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Surgical Technique for 2-Stage Revision Arthroplasty for Chronic Periprosthetic Total Joint Infections

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Prosthetic joint infection should be considered as a possible diagnosis in any painful prosthetic joint at any time after the index procedure. Establishing a diagnosis of prosthetic joint infection can be challenging. Once the diagnosis is established, eradication of infection generally requires coordinated surgical and medical care. For a well-established infection, 2 stage revision arthroplasty is generally preferred by the authors. Static or articulating spacers can be used for the first stage.
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KEYWORDS prosthetic joint infection, infection, two-stage revision, hip arthroplasty, surgical technique, knee arthroplasty

Introduction

Total joint arthroplasty is the definitive treatment for osteoarthritis of the hip and knee, and has been remarkably successful, with over 95% survivorship at 10-year follow-up.[1] Following its success, the incidence of total joint arthroplasty has risen dramatically, with over 1.3 million total knee arthroplasties and over 500,000 total hip arthroplasties expected to be performed in the United States yearly by 2020.[2] Prosthetic joint infection (PJI) is a rare but dreadful complication. PJI is estimated to occur in 0.8%-1.9% of cases following total knee arthroplasty, and 0.3%-1.7% of cases following total hip arthroplasty, with higher infection rates following revision arthroplasty.[3,4] It is estimated that there will be over 65,000 cases of PJI requiring treatment in the United States annually by 2020, at a cost nearing $2 billion.[5]

Clinical presentation and time course of infection can vary. The most common presenting symptom is pain or tenderness around the affected joint (94.6% of cases), while swelling, erythema, warmth, fever, and drainage or sinus tract are less common.[6] Infections may occur from direct seeding, hematogenous inoculation, or recurrence in an inadequately treated previously infected joint.[7] The time course of infection is significant in guiding treatment, but there is no clear consensus in the literature regarding timing. Some authors describe early (<3 months), delayed (3-12 or 3-24 months), and late (>12 or 24 months).[8,9] Alternatively, infectious can be regarded as acute postoperative (<4 weeks), late chronic (>4 weeks), or acute hematogenous (acute onset of symptoms in a prosthesis that was previously asymptomatic.[10] Early infections are often thought to occur at the time of surgery due to direct inoculation or from wound complications, and are often caused by more virulent pathogens. Delayed infections are thought to occur at the time of surgery and are associated with less virulent pathogens. Late infections are thought to occur from hematogenous spread, and may be associated with more virulent pathogens.

When bacteria seed a prosthetic joint, they enter the joint in the planktonic form and loosely adhere to the prosthesis. In 24-48 hours or less,[11-13] biofilm forming bacteria begin to generate a biofilm on the prosthesis, which matures over a period of weeks.[14] As the biofilm matures, it becomes more resistant to host immunity and to antibiotics, and becomes more densely adherent to the prosthetic joint. Early postoperative infections are thought to be more amenable to treatment with DAIR (debridement, antibiotics, irrigation, and retention of the prosthesis), perhaps due to the absence of mature bacterial biofilm.[14] However, as prosthetic infection

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becomes more chronic, DAIR is less likely to eradicate infection, and exchange arthroplasty is the preferred treatment. There is no clear consensus on the time course of infection that necessitates exchange arthroplasty, but many authors recommend 4-6 weeks as a cutoff.

Indications

PJI can occur any time after the index surgery.[3] PJI should be considered as a possible diagnosis in any painful prosthetic joint at any time after the index procedure. Establishing a definitive diagnosis of PJI can be challenging. We currently regard the 2018 MSIS criteria as the standard for the diagnosis of PJI.[15] The 2018 MSIS criteria include criteria for establishing a diagnosis prior to any revision surgery and separate criteria for establishing a diagnosis intraoperatively at the time of revision surgery.

When the diagnosis of PJI is established, eradication of the infection generally requires coordinated surgical and medical treatment. Surgical treatment options include DAIR, 1-stage exchange revision, and 2-stage revision. Strict indications for the use of debridement with retention of hardware vs exchange have not been established. The time interval between the index procedure and presentation of infection is a significant factor in surgical decision making. When a well-established (>4-6 weeks of symptoms) infection is diagnosed in a prosthetic joint, our preferred treatment is 2-stage exchange revision.

