Augment® Bone Graft Products Compare Favorably to Autologous Bone Graft in an Ovine Model of Lumbar Interbody Spine Fusion

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Introduction

Spinal fusion is a procedure used to correct spinal deformities and treat fractured vertebrae, spinal instabilities or chronic back pain. In interbody fusion, all or part of the intervertebral disc is removed and a supporting spacer is inserted between the vertebral bodies for support and to facilitate bone growth between them. In most cases, bone growth is enhanced with graft materials placed within the spacer.

Autologous bone graft (autograft) is one of the materials commonly used to facilitate fusion. Although autograft is considered the “gold standard” due to its osteoconductive and osteoinductive properties, it has limitations including availability, graft quality, and donor site morbidity. Synthetic bone graft substitutes are alternatives to autograft that eliminate donor-site morbidity and graft material variability. Bone graft substitutes have other advantages including unlimited supply, off-the-shelf availability and easy sterilization and storage. Disadvantages can include poor handling or mechanical properties, variable resorption rates, and potentially adverse effects on normal bone remodeling.

Augment® Bone Graft combines the rhPDGF-BB with βTCP with a matrix comprised of β-TCP and collagen (80:20, w:w). In both products, the matrices serve as osteoconductive scaffolds and delivery systems for the bioactive factor.

Materials and methods

All procedures involving live animals were approved by the Colorado State University IACUC. Twenty two mature, female sheep were used. The sheep were distributed into 4 treatment groups; empty (n = 7), autograft (n = 5), Augment (n = 5) and Augment Injectable (n = 5).

Surgical Technique: After standard anesthesia, the disc between L4 and L5 was identified and an anulotomy performed. The sheep were housed indoors for the first two weeks of the study. Postoperative analgesia was provided with fentanyl patch and oral phenylbutazone. Animals were allowed to ambulate for 24 weeks of the study period. Animals were observed twice daily.

 Necropsy: All animals were euthanized by intravenous overdose of pentobarbital sodium 24 weeks after surgery. The lumbar spines were explanted following euthanasia and the soft tissues removed.

MicroCT analysis: MicroCT scanning and analysis was performed on a µCT 80 system (SCANCO USA, Southeastern, PA) using the manufacturer’s analysis software. MicroCT analyses included assessment of bony bridging throughout the central cavity of the vertebral spacer, bone volume/total volume (BV/TV) of the central cavity, and mineral density of the newly-formed bone. Six serial images from each specimen were graded by three independent scorers using a 5-point scale (0 - 4) based on quartiles of fusion.

Histologic analysis: Specimens were fixed in 10% NBF, dehydrated in graded ethanol solutions and cleared with xylenes. Next, they were infiltrated with Acrysol Infiltration Solution, embedded in Acrysol HARD Embedding Solution and allowed to polymerize.

Results

All sheep made uneventful recoveries without any adverse events being noted during the study. There was no evidence of ectopic bone formation or chronic inflammation.

Different amounts of new bone were formed within the PEEK spacers. The newly formed bone resulted in overall successful fusion (≥50% bony bridging) in approximately 48% both by microCT and histologic assessment. The success rates were 14% for the autograft, alternative than bone marrow (BB) that will enhance bone formation. This study we compared Augment Bone Graft and Augment Injectable Bone Graft to iliac crest autograft in an ovine model of interbody spine fusion. The outcome measures include assessment of fusion by microCT and histology and quantitative microCT analyses.

Discussion

The sheep lumbar spine model is widely used because it is comparable to the human spine; however, different studies have reported inconsistent success rates with autograft. These variable success rates of lumbar interbody fusion in ovine models indicate that the model is, overall, a very challenging one.

In the current study, histologic fusion was achieved at 6 months for 80% of the fusion sites treated with a PEEK spacer combined with Augment, 60% of the sites treated with Augment Injectable and 60% of the fusion sites treated with autograft compared with only 7% of the control sites (empty). The low fusion rates observed with empty spacers reinforces that this model is critically-scaled and suggests that fusion rates at 6 months are indicative of the biological activity of the applied graft materials. The histologic fusion rate of 80% in the Augment group is noteworthy, especially as fusion was obtained in a challenging environment with un-instrumented, non-threaded spacers.

In summary, these data strongly suggest that Augment is equivalent to autograft for enhancing spine fusion. Augment is a composite device that exploits the osteoconductive properties of β-TCP with the biologic activities of rhPDGF-BB that will enhance bone formation. The fully synthetic Augment not only avoids the limitations and morbidities associated with autograft, it also eliminates the potential for disease transmission associated with autologous bone allograft.

Significance: These data strongly suggest that Augment is equivalent to autograft for enhancing spine fusion. Augment is a synthetic device that avoids the limitations and morbidities associated with autograft and the potential for disease transmission associated with allograft.