

## Surgical technique

## External fixator arthrodesis antibiotic spacer in two-stage revision total knee arthroplasty for eradication of periprosthetic joint infection

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## ABSTRACT

Two-stage revision total knee arthroplasty remains the gold standard for management of chronic periprosthetic joint infection in North America. Static cement antibiotic spacers used after knee resection to deliver high-dose antibiotics lack primary stability, potentially leading to spacer migration or dislocation, additional bone loss, extensor mechanism erosion, and even knee subluxation or frank dislocation. A custom brace or cast is often required to augment knee stability, which is time-consuming, costly, and prevents monitoring or wound care of the soft tissues. An external fixator arthrodesis antibiotic spacer can provide primary stability without a brace or cast, allowing for soft-tissue monitoring and care, and minimizes potential spacer complications. We present the technique for implanting and removing this specific external fixator arthrodesis antibiotic spacer.

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## Introduction

Periprosthetic joint infection (PJI) remains a feared and challenging complication in total knee arthroplasty (TKA) [1,2]. Two-stage revision TKA with resection of the knee components and placement of a high-dose antibiotic spacer, followed by knee reimplantation after interval systemic antibiotic treatment, remains the gold standard for chronic PJI eradication in North America [1–5].

A number of techniques and spacer types have been used over the years with varying reported success [6–12]. Articulating antibiotic spacers theoretically allow improved patient mobility in the spacer phase and easier TKA reimplantation secondary to easier exposure and less soft-tissue scarring [6–12]. However,

nonarticulating spacers, also known as static spacers, have resulted in excellent PJI eradication and are still indicated in patients with significant soft-tissue compromise (ie, large draining sinuses or requiring muscle flaps), incompetent collateral ligaments, and severe bone loss [4–6]. Traditional nonarticulating spacers have been cement block spacers in which a block of cement is placed in the articulation (Fig. 1) or molded block arthrodesis spacers in which the cement is shaped around the distal femur and proximal tibia within the articulation (Fig. 2). However, without primary stability, cement block static spacers can have motion, causing potential bone loss, extensor mechanism erosion, spacer migration, and even gross knee subluxation or dislocation [13–18]. Although molded block arthrodesis spacers have, in theory, fewer complications than cement block spacers, instability and bone loss remain a potential issue [10–12]. Therefore, this instability often obligates a custom brace or cast to be used, which is costly and does not allow easy monitoring of or care for the soft-tissue envelope. Another option, initially described by Rohner et al [19], is an external fixator arthrodesis spacer, in which external fixator rods are placed intramedullary with a bar-to-bar connector in the articulation to provide primary stability to the static spacer without requiring a brace or cast.

We describe our preferred technique for placement of a custom external fixator arthrodesis antibiotic spacer during two-stage TKA for PJI.

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**Figure 1.** Radiograph of a custom block static spacer.



**Figure 3.** Photograph of a patient with a chronically infected TKA in place with a large, draining sinus on the inferior aspect of the incision.

### Surgical technique

The senior authors' indications for an external fixator arthrodesis antibiotic spacer are patients undergoing two-stage TKA for PJI eradication in which they are not candidates for an articulating TKA spacer. We consider contraindications of an articulating TKA spacer to include an extensor mechanism disruption, large draining sinus or severely compromised soft tissues, soft-tissue reconstruction in the form of skin grafting or muscle flaps (Fig. 3), incompetent collateral ligaments, and severe bone loss. This technique is of particular use in patients who require diligent soft-tissue monitoring in the spacer phase secondary to a soft-tissue muscle flap reconstruction or a tenuous primary closure.

