

DEMINERALIZED BONE MATRIX PROVIDES EQUIVALENT RESULTS TO AUTOGRAFT IN STANDARD POSTEROLATERAL FUSION MODEL IN ADULT RABBITS

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Demineralized Bone Matrix Provides Equivalent Results to Autograft in Standard Posterolateral Fusion Model in Adult Rabbits

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ABSTRACT

Achieving fusion between two bony segments represents a challenge to surgeons. Autograft is often considered the “Gold Standard” for fusion, but its use has well reported limitations including donor site morbidity, increased operative time and potential blood loss. Demineralized Bone Matrix (DBM) provides surgeons with an alternative to autograft providing osteoinductive factors known to be involved in healing.

This study compared the in vivo results of a commercially available DBM product called AlloFuse® (AlloSource®, Centennial, CO) to autograft or empty controls in a standard posterolateral fusion model in adult New Zealand (NZ) white rabbits.

The L5-L6 rabbit spine model of Boden et al¹., was used in this study on 34 adult rabbits. Radiographic analysis, uniaxial tensile testing and peak load testing were used at six, 12 and 26 weeks following surgery.

The results of the study support the equivalence between autograft and AlloFuse. The DBM was able to facilitate fusion with normal bone healing with time. Pre-clinical evidence suggests that AlloFuse DBM may provide a suitable alternative to autograft for routine bone grafting procedures.

Introduction

Achieving fusion between two bony segments represents a challenge to the surgeon as well as the patient. Improvements in surgical technique and patient selection, coupled with advances in our understanding of the cascade of bone healing, continues to improve patient outcome.

Autograft is often considered the “Gold Standard” in fusion. The use of autograft has well reported limitations including donor site morbidity, increased operative time and potential blood loss. Demineralized bone matrix (DBM) provides surgeons with an off-the-shelf alternative to autograft providing a complex cascade of osteoinductive factors known to be involved in healing.

This study compared the in vivo results of a commercially available DBM, AlloFuse® (AlloSource, Centennial, CO), to autograft or empty controls in a standard posterolateral fusion model in adult New Zealand (NZ) white rabbits.

The purpose of this study was to evaluate the:

1. macroscopic and radiographic appearance of the fusion at six, 12 and 26 weeks
2. fusion masses based on three dimensional computed tomography models at six, 12 and 26 weeks
3. mechanical properties of the fusion at 12 weeks
4. histological appearance at six, 12 and 26 weeks

Methods

The L5-L6 rabbit spine model of Boden et al¹, was used in this study (*figure 1*) on 34 adult rabbits. This model duplicates the surgical technique, mechanical environment and biology of graft incorporation associated with a posterolateral inter-transverse process fusion in humans. The surgical model and experimental endpoints used in this study are identical to those reported recently by Walsh and colleagues.²

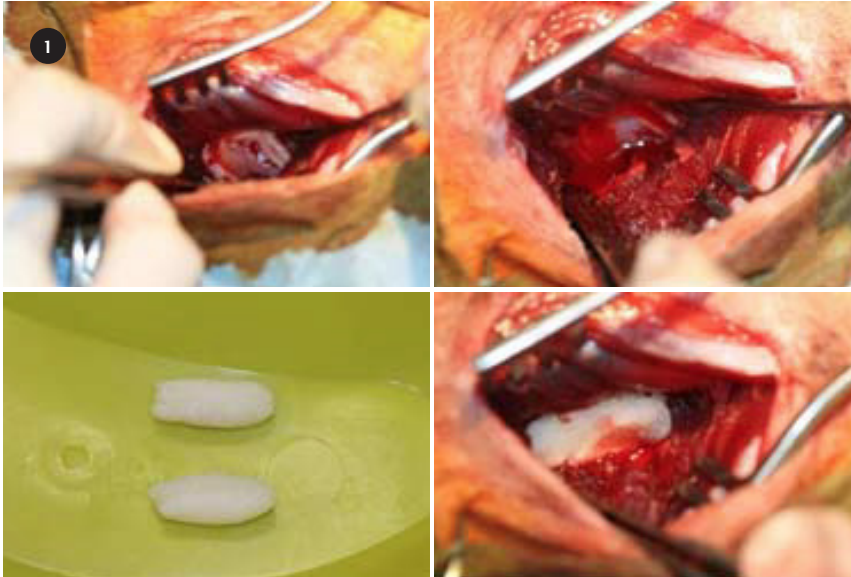


Figure 1. The transverse processes were exposed, decorticated and the AlloFuse (1.5 cc per side) or autograft (1.5 cc per side) implanted.

