Arthroplasty Today 4 (2018) 65–70

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Surgical technique

Antibiotic impregnated total femur spacers: a technical tip

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ARTICLE INFO

Article history:
Received 14 March 2017
Received in revised form
1 June 2017
Accepted 6 June 2017
Available online 1 August 2017

Keywords:
total femur spacer
revision arthroplasty
total hip arthroplasty
total knee arthroplasty
prosthetic joint infection

ABSTRACT

Simultaneous prosthetic joint infection of ipsilateral hip and knee arthroplasties is often accompanied by significant bone loss and presents a challenging reconstructive problem. Two-stage reconstruction is favored and requires the placement of a total femur spacer, which is not a commercially available device. We describe a surgical technique, reporting on 2 cases in which a customized total femur antibiotic impregnated spacer was created by combining an articulating knee spacer and an articulating hip spacer with a reinforced cement dowel construct connecting the 2 spacers. Custom total femoral spacers are useful in the management of infected femoral megaprostheses and cases with ipsilateral injected hip and knee arthroplasties and severe femoral bone loss.

Introduction

Articulating spacers are routinely used in the management of prosthetic joint infection [1]. Techniques have evolved from simple spacers to more complex implants with intramedullary stem extensions to assist in the management of cases with substantial bone loss [2,3]. On rare occasions, a concomitant infection of an ipsilateral total knee arthroplasty and total hip replacement can occur, and this presents a complex management problem. Infected femoral megaprostheses offer similar challenges. This report describes a surgical technique in 2 such cases, in which a customized total femur antibiotic impregnated spacer was created by combining an articulating knee spacer and an articulating hip spacer with a reinforced cement dowel construct connecting the 2 spacers.

Surgical technique

The patient is secured in the lateral decubitus position. We prefer a posterolateral approach to the hip because of its extensile nature. The distal extension of the incision is curved laterally to incorporate a lateral parapatellar approach to the knee joint. The pseudocapsule around the hip is excised and the hip components are removed. Attention is then turned to the knee. The previous incision is utilized as much as possible. Knee components are removed and a complete synovectomy is performed. Thorough irrigation and debridement of both joint cavities is performed. Spacers are then fabricated.

Spacer fabrication

Each spacer is fabricated independently using Simplex polymethyl methacrylate cement (Stryker Orthopaedics, Mahwah, NJ). For each bag of cement, 3 vials (1.2 g each) of tobramycin powder and 3 vials (1 g each) of vancomycin powder are added, as well as a few drops of methylene blue to facilitate identification of small pieces of cement at subsequent surgery. The articular portion of the knee spacer is made from preformed gentamicin-impregnated poly(methyl methacrylate) spacers (InterSpace Knee, Exactech Inc., Gainesville, FL; or The Remedy, OsteoRemedies, Memphis, TN), which contain 1.2 g of gentamicin in each of the femoral and tibial components. Antibiotic cement rods are then created by coating stainless steel Harrington rods with cement and placing them in a mold designed to uniformly coat the rod with antibiotic-impregnated cement (Nimbic Systems, Sugarland, TX) to produce a 13-mm diameter rod (Fig. 1). Various lengths are available up to 400 mm. Each rod is then connected to the articulating femoral and tibial knee components with cerclage wires and coated with

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.artd.2017.06.001.

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http://dx.doi.org/10.1016/j.artd.2017.06.001

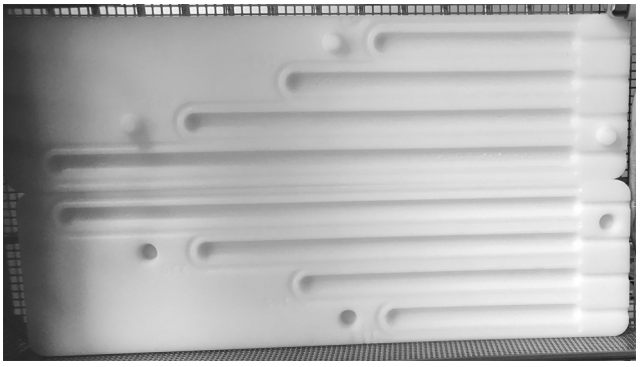

Figure 1. Plastic mold used to create antibiotic cement dowels in total femur spacer fabrication.

additional cement. The femoral spacer is created using a commercially available mold system (DePuy PROSTALAC, Warsaw, IN), which has a constrained acetabular polyethylene component, which is important in these cases. The longest available femoral component (240 mm) is used.

