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Case report

Tibial tray fracture in a modern prosthesis with retrieval analysis

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ABSTRACT

Fracture of the tibial tray is a rarely observed complication of total knee arthroplasty (TKA), predominately in implants placed greater than a decade ago. This case highlights a case of baseplate fracture in a contemporary prosthesis. The patient presented 1 year after TKA with medial knee pain consistent with pes bursitis. The implant-cement-bone construct was intact and she was managed with corticosteroids. She had persistent pain, acutely developed new varus deformity, and presented with a tibial tray fracture. Retrieval analysis suggested fatigue fracture as the likely mechanism. At time of revision, necrotic bone was found at the medial plateau, which likely caused cantilever bending relative to the well-supported portion of the tray and resultant failure. The patient continues to do well 5 years after revision TKA.

Introduction

Implants for total knee arthroplasty (TKA) have evolved greatly over the past few decades. Through numerous advances in design and materials, the durability, longevity, and survivorship of TKA continues to improve. Presently, the most common reasons for failure and revision surgery are aseptic loosening, instability, malalignment, and periprosthetic infection [1]. Introduction of metal-backed tibial components presented a new mechanism of failure—fracture of the tibial tray, first described by Scott et al in 1984 [2]. Fracture of the tibial implant is a rare complication, and many of the documented cases occurred in those placed over a decade ago [2-14]. Several of the earlier reports were attributed to design flaws, and tibial tray fracture has rarely been reported in modern TKA [6,7,15]. We present a case of this rare complication in a modern TKA prosthesis.

Case history

Informed consent was obtained to publish deidentified information regarding this patient's TKA, tibial tray fracture, and subsequent care.

A 67-year-old women (weight: 109.1 kg, height: 179 cm, body mass index: 34.1 kg/m^2) presented to the outpatient clinic in 2008 with chief complaint of right knee pain that was severely limiting her activity. She previously underwent right total hip arthroplasty in 2007 and left TKA in September 2008 with uneventful postoperative courses.

Examination of her knee revealed a fixed valgus deformity of approximately 15°-20° and a range of motion of 0°-110°. Radiographs demonstrated right knee osteoarthritis with valgus deformity (Fig. 1a). The patient failed conservative measures for her symptoms and elected to undergo right TKA in February 2009, utilizing a PFC Sigma design (DePuy, Warsaw, IN) with a polished, chrome cobalt tibial tray. The prosthesis was fixed with cement, and a 12.5-mm polyethylene insert was used. The procedure was uneventful. Postoperatively, the knee was in 5° valgus alignment and knee radiographs demonstrated a stable implant (Fig. 1b). The patient did well after surgery and obtained complete pain relief.

At 1-year follow-up, she complained of recent onset medial knee pain in the area of the pes anserine bursa. Radiographs were unremarkable (Fig. 1c). She was diagnosed with pes anserine

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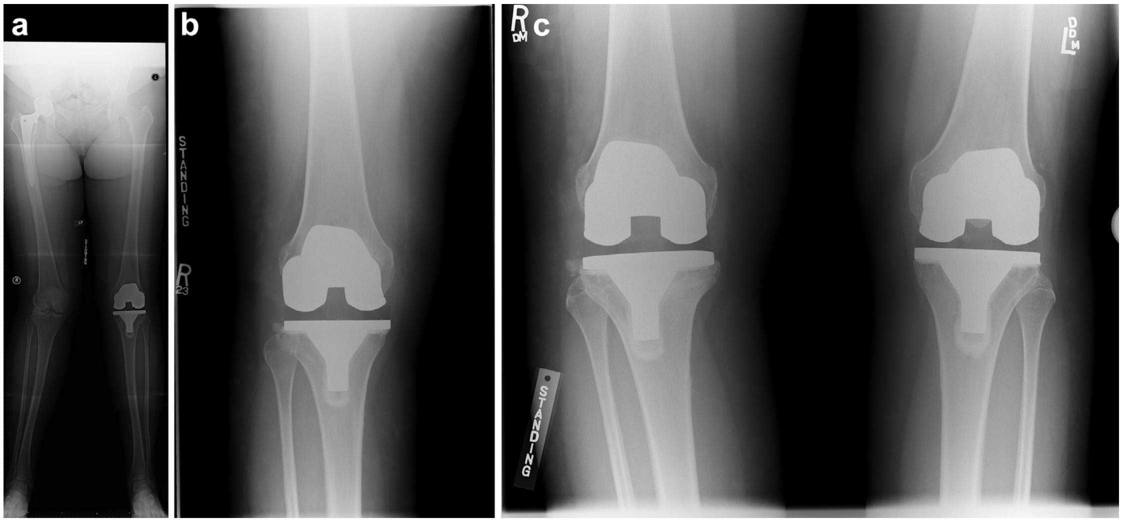

