Dimensional Changes of the Neuroforamen Following Anterior Decompression of the Cervical Spine: A Micro-CT Investigation

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Background

- Anterior cervical discectomy and fusion (ACDF)
  - Addresses both direct and indirect compressive factors

- Indirect neural foraminal decompression
  - 67% increase in foraminal area in the lumbar spine following anterior lumbar interbody fusion (ALIF) (Rao et al.)
  - No studies have been conducted to determine if a similar phenomenon occurs in the cervical spine following ACDF
Study Objective

❖ Using an in-vitro cadaveric model, the purpose of the investigation was to quantify the dimensional changes in the neuroforamen and area available for the cord (AAC) following placement of various interbody devices (IDs) with and without posterior longitudinal ligament (PLL) removal.
Hypothesis

• Placement of an ID will increase the neuroforamen area with no difference between neutral and lordotic IDs, and no difference with or without resection of the PLL.

![PEEK lordotic interbody device (ID)](image)

Representative photographic images of the PLL intact (A) and the PLL resected (B).
Methods

• N=8 spondylotic cadaveric cervical spines (C3-T1)
• Each specimen underwent microcomputed tomography (micro-CT) scanning of the intact spine and after the following discectomies and reconstructions* at three contiguous levels (C4-C5, C5-C6, and C6-C7):
  1. Parallel
  2. Lordotic
  3. Optimal Lordotic
     – 1 mm height increase such that the posterior height of the ID equaled the posterior height of the parallel ID
  4. Parallel with PLL resected
  5. Lordotic with PLL resected
  6. Optimal Lordotic with PLL resected

*Polyether-ether-ketone (PEEK) interbody devices (12 mm wide x 14 mm deep) were utilized for both parallel and 7° lordotic reconstructions
Methods

• Measurements taken from oblique angle that provided the largest view of the neuroforamen (Smith et al.)
  – Oblique angle of image adjusted in transaxial plane – along axis of pedicle
  – Midline of pedicle determined in transaxial plane – for sagittal cut

• Optimal angulation and sagittal depth determined for each FSU
  – Separate exported image for each FSU was utilized for accurate measurements
Methods

• Experimental Endpoints:
  – Neuroforaminal height, width, and area
    (Kitagawa, Mauluccini et al., Smith et al.)
  – Area available for the cord (AAC)
    • Calculated by quantifying the empty space
      compared to the total space available for the cord

Representative midsagittal and axial images demonstrating the anterior (green line), lateral (red lines), and posterior (boney aspect of the posterior arch) boundaries used to calculate the area available for the cord (AAC) for each reconstruction.
Methods

• Statistical Analyses

  – A Repeated Measures Analysis of Variance and Bonferroni post hoc test was performed to assess differences between groups

  – A one-way ANOVA was also performed to ensure no differences between levels (C4-C5, C5-C6, and C6-C7) for each group

  – Significance was indicated at p<0.05
Results

- Bar height represents mean absolute values and error bars represent minus one standard deviation
- Statistical significance is indicated at $p<0.05$
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![Area Available for the Cord](image-url)
Discussion

• Over distraction of the disc space was avoided and interbody cages were trialed to determine appropriate height at each level
• Size 5, 6, 7, and 8 were predominately used, and correlate to the most common sizes used in clinical practice
Discussion

- **Indirect decompression**
  - Foraminal ≈ 30% increase vs. 42% with PLL removed
  - Central canal ≈ 45% increase vs. 100% with PLL removed

- **Posterior disc height importance**
  - Increases in foraminal area is primarily due to increases in foraminal height which is a function of the posterior disc height of the ID

- **Segmental lordosis**
  - Did not differ between IDs
  - Overall trend of increased lordosis with PLL intact
  - Potentially due to ligamentotaxis of the PLL moving the center of rotation anteriorly, essentially placing the interbody spacer wedge directly against the center of rotation and providing more of a distracting force (McAfee et al.)
Conclusions

1. **Indirect Decompression**
   - Creates a significant increase in neuroforaminal area which is further enhanced by PLL resection

2. **Parallel vs Lordotic IDs**
   - Distraction at the posterior aspect of the vertebral body is important

3. **Clinical Implication**
   - In cases of radiculopathy, resection of the PLL may be up to surgeon’s discretion as indirect decompression without PLL resection provides significant dimensional changes - especially with appropriately sized IDs
Disclosures

None of the authors has any potential conflict of interest.

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