



Case report

Two pegs are better than one: rare mode of femoral component failure in unicompartmental arthroplasty requiring revision to total knee arthroplasty

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ABSTRACT

Femoral component fracture is a rare complication in unicompartmental knee arthroplasty, especially in cemented prostheses. We present a 75-year-old man who presented with a fractured single-peg Vanguard component 9 years postoperatively. He was revised to a total knee arthroplasty with an excellent functional outcome at 1 year. The components were additionally examined at an outside biomechanical engineering laboratory. Theories as to the cause of the component fracture include aseptic loosening due to a thin anterior cement mantle and the single-peg Oxford design.

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Introduction

Unicompartmental knee arthroplasty (UKA) is a well-accepted treatment option for isolated medial compartment osteoarthritis with good functional outcomes and low complication rates [1]. UKAs most often require revision due to progression to tricompartmental disease. Fracture of the femoral component has been reported with older, uncemented designs. We report a case of a fracture through the cemented femoral component of a more modern design, of which there is one other recent case report in the literature [2].

Case history

A 75-year-old man with a cemented right medial Vanguard UKA (Zimmer/Biomet, Warsaw, IN) performed in 2007 for symptomatic medial compartment osteoarthritis presented 2 weeks after experiencing sudden onset of right knee pain with no inciting traumatic event. There were no reported postoperative complications from the original procedure and the patient had no functional limitations

before presentation in June 2015. The patient had a body mass index of 26.9 kg/m² and a medical history of multiple cardiac issues and dementia. All history was obtained from his wife. She reported that he complained of sudden-onset severe right knee pain in addition to noticeable crepitus and difficulty with ambulation. Clinical examination confirmed these facts.

Radiographs demonstrated a fracture of the femoral component just posterior to the single peg with a lucency noted at the bone-cement interface of the component segment posterior to the fracture (Figs. 1 and 2). The tibial component appeared intact and well fixed. The patient was indicated for revision to a total knee arthroplasty (TKA) given the catastrophic mechanical failure of his UKA. The risks and benefits of the procedure were discussed and informed consent was obtained. He was made non-weight-bearing in a knee immobilizer for 4 weeks until he was medically cleared for surgery.

The patient was taken to the operating room for conversion to a TKA. The patient's previous medial parapatellar incision was used and extended 2 cm in either direction. Upon entering the joint, the portion of the femoral component previously abutting the posterior condyle was grossly loose and was removed (Fig. 3). The remaining portion of the femoral component was intact and well fixed. An intramedullary guide with a cutting block was placed and the medial distal femoral cut was made around the femoral component. Bone was removed around the component peg and the component was then tapped out using a bone impactor with minimal bone loss.

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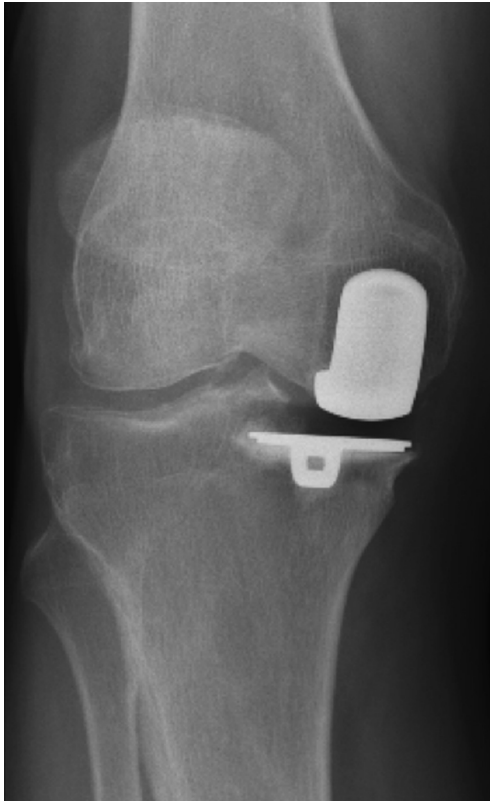


Figure 1. Anteroposterior radiograph of right knee with no evidence of UKA failure.

Tibial component explantation and revision to a primary LEGION tibial base plate (Smith and Nephew, Memphis, TN) proceeded without complication. Autologous bone grafting of the



Figure 2. Lateral radiograph of a right knee with a medial UKA. Note the lucency posterior to the single femoral peg.

