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Assessment of Cervical and Lumbar Kinematics in Simulated Open and Closed Kinetic Chain Pelvic Tilting: A Preliminary Cadaveric Model

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Disclosures

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Introduction & Background

- Both Anterior Pelvic Tilt [APT] and Posterior Pelvic Tilt [PPT] can occur in the setting of either an open kinetic or closed kinetic chain.
- Prior literature analyzing pelvic tilt and spine kinematics have focused primarily on the closed kinetic chain lumbar kinematics
- Our study aims to comparatively assess the effect of open vs closed chain anterior and posterior pelvic tilt on cervical and lumbar spine kinematics using an in vitro cadaveric spine model.

Materials and Methods

This study was designed as an in vitro human cadaveric study to explore the biomechanics of the spine during pelvic tilt while simulating either open or closed chain movements.

- Three fresh-frozen cadaveric spines with pelvis intact were suspended and aligned in the center of a custom metal frame.
- Closed chain tilt was simulated by rotating a mobile sacral axis about a fixed acetabular axis.
- Open chain tilt was simulated by rotating a mobile acetabular axis about a fixed sacral axis.
- Optotrak camera captured cervical and lumbar intervertebral data in the sagittal plane [Figure 1].
- Kruskall Wallis test was used to assess differences in intervertebral displacements and post hoc analysis was conducted using pairwise comparison with Dunn-Bonferroni correction.

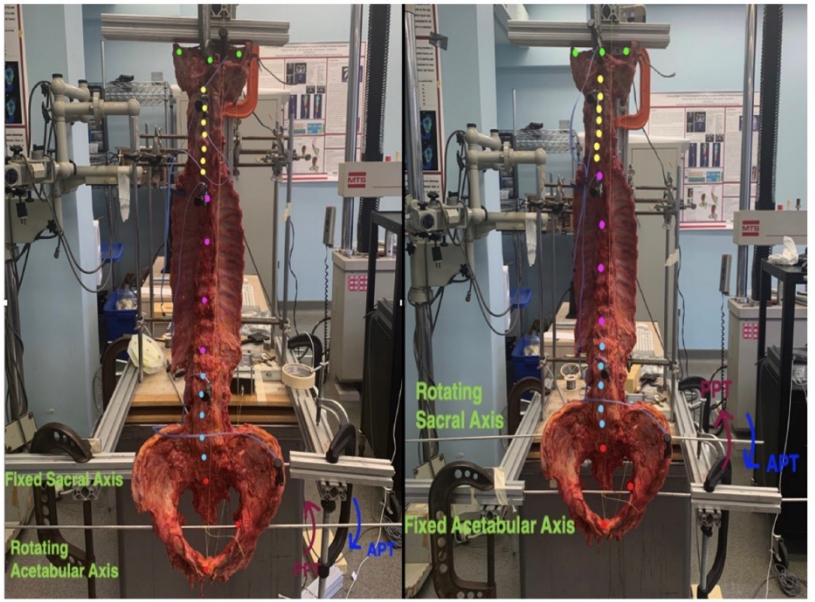

Figure 1: Experimental Setup: A) Coronal/Front view with Sacral axis fixed and B) Coronal/Front view with Acetabular axis fixed. PPT- Posterior Pelvic Tilt. APT-Anterior Pelvic Tilt. The dots represent the digitized points taken for the Optotrak: green dots for the skull, yellow dots for the cervical spine vertebral body (VB), pink dots for the thoracic spine VB, blue dots for the lumbar spine VB and red dots for the sacrum and pelvis.

Results

During PPT, two cervical locations (C2/C3, C3/C4) and four lumbar locations (L1/L2, L2/L3, L3/L4, L4/L5) had significant differences between open and closed chain [Figure 2]. During APT, no locations had significant differences between open and closed chain [Figure 3].

In closed chain PPT, relative intervertebral displacement decompression was significantly different between C2/C3 [4.85 mm] and C5/C6 [1.26 mm] [$p<.05$]. In closed chain APT these types of significant differences were noted between spinal levels L1/L2 [2.87mm] and L5/S1[24.48 mm] and between L3/L4 [2.94 mm] and L5/S1 [24.48 mm] [$p <.05$ for both].

In open chain PPT and APT, no significant differences in relative intervertebral displacement were noted at cervical spinal levels. In open chain PPT, no significant differences in relative intervertebral displacement were noted at lumbar spinal levels. In open chain APT, significant differences in relative intervertebral displacement decompression existed between spinal levels L4/L5 [1.53mm] and L5/S1 [25.14 mm] and between L2/L3 [1.68 mm] and L5/S1 [25.14 mm] [$p<.05$ for both].

