Porous Tantalum Cones for Large Metaphyseal Tibial Defects in Revision Total Knee Arthroplasty

A Minimum 2-Year Follow-up

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Abstract: Sixteen cases of revision total knee arthroplasty requiring the use of porous tantalum tibial cones for 2 T2A, 3 T2B, 4 T3A, and 7 T3B tibial bone defects (Anderson Orthopaedic Research Institute classification) after 13 cases of aseptic loosening and 3 cases of staged reimplantation for infection were reviewed. At an average 31 months (24-38), no patients were lost to follow-up. There were 2 cases of recurrent sepsis requiring removal of a well-fixed cone. In the remaining 14 cases, the reconstructions were functioning well with no reoperations. Radiographs demonstrated reestablishment of the joint line, neutral mechanical axis (average, 5.4° of valgus), and signs of stable osteointegration into the cones. Good short-term results were achieved in complex revisions, with these new reconstructive tools. **Keywords:** porous tantalum cones, tibial bone loss, revision total knee arthroplasty.
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Rates of revision total knee arthroplasty will continue to increase as more primary total joint arthroplasties are performed [1]. Complex revision total knee cases with significant tibial bone loss represent a challenging subset of patients. Reestablishment of a stable well-aligned and supported tibial base is necessary for successful reconstruction [2]. Historically, this has been achieved with impaction grafting [3,4], bulk allograft [5-10], tumor prostheses [11], custom components [12], or a combination of a large allograft combined with a stemmed revision component forming an allograft-prosthesis composite [13,14].

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The porous metal tantalum provides a new tool for modular reconstruction in these cases. Important characteristics of tantalum include its negative charge and interconnective pores, which form a scaffolding and surface for osteoblast-mediated bone ingrowth [15-17]. The lower modulus of elasticity (3 MPa) and high (70%-80%) porosity allow for a more uniform stress transfer and the potential for diminished stress shielding. Basic science research has also demonstrated a lower bacterial adherence, and increased leukocyte activation, when compared to other orthopedic metal implant materials [18,19]. The uneven texture provides an initial scratch fit after insertion. Lastly, the modular nature of the cones allows the surgeon to choose a size and position that best fits the individual defect encountered [20].

Materials and Methods

Institutional review board approval was obtained for this retrospective review. All patients undergoing revision knee reconstruction for any reason, which required the use of a porous tantalum cone for tibial

reconstruction (Fig. 1), were included in this study. All cases were performed by the senior surgeon. These cases represent a consecutive series of patients as porous tantalum cones were used for all cases when massive tibial defects were encountered. In no cases were other techniques such as impaction or bulk allograft used as an alternative.

Our surgical technique has been previously described [21]. Briefly, reconstruction involved the removal of the failed prosthesis (Fig. 2) or bone cement spacer. Tibial lesions were debrided (Fig. 3A) and then graded according to the Anderson Orthopaedic Research Institute (AORI) classification system [22]. This classification system considers bone loss from the tibia and femur independently (T and F): small amounts of bone loss not compromising component stability are grade 1; damaged metaphyseal bone needing augmentation to maintain joint line are grade 2; significant bone loss compromising a major portion of the condyle or plateau that may involve detachment of the patellar tendon or collateral ligament are grade 3. Bone loss is then broken down further into 1 condyle/plateau (A) or 2 (B).

Trial tibial cones were inserted and minor adjustments were made to the depth and periphery of the defect to achieve appropriate seating of the cone (Fig. 3B). Tibial stem reaming was then performed, and the appropriately sized tibial trial was inserted in the correct rotation. Depth of insertion was judged using local landmarks including the tibial tubercle, fibular head, and remaining rim of bone. When a gap existed between the trial cone and the tibial base plate, a medial or lateral wedge was inserted.

Femoral reconstruction proceeded as per standard reconstructive principles. The epicondyles were used for both rotation, as well as a rough estimate to joint line. Femoral component size was chosen to achieve a balanced flexion and extension gap while maintaining posterior condylar offset.

Fig. 1. Porous tantalum step cone before insertion.