Figure 1. (a) Anteroposterior (AP) long leg preoperative radiographs from February 2009 (b) AP right knee at 6 weeks postoperative (c) AP bilateral knees at 1 year postoperative (d) AP and lateral radiographs first demonstrating tibial tray fracture in July 2010 (e) AP long leg radiographs 1 month after revision procedure (f) AP bilateral knees at 5 years after revision procedure.

bursitis and received a short course of oral corticosteroids. She returned 3 months later without improvement in her symptoms and she underwent a corticosteroid injection into the pes anserine bursa. The injection provided partial relief, but she returned 1 month later with progressive symptoms. At this time, the right knee was found to be in 15° varus. Radiographs were obtained and demonstrated a fracture of the tibial tray (Fig. 1d).

The patient underwent revision of the tibial component in July 2010. At the time of surgery, there was necrotic bone within the posteromedial aspect of the tibial plateau. High-speed burrs were used to debride the necrotic bone to healthy bleeding bone. A DePuy PFC Sigma revision tibial component was inserted and fixed with cement. No augments were needed, and the alignment of the knee was corrected. The patient tolerated the procedure well without complications (Fig. 1e). Intraoperative cultures and cell counts did not provide evidence of any underlying infection. She returned to full activity postoperatively and was asymptomatic at her most recent follow-up, 5 years later (Fig. 1f).

Implant analysis

The fractured tibial tray was first examined visually (Fig. 2). The fracture extended through the width of the tray in 2 primary directions (Fig. 3). The first extended from the corner of the posterior notch in the medial direction toward the outer rim. The second segment began at the anterior surface and travelled medially, initially with a similar contour to the outer rim. The segments met in the medial tray and separated the fractured component from the rest of the prosthesis. No indications of material defects, such as porosity, were observed nor were any witness marks from impact or tool damage.

The fractured tibial tray was then sent for analysis by scanning electron microscopy. Study of the component revealed both beach marks and striations. Beach marks are macroscopic indications on the fracture surface that resemble parallel lines, such as those created as water flows over sand on a beach, and indicate the position of the crack front at different times as it grows progressively across the component (Fig. 4). When variations in loading occur, the roughness of the fracture surface changes, creating these lines that can often be seen with the naked eye. Fatigue striations are similar parallel lines on the fracture surface that are observed on the microscopic scale (Fig. 5). As the crack grows under cyclic loading, the crack front progressively advances by a short distance with each or every few cycles. Each striation is an indication of the crack position after each individual or every few cycles. Fatigue striations were observed over the majority of the fracture surface, indicating the component was cracking for a considerable period of time under a relatively low loading scenario.

Because the crack grew by fatigue over most of its length, only small loads were likely present, allowing the 2 halves of the tray to remain attached by even a small ligament of cross-section until final failure occurred. Had the cyclic loads been larger, it would be expected that the remaining ligament of the cross-section holding the 2 halves of the tray together would eventually give way, creating a large area of the fracture surface indicative of ductile overload. Given the significant difference in direction of the 2 fracture segments, it is likely that each grew as separate cracks emanating from anterior and posterior points on the tray, eventually intersecting further out in the medial direction (Fig. 3).

In some small regions where the fracture surface was damaged by rubbing, the morphology of the fracture could not be determined. Such rubbing itself is often consistent with a fatigue mechanism, where partially fractured components are held in close proximity to each other while the crack continues to extend through the component. The opposing faces of the fracture surface tend to rub against each other as they deform under cyclic loading. Therefore, fatigue fracture was determined to be the most likely mechanism of failure.

Discussion

While TKA remains a highly successful procedure, rare complications still do occur. Retrieval analysis indicated fatigue fracture as the most likely cause of this tibial tray fracture, and there were no clear indications of manufacturing defect or damage to the implant during initial placement. Fatigue fracture is the method of failure for any metal structure facing high enough stress loads and/or number of cycles [8]. It has 3 phases: initiation, propagation, followed by sudden fracture [16]. We postulate that loss of proximal tibial bone support under the fractured area led to failure of this implant. Deficient bony support under a portion of the tibial plate can result in the loosened portion functioning as a cantilever, resulting in greater stresses at the junction between the supported and nonsupported segments of the prosthesis [4]. Chatterji et al