Spacer insertion

The acetabulum is gently reamed and thoroughly irrigated. The acetabular component is cemented in place. The femoral component is then articulated with the acetabulum. The tibial canal is reamed to a size 14, and the tibial component with its stem extension is cemented in a stable position. The degree of overlap between the femoral stem of the knee component and the femoral PROSTALAC spacer is adjusted to achieve appropriate limb length and the 2 are then secured together with 2 cerclage wires (Fig. 2). Finally, additional cement is placed at the junction of the 2 femoral components to unitize them. The wound is thoroughly irrigated and then closed in layers.

Postoperative course

Postoperatively, patients are allowed toe-touch weight bearing on the affected limb and are placed on subcutaneous low-molecular-weight heparin for venous thromboembolism prophylaxis. A knee immobilizer is used because minimal stability is present at the knee joint. Limited weight bearing is allowed after 4 weeks if the patient can comply.

We place these patients on a minimum of 6 weeks of targeted parenteral antibiotic therapy, which is directed by an infectious disease specialist. Because of the complicated nature of these infections, we delay reimplantation for 3 months. Although there is no evidence to guide us in determining the optimal time to proceed with reimplantation in these patients, we believe delaying it provides more time to eradicate the infection. This must be balanced with the risk of catastrophic mechanical failure of the spacer, which becomes more likely the longer it is left in place. Therefore, we arbitrarily choose to proceed with reimplantation 3 months following the explant.

Reimplantation of total femur arthroplasty

The work-up prior to reimplantation includes checking erythrocyte sedimentation rates, C-reactive protein, and white blood cell for normalization or persistent downward trend following a minimum 2-week antibiotic holiday. Synovial fluid analysis including cell count, gram stain, and culture is also performed. In these patients, we believe there is essentially one compartment around the prosthesis and choose to sample the knee joint as opposed to the hip joint because it is readily done in clinic without the need for image guidance. We have used a synovial fluid nucleated cell count threshold of 3500 as a sign of persistent infection based on the work

