INTRODUCTION
Abnormal cervical spine motion may result in excessive loading to the intervertebral discs, leading to disc degeneration. Intervertebral range of motion is a standard metric used to evaluate spine motion. However, range of motion only describes the amount of motion, not the quality of motion. The instant center of rotation (ICR) has been proposed as a reliable, stable parameter of the quality of vertebral motion through which abnormalities could be explored [1]. Characterizing the quality of motion may be important for analyzing changes in motion due to pathology or surgical intervention.

ICR has been determined in the cervical spine using static radiographs collected at full flexion and extension [2]. Single-plane sagittal radiographs collected during active motion have also been analyzed [3]. Additionally, center of rotation has been reported for patients who received anterior cervical fusions and disc arthroplasty [4]. Limitations of these previous studies include data collection during static end range-of-motion positions and manual identification of landmarks on radiographs.

METHODS
Normal control subjects (n=3) performed three continuous flexion/extension motion trials within a biplane x-ray system while images were collected at 30 frames per second for 3 seconds. The full range of motion for each vertebra was tracked using a model based tracking technique [5] to match subject-specific 3D bone models to the collected biplane radiographs. Three dimensional motion of the cervical spine was then recreated and relative rotations between each pair of adjacent vertebrae were calculated.

Anatomical coordinate systems were defined for each vertebrae from points defined from bony landmarks on the subject-specific 3D bone models of each vertebra (Figure 1). Relative rotations between adjacent vertebrae were then calculated using these anatomical coordinate systems to determine the rotation of the superior bone with respect to the inferior bone for each adjacent pair (Figure 2). Calculating the relative rotations with respect to anatomical coordinate systems in this way allowed for comparison between subjects.
well as the angle of rotation about this axis, were found first and used to calculate the ICR, which is defined in this study to be the point of intersection between the helical axis and the Y-Z plane of the inferior vertebra’s anatomical coordinate system.

It is well understood that there is error in calculating helical axis parameters for rotations with an angular velocity approaching zero. Similar to previous studies, a threshold was set at .08 rad/sec for this study [7]. This limited our analysis by excluding portions of the motion when the bone positions were relatively static between frames.

RESULTS
Subtle differences in the ICR location were seen when looking at the entire range of dynamic data (Figure 4).

DISCUSSION
This is believed to be the first study to report ICR in the cervical spine during in vivo flexion/extension. Small, consistent differences in ICR location were observed, with the ICR located more anterior during flexion and more posterior during extension. Contrary to previous reports, the ICR was located near the geometric center of each vertebra.

Future analysis of more subjects will be done to compare cervical spine motion of normal control subjects to patients who have undergone physical therapy or surgical intervention. This may provide valuable information about changes in cervical spine motion due to various treatments.

REFERENCES

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