Influence of Age on Posterolateral Spinal Fusion in Rabbits Using Autograft

INTRODUCTION:
Successful posterolateral fusion with continuous bony bridges between the transverse processes of adult rabbits has been reported by numerous groups using autologous bone harvested from the iliac crest using the Boden model [1]. Age in general has an overall adverse effect on skeletal healing although its role in posterolateral fusion is not well understood. This study examined the influence of animal age on spinal fusion using a standard model and experimental endpoints. We hypothesized that fusion quality and quantity would be less with increasing age.

METHODS:
A single level posterolateral spinal fusion between the fifth and sixth lumbar segments were performed in 6 month and 2 year old New Zealand white rabbits (n=6 per group) following ethical clearance using the Boden model [1]. The transverse processes of L5 and L6 were decorticated bilaterally using a Midas Rex burr and graft material was placed in a bridging fashion over the transverse processes and intertransverse membrane. A total of 3.0 g autograft was harvested from both iliac crests. This was morcelized into small pieces and 1.5 g was used on each side. The multifidis and longissimus muscles were replaced over the graft site and the fascia and skin were closed in layers. All animals were sacrificed at 12 weeks following surgery.

Posteroanterior Faxitron radiographs and axial computed tomography slices were taken for all animals. DICOM data was imported and analyzed with MIMICS software (Version 12, Materialise, Belgium). Three-dimensional models were created to visualize the fusion masses between the transverse processes as well as individual slices in the axial, coronal and sagittal planes. Bone mineral density measurements were performed using a Lunar DPXL Dexas machine. A region of interest between the transverse processes was used to assess the bone mineral density (BMD). Tensile mechanical testing was performed using an MTS Bionix testing machine. The peak load and stiffness for each animal was determined from the load versus displacement graphs. Sagittal and coronal plane histology was evaluated in a blinded fashion using H&E, Tetrachrome and Pentachrome stains. Assessment included overall bony response on and between the transverse processes. Mechanical data was analyzed using ANOVA followed by a Games Howell post hoc test when appropriate (SPSS 15, SPSS Inc., Chicago IL).

RESULTS:
Radiographic and computed tomography data confirmed the delay in healing in the posterolateral fusion mass in the 2 year old animals compared to the 6 month old animals. Radiographic fusion rates decreased from 83% in the 6 month old animals to 50% in the 2 year old cohort. Some new bone formation was observed directly on the vertebral body was decreased in the older animals (P<0.05). Tensile mechanical data revealed a 30% reduction in peak load (P=0.024) and 34% reduction in stiffness (P=0.073) in the 2 year old animals when compared with the 6 month old animals.

Histology demonstrated a reduction in overall biological activity in the 2 year old animals compared to the 6 month animals. This reduction in activity was observed in the more challenging intertransverse space as well as adjacent to the transverse processes and vertebral bodies at the decortication sites. Numerous sites of new bone formation was present in the middle of the fusion mass in the 6 month animals while the bone graft in the 2 year old animals were less viable (Figure 3).

DISCUSSION:
Skeletal healing is a complex process mediated by a cascade of both local and systemic biological factors. Mechanical stability and patient related factors can significantly influence the outcome of bone healing. Patient age has been shown to be related to a slowing or delay in skeletal repair. In the situation where autograft is utilized, this may be related to overall graft quality as well as the level of growth factors, hormones and nutritional supply in the surrounding milieu. This study demonstrated a reduction in fusion rate as well as an overall decrease in the properties of the fusion complex in the 2 year old group compared to the more traditionally used 6 month animals. Radiographs, CT, histology and mechanical properties were inferior in the 2 year old rabbits. This aged rabbit model may be useful in evaluating new treatment modalities in a more difficult model considering that autograft did not fair too well. The mechanisms behind this overall reduction requires further studies and may provide insight into more clinically relevant questions in the future.

REFERENCE: