**Introduction:** The main question with disc replacements as well as the spine is the determination of its axial center of rotation due to the anatomic and functional complexity of the spine. Therefore, the objective of this study was to develop and validate a new method to determine the axial center of rotation for spinal segments.

**Materials and Methods:** To determine the axial center of rotation, a custom six degree of freedom device allowing for full range of motion was used. A Canon GL2 camcorder was mounted so that the lens looked directly down on the specimen. WINanalyze motion analysis software (Mikromak, Germany) was used to track markers on the specimen when a rotational torque was applied. The area that encompasses the center of rotation was determined by finding the five markers with the least amount of motion. Four separate experiments were performed to verify the testing device. The first experiment examined if WINanalyze could accurately determine the center or rotation in a known model. The second experiment examined the effects of tilting on the model while the third experiment examined if placement of the superior ring off-center around the model influenced the determination of the center of rotation. The fourth experiment examined the effects of translation. WINanalyze exported the x and y coordinates of markers placed onto the specimen from the beginning to the end of each trial. The distance that each marker moved was then calculated using the distance formula.

After validating the method, we tested four fresh human cadaveric spines. Thirteen spinal segments were tested: three L4-L5 segments; two L2-L3 segments; two L1-L2 segments; and one segment each of T10-11, T8-9, T6-7, T4-5, T2-3, and C7-T1. The inferior vertebral body was potted in a PVC pipe with plaster. Each segment was rigidly fixed at its base, allowing for full range of motion for the superior segment. Each segment was placed with the intervertebral disc oriented parallel to the ground. A plastic grid was placed on the superior vertebra to allow for marker placement using WINanalyze software. A PVC pipe ring was placed around the superior vertebra via fixation screws so that the vertebra would be free to rotate and translate during force application. A metal ring was mounted onto the superior PVC pipe ring. Fishing wire, three meters in length was wrapped around the metal ring and draped across four pulleys, with two pulleys directly horizontal to the metal ring and two superior pulleys attached to the Instron 4411 (Instron, Norwood, MA) machine. One set of pulleys rotated the specimen in the clockwise direction while the other set rotated in the counterclockwise direction (Fig 1). Torques of 3.5 N-m, 7 N-m, 11 N-m, and 14 N-m in both the clockwise and counterclockwise direction were applied to the specimens in random order. Using WINanalyze software markers were placed outlining the vertebral body, spinal canal, facet joints, and the spinous process (Fig 1). The x and y coordinates of each marker placed onto the specimen from the beginning to the end of each trial was found and the total distance that each marker moved was calculated. The five markers that moved the least distance were connected to encompass an area of the center of rotation. The marker angular displacement was calculated as the angle between a virtual line drawn between two points at the initial and final torque conditions.

**Results:** Validation testing verified that the custom device and WINanalyze software accurately determined the axial center of rotation in a model with a known axial center of rotation. Tilting the segment, placement of the segment in the center of the device, and translating the segment had no effect in determining the axial center of rotation. In the thoracic spine segments, rotation at all forces and in the clockwise and counterclockwise direction was averaged, with the five points that moved the least forming an area around the posterior part of the vertebral endplates and the anterior part of the spinal canal (Fig 2a). Angular displacement of the thoracic spine segments was similar in both the clockwise and counterclockwise directions, with an average clockwise to counterclockwise angular displacement ratio of 0.973. The lumbar spinal segments also averaged an axial center of rotation also at the posterior part of the vertebral endplates and the anterior part of the spinal canal. (Fig 2b). The average clockwise to counterclockwise angular displacement ratio of the lumbar spinal segments was 0.868.

**Acknowledgements:** VA Rehab R&D, John C. Griswold Foundation.

**Figure 1:** Marker points established for data collection.

**Figure 2:** Average Area encompassing center of rotation.

**A:** Thoracic spine segment. **B:** Lumbar spine segment.