Fracture of the tibial tray of the PCA knee

A case report of early failure caused by improper design

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Knee prostheses with metal backing of the polyethylene tibial component are nowadays used almost universally. Eight cases of fracture of the metal tray are reported in the literature. We present a case in which the failure could be expected because of improper design of the tibial tray.

Case report

A 57-year-old farmer (height 187 cm, body weight 83 kg) had had seropositive destructive rheumatoid arthritis since 1974. Prior surgery included synovectomy of both wrists and the left ankle, arthrodesis of the left wrist, and left hip replacement. In 1985, a left total knee replacement was performed because of pain, instability, and deformity (HKA angle 167°). A PCA prosthesis (Howmedica®) with a stemmed tibial component was used. The tibial tray was porous-coated and had slots between the tray and stem to aid in removal. A subtotal synovectomy was performed, and a minor cystic destruction in the lateral tibial plateau was filled with autologous bone. The tibial component was cemented, whereas the femoral component was fixed without cement. A 9-mm polyethylene bearing was used. Postoperative radiographs showed a good position of the prosthesis, and the alignment of the knee had been corrected to a HKA angle of 177°. The postoperative course was uneventful. One year later, the right knee was replaced with the same type of prosthesis; to date the knee has caused no problems. The patient was satisfied with both replaced knees and could walk on level ground without a supporting cane, and he even practiced his favorite pastime, dancing. After 2 years, radiographs of the left knee showed signs of loosening of the tibial component with wide radiolucency between bone and cement, but the patient had no complaints. Several detached beads from the porous coating were also seen (Rosenquist et al. 1986).

About 4 years after replacement, the patient felt sudden pain in his left knee while walking. Radiographs showed a fracture and forward tilt of the tibial tray in relation to the stem, which seemed to be firmly fixed. Motion was between –10° and 110°. The knee was unstable between 10° of valgus and 10° of varus. At revision the tibial stem was found to be separated from the tray, which was fractured into two pieces (Figure 1). Beneath the tray the condyle bone was deficient and replaced by fibrous tissue, offering the metal tray almost no support. The stem was still firmly fixed and removed with great difficulty. The femoral component was also loose, and a large cystic cavity in the anterior part of the lateral femoral condyle had to be filled with cement and autologous cancellous bone. A total condylar knee (Scan Knee®) was cemented with a 22-mm polyethylene bearing to restore the proximal tibia and stability of the knee. Five tissue samples were found to be negative on bacteriologic cultivation. The postoperative course was uneventful.

Discussion

There are several possible mechanisms for a fracture of the tibial metal tray. The one most often referred to is insufficient bone support, especially when combined with a distally well-fixed stem. Axial malalignment, overweight, high-activity level, inadequate manufacturing, and improper design of the prosthesis are other possible explanations.

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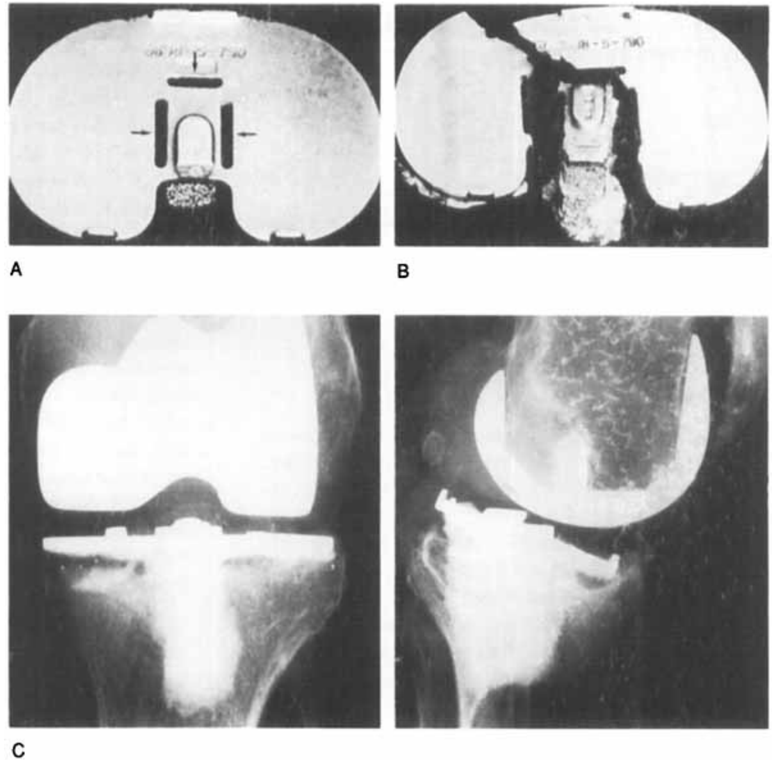

Figure 1. A 57-year-old man with rheumatoid arthritis operated on with a PCA prosthesis.

A. The stemmed tibial PCA component with slots (arrows) to aid in removal. Note the small connecting bridges between the stem and tray.

B. The removed tibial component. Note fracture of all the connecting bridges between the stem and tray.

C. After 4 years. The tibial component is fractured. The stem seems well fixed.

Lack of bone support beneath the tray could be due to preexisting deficient bone stock. Another cause of poor bone quality could be infection, which, however, has not been demonstrated in any of the cases reported so far. Dannenmaier et al. (1985) suggested that bone resorption in their case was due to a reaction to polyethylene wear, while others (Gradisar et al. 1989, Mendes et al. 1984, Scott et al. 1984) suggest "stress shielding" as a cause of bone resorption in the proximal tibia. In the previously reported cases a combination of a firmly fixed stem and deficient proximal bone most likely increased the load of the tray, giving rise to fatigue fractures.

Stress distribution in the tibial component is dependent on the axial alignment. In all the cases reported earlier, varus malalignment resulting in increased medial joint forces was an etiologic factor to consider. In our case, there was no malalignment.

Not surprisingly, weight and activity level of the patient have been shown to be of importance for prosthetic failure (Morrey and Chao 1988). All reported patients with fracture of the tibial metal component weighed more than 95 kg, and most of them were relatively active. Our patient had also been active in spite of multiple joint problems, but he was only slightly overweight.

In the manufacturing of a porous-coated prosthesis, the cobalt-chromium-molybdenum alloy has to go through a sintering process, which has been shown by Pilliar (1983) to decrease the fatigue strength of the material by 16 percent. This is a factor to consider in metal-tray fractures (Ranawat et al. 1986, Morrey and Chao 1988).

The stemmed PCA tibial component with slots surrounding the stem was analyzed by Skinner et al. (1987) with a three-dimensional finite element method. They concluded that this type of prosthesis runs a great risk of fracturing at the weak points caused by the slots if the support beneath the metal tray becomes inadequate. Our observations, as well as those by Gradisar et al. (1989), support the prediction of Skinner et al. (1987).

The fractures of the metal tray in our case were in part due to the stem being firmly cemented to the tibia at the same time as the tray did not have adequate bone support, due to preexisting deficient bone stock and later bone resorption. However, the most important factor was the use of an improperly designed tibial component. We now consider the use of a tibial metal tray with slots between tray and stem inappropriate. The PCA stemmed tibial component is no longer manufactured with slots, but the old slotted model is still in clinical use and is kept in

stock. We advise against using tibial components with this specific design.

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