Surgical Technique for Implantation of Articulating Spacers with Stem Extensions for Treatment of Infection Following Total Knee Arthroplasty

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Introduction

This article describes our technique of adding a custom-made antibiotic-coated stem to an articulating spacer to improve fixation and effectively deliver antibiotics to the medullary canal in the treatment of infection following total knee arthroplasty.

Two-stage reimplantation continues to have the highest rate of success for eradication of periprosthetic infection after total knee arthroplasty. Articulating spacers, as compared with static spacers, have been shown to decrease bone loss, reduce the difficulty in removing the spacer during final revision arthroplasty, shorten hospital stay, and improve postoperative range of motion¹.

Multiple techniques involving various antibiotic-impregnated articulating cement spacers have been reported^{1,2}. We developed a technique to modify commercially available, prefabricated cement spacers with the addition of stem extensions. This technique provides enhanced spacer fixation; improves stability, which is necessary in cases with severe bone loss (in both primary and revision cases with stemmed components); and delivers antibiotics to the bone canals.

The technique involves the following steps:

Step 1: Obtain Items Required for Intraoperative Assembly

Make sure all required items are ready prior to the start of the operation.

- Commercially available knee cement spacers (Exactech, Gainesville, Florida) (Fig. 1).
- Stem mold (Nimbic Systems, Stafford, Texas) (Fig. 2).

- A 5.5-mm knurled spinal fixation rod (Medtronic, Minneapolis, Minnesota) (Fig. 2). Other commercially available devices, such as a Rush rod, can also be used. However, the knurled spinal fixation rod is much stronger and, with its rough surface, facilitates removal of the stem with all of the cement in one piece at final revision.
- Antibiotics: 10 g (one vial) of vancomycin powder and 10.8 g (nine vials of 1.2 g each) of tobramycin.
- Cement: three batches, one for the stems and two for the fixation. Note that this technique and antibiotic dose is specifically for Simplex cement (Stryker, Mahwah, New Jersey). Other bone cement composites such as Palacos (Zimmer, Warsaw, Indiana) have different elution properties. We prefer Simplex due to the slower release of the antibiotics.
- Sterile mineral oil (to aid in later removal of the stems from the mold slots).
- Methylene blue dye (to provide color for later cement identification and removal).
- Drill-bits (2.5, 4.0, 5.0, and 5.5 mm).

Step 2: Remove the Components and Perform Thorough Debridement

Remove the components and debride all cement and necrotic, devitalized, and infected tissue.

- Through a medial parapatellar approach (Video 1), remove the polyethylene and both components of the prosthesis complicated by the infection using osteotomes and a small blade

saw (Videos 2 and 3). Take care to avoid any excessive bone damage.

- Thoroughly debride all cement and necrotic, devitalized, and infected tissue and synovium (Video 4).
- Prepare the tibial and femoral intramedullary canals with sequential reaming with thin-shafted reamers to a diameter of 13 or 14 mm (Video 5). This corresponds to the diameter of the cement-coated stem (13 mm).
- Copiously irrigate the osseous surfaces and intramedullary canal with a total of 9 L of antibiotic solution using pulse lavage (Video 5).

Step 3: Size the Spacers

Use the polyethylene insert to size the tibial spacer and the anteroposterior dimension of the explanted femoral component to size the femoral spacer.

- Estimate the tibial spacer size by using the explanted polyethylene insert as an initial guide. Estimate the femoral spacer size by matching it to the anteroposterior dimension of the explanted femoral component or to the flexion gap at 90° (Video 6). Exactech implants are available in three sizes (small, medium, and large), although cement molds made by other manufacturers may be available in additional sizes.
- Place the trial tibial and femoral spacers over the osseous surface and gently reduce the knee (Video 7).
- It is not important to achieve soft-tissue balance at this point, but make sure the spacers fit roughly onto the bone ends and allow reduction to nearly full knee extension. If either of the components is malpositioned (for example, the femoral component is in excessive internal rotation), some bone cutting may be required to provide an improved position for the articulating spacer.