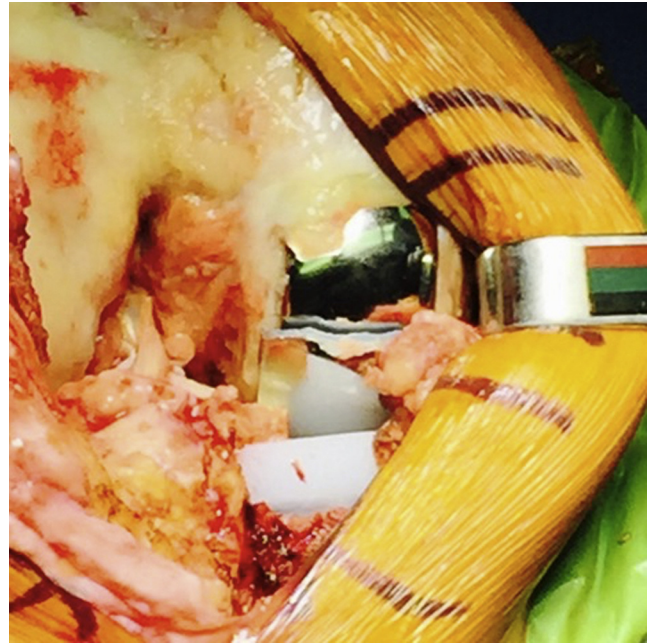


Figure 3. Intraoperative photograph showing the clearly fractured and grossly loose femoral UKA component.

explant component's keel site was performed. A cemented stem extension was used to enhance tibial base plate fixation around the graft and also because of increased metaphyseal bone porosity noted throughout the tibia. Additional components included a primary posterior-stabilized oxinium femoral component and highly cross-linked polyethylene articular insert (Smith and Nephew, Memphis, TN). The patella was left unresurfaced as there was no evidence of chondrolysis (Fig. 4a and b).

The explanted Biomet Vanguard UKA components were sent to an institutional review board–approved retrieval laboratory for analysis (Fig. 5). Following disinfection in formalin, the components were graded for damage by an experienced clinician investigator using a 10× digital microscope. The femoral component was sectioned using a metallurgical diamond saw in the M/L direction immediately next to the 2 exposed fracture surfaces. The fracture surfaces were subsequently mounted on an aluminum stub using double-sided conductive tape and imaged using scanning electron microscopy at up to 200× magnification and accelerating voltages of 10 kV. Additional sections of the femoral component were mounted in Bakelite and progressively ground and polished using metallurgical preparation equipment to a final polish of 0.05 micron polishing compound. Polished faces were etched with aqua regia and imaged under optical microscopy at up to 1000×.

The cobalt-chrome femoral component showed evidence of relative motion between cement and bone with sparse osseous integration and little to no plastic deformation. The articular surface showed a transverse fracture with evidence of fatigue striations and some embedded polyethylene on the fractured surface (Fig. 6). The component showed grade 2 scratching (10%–50% surface area) and grade 1 burnishing (<10%) [3] (Fig. 7). The tibial component showed excellent osseous integration and no evidence of motion. The polyethylene insert demonstrated the posteromedial damage from abrasion against the fractured femoral component.

Electron microscopy revealed crack initiation and fatigue fracture propagation from the superior aspect of the femoral implant at a region coincident with an interior corner of the device (Fig. 8). Fast fracture is indicated toward the center (M/L) of the fracture

