

Early Post-operative Fracture of Titanium Cementless Tibial Baseplate: Case Report and Review of the Literature

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Learning Point of the Article:

Although rare, orthopedic surgeons must maintain a high index of suspicion for tibial baseplate fracture as a complication of total knee arthroplasty with cementless implants, even in short-term follow-up.

Abstract

Introduction: Modern improvements in design and materials have led to a recent resurgence in the popularity of cementless total knee arthroplasty (TKA). Although early catastrophic failure is known to infrequently occur in cemented constructs, it is uncommon in modern designs of cementless knee systems.

Case Report: Here, we report a 70-year-old female with a case of early fracture of the tibial component in a cementless, highly porous titanium-coated baseplate (Triathlon Tritanium, Stryker Orthopaedics), occurring within 20 months of the index procedure. Our case was successfully managed with a cemented tibial cone and stem construct; however, the etiology of failure remains uncertain.

Conclusion: Tibial baseplate fracture following TKA with modern cementless titanium three-dimensional -printed porous implants is scarcely reported in the literature, and a high index of suspicion should be maintained in the setting of unexplained pain even at short-term follow-up.

Keywords: Baseplate fracture, polyethylene wear, polyethylene fracture, cementless total knee arthroplasty, revision total knee arthroplasty.

Introduction

Total knee arthroplasty (TKA) has evolved considerably over the past few decades with respect to implant design and materials. Despite these advancements, fracture of the tibial baseplate remains a rare yet considerable challenge. While this has been reported in the literature in the past, these reports have primarily focused on cemented constructs in older implant designs that fractured many years after implantation due to fatigue failure resulting from osteolysis underneath the baseplate [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]. In recent years, improvements in design and manufacturing capabilities have increased interest in cementless TKA with the goal of improving long-term fixation

relative to cement [13]. While reports of cementless tibial baseplate fracture have been reported in certain designs, there are few reports to our knowledge of a tibial baseplate fracture in the most commonly used, modern cementless three-dimensional (3D)-printed porous titanium-coated design at short-term follow-up (Table 1) [1, 3, 4].

Case Report

Verbal informed consent was obtained from the patient before submission of this report. A 70-year-old female underwent an uneventful right TKA utilizing conventional guides (Stryker Triathlon Cementless Knee System; Stryker Corporation, Kalamazoo, MI) at an outside hospital and was discharged home

Author's Photo Gallery



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Figure 1: Pre-operative anteroposterior and lateral radiographs of the right knee obtained 1 month before the patient undergoing total knee arthroplasty.

on post-operative day 1 (Fig. 1 and 2). We are not able to determine the degree of varus/valgus deformity pre-operatively, as full-length standing radiographs were not obtained at her original surgery. In the immediate post-operative period, her tibial component was in 3° of varus, femoral component was in 4° of varus, and tibial slope was 3° of posterior slope on short Anteroposterior and lateral radiographs (Fig. 2). The patient had a medical history notable for obesity (body mass index [BMI] 40.77 kg/m²), type 2 diabetes mellitus (hemoglobin A1C 6.1%), hypertension, hyperlipidemia, obstructive sleep apnea, chronic obstructive pulmonary disease, non-ST segment elevation myocardial infarction, and prior aortic valve replacement. One month post-operatively, she began to develop sharp right knee pain with ambulation and was referred to pain management. Her radiographs at that time did not show any clear signs of implant failure, and she was referred to pain management after unrevealing radiographic and infectious workups (Fig. 3). Over the course of the next year, she experienced progressively worsening medial knee pain preventing full weight-bearing. She presented for a second opinion to our institution 20 months post-operatively and was found to have catastrophic failure of the polyethylene insert and a fractured tibial baseplate (Fig. 4); she was indicated for revision surgery.

A standard midline medial parapatellar exposure was performed utilizing the patient's prior incision. Upon entering the joint, both the patellar and femoral components were noted to be well-fixed and were left in situ to reduce her morbidity from the removal of well-fixed components. The polyethylene was visualized and noted to be fractured posteromedially. The posteromedial corner of the tibial baseplate demonstrated a fracture with loosening of this piece and impaction of the posteromedial tibia. The remaining tibial baseplate was grossly well-fixed. The remaining tibial component was removed using

a combination of an oscillating saw and flexible osteotomes. Due to some bone loss following extraction of the primary baseplate, along with her body weight and relative osteopenia, a press-fit cone and short, fully cemented tibial stem construct were used for additional fixation (Stryker Triathlon Revision Knee System; Stryker Corporation, Kalamazoo, MI) (Fig. 5). Intraoperative cultures taken were ultimately negative for any signs of infection. She had no complications in the post-operative period. At her most recent follow-up, approximately 3.5 years after surgery, she was ambulating using a cane outdoors or without assistive devices around the house with resolution of her pre-operative pain.

