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Case report

Fracture of the insert cone of a polyethylene liner in a failed posterior-stabilized, rotating-platform total knee arthroplasty

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ABSTRACT

Failures unique to posterior cruciate-substituting total knee prostheses rarely include polyethylene post fractures but have been described. We report a case involving a fracture of the distal insert cone of a rotating-platform (RP) polyethylene liner in a primary total knee arthroplasty. This case highlights a 67-year-old male presenting with new-onset knee pain and recurrent effusions with osteolysis 11 years following placement of a posterior-stabilized, RP total knee arthroplasty. At the time of revision surgery, the polyethylene insert cone was found to be fractured just below the junction between cone and the body of the insert. Liner exchange, synovectomy, and osteolytic-defect curettage and cement packing were performed. One year following revision surgery, the patient is without pain and has returned to function without limitations. Clinicians must be aware of this possible failure with RP prostheses in the setting of pain with a stable knee, recurrent aseptic effusions, and osteolysis.

Introduction

While the merits of retaining the posterior cruciate ligament in total knee arthroplasty (TKA) continue to be debated [1-4], the literature greatly varies with regard to the preferred design. Both cruciate-retaining and posterior-stabilized (PS) designs have demonstrated excellent patient satisfaction and survivorship [5-7]. Advocates of the PS TKA cite improved range of motion (ROM) and more uniform, predictable femoral-tibial sagittal plane kinematics [8-11]. While not normal, the PS TKA more closely mimics native knee kinematics with femoral roll back via interaction of the cam and post mechanism [12]. More debate lies within the PS TKA realm regarding the superiority of fixed- vs mobile-bearing prostheses. Mobile-bearing PS TKA may decrease the rate of lateral release to correct patellar maltracking [13,14] in addition to lessening polyethylene wear rates [15] due to more uniform kinematic contact pathways and a more centralized, symmetric cam-post engagement [11,13,16-18]. Unique disadvantages of the PS TKA design include patellar crepitus/clunk syndrome [19-21], fractures of the tibial polyethylene post that articulates with the cam, and polyethylene insert dislocations in the mobile-bearing designs [22-26].

There have been numerous reports of tibial polyethylene post fractures in fixed-bearing prostheses [25,27-34]. In a mobile-bearing PS TKA design, there is a distal polyethylene insert cone that articulates with the tibial component providing a means for rotation and bearing stability (Fig. 1). Recently, Tanikake et al [35] reported a case involving a nontraumatic fracture of the polyethylene insert cone in a 72-year-old male with a Vanguard Rotating Platform High Flex implant (Biomet, Warsaw, IN) 27 months after his index TKA with an acute onset of pain and instability. We report a case of a nontraumatic primary TKA failure secondary to a polyethylene insert cone fracture involving pain, recurrent aseptic effusions, and progressive osteolysis 11 years following the index TKA. To our knowledge, this has not been reported with this particular implant.

Case history

Institutional review board approval and informed consent were obtained from the patient for publication of de-identified data and

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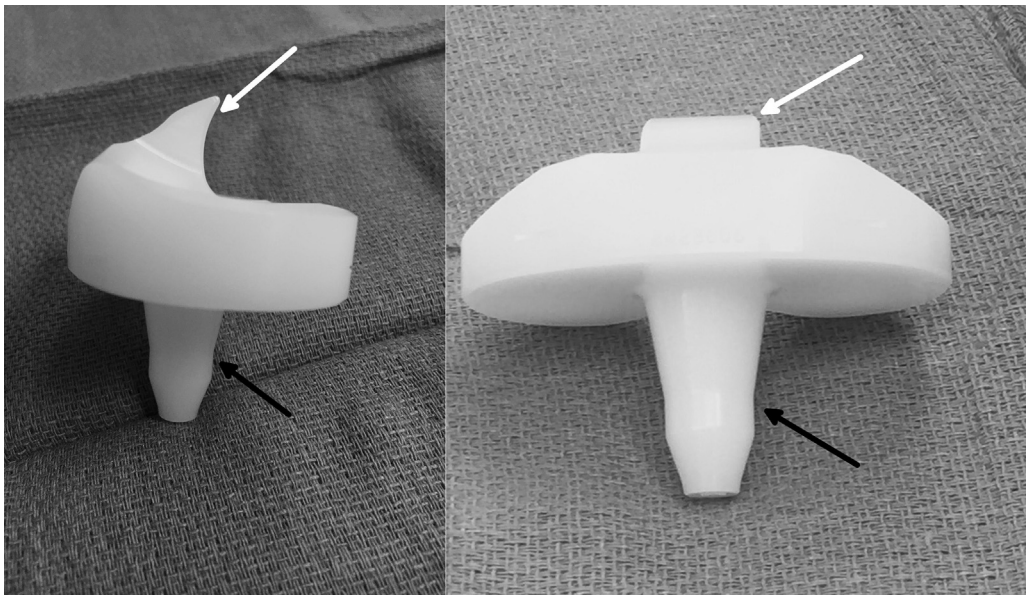

