Treatment of a Diabetic Foot Ulceration with Infected Bone using a Modified Masquelet Technique Approach with Resorbable Antibiotic Loaded Bone Cement in Combination with Extracellular Matrix Dressings and Amniotic Allografts: A Case Report

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Abstract

The traditional Masquelet Technique is comprised of two steps to achieve osseus reconstruction. During the first step of the process a cement spacer is inserted into an osseus void and a bioactive membrane is formed over a period of time. Once this is completed, the second step of the process involves removing the cement spacer and implanting a cancellous autograft within the induced membrane to achieve osseus reconstruction of the defect. In this case series, we present a modified Masquelet Technique where antibiotic loaded resorbable cement was used to fill osseus defects resulting from the resection of diseased bone within a foot ulceration. As resorption of the cement occurred, a combination of amniotic allografts and synthetic extracellular matrix were used induce soft tissue growth to fill the void, maintaining length, and heal the surrounding wound. The aim of this case study was to highlight this modified Masquelet Technique utilizing calcium sulfate resorbable antibiotic loaded cement and combination therapy using amniotic allografts and synthetic extracellular matrix dressings as a therapeutic option for the management of foot ulcerations with osteomyelitis to maintain length following resection of the diseased bone and to achieve wound closure.

Introduction

Masquelet et al introduced the Maquelet Technique in 2000 which involves a two-stage surgical procedure intended for use in large segmental bone defects, often resulting from trauma or infection. [1]. The first stage of the process involves removing diseased or damaged bone and then implanting a cement spacer, polymethyl methacrylate (PMMA), into the bone defect. Masquelet et al described the formation of a bioactive membrane rich in osteogenic factors which promotes vascularization and bone regeneration. [1]. After period of time, the second stage was initiated which involved removing the cement spacer and implanting a bone graft to fill the space. [1]. The biologically active environment created by the induced membrane facilitated new bone formation within the bone graft and the technique was demonstrated to show promising results in achieving bone union and functional recovery. [1].

Poly(methyl methacrylate) (PMMA) is a commonly used cement that can be mixed with antibiotics to deliver antibiotic therapy directly to an infected site. The use of PMMA bone cement has disadvantages however which include the release methyl methacrylate (MMA), high exothermic temperature during the polymerization of PMMA, which can cause thermal necrosis, it is not resorbable and therefore requires a second surgery for removal, and it can become a nidus for infection if colonized by bacteria. [2,3,5] Resorbable bone cements, such as calcium sulfate, have the advantage of being completely resorbable, therefore they do not require additional surgery to remove and do not act a nidus for infection [4]. A wide range of antibiotics can be loaded into antibiotic cement depending on the target organism, including Vancomycin and Gentamycin [2].

Stimulan® Biocomposites® Rapid Cure is manufactured from medical grade calcium sulfate and its intended use is as a bone void filler for voids or gaps that are not intrinsic to the stability of the bony structure [4]. When used in bone voids, it provides a bone graft substitute that is resorbed and replaced with bone during the healing process [4]. It is engineered through a DRy26™ recrystallization method which is a multiple step process beginning with pharmaceutical grade precursors and takes over six weeks to complete [6]. It contains no hydroxyapatite, PMMA, or insoluble impurities [4] and is completely absorbable [4, 7-12]. It has been demonstrated to not act as a nidus for infection [4,12].

PalinGen® XPlus Hydromembrane is chemically cross-linked with extracellular matrix fibers to give it strength, shape, and slower resorption in vivo.[13] PalinGen® Flow is cryopreserved liquid amniotic allograft.[13] These amniotic allografts contain collagen types I, III, IV, V, and VII, cytokines, hyaluronic acid, fibronectin, laminin, fibrinogen, amino acids, proteoglycans, tissue inhibitors of metalloproteinases (TIMPs), extracellular matrix proteins and mesenchymal stem cells which are all recognized as part of the complex wound healing process.[14]

Amniotic allografts also include key growth factors such as fibroblast growth factor (FGF), epidermal growth factor (EGF), platelet derived growth factor (PDGF), vascular endothelial growth factor (VEGF), and transforming growth factor beta (TGF-β).[15] Amniotic tissues have been proven to be multipotent and capable of differentiating into adaptogenic, osteogenic, myogenic, endothelial, and neurogenic cell lineages.[15-21] They are derived exclusively from the amnion and are chorion-free.[15-21]

The aim of this case study was to highlight a modified Masquelet Technique utilizing calcium sulfate resorbable antibiotic loaded cement and combination therapy using amniotic allografts and synthetic extracellular matrix dressings as a therapeutic option for the management of foot ulcerations with osteomyelitis to maintain length following resection of the diseased bone and to achieve wound closure.

Case Report

During the initial visit a thorough history was obtained which was comprised of their past medical history, current medications, allergies, surgical history, and social history. A complete review of systems was performed, and a lower extremity focused exam was conducted which included vascular, dermatologic, neurologic, and musculoskeletal. Radiographs were obtained of the feet and blood tests were performed including glycosylated hemoglobin levels. A wound swab was then collected from the wound and sent for culture/sensitivity testing. Based on imaging and clinical exam findings, if osteomyelitis was suspected, the following protocol was performed.

