Management of Infected Bone Following Limb Salvage Reconstruction Surgery

Here's an update on the latest treatment options.

BY NICHOLAS J. BEVILACQUA, DPM

In the setting of bone infection after a reconstructive surgical procedure, developing a treatment protocol is essential for limb salvage. Reconstructive limb salvage surgery for patients with diabetes and neuropathy is challenging, and there is a heightened risk of infection. In cases where there is a severe, limb-threatening post-operative infection, below-the-knee amputation is considered. There may be certain situations where a more definitive, high-level amputation may provide better overall outcomes compared to drawn out attempts at limb salvage. However, patients strongly prefer to save their foot and given the grave physical and psychological costs, every effort should be made to avoid a major limb loss situation.

Figure 1b: Lateral foot radiograph demonstrating acute midfoot dislocation at the level of the tarsal-metatarsal joints.

Figure 1c: CT scan demonstrating acute midfoot dislocation at the level of the tarsal-metatarsal joints.

Figure 1a: AP foot radiograph of the patient demonstrating acute midfoot dislocation at the level of the tarsal-metatarsal joints.

The following cases will highlight a staged approach to clearing infection and obtaining a functional fusion after an initial reconstructive procedure is complicated with a post-operative bone and soft tissue infection.

Case 1

The first case involves a 60-year old male with diabetes and peripheral neuropathy who had a misstep while walking. He presented to the emergency department, a comprehensive clinical exam was performed, and he was diagnosed with an unstable, midfoot dislocation. Foot and ankle radiographs and a CT scan were performed (Figures 1a-c). Of note, at the time of injury, he was one year status post-Charcot foot reconstruction on his contralateral foot, and he had just returned to work one month prior.

Because of the unstable deformity with a pronounced medial bone prominence and the concern for skin breakdown, the decision was made to manage this condition surgically. He was medically optimized for surgery, and underwent ORIF of the tarsal dislocation. The "Super Construct" concept as described by Sammarco was employed, and an extensive medial column fusion was performed to extend the fusion beyond the zone of injury (Figures 2a and b).[1]

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Initially, the patient progressed well, however after nine weeks, he developed a superficial wound dehiscence which progressed to a deep wound with exposed hardware (Figure 3). He developed clinical signs of infection and was admitted to the hospital. He had an elevated white blood cell count, ESR (97 mm/hr) and CRP (110.3mg/dl).

The patient was taken to the operating room for incision and drainage, removal of hardware, thorough debridement, deep tissue cultures, and antibiotic impregnated absorbable beads. After removing the hardware, the bone and soft tissue was adequately debrided and the wound was copiously irrigated. Deep tissue and bone cultures were taken (after removing the outer layer of gloves and using clean, unused instrumentation).

Infection following plate fixation is primarily extra medullary and placement of antibiotic beads delivers antibiotics locally and helps control infection.[2] The absorbable calcium sulfate antibiotic carrier was mixed with vancomycin and tobramycin. The beads were placed directed into the clinically infected bone and also placed along the entire wound to help manage any dead space (Figure 4).

His midfoot was noted to be stable at the time of surgery; however, if deemed unstable, an external fixation would have been applied for skeletal stabilization. A well-padded posterior splint was applied and the patient remained non-weight-bearing. He was treated with culture-directed antibiotics via a PICC line for six weeks. Over the next few weeks, clinical success was achieved as there was reconstitution of affected bone, healing of overlying soft tissue, and a drop in inflammatory markers (Figures 5). His midfoot remained stable. He was fitted with a custom molded AFO, and he returned to ambulating in normal shoes.

Figure 3: Wound dehiscence with exposed screw head.

Case 2

The next case highlights a staged approach for the treatment of an infected tibiotalocalcaneal (TTC) fusion. Infection after TTC fusion can be devastating and often results in a below-the-knee amputation. Successful management can be achieved with a staged approach.

The patient is a 74 year-old male with diabetes and peripheral neuropathy with a transmetatarsal amputation and resultant equinovarus deformity, who underwent TTC fusion at an outside facility with an intramedullary nail two months prior. He presented to the emergency department with swelling and drainage from the surgical site. A comprehensive clinical exam was performed and revealed a red, hot, swollen foot with ascending cellulitis and multiple wounds from the previous incisions, with exposed hardware and purulent draining sinuses from multiple screw sites associated with the intramedullary nail. Radiographs revealed failed hardware and a non-union (Figures 6a and b). The patient had a limb-threatening infection. Treatment options included a definitive high-level amputation (BKA) or a staged approach for limb salvage. He requested every effort be made to save his foot and as a result, the treatment priorities were infection control and limb salvage.