Figure 1. Coronal profile of the posterior-stabilized, rotating-platform polyethylene insert. Black arrow denotes insert cone. White arrow denotes tibial post.

media of the episode surrounding his right TKA. A 56-year-old male underwent an uncomplicated TKA with a PS rotating-platform (RP) design prosthesis (PFC Sigma Rotating Platform; DePuy Inc, Warsaw, IN) using a gap-balancing technique for advanced post-traumatic osteoarthritis of the right knee. His postoperative course was unremarkable and he returned to his previous recreational activities including athletic coaching as well as activities of daily living without limitation. His Knee Society Score at 1 year following the index procedure was 200 and remained unchanged over the next 9 years. He maintained routine follow-up every 2 to 3 years for radiographic and clinical examination. For the first 9 years following the index procedure, he was clinically asymptomatic and radiographs demonstrated no signs of wear or impending failure (Fig. 2).

During a subsequent routine 11-year follow-up visit, the patient (body mass index, 30.8) reported recurrent knee effusions with activity and pain along the medial joint line of his right knee for several months. He denied any history of recent trauma. His clinical examination revealed a well-healed surgical incision and he maintained a normal gait pattern. His ROM remained consistent with previous examinations (0°-124°); however, a new-onset, moderately-sized effusion was noted. His total Knee Society Score at this visit was 195. Additionally, tenderness to palpation over his medial joint line was reproducible and consistent with his description. There was no coronal or sagittal plane deformity/instability, patellar crepitus, or maltracking. Radiographically, amid prosthetic components that remained well-positioned and well-fixed, the patient was found to have developed an osteolytic defect of approximately 2 cm^2 in the medial tibial plateau (Fig. 3). To rule out infection, his knee was aspirated and serum laboratory infectious markers were obtained, all of which were negative (synovial white blood cell count, 525 cells; neutrophils, 14%; crystals, gram stain, and culture-negative; erythrocyte sedimentation rate, 5 [normal, 1-15 mm/h]; C-reactive protein <2.90 [normal, <3.00 mg/L]). Given the radiographic evidence of osteolysis and progressively worsening symptoms of pain and swelling, the patient underwent right revision surgery 11 years and 4 months following his index procedure. Upon arthrotomy, a copious amount of clear straw-colored fluid was evacuated. An 8 × 18 mm piece of delaminated polyethylene was encountered. It was found to have originated from the patellar bearing which was subsequently revised. A synovectomy of the joint was performed. There was a moderate amount of symmetric, delaminated wear of both sides of the polyethylene tibial insert. Upon removal of the insert, the polyethylene insert cone was found to be fractured 10 mm below the surface of the mobile-bearing tibial tray (Fig. 4). The remaining

Figure 2. Anteroposterior, lateral, and Merchant radiographs of the right total knee arthroplasty at the 9-year follow-up interval.

Figure 3. Anteroposterior, lateral, and Merchant views of the right total knee arthroplasty 11 years following operation. White arrow denotes osteolytic defect of the medial tibial plateau.

insert cone was removed. The osteolytic defect of the medial tibial plateau was curetted and packed with bone cement. A new RP polyethylene tibial insert (15 mm, previously 12.5 mm) was placed. His remaining hospital course was uncomplicated and he was discharged on postoperative day 1. No postoperative restrictions were placed on the patient.

Follow-up for the patient was performed at 2 and 6 weeks and at 1 year following his revision surgery. His preoperative effusion was not detectable at his 5-week nor 1-year follow-up evaluation. The remainder of his examination at his most recent follow-up revealed ROM of 0°-130°, without instability, patellofemoral crepitus, or maltracking. Knee Society Scores at 1 year following the index procedure were as follows: function, 90; knee, 100; ROM, 25; total, 190. The patient returned to his premorbid recreational and activity of daily living without limitation. Lastly, his most recent radiographs were unremarkable with no evidence of recurrent osteolysis and well-aligned, well-fixed prosthetic components (Fig. 5).

