CHAPTER 41

ANTIBIOTIC-IMPREGNATED POLYMETHYLMETHACRYLATE BEADS: Clinical Applications

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Polymethylmethacrylate (PMMA) antibiotic-impregnated beads have proven to be a useful tool in eradicating infection. The polymethylmethacrylate resin provides a medium for the antibiotic to leach out and deliver a locally high concentration of antibiotic. The antibiotic levels have been measured to be 10 to 100 times the MIC. The authors have found this therapy to be helpful specifically in the treatment of diabetic infections and chronic osteomyelitis (Fig. 1).

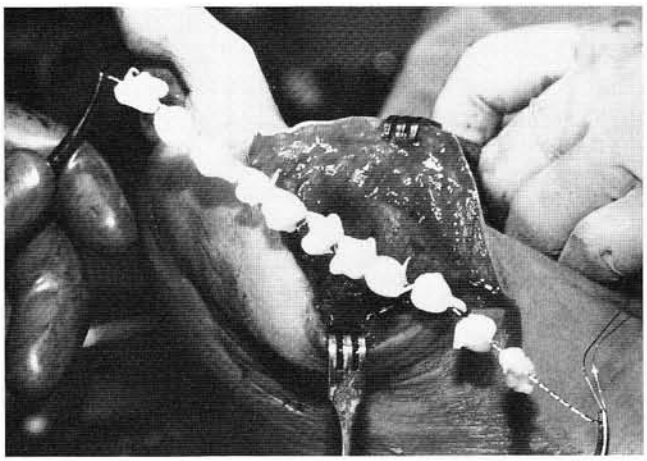

Figure 1. Antibiotic beads before insertion into infected open wound.

INDICATIONS

The authors recommend the use of PMMA antibiotic-impregnated beads in a patient with a condition that would cause a decrease in the tissue levels of an administered antibiotic. Included in this category are patients with diabetes and osteomyelitis who exhibit an ankle/brachial index of .5 to 1. These patients may have either already undergone a bypass procedure, or are not considered to be candidates. Also included in this category are patients with chronic osteomyelitis. The authors believe that the ability to fully close the wound, allowing the highest concentration of antibiotic, is a factor in the success of the procedure.

The authors are currently following 20 patients who have met this criteria. All patients underwent insertion of antibiotic impregnated beads, as an adjunct to oral or intravenous antibiotic therapy for osteomyelitis. The majority of the patients have diabetes with moderate peripheral vascular disease. Of these patients, 90% healed without complications.

THEORY OF CLINICAL APPLICATION

The benefit of PMMA-antibiotic impregnated beads is the ability to deliver a high local concentration of antibiotic to an area which has relatively poor blood supply. The antibiotic leaches out into the cavity and aids in the eradication of the infection. The PMMA acts as the carrier of the antibiotic.

The exact method in which the antibiotic leaches out of the polymethylmethacrylate is still being debated. One theory proposes that the antibiotic leaches out by direct diffusion through the PMMA, the other proposes that the antibiotic gains passage through small cracks that develop within the PMMA as it hardens. The highest concentration of the antibiotic occurs within the first 48 hours, and steadily decreases over the next 10 to 14 days.

PROCEDURE

Antibiotic beads are available commercially under the brand name Septopal, or they can be made in the operating room on the back table during the procedure. The authors prefer to make their own beads, because it is relatively easy, and cost-efficient.

Gentamicin and Tobramycin are the two most common antibiotics utilized with the PMMA beads. Both antibiotics are aminoglycosides that have a very broad spectrum when used locally at high concentrations. They are effective against gram-negative and most gram-positive bacteria, however anaerobes are resistant to their activity.

The powder or liquid form of the antibiotic can be used. The powdered form of the antibiotic (Gentamicin 0.5 mg to 1 mg, or Tobramycin 1.2 mg) is mixed with the powdered polymer. The liquid monomer is then added. The liquid form of the antibiotic can also be used but its preparation is somewhat more time-consuming. Ten, 2 ml vials with 80 mg of Gentamicin are added after the powdered polymer has been mixed with the liquid monomer. A vacuum suction can be used to expedite the mixing process.

Once the antibiotic and PMMA are in a paste consistency, the mixture is placed in a 10 cc syringe. Drops of the mixture are placed on a double strand 28 gauge wire. It is recommended that a large number of small beads be placed on the wire, giving a greater surface area to leach out the antibiotics. The diameter of the beads should be approximately 7 mm.