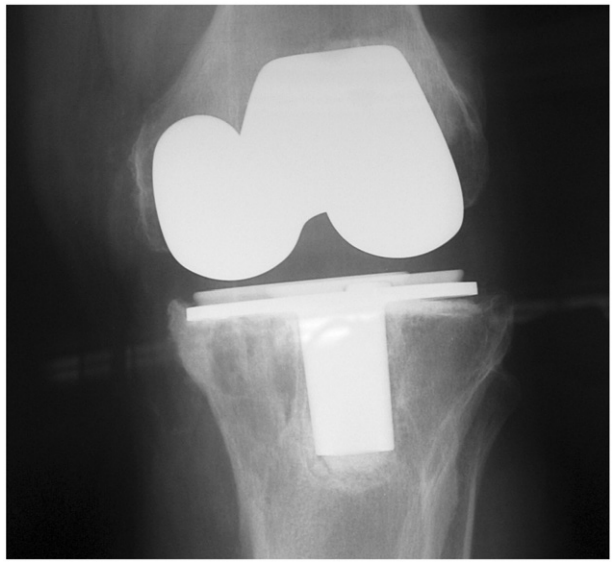

Fig. 2. Failed primary knee with tibial osteolysis and subsidence.

The patellar component was then examined. A stable prosthesis with minimal wear was left in place. Loose components were removed and a decision was made regarding repeat cementing, porous tantalum augmentation, or patelloplasty.

After achieving a stable trial reconstruction, the trial polyethylene and tibial component were removed and the real porous tantalum augment was inserted. The cone was press fit into the remaining rim of bone in the same position as the trial. Gaps between the porous tantalum augment and the intact bony rim were filled with a mixture of morselized allograft bone, any autograft bone, and demineralized bone slurry (Fig. 3C). Once again, the trial tibial component and poly was inserted to ensure that the alignment, rotation, and joint line had not changed. The position of the trial components was marked and they were removed. Pulse lavage was then performed using antibiotic rinse.

When stable bony fit of the trial components was achieved, diaphyseal press-fit uncemented stems were used. In cases with thin cortices with wide canals where a good press-fit was not obtained, a cemented stem was chosen. When diaphyseal, metaphyseal offset existed, an offset stem was used. In all cases, the metaphyseal portion of the tibial component in the region of the augment was cemented. Antibiotic cement was used in all cases, 1.2 g of tobramycin per bag.

All patients were permitted to weight bear as tolerated postoperatively. The patient with an extensor mechanism allograft was placed in a stovepipe cast. All other patients were encouraged to mobilize through a full range of motion.