Preoperative Planning

When the decision is made to proceed with 2 stage revision arthroplasty, meticulous preoperative planning is required. Prior to the first stage, all surgical records from the index surgery must be obtained. Appropriate equipment for extracting the infected implant must be available. If articulating antibiotic spacers are to be used, molds for the articulating spacers must be available. When possible, preoperative cultures should be obtained to identify the causative organism. Cultures will help to guide antibiotic treatment. Intraoperative cultures and sonication of the explanted prosthesis should be performed. Necessary equipment for obtaining culture and for sonication should be available.

Prior to the second stage, the patient will complete a course of parenteral antibiotics as directed by cultures and recommendations from Infectious Disease specialists. Antibiotic therapy will be followed by an antibiotic holiday to confirm eradication of the infection. Thereafter, the second stage of the procedure can be scheduled. Equipment for extracting the spacer and for implanting the revision prosthesis should be available.

Surgical Technique for Stage 1

Preoperative antibiotics are held until intraoperative cultures are obtained. Tranexamic acid is generally utilized in patients who do not have a contraindication.

Knee Explantation

A well-padded tourniquet may be placed on the proximal thigh. If the infecting organisms is not known from prior aspiration, the knee may be aspirated at this point, with the resultant fluid sent for cell count with differential and culture. In general, the standard medial parapatellar approach will be utilized. When the joint capsule is incised, joint fluid may be aspirated in a sterile syringe and sent for cell count and culture. After completing the approach, a complete synovectomy should be performed, a fresh frozen specimen is sent to pathology, and 3-5 tissue specimens should be collected. These should be sent for aerobic and anaerobic bacterial cultures and for fungal cultures.

The infected prosthesis should now be extracted. The polyethylene can generally be removed with an osteotome or extraction tool. The cement-bone interface of both the femoral and tibial component can be disrupted with a combination of oscillating-saw and osteotomes, taking care to minimize bone loss. We prefer to meticulously disrupt the cement interface of the femur so that the implant can be gently removed by hand without adherent bone. For the tibia, once the cement-bone interface is disrupted, the tibial component can be removed with gentle tamping. The patellar prosthesis is removed in a similar manner. Any remaining cement should be removed. All components should be sent for sonication. At this point, intravenous antibiotics may be administered. We irrigate the knee with 3 liters of saline, followed by an IrriSept (Irrimax Corporation, Gainesville, FL) soak, then irrigation with an additional 6 L of saline. A new down sheet is placed and the surgical team changes gloves.

Static or articulating spacers may be utilized (see Figs. 1, 2). For an articulating spacer, we utilize appropriately sized Biomet femoral and tibial molds. Assuming the patient has no relevant allergies, spacers are created with Biomet gentamycin cement (Biomet, Inc. Warsaw, IN) and an additional 1 gram of vancomycin added to each bag of cement. Once the molded components have hardened, an additional bag of cement is mixed for cementing the components to the bone and the knee placed in full extension until the cement hardens. A drain is placed, and the wound is then closed in standard layered fashion.

Hip Explantation

Each surgeon should use the approach that they are most comfortable and familiar with. The patient is appropriately positioned on the table for the desired approach. The approach is completed in the standard fashion and the hip dislocated. When the capsule of the hip is opened, a fresh frozen specimen is sent to pathology, and 3-5 tissue cultures are collected from the joint lining.