After the wound is drained and debrided of infected and fibrotic tissue, the strand of beads is placed into the wound, and the wound is then closed. Care should be taken not to place too much tension on the wound edges or dehiscence may occur (Fig. 2). The beads are left in place for 1 to 2 weeks, and then removed from the wound. This period of time will give sufficient antibiotic coverage. After two to three weeks, connective tissue forming around the beads may make removal more difficult. The patient should be kept non-weight bearing during the period of time that the beads are in the wound.

Figure 2. Dehiscence of the medial aspect of the 1st MPJ following insertion of antibiotic beads.

CASE PRESENTATION

A 70-year-old female with insulin-dependent diabetes presented to the office with a decubitus ulceration on the plantar posterior aspect of the right heel. The patient lived independently. The lesion had been present for approximately one month, but had been ignored. The lesion was painful when the patient ambulated, or was lying in bed (Fig. 3A).

Upon examination, it was noted that the patient had a low grade fever. Patent pulses were noted on Doppler examination only. The ankle/brachial index was .68 mm Hg. The central aspect of the ulceration appeared to be necrotic, and upon probing it was noted that it extended to the bone. Radiographs showed a sinus tract that penetrated deep into the posterior calcaneus (Fig. 3B). The patient was admitted to the hospital, and a vascular consult was obtained. After admission, the patient had multiple medical complications which dictated that the least invasive limb salvage procedure be selected. Because the ankle/brachial index was greater than .5 mm Hg, it was felt that revascularization was not required for successful healing.

The patient was taken to the operating room where an incision and drainage was performed. PMMA antibiotic-impregnated beads were used as an adjunct to therapy due to the relative avascularity of the extremity, and the knowledge that debriding all of the suspected osteomyelitic bone would require the removal of the entire calcaneus.

CLINICALLY ILLUSTRATED PROCEDURE

Figure 3A. Clinical appearance of diabetic decubitus ulceration of the right heel.

Figure 3B. Lateral radiograph of the calcaneus reveals a sinus tract coursing through the posterior aspect of the calcaneus and ending close to the subtalar joint.

Figure 3C. The ulceration has been circumscribed to bone. An incision is extended both medially and laterally to gain exposure to the posterior calcaneus, and to gain mobility of the flaps for closure. The plantar aspect of the calcaneus is debrided and cultures and biopsies are obtained.

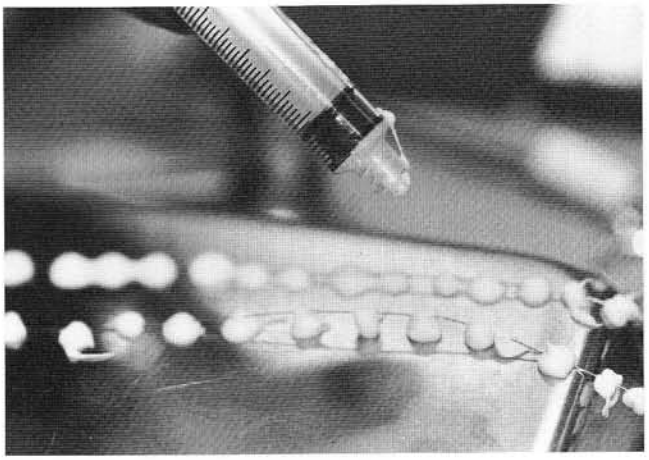

Figure 3D. PMMA Tobramycin-impregnated beads are then constructed on the back table in the operating room. The mixture is placed into a 10 cc syringe, before hardening and then extruded on double-braided 28 gauge wire.

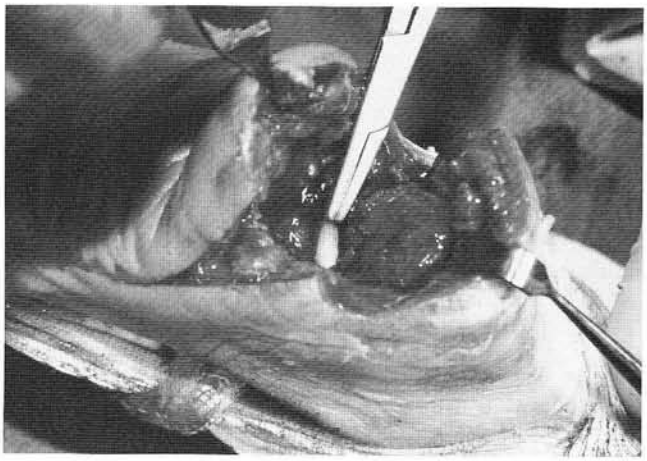

Figure 3E. A separate bead is imbedded deep within the sinus tract. It will not be removed.