Animals were euthanized at six, 12 and 26 weeks following surgery. A sample size of n=3 per group was used at six and 26 weeks while n=8 per group was used at 12 weeks.

The endpoints included routine posteroanterior Faxitron radiographs as well as computed tomography (CT). The CT scans were used to generate 3D models for presentation purposes to examine the fusion mass. Models were created using Mimics software (Materialise, Belgium) using a threshold analysis technique. Images were examined in the axial, sagittal and coronal planes to assess the overall quality of the fusion mass.

Uniaxial tensile testing was performed at a displacement rate of 0.5 cm/min using an MTS 858 Bionix Testing Machine (MTS, Eden Prairie, MN, USA) for the 12 week group only. Samples were dissected so that only the new bone formed between the vertebral bodies and the fusion mass participated to resist the tensile load.

The peak load, stiffness and energy to peak load were determined for all samples. The highest point of the graph was taken as the peak load. The stiffness in the linear region of the curve based on a linear regression was calculated. The energy was taken as the area under the curve to the peak load. Data was analyzed using ANOVA using SPSS for Windows.

Samples were fixed in phosphate buffered formalin for a minimum of 48 hours. Spines in the six and the 26 week groups were fixed immediately following euthanasia. Spines in the 12 week group were fixed following mechanical testing. Spines were decalcified in 10% formic acid-phosphate buffered formalin at room temperature. The decalcified spines were sectioned in the sagittal plane for haematoxylin and eosin (H&E) and tetrachrome staining. Stained sections were examined under light microscopy using an Olympus Microscope (Olympus, Japan). Histology was qualitatively assessed versus time at each time point and summary written.

Results

Radiographs revealed a progression of healing in the autograft as well as the AlloFuse group with time. Fusion was achieved in both groups by 12 weeks while the empty decorticated controls showed some reaction on the decorticated transverse processes but no fusions.

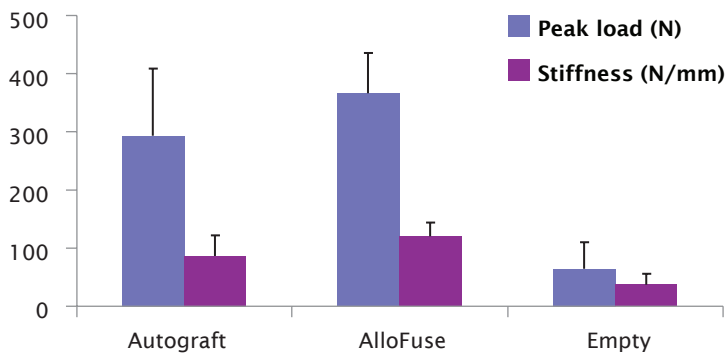
Empty decorticated control



Autograft



AlloFuse



No statistical differences were detected between the tensile properties for fusions treated with autograft and AlloFuse while both were superior to the empty decorticated controls.

