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Surgical Technique

Acetabular wedge augments for uncontained tibial plateau defects in revision total knee arthroplasty

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ABSTRACT

Tibial bone loss is a common scenario encountered during revision total knee arthroplasty. Reconstructive options depend on the amount and location of bone loss, but few good solutions exist to address large, uncontained tibial defects where cortical support is lost in the metadiaphyseal region. We describe a novel technique using acetabular augments to buttress a revision tibial component and recreate a hemiplateau during tibial revision total knee arthroplasty. In selected scenarios, this construct can create a biomechanically friendlier surface onto which to support the tibial tray and a less expensive option when compared to traditional stacked augments or cones.

Level of Evidence: IV—Case series.

Introduction

Surgeons have multiple options when considering management of damaged or deficient tibial metaphyseal bone loss in the setting of a revision total knee arthroplasty (TKA). Surgical decisions are dependent on the primary mode of tibial failure and remaining amount of host bone. These solutions can range from bone stock restoration to bone replacing techniques. Restoration options primarily refer to using femoral head impaction grafting to regain structural support [1,2], while replacement options abound: stemmed components with hybrid fixation [3], modular augments, porous metal metaphyseal-replacing sleeves [4] or cones [5,6], or use of a megaprosthesis [7]. The applicability of each option depends on the surgeon preference and comfort using varying constructs, the cost of revision implant materials, and the primary mode of tibial failure, which is often determined intraoperatively after implant removal and assessment of remaining host bone.

The Anderson Orthopaedic Research Institute (AORI) classification of bony defects is the gold-standard measure used to classify such bony defects [8]. However, sometimes the utility of a type II (damaged metaphysis) or type III (deficient metaphysis) diagnosis is not always applicable because it cannot distinguish between contained and uncontained defects [9,10]. Specifically, when addressing uncontained tibial-sided bone loss, surgeons tend to gravitate toward using augments with or without cement and additional bone grafting [11]. However, these augments have limitations when used in cases of presumed type II bone loss. There are reports of failure when used alone or when the uncontained metaphyseal defects is larger than 40% of the tibial surface and involves more than 25% of the peripheral cortical rim [12,13]. Furthermore, the 3-dimensional shape of an uncontained bony defect usually does not allow for the use of 1 implant, resulting in the use of multiple fixation constructs, such as stacks of augments or cones with additional screws, thus increasing the overall surgical cost of the revision episode of care.

The purpose of this study is to describe a novel surgical application using a highly porous acetabular wedge augments to reconstitute metadiaphyseal support for a stemmed prosthesis in revision TKA. Secondarily, we report on the survivorship and outcomes of this construct in a series of patients with uncontained

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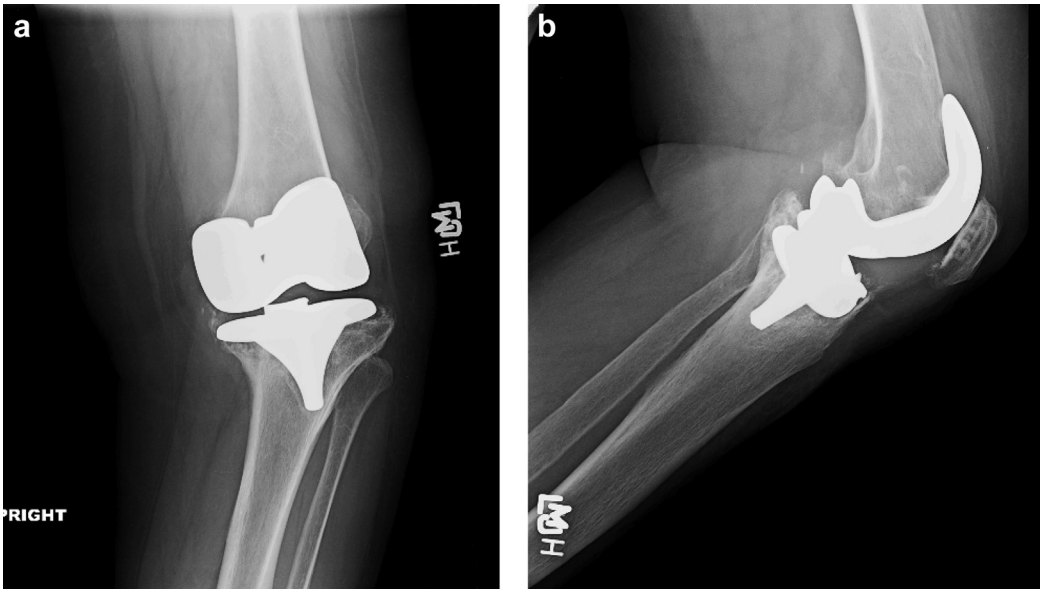

