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Surgical technique

Creating a dual articulating antibiotic spacer for management of an infected total femur prosthesis hemiarthroplasty

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ABSTRACT

The gold standard for management of chronic periprosthetic joint infections is a 2-stage revision arthroplasty with the first stage being explantation, debridement, and placement of a spacer. While there are implants designed to manage periprosthetic infections in hip and knee arthroplasty, there are not any commercially available implants designed to specifically manage an infected total femur megaprosthesis. This creates a unique surgical challenge and requires custom construction of a spacer to be performed by the surgeon intraoperatively. Here, we present our surgical technique for manufacturing a dual articulating total femur spacer. This technique facilitates range of motion at both the hip and knee joints, provides stability for axial loading in the extremity, and preserves the acetabulum while the patient undergoes antibiotic therapy to eradicate the infection.

Introduction

Total femur replacement (TFR) is a well-described procedure that can be used in patients with oncologic tumors requiring resection and those with failed hip and knee arthroplasties associated with massive bone loss [1-6]. Often, it is the only option that remains for patients in these situations to maintain limb function as an alternative to amputation [7]. Therefore, periprosthetic joint infections (PJIs) can be a devastating complication after these procedures and occur at a higher rate than is seen in primary hip and knee arthroplasty procedures (4.8%-44% vs 2%-2.4%, respectively) [7-13]. The gold standard for management of these infections is a 2-stage revision arthroplasty with the first stage being explantation of previous implants, thorough debridement, and placement of an antibiotic-impregnated cement spacer. This is followed by a course of targeted intravenous (IV) antibiotic therapy and ultimately staged reimplantation, which has shown success rates of up to 95% [14-16].

While there are multiple commercially available antibiotic-impregnated cement spacer options for PJI involving a total hip arthroplasty or a total knee arthroplasty, there are no such implants or systems currently available for cases of PJI involving a TFR. This creates a unique surgical challenge for the orthopedic surgeon as little guidance exists on how best to create a spacer in these rare cases. While initial techniques described in the literature demonstrated articulating hip joints with a fixed knee joint [17-20], total knee arthroplasty literature has shown improvements in range of motion (ROM) as well as improved soft-tissue management at the definitive surgery when an articulating spacer is used, which has led toward the favoring of a dual articulating spacer [21,22]. To our knowledge, 3 techniques describing dual articulating total femur spacers have been described to date, with each involving an acetabular cup at the definitive procedure [23-25]. Here, we present our surgical technique for manufacturing a dual articulating total femur spacer which allows preservation of the native acetabulum using a hemiarthroplasty head, modular proximal femur body, femoral intramedullary nail, and a commercially available injection-molded articulating distal femur.

Surgical technique

Patient background

The case presented here involves a 19-year-old male with a low-grade osteosarcoma who was initially managed with a distal femur replacement. He subsequently developed a PJI and underwent a

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2-stage revision distal femur replacement but developed a repeat PJI 4 months after reimplantation. He was subsequently referred to the senior author for further management who provided all care thereafter.

At our institution, an articulating distal femur spacer was placed; however, the infection was unable to be cleared, and osteomyelitis in the residual proximal femur developed. A repeat distal femur spacer exchange was performed, followed by a staged TFR (Fig. 1). Three months after the TFR, the patient developed a repeat PJI, and a dual articulating total femur spacer, as described in the following sections, was placed.

Surgical approach

Once adequately anesthetized, the patient is placed in the lateral decubitus position with standard padding of all bony prominences. The operative limb is then prepped and draped free, and a standard lateral approach to the femur is made with dissection carried down to the iliotibial band. The iliotibial band is split in line with its fibers, and the vastus lateralis is elevated anteriorly, exposing the implant below. After careful dissection, the entire length of the implant is exposed. The abductor muscle attachment to the remaining greater trochanter is preserved in continuity with the vastus lateralis and reflected anteriorly. A hip capsulotomy is then performed, and all components of the implant are removed proximally and distally in standard fashion using the described explant techniques. The wound is then copiously irrigated and debrided in the standard fashion. The total femur spacer is then prepared on the back table after packing the open wound.

Spacer preparation and implantation

Initial attention is directed toward creation of the articulating distal femur portion of the spacer. The appropriate size-matched Biomet StageOne knee cement spacer molds are selected (Biomet Orthopedics LLC, Warsaw), and the articulating cement spacers are prepared according to manufacturing guidelines with 2 batches of Simplex Bone Cement (Stryker Corporation, Kalamazoo) mixed with 2 grams of vancomycin and allowed to polymerize.

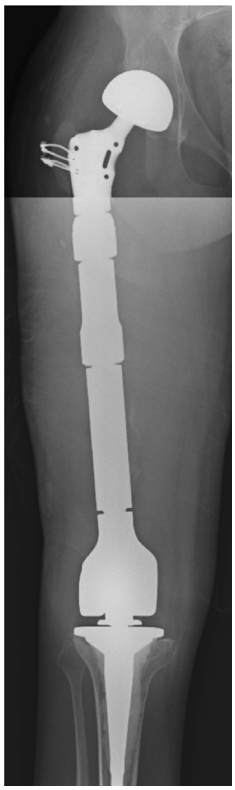

Figure 1. Preoperative anteroposterior radiograph of the patient's infected total femur arthroplasty.