Autograft

AlloFuse

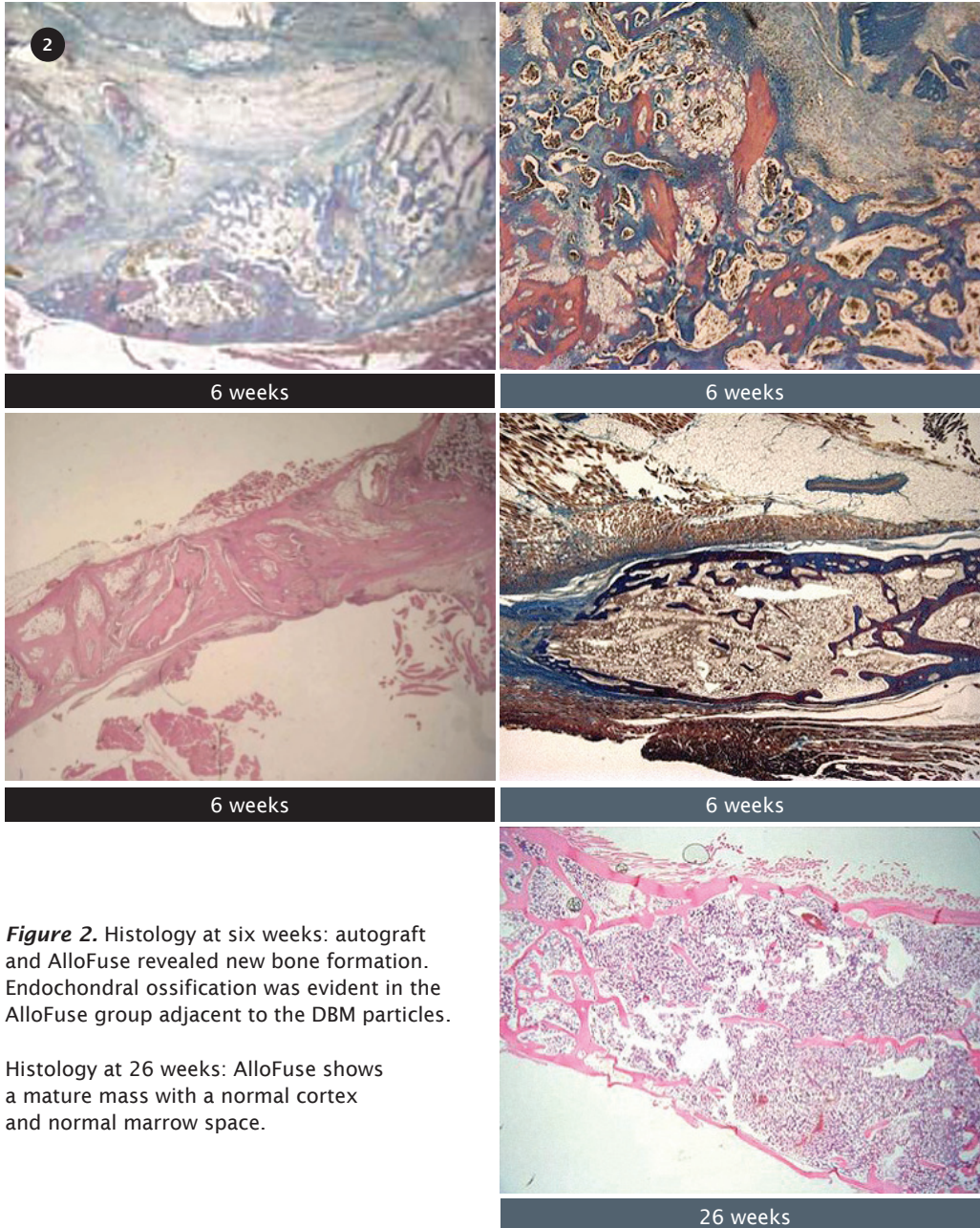


Figure 2. Histology at six weeks: autograft and AlloFuse revealed new bone formation. Endochondral ossification was evident in the AlloFuse group adjacent to the DBM particles.

Histology at 26 weeks: AlloFuse shows a mature mass with a normal cortex and normal marrow space.

Conclusion

The results of the current study support the equivalence between autograft and AlloFuse. The DBM was able to facilitate fusion with normal bone healing with time.

Pre-clinical evidence suggests that AlloFuse DBM may provide a suitable alternative to autograft for routine bone grafting procedures.

References:

1. Boden et al., Delivery of recombinant human bone morphogenetic protein-2 using a compression-resistant matrix in posterolateral spine fusion in the rabbit and in the non-human primate, 27(4): p. 353-60, Feb 15 2002.
2. Walsh, W.R., F. Vizesi, D. Michael, J. Auld, A. Langdown, R. Oliver, Y. Yu, H. Irie, and W. Bruce, beta-TCP bone graft substitutes in a bilateral rabbit tibial defect model [epub ahead of print] [Record Supplied By Publisher]. Biomaterials, 2007.



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