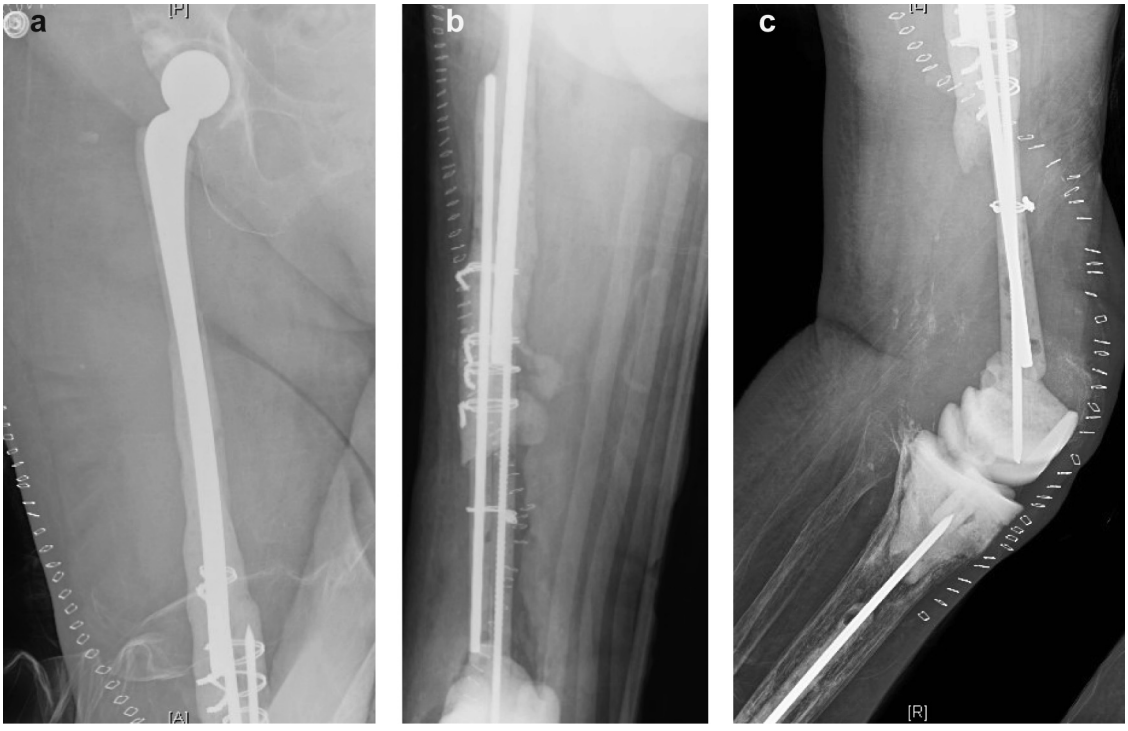

Figure 2. Postoperative anteroposterior (AP) (a and b) and lateral (c) radiographs of a dual-articulating total femoral spacer implanted in patient 1. AP, anteroposterior.

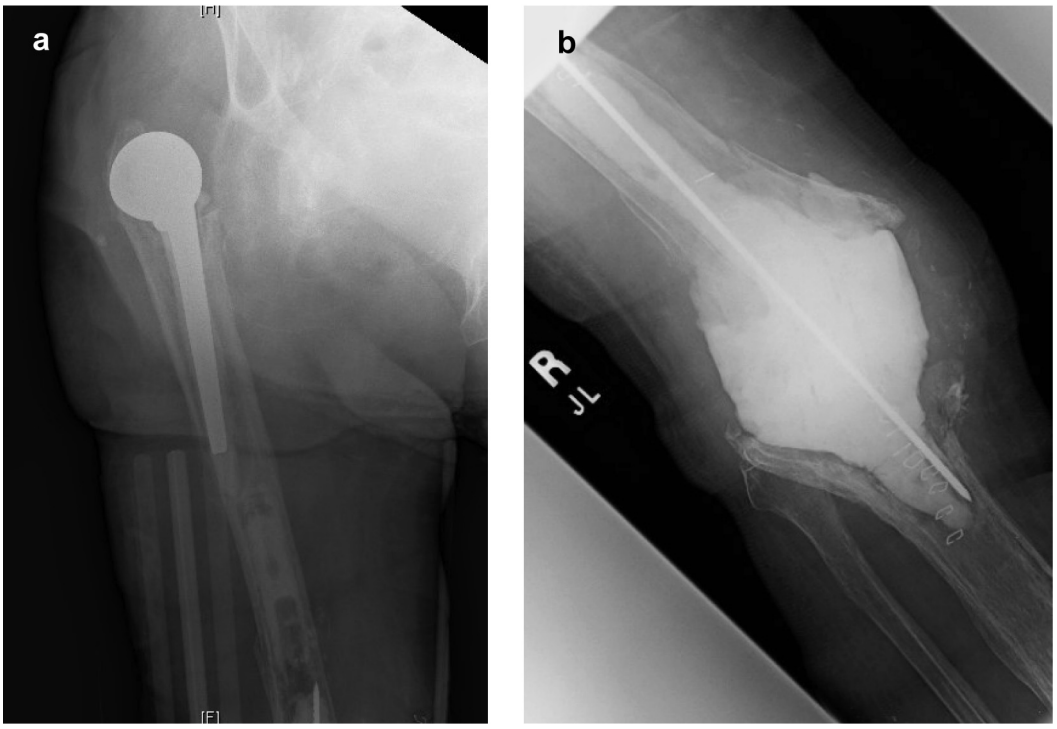

Figure 3. (a) AP radiograph of case/patient 1, showing dislocated cemented hemiarthroplasty with severe associated femoral bone loss; (b) AP view of the same patient's ipsilateral knee with a static cement spacer in place. AP, anteroposterior.

