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Case report

A novel use of a tibial cone in a proximal femoral replacement

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ABSTRACT

Revision total hip arthroplasty in the setting of severe femoral bone loss can be challenging, with salvage options often limited to modular tapered stems, allograft prosthetic composites, and megaprostheses. This case highlights a 79-year-old woman with 2 years of thigh pain who is 8 years status post a revision proximal femoral allograft prosthetic composite reconstruction. Radiographs demonstrated significant stem subsidence into the femoral condyle. In an attempt to avoid a total femoral replacement and spare her functioning native knee, a tibial cone was used in conjunction with a proximal femoral replacement to structurally fill the flaring femoral canal and serve as a stable pedestal for the megaprosthesis body and provide the potential for biologic ingrowth. At 12-month follow-up, she ambulates with a cane, and radiographs reveal stable implant position.

Introduction

Total hip arthroplasty (THA) reliably provides significant improvement in functional outcome and quality of life in patients with hip arthritis [1,2]. By the year 2030, the incidence of primary and revision THA is expected to increase by 174% and 137%, respectively, compared with 2005 [3]. Undoubtedly, revision THA continues to burden our health-care system [4], with the most common reasons for revision to be dislocation and mechanical loosening, followed by infection, osteolysis, and periprosthetic fracture [5].

In patients requiring revision THA with extensive proximal femoral bone loss (Paprosky class IIIB and IV) [6], surgical treatments become more limited consisting of uncemented modular tapered stems, impaction bone grafting, allograft prosthetic composites (APCs), and proximal femoral replacement [7]. An APC is theoretically advantageous for its restoration of bone stock and amenability to soft-tissue reattachment; however, it has a high complication rate [7-10]. After an APC fails, a proximal femoral replacement is often the best salvage option, with good reported 5-year survivorship [11,12]. Even amidst promising outcomes of megaprostheses, in cases of severe metaphyseal and diaphyseal femoral bone loss, reconstruction is often challenging and may require creativity on the part of the surgeon to build a stable and durable construct.

We present the following case to demonstrate a novel approach to femoral reconstruction in revision THA where a highly porous tantalum tibial cone was used in conjunction with a proximal femoral replacement in a patient with substantial bone loss after a prior APC failure.

Case history

Informed consent was obtained to having deidentified details of this patient's case submitted for publication.

A 79-year-old woman with a history of congenital hip dysplasia underwent a primary THA at the age of 38, in 1975. In 1995, she had a revision THA to a modular system (DePuy Synthes, Warsaw, IN), with an associated wire at the level of the metaphyseal sleeve. In 2006, the patient presented to our institution with severe start-up pain and antalgic gait. Radiographs demonstrated severe osteolysis, secondary to metal debris from the wire eroding through the sleeve, resulting in bone loss and component loosening. The patient was revised to a long S-ROM APC component supplemented by lateral femoral strut grafts. One week postoperatively, she heard a pop, and she sustained a periprosthetic distal femoral shaft fracture

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at the tip of the stem. A subsequent revision, involving a similar APC 6 cm longer, was completed. At the 1-year postoperative visit, she had no pain, ambulated without an assistive device, and radiographs demonstrated a well-positioned revision APC (Fig. 1 – earliest available radiographs through the electronic medical record).

At the 4-year postoperative visit in 2012, she had radiographic evidence the stem was loose, and beginning to subside (Fig. 2a and b). At this time, she had no desire to undergo revision surgery, given her lack of symptoms. In 2016, she represented (now for the first time to our orthopaedic surgery team) with worsening left thigh pain for the past 2 years, and the sense of her left leg was getting shorter. Radiographs demonstrated massive subsidence of the stem distally through the lateral femoral condyle (Fig. 2c and d). C-reactive protein was normal at <0.1 mg/dL (normal range 0.0-1.0 mg/dL), and erythrocyte sedimentation rate was slightly elevated at 18 mm/h (normal range, 0-15 mm/h). Left hip synovial fluid revealed 968 total nucleated cells and no growth on cultures after 5 days, indicating no underlying periprosthetic infection preoperatively.

After a discussion regarding surgery, she consented for a left proximal femoral replacement vs total femoral replacement. In effort to avoid a total femoral replacement and save her otherwise well-functioning native knee, it was felt preoperatively that her distal femur with surrounding allograft would benefit from additional structural support in the form of a tibial cone. This would serve to provide a stable base for the megaprosthesis to sit within her widening femoral canal distal to the isthmus, while at the same time maximizing the native distal femoral length to accommodate a cemented stem. In addition, the porous tibial cone would provide for osseointegration to maximize the potential for long-term survivorship because the length of the cemented stem was limited by the length of the remaining femoral bone.