The femoral component may then be extracted. Blade type stems can be removed with a thin burr by working meticulously around the implant. The implant usually has a screw-in inserter, and this tool or a slap hammer can be used to complete extraction once most of the ongrowth is removed

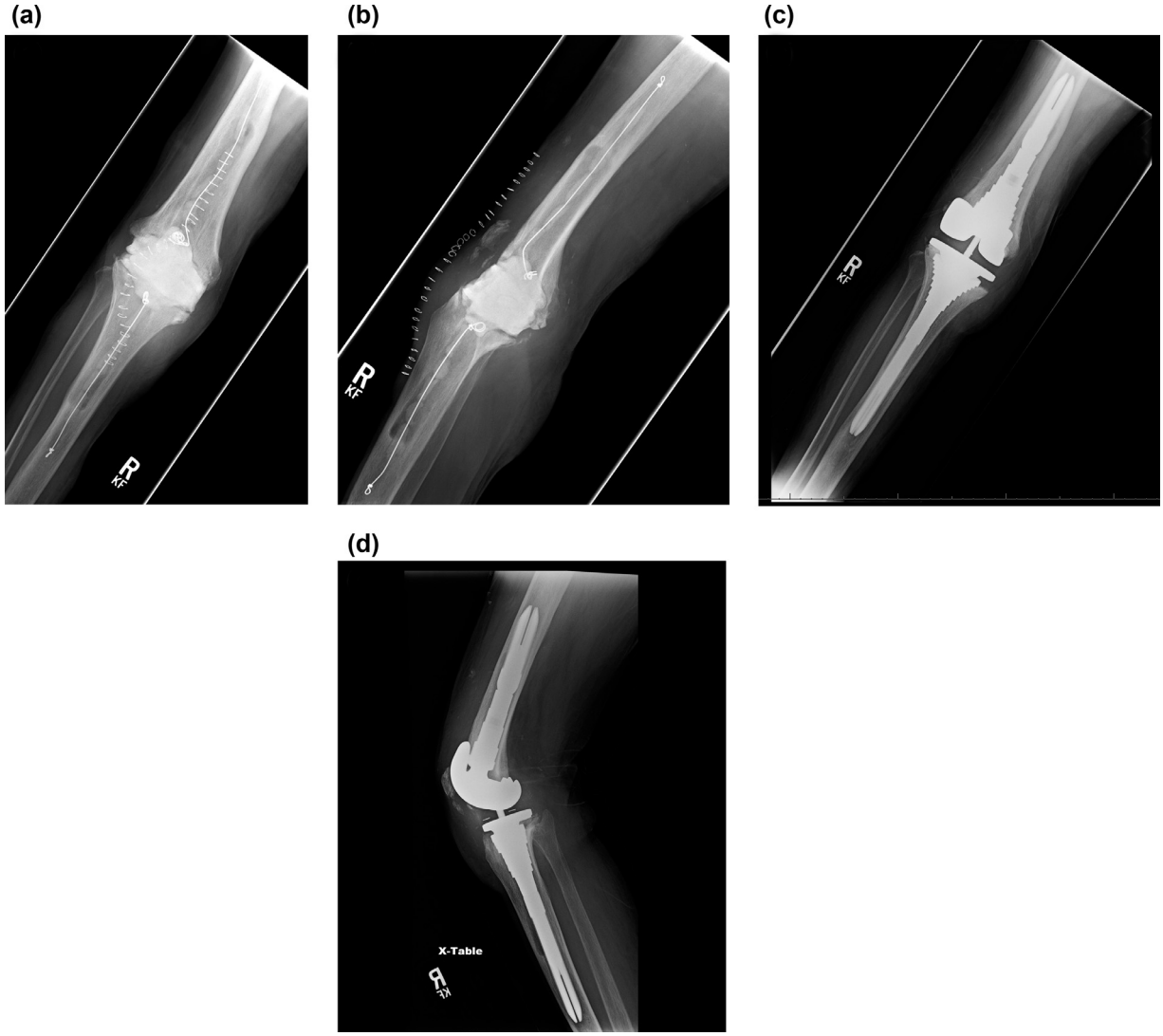

Figure 1 A 65-year-old female who had TKA done at an outside facility, and subsequently explanted for infection with static spacer placement (a and b). She developed a soft tissue defect requiring soft-tissue coverage. She subsequently underwent reimplantation with DePuy LCS Complete revision components (c and d) [DePuy Synthes Companies, Warsaw, IN].

with the burr. Extensively ingrown components may require an extended trochanteric osteotomy for removal. The femoral canal should be curetted. All cement, if any present, should be removed.

