Cervical kyphosis does not imply cervical deformity: predicting cervical curvature required for horizontal gaze based on spinal global alignment and thoracic kyphosis

Bassel G. Diebo, Vincent Challier, Shaleen Vira, Barthelemy Liabaud, Renaud Lafage, Jensen Henry, Themistocles Protopsaltis, Frank Schwab, Virginie Lafage

NYU Hospital for Joint Diseases, New York, United States
**Definition**
- Lower Endplate C2
- Lower endplate C7

**Widely accepted as “normal cervical alignment”**
- 5 to 20 degrees in lordosis

**Smith et al, JNS Spine, 2012:**
- Spontaneous improvement of cervical alignment following correction of thoracolumbar deformity

**Is cervical lordosis always “normal”?**
**BACKGROUND: CERVICAL KYPHOSIS IN HEALTHY INDIVIDUALS**

**MORPHOLOGICAL STUDY OF THE LOWER CERVICAL CURVATURE: RESULTS OF 230 ASYMPTOMATIC SUBJECTS, EUROSPINE 2007, FALINE ET AL:**

**Method**
- Full spine Xrays
- Dedicated Software

**RESULTS:**
- 29% only with lordotic alignment > 10 degrees
- 32% With straight, kyphotic or sigmoid kyphotic

Cervical kyphosis is a strong player in healthy individuals
Le Huec, 2015:
- 34% of asymptomatic subjects with C2-C7 kyphosis
- C7 slope predicts the cervical alignment

Marnay T, 1988:
- C2-C7 should be proportional to T1 slope

Protopsaltis, 2013:
- T1 slope minus C2-C7 lordosis should be within 17 degrees
To investigate the effect of global alignment on cervical alignment while controlling for thoracic kyphosis.

- Establish quantitative **method** to identify “gaze friendly” cervical curvatures with respect to thoracolumbar sagittal alignment.
Retrospective single center study:
- Patients underwent full body imaging for various spinal pathologies

Inclusion:
- Age > 18yrs
- Horizontal gaze maintained:
  - CBVA between -4.7 to 17.7
  - SLS between -5.1 to 18.5
  - McGS between -5.7 to 14.3
- Thresholds chosen based upon correlation between horizontal gaze and HQRoL
  - Lafage R, 2015

Exclusion: diagnosis of cervical pathology, presentation with cervical complaint, instrumentation above T3, fractures, malignancies, infection, NM scoli, ank spond
**Global**
- C7 sagittal vertical axis, SVA

**Spino-Pelvic**
- Pelvic incidence, PI
- Pelvic tilt, PT
- Thoracic kyphosis: TK (T1-T12)
- Lumbar lordosis: LL (L1-S1)

**Cranial**
- Chin brow vertical angle, CBVA
- McGregor, McGS
- Slope of line of sight, SLS

**Cervical:**
- Cervical curvature, C2-C7
- C2-C7 SVA
Stratified into 4 groups by Thoracic Kyphosis
- >50, 40-50, 30-40, <30

Patients were then sub-stratified based upon SVA:
- Posterior alignment: SVA <0mm
- Aligned: SVA 0-50mm
- Malaligned: SVA > 50mm

Statistical analysis:
- Compare C2-C7 cervical curvature between SVA groups in every TK group
- Stepwise linear regression to create formula predicting cervical lordosis
  - Random selection of 60% of patients
  - Used full cohort for formula validation
744 patients:
- Age: 53±19 y/o
- BMI: 26.5±5.7
- 71.6% females

Diagnosis:
- 54.8% adult spinal deformity
- 31.7% Stenosis
- 12.7% Degen spondy
- 8.4% DDD

Thoracic kyphosis groups:
- TK > 50, N = 265
- TK < 50 and > 40: N = 172
- TK < 40 and > 30: N = 163
- TK < 30 : N = 144
### RESULTS: more SVA and more TK => more lordotic CC

**Impact of SVA and thoracic kyphosis on C2-C7 Curvature**

- **SVA < 0 mm**: CC was mostly neutral or kyphotic
- **SVA 0-50 mm**: CC was lordotic
- **SVA > 50 mm**: CC was always lordotic
- **SVA < 0 mm**: Max cervical lordosis was 12°
- **SVA > 0 mm**: CC was kyphotic if TK < 40°

**TS - CL**:
- No significant differences
- Range in all groups: 18° - 23°

**RESULTS**

- **MORE SVA AND MORE TK => MORE LORDOTIC CC**

**Cervical lordosis significantly increased with increase of SVA (within TK group: purple curve)**

**Cervical lordosis significantly decreased with decrease thoracic kyphosis (Dashed line)**

- For TK < 30, CC was mostly kyphotic

**When SVA > 50 mm => Cervical curvature was always lordotic**

**When SVA < 0mm => CC was mostly neutral or kyphotic**
Development: regression analysis:
- C2-C7 CC as dependent variable
- TK, LL, LL-TK, SVA as independent
- Control for:
  - Age, gender, PI

Validation:
- Real C2-C7 CC as dependent variable
- Predicted C2-C7 CC as independent
- Control for:
  - Age, gender, PI and TK

Difference of 1.2° between actual and predicted CC

LL minus TK is an independent predictor of CC
(R = 0.644, p < 0.05)

Simplified Formula:
CC = 10 - (LL-TK)/2

RESULTS: FORMULA
Limitation:
- Incorporation of the pelvis
  - Pelvic morphology
  - Pelvic tilt
- Heterogeneity of the cohort
- Lack of clinical/soft tissue data

Conclusion:
- Kyphotic cervical alignment could keep the horizontal gaze in some well and posteriorly aligned patients
- However, lordotic cervical alignment is recommended for patients with SVA > 50 regardless of thoracic kyphosis.

Preliminary formula to predict CC:
- CC = 10 - (LL-TK)/2
Bassel G. Diebo, Vincent Challier, Shaleen Vira, Barthelemy Liabaud, Renaud Lafage, Jensen Henry, Themistocles Protopsaltis:
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Virginie Lafage
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- (b) (c) Nemaris

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