The knee joint is first exposed with an extensile exposure and quadriceps snip as necessary. The existing TKA components are removed using saws and osteotomes at the bone-cement interface to minimize bone loss. Thorough debridement of all contaminated tissue, avascular tissue, and foreign material is paramount. All remaining cement and foreign material (eg, suture material) are carefully removed. The femoral and tibial canals should be reamed to 12–15 mm depending on the patient size to remove all avascular tissue and facilitate antibiotic delivery to the bones. In our experience, 3 commonly missed sites of cement during TKA resection and debridement are femoral lug holes, tibial pin holes from the extraarticular tibial cutting guide, and patellar lug holes. We routinely obtain an intraoperative radiograph to ensure that we have adequately removed all cement and foreign material during



**Figure 2.** Radiograph of a molded block arthrodesis spacer.



**Figure 4.** Photograph of the powdered antibiotics we routinely use for high-dose antibiotic spacer during two-stage TKA revision for PJI eradication. We use 3 g of vancomycin and 2.4–3.6 g of gentamicin per 40-g batch of Simplex Bone Cement (Stryker, Mahwah, NJ) and add 150 mg of amphotericin per batch in patients with chronically draining sinuses or recurrent PJIs. We also add methylene blue to facilitate cement removal at TKA reimplantation.



**Figure 5.** Two external fixator bars thinly coated with high-dose antibiotic cement with methylene blue and a bar-to-bar connector.

the debridement. During the exposure, debridement, or component removal, we routinely obtain 3–5 deep tissue cultures; we send these for aerobic, anaerobic, and fungal cultures and routinely hold them for at least 14 days.

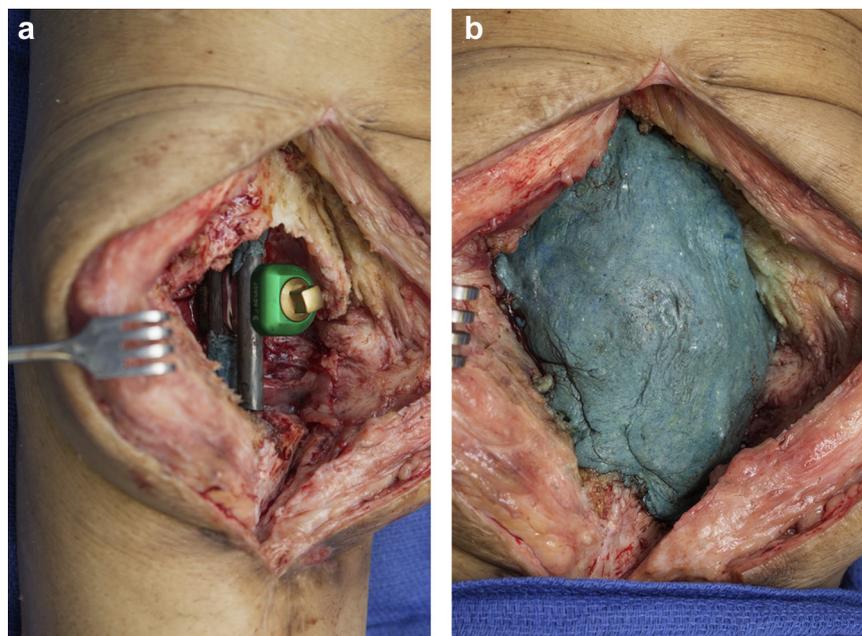
During component removal and debridement, an assistant can be preparing the antibiotic spacer. We routinely use high-dose antibiotic spacers consisting of 6–8 g of antibiotics per 40-g batch of Simplex Bone Cement (Stryker, Mahwah, NJ) (Fig. 4). We use powdered 3 g of vancomycin and 2.4–3.6 g of gentamicin per batch

of cement; tobramycin is an acceptable alternative if gentamicin is not available. In patients with fungal PJIs, chronic draining sinus tracts, or recurrent PJIs, we consider adding 150 mg of amphotericin per 40-g batch of cement as well. It is important to note the type of cement being used because certain cement types (ie, Palacos; Zimmer-Biomet, Warsaw, IN) have higher porosity and elution properties; thus, the antibiotic concentration should be decreased by roughly one-third the dose to avoid systemic toxicity. Methylene blue is added to the mixture to facilitate cement removal at TKA reimplantation. When mixing the antibiotic cement, it is recommended to mix the powder with the liquid monomer first and then sequentially add all of the antibiotics, mixing them thoroughly; if the antibiotics and powder are mixed together and the liquid monomer added to this combination, achieving adequate consistency of the cement would be difficult.

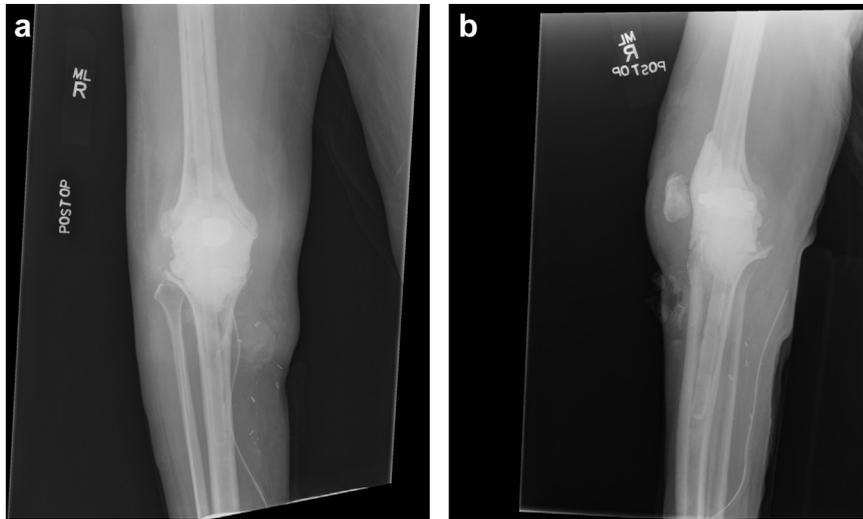
We use a Hoffmann II external fixator (Stryker, Mahwah, NJ); 2 carbon fiber bars and one bar-to-bar connector are necessary. Thinly coat the 2 external fixator bars with the antibiotic cement (Fig. 5); if coated too thickly, it is difficult to place these bars into the intramedullary canals without excessively reaming.

Once the bars are prepared and the knee joint has been thoroughly irrigated and debrided, the antibiotic-coated bars are inserted into the femoral and tibial intramedullary canals. The bar-to-bar connector is then used to connect the 2 bars in the joint space with the knee in roughly 5 degrees of knee flexion (Fig. 6a); fully tighten the bar-to-bar connector. Place the rest of the cement around the bars and bar-to-bar connector, filling the joint but not overstuffing it (Fig. 6b). The cement is then allowed to harden. The knee is then closed in layers with monofilament suture in the arthrotomy.

Postoperative radiographs (Fig. 7) show the antibiotic-coated intramedullary bars, bar-to-bar connector in the knee joint, and surrounding antibiotic cement with the knee fixed in extension. We keep patients weight-bearing as tolerated without a brace or cast. The incision is monitored per patient-specific needs (Fig. 8). Patients are routinely placed on appropriate mechanical and chemical venous thromboembolism prophylaxis and microorganism-specific antibiotics as directed by infectious disease specialists.



**Figure 6.** Intraoperative photograph (a) of the antibiotic cement–coated bars inserted into the femoral and tibial intramedullary canals and a bar-to-bar connector securing the bars together in the center of the knee joint. Photograph showing (b) additional antibiotic cement packed around the arthrodesis spacer to provide additional antibiotic delivery.



**Figure 7.** Anteroposterior (a) and lateral (b) radiographs of the external fixator arthrodesis antibiotic spacer with antibiotic-coated intramedullary rods, the bar-to-bar connector in the knee joint, and additional packed antibiotic cement.

The main potential unique complication of this technique compared with using a traditional static spacer is fracture of one of the carbon fiber bars. If this were to occur, the options include placing the patient in a brace or cast to restore knee stability or to perform a revision surgery for the spacer; we would only choose the latter option if the plan was to leave the spacer in place for an extended period of time. If the spacer was to be revised, we would revise it to another fixator-type arthrodesis spacer as described here.