After removal of the femoral prosthesis, the acetabulum should be exposed, and a thorough debridement performed. If there are no screws in the shell and the liner is a standard liner without wear, the acetabular component can now be removed with explant osteotomes. There are several available systems for removing a standard, noncemented, hemispherical cup (such as the Zimmer Implex osteotomes [Zimmer Biomet, Warsaw, IN] and the Stryker EZout [Stryker Corporation, Kalamazoo, MI]). Using a curved, appropriately sized blade, the acetabular shell-bone interface is disrupted, taking care to minimize bone loss, and the cup is then extracted. If there are screws or a nonstandard liner, the acetabular polyethylene must be removed first. Removal technique will depend on locking mechanism. Some implants have implant specific instruments to disengage the locking mechanism. Another simple technique is to use a drill and screw on the rim of the shell to pop the liner out. Any screws inserted in the acetabular shell should be removed. Then a trial liner is inserted and the acetabular explant osteotomes are utilized. Once the shell is removed, the acetabular bone can be debrided with an appropriate sized reamer.

After the components have been removed and the debridement completed, a spacer device can be placed. Several types of spacers are available, including static spacers, custom-molded articulating spacers, prefabricated cement spacers, and metal-on-polyethylene spacers (see Figs. 3, 4). It is the author's preference to use a Biomet StageOne spacer mold for the hip. Girdlestone resection with a bag of antibiotic cement molded into the acetabulum (Fig. 3c) is a less functional option, but can be useful when acetabular bone is compromised.

