IN VIVO SEGMENTAL MOTION MEASUREMENT IN ASYMPTOMATIC AND CHRONIC LOW BACK PAIN SUBJECTS USING VOLUME MERGE METHOD

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INTRODUCTION

Spinal instability has been suggested as a potential cause of low back pain and axial rotational instability, in particular, has been implicated in its pathogenesis due to the presence of disc degeneration (DD) [1]. The use of radiographs has been under scrutiny in that it has been shown to be difficult to accurately measure vertebral translations and impractical to measure out of plane rotations with the 2D radiographic images [2, 3]. More precise techniques are generally invasive. The current study has expanded on a 3D non-invasive imaging technique to compare *in vivo* vertebral motions in human lumbar spines for healthy and chronic low back pain (LBP) subjects [3].

METHODS

Using serial CT scans, a 3D computer model was developed to analyze lumbar segmental motion under axial torsion *in vivo* (Figure 1A). Male volunteers in their thirties (9 healthy (mean age: 33.8 ± 2.8 years) and 5 LBP (mean age: 33.0 ± 3.5 years)) were recruited to participate in this imaging study (IRB approved). The subjects were placed on a custom jig positioned in the CT scanner. The subjects were scanned in three positions: neutral (supine) and right and left rotated to 50° [4]. Reconstructed lumbar CT images were analyzed using the volume merge method, which virtually merged two 3D vertebrae models to calculate segmental motions in increments of 0.1mm and 0.1° (resolution: 0.2° and 0.1mm) (Figure 1B). Segmental rotations and translations between adjacent vertebral bodies were calculated in three major planes. All subjects were scanned using MRI for determination of disc degeneration using Thompson's grading system. Statistical analysis was conducted using unpaired t-tests with α=0.05.

RESULTS AND DISCUSSION

Segmental rotations were greatest in torsion with a trend for larger motion at L3/4 in LBP group (2.1° vs 1.6°, $p<0.08$) (Figure 2). Lateral bending occurred in the direction opposite external rotation for upper vertebrae and with external rotation for the lower vertebrae, but these motions were not significantly different between groups. Segmental translations were neglible, except for the frontal plane with the greatest magnitudes in the upper vertebrae (range -6.0° at L1/2 to 1.4° at L5/S1). In addition, the frontal plane translations showed significant differences between levels ($p<0.01$) but not between groups ($p>0.4$). There was a trend for greater degeneration in the LBP versus healthy group at L3/4 and L4/5 ($p<0.1$ and $p<0.09$, respectively).

CONCLUSIONS

Eventhough there was a relatively small sample size, some trends were determined. As expected there was greater level of degeneration in the LBP group, which also showed greater motion in torsion in the middle vertebrae. In addition, pure *in vivo* torsion resulted in complex coupled motions with large lateral bending and frontal plane movements, especially in the upper lumbar vertebrae. Additional studies into segmental motion will be conducted in order to determine potential correlations with lumbar DD and LBP subjects' pain mapping.

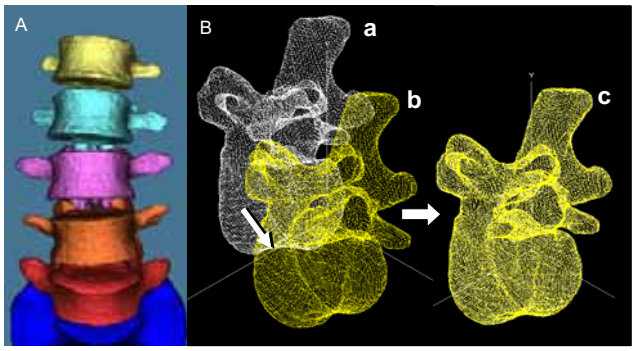

Figure 1: (A) 3D reconstruction of subject's lumbar spine from CT scans. **(B)**Vertebral body in the neutral position (a) was virtually rotated and translated toward the real rotated position (b) with 0.1° and 0.1mm increments, respectively, until the highest value of volume merge was calculated (c).

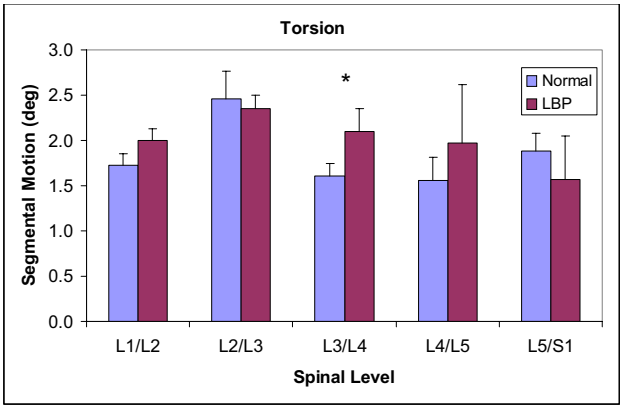

Figure 2: Comparison of torsional segmental motion between healthy and LBP subjects (mean ± standard error of the mean). * $p<0.08$

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