Figure 1. Representative anteroposterior (AP) (a) and lateral (b) knee radiograph demonstrating significant varus collapse of primary tibial base tray with significant metaphyseal bone loss.

metaphyseal bone loss involving 40%-70% of the supporting medial tibial plateau cortical rim. Finally, we will propose a modification to the AORI classification for tibial bone defects to include contained and uncontained defects to better drive surgical decision-making.

Surgical technique

Patients are first evaluated in the clinic and indicated for revision knee arthroplasty. All patients get biplanar EOS(R) standing hip-knee-ankle radiographs (EOS Imaging, Paris, France). Complete infection workup, including serum erythrocyte sedimentation rate and noncardiac C-reactive protein, is obtained, with joint aspiration pursued if either of the serum markers are elevated. Indications for considering a hemiwedge acetabular augment are for isolated medial tibial defects with significant bone loss extending into the metadiaphyseal region with an estimated <50% of supportive cortical rim remaining to achieve fit with a standard wedge or trabecular metal cone. At the time of surgery, prior components are explanted using a microsagittal saw, flexible osteotomes, and other disimpaction tools, as conversion to a more constrained prosthesis is usually indicated. Thorough synovectomy and medial release should be performed as well in an attempt to preserve the superficial medial collateral ligament sleeve, as this can influence one's ability to choose a posterior-stabilized vs a constrained or hinge construct.

Once all components are removed, meticulous attention needs to be used to remove all cement (if present) from the tibial cut surface and the canal. The use of a small round burr, osteotomes and gouges from a knee revision system can expedite the process. At this time, a freshening cut of the tibial surface should be performed at a 90° angle to the mechanical axis of the tibia. All fibrous tissue should be aggressively removed to determine the final amount of bone defect for staging and decision-making. The medial tibial plateau defect should be closely examined, noting the amount and quality of intact cortical rim, depth of bone loss, and overall surface area remaining of cut tibial surface to help size and position the revision tibial tray position. A stemmed tibial trial with or without a sleeve can then be placed after sequential reaming of the tibial canal to confirm tray sizing and rotation. If the amount of overall depth of medial structural bone loss is so significant, trialing components, even with a sleeve and proximal block augments, will show medial collapse as the tibia sleeve-stem construct rotates the sleeve tilts because of the lack of medial bone support.

An acetabular augment trial should then be placed by trial-and-error sizing, starting with the thinnest, smallest diameter wedge to assess buttress fit with the convex surface resting on the remaining diaphyseal medial cortex. Sizing should be based on achieving a flat tibial surface so that the lateral cortical height is the same as the augment, while also insuring the anteromedial overhang of the convex component is not too excessive to prevent closure of the medial tissue sleeve. Commonly, the convex portion of the acetabular augment does not have perfect contact to the remaining metadiaphyseal bone and the use of a high-speed burr is required to shape the bone to maximize contact surface area and augment fit. When cementing final implants, we recommend placing the stemmed component first and press-fitting the acetabular augment secondly into the previously prepared bony bed. Finally, cement should be used to fill in gaps and adjoin the constructs.

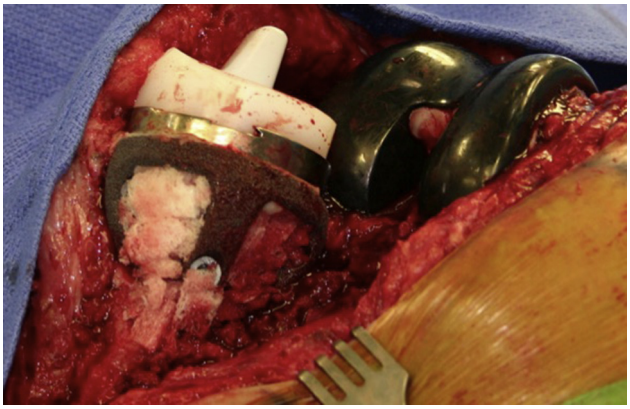

Figure 2. Intraoperative image demonstrating placement of acetabular augment and securing in a buttress fashion with placement of screws from medial to lateral with final packing of bone graft around the augment. Alternatively, this can be cemented into place and remaining slots can be filled with bone graft substitute before final closure.