by Shukla et al [4]. However, new data suggest that a value of 1100 may be preferable to improve sensitivity of detecting persistent infection [5]. Frozen sections at the time of reimplantation have demonstrated high specificity for persistent infection and can provide additional information. However, their sensitivity is low [6].

The technique for reimplantation is similar to what has been previously described by Friesecke et al. [7]. The patient is placed in the lateral decubitus position. An extensile posterolateral approach to the hip is performed and extended into a lateral approach to the femur and anterolateral approach to the knee. If possible, a portion of the soft tissue over the lateral thigh is left intact. It is possible in some cases to perform the procedure through a proximal window, through which the prosthesis can be passed and implanted at the knee through a second distal window. A stemmed tibial component is implanted after appropriate preparation of the proximal tibia. Attention then turns to the acetabulum, and the appropriately sized acetabular component is inserted after under-reaming by 1 mm. Multiple transacetabular screws are placed for supplemental fixation, as a constrained liner is required in most cases due to abductor insufficiency. A femoral trial is built using modular segments to optimize leg length and soft tissue tension. Once the appropriate size is determined, the final prosthesis is placed. The distal portion of the femoral prosthesis is first linked to the tibial component. The femoral head is then impacted and the hip joint is reduced. The abductors insertion is reattached to the prosthesis using heavy, nonabsorbable sutures. The wound is then closed in layers.

Case examples

The first patient is a 74-year-old obese female with multiple medical problems including type 2 diabetes and chronic lymphedema presented with a dislocated, chronically infected revision right total knee arthroplasty and an ipsilateral dislocated, infected right cemented hemiarthroplasty of the hip. Her presenting serum white blood cell count was 8000 (ref 4500-11,000) and the nucleated cell count from an aspiration of her hip was 24,750. Cultures of fluid from the hip and knee both grew methicillin-resistant *Staphylococcus epidermidis*. Prior to presenting to us, the knee had been explanted, and a static cement spacer was in place. But, the infected, dislocated hemiarthroplasty remained in place (Fig. 3a and b). There was extensive bone loss throughout the femur. A 2-stage revision using a total femur spacer was performed as described above (Fig. 2a-c). Estimated blood loss was 900 mL. Postoperatively, she was placed on parenteral vancomycin. On postoperative day (POD) 2, she developed severe refractory hypoglycemia requiring admission to the intensive care unit. Her serum creatinine subsequently slowly increased over the next several days from 0.7 to 2.0 mg/dL on POD 14. Her preoperative creatinine level was 0.9 mg/dL (ref 0.5-1.1). Nephrologist was consulted and suspected that the kidney injury was due to multiple factors, including intraoperative hypotension, dehydration, hypoglycemia, and a possible contribution from vancomycin toxicity. Serum vancomycin troughs were obtained regularly during therapy and all were within goal range (15-20 mcg/mL), with the exception of 1 trough level drawn on POD 2 that was 25.2 mcg/mL (target 15-20). Four months after the spacer was inserted, she underwent second-stage reimplantation of a total femur arthroplasty (Fig. 4a and b). Two weeks following surgery, her creatinine has improved to 1.1 mg/dL.

The patient is now 3 months status after total femur reconstruction. She demonstrates no signs of infection but is chronically suppressed on oral antibiotics per our protocol. Prior to explantation, she was wheelchair bound and had been nonambulatory for more than a year. Currently, she remains in therapy and is able to transfer short distances.

