A Novel Biologic Composite for Use in Orthopaedic Surgery: A Viable Alternative to Bone Cement

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Introduction: Polymethylmethacrylate (PMMA) is a widely used polymer in orthopaedic implants and in procedures requiring vertebral linings, such as in vertebroplasty or kyphoplasty. However, PMMA has many drawbacks, including toxicity associated with leakage of the material, poor integration with bone, and a highly exothermic reaction that can be harmful to the surrounding structures. For this reason, it is widely accepted that superior materials for biologic filling of bone are necessary. The ideal composite is one that is non-toxic to surrounding structures, confers as great a biomechanical advantage to bone as PMMA, and is osteoinductive and hence biologically integrated over time. In our experimentation, we postulate that the addition of micronized cortical bone will not only impart strength to a biologic composite, but will also confer it greater biointegration over time.

Methods: All materials were received from and created at the University of Miami Tissue Bank. To investigate the biomechanical properties of the material, 1 cm diameter cylinders were created using plastic tubing of equal width. The powdered material was combined with water and each cylinder filled prior to hardening of the material. The material was then allowed to dry for at least 24 hours, and the hardened cylinders were then removed from the tubing and loaded axially on a MTS 820 machine to investigate their biomechanical properties. A total of 4 different formulations were investigated: group 1 (n=10) was composed of calcium sulphate (CS); group 2 (n=15) was composed of calcium sulphate with micronized bone (CSMB); group 3 (n=4) consisted of tetracalcium phosphate (TCP); group 4 (n=5) consisted of tetracalcium phosphate with micronized bone (TCPMB). The results of axial compression were recorded in neutons to failure and analyzed.

Results: A statistical significance at an alpha level of 0.05 was seen between the calcium sulphate and the calcium sulphate plus micronized bone groups (p=0.02). There was no statistically significant difference between the tetracalcium phosphate and the tetracalcium phosphate with micronized bone. The mean values were 270 ± 144 N for group 1 (CS), 388 ± 99 N for group 2 (CSMB), 390 ± 81 N for group 3 (TCP), and 429 ± 90 N for group 4 (TCPMB). The results are summarized in figure 1.

Discussion: Our analysis demonstrated a significant difference in biomechanical strength between the CS and CSMB formulations. Furthermore, the mean value of the TCPMB versus the TCP alone was greater despite not being statistically significant. This demonstrates that adding micronized bone to a synthetic bone composite can indeed provide increased biomechanical strength to the composite and moreover increase its biointegration in an in-vivo setting. This provides a superior option for orthopaedic implants and for the filling of bone defects in spine surgery, as these substances not only impart biomechanical strength to bone defects but also provide greater osteoinductive properties to the implants.
Significance: There has long been a need to discover a synthetic bone composite that is superior to PMMA for use in orthopaedic surgery, and viable options that impart biomechanical strength to bone while also providing biointegration are important to explore.

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