Discussion

The impetus for design of the RP TKA was to decrease contact stresses and, thus, increase survivorship duration at a time when the polyethylene wear-rate was higher than desired [36-38]. Long-term studies are needed to parse out a potential difference between fixed- and mobile-bearing knee prostheses since the advent of second-generation TKA polyethylene types that introduced increased cross-linking and antioxidants. Midterm studies appear promising with one study reporting a 10-year survivorship rate of 96.7% for a PS RP-TKA [39]. This particular RP design introduces another potential mode of failure in the form of the distal polyethylene insert cone.

Fracture of the polyethylene tibial stabilizing post is a rare but well-described complication of PS TKAs [25,27-32,34]. The usual mechanism for tibial post fracture is excessive rotation between the tibia and femur [27]. Technical error resulting in post failure can be devised from excessive rotation and flexion of the femoral component leading to asymmetric wear and impingement of the cam within the femoral box [17]. The RP may mitigate small deviances in technique to centralize the cam within the femoral box. However, if third-body debris interrupts bearing rotation and this centralization effect, the tibial insert will likely no longer interact with the mobile-bearing tibial tray as designed. We posit that the large piece of delaminated polyethylene from the patellar component in this case may have disrupted the normal rotation of the mobile-bearing. It is possible that this disruption coupled with unexpected in vivo oxidation of the polyethylene liner had caused increased cantilever stresses and eventual gross fracture of the insert cone [32,40,41]. A similar kinematic phenomenon is reported as yoke fractures in rotating-hinge knee prostheses. An analogue of the yoke in rotating-hinge prostheses is the polyethylene insert cone in a PS RP-TKA. Although a PS RP-TKA and a rotating-hinge knee prosthesis are designed with different levels of constraint, some authors surmise that abnormal rotary moments of the polyethylene insert on the tibial tray increases cantilever stresses on the yoke [42-44]. Another mechanism of failure may be fatigue failure due to the normal adduction-abduction coronal plane moments which occur routinely during gait. This effect could be amplified in patients with coronal plane instability and femoral condylar lift-off.

In the case previously mentioned, Tanikake et al [35] reported a polyethylene insert cone fracture in a 72-year male who developed sudden pain and instability 2 years and 2 months following TKA. This patient also demonstrated radiographic signs of polyethylene insert dislocation. After spectron electromicrograph analysis, the

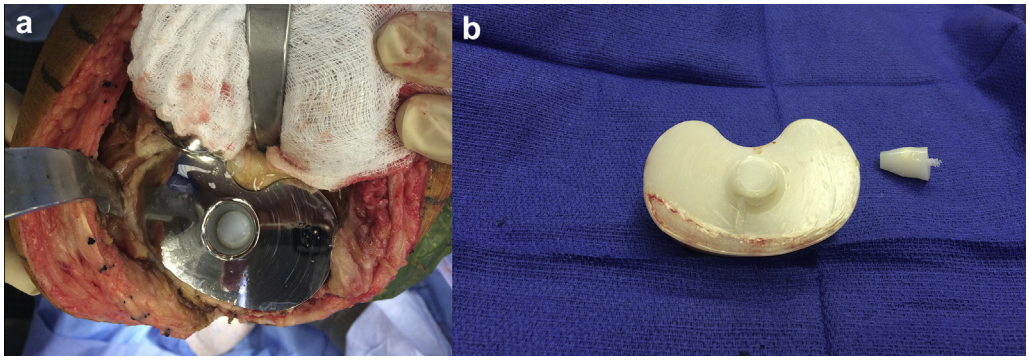

Figure 4. (a) Bird's eye view of broken polyethylene insert cone within a rotating-platform tibial tray. (b) Backside of the retrieved rotating-platform polyethylene tibial insert with delamination and a broken polyethylene insert cone.