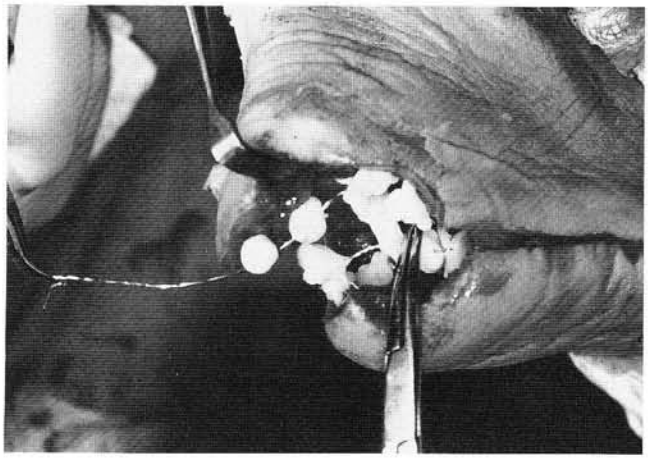

Figure 3F. The beads are inserted into the open wound, and the wound is then closed.

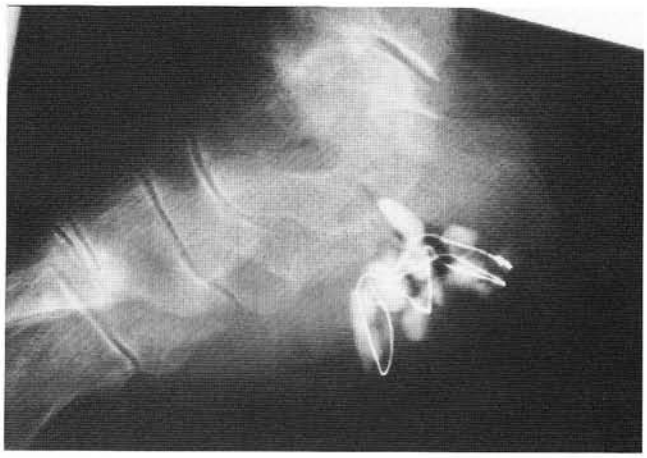

Figure 3G. Postoperative radiograph revealing the beads in place.

Figure 3H. Postoperative radiograph reveals the removal of the chain of beads. The beads were left in the wound for ten days.

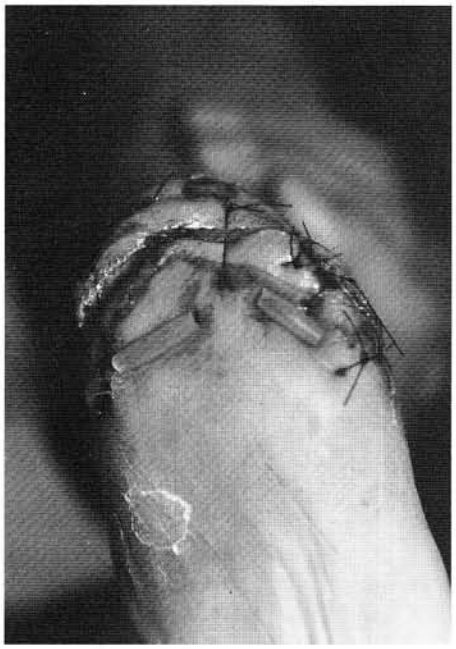

Figure 3I. Clinical appearance of the wound after final closure.