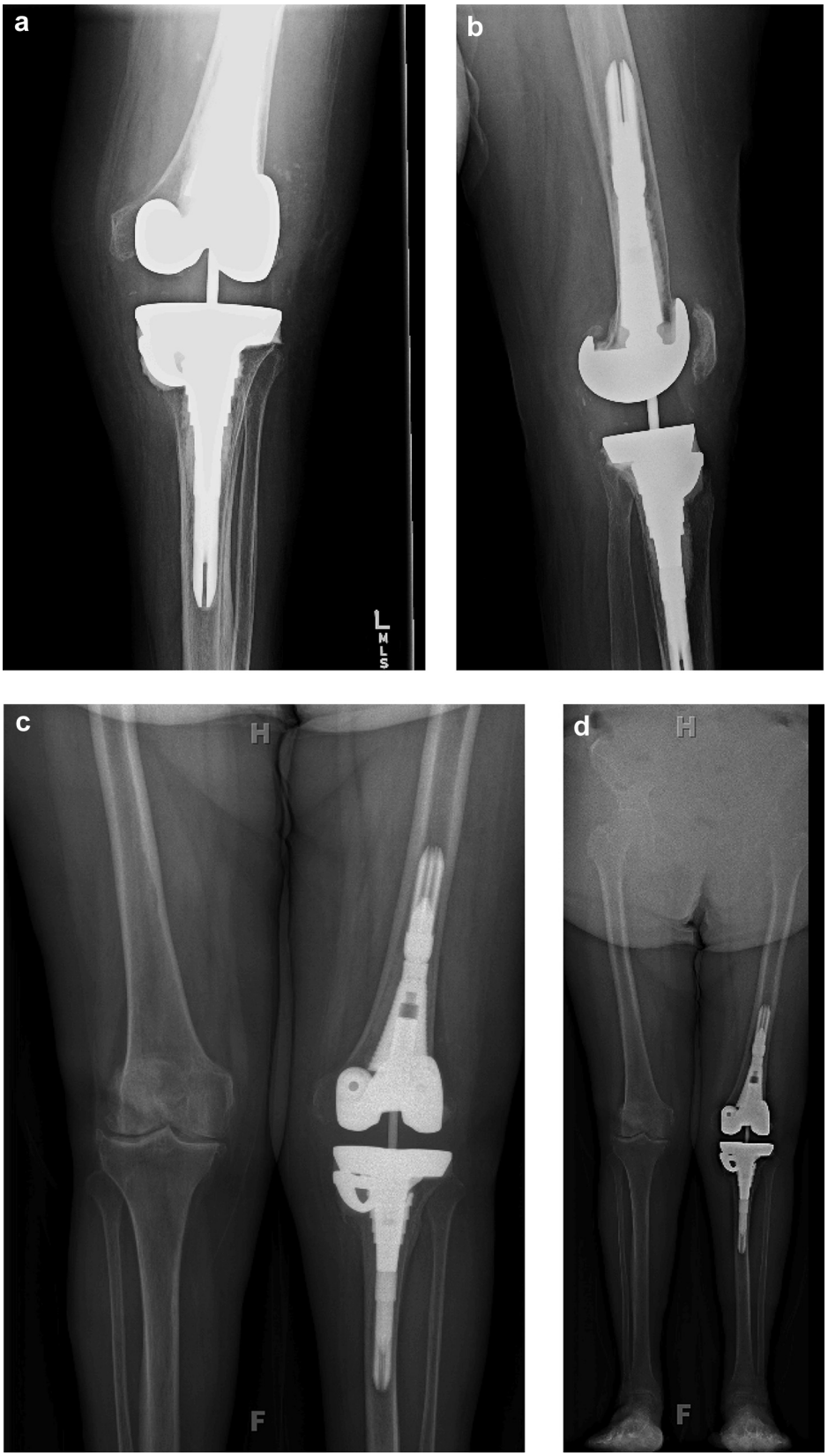

Figure 3. Postoperative AP (a) and lateral (b) single limb knee radiographs as well as bilateral knee (c) and hip-knee-ankle (d) EOS biplanar images showing the final construct with supporting wedge augment cemented into position supporting revision tibial tray and restoration appropriate coronal limb alignment.