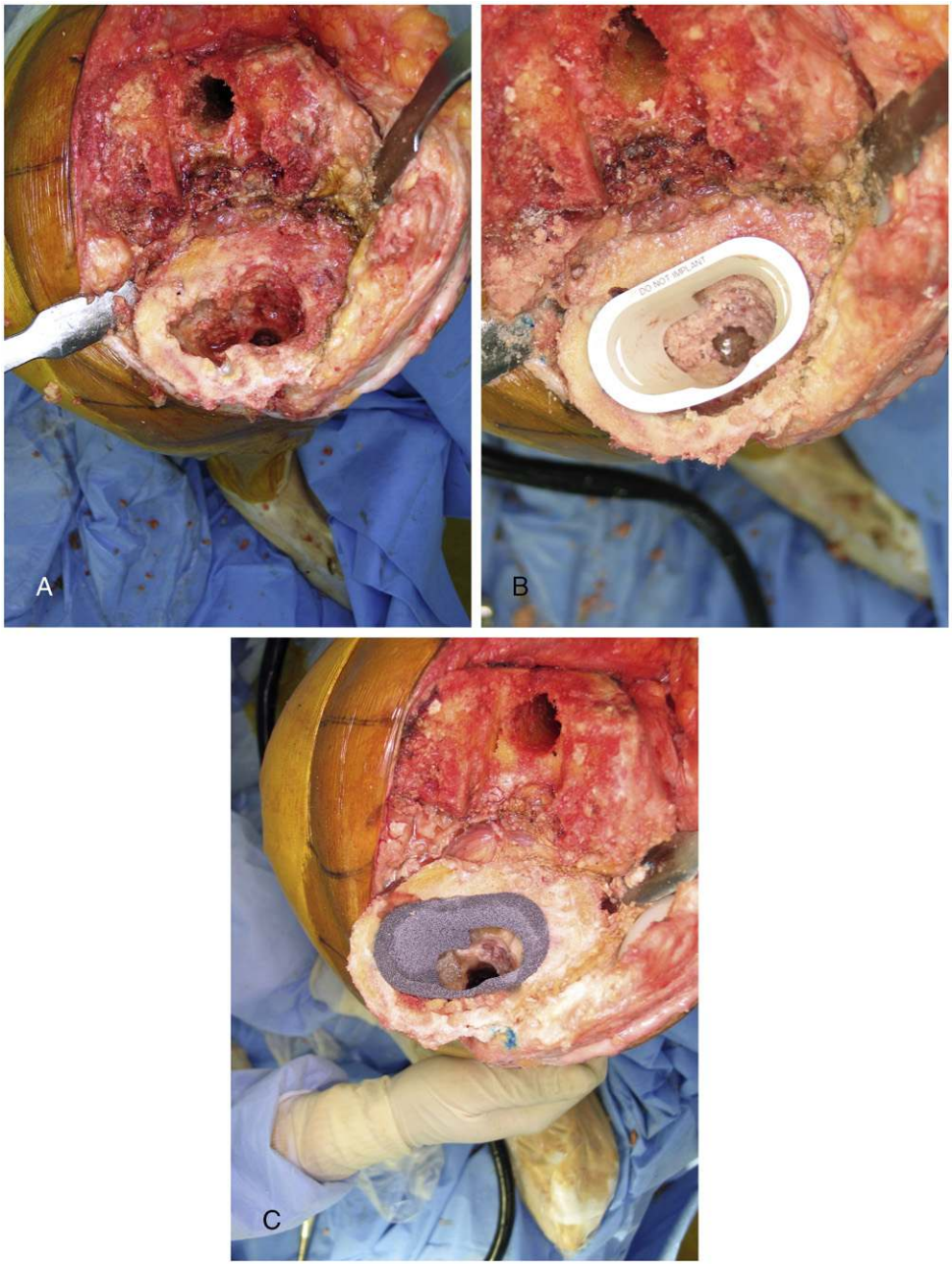

Fig. 3. A to C, Tibial defect, trial cone, and final cone positioned with moselized graft at the periphery.

Patients were seen at scheduled routine follow-ups at 3 weeks, 6 weeks, 6 months, and then yearly, for clinical and radiographic assessment.

Results

Demographics

Sixteen revision procedures were performed on 15 patients. Average patient age at surgery was 66.1 years (range, 48-83 years). There were 8 females (1 case bilateral) and 7 males. Seven cases involved left knees and 9 right knees. The diagnosis was aseptic loosening in 13 cases and staged reimplantation after infection in 3 cases.

Surgical Data

Approaches included 15 medial parapatellar and 1 midline (associated with the extensor allograft). A quadriceps snip was required in 5 cases, and in 2 of those, a tibial tubercle osteotomy was also needed for exposure. Metal wires were used for tubercle osteotomy fixation (3 in 1 case and 2 in the other). All wires were placed distal to the cones, and bone healing was achieved in both cases. Ten medial