Results

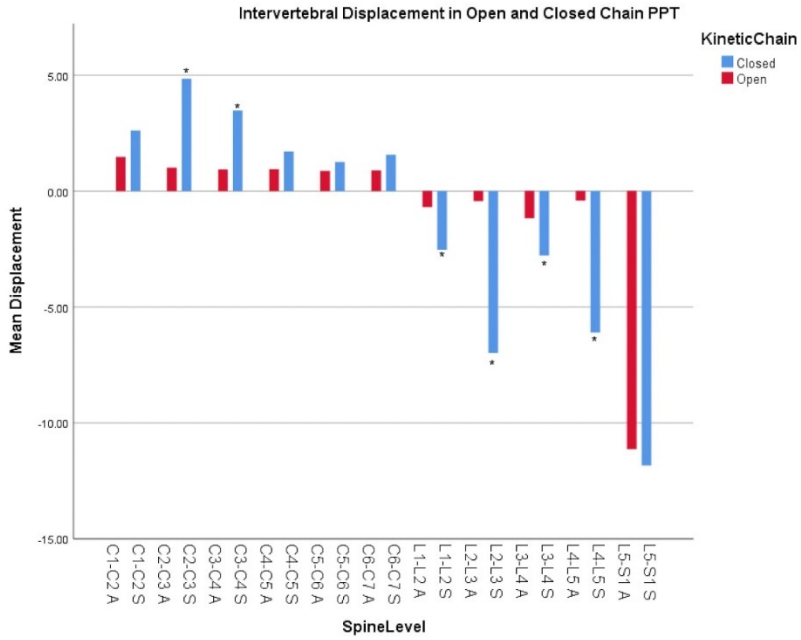

Figure 2: Cervical and Lumbar intervertebral displacement in open and closed chain pelvic tilt. Multiple spinal locations (C2/C3, C3/C4, L1/L2, L2/L3, L3/L4, L4/L5), indicated by asterisks, had significant differences between open and closed chain. In closed chain PPT, relative intervertebral displacement decompression was significantly different between C2/C3 [4.85 mm] and C5/C6 [1.26 mm] [p<.05]. In open chain PPT, no significant differences in relative intervertebral displacement were noted at cervical or lumbar spinal levels.

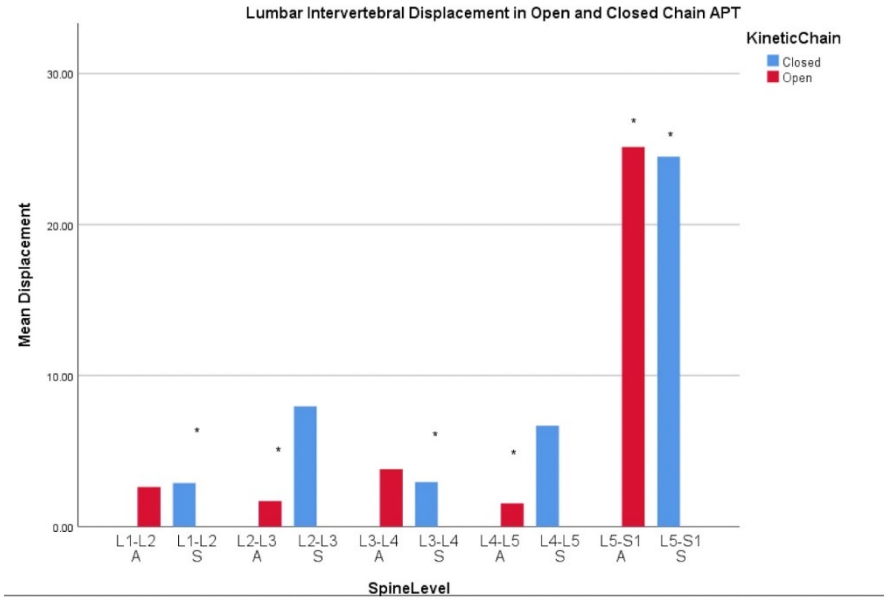

Figure 3: Lumbar intervertebral displacement in open and closed chain pelvic tilt. There were no significant differences between open and closed chain displacement. Asterisk indicates significant differences between displacement seen at certain spinal levels within the same kinetic chain. During closed chain APT, there were significant displacement differences between L1/L2 [2.87mm] and L5/S1[24.48 mm] and between L3/L4 [2.94 mm] and L5/S1 [24.48 mm] [p <.05 for both]. During open chain APT, there were significant displacement differences seen between spinal levels L4/L5 [1.53mm] and L5/S1 [25.14 mm] and between L2/L3 [1.68 mm] and L5/S1 [25.14 mm] [p<.05 for both].

Conclusion/discussion

The greatest overall displacement was seen in the L5/S1 vertebral segment, which showed a large compression during PPT and a large decompression during APT. This would indicate that this vertebral segment may take on the majority of stress during varying degrees of sagittal pelvic misalignment.

Notably, only PPT produced significant differences in intervertebral displacement between open and closed chain at specific lumbar and cervical locations. In all these locations, the displacement was larger with closed chain movement, which is expected, given that open chain movements allow joints to move independently from other segments of the body.

The results of this study may be helpful to determine how a patient's pelvic tilt may cause impingement or other pain in certain areas of the spine which can be used to determine which stabilizing muscles are important to rehabilitate. The data produced here may also be helpful in determining which rehabilitation exercises may be more difficult or prone to injury for patients with either excessive anterior or posterior tilt. The results of this study demonstrate that altering the pelvic tilt significantly changes the angle of lumbar lordosis. In fact, an increase in pelvic tilt is a cornerstone of a variety of posture problems, including those that affect not only the low back but the cervical spine as well.

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