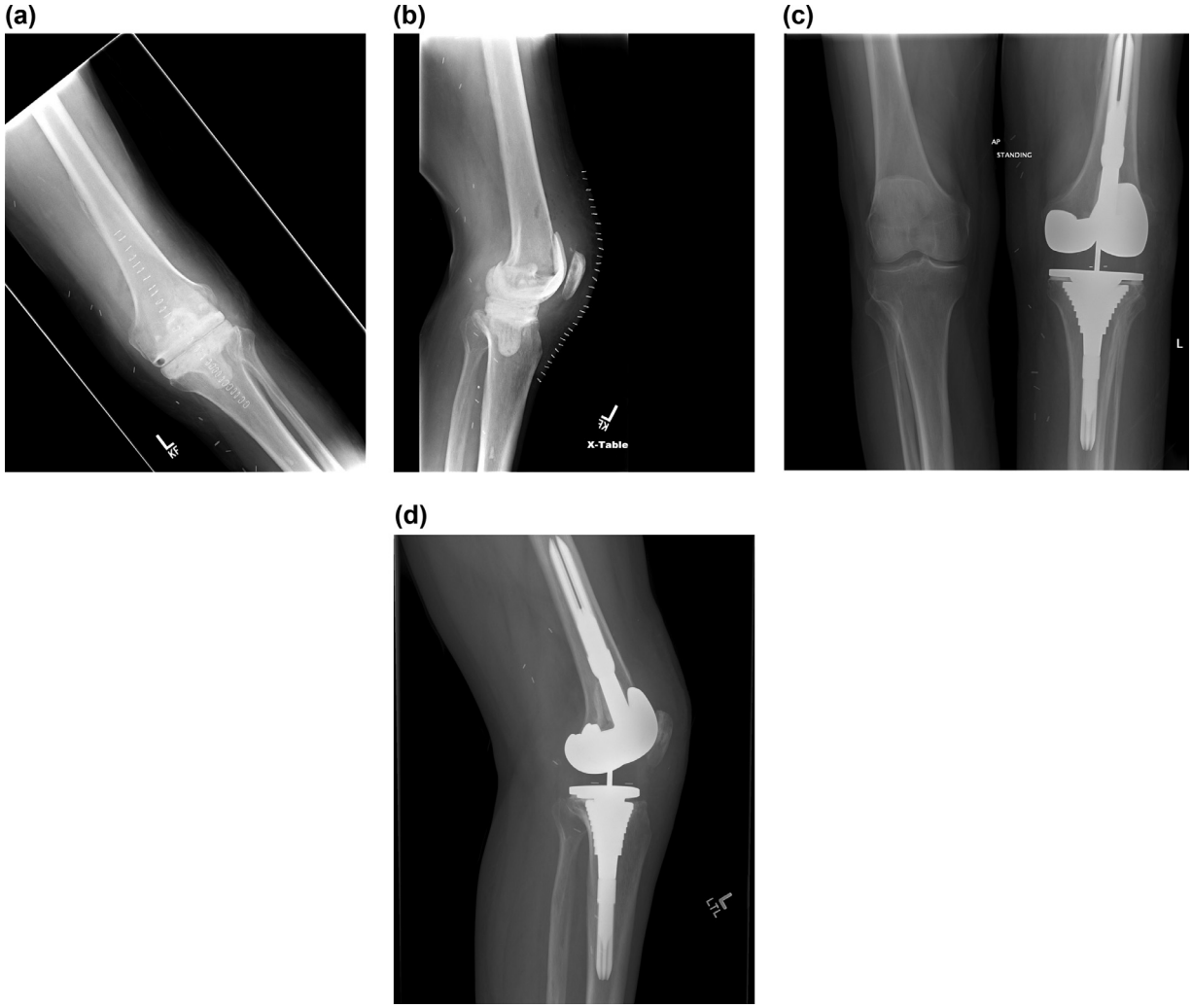

Figure 2 A 76-year-old male who had TKA done at outside facility, who presented with grossly infected TKA. He underwent two stage revision with Biomet articulating spacer for stage one (a and b). He was subsequently reimplanted with DePuy LCS Complete revision components (c and d) [DePuy Synthes Companies, Warsaw, IN].

Postoperative Care

After successful completion of the first-stage of the 2-stage revision, a course of antibiotics is begun. Antibiosis is guided by culture results, and directed by an infectious disease specialist. A 6-week course of parenteral antibiotics is completed. After completion of antibiotics, we allow a 6 weeks antibiotic holiday before the second stage. After 2 weeks off antibiotics, labs (Erythrocyte Sedimentation Rate, C-Reactive Protein, and Complete Blood Count) are drawn to confirm resolution of infection. A clinical exam of the patient and wound are done. If inflammatory markers are declining, and there are no clinical concerns for persistent infection, we proceed with the second stage.

Surgical Technique for Stage 2

In the second stage, the spacer is removed. The explanted spacer is sent for sonication culture. It is our practice to send 3-5 tissue cultures at reimplantation. Frozen section analysis is performed intraoperatively to rule out active infection. The pathology report should indicate less than 5 WBC/HPF. In cases of active infection, a repeat debridement should be performed and a new spacer placed. If infection is ruled out, the surgeon may then proceed with reimplantation of a new prosthesis in the standard way. Revision components of the surgeon's choice are used. Implant choice will depend on the bone loss and the reconstruction needs.

Outcomes

The goal of 2-stage revision of periprosthetic infection is to provide the patient with an infection free prosthetic joint. Two-stage revision is regarded as the gold standard in the United States. Two stage revision has excellent success in infection control. In the hip, reported rates of infection eradication and successful replantation range from 80% and 95%.[16] In the knee, large case series have reported infection