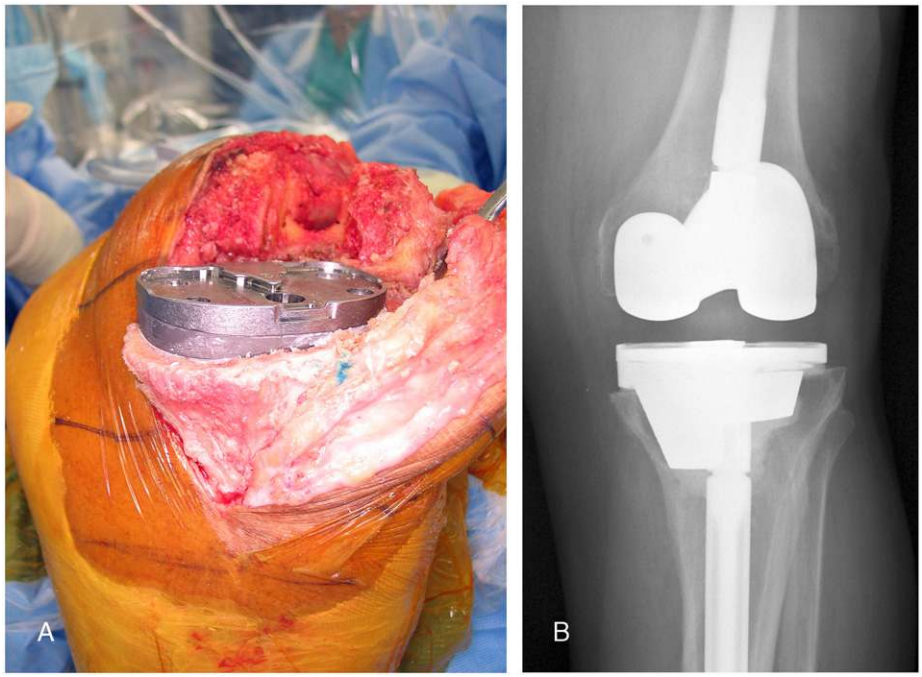

Fig. 4. A and B, Completed tibial reconstruction with hybrid cement technique and a wedge augment on top of the stable base created by the cone.

releases were required for soft tissue balancing and 4 lateral patellar releases were performed to achieve central patellar tracking.

On the femoral side, posterior and/or distal porous metal augments were used in all cases. Two femoral cones were needed to address femoral bone loss, both F3B (AORI Classification). Patellar management involved 8 retained well-fixed originals, 1 all-poly cemented revision, 4 porous tantalum augments and cemented poly patellar components, 2 patelloplasty, and 1 extensor mechanism allograft (patella unresurfaced). The extensor mechanism allograft was performed as per the technique of Burnett et al [23].

Tibial defects were classified according to the AORI system as 2 T2A, 3 T2B, 4T3A, and 7 T3B tibial bone defects. In all of these cases, a cone was required to reestablish a stable proximal tibial platform for knee reconstruction. Of the 16 cones used, 5 were stepped (30/15 mm). Two large and 3 medium step cones were inserted. Four of the steps were thicker medially and 1 laterally. The 11 remaining cones were nonstepped and consisted of 2 extra small (48 × 15), 3 small (52 × 15), 4 medium (one 59 × 15 mm, three 59 × 30 mm), and 2 large (one 67 × 15, one 67 × 30). There were no fractures or complications related to the insertion and impaction of the cones.

Fixation involved hybrid fixation, with proximal cementation through the region of the cone in 12 cases and a cemented stem in 4 cases. Cemented tibial rods were 75 to 100 mm in length, and diaphyseal press-fit uncemented stems were from 75 to 200 mm in length. Four rods were offset.

Tibial augments were required in 8 cases on top of the porous tantalum cone (Fig. 4A and B). Seven medial and 1 lateral wedge were used. In all cases, a constrained-condylar polyethylene tibial insert was used. Poly thicknesses ranged from 10 to 23 mm. In no cases was a hinged prosthesis required to achieve stability.

Clinical Outcomes

Two cases of recurrent infection occurred. In the first case, the reconstruction was performed in conjunction with an extensor mechanism allograft for staged revision of a failed revision total knee arthroplasty with extensor deficit. Resection was performed at 8 months postoperatively. At that time, the tibial cone was noted to be well ingrown with bone and required significant work with a burr and osteotome along the interface to remove the cone.

The second case was also a recurrent infection and occurred 3 months postoperatively. Resection was performed at an outside institution. The surgeon's notes report stable bony ingrowth of the tibial cone at the time of resection.

The remaining 14 cases were functioning well and average 31 months follow-up (24-38 months). All patients achieved full extension on clinical

examination, and average range of motion was 109° (range, 90°-120°). Knees were stable to varus-valgus stress in extension and to anteroposterior stress in flexion. Patella tracked well in all cases. Good quad strength was noted with no extensor lag on straight leg raise. No significant pain was noted in 13 patients. One patient with inflammatory arthritis complained of mild aching and had a mild effusion. Septic workup, including aspiration, was negative for infection. Of 14 patients, 13 walked without aids. One patient, aged 86 years, is now living in a nursing home, has moderate dementia, and uses a walker for ambulation, but not because of the operated knee. There were no cases of aseptic loosening. No revisions or reoperations were performed, or planned in the 13 patients (14).

Radiographic Outcomes

Serial x-rays were examined preoperatively, postoperatively, and at each subsequent visit. Review of the 14 nonrevised cases revealed signs of stable bony ingrowth at the bone-trabecular metal interface, and streaming trabeculations into the trabecular surface. Average tibiofemoral alignment was 5.4° of valgus (range, 4°-7°). No cases of progressive osteolysis, loosening, or subsidence were noted.