The patient ultimately underwent revision THA with a proximal two-thirds femoral replacement. An extended version of her prior posterior approach was employed at the hip and continued down the lateral aspect of the femur with removal of extensive heterotopic ossification around the acetabulum. Frozen sections were negative for acute inflammation. Cables were removed, and an osteotomy was made at a templated region of the proximal aspect of the native femur, allowing for the removal of the majority of the APC. The acetabular component was stressed and found to be stable. A new 28-mm +0 femoral head and 10 degree lipped 50-mm DePuy Duraloc liner were placed. The distal femur was reamed centrally to accept a new stem. Given the widened femoral canal and the paucity of good bone stock, there was concern that the stem would be at an increased risk of failure, secondary to loosening, if the construct relied solely on cement fixation. Therefore, an 8-mm Stryker tritanium tibial cone was then reamed for in the proximal most aspect of the remaining femur, cables were placed distally, and the cone was impacted into place. The megaprosthesis was then constructed and was cemented in place at the appropriate height and anteversion. An intraoperative photograph (Fig. 3) draws attention to the interface between the femoral body proximally and the tibial cone distally. Immediate postoperative radiographs are shown in Figure 4a and b. She was made weight-bearing as tolerated on her left lower extremity and educated on posterior hip precautions. She was maintained on aspirin 81 mg twice daily for 4 weeks for deep venous thrombosis prophylaxis and discharged on prophylactic oral doxycycline 100 mg twice daily until intraoperative cultures returned negative.

Postoperatively, she experienced 2 hip dislocations at 6 months and 1-year and underwent successful closed reduction in the emergency room on both occasions. Radiographs at 1-year follow-up show a stable reconstruction (Fig. 4c-e)—though it should be noted that the radiographs obtained at the time were non–weight-bearing, which is a limitation in assessing the stability of this construct. At 15-month follow-up, a discussion regarding placement of a constrained liner was held, though the patient was not interested in pursuing this. At this time, no new radiographs were taken, and she ambulates with a cane without pain.

Discussion

Revision hip reconstruction in cases of severe femoral bone loss can be challenging, with surgical options often limited to modular tapered stems, APCs, and megaprostheses [7]. Contemporary protocols employing APCs have shown superior tissue-surface attachment in addition to sparing bone height [7,8,10]. Notwithstanding these mechanical merits, our patient's course parallels existing literature demonstrating a notable failure rate in APCs,

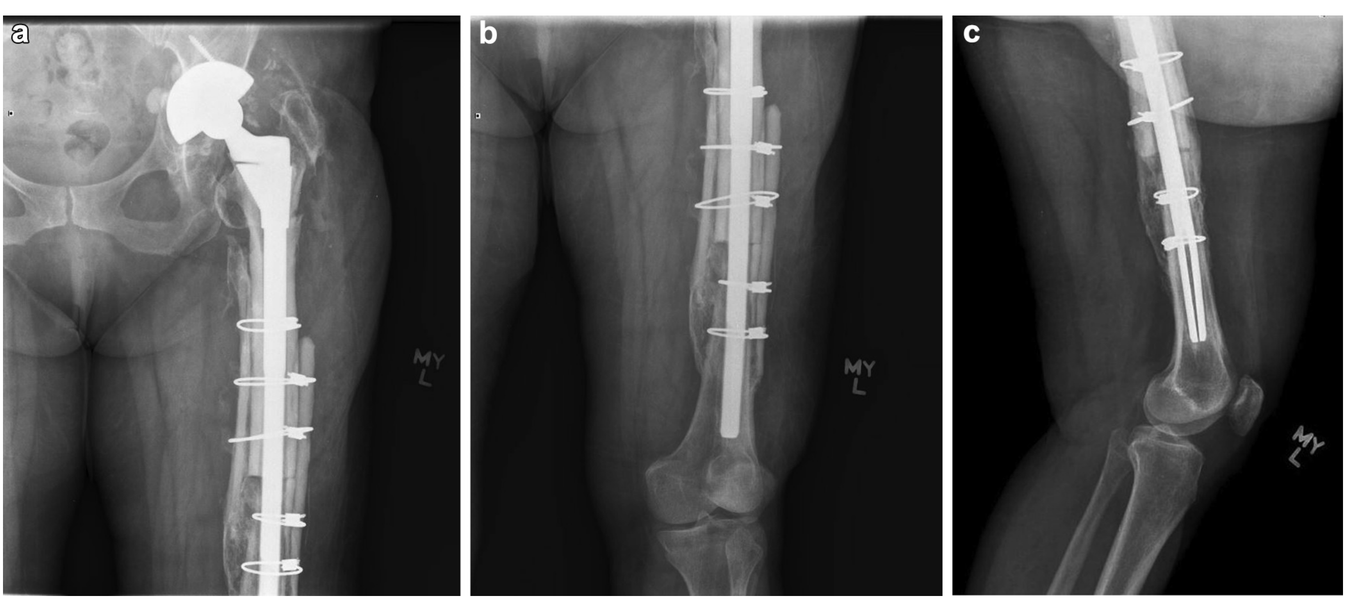

Figure 1. Anteroposterior (AP) proximal (a), AP distal (b) and lateral (c) radiographs of the left femur show a stable femoral allograft prosthetic composite in 2008, using an S-ROM stem reinforced with strut grafts laterally.