The next patient is a 56-year-old male presented to our clinic after undergoing numerous operations by another surgeon on his right lower extremity to treat a leiomyosarcoma of the right thigh. These included wide surgical excision chemotherapy

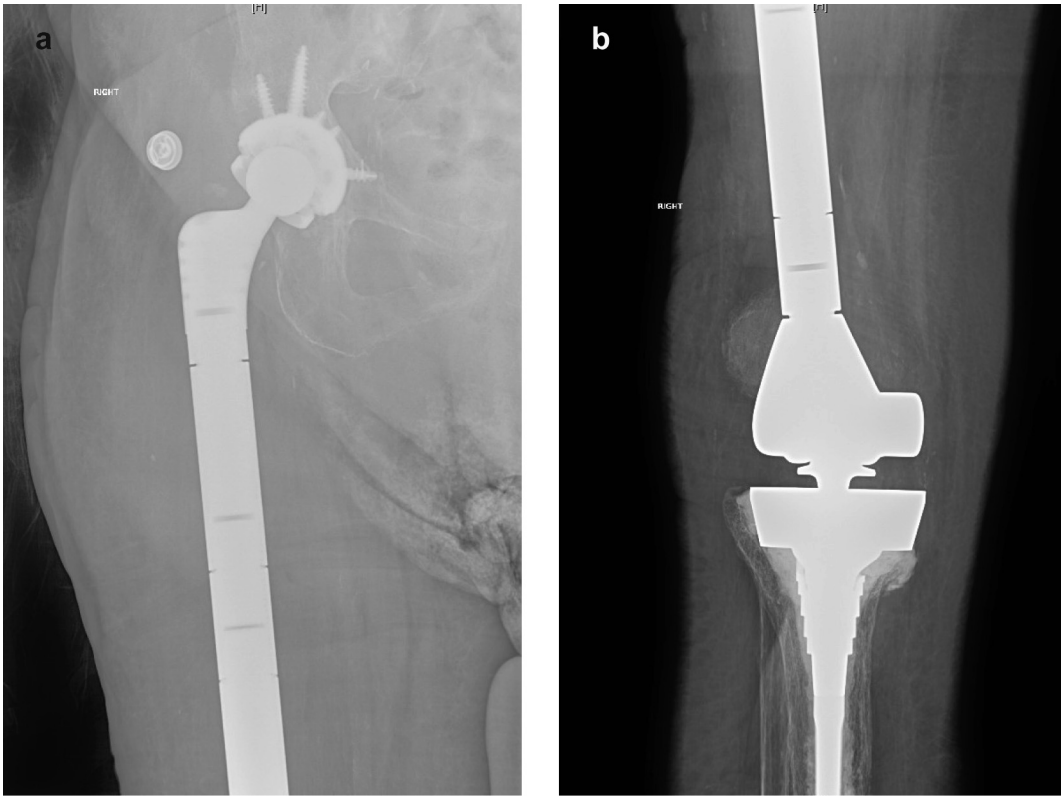

Figure 4. Postoperative AP femur (a) and knee (b) radiographs of total femur arthroplasty following second-stage reimplantation surgery for patient 1. AP, anteroposterior.

and radiation to treat the tumor; intramedullary femoral fixation for a radiation-induced mid-shaft femur fracture; a distal femoral arthroplasty that replaced the entire distal half of the femur to treat a femoral nonunion (Fig. 5a-c); and finally, a total femur replacement to treat presumed aseptic loosening of the distal femoral arthroplasty. Following these operations, he presented to us with a draining sinus that communicated with his total femur prosthesis. His erythrocyte sedimentation rates was 71 mm/h (ref 0-10); C-reactive protein 2.47 mg/dL (ref 0-0.5), and culture of the fluid grew *Streptococcus mitis*. He was diagnosed with deep infection of the total femur arthroplasty, and we recommended 2-stage treatment using a total femur spacer