Discussion

The use of cementless primary TKA has increased in recent years due to interest in the potential benefits of long-term biologic fixation, akin to the rise in cementless total hip arthroplasty [14]. While early studies of modern cementless TKA designs have shown successful outcomes and survivorship compared to cemented constructs, concerns remain about the possibility of early revision or changes in failure modes as the indications for cementless TKA expand [13, 15, 16]. In our case, the patient is a 70-year-old woman with early cementless Stryker Triathlon tibial baseplate failure consisting of posteromedial fracture of both the baseplate and polyethylene insert within 2 years after her index procedure, with symptoms that developed around 1 month after surgery. While her etiology of failure is not clear, two possibilities include: (1) Catastrophic failure of her highly cross-linked polyethylene insert leading to direct metal-on-metal contact resulting in baseplate fracture, or (2) fatigue/catastrophic failure of the

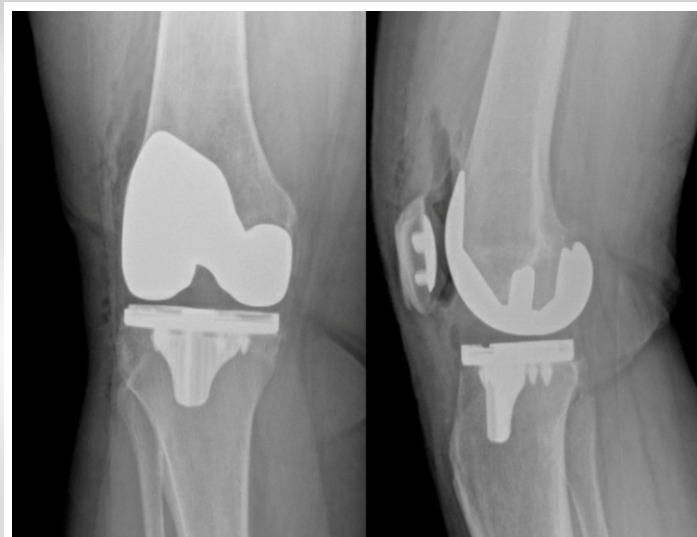


Figure 2: Immediate post-operative Anteroposterior and lateral radiographs of the right knee following cementless total knee arthroplasty (Triathlon Tritanium, Stryker Orthopaedics).

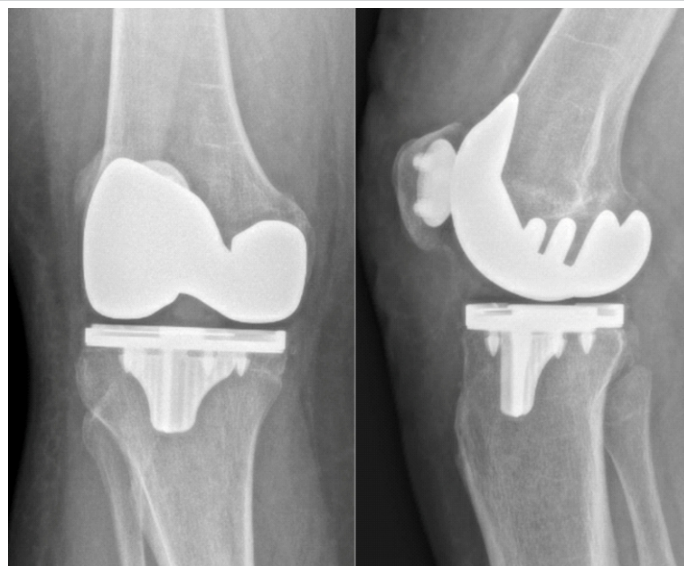


Figure 3: One-month post-operative anteroposterior and lateral radiographs of the right knee following report of increasing pain.

tibial baseplate resulting in subsequent polyethylene fracture.

There have been a number of possible explanations to tibial baseplate fracture in previous studies (Table 1). In cemented designs, component fractures were often the result of either (1)

progressive fatigue failure of the baseplate itself due to causes, such as osteolysis resulting in loss of tibial bone support or (2) polyethylene fracture leading to direct contact of the femoral component on the tibia component with subsequent fracture of the tibia secondary to metal-on-metal wear [1,4,5,6,7,8,11,12,17,18,19,20,21]. Contributing factors to baseplate fracture have also included design of the prosthesis, male gender, BMI, patient activity level, increased implantation time, and component under-sizing/malposition, such as residual varus alignment [6,12,21,22]. In our study, given her short time of implantation, polyethylene wear and chronic fatigue failure of the implant appear less likely as etiologies, suggesting that these modern designs of cementless TKA components may have unique failure modes relative to older cemented designs (Table 1).

