INTRODUCTION: Effects of spinal motions on relief of low back pain have been reported in the literature [1,2]. Although the exact mechanism of pain relief remains unclear, an in vitro study using porcine lumbar spines demonstrated that small vertebral rotations cause depressurization of the nucleus pulposus via an increase in intervertebral disc height during torsion [1,3]. A similar study using human cadaveric lumbar spines, however, showed neither a decrease in disc pressure nor an increase in disc height during axial rotation [2]. Although these in vitro studies allowed measurements of disc pressure and disc height using cadaveric specimens, the lumbar segmental movements may be different in vivo. Furthermore, the previous studies only measured changes in overall disc height during torsion. Measurement of disc height distribution, rather than a single overall disc height, during axial rotation is required due to coupled segmental motions during torsion. We have developed an in vivo technique for the measurement of the intervertebral disc (IVD) height distribution during torsion using subject-based 3D CT models [4]. The objective of this study was to determine said disc height distribution changes during torsion in vivo.

METHODS: Lumbar spinal geometry data, via CT scans (IRB-approved), was obtained in vivo from 81 human subjects aged 23 to 59 years old. Data was collected while the subjects’ spine was in neutral position as well as rotated 50° to the right. CT data was used to create point clouds of each vertebral body. Using a custom-written Visual C++ program, the point clouds of each endplate (superior and inferior) were individually separated from those of the vertebral body. The endplate point clouds were then pieced together, superior to inferior, in order to create a point cloud model of the IVD. Each IVD was separated into 5 zones: posterior, left lateral, anterior, right lateral, and the central nucleus pulposus (Figure 1). The average heights of each of the 5 zones of the IVD were calculated in both the neutral and rotated positions. Statistical analysis was carried out through paired t-tests. Significance was set at p < 0.05. Data is presented as mean±SD.

RESULTS: The average height of an IVD while the spine was in the neutral position was 7.3±1.59 mm. When the spine was rotated 50° to the right, there was a small but significant increase in the overall average IVD height to 7.4±1.52 mm (p < 0.0002). The right side showed larger separation in most levels with the exception of L5/S1, which did not show differences as large as the other levels in peripheral IVD height during torsion. The posterior and right zones increased in height from neutral to rotated position of the spine (p < 0.0001), while the left, anterior and central decreased. Said differences were significant: left and central: p < 0.0001, anterior, p = 0.02. Specifically, the right side had an increase in mean separation of 7.00±1.66 mm in neutral position vs. 7.97±1.92 mm in the rotated position. Conversely, the left side decreased from 7.29±1.74 mm to 6.76±1.69 mm in torsion. Figure 1 summarizes these changes and shows that on average, the height of each lumbar IVD during rotation was greater than its height while the spine was neutral.

DISCUSSION: The results of the present study show that the overall average disc height in the right 50° position of the spine was greater than the overall average disc height in the neutral position. This result agrees with a previous in vitro study using cadaveric porcine lumbar spine showing an increase in the disc height by 0.23 mm during 2° axial rotation of the spine [3]. Such motion correlates to our previous measurements of segmental rotational range of motion between 0.6°-2.2° in torsion [5]. In the present study, the more significant changes of the disc height were noted in the peripheral zones. As the spine was rotated 50° to the right, the disc height in the right lateral zone increased while the left lateral zone decreased, and the disc height in the posterior zone increased while the anterior zone decreased. This disc height distribution corresponds to the coupled segmental motions (anterior flexion and lateral bending) associated with axial rotation [5]. The disc height in the central zone, which corresponds to the region of the nucleus pulposus, significantly decreased during torsion in the present study. At the L5/S1 level, the changes were not as significant as in the other levels. The left side of L5/S1 remained at the same mean IVD height. This can be attributed to the fact that the sacrum is usually considered a static reference frame for spinal motion and its mobility is generally much more restricted than that of the lumbar spine. The fact that the upper levels in the spine move in a direction opposite to those in the lower levels leads us to term it a paradoxical motion. This might be caused by the specific structural configuration of the spine at such levels, mainly the facet joints orientation and segmental lordosis, due to which the L5 vertebra is usually tilted anteriorly in contraposition to the mostly parallel stacking of the upper lumbar levels. This result does not support the hypothesis that depressurization of the nucleus pulposus via an increase in intervertebral disc height during torsion proposed in a previous study [1]. It has been postulated that the increase in disc height would decrease facet joint loading [1]. It remains to be clarified whether the increase in the disc height in the posterior region noted in the present study would cause the decrease in the facet loading or the increase of the posterior disc height was brought by overriding of the facet joint during torsion due to three-dimensional orientation of the facet joint [6]. Future studies will investigate correlations between the changes in disc height distribution and in facet kinematics and/or changes in facet joint space width during torsion.

SIGNIFICANCE: To understand the relief that torsion often provides for lower back pain by studying the structural change of intervertebral discs during motion.

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REFERENCES


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