Antibiotic Cement-Coated Plates for Management of Infected Fractures

Janet D. Conway, MD, Lee M. Hlad, DPM, and Samantha E. Bark, DPM

Abstract

Deep infection in the presence of an implant after open reduction and internal fixation is usually treated with removal of the implant, serial débridement procedures, lavage, intravenously administered antibiotics, and occasionally, placement of antibiotic-impregnated beads. If infection occurs during the early stages of bone healing, fracture stabilization might be compromised after implant removal.

Osteomyelitis, unstable owing to a bone deficit or fracture, was treated with an antibiotic cement–coated (tobramycin and vancomycin) plate. The goal was successful eradication of infection with the patient remaining infection-free for 1 year. Four patients were treated with antibiotic-coated plates for osteomyelitis and all have achieved successful union, clinically free of signs of infection for more than 1 year. One patient experienced a prominent and painful plate, necessitating removal.

Based on our experience, early aggressive débridement coupled with broad-spectrum antibiotic cement–coated plate insertion, provides fracture stability and helps eradicate the infection with 1 surgical procedure.

Deep infection in the presence of an implant after open reduction and internal fixation (ORIF) is usually treated with removal of the implant, serial débridement procedures, lavage, intravenously administered antibiotics, and, in some cases, placement of antibiotic-impregnated beads. If infection occurs during the early stages of bone healing, stabilization of the fractures might be compromised after removal of the implant. Although antibiotic-impregnated beads offer local delivery of antibiotics, they do not provide structural support of the fracture site. The beads often are difficult to remove after in-growth of granulation tissue. In areas of subcutaneous bone, an antibiotic bead pouch might be preferred to an open wound. Published research regarding the use of antibiotic-coated plates during the acute or chronic stages of infection is scarce. Plates offer the versatility of fracture stabilization, and the addition of antibiotic cement to the plates might aid in eradication of infection without necessitating a second surgery for removal. The patients provided written informed consent for print and electronic publication of these case reports.

Technique

After removal of implants, we perform débridement of the soft tissues with a hydroscalpel (Versajet; Smith & Nephew, London, United Kingdom), mechanical débridement of bone, and curettage with high speed burr. The wound is then irrigated with pulse pressure lavage and a minimum of 3 L sterile normal saline. The extremity is re-prepped and re-draped; the entire surgical team's gowns and gloves are changed; and new instrumentation, including cautery and suction equipment, is used. The cement is prepared with tobramycin (3.6 g) and vancomycin (1 g) per 40-g bag of cement. The plate is placed in silicon tubing, and the antibiotic-prepared cement is injected into the tubing and molded until dry. Care is taken to mold the locations of the screw holes by making incisions in the tubing at the appropriate locations. Screws are placed through the screw holes to ensure locking capability, and Kirschner wires are placed through temporary fixation holes (**Figure 1**). Once dry, the screws and wires are removed from the plate, and the cement-coated plate is removed from the tubing. The antibiotic-coated plate is applied to the fracture or osteotomy site and is seated with screws as appropriate (**Figure 2**). The wound is closed primarily. Wound drains or vacuum-assisted closure devices

Figure 1. Prepared plate waiting for cement to dry. (Reprinted with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore).

Figure 2. Plate applied to fracture site. (Reprinted with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore).

Authors' Disclosure Statement: Dr. Conway wishes to report that she is a paid consultant for Biomet and Medtronic and received research support from Medtronic for an unrelated study. The other authors report no actual or potential conflict of interest in relation to this article.

are not routinely used unless there is high risk for hematoma formation. The authors prefer to have high local concentrations of antibiotic in the surrounding tissues and wound.