Step 4: Construct the Stems

Divide the rod, coat the rods with antibiotic cement, and connect them to the articulating components.

- The rods are coated with antibiotic cement with use of a commercially available spacer mold. These spacer molds allow for four different lengths of stems. Typically, the shortest two lengths are used when primary knee arthroplasty components are removed. Longer lengths are used for cases with more severe bone loss, where a longer rod is preferred.

- Use a commercially available 5.5-mm knurled spinal fixation rod (Medtronic), or similar Rush rod, for the tibial and femoral stems. Typically, one rod can be used for both stems (Video 8). Only a few millimeters of the rod should be outside of the mold (Fig. 3). This exposed section will be covered with the remainder of the cement later.
- Mix all of the antibiotic powders together in one container and then roughly divide them equally for each batch of cement. Approximately 3.3 g of vancomycin and 3.6 g of tobramycin powder are used for each single batch of cement.
- Use one batch of cement to coat both rods. Mix this batch of cement with monomer and a few drops of methylene blue. Add one-third of the mixed antibiotics to this cement when the cement is “runny,” or in a liquid state (Video 9).
- Use a small amount of mineral oil to coat the mold recesses (Video 10). The mineral oil is only used to coat the mold; it is not mixed with the cement. Therefore it will not affect the elution properties of the antibiotic cement.
- Place the cement into each half of the mold, inside the two slots. Once the mold has been filled, close the two halves of the mold and use C clamps to hold it in place (Video 11).
- Once the cement has hardened, carefully remove the stems from the mold using an osteotome around the edges. Clean away any excess cement (Video 12).
- The tibial component typically has an indentation into the central region. Drill the backside of the tibial component with a small drill-bit and sequentially enlarge the drill-hole to 5.5 mm (Video 13).
- The drilled hole should be perpendicular to the articulating surface, with a slight posterior slope. Since the spacers are thin, the drill may penetrate the spacer, especially the femoral component. If the drill does penetrate to the articulating surface, at the final assembly, place the stem flushed with the articulating surface and use a small amount of cement to coat the exposed metal.
- Next, drill the femoral component in a similar fashion (Video 14). A few degrees of valgus alignment is desirable.

Step 5: Implant the Spacers

Apply the cement only to the metaphysis and under-surface of the tibial spacer and place a large amount of cement on the medial and lateral condyles of the femoral spacer.

- Mix the remaining two batches of cement with a few drops of methylene blue. Add the remaining antibiotic powder to the cement while the cement is in the runny, liquid state and mix. Apply a small amount of the cement to the tips of the rod and fit the rods into the predrilled holes (Video 15). Placing the components in warm, sterile saline solution will speed up the cement curing time.
- Use the rest of the cement for fixation of the spacers to bone. First, cement the tibial spacer. Apply the cement only to the metaphysis and undersurface of the tibial spacer as necessary to achieve fixation and cover all of the exposed metal surface of the rod. No pressurization of the cement is required; in fact, it is not desirable. Advance the tibial component into the tibial canal and gently press onto the tibial surface in the proper rotational position (Video 16). Clean the cement from around the edges.
- Place a large amount of cement on the medial and lateral condyles of the femoral spacer to allow balancing of the extension space. Place the femoral component gently into place with appropriate rotation (Video 17).
- Carefully reduce the knee to approximately 10° of flexion and clean off the excess cement. Leaving the knee in a small degree of flexion until the cement is cured allows some tension of the soft tissues and will provide better soft-tissue stability in the postoperative period; avoid hyperextension.

Step 6: Postoperative Protocol

Patients should walk with partial weight-bearing with a brace locked in extension for three to four weeks.

All patients are given a postoperative removable knee brace, locked in full extension for three to four weeks, to allow soft-tissue healing, especially in cases with preoperative wound drainage. This is followed by gentle knee flexion exercises, both passive and active, from 0° to 60°. This can be advanced as tolerated without limit.

