinical result. The important issue is not so much the cause of the bone resorption but the fact that the clinical radiographs could not give an accurate picture of the state of the interface.

The extent of the fibrous tissue does not necessarily imply that all threaded implants ultimately become encapsulated in fibrous tissue. In dental surgery, for instance, it is known that, with careful surgical technique, proper implant design, and a postoperative period of non-loading, it is possible to establish long-term "osseointegration" of threaded titanium implants. This implies direct apposition of bone to metal with a very thin proteoglycan interlayer (Brånemark et al. 1977; Albrektsson et al. 1981; Linder et al. 1983). This raises the fundamental question of whether a similar interface can be obtained for an orthopaedic implant where surgical trauma is more severe and the interface is loaded relatively soon after operation. A more important question may be whether a fibrous tissue interface can provide as good a long-term, painless fixation for the acetabulum as direct bone-implant contact.

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