Case report

Stacked Titanium Metaphyseal Cones for Reconstruction of Large Tibial Defects in Revision Knee Arthroplasty

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A B S T R A C T
Failed total knee arthroplasties with large bone defects are increasing rapidly because of the growing population of young, active patients undergoing primary total knee arthroplasty. There are limited options when tibial metaphyseal bone loss is so extensive that a tibial component with augments and thickest available polyethylene cannot fill flexion and extension gaps once the femoral component is appropriately positioned. Previously, allograft or megaprostheses would be required. However, allografts require contouring and fixation and may not incorporate into surrounding bone. Most endoprostheses do not osseointegrate and are associated with high risk of failure. To our knowledge, we are the first to describe stacked porous titanium cones for reconstruction of massive tibial metaphyseal defects, a straightforward technique with standard revision implants highly likely to osseointegrate.

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Introduction

Over 330,000 revision total knee arthroplasties (TKAs) were performed from 2009 to 2013 [1]. The number of revision TKAs performed is expected to increase 601% between 2005 and 2030 [2]. Implants with excellent initial stability, durable fixation, and, in some cases, osseointegration are essential to long-term survival after revision TKA. Achieving this goal is complicated by the varying degrees of bone loss present after component removal.

Several techniques are available to reconstruct bone defects during revision TKAs. Small, contained defects can be restored with cement, with or without screws [3]. Larger defects require reconstruction with metal augments, allograft, metaphyseal cones or sleeves, and, in cases of severe bone loss, megaprostheses [4].

For large metaphyseal defects, both contained and uncontained, porous metaphyseal cones provide a versatile reconstruction option that achieves immediate stability with an increased potential for osseointegration [5,6]. Porous metaphyseal cones may be used in conjunction with stemmed implants of various manufacturers and have excellent midterm survival [7]. While tantalum cones have also demonstrated favorable early survivorship [8], there are limited options when tibial metaphyseal bone loss is so extensive that a tibial component with augments, together with the thickest available polyethylene, cannot fill the flexion and extension gaps once the femoral component is appropriately positioned. Previously, the use of allograft or a megaprosthes would be required. Allograft requires contouring to fit the bone defect and fixation to the surrounding bone; even so, incorporation may not occur [9]. Most megaprostheses do not osseointegrate and are associated with a high rate of reoperation [10,11]. Herein, we describe the technique of using stacked titanium metaphyseal cones for the reconstruction of a large, uncontained tibial metaphyseal defect to regain tibial height.

Surgical technique

Patient case

A 72-year-old gentleman presented to our office with a chief complaint of 7 years of progressively left generalized knee pain and instability after revision TKA.

The history began when the patient had a left primary TKA, followed by 3 revisions for aseptic loosening. His most recent...
revision surgery was 7 years prior to presentation, when reconstruction was performed with a varus/valgus constrained rotating platform prosthesis, metaphyseal sleeves, and press-fit stems. He subsequently began to have left generalized knee pain and instability. After 7 years of progressive symptoms and the development of left lower leg pain, he had difficulty performing his activities of daily living, at which time we assumed his care.

On physical examination, the patient ambulated with an antalgic gait. His left knee incision was well-healed without erythema. Ligamentous examination of the left knee demonstrated 12 to 14 mm of laxity to varus/valgus stress at 30 degrees of flexion and 4 to 6 mm of laxity to varus/valgus stress at 90 degrees of flexion. He had no pain with the passive range of motion of the left knee, which had 0 to 95 degrees of flexion.

Plain films of the left knee showed a varus/valgus constrained prosthesis with radiolucencies surrounding the subsided tibial component that had migrated into varus with impending fracture at the tip of the stem (Fig. 1). Inflammatory markers and joint aspiration were negative for infection. After being explained the risks, benefits, and alternatives, the patient elected to proceed with left knee arthroplasty revision.

**Intraoperative technique**

Left knee exposure was achieved through a medial parapatellar approach. Synovectomy was performed to improve exposure and further mobilize the knee. The frozen section demonstrated no evidence of acute inflammation.

Rigid osteotomes and a carbide burr were used to disrupt the femoral and tibial bone-implant interfaces. The tibial component was easily extracted, suggesting it was grossly loose. After component removal, residual cement was debrided. On the tibial side, a large, uncontained medial defect was observed with significant metaphyseal bone loss. The tibial tuberosity was intact. No significant femoral metaphyseal bone loss was found.

Under fluoroscopic guidance, a long drill was used to disrupt the bony pedestal that had formed at the tip of the tibial stem. A ball-tipped guide wire and flexible reamers were used to remove more of the bony pedestal and recanalize the tibia. Hand reaming with sequentially larger rigid reamers was performed of the tibial canal, bypassing the distal extent of the prior stem.

Using augments, the femoral component trial was positioned to restore the joint line and rotated to create a rectangular flexion gap. However, even with the thickest trial tibial augments and liner, the symmetric flexion and extension gaps were not filled. The stemmed tibial component trial was also rotationally unstable because of metaphyseal bone loss.