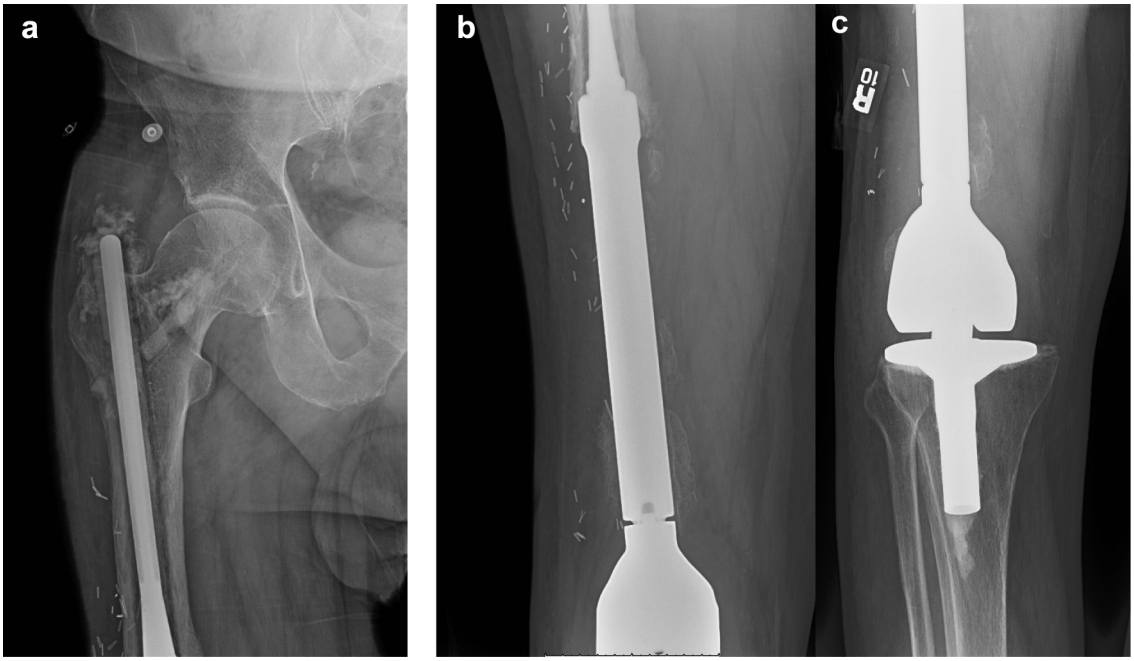

Figure 5. AP radiographs of a hip (a), femur (b), and knee (c) demonstrating a loose distal femoral replacement arthroplasty with loss of a large segment of distal femur and considerable damage to the proximal femur.

