Efficacy of Adipose-Derived and Bone Marrow-Derived Stem Cells in Spinal Fusion: A Comparative Study in a Rat Model

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Introduction

Although bone marrow-derived stem cells (BMSCs) have been widely used in spinal fusion research, adipose-derived stem cells (ADSCs) offer a number of advantages as a clinical cell-source, including: increased tissue volume availabiltiy, higher stem cell concentrations, and reduced donor site morbidity. In this study, the efficacy of ADSCs vs. BMSCs in achieving successful spinal fusion, when combined with a clinical-grade bone graft substitute, is compared in a rat model.

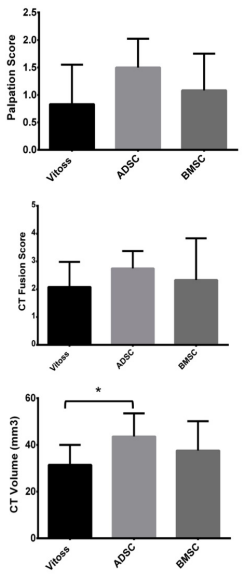
Methods

ADSCs were isolated from the inguinal fat pads, while BMSCs were isolated from the long bones of syngeneic female 6-8 week old Lewis rats and cultured in vitro until passage 2 for subsequent transplantation. Posterolateral spinal fusion surgery at L4-5 was performed on 36 female Lewis rats (6-10 wk old) divided into 3 experimental groups: [1] Vitoss (Stryker) bone graft substitute only (VO group, n=12); [2] Vitoss + 2.5 x 10^6 ADSCs/side (n=12); and [3] Vitoss + 2.5 x 10^6 BMSCs/side (n=12). Fusion was assessed eight weeks post-surgery via micro-computed tomography (MicroCT) analysis, manual palpation, and histology. Manual palpation scoring was conducted by blinded researchers as follows: 0=non-fused; 1=partial fusion, some motion across operative joint;

Results

MicroCT imaging analyses showed that the average fusion volume in the ADSC group was significantly higher than in the BMSC and VO groups (44.3 mm^3 vs. 27.6 mm^3 and 30.0 mm^3, respectively, $p < 0.01$). Similarly, average manual palpation score was the highest in the ADSC group compared with the BMSC and VO groups (1.5 versus 0.7 versus 0.8, $p = 0.03$).

Fusion Assessment



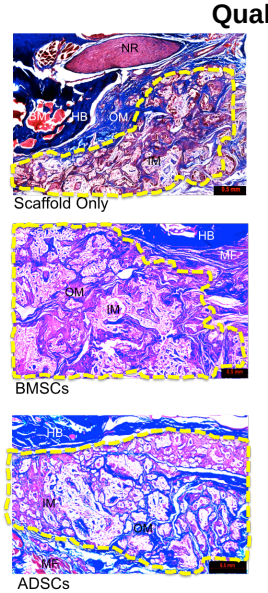
Palpation Score:
0 = Nonfused
1 = Partial Fusion
2 = Solid Fusion
Score = Avg

CT Fusion Score:
Each Side:
0 = Nonfused
1 = Partial Fusion
2 = Solid Fusion
Score = Avg. Sum of Both Sides

*Data presented as mean ± STD, (n= 12), * = ($p < 0.05$)*

Histologically, ADSC and BMSC groups showed a higher concentration of osteogenic matrix and osteoblasts in the fusion mass compared to VO.

Assessment of Fusion Mass Bone Quality



Masson's Trichrome Stain

BM = Bone marrow
HB = Host bone
OM = Osteogenic matrix
IM = Implant
MF = Muscle fibers

Conclusions

When combined with a clinical grade bone graft substitute in a rat model, ADSCs yielded increased fusion mass volume and rates of fusion than bone marrow-derived stem cells. Ongoing studies will explore whether freshly isolated ADSCs will yield similar results.

Learning Objectives

By the conclusion of this session, participants should be able to:

1) Describe the potential role of BMSC and ADSC in spinal fusion.
2) Discuss the translational importance of these treatments.
3) Identify advantages offered by these alternatives therapies.

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