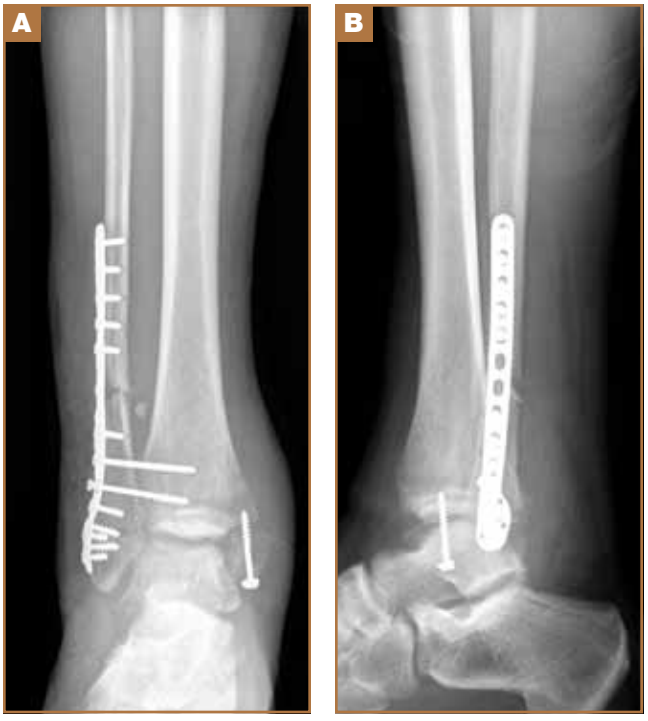

Figure 3. Case 1—(A) Anteroposterior and (B) lateral preoperative radiographs of a 31-year-old man with a chronic lateral wound. (Reprinted with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore).

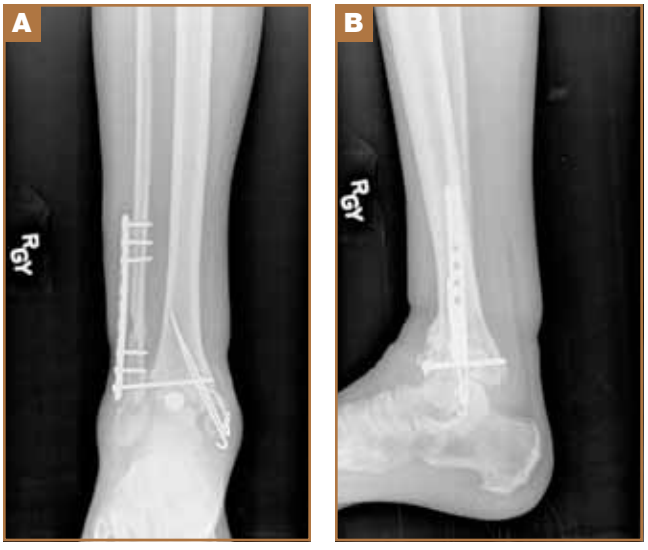

Figure 4. Case 1—(A) Anteroposterior and (B) lateral radiographs obtained 25 months postoperatively, with the patient bearing weight, show acceptable alignment with the fibular union and functional painless nonunion of the medial malleoli. (Reprinted with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore).

Clinical Series

Case 1

A 31-year-old man fell from a ladder and sustained a bimalleolar ankle fracture-dislocation that was treated with ORIF. Three weeks after initial injury, the patient presented with an infected lateral wound with purulent discharge. He was taken to the operating room for initial débridement, irrigation, and fracture stabilization with an antibiotic-coated plate and tension-band wiring of the medial malleoli. He was discharged from the hospital on day 4 after admission. Cultures of the wound grew beta-hemolytic strep group G and coagulase-negative staphylococci in broth that was sensitive to oxacillin, vancomycin, and gentamycin. The patient was treated with a 6-week regimen of Unasyn (Roerig, New York, New York), developed bony union, and has been free of clinical signs of infection for 2 years (**Figures 3, 4**).

Case 2

A 27-year-old male carpenter fell from a height of 12 feet and sustained a fracture of the distal radius that was treated with external fixation. The proximal pin site became clinically infected and subsequently developed osteomyelitis. The patient had a draining wound with a fracture for 2 months. He underwent débridement with partial resection of the radius and placement of an antibiotic cement–coated plate and calcium phosphate bone-void filler impregnated with antibiotics. Pathology specimens were positive for osteomyelitis, and bone cultures showed methicillin-sensitive *Staphylococcus aureus* (MSSA). He received intravenously administered antibiotic therapy for 6 weeks after surgery. The patient has remained free of clinical signs of infection for more than 1 year and has achieved bony union (**Figures 5A, 5B**).

