A quantitative study of parathyroid hormone (1-34) and bone morphogenetic protein-2 on spinal fusion outcomes in a rabbit model of lumbar dorsolateral intertransverse process arthrodesis

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Introduction

Lumbar spinal fusion is a common neurosurgical procedure. Over 250,000 lumbar spinal fusion operations are performed annually in the U.S. and, by far, dorsolateral intertransverse process arthrodesis (DIPA) is the most common type of fusion technique performed in the lumbar spine. Unfortunately, the rate of non-fusion (pseudoarthrosis) has been reported to be as high as 35%. Pseudoarthrosis is also one known cause of Failed Back Surgery Syndrome (FBSS), which is characterized by chronic back pain that is often unbearable and debilitating to the patient. In this study, our goal was to explore methods of improving the rate of fusion by first establishing an accurate animal model – more specifically the New Zealand White rabbit model, which has a pseudoarthrosis rate nearly identical to that of humans as well as similar spinal anatomy. We also aimed to assess the effects of osteoinductive agents PTH (1-34) and rhBMP-2 on bone turnover after DIPA spinal fusion in the rabbit model. We hypothesize that the use of both PTH (1-34) and rhBMP-2 has a synergistic effect on stiffness and composition of the bone fusion mass.

Methods

Surgery

Harvested cancellous bone from iliac crest is placed between L5 & L6 transverse processes after decortication.

Treatment

24 NZW rabbits will be assigned to each of the following 4 groups:

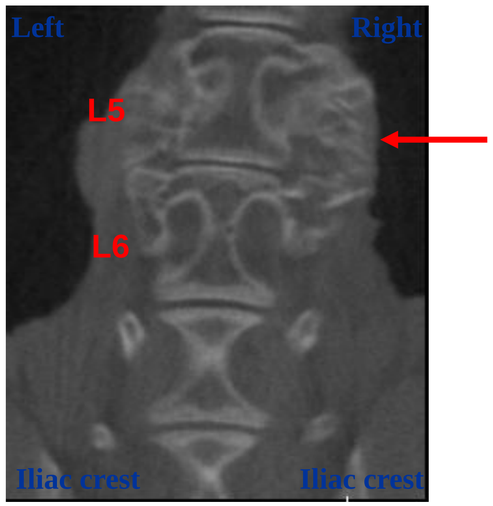
(1) Spinal fusion with iliac crest autograft and saline-based injections (control)
(2) Spinal fusion with rhBMP-2 matrix alone
(3) Spinal fusion with iliac crest autograft and PTH (1-34) injections
(4) Spinal fusion with rhBMP-2 matrix and PTH (1-34) injections

Rabbits are euthanized at postoperative week 6.
Each specimen undergoes manual palpation, radiographic analysis, four-point non-destructive biomechanical testing, and histological analysis.

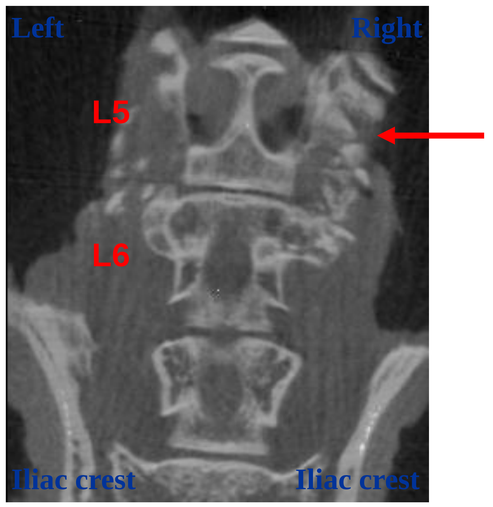
Results

Based on the CT reconstructions, the spine fusion rates for the control group (n = 9) and the PTH (1-34) group (n = 5) were 44% and 60%, respectively. Although manual palpation is used as the standard measure of fusion, radiographic analysis proved more effective in differentiating fused masses based on bone, not fibrous tissue.

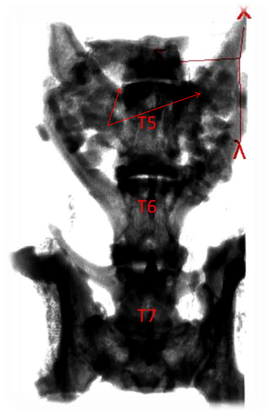
Coronal view of lower lumbar spine: **Fusion** between L5 and L6 vertebrae as demonstrated by **complete bridging with solid bone and lack of intervening soft tissues or gaps** (red arrow)



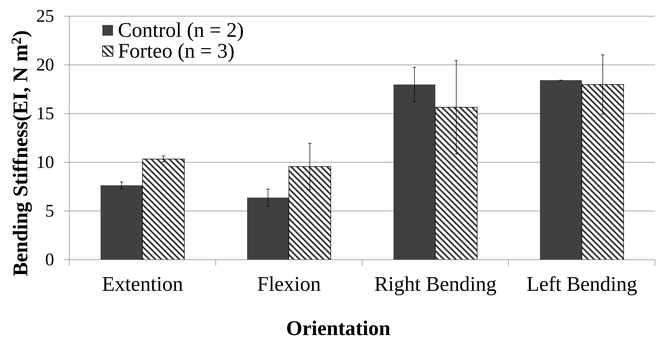
Coronal view of lower lumbar spine: **Pseudoarthrosis (non-fusion)** as demonstrated by **absence** of complete bridging with solid bone between L5 and L6 transverse processes (red arrow)



Anterior aspect of the 3D reconstruction of a specimen from the PTH (1-34) group, using CT radiographs. Red arrows highlight the fused segment between the transverse processes of L5-L6.



In both the control and PTH (1-34) groups, lateral bending in both the right and left orientations proved to be the stiffest testing orientation.



Conclusions

The New Zealand White rabbit model of dorsolateral lumbar spinal fusion is feasible. Furthermore, multiple methods of assessing fusion maximize the accuracy of this animal model. Preliminary data suggests that PTH (1-34) may enhance both the composition and mechanical properties of L5-L6 fusion in rabbits. As demonstrated by biomechanical testing, the enhanced bone formation in the PTH (1-34) group may be responsible for an increase in stiffness. We expect that data from the additional two groups will allow for further investigation of individual efficacies as well as any synergistic effects of PTH (1-34) and rhBMP-2.