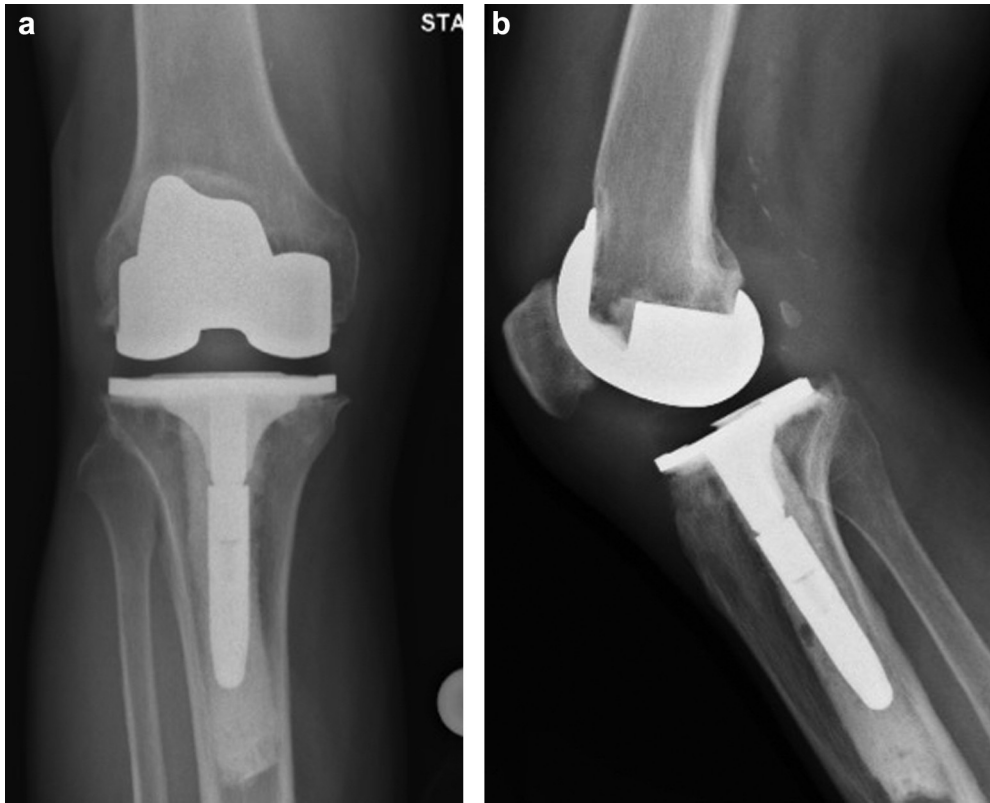


Figure 4. (a) Anteroposterior and (b) lateral radiographs of final TKA components at 1 year postoperatively.

surface, with evidence of grain boundary cracks (Fig. 9). The stress state leading to such a fracture would be one of opening the “C” shape of the device. Metallurgical analysis suggests a characteristic

dendritic cast structure with evenly distributed carbide precipitates throughout, occasional intermetallic deposits at grain boundaries, and no evidence of residual pores from casting. Grain sizes are typically 30–40 microns (Fig. 10).

The patient had an uneventful postoperative course other than occasional activity-related knee swelling that resolved with rest. At final follow-up (13 months postoperatively), the patient was back to his baseline function before his component failure. His knee range of motion was 3°–120°, he was ambulating without assistive devices, and he did not complain of knee pain. His Oxford Knee Score at final follow-up was 46 (out of a possible 48).



Figure 5. Explanted Vanguard femoral UKA component.



Figure 6. Close-up of fracture through femoral UKA component with evidence of fatigue striations.

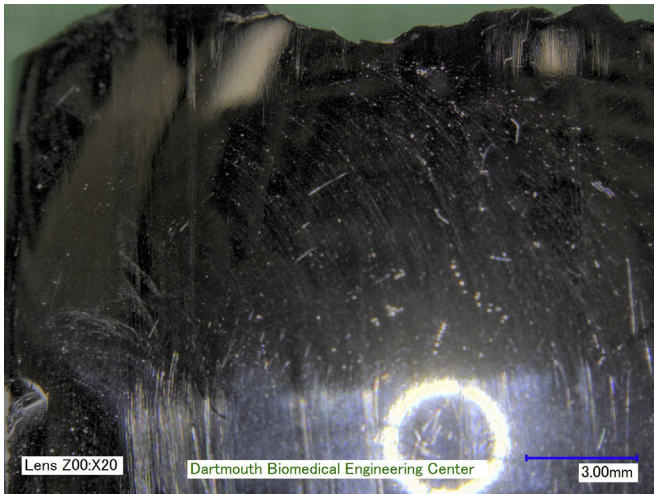


Figure 7. Close-up of the articular surface of the explanted femoral component with signs of scratching and burnishing.

Discussion

Component fracture is a rare complication of UKAs with most modes of failure consisting of component loosening, early wear, or progression of osteoarthritis [4]. Previous reports of fractured femoral unicompartmental arthroplasty components were noted in older models that were either uncemented or showed poor osseous integration [5,6]. Another report showed component fracture was responsible for 3.3% of UKA failures and suggested body mass index >30 kg/m² and poor limb alignment as predisposing conditions [7].

Reasons for this mode of component failure with modern cemented designs remain unclear. The only other reported case of a Vanguard femoral component fracture supposed that inadequate posterior cement mantle caused aseptic loosening and therefore a stress riser posterior to the single peg, eventually leading to fatigue and breakage with repetitive loading [2]. We found similar macroscopic findings in our case, but a fracture pattern opposite the previously cited failure. This leads us to believe that an inadequate or failed anterior cement mantle combined with subsidence or compression of the distal femoral condyle caused repetitive

