Bioglass for the Treatment of Osteomyelitis

Chronic osteomyelitis remains a challenging entity to treat, typically requiring surgical debridement(s) followed by prolonged antibiotic therapy. While pharmacological advances have yielded increasingly powerful antibiotics for the treatment of infection, an epidemic of multiple-drug resistant organisms has also emerged.

The surgical treatment of osteomyelitis is often complicated by the need for bony reconstruction. Local dissolution of bone matrix mineral from acidosis often creates a ''dead space'' in the bone after debridement. Although its use has been shown to increase the likelihood of fusion, synthetic bone graft substitutes are generally not recommended due to the propensity of retaining bacterially produced biofilms. However, new research has led to the advent of alternative synthetic bone substitutes with biocompatible osteoconductive properties that can also combat the pathogens locally, such as bioactive glass.

A recent multicenter study, Lindfors et al (***Bone*. 2010;47(2):212-218**) investigated the outcomes of the use of bioactive glass (BAG-S53P4) in 11 patients treated for chronic osteomyelitis. Ten patients had osteomyelitis

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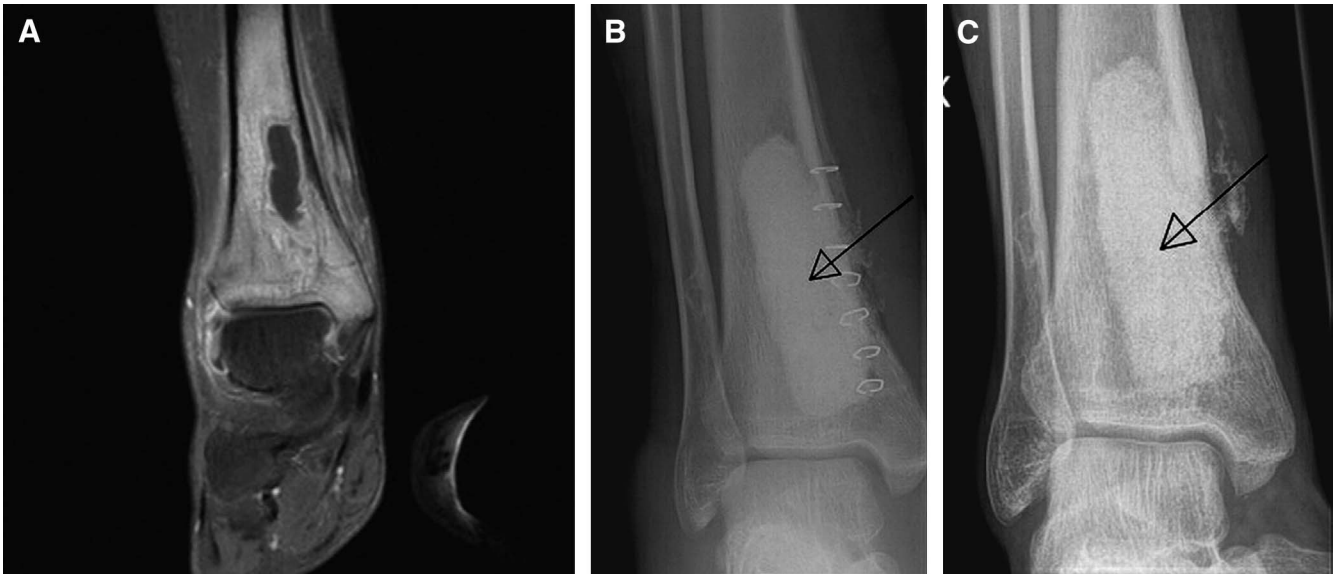

A-C, *osteomyelitis caused by S. aureus in distal tibia treated with BAG-S53P4 as bone graft substitute.* **A**, *preoperative MRI showing osteomyelitis in tibia;* **B**, *postoperative X-ray showing BAG-S53P4 in the treated bone cavity (arrow); and* **C**, *X-ray at 5 months follow-up showing the treated region (arrow). (From Lindfors NC, Hyvönen P, Nyyssönen M, et al. Bioactive glass S53P4 as bone graft substitute in treatment of osteomyelitis. Bone. 2010;47(2):212-218.)*

of the lower extremity and 1 had osteomyelitis in the lumbar spine. All patients had radiographically confirmed osteomyelitis and underwent meticulous surgical debridement. Cavitary bone defects were filled with BAG-S53P4 (BonAliveR, Bonalive Biomaterials Ltd., Finland). In particular, the lumbar osteomyelitis patient had metal implants which were covered with the bioactive glass. Mean follow up was 24 months and outcome of the treatment was evaluated by the surgeon as excellent (no complications), good (a small complication) or a temporary stable situation. Good or excellent outcome was seen in 9 of the 11 patients. Only 2 patients required reoperation; 1 due to a compromised vascularized muscle flap and the other for hematoma in the operative cavity theorized to have led to superimposed infection.

The bioactive process that leads to bone bonding has been described through reactions at the glass surface: sodium ions from the glass are exchanged for acid ions (H^+ and H_3O^+) in the adjacent tissue, leading to formation of silanol (SiOH) groups at the glass surface. Repolarization then leads to an SiO_2 rich layer. This is followed by migration of Ca^{2+} and PO_4^{3-} groups to the surface and cystallization, thereby creating a hydroxyapatite on top of the Si-rich layer. In a final step, cell interaction with the hydroxyapetite layer initiates the bone forming pathway. The antibacterial properties can be explained by an initial rapid rise in pH of the bioglass, seen as high as 11.65 in body fluid studies. Additionally, in vitro studies demonstrated angiogenic properties of the bioactive glass.

It was also noted that use of the bioactive glass only required a single operation, thus avoiding the typical multiple debridements necessary with use of antibiotic impregnated beads (a minimum of 1 operative debridement and placement of the beads and a later second for bead removal and replacement with cancellous autograft or vascularized bone graft). Overall, the authors concluded that use of BAG-S53P4 is a good, effective usable material for treatment of osteomyelitis.

The drawbacks to the study are the small sample size and the lack of randomization or comparison to a control group. Nevertheless, the results of the study show promise for the use of bioactive glass in treatment for chronic osteomyelitis. In particular, the antibacterial and osteoconductive properties make it a potentially valuable substitute for allograft as a fusion augmenting agent in treatment of chronic spinal osteomyelitis.

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