A Synthes (DePuy Synthes, Raynham) size-10-diameter retrograde-antegrade femoral nail (RAFN) that closely matches the overall length of the removed total femur prosthesis when combined with the modular body and head is then selected. The distal portion of the femoral nail is fully coated with cement and secured to the distal femur mold in approximately 5 degrees of valgus using 2 batches of Palacos Bone Cement (Zimmer Biomet, Warsaw) mixed with 2 grams of vancomycin and 2.4 grams of tobramycin per batch (Fig. 2). The tibia tray is also cemented to the proximal tibia at this time.

A trial reduction is then performed using a trial Arcos modular proximal femoral body and hemiarthroplasty head (Zimmer Biomet, Warsaw). Adjustments can be made through the offset or length options of the body as well as with the neck length of the hemiarthroplasty head. Once the final proximal modular Arcos femoral body is chosen, it is positioned with 15° of anteversion and then fully coated with cement and advanced over the proximal aspect of the RAFN; this is then secured using 2 batches of Palacos bone cement mixed with 2 grams of vancomycin and 2.4 grams of tobramycin. After allowing the cement to polymerize, a unipolar trial head is then placed on the femoral stem.

The total femur spacer is then reduced into the acetabulum and brought into articulation with the tibial tray in the knee. The spacer is checked for fit, length, alignment, and stability. Final adjustments to stability, if needed, can be performed through modifications of the neck length. Once the neck length is confirmed, the hemiarthroplasty head is then attached, and cement is placed up to the level of the head rim. The final implant is then reduced into the acetabulum, and the wound is irrigated and closed in a standard layered fashion (Fig. 3).

Postoperative protocol

Postoperatively, the patient was allowed to be touch-down weight bearing in a hinged knee brace with hip and knee ROM as tolerated to the operative limb. A hinged knee brace was used to provide additional stability to the knee, particularly in the varus and valgus planes, and left unlocked to allow flexion and extension exercises to reduce stiffness. He was placed on an oral anticoagulant for deep vein thrombosis prophylaxis for a period of 6 weeks and targeted IV antibiotic therapy for 6 weeks under the management of our infectious disease colleagues.

Two weeks postoperatively, the patient demonstrated nonirritable hip ROM and knee ROM of 0°-20°. Six weeks postoperatively, the hip remained nonirritable, and he had 0°-35° of ROM at the knee. Three months postoperatively, he underwent staged reimplantation of a total femur prosthesis (Fig. 4).

Reimplantation and outcome

Following standard protocols at our institution for the management of a chronic PJI, we provided the patient with a 6-week antibiotic holiday after the 6-week course of targeted IV antibiotic therapy. Laboratory tests on infections including the white blood cell count, erythrocyte sedimentation rate, and C-reactive protein were then checked for normalization before reimplantation. In this case, after reimplantation, the patient was placed on an 8-month course of oral antibiotic suppression therapy with sulfamethoxazole-trimethoprim.

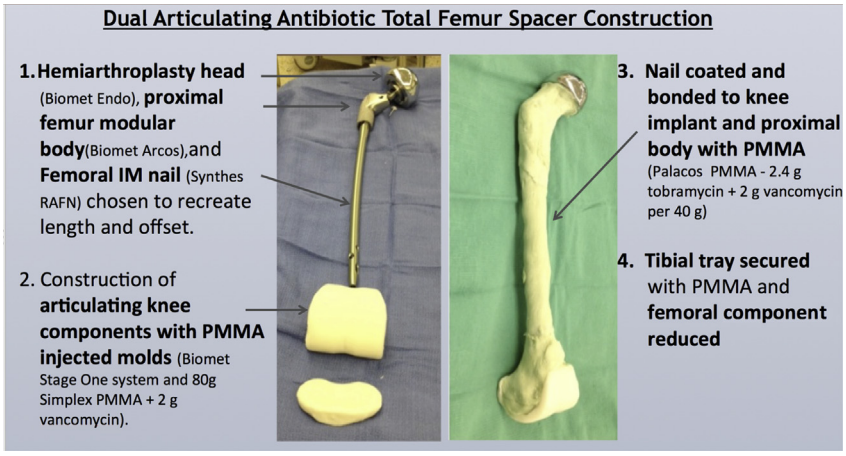

Figure 2. Outline of the components involved in constructing this dual articulating total femur antibiotic spacer.

It is now 5 years postoperatively from reimplantation, and the patient has not shown any signs of recurrent infection. He ambulates without assistive devices and has 0°-120° of knee ROM.