Infection following plate fixation is primarily extra medullary and placement of antibiotic beads delivers antibiotics locally and helps control infection.

He had an elevated white blood cell count, ESR (86 mm/hr) and CRP (199.3mg/L). Infection after intramedullary nail fixation involves the intramedullary canal, unlike the previous case, where the infection was primarily extramedullary. Local delivery of antibiotics in intramedullary infections can be difficult because of the difficulty to introduce antibiotic beads into the medullary canal and beads do not provide stability[2,3]. An antibiotic impregnated cement rod provides increased surface area for local delivery of antibiotics as well as providing stability across the tibiotalar and talocalca-

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Figure 2a: Lateral radiograph of the patient after ORIF of tarsal discoloration and extended medial column fusion.

Figure 2b: AP foot radiograph after ORIF of midfoot dislocation and extended medial column fusion.

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neal joints.[3] The rod occupies dead space and is easy to remove after eradication of infection.[3,4,5]

The patient was taken to the operating room for a planned staged approach. The first surgery consisted of an incision and drainage, removal of hardware, thorough debridement, deep tissue cultures, and placement of an antibiotic impregnated cement rod.

After nail removal, the canal was reamed at least 1-2mm larger than the original nail to remove the slimy endosteal layer. Reaming is a very important part of the debridement.[2] The wound and canal were copiously irrigated and deep tissue and bone cultures were taken from the intramedullary canal (after removing the outer layer of gloves and using clean, unused instrumentation).

The antibiotic impregnated cement rod was constructed in the operating room using materials that are readily available. The components of this rod consisted of poly methymethacrylate (PMMA) cement with antibiotic powder (2g vancomycin and 2.4g tobramycine), a 40 mm chest tube, and a Steinmann pin. A 40 mm chest tube was chosen because the inner diameter corresponds to 10 mm nail. The chest tube is cut to the appropriate length, which is often the length of the nail removed. The cement is then transferred into a cement gun and injected into the chest tube. A Steinmann pin is gently inserted into the center of the chest tube and the end is left proud. Once the cement hardens, the chest tube is cut with a scalpel and removed. The end of the Steimann pin may be bent to facilitate removal (Figure 7).[3] Choice of the particular implant to be coated should be made on an individual, case-dependent basis considering both the patient characteristics and anatomy of bone and joints involved.[5] The rod is then inserted through the same plantar incision used to remove the previous nail, and care is taken to keep the bent end of the Steinmann pin superficial to the plantar cortex of the calcaneus to facilitate future removal (Figure 8).[3]

The patient was placed in a well-padded posterior splint and remained non-weight-bearing. He received parental antibiotics via a PICC line for six weeks and inflammatory markers (ESR and CRP) were followed.

Upon resolution of signs of infection (approximately two months), the patient underwent definitive treatment. The surgery consisted of removal of the antibiotic cement rod and repeat debridement. Intra-operative frozen section analysis exhibited < 5 cells per high power field, and the joints were prepared for fusion. Definitive fixation was placed using an antibiotic impregnated ce-

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Figure 4: AP radiograph following removal of hardware, debridement and insertion of antibiotic impregnated absorbable beads.

Figure 5: Clinical photo taken after resolution of infection with intact skin envelope and stable, plantigrade foot.

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Figure 6a: Patient with previous TMA and infected TTC fusion with exposed hardware and draining sinus.

Figure 6b: AP ankle radiograph of the patient with infected, failed TTC fusion.

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ment-coated intramedullary nail. The antibiotic cement-coated interlocking intramedullary nail was fashioned using the technique described by Riel and Gladden.[6] The authors describe a simple technique using a chest tube to create an antibiotic cement-coated interlocking nail without the need for custom molds.[6]

The patient progressed well throughout the post-operative period. Clinical success was considered with reconstitution of affected bone and fusion across the tibiotalar and talocalcaneal joints, healing of overlying soft tissue, and drop-in inflammatory markers. The patient returned to ambulating in normal shoes.

Figure 7: Antibiotic impregnated cement rod fashioned in the OR.