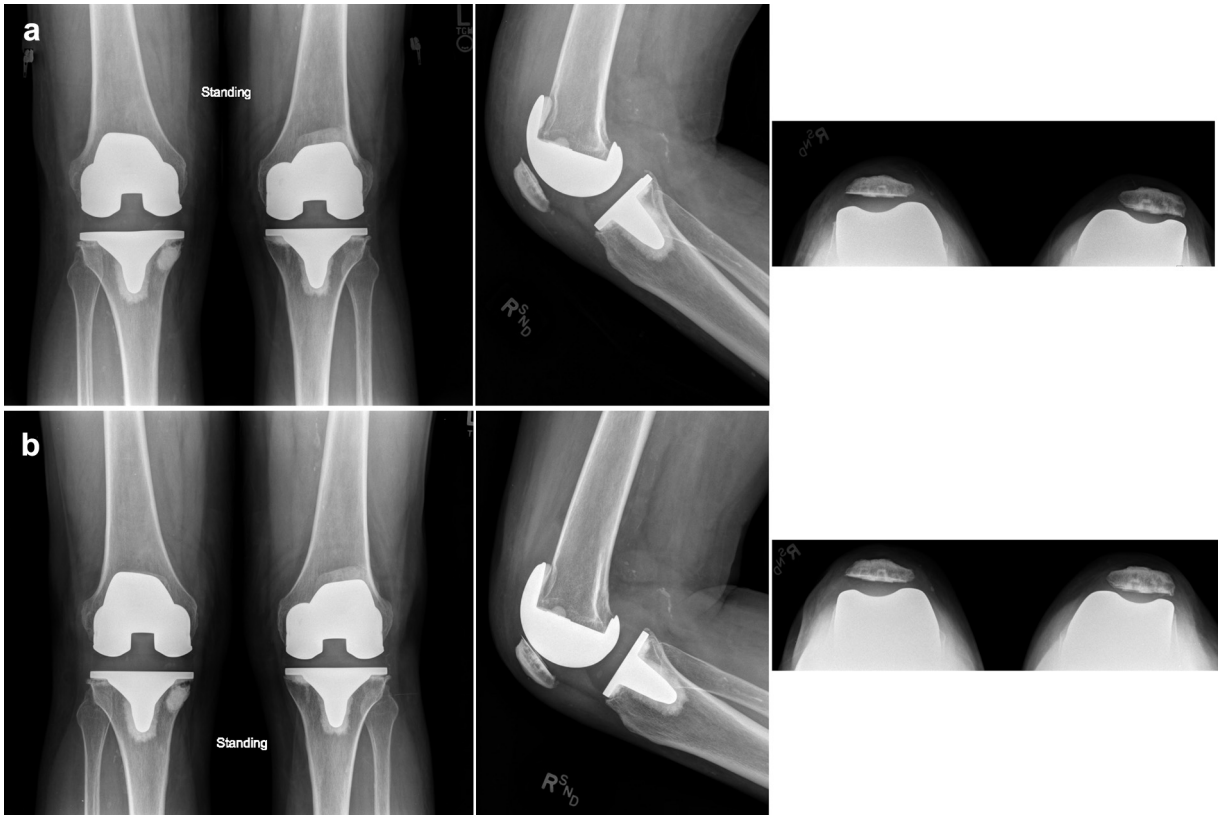

Figure 5. (a) Anteroposterior, lateral, and Merchant views of the right revision total knee arthroplasty at the 5-week postoperative visit. (b) Anteroposterior, lateral, and Merchant views of the right revision total knee arthroplasty at the 1-year postoperative visit.

authors surmised, based on an in vivo kinematic study by Kurita et al [45], that increased longitudinal stresses acting on the polyethylene insert cone in a highly congruent, PS, RP polyethylene liner resulted in the described failure. The patient also exhibited a 15° flexion contracture, and this limited ROM and abnormal shear forces generated across the joint may have been a contributing factor to failure. In contrast, our report details a case of late polyethylene insert cone fracture 11 years following the index procedure without polyethylene dislocation and associated with some delaminating wear of both the tibial insert and patellar component. Furthermore, our report describes a patient who had subtle pain along the medial joint line without signs of instability on examination but with radiographic evidence of focal osteolysis. This underscores the point that surgeons must remain vigilant for such a rare problem as polyethylene insert cone fractures do not always present with sudden onset of pain and instability. The authors suspect the cone fracture occurred at some time following the patient's 9-year postoperative evaluation because no effusion, pain, or radiographic osteolysis was evident at that time. We opine that the fracture allowed increased multidirectional wear patterns on the inferior aspect of the bearing, resulting in increased polyethylene wear generation and subsequent osteolysis.

Summary

In conclusion, it is difficult to diagnose failure of the polyethylene insert cone in a mobile-bearing TKA design when instability is not present. This is the second report of such a polyethylene fracture in a patient with a primary TKA, and the first, to our knowledge, with this particular implant. In contrast to a previously published report, our patient did not exhibit frank instability as we believe there was enough intact polyethylene insert cone to provide adequate stability. In other cases, however, late, atraumatic instability, effusions, and radiographic evidence of osteolysis raise the clinician's suspicion of this bearing complication.

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