By reaming over the shaft of the final rigid reamer, the proximal tibial metaphysis was prepared for the largest cone within the revision TKA system (Stryker Triathlon Total Stabilizer, Mahwah, NJ). However, the extent of the tibial metaphyseal bone loss was so great that the largest tibial cone trial achieved fixation far below the level of the most proximal tibial bone. As a result, this single cone did nothing to regain tibial height or close the large flexion and extension gaps.

To remedy this, a smaller cone was stacked within the largest metaphyseal cone such that the trial construct extended above the proximal-most aspect of residual tibial bone (Fig. 2a). Once the stemmed tibial component trial with augments, polyethylene trial, and stemmed femoral component trial with augments were also placed (Fig. 2b and c), the knee was found to have excellent stability to varus/valgus stress in full extension, midflexion, and 90 degrees of flexion. Tibial component rotational stability was also achieved.

Once the trials were removed and bone was irrigated and dried, the largest 3D printed porous titanium tibial metaphyseal cone (Stryker Triathlon Tritanium Cone Augment; Mahwah, NJ) was impacted into place with excellent initial stability (Fig. 3a). The periphery of the smaller porous titanium tibial cone was coated with cement, then stacked inside the larger cone to create a unitized construct. Cement was then generously applied to the proximal tibia, with care taken to avoid the lumen of the cone construct.

![Figure 1. Preoperative anteroposterior (a) and lateral (b) plain films of the left knee.](image-url)
The proximal aspect of the press-fit stemmed tibial component with augments was coated with ample cement and implanted with hybrid fixation. While downward axial force was applied to the tibial component, which was held in the desired rotation, the medial cement mantle was contoured in a tapered fashion from the tibial component proximally to the residual bone distally. The tibial cement was allowed to harden, then the stemmed femoral component with augments was implanted in hybrid fixation, followed by placement of a 31-mm polyethylene component. Immediate postoperative images are shown in Figure 4, demonstrating a gain of 1.2 cm of tibial height with the new construct.

Postoperative course

The patient’s hospital course was unremarkable. He was discharged home on postoperative day #1 with a routine primary TKA rehabilitation protocol. Final intraoperative cultures demonstrated no growth. At the most recent 7-month follow-up visit, he was pain-free, ambulating without any assistive device, and had left knee range of motion from 0 to 115 degrees of flexion.

Discussion

The number of failed TKAs with large bone defects is increasing rapidly because of the growing population of young, active patients undergoing primary TKA [2,12]. The size and volume of osteolytic lesions are often underestimated during the preoperative evaluation [13]. This uncertainty makes preoperative planning more complex, as it is necessary to have a wide variety of implants and structural bone grafts available for revision TKA [14]. An additional challenge during revision TKAs is creation of a durable construct with intraoperative efficiency. As a result, the utilization of a simple, versatile implant with high likelihood of successful osseointegration is ideal for bone defect reconstruction in revision TKAs.

Allograft and endoprostheses have been used to reconstruct large bone defects in revision TKAs. However, allografts require contouring and additional fixation and may ultimately not
incorporate into the surrounding bone [9]. Most endoprostheses do not osseointegrate and are associated with a high risk of failure [10,11]. To our knowledge, we are the first to describe the use of stacked porous titanium cones for the reconstruction of a massive tibial metaphyseal defect, a straightforward technique with standard revision implants that have a high propensity for osseointegration.

The use of stacked porous tantalum cones has been reported for the treatment of femoral metaphyseal defects in revision TKAs. Boureau et al. used a two stacked cone technique in 7 cases of severe distal femoral defects without evidence of implant migration or loosening at a mean 17 months of follow-up [15]. Similarly, Rajgopal et al. used a stacked cone technique in 16 cases of severe femoral metaphyseal bone loss in primary and revision TKAs [16]. At the end of a mean 57 months of follow-up, all implants were osseointegrated without radiolucencies [16]. These studies suggest that stacking metaphyseal cones is both durable and effective in the reconstruction of large bone defects in revision TKA.

Figure 4. Postoperative anteroposterior plain films of the left knee (a), femur (b), and tibia (c), as well as lateral plain films of the left knee (d) and tibia (e).
The stacked cone technique does have some limitations. First, the smaller lumen of the stacked cone construct may preclude the use of an offset stem. Also, with a smaller lumen, the use of larger diameter stems may prevent removal of the stemmed tibial component separately from the stacked cone construct should an explant be necessary. There is an increased cost that must be considered with the use of a second cone. However, with the high revision rates associated with structural allograft and endoprostheses, the stacked cone technique may in fact provide cost benefit [9,17]. Further study is required to evaluate the long-term survivorship of the stacked cone technique.

Summary

In cases of severe proximal tibial bone loss, reconstruction with stacked cones allows for efficient restoration of tibial height with an excellent potential for implant osseointegration. We describe for the first time, and propose consideration of, stacked porous titanium metaphyseal cones as an alternative to the use of allograft or megaprostheses for the reconstruction of severe proximal tibial bone defects in revision TKA.

Conflicts of interest

S. Nandi is in the editorial or governing board of Journal of Arthroplasty and is a board or committee member of AAHKS and AAOS.

Informed patient consent

The patient in this report provided informed consent for publication of this manuscript.

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