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Case report

Catastrophic tibial baseplate failure of a modern cementless total knee arthroplasty implant

William F. Scully, MD [a, *], Matthew E. Deren, MD [b], Michael R. Bloomfield, MD [c]

[a] Crystal Clinic Orthopaedic Center, Akron, OH, USA
[b] University of Massachusetts Medical School, Worcester, MA, USA
[c] Department of Orthopaedics, Cleveland Clinic Foundation, Cleveland, OH, USA

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ABSTRACT

Tibial baseplate fracture following primary total knee arthroplasty is a rare complication, particularly with modern implants and surgical techniques. This case details the first known report of mid-range follow-up catastrophic failure of a cementless modular, trabecular metal tibial baseplate. This failure highlights the importance of continued follow-up for novel implants, to include cementless knee arthroplasty designs, particularly if new symptoms arise or periarticular bone loss is identified on radiograph.

Introduction

Fracture of the tibial baseplate is a rare and catastrophic complication of total knee arthroplasty (TKA) that often portends a challenging revision surgery. Previous reports have detailed this mechanism of failure in both cemented and cementless tibial baseplates from multiple different manufacturers [1-3]. However, with improvements in implant design and metallurgy, and the advent of highly cross-linked ultra-high molecular weight polyethylene (UHMWPE) inserts, case reports of this type have waned in recent years based on a review of the literature.

NexGen (Zimmer, Inc., Warsaw, IN) trabecular metal tibial trays were introduced in 1999. Trabecular metal is a highly porous biomaterial that is composed of elemental tantalum. The original version of this cementless implant consisted of a monoblock design with a porous tantalum (trabecular metal) undersurface with 2 hexagonal pegs and a shape-molded UHMWPE bearing surface [4]. Multiple publications have documented excellent mid- to long-term survivorship and clinical results of this tibial component without any reports of structural implant failure with 10-year follow-up [5-10].

Subsequently, a modular design was released, consisting of a titanium alloy tray coated with a porous tantalum layer (trabecular metal) and a separate UHMWPE insert. Similar to the monoblock version, this tibial tray has 2 hexagonal pegs, but it also contains a small circular peg, termed a "central boss," in the central posterior portion of the tray that houses a lock-down screw [4]. Comparing the monoblock and modular baseplate designs, the 2 hexagonal pegs have the same length, orientation, cross-sectional hexagonal geometry, and anterior/posterior position. However, on the modular baseplates, the medial/lateral distance between pegs was narrowed on baseplate sizes 3 and 4, based on surgeon feedback per the manufacturer.

Long-term survivability and outcome studies devoted to the modular version of the trabecular metal tibial baseplate are lacking, with the largest study to date reporting 2-year follow-up data on 47 of these components [11]. No structural implant failures have been reported in the much more limited collection of studies reporting on this modular design [4,11-13].

Presented herein is the first report of catastrophic failure of a modular, trabecular metal tibial baseplate with a sagittally oriented fracture of the tray and severe medial proximal tibial bone loss. Case details are reviewed and management of this complication

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* Corresponding author. Crystal Clinic Orthopaedic Center, 3925 Embassy Parkway, Akron, OH 44333, USA. Tel.: +1 330 929 9136.
E-mail address: williamscully13@gmail.com

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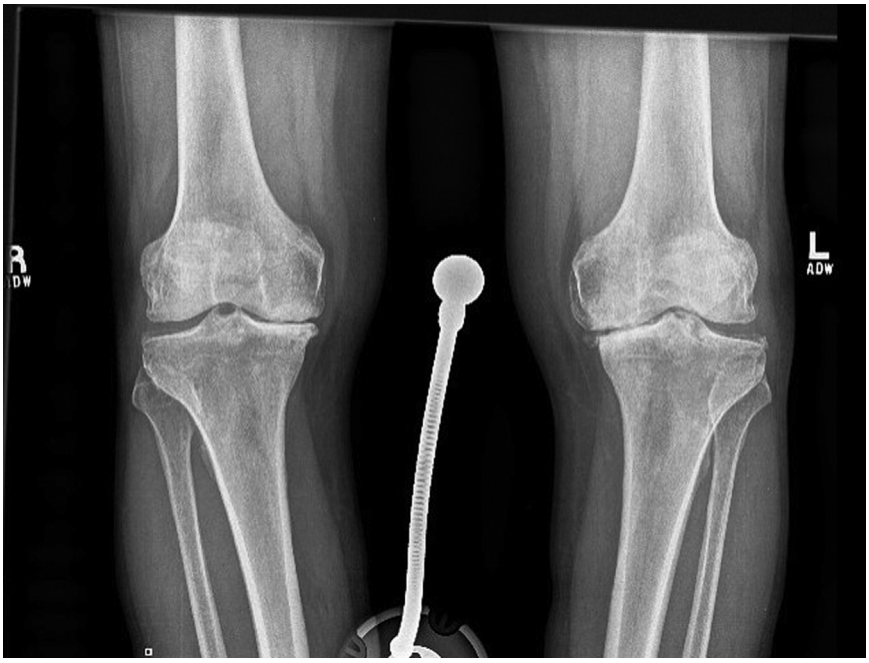

