Selective Densitometry and Novel Posterior Plate Design for Lumbar Spine Fixation

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CLINICAL MOTIVATION

- Bone mineral density (BMD) has been identified as a major factor in spine construct strength, with failures resulting in pedicle screw loosening and pullout
- BMD as a function of vertebral region has not yet been reported on for the lumbar spine

STUDY OBJECTIVE

The goal of this study was two-fold: 1) To report BMD of anatomical regions within lumbar vertebrae using the correlation between HU and BMD and 2) To apply BMD findings toward novel spinal fixation hardware design

METHODS

- 3D models of fifteen lumbar vertebrae (three subjects, L1-L5) were generated by high-resolution CT scans
- Each lumbar spine was segmented from its surrounding tissue, followed by segmentation of each vertebra into seven anatomic regions
- Hounsfield Unit (HU) values for each vertebral region mask were exported and converted into BMD using calibration phantoms of known BMD

RESULTS

- A segmented vertebra mask was exported as a solid model and its surfaces were used as geometric references for plate design within CAD software
- Plate prototypes underwent preliminary biomechanical testing
- Three distinct groups of vertebral regions exhibited statistically significant differences in BMD (p < 0.03)
- The lamina and inferior articular processes were shown to have significantly higher BMD than the pedicles (p < 0.02)
- Vertebral body BMD was lowest overall

CONCLUSION

- BMD results indicate a possible need to evaluate specific anatomical regions for bone quality
- Pedicles in the lumbar spine rank third in BMD as opposed to first in cervical spine
- Based on BMD considerations, hardware fixation to the lamina and inferior articular processes may be advantageous in the lumbar spine
- Preliminary biomechanical test results support further refinement of posterior plate design

REFERENCES