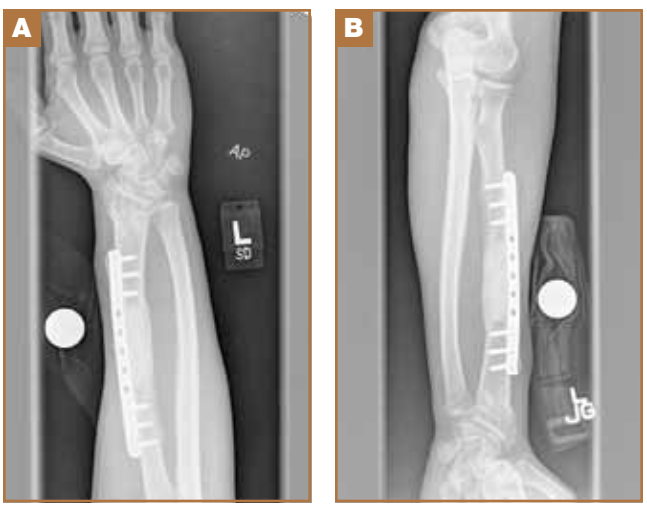

Figure 5. Case 2—(A) Lateral and (B) anteroposterior postoperative radiographs, obtained 14 months after surgery, of a 27-year-old man who underwent resection of the radius, which had become osteomyelitic from an infected pin-tract site. The void was filled with antibiotic cement, and an antibiotic cement–coated plate was applied. (Reprinted with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore).

Case 3

A 44-year-old woman with insulin-dependent diabetes mellitus and venous stasis sustained a trimalleolar ankle fracture after a low-energy fall that was initially treated with ORIF. She underwent revision ORIF to treat a malunion 3 months after initial treatment. At 8 months, the patient developed a draining sinus communicating with the plate. Computed tomography revealed nonunion and indicated infection. The patient underwent resection of the osteomyelitis and repair of the fibular nonunion with an antibiotic-coated plate. Tissue cultures were positive for coagulase-negative staphylococcus, and pathology specimens were positive for osteomyelitis. She received postoperative antibiotics intravenously and 6 weeks of antibiotic therapy after discharge from the hospital. The patient has remained free of clinical signs of infection for more than 1 year and has achieved bony union (**Figures 6, 7**).

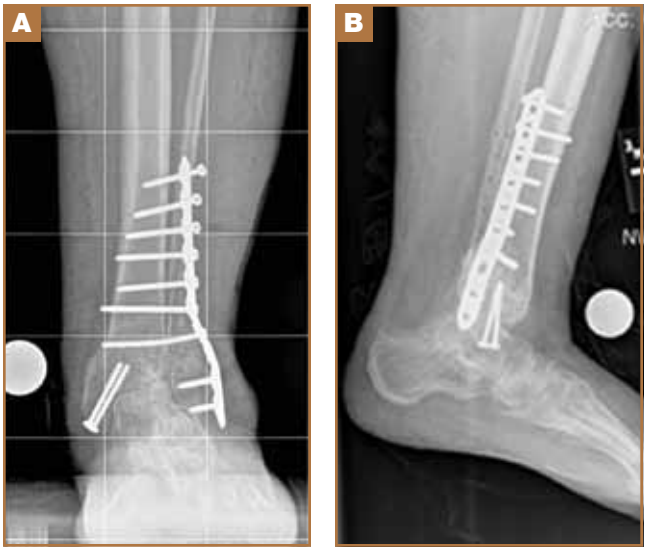

Figure 6. Case 3—(A) Anteroposterior and (B) lateral preoperative radiographs of a 44-year-old woman for whom the fixation device failed. She experienced open draining sinus of the lateral ankle. (Reprinted with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore).

Figure 7. Case 3—Radiograph obtained 12 months postoperatively shows osseous union of the fibula and medial malleoli with bony synostosis of the syndesmosis. Valgus positioning of the ankle can be seen and will be addressed if it becomes symptomatic. (Reprinted with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore).

Case 4

A 48-year-old man sustained an open olecranon fracture in another country. The fracture was initially treated with 1 dose of intravenously administered antibiotics and 5 days of orally administered antibiotics. The patient returned to the United States and was treated with intravenously administered antibiotics for cellulitis of the elbow for 11 days before referral to our institution, where he underwent ORIF with placement of an antibiotic-coated plate and tension-band wiring. Soft-tissue and bone cultures had no growth. He received intravenously administered antibiotics for 6 weeks. At 5 months postoperatively, the plate was removed because of pain. The patient has remained free of clinical signs of infection for more than 1 year and has achieved bony union (**Figures 8A-8C**).

Discussion

Acute infections of fractures have recently been

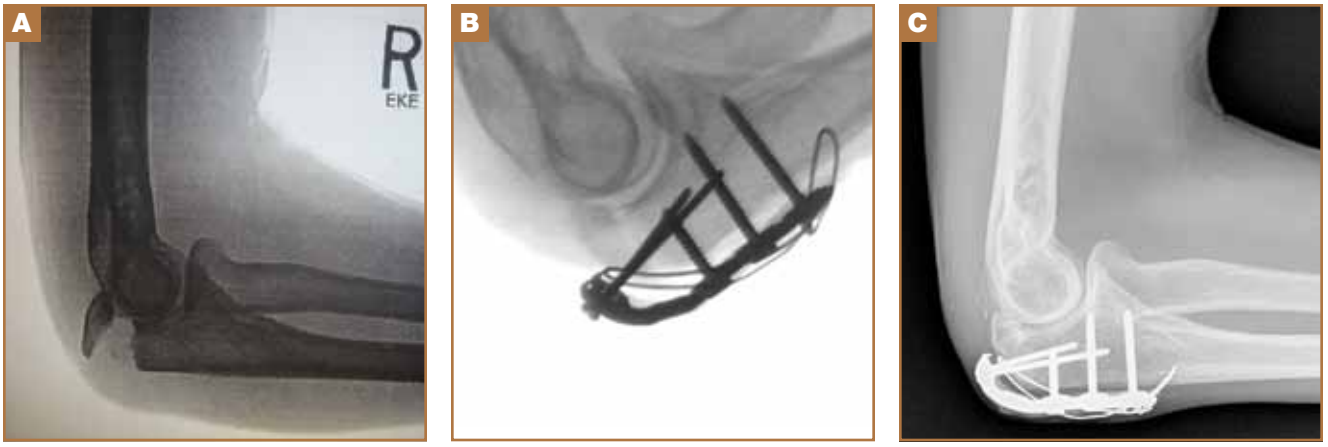

Figure 8. Case 4—Radiographs of a 48-year-old man who had an open olecranon fracture treated conservatively in another country. (A) Preoperative lateral view of the elbow. (B) Intraoperative lateral view of the elbow shows fracture reduction. (C) Postoperative view, obtained 6 months after surgery, shows complete bony union. (Reprinted with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore).

treated with success by Berkes and colleagues,[1] who reported a 71% union rate achieved with operative débridement, antibiotic suppression, and retention of fixation until fracture union occurs. The study by Berkes and colleagues[1] had a small patient population, and larger cohorts are needed to show more reliable results; however, this treatment maintains structural support for the fracture during healing but requires multiple trips to the operating room for débridements as well as the use of systemic intravenous antibiotic therapy.

A technique that was developed by the primary author (Janet D. Conway, MD) and has not been described in the literature allows for use of antibiotic cement–coated plates to treat early postoperative infections and osteomyelitic nonunions. This approach permits fracture stabilization and local delivery of high concentrations of broad-spectrum antibiotics and can reduce the number of débridement procedures required in the operating room. We present a technique that includes the use of antibiotic cement–coated plates to treat early postoperative infections associated with fractures and nonunions in order to provide eradication of infection and bony stabilization.

Our approach parallels the current theory that treating infection at a site of union is preferable to treating infection at a site of nonunion.[1] Fixation devices should remain in place until osseous union is achieved. With the addition of antibiotics to the plate, removal might not be necessary unless a device is loose, nonfunctional, or, ultimately, causing pain. Other options, such as external fixation, can be burdensome to patients and can be associated with other risks. One of our 4 patients required fixation removal because of pain at the elbow; however, even noncoated olecranon plates typically are removed because of pain after fracture healing. Antibiotic cement adds bulk to the construct and can become very prominent in areas of little soft-tissue coverage (**Figure 9**).