Figure 1. Preoperative bilateral anteroposterior knee radiographs.

with a complex revision TKA procedure, incorporating an asymmetric tibial cone, is detailed.

The patient was made aware of our intentions to publish this case report detailing his condition and gave his verbal permission to proceed.

Case history

At age 56, this Caucasian male patient underwent simultaneous bilateral TKA procedures for advanced varus osteoarthritis at an outside hospital (Fig. 1). The patient's past medical history was significant for obesity (35.5 kg/m^2) and hypertension. The left knee was reconstructed with a Zimmer NexGen cemented, cruciate-retaining size F femur, cementless modular trabecular metal size 5 tibial tray, 12-mm polyethylene insert, and 26-mm cemented patellar component. The right knee was replaced with a Zimmer NexGen cemented, cruciate-retaining size E femur, cementless modular trabecular metal size 6 tibial tray, 12-mm polyethylene insert, and 26-mm cemented patellar component (Fig. 2a and b). There were no perioperative or early postoperative complications. The patient subsequently anecdotally noted that both knees functioned well for approximately 4 years while he continued work as a FedEx truck driver. However, in the preceding months before revision surgery, he began to experience increasing medial-sided left knee discomfort. He denied injury, illness, or known cause for his deteriorating left knee function. Radiographs were obtained by the original surgeon around the time of symptom onset but no intervention was performed (Fig. 3a-c).

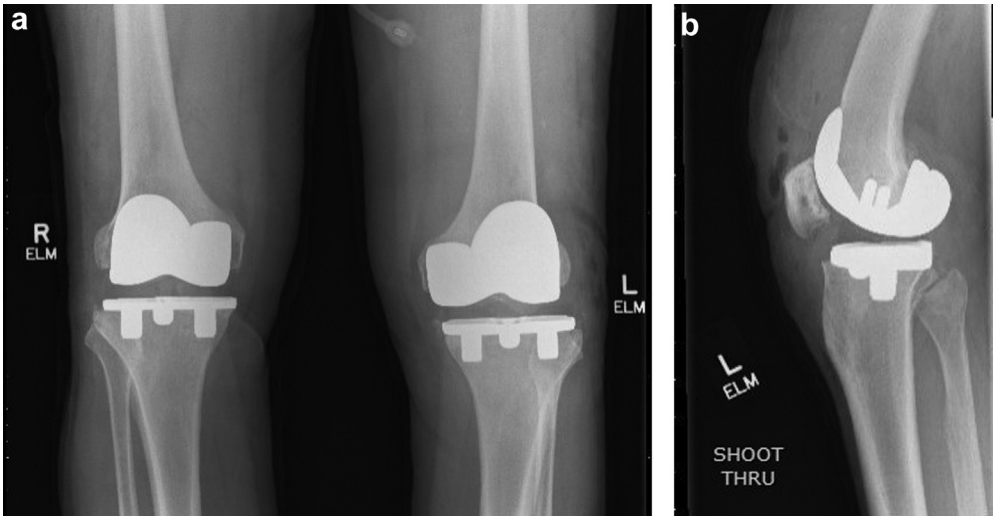

Figure 2. Initial postoperative knee radiographs. (a) Anteroposterior bilateral knees. (b) Lateral left knee.

