Distraction Increases Vertebral Body Growth, Intervertebral Disc Height and Volume, and Nucleus Pulposus Expansion; An in Vivo Study on Rodent Tail Model

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Introduction

• Hypothetically distraction-based growth-friendly techniques spare growth plates and spinal growth
• The effect of distractions on disc and vertebral body are unknown
• To evaluate the effect of distraction on an immature animal spine model
Materials and Methods

- 32 C57/BL6 female mice, 8 animal in 4 groups

Initial MicroCT and X-ray

MicroCT every 14 days and X-ray every 7 days
Surgical Procedure

- Pins inserted in 7\textsuperscript{th} and 9\textsuperscript{th} Vertebral body
- Distraction at 2x body weight
- Adjust strain to keep distraction forces
Materials and Methods

- The vertebral growth, end plate morphology
- Bone volume fraction (BV/TV)
- Intervertebral disc growth, volume and viscoelastic behavior
- Glycosaminoglycans (GAGs) content of the intervertebral disc
- Histologic evaluation of disc and growth plates
Results

• All animals completed the study, No complications
• Mean weight of 23.4 g, no weight differences
• Osteointegration with fully mineralized lamellar bone forming around the implant site

microCT

Histology
Disc Height

- Disc height increased significantly in distracted levels compared to control vertebral in all groups.
Disc Volume

- Disc volume increased in distracted levels compared to control levels in all groups.

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<thead>
<tr>
<th>Week</th>
<th>Control</th>
<th>Distracted</th>
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<td>6-20 Wk.</td>
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• G6-20wks group had 60% increased in stiffness compare to its control.
All groups with distraction had statistically significant increase in loss of tangent compared to their control groups.

Viscoelastic Behavior of Intervertebral Disc

Loss Tangent

- 6-20 Wk Dist.
- 12-20 Wk Dist.
- 6-16 Wk Dist.
- 6-20 Wk Sham
Intervertebral Disc Composition

- GAG (Glycosaminoglycans) content decreased in distraction group level compared to control groups.
Histologic evaluation showed expansion of disc and proliferation of nucleus pulposus.
Vertebral Body changes

- Vertebral length increased in distracted levels compared to control levels in all groups
End plate bone volume fraction decreased in distraction levels in all groups compared to their controls.
End Plate Morphology

- Deepening in the center of end plate, increase pore size, decrease bone concentration at the center

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Summary

• Disc Height and Volume increased
• VB length increased
• Endplate TV increased, Bone volume decreased
• Mechanical evidence of degeneration
  – GAG content ↓
  – Stiffness ↑
  – Delta tangent ↑
• Microscopic evidence of regeneration
  – NP volume expanded
  – NP Proliferation
Limitations

- Animal Study
- Tail model
- Non Human Primates (Monkeys) best spinal models but limited availability
Conclusion

• First study to evaluate the effect of distraction on immature spine
• Growth modulation of VB and disc were achieved with no endplate diastasis or growth arrest
• Detailed new information on growth plate and disc provided and will be a road map for future work on spinal growth modulation