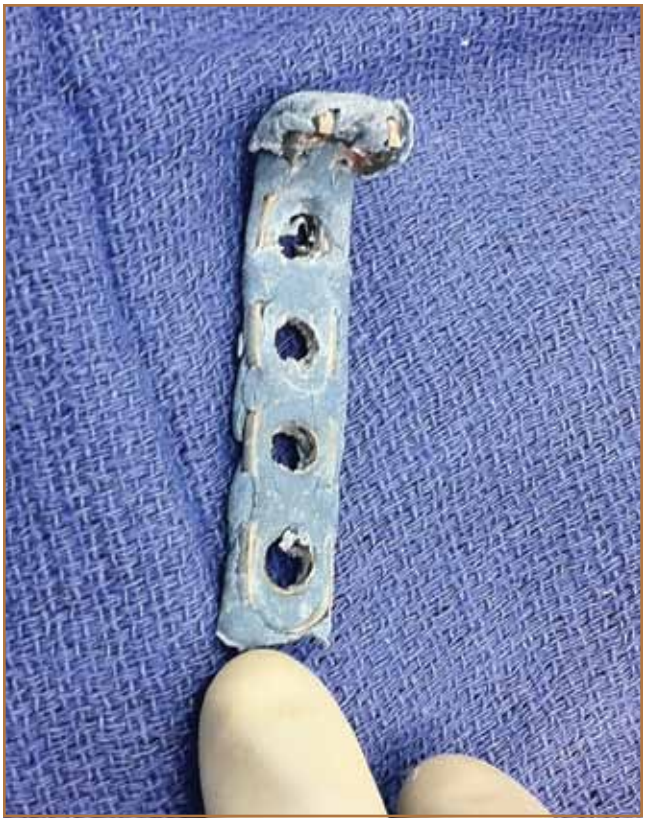

Figure 9. An antibiotic cement–coated plate at time of removal. (Reprinted with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore).

Studies, assessing variables that correlate with higher likelihood of failure for primary repairs, have shown that open fracture, use of an intramedullary nail, and smoking are the highest risk factors for infected nonunion.[1–4] Among our 4 patients, 3 were smokers and 1 originally had an open fracture. Smokers have been found to have a 37% higher nonunion rate and are 2 times more likely to develop wound infection and osteomyelitis.[1,5] More than 60% of the time, infections are caused by *S aureus* or coagulase-negative staphylococci.[1,5,6] In our study population, 3 of the 4 patients had coagulase-negative staphylococci grow in the cultures. Implants infected with *S aureus* or *Candida* require surgical removal. Those with less virulent coagulase-negative staphylococci might not necessitate removal; however, our population had had antibiotic therapy and continued draining sinus.[5] Rightmire and colleagues[7] reported that those who develop infection earlier than 16 weeks postoperatively have a 68% success rate and that smoking is a major risk factor for infection. Development of *Pseudomonas* in the wound has been shown to have a positive correlation with amputation.[1,2] Infection with *Pseudomonas*, smoking, and involvement of the femur, tibia, ankle, or foot tended to result in failure.[1,2] Being clinically free of signs of infection after 3 months offers a 50% cure rate, with 78% at 6 months and 95% after 1 year.[2]

When determining an antibiotic to use with the polymethylmethacrylate (PMMA) cement, many factors must be considered, including spectrum, heat stability, and elution characteristics.[8] A synergistic effect has been seen with combinations of antibiotics (eg, vancomycin and tobramycin used together). Vancomycin concentrations increased by 103% and tobramycin by 68% when used together compared with their elution rates when used alone, showing passive opportunism.[9] This will, in essence, increase concentrations of antibiotics at the site locally, which will increase the bacteriocidal potential but also create a larger antimicrobial spectrum.[9]

The authors used Cobalt Bone Cement (Biomet Orthopedics, Inc, Warsaw, Indiana) which been shown to have higher elution properties than Simplex P Bone Cement (Stryker, Kalamazoo, Michigan).[3,10] The majority of elution occurs in the first 3 to 5 days but can continue for weeks after implantation. We place the cement on the plate allowing for its retention, hoping to eliminate a second surgery for removal.[8] We recommend 3.6 g of tobramycin, and 1 g of vancomycin per 40-g bag of PMMA.[3] This dose has been shown to be safe in respect to renal toxicity, plus the entire dose is not administered in a single setting because only a small portion of the cement is used when coating the plate. We close all wounds primarily, and do not regularly use drains or vacuum-assisted closures

to help prevent a decrease in the local concentration of the antibiotics.[11]

Broad-spectrum antibiotics are used to coat the plate in order to cover as many microbial organisms as possible without knowing the final offending organism. In our experience, this current technique provides antibiotic delivery with bony stability, therefore eliminating the need for multiple sequential surgical procedures. This difficult patient problem does not occur with enough frequency to warrant a large randomized clinical trial. However, this technique has been effective in these cases and may be useful to orthopedic surgeons in the future.

Conclusion

Based on our experience, early aggressive débridement, coupled with broad-spectrum antibiotic cement–coated plate insertion, provides fracture stability and helps eradicate the infection with 1 surgical procedure.

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Acknowledgment: The authors thank Dori Kelly, MA, for professional manuscript editing.

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Am J Orthop. 2015;44(2):E49-E53.

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