In the 2 cases with a tibial tubercle osteotomy for exposure, there was stable bone healing both distal to and at the level of the cone. No wires required removal (Fig. 5).

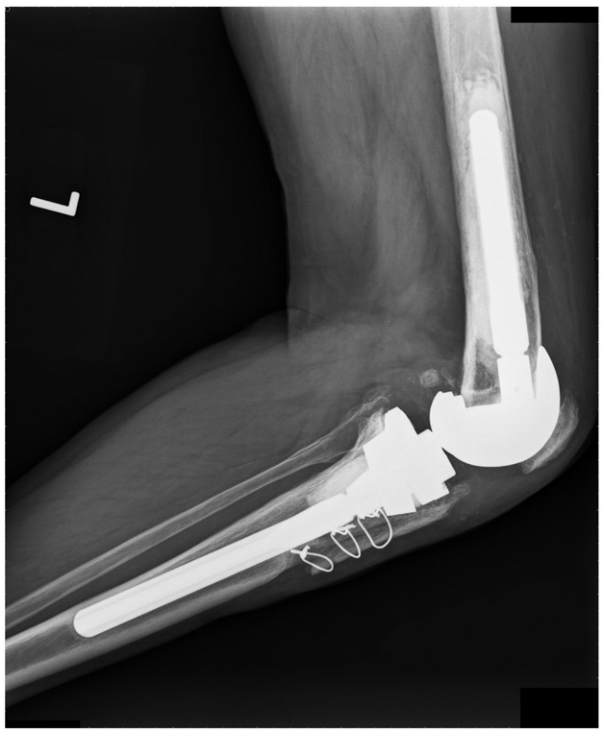

Fig. 5. A lateral radiograph demonstrating a healed tibial tubercle osteotomy.

Discussion

Large tibial bone defects present a challenging reconstructive problem. Traditionally, lesions have been treated with bone in the form of bulk allograft or impaction grafting [3-10], modular tumor or custom components [11,12], or allograft-prosthesis composites [13,14]. All of these techniques have been shown to be durable in midterm outcomes, but concerns exist for a number of reasons, including disease transmission; resorption, fracture, or immune reaction to allograft; the cost of custom prostheses, and the inability to modify the construct intraoperatively; and the overall technical challenge of applying these techniques.

Porous tantalum augments provide surgeons with a powerful tool for addressing these concerns. When compared to bone, there is no risk of disease transmission, fracture, or resorption. In contrast to custom prostheses, cones are used in a modular nonlinked fashion, can be inserted at multiple angles and positions, can be used with any revision system, and come in a number of sizes, to address the specific dimensions of the lesion encountered. Biomechanical studies have shown a modulus of elasticity closer to that of bone and an interconnective porous nature that allows bony ingrowth suggesting the possibility for more stable long-term fixation [16,17]. Recent animal studies have also shown promise in achieving patellar tendon attachment to porous tantalum structures [24].

Multiple studies examining the use of porous tantalum acetabular cups in hip reconstruction have been published [25-27] and presented [28]. Porous acetabular augments have been designed and used as an alternative to allograft bone reconstruction for large acetabular defects [29,30]. They have all shown very promising early clinical results, although long-term data do not yet exist.

Clinical results at a minimum 2 years with 15 porous tantalum cones used in revision total knee arthroplasty were recently published [31]. No cases of aseptic loosening or migration were noted at an average 34 months. Evidence of osteointegration was observed on follow-up radiographs.

This study is the second that we are aware of to demonstrate good early outcomes with porous tantalum cones for large tibial defects. Even in the 2 cases where components were removed because of recurrent infection, the porous cones were found to be well fixed with stable bony

ingrowth. We do not believe that the high rate of reinfection (2/3) in this complex subset of patients is related to the use of porous tantalum cones. In fact, we believe that the porous cones are a better alternative than placing large amounts of dead bone or large metal augments into the defect. Basic science research has demonstrated lower bacterial adherence and increased leukocyte activation on porous tantalum surfaces when compared with other reconstructive materials [18,19].

The remaining 14 knees were functioning well with radiographic evidence of osteointegration of the cones. Short-term results with the use of porous tantalum cones for tibial bone loss in revision total knee arthroplasty show promising results. In particular, the potential for long-term biologic fixation distinguishes this technique from other options. This is an early retrospective study, and certainly longer-term follow-up will be important in determining the durability of these new reconstructive tools.

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