One possible contribution to TKA failure includes technical considerations. Several radiostereometric analysis studies have demonstrated that there is a typical biphasic migration pattern with cementless components during the osseointegration period that is significantly longer than that of their cemented counterparts and can last up to 2 years [23,24]. It is possible that early micromotion is less well tolerated with titanium as the baseplate material, and this predisposed our patient to early

Table 1: Reported tibial baseplate fracture cases following total knee arthroplasty

Study (Tibial baseplate fracture)	Year published	Number of cases	Implant	Fixation type (cementless vs. cemented)	Time to fracture
Retrieval study of tibial baseplate fracture after total knee arthroplasty; Chatterjee <i>et al.</i> [6]	2005	25	10 kinematic, 6 Miller-Galante, 5 porous-coated anatomic, and 4 ortholoc II	Cemented (12 patients); Cementless (13 patients)	Mean, 10.8 months (range, 1–36 months)
Fracture of the metal tibial tray after kinematic total knee replacement; Abernethy <i>et al.</i> [20]	1995	16	Howmedica Kinematic prosthesis	Cemented	Mean 56.5 months (Range 23 months–105 months)
Implant fracture of the regenerex® modular metal tibial component: A report of three cases; Rytter <i>et al.</i> [4]	2019	3	Zimmer biomet; regenerex® modular TKR.	Cementless	10, 12 and 23 months
Fracture of the tibial component in total knee arthroplasty: Report on two cases; Da Palma <i>et al.</i> [20]	2015	2	Howmedica PCA prosthesis	Cementless	9 years, 2 years
Early tibial tray failure of a duracon knee with retrieval analysis; Ho <i>et al.</i> [7]	2004	1	Howmedica duracon prosthesis	Cemented	3 years
Total knee replacement with an uncemented porous tantalum tibia component: A failure analysis; Fokter <i>et al.</i> [1]	2022	1	Zimmer NexGen® LPS-(Limb Preservation System) flex trabecular metal™	Cementless	3.6 years
Fracture of the tibial baseplate 16 years after Miller-Galante II total knee arthroplasty; Mineta <i>et al.</i> [11]	2017	1	Zimmer Miller-Galante II (MG II)	Cementless	16 years
Tibial tray fracture in a modern prosthesis with retrieval analysis; Callaghan <i>et al.</i> [5]	2018	1	DePuy PFC (Press Fit Collar) sigma design	Cemented	1.4 years (17 months)
Fracture of the tibial tray after total knee arthroplasty; Altintas <i>et al.</i> [8]	1999	1	Zimmer MillerGalante II (MGII)	Cemented	6 years
Fracture of the tibial tray of the PCA knee: A case report of early failure caused by improper design; Flivik <i>et al.</i> [18]	1990	1	Howmedica PCA prosthesis	Cemented	4 years
Fractured Whiteside Ortholoc II knee components; Swartz <i>et al.</i> [12]	2001	1	Whiteside Ortholoc II	Cementless	9 years
Early tibial component fractures in a cementless, 3D-printed, titanium implant; Lam and Duffy [31]	2022	3	Triathlon titanium tibial baseplate; Stryker Orthopedics	Cementless	3 years, 4 years, 1.4 years (17 months)
Catastrophic tibial baseplate failure of a modern cementless total knee arthroplasty implant; Scully <i>et al.</i> [3]	2019	1	Zimmer NexGen modular trabecular tibial tray	Cementless	4 years

PCA: Porous-coated anatomic, TTK: Total knee replacement, 3D: Three-dimensional

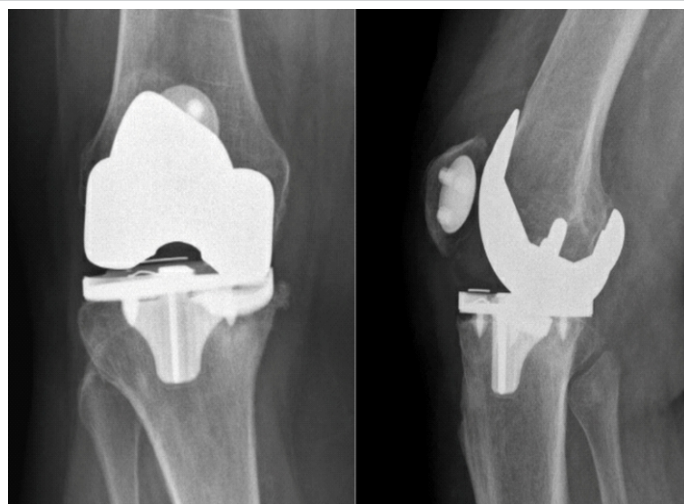


Figure 4: Anteroposterior and lateral radiographs taken on presentation to clinic demonstrating fracture of the tibial baseplate and extruded polyethylene insert.