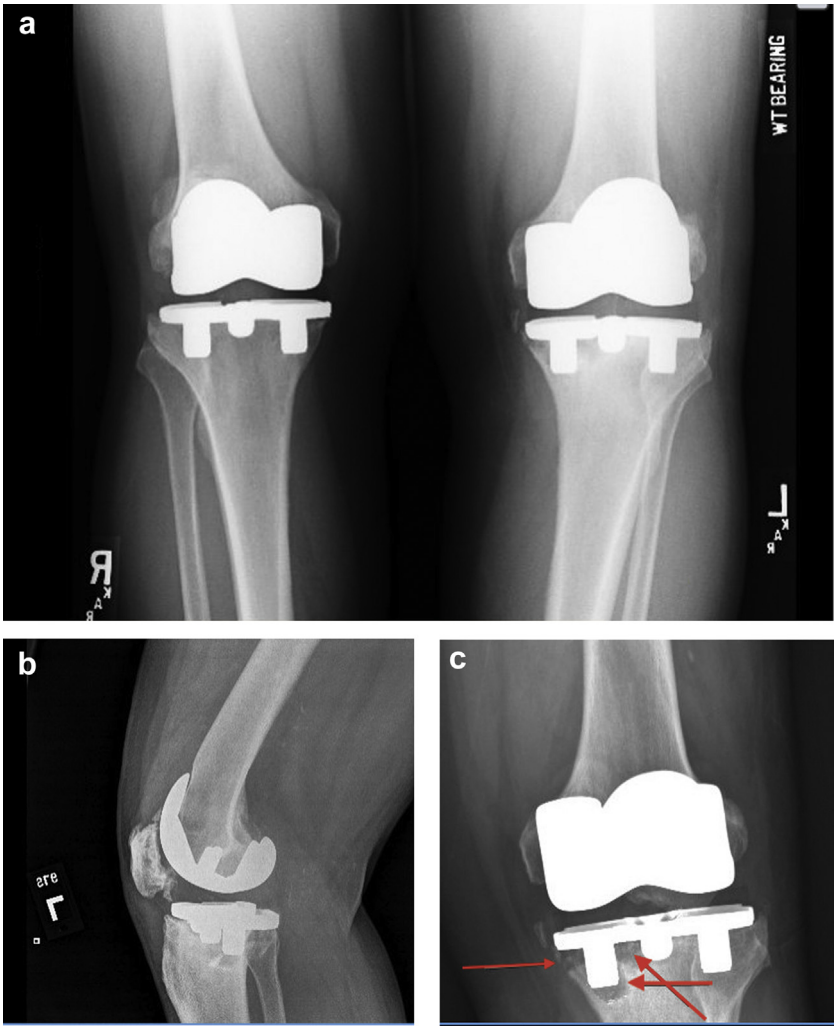

Figure 3. (a-c) Follow-up knee radiographs approximately 4 years following the index surgeries, depicting unilateral proximal medial tibial bone loss beneath the left tibial baseplate. Heterotopic ossification is present about the patella.

On clinical evaluation at the time of presentation at our office, he was noted to have a well-healed anterior longitudinal surgical incision about the left knee, without erythema, excess warmth, or drainage. He was diffusely tender about the knee, most notable along the medial joint line and proximal medial tibia, and had medial-sided knee mechanical pain with weight bearing. His range of motion was limited to 10°-90° with palpable medial-sided crepitus through this arc of motion, and grade II medial-sided laxity with varus/valgus stress testing.

Radiographs of the left knee (Fig. 4a and b) depicted catastrophic failure of his tibial baseplate in conjunction with severe medial-sided tibial bone loss. Given these findings, his weight bearing was immediately protected and he was indicated for an expedited surgical revision. As part of a standard workup, infection was ruled out via standard laboratory tests to include a white blood cell count of 7.3 (normal range 3.7-11.0 $\times$ 10^9/L), C-reactive protein of 0.3 (normal <0.9 mg/L), and erythrocyte sedimentation rate of 2 (normal range 0-15 mm/h), all of which were within normal limits. The patient also had a preoperative knee aspiration, which yielded a cell count of 647 cells/mL with 8% neutrophils and negative gram stain and aerobic/anaerobic cultures.