- Patients can begin walking immediately with the knee brace initially locked in extension. They are encouraged to gently bear weight (70 lb [32 kg]) as tolerated.
- All patients receive at least six weeks of intravenous antibiotic therapy, based on the intraoperative cultures, under the direction of an infectious disease specialist.
- The surgical wound should be monitored closely for any signs of infection along with serial measurements of the erythrocyte sedi-

mentation rate (ESR) and C-reactive protein (CRP) level.

- After completion of intravenous antibiotics and a two-week antibiotic holiday, the knee is aspirated. Revision total knee arthroplasty can be scheduled if the white blood cell count in the knee joint aspirate has normalized, culture shows no growth, and the blood inflammatory markers are normal or nearly normal.

Results

The above technique using the articulating spacers with stem extension was employed in a two-stage revision arthroplasty to treat thirty-three patients with infection at the site of a primary or revision total knee arthroplasty³. At the time of follow-up, at a minimum of two years, thirty (91%) of the thirty-three infections had been successfully eradicated (no recurrent infection after final implantation and completion of antibiotics). The spacers had been in place for an average of fourteen weeks (range, eight to thirty-one weeks). No adverse soft-tissue effects or spacer fracture, dislocation, or loosening were noted at the time of the final-stage revision procedure. This technique is safe and efficacious for treatment of infection at the site of a total knee arthroplasty.

What to Watch For

Indications

- Infection at the site of a total knee arthroplasty.

Contraindications

- Patient's condition not suitable for a two-stage arthroplasty.
- Severe bone loss or ligament insufficiency.
- Organisms resistant to the current antibiotics that can be added to the cement.
- Allergy to cement or antibiotics.

Pitfalls & Challenges

- Make sure all required items are ready prior to the start of the operation.
- Avoid any excessive bone damage while removing the components. Thoroughly remove all cement and necrotic, devitalized, and infected tissue. Ream the canal to 13 to 14 mm to ensure that the stem can easily engage in the canal. Make sure that the knee can be reduced with the trial spacer.
- Use one batch of cement for the stems and two for fixation of the spacers to bone. Apply the cement only to the metaphysis and undersurface of the tibial spacer, not on the stem.

The goal is to cement as little metaphyseal bone as possible—just enough to achieve a stable spacer. This technique facilitates later spacer removal. Place the spacer over the osseous surface gently and avoid cement pressurization.

- Renal insufficiency or failure is a potential side effect of using high doses of antibiotics. Pre-operative baseline renal function tests and measurements of creatinine levels as well as close monitoring of renal function postoperatively are recommended.
- We developed this technique and antibiotic doses using Simplex bone cement. Renal complications can occur from use of vancomycin and tobramycin, but in our experience this has not been a clinical problem. Other brands of cement have different elution characteristics, and this dose of antibiotics may be excessive with use of those brands.
- Place a large amount of cement on the femoral spacer to allow balancing of the extension

space. Reduce the knee gently to 10° of flexion.

- Patients should walk with partial weight-bearing with a brace locked in extension for three to four weeks. Gentle range-of-motion exercises are encouraged after that point with a goal of 90° of knee flexion.

Clinical Comments

- How much antibiotics per batch of cement is used for knee articulating spacers for gram-positive infection?
- How do you ensure easy removal of the stems from the mold?
- How do you avoid hyperextension of the knee with articulating spacers?
- How can you ensure ease of visualization and removal of the cement spacer at the final revision arthroplasty?

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Figures

Fig. 1

Exactech knee cement spacer trials.

Fig. 2

Knurled spinal fixation rod, stem mold, and clamps.

Fig. 3

Mark where the rod should be divided (arrow). Only a few millimeters of the rod should be outside of the mold (arrowheads).

Fig. 1

Fig. 2

Fig. 3