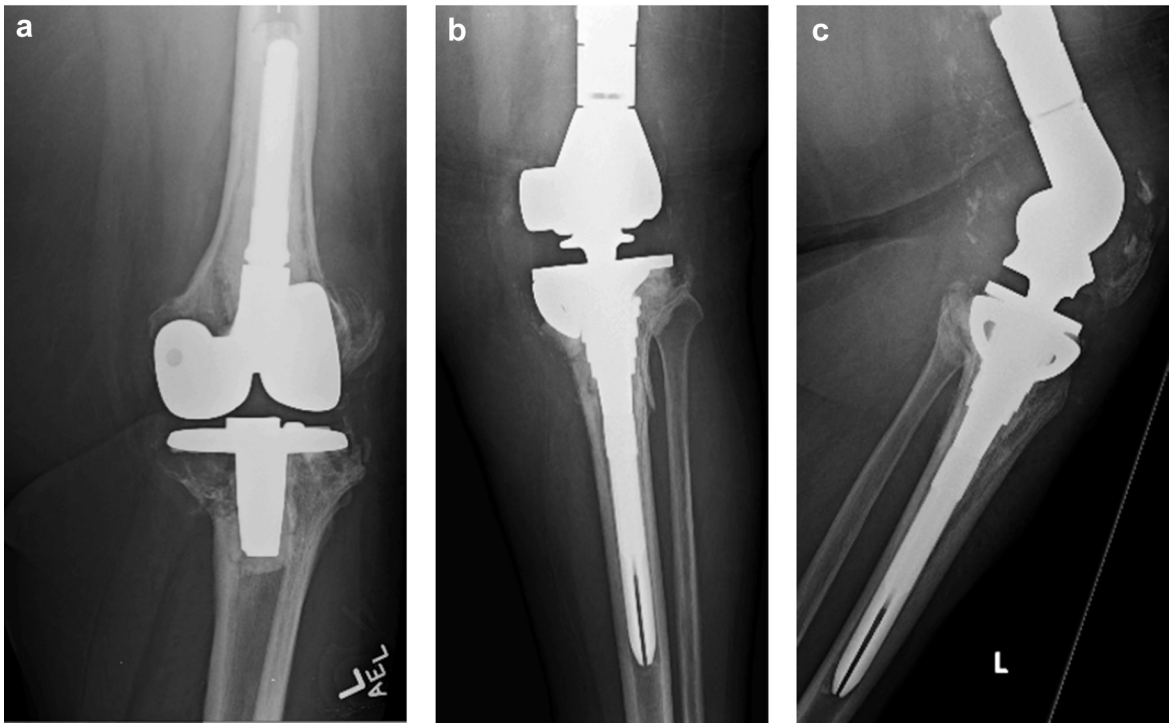

Figure 4. Preresection AP knee radiograph (a) of a patient with severe osteolysis, medial tibial bone destruction, and a concomitant periprosthetic joint infection. After 2-stage exchange arthroplasty, a wedge augment was needed for an uncontained medial defect and subsequent AP (b) and lateral (c) radiographs at 2-year follow-up show endoprosthetic reconstruction with stable, supportive medial wedge buttress augment.

Postoperatively, subjects are allowed full active range of motion with 50% restricted weight bearing for the first 6 weeks using a walker and transitioning to crutches or a 4-point cane. Patients are seen at 2 and 6 weeks after surgery to insure proper wound healing. Outpatient physical therapy is instituted after the wound is examined at the first postoperative visit. Radiographs are taken at 6 weeks, and if components show stable alignment and fixation compared to intraoperative and recovery room films, they are progressed to full weight bearing.