On subsequent surgical exploration, the tibial baseplate was found to have a complete and displaced, sagittally oriented fracture with the medial half collapsed into a large, uncontained proximal medial tibial defect (Anderson Orthopedic Research Institute classification IIA) (Fig. 5a). The locking mechanism for the polyethylene insert was also damaged. The femoral component had no macroscopic damage. The broken tibial baseplate fragments were completely removed (Fig. 5b) along with the femoral component in the process of performing a full revision TKA procedure. Given the substantial, uncontained medial-sided tibial bone loss, an asymmetric tibial cone (Stryker, Mahwah, NJ) was utilized to provide medial-sided structural support for the revision tibial baseplate (Fig. 6), and stemmed, cemented femoral and tibial components were selected with a varus/valgus constrained polyethylene liner (Fig. 7a and b). Constraint was utilized to account for medial collateral ligament laxity. Three intraoperative tissue samples were sent for aerobic and anaerobic cultures, all of which came back negative.

The patient had no perioperative complications. Following a standard course of physical therapy, he returned to work at full capacity 2 months following the revision surgery. At 1 year follow-up, the patient is doing well with substantial improvement in his functional scores, no regular reported discomfort, normal gait without any assistive device, and range of motion of 0°-120° (Fig. 8a-c).

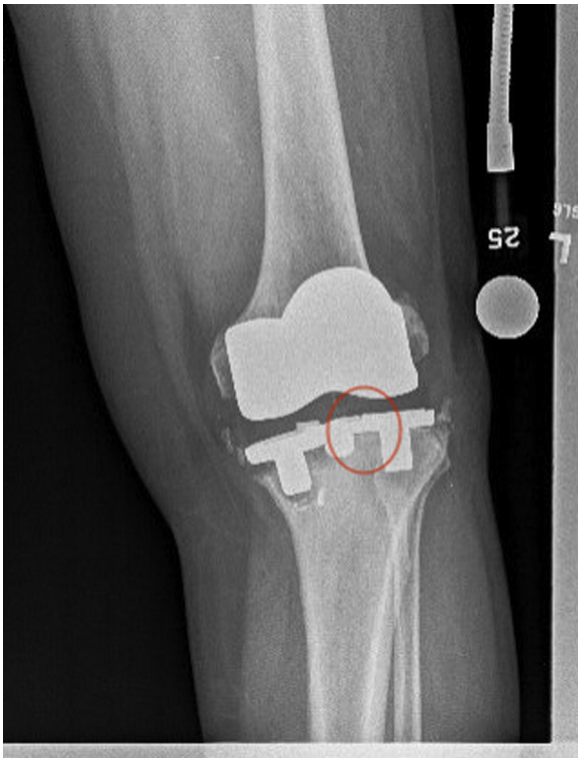

Figure 4. Subsequent left knee radiographs depicting fracture and displacement of the tibial baseplate.

Discussion

This case report details the first account of catastrophic failure with fracture of a modular, cementless trabecular metal tibial baseplate. This failure mechanism remains very uncommon but several important observations have been noted from analyses of prior baseplate fractures that can be correlated with this report. The common pathway preceding fracture of the baseplate is focal loss of the structural support beneath the tray. Prior retrieval analyses of 25 baseplate fractures involving several designs and manufacturers have documented a 100% correlation between the location of the baseplate failure and underlying proximal tibial bone loss [1]. Proximal tibial osteolysis secondary to polyethylene wear is the most commonly cited cause for this evolving boney structural deficiency [1]. With the development of focal proximal tibial loss, cantilever bending of the tibial baseplate occurs at the junction between supported and unsupported bone, which eventually leads to fatigue failure of the implant in the cases of fracture [2].

Careful inspection of the patient's radiographs at the time of symptom onset and prior to baseplate fracture (Fig. 3a-c) reveals this characteristic bone loss about the proximal medial tibia which likely led to the subsequent baseplate failure. The cause of this bone loss remains unclear in this case. With the superior wear properties of highly cross-linked UHMWPE [14] and minimal macroscopic wear noted on the polyethylene insert at the time of revision surgery, it is unlikely that substantial wear-induced osteolysis developed in this case at just 4 years postop. Periprosthetic joint infection, another potential cause for implant loosening and periimplant bone loss, was also definitively ruled out as detailed previously.

Various design characteristics of the tibial baseplate have also been analyzed for a potential predisposition to baseplate fracture. Design features that have been postulated to potentially increase baseplate fracture susceptibility include large posterior cutout for the posterior cruciate ligament, decreased thickness of the baseplate, type of metal (more failures cited in cobalt-chrome baseplates vs titanium), and overall implant geometry [1]. None of these features apply to the baseplate in question.