Discussion

Management of a PJI that necessitates placing a total femur antibiotic spacer is an uncommon and uniquely challenging task for the orthopedic surgeon. With no consensus on the ideal spacer and no commercially available implant designed specifically for this purpose, the surgeon must have a thorough plan preoperatively for the desired spacer construct they plan to build intraoperatively. As the value of articulating spacers over static spacers has been demonstrated in the literature, [21,23] we feel that creating a dual articulating spacer has the potential to provide additional benefits to both the patient and the surgeon over the previously described spacers with a static knee component.

We acknowledge that other dual articulating spacer techniques have been described and would be options in cases where a previous total hip arthroplasty was present. However, we feel the current technique offers a simpler, stronger construct that can also be performed when there is a native acetabulum present that the surgeon is trying to preserve. By using a hemiarthroplasty head, we are able to adjust the head size in 1-millimeter (mm) increments and the neck length in 3-mm increments, which is in contrast to commercially available prefabricated molds that generally allow adjustments in the

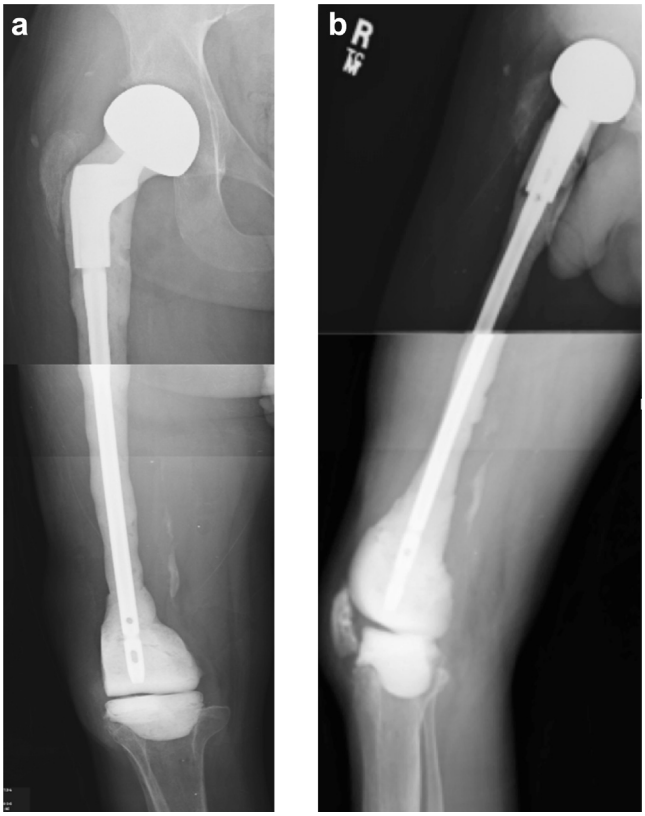

Figure 3. Anteroposterior (a) and lateral (b) radiographs demonstrating the dual articulating total femur antibiotic spacer in situ.

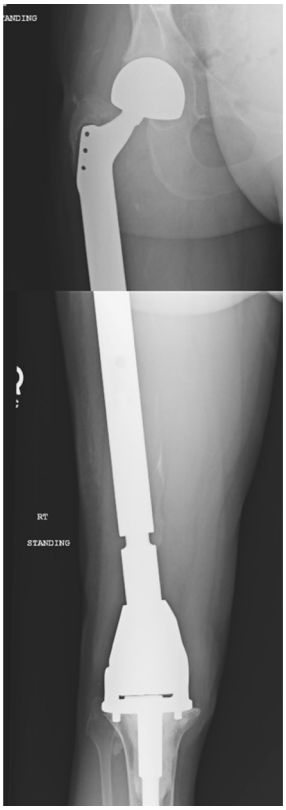

Figure 4. Anteroposterior radiograph after staged reimplantation of the total femur arthroplasty.

head size of 4-mm increments and the neck length in 6-mm increments. Of note, the same construct design can also be used with a standard head and cup construct if indicated by the clinical scenario.

This technique also allows the surgeon to adjust the length and stability as it is being built while maintaining a relatively simple construct design overall. We currently favor the use of an intramedullary nail over Ender pins or Harrington rods, similar to the technique described by Sanz-Ruiz et al. for the additional stability the nail provides to address the concern for spacer fracture [23].

One limitation of this technique is the higher cost associated with its construction than that of other previously described spacers. At our institution, the increased cost of constructing our described spacer (hemiarthroplasty head and neck, modular proximal femur body, and RAFN) compared with other previously described techniques is approximately $1500. While this construct is slightly more expensive than a prefabricated hip spacer with Ender pins or Harrington rods, we feel that the simplicity in construction, ease of length and head size modifications, and potential increase in construct strength justify the added cost. While there are no studies that assess if the added stability gained with an intramedullary nail (RAFN) over Ender pins or Harrington rods is a necessary expense, the potential patient morbidity and substantially higher costs that would be incurred by a spacer fracture leads us to favor this stronger construct.

Summary

Management of a PJI that necessitates a total femur antibiotic-impregnated spacer is a challenging task for the orthopedic surgeon and requires custom creation of the implant and appropriate preoperative planning. We present one method for construction of a dual articulating total femur spacer to further add to the limited body of literature on this topic.

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