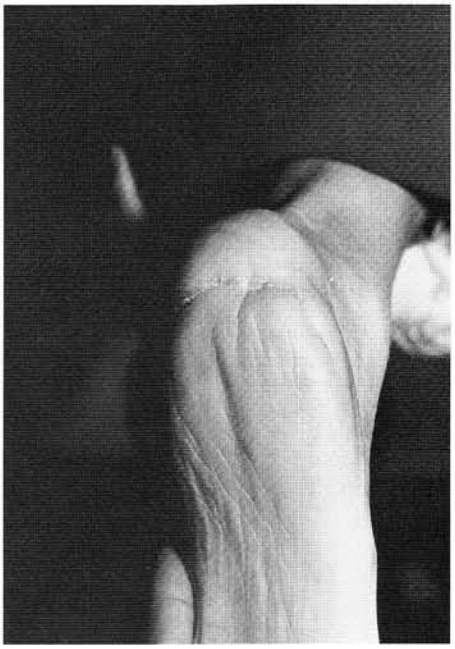

Figure 3J. Clinical appearance at six months post-operative.

Culture results revealed a growth of *Pseudomonas aeruginosa,* and the pathology specimen revealed a diagnosis of acute osteomyelitis. A combination of intravenous Clindamicin and oral Cipro was chosen for antibiotic coverage. Following the removal of the beads the patient was non-weight bearing for four weeks. She was then allowed to bear weight with the addition of a soft orthotic. A 1/4 inch heel lift was added to the right to compensate for the loss of height from the procedure. The patient is currently 1.5 years postoperative. She continues to live independently in her own home.

COMPLICATIONS

The use of PMMA antibiotic-impregnated beads results in few complications because of the very low systemic absorption of the antibiotic. The most common complication seen by the authors has been a delay in healing resulting from avascularity of the wound. Another complication noted by the authors is wound tension resulting from the insertion of too many beads.

CONCLUSION

PMMA antibiotic-impregnated beads have proven to be an important adjunct in the treatment of diabetic foot infections and chronic osteomyelitis. Some patients can be treated in the outpatient setting. The use of this procedure is a cost-effective alternative to aggressive wound care, and can prevent open wound complications.

BIBLIOGRAPHY

Baker AS, Greenham LW: Release of gentamicin from acrylic bone cement. *J Bone Joint Surg* 70:1551-1557, 1988.

Bavston R, Milner RDG: The sustained release of antimicrobial drugs form the bone cement-An appraisal of laboratory investigations and their significance. *J Bone Joint Surg* 64(B):460-464, 1982.

Hedstrom S, Lidgren L, Tortholm C, Onnerfalt R: Antibiotic containing bone cement beads in the treatment of deep muscle and skeletal infections *Acta Orhtop Scand* 51:863-869, 1980.

Jacobs AM, Seifert AM, Kiritis TJ, Protzel HR: Antibiotic loaded bone cement in the management of diabetic foot infections. In Frykberg RG, ed, *The High Risk Foot in Diabetes Mellitus* New York, NY: Churchill Livingstone; 1991:421-440.

Law HJ, Fleming RH, Gilmore MP, et al.: In vitro measurement and computer modeling of the diffusion of antibiotics in bone cement. *J Biomed* 8:140-55, 1986.

Levin PD: The effectiveness of various antibiotics in methylmethacrylate. *J Bone Joint Surg* 57(B):234-237, 1975

Marcinko D: Gentamicin-impregnated PMMA beads: An introduction and review. *J Foot Surgery* 2:116-221, 1985.

Patzakis MJ, Mazur K, Wilkins J, Sherman R, Holtom P: Septopal beads in patients with chronic osteomyelitis *Clinical Orthopaedics and Related Research* 295:112-118, 1993.

Picknell B, Mizen I, Sutherland R: Antibacterial activity of antibiotic in acrylic bone cement. *J Bone Joint Surg* 3:302-307, 1977.

Schein C, Black J: Implanted gentamicin beads in the treatment of osteomyelitis. *J Am Podiatr Med Assoc* 10:563-567, 1987.

Vecsei V, Barquet A: Treatment of chronic osteomyelitis by necrectomy and gentamicin-PMMA beads *Clin Orthop* 159:201-206, 1981.

Von Frauhofer JA, Polk HG Jr, Seligson D: Leaching Tobramycin from PMMA bone cement beads. *J Biomed Mater Res* 19:751-756, 1981.

Wroblewski BM: Leaching out from acrylic bone cement:Experimental evaluation. *Clin Orthop* 124:311-312, 1977

Yu G, Lo Wai-Leng KG, Hughes S:Gentamicin-Impregnated Polymethylmethacrylate Beads: An exposition and explanation of their use. In Dinapoli DR, ed. *Reconstructive Surgery of the Foot and Ankle, Update '90* Tucker GA: Podiatry Institute Publishing; 1990:106-112.