Malpositioned components, limb malalignment, and uneven joint balancing have also previously been postulated to predispose to baseplate fracture. Furthermore, the eccentric joint contact forces seen in malalignment are further magnified in the setting of elevated patient body mass index, and many of the prior reports cite the combination of these factors—component malposition and patient obesity—as likely contributory causes for the implant failure. In this particular case, the patient's initial left tibial component position appears to be in approximately 5° of varus, although this assessment is limited by the poor quality of the available films and inherent limitations measuring alignment on short knee images [15] (Fig. 2a). The femoral component also appears to be in slight varus compared to the other knee, further increasing the overall varus of his limb alignment. The space between the medial and lateral compartments on Figure 3a also appears slightly asymmetric (narrower medially), suggestive of varus/valgus imbalance with the knee being tighter medially.

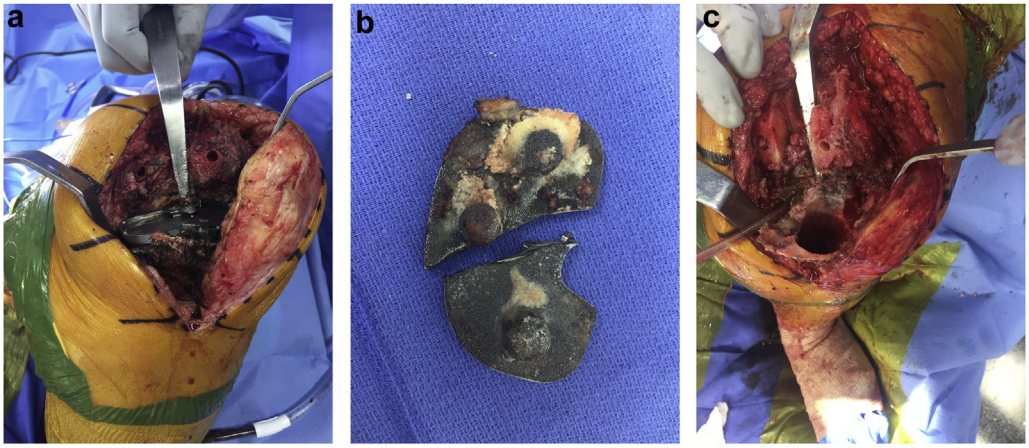

Figure 5. (a-c) Clinical photographs depicting the fractured tibial baseplate and underlying severe proximal medial tibial bone loss. Note the extensive metallosis within the tissue appearing black. Underside of explanted tibial baseplate shows limited bony ingrowth medially. Final photograph shows the medial tibial bone loss just before final preparation of the tibial asymmetric metaphyseal cone.

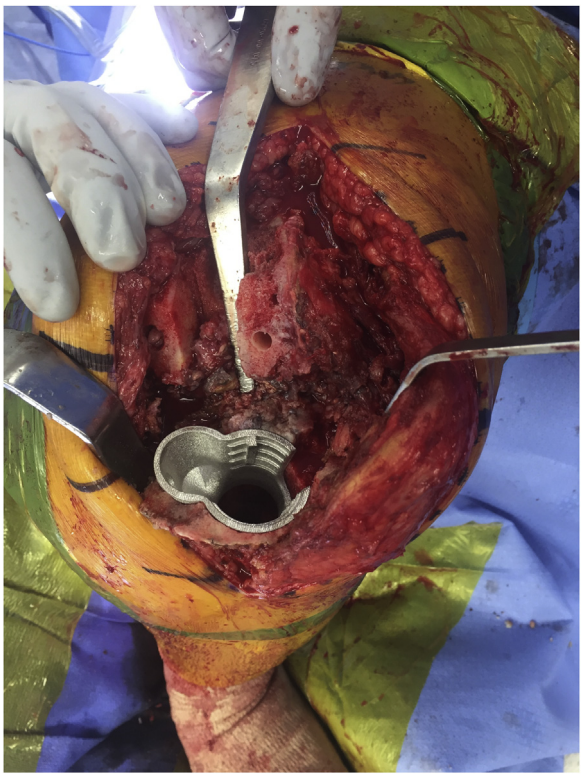

Figure 6. Clinical radiograph of a Stryker asymmetric cone utilized to fill the proximal medial tibial void and support the revision baseplate.

Also noteworthy, the left tibial baseplate (size 5) was one size smaller than the right (size 6), which might indicate that his left tibial baseplate was undersized. An undersized tibial component would less effectively transfer load to the underlying proximal tibial cortices and be at greater risk of subsidence and/or loosening [16]. Conversely, the femoral component on the patient's left knee (size F) was one size larger than the right (size E), which, while still within accepted manufacturer guidelines, also theoretically has the potential to alter the distribution of joint forces, particularly on a smaller tibial baseplate where these forces would be further concentrated. Although potentially projectional, the "oversized" femoral component is evident on the radiographs by the overhanging position of the femur relative to the tibia medially on the anteroposterior view (Fig. 2a), and overhanging posterior condyles on the lateral view (Fig. 2b). Additionally, the femoral component appears posteriorly positioned on the tibia on the lateral view, which could be seen with a tight flexion gap secondary to an oversized femoral component (Fig. 2b). His body mass index at the time of revision surgery was 36.6 kg/m^2, falling in the obese category. Attributing this combination of findings and observations to the preceding proximal medial tibial bone loss or subsequent baseplate failure would be speculative, but the potential association cannot be ignored and warrants future study.

Another relevant consideration in this case relates to cementless fixation. Prior cementless baseplate fractures have been reported [1], but many of these earlier cementless designs were plagued by poor osteoconductive surfaces and inadequate fixation devices and are no longer in wide circulation [16]. Improved results, comparable to modern cemented tibial baseplates, have been reported with newer cementless implant designs currently in circulation, to include the 2 versions of the implant involved in this case [4-13,17]. Although difficult to confirm on the retrieved fracture implant, incomplete biologic ingrowth on the tibial baseplate on the medial side where the most sclerotic bone was likely present from the patient's preoperative severe varus alignment, could have also contributed to eventual fatigue failure of the implant.

Ultimately, the cause of this particular implant failure is likely multifactorial, potentially resulting from a combination of factors that led to asymmetric and excessive forces across the implant to include component malpositioning, suboptimal component sizing, and elevated patient body weight. Whether these factors collectively led to the preceding proximal medial tibial bone loss, or this

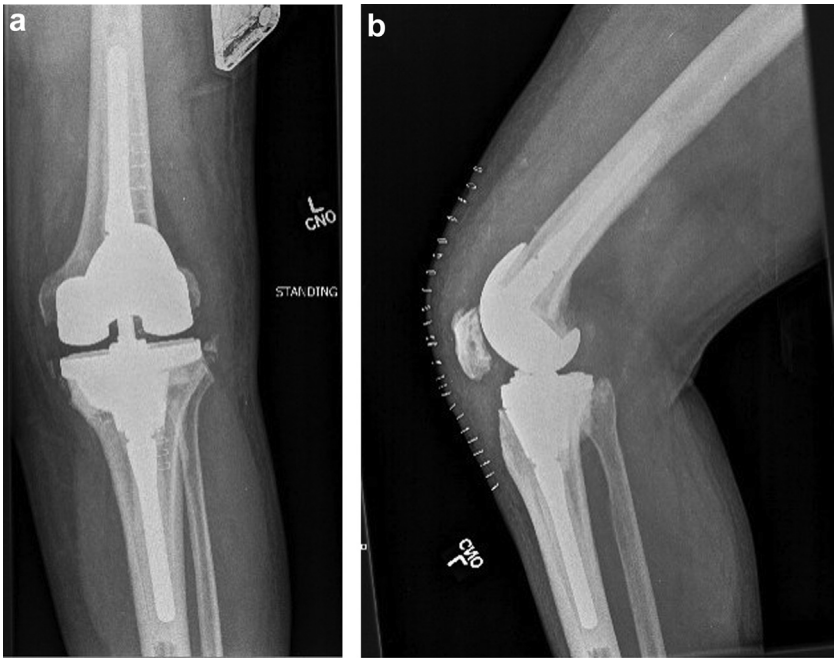

Figure 7. (a, b) Postoperative left knee radiographs depicting the revision total knee construct.