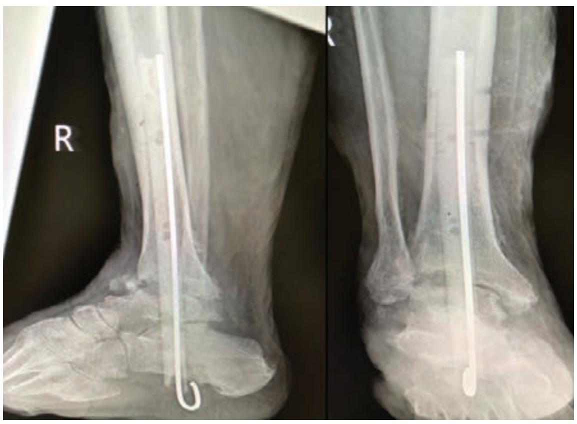

Figure 8: Lateral and AP ankle radiographs of the patient after removal of hardware, debridement and insertion of antibiotic impregnated cement rod.

Conclusion

Bone infection at the site of implantable hardware after foot and/or ankle reconstructive limb salvage surgery can often result in a below-the-knee amputation. Limb salvage procedures, often with a staged approach, are necessary for infection control and limb preservation.

Infection following surgical foot reconstruction with plate fixation primarily involves extramedullary bone with intramedullary canal involvement limited to where the plate was. Infection control can often be achieved with hardware removal, thorough debridement and local delivery of antibiotics by antibiotic beads, and skeletal stabilization by means of a splint, cast, or external fixation.

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Infection following intramedullary nail fixation for TTC fusion spreads along the intramedullary canal along the length of the nail. Traditional methods of local antibiotic delivery are insufficient and do not provide stability across the nonunion sites. Miller, et al. reported the successful and novel use of an antibiotic-impregnated cement-coated intramedullary nail in the staged treatment of infected failed total ankle arthroplasty or arthrodesis.[4] They recommend that a staged treatment should include local delivery of antibiotic, and stabilization. Madanagopal and colleagues extended the concept of PMMA sticks and developed the antibiotic-impregnated cement rod for the treatment of chronic tibia osteomyelitis.[2] Paley and Herzenberg retrospectively reviewed nine cases of intramedullary infection treated with antibiotic-impregnated molded cement rods.[7] In all cases, the canal cultures were negative after rod removal and no patients required antibiotics after the rod was removed.[7]

The antibiotic impregnated cement rod is ideal for local delivery of antibiotics along the length of the previous nail. The fashioned rod can easily be removed after eradication of infection, and definitive fixation using definitive metal (with or without antibiotic-coated) intramedullary nail can be used to achieve functional limb salvage. **PM**

References

[1] Sammarco VJ. Superconstructs in the treatment of charcot foot deformity: plantar plating, locked plating, and axial screw fixation. Foot Ankle Clin. 2009 Sep;14(3):393-407.

[2] Madanagopal SG, Seligson D, Roberts CS. The antibiotic cement nail for infection after tibial nailing. Orthopedics. 2004 Jul;27(7):709-12.

[3] Mendicino RW, Bowers CA, Catanzariti AR. Antibiotic-coated intramedullary rod. J Foot Ankle Surg. 2009 Mar-Apr;48(2):104-10.

[4] Miller J, Hoang V, Yoon RS, Liporace FA. Staged Treatment of Infected Tibiotalar Fusion Using a Combination Antibiotic Spacer and Antibiotic-Coated Intramedullary Nail. J Foot Ankle Surg. 2017 Sep-Oct;56(5):1099-1103.

[5] Ismat A, Walter N, Baertl S, Mika J, Lang S, Kerschbaum M, Alt V, Rupp M. Antibiotic cement coating in orthopedic surgery: a systematic review of reported clinical techniques. J Orthop Traumatol. 2021 Dec 23;22(1):56.

[6] Riel RU, Gladden PB. A simple method for fashioning an antibiotic cement-coated interlocking intramedullary nail. Am J Orthop (Belle Mead NJ). 2010 Jan;39(1):18-21.

[7] Paley D, Herzenberg JE. Intramedullary infections treated with antibiotic cement rods: preliminary results in nine cases. J Orthop Trauma. 2002 Nov-Dec;16(10):723-9.

Dr. Bevilacqua is in private practice at North Jersey Orthopaedic Specialists in Teaneck, NJ. He is board-certified in Foot and Reconstructive Rearfoot and Ankle Surgery by the American Board of Foot and Ankle Surgery (ABFAS). He is a Fellow of the American College of Foot and Ankle Surgeons (ACFAS).