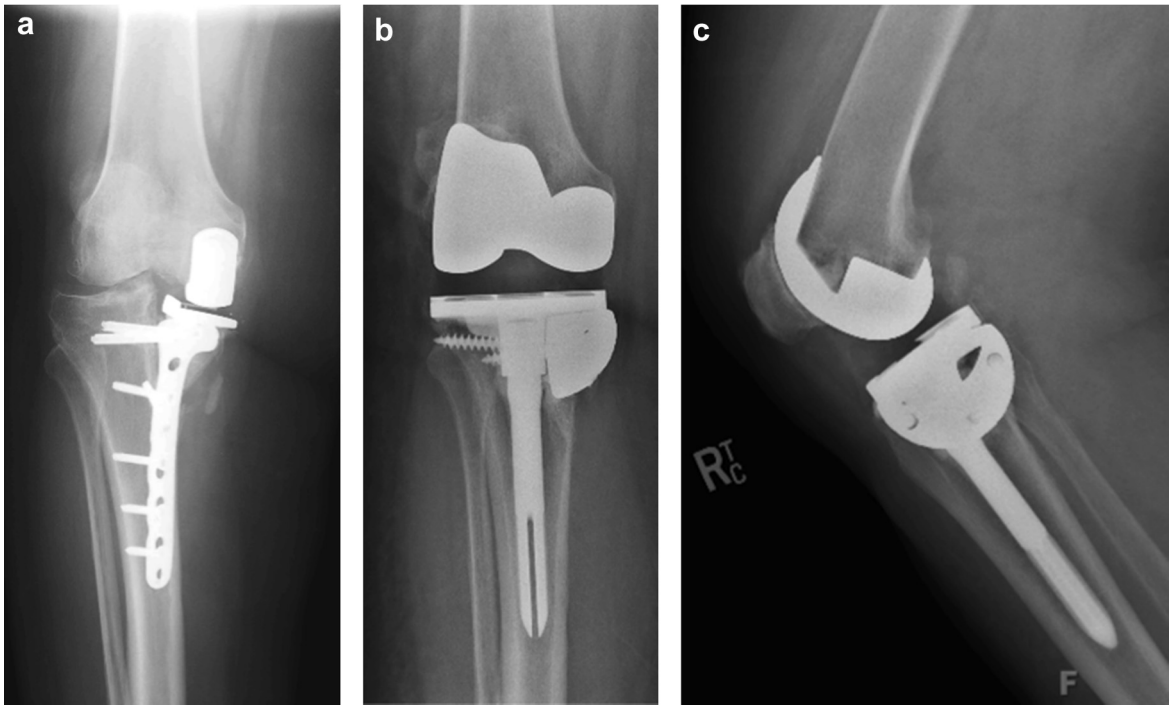

Figure 5. Preresection AP knee radiograph (a) of a patient with prior tibial plateau fracture who had extreme medial-sided collapse and a large, hemiplateau defect. At 10-year follow-up, the patient is doing well and AP (b) and lateral (c) radiographs demonstrate a stable reconstruction of the medial metaphysis using the buttress wedge augment with maintained tray and component positioning.

Table 1
Modification to the AORI classification for tibial bone loss in revision TKA.

AORI classification	Stambough-Nunley modification	Combined classification designation	Treatment recommendation
Type I—intact metaphysis	No change	I	Standard revision components ± augment
Type II—damaged metaphysis			
A—one condyle affected	Contained (C)	II-AC	Long-stemmed implant with standard tibial augment vs PMMA ± short rebar cortical screws
	Uncontained (U)	II-AU	Long-stemmed implant with acetabular wedge augment vs cone vs sleeve
B—two condyles affected		II-B	Long-stemmed implant with bilobed cone vs sleeve
Type III—deficient metaphysis	Contained (C)	III-AC	Long-stemmed implant with asymmetric or stacked cones vs large sleeve
	Uncontained (U)	III-AU	Long-stemmed implant with acetabular wedge augment vs cones ± stacked cones

Threshold for contained/uncontained defect is >3 cm in depth and >50% of cortical rim loss in the medial hemisphere after intraoperative implant removal.

Case series

Between 2006 and 2014, 2 senior arthroplasty surgeons in our division of adult joint reconstruction have used highly porous metal acetabular wedge augments to treat 7 patients with uncontained, unicondylar tibial bone defects with excessive loss of supportive cortices in the metadiaphyseal region (>50%) in revision TKAs. For scale, there were more than 400 revision knee procedures done by these surgeons over the same period. Clatworthy et al. [14] proposed a separate classification distinguishing circumferential uncontained or partially contained defects, but their treatment recommendations are not viable for modern reconstructive techniques, especially regarding uncontained defects (type 3 and 4), as they championed structural bone grafting with partial or whole proximal tibias for these severe defects. Both the AORI and Clatworthy classifications fail to include modern management strategies with augments and cones, thus rendering them outdated.