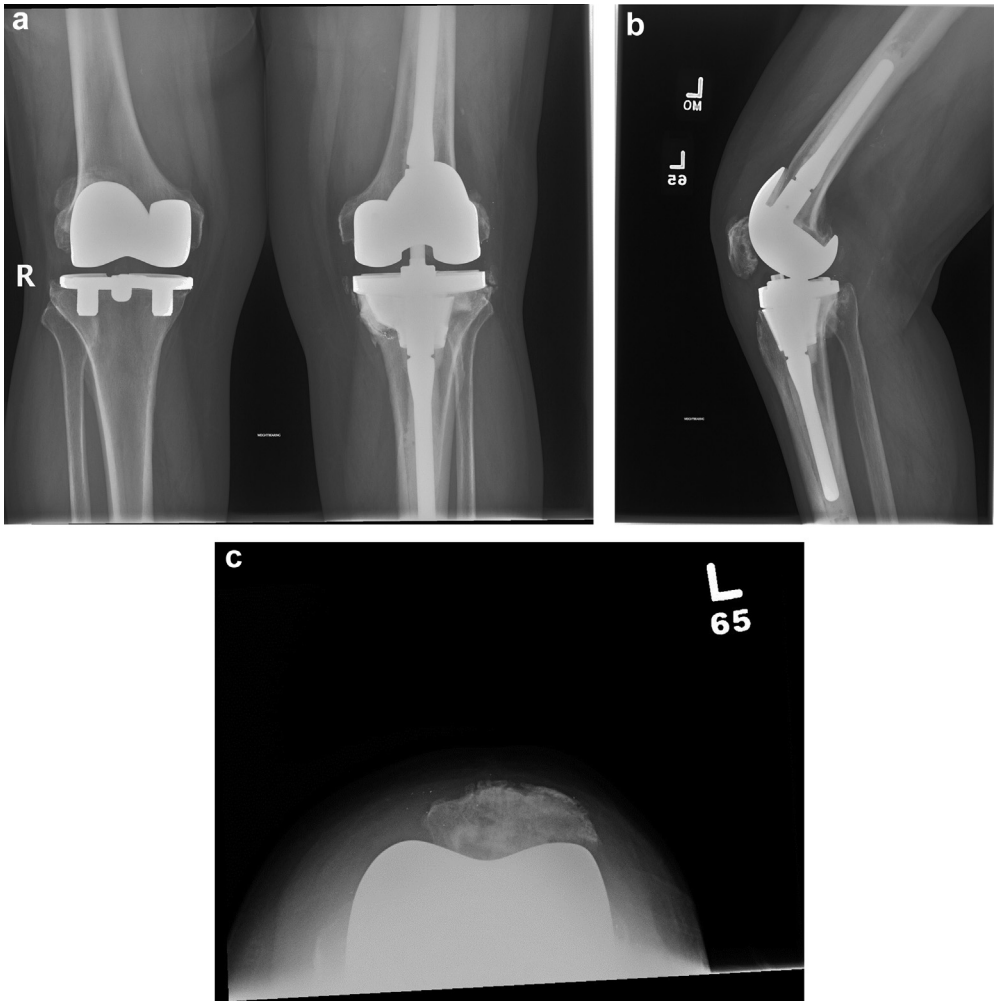

Figure 8. Anteroposterior bilateral (a), lateral left (b), and Merchant left (c) knee radiographs 1 year postop following the revision left total knee arthroplasty procedure.

boney destruction was the result of another process such as aseptic loosening and/or incomplete biological ingrowth of the implant remain unclear. The potential role of this particular implant's design characteristics and materials also warrants further consideration.

As noted previously, mid-long-term follow-up of this particular modular, trabecular metal tibial tray is presently lacking. This is the first report of this particular type of failure involving this implant. Follow-up and radiographic surveillance following TKA is variable between individual providers. This case of catastrophic tibial failure points toward routine surveillance of cementless TKA to identify loosening early, prior to severe bone loss which developed in this case. Particularly concerning is that the patient did not develop symptoms until 4 years after surgery. The development of new-onset pain in an otherwise well-functioning knee arthroplasty should certainly warrant further evaluation, as described in this case with radiographs and an infectious workup. Further investigation with more lengthy follow-up studies is necessary to confirm the functionality and safety of these implants.

Summary

This is the first known case report of mid-range follow-up catastrophic failure of a cementless modular trabecular metal tibial baseplate in a TKA. This failure highlights the importance of continued follow-up for novel implants, to include cementless knee arthroplasty designs, particularly if new symptoms arise or periarticular bone loss is identified on radiograph.

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