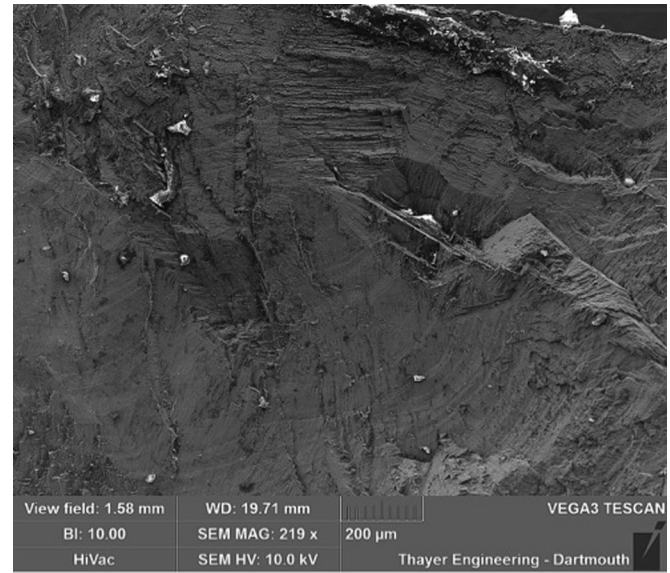


Figure 9. Electron microscopy showing crack around grain boundaries.

stress in flexion and ultimately component fracture. Our patient additionally was not obese, eliminating this as a potentially predisposing factor. During ambulation, loosening at the anterior cement mantle, as indicated by burnishing of the matte cobalt backside of the component, and compression or subsidence of the distal femoral condyle would permit sliding of the device up the inclined anterior bone face. Such a motion would serve as a wedge to open the “C” shape of the device, thereby putting it in a fatigue state of tensile stress at the region of crack initiation. Crack initiation at the corner of the femoral casting, a stress riser, would then lead to propagation during subsequent ambulation and eventual fracture.

A potential factor that could affect component fixation is implant design. This patient received a single-peg Vanguard design. Twin-peg components with updated instrumentation have increased in availability of late. These implants offer improved fixation and additional surface area for better bearing contact during deep flexion. Twin-pegged implants have thus far had excellent clinical results and published studies to date have shown no femoral loosening [8,9]. A recent radiographic

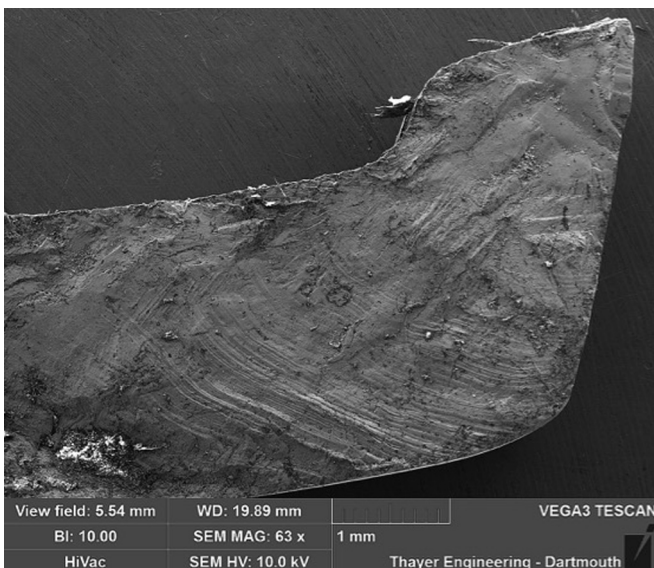


Figure 8. Electron microscopy revealing crack initiation and propagation sites.

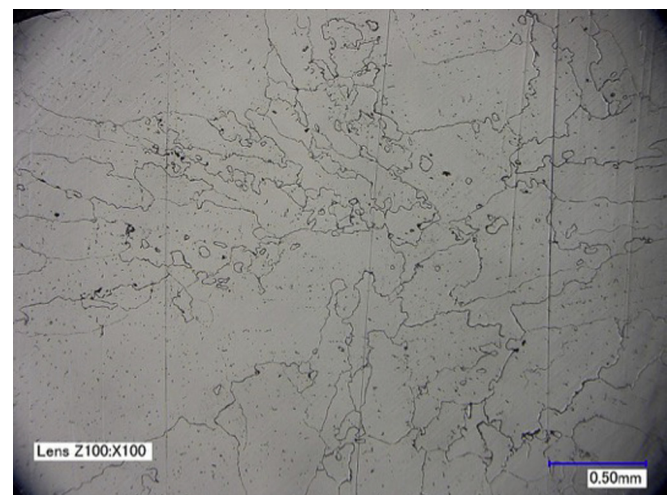


Figure 10. Microstructure overview showing the presence of carbide precipitates within the grains as well as intermetallic phases along the grain boundaries.

comparison of single-peg and twin-peg Oxford designs showed improved component positioning in the twin-peg cohort [10]. The improved fixation with this design may decrease the incidence of femoral component loosening and therefore prevent component fracture.

Summary

Component fracture is a rare complication for UKA. This complication should be managed with revision TKA. Factors that predispose femoral components to aseptic loosening such as inadequate cementation and component design should be addressed at the time of primary surgery to prevent future component fracture. The authors recommend use of twin-pegged femoral components to potentially decrease the risk of this catastrophic failure mechanism.

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