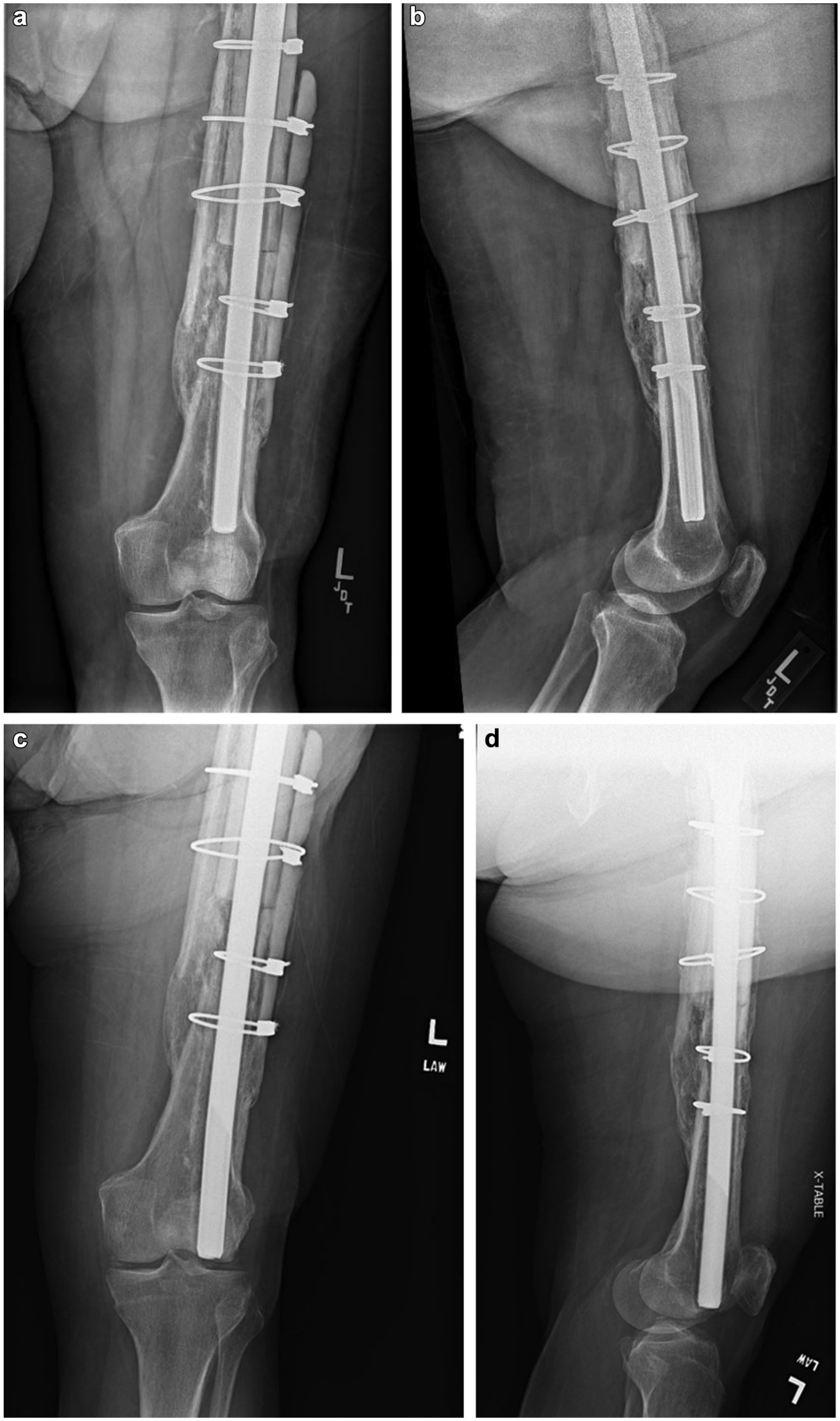

Figure 2. AP (a) and lateral (b) radiographs of the left femur show prosthesis subsidence into the supracondylar region in 2012 and then further distally to the subarticular area of the lateral femoral condyle in 2016 (c and d).

