Why are cervical vertebrae not suitable for age estimation?

Bianca Gelbrich [1]

Miriam Fischer [2]

Angelika Stellzig-Eisenhauer [3]

Götz Gelbrich [2]

[1]*University Hospital of Leipzig (Germany), Department of Orthodontics*

[2]*University of Würzburg (Germany), Institute of Clinical Epidemiology and Biometry*

[3]*University Hospital Würzburg (Germany), Department of Orthodontics*

Corresponding author:
Bianca.Gelbrich@medizin.uni-leipzig.de

ORAL PRESENTATION

ABSTRACT

Background: The ability of cervical vertebrae (CV) staging to contribute in forensic age estimation is being discussed as a controversial issue. In head-to-head comparisons, CV methods have repeatedly been shown to be inferior to methods using hand bones or teeth. A reason might be the large variability of CV geometries in the end stage of development. Here we study measures of the geometry of adult CV and demonstrate that the description of the "typical" appearance of adult CV is often not met.

Methods: Lateral cephalograms from clinical routine of 309 subjects aged 20 years or above (median 24 years, 51% female) were evaluated. The criteria for the end stage of CV development (e.g., Hassel-Farman stages V/VI or Baccetti stage V) were examined using quite liberal thresholds of metric quantities for definition: 1. rectangular shape of C_3 and C_4 – considered fulfilled if anterior:posterior height ratio was ≥0.9 and the angles between the anterior/posterior and the superior side were ≥70° and ≤110°; 2. at least one of C_3/C_4 rectangular in vertical shape (if not both, the second is squared) – considered fulfilled of height:width ratio was ≥0.9; 3. Significant concavities at the inferior margin of C_2, C_3 and C_4 - considered fulfilled if the angles of the concavities were ≤160° (reference images for established staging schemes suggest <150°). Metric data of the adults were also compared to those of 102 children aged 8-10 years (49% female).

Results: Adult CV often violated the criteria of rectangular shape (45% C_3, 34% C_4), of height:width ratio (17% C_3, 36% C_4) and inferior concavity (10% C_2, 10% C_3, 18% C_4). All of the criteria for an adult CV shape were fulfilled in only 24% of the subjects (95% confidence interval 19-29%). The variability of measures of the CV shapes was large; for example, the 95% reference ranges (2.5th-97.5th percentile) for the height:width ratios were 0.81-1.20 (C_3) and 0.78-1.14 (C_4). Moreover, overlap with the data of the children was considerable: 6% and 10% of C_3/C_4 height:width ratios of children were in the adult reference ranges.

Conclusions: While hand bones and teeth have well-defined appearances in the end stage of development (closed epiphyseal lines and closed root apices, respectively), adult cervical vertebrae have largely varying shapes with a material overlap even with young children. This makes it difficult or even impossible to define the "typical" end stage appearance of CV that would capture all adult cases and, at the same time,

reliably separate younger from older subjects. We conclude that CV are of limited value for age estimation. As this limitation arises from biological variability of adult CV geometry, it cannot be overcome by using innovative imaging techniques like cone beam CT.