Six women and 1 male received an acetabular wedge augment as part of their revision TKA. The average age at time of revision was 65 years of age (median 66 years, standard deviation 5.5 years, range 58-71 years). All patients had medial tibial plateau defects >3 cm in depth and >50% of cortical rim loss in the medial hemisphere after intraoperative hardware removal. Three patients received the wedge augment as part of their stage 2 reimplantation for prosthetic joint replacement while 4 other patients had substantial osteolysis and varus collapse with component subsidence (Fig. 1). Acetabular augment types used included four 10 × 50/52 mm Gription (Depuy, Warsaw, IN) acetabular wedges and 3 Trabecular Metal (Zimmer Biomet, Warsaw, IN) augments of the following dimensions depending on defect size and depth: 10 × 50 mm, 10 × 58 mm, and 20 × 56 mm. All augments were oriented in a buttress fashion, with the convex surface facing medially to recreate the metaphyseal flare and the flat surface placed at the level of the cut lateral plateau perpendicular to the tibial mechanical axis. One augment was affixed to the host lateral bone with 3 cortical screws and then packed with cancellous bone chips before cementation of the tibial base tray (Fig. 2). All other augments were press-fit against the host bone distally and supported proximally by the undersurface of the tibial plate while remaining out of the way of the tibial stem. Cement was then used to fill the remaining bone void and unitize the augment to the bone and the tibial construct.

For overall constraint, 2 patients received a distal femur replacement with a linked hinge, 4 patients received varus-valgus constraining components, and 1 subject had a standard posterior stabilized polyethylene articulation implanted. All tibial constructs were affixed using hybrid fixation principles with long, cementless tibial stems. Six of the 7 recipients had a sleeve that was mated to the condylar-stem interface. Revision components used include PFC Sigma TC-III with MBT tibial tray (Depuy, Warsaw, IN) in 6 cases, with the other patient receiving a Legion Oxinium (Smith & Nephew, Memphis, TN) primary femur and revision base tray.

At a minimum 3-year follow-up (range 3-12 years, average 5 years), 100% of acetabular wedge augments remained implanted as part of the current construct with no clinical or radiographic findings of component failure at most recent follow-up (Fig. 3). No subjects have undergone further revisions in the operative knee. One patient died 15 months after revision surgery using the acetabular augment secondary to septicemia but was never explanted due to rapid demise and multisystem organ failure.

Discussion

In practice, wedge augments offer the practical benefit of addressing defects of varying size and geometry while affording the surgeon the ability to use a highly porous metal construct to optimize bony fit and fixation and provide a flat surface that provides a buttress to support the cemented revision base tray. In comparison to other segmental half-block taper augments that only recreate the contour of the lost bone and concentrate stresses on the remaining cortical rim, the hemispherical design of the acetabular wedge offers more load-bearing capacity by maximizing surface contact area. A wedge augment has the advantage of using screws or cement to affix to bone, whereas typical tibial augments, either rectangular or triangular in nature, are mated to the undersurface of tray and more directly experience the added axial strain of the overall construct. Furthermore, additional bone is often cut to create a flat surface, which in turn can compromise medial soft tissue attachments that influences final knee stability. We want to reiterate, however, that the addition of a wedge augment was utilized in 1.7% of all revision knee procedures during this time and was only used after trialing with a sleeve and/or long cementless stem construct was determined to be insufficient to reconstitute a stable medial buttress due to the excessive bone loss (Fig. 4). Although 6 of 7 cases in our series were complete revisions, it is feasible that if a surgeon were to keep a pre-existing femoral component of another system, a sleeve would not be an option on the tibial side because it is proprietary to a limited number of manufacturers and must only mate with their revision tibial system (Fig. 5).

The AORI classification [8] has inherent limitations in terms of determining treatment options for uncontained defects with large areas of cortical bone loss. Because of limitations in describing contained and uncontained defects, we have developed a modification to the AORI system that differentiates unicondylar contained vs uncontained defects in a damaged or deficient tibial metaphysis and offers contemporary treatment strategies based on the available supportive bone stock (Table 1).

We believe the use of acetabular augments may offer some cost-saving effects as well. As the market for tibial cone use emerges with more device manufacturers offering highly porous metal options, surgeons may find themselves defaulting to these in combination with other augments to regain tibial height. In cases of medial unicondylar plateau metadiaphyseal defects, the cost of an acetabular wedge augment is around $2500 compared to that of a highly porous tibial cone, which lists from $7200 for standard designs to $8100 for stepped or asymmetric options [15].

Summary

In select circumstances, the use of acetabular wedge augments in revision knee arthroplasty for cases with unicondylar deficient or damaged tibias with unsupportive cortices provides surgical flexibility to create a biomechanically friendlier surface onto which to affix the tibial tray and support the prosthesis when compared to traditional half-block rectangular or triangular augments. To date, these augments have proved to be excellent reconstructive options for complex revision knee arthroplasty cases with substantial bone loss and have achieved great survivorship at an average of 5 years, but longer follow-up is needed to assess durability.

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