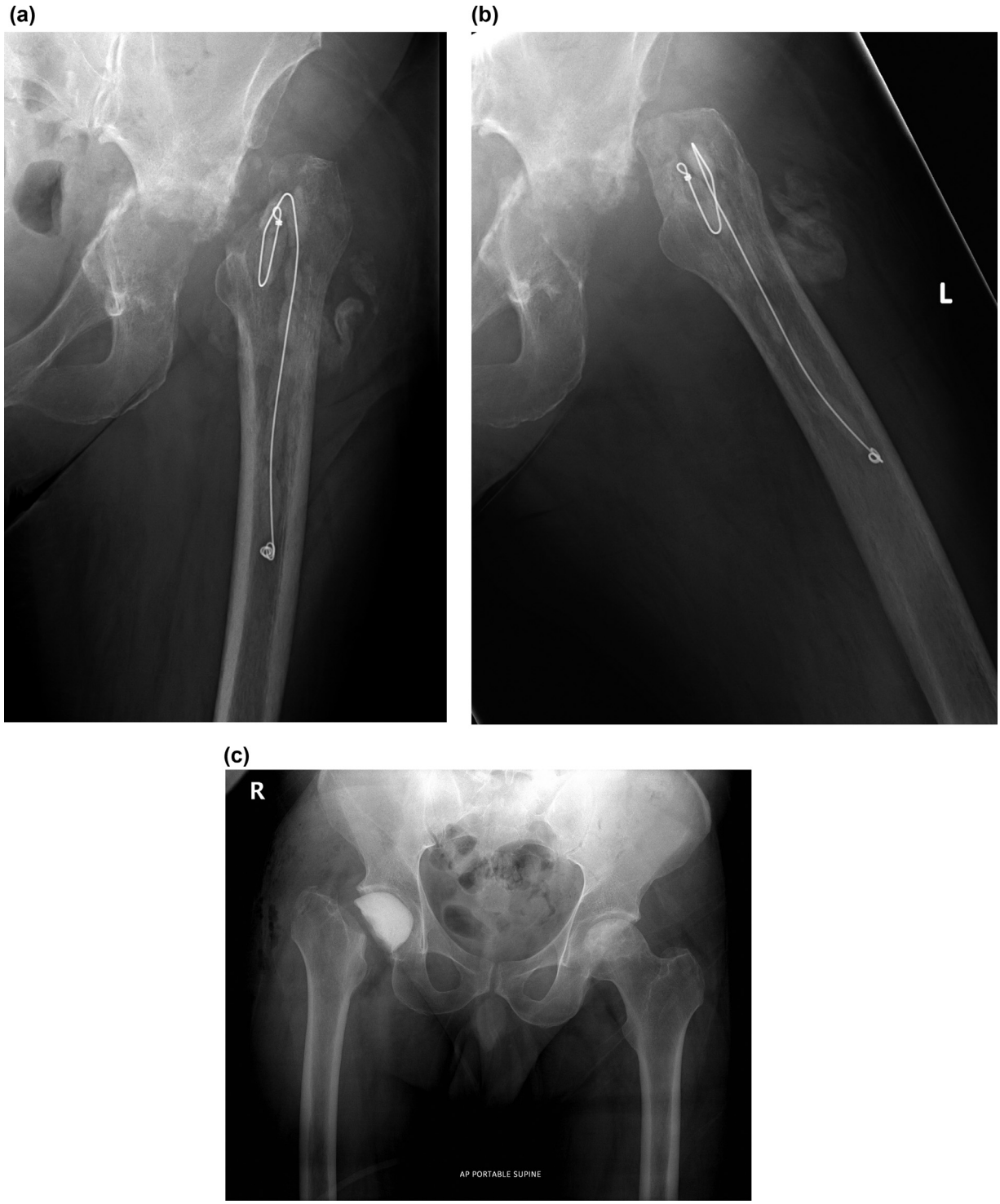

Figure 3 Demonstrating 2 static hip spacer constructs. In (a) and (b), a static spacer was fashioned along a wire with antibiotic cement and inserted into the femoral canal. No acetabular spacer was placed due to acetabular bone loss to prevent risk of intrapelvic migration. In (c), antibiotic cement was placed into the acetabulum. Pressure was applied until the cement hardened to conform to the shape of the acetabulum to remain in place and ease reconstruction at a later date.