At TKA reimplantation, removal of the external fixator arthrodesis antibiotic spacer is similar to that of a molded block arthrodesis spacer. Once the arthrotomy has been performed and the cement exposed, an osteotome is used to remove the cement around the bar-to-bar connector. Once the bar-to-bar connector is

exposed near circumferentially, it can be loosened and removed. The knee can then be flexed gently, and the intramedullary antibiotic-coated bars can be easily removed from the canals.

### Discussion

Two-stage revision TKA remains the gold standard for chronic PJI eradication in North America [1-5]. A number of types of antibiotic spacers have been described with varying success [6-12]. While articulating TKA spacers are becoming more common, we consider nonarticulating antibiotic spacers in patients with a deficient extensor mechanism, soft-tissue compromise, soft-tissue reconstruction including skin grafting or muscle flap coverage, incompetent collateral ligaments, and severe bone loss. Static



**Figure 8.** Photograph of the same patient showing the status after TKA resection and placement of an external fixator arthrodesis antibiotic spacer, rotational gastrocnemius flap, and skin grafting. The wound can be monitored and wound care performed easily without a cast or brace.



**Figure 9.** Radiograph of an intramedullary rod antibiotic spacer with significant bone erosion into the anterior cortex of the femur.

antibiotic TKA spacers, however, lack primary stability and have the potential to cause additional bone loss or knee subluxation during the spacer phase [16–18].

Another option is an external fixator arthrodesis antibiotic spacer that provides primary knee stability and delivers high-dose antibiotics during two-stage TKA revision for PJI eradication [19]. In the original technique reported by Rohner et al [19], stainless steel rods were cemented into the intramedullary canals; furthermore, that specific technique was initially used only for cases with significant bone loss. The modification of their technique presented here involves the use of carbon fiber rods as they are smaller in diameter, allowing coating them with high-dose antibiotic cement and, in theory, improving antibiotic delivery to the intramedullary canal. Furthermore, coating the carbon fiber dowels makes them significantly easier to remove at reimplantation than cemented stainless steel rods. Frieler et al [20] did not find any significant difference between microbial growth on carbon fiber rods or stainless steel rods.

Traditional static spacers, especially cement block spacers, are inherently unstable, which may cause a number of potential complications. Struelens et al [13] reported a 57% mechanical complication rate of mainly custom block spacers during two-stage TKA revision, namely complications secondary to spacer migration. First, these spacers can migrate and cause erosion into the extensor mechanism; Wilson et al [14] reported on a case series of 3 patients who had patellar tendon disruptions from erosion of cement block spacers. Furthermore, with repetitive motion at the cement spacer-bone interface and migration of the cement spacer, additional bone loss can occur. Faschingbauer et al [15] reported a 7% and 2% rate of additional tibial and femoral bone loss, respectively, with a static cement spacer internally stabilized using a Steinmann pin. Although uncommon, the knee can subluxate or even fully dislocate in the spacer phase, placing neurovascular structures at risk. In the study by Struelens et al [13], the spacer had dislocated or caused significant knee subluxation in 7% of patients.

Other antibiotic cement TKA spacers, including an intramedullary rod arthrodesis spacer [19] and augmenting molded spacers with smooth Steinmann pins [18], have been used to improve knee stability and prevent the aforementioned complications. However, in the author's experience, the intramedullary rod arthrodesis is more expensive, technically challenging to insert, and difficult to remove; furthermore, it can cause substantial bone erosion into the intramedullary canal due to the stiffness of the rod, especially in the femur due to the anterior femoral bow (Fig. 9). Although Steinmann pins do add stability to a static spacer construct, they are not as rigid as the external fixator arthrodesis spacer described here and are still associated with bone loss [15]; furthermore, there have been reports of devastating pin migration [18].

## Summary

An external fixator arthrodesis high-dose antibiotic spacer used during two-stage TKA revision for eradication of PJI is an alternative

to the traditional static spacer to better provide knee stability, prevent additional bone loss, and facilitate soft-tissue care during the spacer phase.

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