Redefining Cervical Spine Deformity Classification through Novel Cut-Offs: An Assessment of the Relationship Between Radiographic Parameters and Functional Neurological Outcomes

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Disclosure Statement

• There are no disclosures relevant to the present study.
**Cervical Deformity (CD)**

**AMES-ISSG Classification**

- Includes 5 modifiers encompassing sagittal, regional, and global alignment
- Based upon a modified Delphi approach, expert surgeon opinion and available literature

**Lack of Connection to HRQLs**

- Bakouny and colleagues suggested that the modifiers of CBVA and TS-CL were not specific to individuals with cervical deformity and can occur in asymptomatic patients
  - And furthermore that the radiographic parameter cut-offs were **unrelated to patient-reported outcomes.**

**Objective**

To investigate the relationship between cervical parameters and the Health Related Quality of Life (HRQL) measure, mJOA.
Materials and Methods: Design and Inclusion Criteria

- Retrospective review of prospective, multicenter CD database (2013-2018 at 13 centers)

- Inclusion criteria:
  - Patients ≥ 18 years old
  - Patients had available preoperative radiographic sagittal imaging and HRQL data

- Data collection forms for preoperative demographics, CCI, and frailty (Miller et al.)

- mJOA HRQL scores were collected and categorized by severity per Tetreault et al.

  - 18 → None
  - 15-17 → Mild
  - 12-14 → Moderate
  - <12 → Severe

STATS

- The statistical method was the same as previously published literature by Tang et al.
  - After determining data followed a parametric distribution using the Shapiro Wilk Normality test (p=0.15, p>0.05), Pearson correlations were ran for all combinations of radiographic measures and mJOA
  - For significant correlations, linear regression and a binary logistic regression model were performed to determine a possible threshold of radiographic measures for which the correlation with mJOA scores was most significant.
  - The logistic regression model assigned values as binary variables > or < than a predicted threshold value.
  - Predicted threshold values were made at various increments for all radiographic variables and frailty.
    - The rough threshold for each ‘modifier’ was the value that demonstrated the lowest p-value.
  - Degree of myelopathy severity was evaluated by categorizing mJOA scores into groups: 18 (None), 17-15 (Mild), 14-12 (Moderate), 12 (Severe).
  - mJOA score published cut-offs of:
    - 14 for moderate and
    - <12 for severe myelopathy disability were used to find the new modifiers
Statistical Subanalyses

- **Spearman’s rho** assessed the strength of association between existing CD classification and the novel proposed.
- Predictive values of the modifiers were compared with binary logistic models, with each modifier as the sole predictor of each outcome. 3 outcomes were assessed:
  - Reoperation
  - Major complication
  - Mortality up to 2-years

- Statistical analysis was performed using SPSS software (version 21.0 IBM, Armonk, NY).
- All analyses were 2-sided and the level of significance was set to $p<0.05$
# Results: Correlations between Possible Modifiers of CD and mJOA Scores

- **123 CD patients** were included (60.5±10.1 years, 65% female, 29.1±8.2 kg/m²)

<table>
<thead>
<tr>
<th>HRQL</th>
<th>Correlation (Pearson’s r)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline mJOA Scores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McGregor’s Slope</td>
<td>-0.236</td>
<td>0.015</td>
</tr>
<tr>
<td>T1 Slope</td>
<td>0.006</td>
<td>0.945</td>
</tr>
<tr>
<td>C2-C7 Lordosis</td>
<td>0.225</td>
<td>0.012</td>
</tr>
<tr>
<td>TS-CL</td>
<td>-0.246</td>
<td>0.006</td>
</tr>
<tr>
<td>C2-T3 Angle</td>
<td>0.180</td>
<td>0.046</td>
</tr>
<tr>
<td>C2 Slope</td>
<td>-0.234</td>
<td>0.009</td>
</tr>
<tr>
<td>cSVA</td>
<td>-0.033</td>
<td>0.714</td>
</tr>
<tr>
<td>CBVA</td>
<td>-0.055</td>
<td>0.841</td>
</tr>
<tr>
<td>PT</td>
<td>0.004</td>
<td>0.966</td>
</tr>
<tr>
<td>Frailty</td>
<td>0.517</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Pearson correlations determined significant correlation between baseline mJOA scores and:
- McGregor’s Slope
- TS-CL
- CL
- C2-T3
- C2 Slope
- Frailty
**Results:** Predicted Thresholds with Logistic Regression Analyses