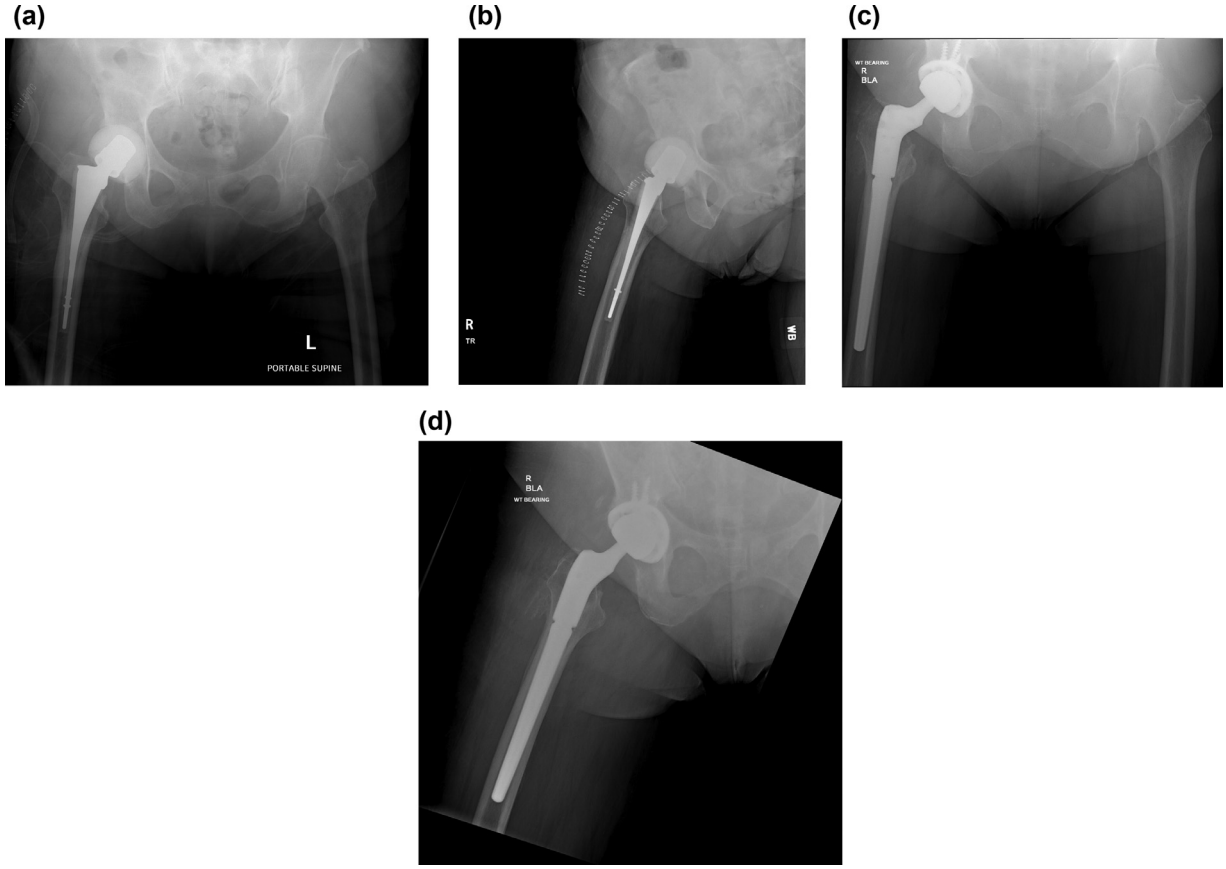

Figure 4 A 74-year-old female who had right THA done 3 years previously at outside facility, and presented with infected right THA. She had explantation of infected components and placement of a Biomet articulating spacer (a and b) [Zimmer Biomet, Warsaw, IN]. She subsequently underwent second stage with reimplantation with Biomet G7 multihole shell and Arcos stem (c and d).

eradication and successful replantation ranges from 72% and 93%.[17] The largest reported case series[18] reported infection free implant survival for knee revisions of 85% at 5 years and 78% at 10 years.

Conclusions

Periprosthetic infections remain a difficult diagnostic and treatment challenge. In chronic infections (>4-6 weeks), 2-stage revision remains the standard of care in the United States. Explantation, thorough debridement, antibiotic spacer placement, and culture directed antibiotic therapy act synergistically to sterilize and prepare the joint for subsequent reimplantation. Two stage revision has demonstrated high rates of infection eradication and long-term implant survival in both the hip and the knee.

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