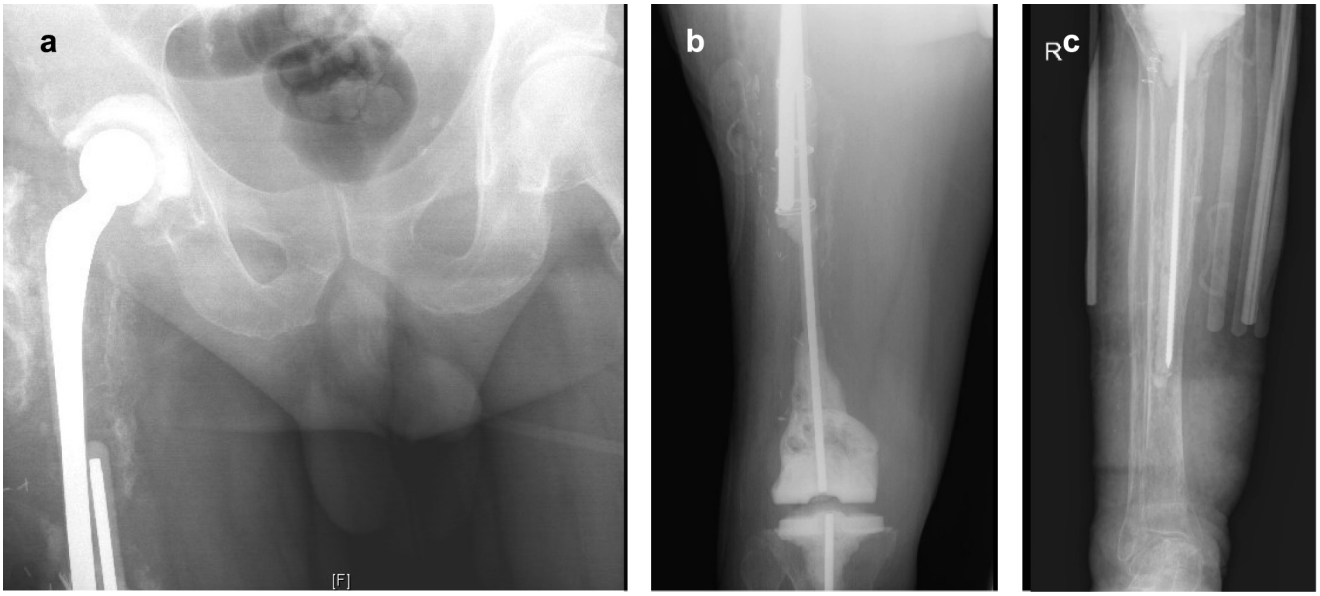

Figure 6. AP radiographs of the hip (a), femur (b), and tibia (c) demonstrating a dual-articulating total femoral spacer implanted in case/patient 2. AP, anteroposterior.

(Fig. 6a-c). Estimated blood loss was 1000 mL. His postoperative course was uncomplicated. After placement of the spacer, he received 6 weeks of parenteral antibiotics prior to undergoing second-stage reimplantation of a total femur replacement arthroplasty 3.5 months after the spacer was inserted (Fig. 7a-c).

The patient is now 6 months status after reimplantation and demonstrates no signs of recurrent infection. He ambulates without difficulty with the use of a cane and has a mild Trendelenburg gait. He also remains free of tumor recurrence.

Discussion

Deep infection of ipsilateral hip and knee arthroplasties in the setting of severe femoral bone loss represents a rare but challenging surgical problem. In ideal situations, these patients are managed with a 2-stage approach with placement of a temporary total femur spacer. However, these must be created by the surgeon at the time of surgery because no such device is available commercially. We have found the technique described herein useful in the management of these challenging cases.

One concern with using high doses of vancomycin and aminoglycosides in cement spacers is the potential for associated nephrotoxicity. Studies evaluating the use of high doses of vancomycin and aminoglycosides in hip and knee cement spacers have demonstrated their safety in patients without a history of renal impairment [8,9]. Studies examining systemic absorption of antibiotics from cement spacers have shown that very little antibiotic is absorbed systemically [10,11]. One study demonstrated that when