Figure 3. An intraoperative photograph was taken during cementation of the proximal femoral replacement stem to the remaining native distal femur. The black arrow draws attention to the interface between the femoral body proximally (toward the top of the photo) and the tibial cone distally (toward the bottom of the photo).

even in experienced hands. In 2010, Babis et al. [10] realized a 10-year survivorship of 69% in patients followed for 12 years post-APC reconstruction, whereas in 2012, Rogers et al. [8] reported an overall 15% structural failure rate of APCs from 16 studies with a minimum follow-up period of 2 years. Structural failure of APCs requiring revision have been shown to occur via multiple mechanisms including aseptic loosening, allograft resorption, allograft nonunion, allograft fracture, native bone fracture, and deep infection [7-10]. Femoral fracture and massive stem subsidence were notable mechanisms of failure that complicated our patient's outcome. Though structural failure secondary to fracture has been reported in APC [9], massive subsidence has been more clearly documented in cases of femoral impaction grafting [13].

The use of the porous tibial cone has grown into prominence in revision total knee arthroplasty (TKA) owing to some of its structural and biologic advantages. Surgical techniques employing tantalum cone implantation have been shown to be simple, possibly decreasing the length of procedure and thus reducing the risk of infection [14,15]. Its use also incidentally adds to the averted risk of disease transmission accompanied with using structural allografts [16]. Compared with cortical allografts, porous tantalum implants have been shown to offer superior structural rigidity and higher surface friction coefficients attaining desirable stability [17,18]. Tantalum metal also provides suitable scaffolding for osseointegration, even in cases of significant bone loss [19,20], as the corresponding porous elements therein promote osteoblast expression and accommodate recipient bone growth into the metal surface [21-23]. A 2015 report showed promising survivorship in the intermediate-term follow-up (5-9 years) [20].

In this patient's case, our primary purpose for using a tibial cone as a structural augment was to provide a stable base for the megaprosthesis to sit within a short segment of native distal femur. Given the extent of proximal femoral bone loss, there was concern

Figure 4. Immediate postoperative AP radiographs of the left femur (a and b) show appropriate placement of the proximal femoral megaprosthesis and the associated tibial cone. AP (c and d) and lateral (e) radiographs of the left femur at 1-year follow-up demonstrate stable component positioning without evidence of subsidence.

that a tapered femoral stem alone would be at greater risk to subside, as being distal to the isthmus, it would sit in an increasingly widening femoral canal. It is important to note that our unconventional utilization of a tibial cone in a proximal femoral replacement may not afford identical structural advantages as would be seen in TKA. In revision TKA, a tibial cone serves as a mechanical anchor in the weaker cancellous metaphyseal bone, functioning as a physical “stop-point” that allows the prosthesis to interphase sooner with the nearby cortical shell surrounding it. This potential structural support may be less realized in this patient's case compared with the setting of revision TKA, given the largely cortical-only makeup of her remaining bone stock.

Our second goal in using a tibial cone was for the potential for biologic fixation. Rather than using a standard collared bony ingrowth surface sitting on top of the distal femur, we felt a tibial cone sitting within the canal provided a way to achieve greater bony contact to its porous metal, and possible future bony ingrowth, offering the potential to offload stress from the bone cement interface. Though the additional volume occupied by the tibial cone in the femoral canal may limit the thickness of the proximal cement mantle to some degree, the benefits of potential biologic fixation outweighed this risk in this specific case. Furthermore, we submit that 1-year follow-up in this case is not intended to assess long-term stem subsidence but rather to highlight the patient's improved clinical status and stable bone-implant junction on radiographs since the time of surgery. For these reasons, it may be difficult to clearly define the exact contribution of the tibial cone to the stability of this proximal femoral replacement construct. Nevertheless, we felt that the theoretical potential to achieve biologic fixation with the tibial cone in addition to the cement fixation surrounding the stem may lead to better long-term survivorship for this patient than a cemented stem alone. Moreover, we are not implying from this single case report that this technique is generalizable in all proximal femoral replacements. The potential long-term benefits of the novel use of a tibial cone in this patient will certainly be best realized with continued follow-up.

Summary

This case demonstrates a creative approach to femoral reconstruction in a patient with a failed proximal femoral APC in the setting of substantial diaphyseal bone loss. In effort to spare her well-functioning native knee by avoiding a total femoral replacement, a tibial cone was found useful to provide structural augmentation to a proximal femoral replacement. Tantalum tibial cones have shown desirable outcomes in revision TKA surgery attributed to their structural integrity and osseointegrative qualities. This case report is the first of its kind to suggest a potential use for this type of implant in revision THA surgery.

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