- Logistic regression models assigned values as binary variables greater or less than a predicted threshold value, tested at increments.

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**McGregor’s Slope**
- **Low:** >-9° and <0°
- **Moderate:** -12° to -9° or 0° to 19°
- **Severe:** <-12° or >19°

**TS-CL**
- **Low:** <26°
- **Moderate:** 26° to 45°
- **Severe:** >45°

**C2-C7 Lordosis**
- **Low:** >3°
- **Moderate:** -21° to 3°
- **Severe:** <-21°

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**C2-T3 Angle**
- **Low:** >-25°
- **Moderate:** -35° to -25°
- **Severe:** <-35°

**C2 Slope**
- **Low:** <33°
- **Moderate:** 33° to 49°
- **Severe:** >49°

**Frailty**
- **Low:** <0.18
- **Moderate:** 0.18 to 0.27
- **Severe:** >0.27

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- McGregor’s Slope: $M(\chi^2 = 5.522, p=0.020)$ and $S(\chi^2 = 4.291, p=0.036)$
- TS-CL: $M(p=0.201)$ $S(\chi^2 = 7.8, p=0.005)$
- CL $M(\chi^2 = 8.947, p=0.004)$ and $S(\chi^2 = 9.3, p=0.009)$
- C2-T3 angle: $M(\chi^2 = 5.485, p=0.046)$ and $S(\chi^2 = 5.485, p=0.046)$
- Frailty: $M(p=0.129)$ $S(p=0.002)$
Decrease in mJOA scores with CD Severity
Results: Comparison with Established Ames CD Classification

• **TS-CL and horizontal (CBVA/MGS)** are the two modifiers in common between the Ames CD classification and the proposed cutoffs for moderate and severe deformity in this study.
  - Spearman’s Rho between the Ames and New:
    - **TS-CL**: 0.417 (p<0.001)
    - **Horizontal**: 0.518 (p<0.001)

• Binary logistic regression models analyzed each modifier from the Ames classification and the new modifiers for their predictive value of reoperation, major complications and mortality.
  - **AMES-ISSG**: cSVA predictive ability of reoperation (OR: 3.818[1.280-11.387], p=0.016)
  - **New Modifiers**:
    - **TS-CL modifier** revealed significant predictive ability for reoperation (OR: 2.151[1.024-4.517], p=0.043), and a trend for mortality (OR:2.332 [0.864-6.293], p=0.095).
    - **CL modifier** trended as predictive for mortality (OR: 0.469[0.193-1.139], p=0.094).
    - **C2-T3 modifier** significantly predicted the outcome of reoperation (OR: 0.435[0.246-0.769], p=0.004) and trended for mortality (OR: 0.536[0.266-1.081], p=0.082).
    - **C2 Slope modifier** significantly predicted reoperation (OR: 1.960[1.102-3.483], p=0.022) and mortality (OR: 2.043[0.979-4.263], p=0.050).
Conclusions

- **Novel thresholds** for moderate and severe disability were established for McGregor’s Slope, TS-CL, CL, C2-T3 angle, C2 Slope and frailty in cervical deformity patients.

- Each modifier correlated with moderate or severe neurologic myelopathy HRQL by way of mJOA score.

- These cut-off values can be utilized in further refining existing classifications and developing our collective understanding of severity grades for cervical deformities.