IN VIVO CHARACTERIZATION OF INTRADISCAL PRESSURE IN HEALTHY THORACIC INTERVERTEBRAL DISCS

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Introduction

Intervertebral disc degeneration is associated with high medical costs and decreased quality of life. The structural role of the spine and the clinical response to intervention indicate a relationship between spinal pathology and mechanical factors. By better understanding these mechanics, we can hope to uncover causes for spine pathologies and develop more efficacious treatment methods. Measurement of intradiscal pressure (IDP) is one repeatable and minimally invasive method to quantify spinal loading in vivo. While extensive IDP data have been collected from the lumbar spine, we are not aware of any studies quantifying IDP of the thoracic region. Articulating rib heads and the sternum anteriorly make the middle thoracic spine mechanically unique from the lower region. The thoracic spine can be divided into three segments with the lower section being pathologically distinguishable by having a higher incidence of disc degeneration. The purpose of this study is to measure the IDP of healthy thoracic discs during different body positions and maneuvers. This information will provide a more complete picture of spine biomechanics and be applicable to spinal modeling and pathologies.

Methods

This study was conducted with the approval of our local institutional review board. Six volunteers (4 male; 2 female; age range 19-47 years) consented to participate after information concerning the risk of the procedure was explained. Magnetic resonance imaging was used to identify at least one radiologically normal disc from the middle thoracic (T6-7 or T7-8) and lower thoracic regions (T9-10 or T10-11) in each volunteer for IDP measurement. Pressure measurements were taken with a needle-mounted thin film metal diaphragm pressure transducer (Gaeltec, Isle of Skye, Scotland). The needle was placed into the nucleus pulposa under fluoroscopic guidance after preliminary administration of local anesthetic. With the transducer in place, pressure was measured while the subjects performed a sequence of maneuvers in the prone, sitting, and standing positions (Table 1). Data were recorded at 22 Hz with a laptop data acquisition system (National Instruments DAQ-516 ADC, LABVIEW, Sony VAIO Laptop). In the prone, sitting upright, and standing upright positions, readings were taken with the needle oriented horizontally and vertically to assess the directional dependence of the sensor, while the rest of the positions were recorded with a vertical needle orientation. Angles of flexion and extension were measured externally with an inclinometer. Subjects held their breath during maneuvers in order to minimize the effect of ventilation on thoracic IDP.

Table 1: Maneuvers performed during IDP measurements

<table>
<thead>
<tr>
<th>Position</th>
<th>MANEUVERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prone with needle vertical</td>
<td>8. Standing upright</td>
</tr>
<tr>
<td>3. Sitting upright</td>
<td>10. Standing in 30° flexion</td>
</tr>
<tr>
<td>4. Sitting holding 20 kg with arms flexed to 90°</td>
<td>11. Standing valsalva</td>
</tr>
<tr>
<td>5. Sitting in 15° extension</td>
<td>12. Standing with 20 kg with arms each side</td>
</tr>
<tr>
<td>6. Sitting in 30° flexion</td>
<td>13. Standing with 20 kg with arms flexed to 90°</td>
</tr>
<tr>
<td>7. Sitting valsalva</td>
<td>14. Standing in 30° flexion with weights at sides</td>
</tr>
</tbody>
</table>

Results

Itradiscal pressure measurements from one middle and one lower thoracic disc were taken in all but one of the participants. Due to the inability to access a middle disc in one subject, two discs from the lower region were measured. Figure 1 compares the average pressures in the middle and lower thoracic discs during a variety of maneuvers. The pressures recorded at each disc level were similar to each other in each of the positions. There was also minimal deviation in pressures when the needle orientation was varied from horizontal to vertical in the lying prone, upright sitting, and upright standing positions (data shown for prone only). The highest pressure recorded was from the lower thoracic region while the subject was sitting and holding 20 kg with arms flexed (2.48 MPa). The lowest pressure was observed in the lower thoracic discs when the needle was oriented horizontally while in the prone position (0.18 MPa).

Figure 1: Average pressures in selected maneuvers taken from the middle and lower thoracic discs. The numbered positions correspond to those listed in Table 1.

Discussion

This study used a minimally invasive technique to measure IDP of the middle and lower thoracic discs in various body positions. Interestingly, there was not a significant difference found in pressures recorded from these two regions of the spine. These data suggest that biomechanical differences other than pressure may be important in elucidating the pathomechanics of disc degeneration in the thoracic spine. Figure 2 compares pressures from the lumbar spine reported by Nachemson in 1970 to those of the middle and lower thoracic spine from our work. There were some significant differences in pressures between the lumbar discs, and middle and lower thoracic spine. The information presented here will aid in understanding spine biomechanics, and its relationship to spine pathology and treatment.

Figure 2: Comparison of intradiscal pressures taken from the lumbar*, and middle and lower thoracic discs. *Significant difference between lumbar and thoracic pressures (p<0.05).

References


Acknowledgements

This study was supported by AO North America, Midwest Orthopaedic Research Foundation, and the Center for Diagnostic Imaging.