fatigue failure. This could have been exacerbated by the patient's pre-operative BMI of 42, which can predispose to medial tibial collapse in cemented TKA designs [25,26,27,28]. Several factors may contribute to this early failure of biologic fixation. While there were no full-length films pre-operatively, the implants appeared to be in some varus alignment, which may lead to overload of the medial side and predispose the implant to fatigue failure if it failed to osseointegrate, and this would more specifically affect the posteromedial portion during flexion [6,7,10,11,29]. Fatigue failure resulting in baseplate fracture can also occur in a well-aligned component that are not well-supported by host bone [6,21]. Sepehri and Masri report a case which they attribute to inadequate tibial baseplate size and positioning with insufficient cortical support [2]. In our case, the tibial baseplate sized at 3 appeared well-sized and appropriate, and the overall tibial bone stock appeared sufficient to support a cementless component, so this is less likely.

Biomaterial issues may also have possibly contributed to early tibial baseplate fracture in this design. Kurtz et al. found that in titanium alloy tibial baseplates, the presence of equiaxed or acicular microstructure formed during manufacturing influences fatigue fracture propagation [21]. The Stryker Triathlon is a 3D-printed highly porous titanium alloy with a sequentially annealed highly cross-linked polyethylene insert. The X3 polyethylene insert associated with the Stryker Triathlon system is a modern highly cross-linked polyethylene which may be predisposed to early catastrophic failure [30]. In addition, there have been case reports of early polyethylene fracture of sequentially annealed polyethylene in the setting of primary TKA [6,11,21]. Sonn and Meneghini describe a case requiring revision of a yellow-discolored polyethylene insert thought to be due to oxidation, which was found to have

significant posteromedial polyethylene wear within just 5 years of implantation [30]. This significant wear precipitated the direct articulation of the femoral component with the tibial tray, leading to tibial component damage [30]. It is possible that this same mechanism of failure occurred in the cementless component used in this study, with polyethylene fracture followed by tibial component fracture due to direct articulation with the femoral component. There is a paucity of reports of cementless tibial baseplate fractures following primary TKA in the literature. Scully et al. described the first known case, although the time to fracture was 4 years from the index surgery [3]. Lam and Duffy reported the first case series of three patients with early tibial component fractures in a cementless, 3D-printed implant [31]. However, only one case they describe is within 2 years of the index procedure.

A notable limitation to our single case report is that the findings are based on one patient and cannot establish the incidence, risk factors, or generalizability of early tibial baseplate fracture. Further, while we propose the above failure mechanisms in this patient, the exact cause of failure remains unclear. In the present study, no detailed metallurgical, fractographic, or material analysis was performed to confirm the mechanism of component fracture. Due to limited assessment of implant positioning, the possible contribution of component malposition, inadequate cortical support, or impaired osseointegration cannot be definitively established. Our proposed explanation of early polyethylene fracture was not conclusively demonstrated, and the sequence of polyethylene and baseplate failure remains uncertain. As noted above, the unavailability of full-length standing radiographs limits accurate assessment of pre-operative deformity and post-operative mechanical alignment. Multiple risk factors, including obesity, possible varus alignment, osteopenia, and comorbidities, may confound the attribution of failure to



Figure 5: Anteroposterior and lateral radiographs taken post-operatively demonstrating revision of tibial baseplate with retention of femoral and patellar components.

implant design or material properties. The findings from this single reported cementless titanium baseplate design cannot be extrapolated to all cementless TKA systems or implant materials. Finally, our case report and literature review cannot establish comparative failure rates between cementless and cemented implants. Larger studies with systematic implant surveillance and retrieval analysis are required to identify risk factors and clarify failure mechanisms.

Conclusion

Cementless 3D-printed porous titanium tibial baseplate fracture is a rare and devastating complication of TKA. We report a case of early catastrophic failure occurring within 20 months of the index procedure. Based on previous literature, possible etiologies for such a component failure may include early fatigue failure of the titanium baseplate versus catastrophic

failure of the polyethylene insert followed by baseplate fracture due to the articulating metal surfaces. Further studies will have to continue to follow the outcomes of cementless TKA with newer biomaterials and designs.

Clinical Message

TKA is evolving as a procedure with regard to the innovative types of materials and designs used for implants. While highly infrequent, orthopedic surgeons must be aware of the complications that can arise in modern cementless TKA implants to better plan revision surgeries and improve patient outcomes. Our case report adds to the scarce literature describing a tibial baseplate fracture in a modern cementless titanium 3D-printed porous implant in a short follow-up period from the index procedure.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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