The diseased bone was resected and sent for surgical pathology and culture/sensitivity testing. Resorbable antibiotic cement mixed with antibiotics were then formed into the shape of the resected bone to achieve anatomic length. Amniotic allografts were implanted into the surrounding tissues followed by synthetic extracellular matrix dressings overtop.
The patient was seen weekly thereafter. At each weekly visit, the resorbable antibiotic cement spacer was removed and either cleansed then reimplanted or a new resorbable antibiotic cement spacer mixed with antibiotics was formed into the shape of the remaining void to achieve anatomic length. The size of resorbable antibiotic cement spacer progressively getting smaller it resorbed and soft tissue grew in to fill the space. Amniotic allografts and synthetic extracellular matrix dressings were then implanted each time into the wound surrounding the resorbable antibiotic cement spacer. Wound size measurements were record at each visit. Wound size was calculated as the product of the length, width, and depth in cubic centimeters (cm3). Wound sizes were compared to the initial wound size and expressed as a percentage of wound closure. The goal of therapy was to achieve greater than 95% wound volume decrease.[15]

History and physical exam

Initial visit occurred January 3, 2024 with a 75 year-old male with past medical history diabetes mellitus type II, peripheral neuropathy, and hemodialysis dependent kidney failure. Patient has no known allergies. No pertinent surgical or social history other than a history of former tobacco use. Physical examination demonstrated non-palpable pedal pulses and complete loss of protective sensation. No gross deformity of the foot was identified besides pes planus and the patient ambulated without ambulatory aids. Notably, the patient was awaiting kidney transplant which was contingent on the healing of his foot ulceration.

Initial Wound Presentation

The diabetic foot ulceration, was located on the plantar aspect of the left hallux interphalangeal joint and had been present since August 2023. The patient reported no pain from the ulceration, likely due to loss of sensation in the foot secondary to peripheral neuropathy. The ulceration measured 2.7 cm x 2.0cm x 0.7cm with exposed bone and deep tissues. No tunneling, undermining, or sinus tract was present. There was purulent drainage, malodor, periwound calor, erythema, and edema present. The wound bed was noted to be mixed fibrotic and granular tissue.

Ancillary Testing

Doppler examination of the pedal arteries demonstrated multiphasic waveforms. A computed tomography scan and radiographs of the left foot revealed evidence of osteomyelitis in the hallux proximal phalanx head and hallux distal phalanx base, including pathologic fracturing, and concerning findings for septic arthritis of the hallux interphalangeal joint. Glycosylated hemoglobin had a reported value of 6.9. Wound swab and bone biopsy were obtained and sent for culture and sensitivity testing, both of which cultured methicillin sensitive staphylococcus aureus (MSSA). Patient was started on oral antibiotic therapy with Doxycycline, and it was continued throughout the duration of treatment.

Treatment Protocol

On January 10, 2024, the left hallux interphalangeal joint was excised along with the head of the proximal phalanx and base of the distal phalanx and the treatment protocol was initiated. Vancomycin was the chosen as the antibiotic to be loaded into the resorbable bone cement. The patient's left foot was offloaded with an Optima Molliter Motus 2.0 offloading boot and a knee scooter.

Wound Trajectory

One week following the procedure the wound volume had decreased by 49% and amniotic allografts and synthetic extracellular matrix dressings were reapplied. At three weeks, the wound volume had decreased by 71% and at five weeks the wound volume had decreased by 93%. At seven weeks the wound achieved 98" closure. At week nine the wound was fully closed and healed, and the patient was accepted for kidney transplant.

Discussion

The outcome of this case report supports the use of antibiotic loaded cement in combination with amniotic allografting and synthetic extracellular matrices as a therapeutic option for the management of foot ulcerations with osteomyelitis to maintain length following resection of the diseased bone and to achieve wound closure.
It is important to note that this case was performed at the Southern Arizona Veteran Affairs Health Care System, therefore cost and reimbursement were not factors in determining treatment. Anthem™ Wound Matrix is branded specifically for the Department of Veteran Affairs. In private and commercial, it is branded as Phoenix™ Wound Matrix. Antibiotic loaded resorbable cement pellets and synthetic extracellular matrices are all reimbursable through Medicare and private insurance and have their own designated HCPCS codes. The cost to benefit ratio would need to be assessed on an individual provider and patient basis. All pricing of the wound care products used in this case are available to the public through the Department of Veteran Affairs Federal Supply Schedule.

Conclusion

Radiographs obtained at the end of therapeutic period demonstrated no new osseous erosions concerning for osteomyelitis and throughout the course of the therapy no new soft tissue infections occurred. We had the privilege of caring for this patient during a critical time in their health journey. Since then, they have successfully undergone a kidney transplant and are now thriving, free of ulceration and enjoying a renewed quality of life.

Conflict of Interest Statement

The authors of this article declare no conflict of interest. The companies involved had no role in the design of the study; in the collection, analyses, or interpretation of date; in the writing of the manuscript, or in the decision to publish the results.

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