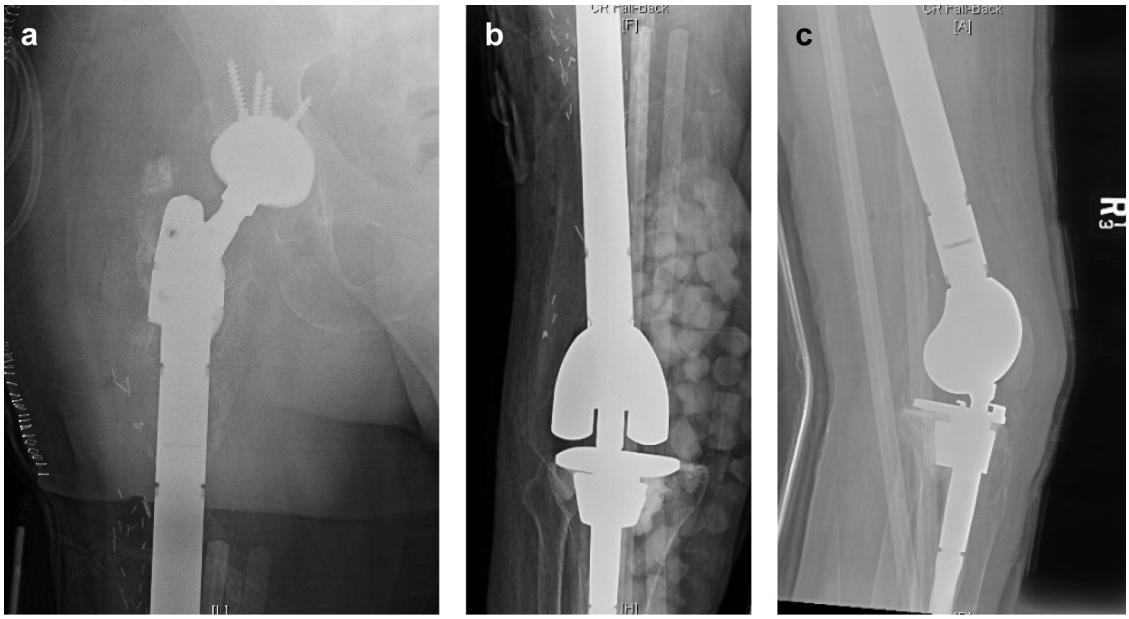

Figure 7. Postoperative AP (a and b) and lateral (c) radiographs following second-stage reimplantation of the total femur arthroplasty in patient 2. AP, anteroposterior.

2 batches of cement with 2 g vancomycin per 40 g batch of cement were implanted, peak serum vancomcyin levels were 30 times below the toxic threshold [11]. Another study of 334 patients receiving spacers with an average of 10.5 g of vancomycin and 12.5 g of gentamicin demonstrated no renal dysfunction based on serial creatinine measurements [12].

There have been case reports associating kidney injury with antibiotic cement spacers [13-15]. Our construct uses up to 6 batches of cement, which is considerably more than what is routinely used in single hip or knee spacers. This could increase the risk of associated kidney injury. Although it is unknown whether the kidney injury seen in the first case is directly related to the nephrotoxicity from the antibiotic spacer, there is a chance that it may have played a role. We closely monitored vancomycin trough levels in this patient because she was also receiving parenteral vancomycin. With the exception of one mildly elevated level, she did not experience toxic serum concentrations. Although the spacer may have contributed, we believe that other factors were more likely responsible for her kidney injury, including underlying diabetes mellitus, intraoperative blood loss, intraoperative hypotension, dehydration, and refractory hypoglycemia requiring an intensive care unit admission. Attempts should be made to minimize these factors as much as possible to help prevent postoperative kidney injury.

No recommendations have been made in the literature in terms of the maximum amount of vancomycin or tobramycin that should be implanted in a patient with a cement spacer. However, to minimize the risk of kidney injury while maintaining adequate local antibiotics levels, the authors would suggest not using more than 3 g vancomycin and 3.6 g tobramycin per 40 g bag when constructing total femur spacers and not more than 5 of these batches of cement, because to our knowledge this is the highest dose that has been reported with safe use in the literature [12]. If additional cement is required to implant or unitize the spacer, nonantibiotic cement can be used for this purpose. Careful monitoring of kidney function and serum antibiotic levels should be performed in patients with underlying kidney disease or those at risk for kidney injury. Consideration should also be given to using a parenteral antibiotic that is not nephrotoxic in these patients if targeted therapy allows.

Recent data suggest that chronic oral antibiotic therapy following surgical treatment of prosthetic joint infection can significantly improve infection-free survival [14]. We believe such an approach is of particular value in patients who undergo reimplantation of total femur prostheses following infection because options for treating reinfections are limited. We prefer doxycycline for its broad spectrum coverage, including some strains of methicillin-resistant *Staphylococcus aureus*.

Summary

Custom total femoral spacers are useful in the management of infected femoral megaprostheses and cases with ipsilateral injected hip and knee arthroplasties and severe femoral bone loss. However, based on this report of 2 patients with limited follow-up, we cannot yet draw any conclusions regarding their long-term effectiveness.

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