Vertebral Body Screw Location: Effects on Pull Out Strength

1Mhatre D.; 1Parepalli B.; 1Goel VK.; +1,2Biyani A.; 1,2Smith A.; 1Kiapour A.; 1Parikh R.; 1Chikka A.
1Engineering Center for Orthopaedic Research Excellence (E-CORE)
Departments of Bioengineering and + 2Orthopaedic Surgery
Colleges of Engineering and Medicine
University of Toledo, Toledo, OH 43606
Senior author: ashok.biyani@utoledo.edu

INTRODUCTION:
Corpectomy is frequently indicated for a collapsed vertebral body due to trauma or tumor. The resected vertebral body is replaced with an anterior column support such as a cage filled with bone graft material and supplemental lateral plate/rod instrumentation. Such devices typically consist of two screws inserted laterally in a coronal plane in the mid portion of the vertebral body and the screws are then anchored with a side plate or rods, Figure 1. More recently, an extreme lateral or a direct lateral approach for spinal fusion has gained popularity, which utilizes a side plate with juxta-endplate screws to minimize laceration of segmental vessels. The highest density of bone is observed adjacent to endplates (Area fraction > 0.29) compared to area in center of vertebra (Area fraction < 0.20) [1]. As bone is stronger near the endplate, the authors hypothesize that such a fixation will be biomechanically superior to traditional screws inserted through the mid portion of the vertebra. Additionally, the latter fixation point places the lateral screw in the trajectory of a pedicle screw, should supplemental posterior pedicle screw fixation become necessary for an unstable spine. The purpose of this study is to compare the pull out strength of fully inserted screw in vertebral body at two positions, middle of the vertebra and near the inferior endplate, Figure 1. Effects of BMD (Bone Mineral Density) were also analyzed.

MATERIALS AND METHODS:
Standard pull-out strength testing described as per ASTM F543-01 [2] was used for this study. Total of 7 cadaveric paired vertebrae T11 and T12 vertebral bodies were used. Vertebral bodies were DEXA scanned. Vertebral bodies were placed in a bondo (2-part epoxy resin) for fixation. For each specimen consisting two vertebrae, vertebral screws (Anterior Expidium, Depuy spine, Inc.) were inserted laterally at middle near the posterior half of one vertebra in one body and near endplates of the other vertebra. Each potted vertebra was fixed to MTS machine with the help of a C-clamp. The screws were fully inserted manually and then were pulled out axially at 5mm/min. Care was taken that screw pull-out force remained axial and vertebra was held accordingly throughout the testing. The force and displacement were measured until the screw was almost out of the vertebra. The maximum pull out force was also determined. One vertebra failed during the testing so its pull-out data and the data for its adjacent vertebra were not considered in the experiment; therefore the results for six sets of specimens were compared.

RESULTS:
In each paired vertebrae, the maximum pull out force was always greater for screws placed near the endplate than screw inserted in the middle of the vertebral body, Figure 2. Maximum strength values increased with increase in BMD. Specimens with normal bone density showed increase in pull out strength around 30%. In case of osteoporotic bone the increase in pull out strength was remarkably high (70-90%), Fig 2.

CONCLUSION:
The increase in pull out strength for screw placed closer to endplate varied from 30-90 % of the values for centrally placed screws. One of the advantages of the screws placed closer to the endplates is the ease in placement of pedicle screws for a supplemental posterior instrumentation. Since there is a trend of higher percentage increase in osteoporotic vertebrae, the placement of screw closer to the endplate region will be more effective for osteoporotic spines. Further work is being pursued to verify the trend by testing additional vertebrae over a wider range of BMD, especially the lower range.

REFERENCES: