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BRIEF REVIEW ON FUNDAMENTALS OF CERVICAL SPINE ALIGNMENT

SERVİKAL SPİNAL DENGE PARAMETRELERİNİN KISA DERLEMESİ

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ABSTRACT

The cervical spine where not only loads the mass of the head but also makes the widest range of motion relative to the rest of the spine, plays an important role in influencing subjacent global spinal alignment and pelvic tilt as compensatory changes occur to maintain horizontal gaze. The management of complex cervical pathologies could be handled with understanding of cervical biomechanics as well as the normative data for cervical alignment.

The major parameters used to assess cervical spine alignment include Cobb angles, Jackson stress lines, and Harrison posterior tangent lines for sagittal curvature; gravity line or C-2 plumb line for sagittal vertical axis; and the Chin-Brow to vertical angle for horizontal gaze. Thoracic inlet angle, cervical tilt, neck tilt, and cranial tilt are new parameters that being discussed in the literature for cervical alignment.

Key Words: Cervical alignment, cervical lordosis, sagittal vertical axis

Level of Evidence: Review article, Level V

ÖZET

Servikal omurga sadece kafanın yükünü taşımakla kalmaz, omurganın kalanından daha fazla hareket kabiliyetine sahiptir ve pelvik tilt kadar horizontal dengenin sağlanmasında da önemlidir. Kompleks servikal patolojilerin yönetilmesinde servikal biyomekaniğinin anlaşılması ve normal değerlerine hâkim olunması büyük önem taşımaktadır. Servikal omurga denge parametrelerinde en sık kullanılan parametreler Cobb açısı, Jackson stres çizgileri, Harrison posterior tanjant çizgileri, yerçekimi merkezi veya sagital verteks aksı için C-2 şakül hattı ve kaş-çene hattının vertikal açısıdır. Torasik giriş açısı, servikal tilt, boyun tilti ve kranial tilt ise servikal denge için literatürde tartışılan yeni parametrelerdir.

Anahtar Kelimeler: Servikal denge, Servikal lordoz, Servikal vertikal aks

Kanıt Düzeyi: Derleme, Düzey V.

INTRODUCTION

The cervical spine where not only loads the mass of the head but also makes the widest range of motion relative to the rest of the spine, plays an important role in influencing subjacent global spinal alignment and pelvic tilt as compensatory changes occur to maintain horizontal gaze [20]. However, there are few literature that have defined the baseline values for cervical spine alignment.

Indications for surgery to correct cervical alignment are not inspected in the recent publications and there is no set standard to suggest the ratio of correction to be planned. Classifications of cervical deformity have yet to be fully established and treatment options defined and clarified [20].

The management of complex cervical pathologies could be handled with understanding of cervical biomechanics as well as the normative data for cervical alignment. The aim of our paper is to review the cervical alignment parameters in the literature and provide guidance for proper surgical treatment and search the nominative data.

THE PARAMETERS OF CERVICAL SPINE ALIGNMENT

3 Column Theory

Louis defined a 3 column theory for cervical spine in 1985 [16]. Vertebral bodies and discs compose the anterior column and articulating facet joints compose two posterior columns. The weight of the head is transferred to the condyle to the lateral masses of C_1 and then to the C_{1-2} joint. Then load is divided with the C_2 articular pillars to the anterior column which includes the C_{2-3} disc and the posterior column which includes the C_{2-3} facets [18]. The load distribution of the cervical spine is primarily in the posterior columns with the ratios 36 % in the anterior column and 64 % in the 2 posterior columns [18]. The natural curvature of the cervical spine is a lordosis as a result of the wedge shaped cervical vertebrae to compensate for the kyphotic curvature of the thoracic spine[4]. Pathologies of this curvature like loss of lordosis or the development of cervical kyphosis, are associated with neurological symptoms such as pain and disability [1,5,8,17,22].

Cobb Angle

Cobb angles are measured from C_1 to C_7 or C_2 to C_7. The 4-line method includes drawing a line either parallel to the inferior endplate of C_2 or extending from the anterior tubercle of C_1 to the posterior margin of the spinous process, and another line parallel to the inferior endplate of C_7. Perpendicular lines are then drawn from each of the 2 lines noted above and the angle subtended between the crossing of the perpendicular lines is the cervical curvature angle **(Figure-1)** [2,9].

Jackson Physiological Stress Lines

The Jackson physiological stress lines method which requires drawing 2 lines, both parallel to the posterior surface of the C_7 and C_2 vertebral bodies, and measuring the angle between them **(Figure-2)** [11].

Figure-1. C_{2-7} Cobb angle

Figure-2. Jackson stress lines angle

Harrison Posterior Tangent Method

Harrison posterior tangent method involves drawing lines parallel to the posterior surfaces of all cervical vertebral bodies from C_2 to C_7 and then summing the segmental angles for an overall cervical curvature angle **(Figure-3)** [9].

Figure-3. Harrison tanjant açıları

Sagittal Vertical Axis

Translation of the cervical spine in the sagittal plane is measured through the cervical sagittal vertical axis (SVA). Both C_2 SVA and C_7 SVA have been used to define sagittal alignment globally by measuring the distance between the C_2 and C_7 plumb lines, respectively, from the posterior superior corner of the sacrum. Cervical SVA can also be defined regionally using the distance between a plumb line dropped from the centroid of C_2 (or dens) and the posterosuperior aspect of C_7 **(Figure-4)** [20].

Chin-Brow to Vertical Angle

The Chin-Brow to vertical angle (CBVA) is an assessment of horizontal gaze. This measurement is especially useful in the management of severe, rigid, cervical kyphotic deformities, as the loss of horizontal gaze has a significant impact on activities of daily living and quality of life [21]. The CBVA is defined as the angle subtended between a line drawn from the patient's chin to brow and a vertical line **(Figure-5).**

Figure-4. Sagittal vertical axis C_2-C_7 plumb lines distance measurement

The angle is measured on clinical photographs of the patient standing with hips and knees extended while the neck is in a neutral or fixed position [21]. This parameter is gaining popularity, and deformity correction that has considered CBVA has been shown to be associated with positive postoperative outcomes such as improved gaze, ambulation, and activities of daily living [3,12,19,23].

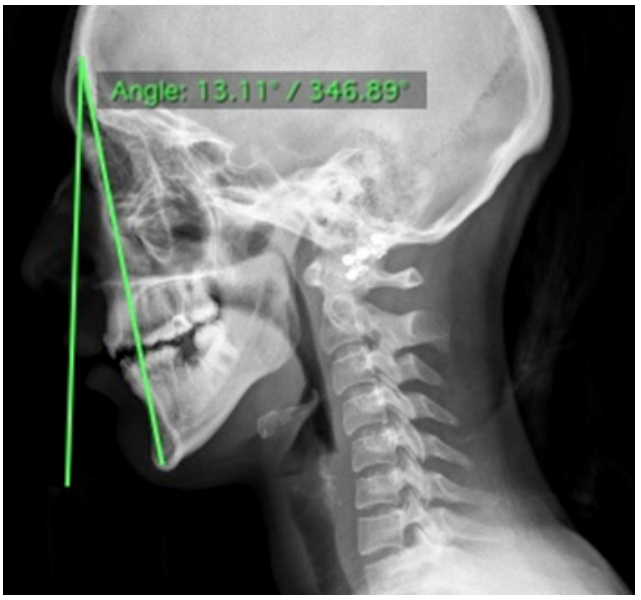

Figure-5. Chin-Brow vertical angle

Thoracic Inlet

The thoracic inlet angle (TIA) was defined as the angle between a line originating from the center of the T_1 endplate and perpendicular to the T_1 endplate and a line from the center of the T_1 endplate and the upper end of the sternum **(Figure-6)**[14].

Figure-6. Thoracic inlet angle

Neck Tilt

Neck tilt was defined as an angle between 2 lines both originating from the upper end of the sternum, with 1 being a vertical line and the other connecting to the center of the T_1 endplate **(Figure-7)** [14].

A relationship exists such that thoracic inlet angle equals T_1 slope (T1S) which is the angle between a horizontal plane and a line parallel to the superior T_1 endplate **(Figure-8);** plus neck tilt. This is similar to the equation in the lumbar spine in which pelvic incidence equals the sacral slope plus the pelvic tilt.

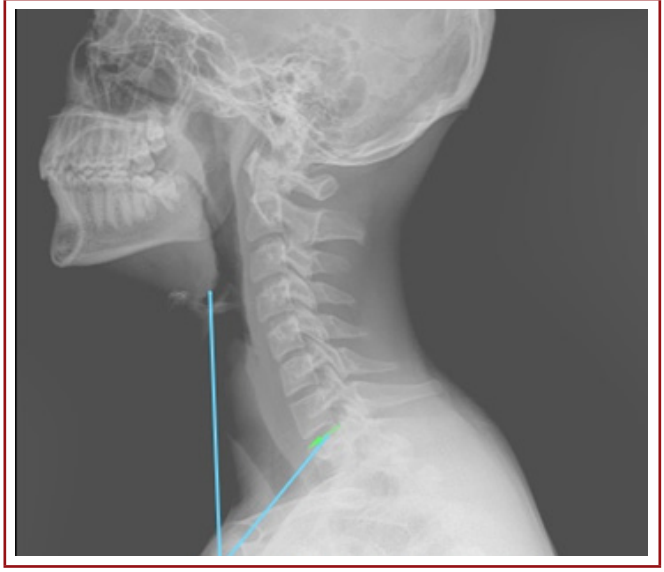

Figure-7. Neck tilt

Figure-8. T_1 Slope angle

Cervical Tilt

Cervical tilt was defined as the angle between 2 lines, both originating from the center of the T_1 upper endplate; one is perpendicular to the T_1 endplate and the other passes through the tip of the dens **(Figure-9)** [14].

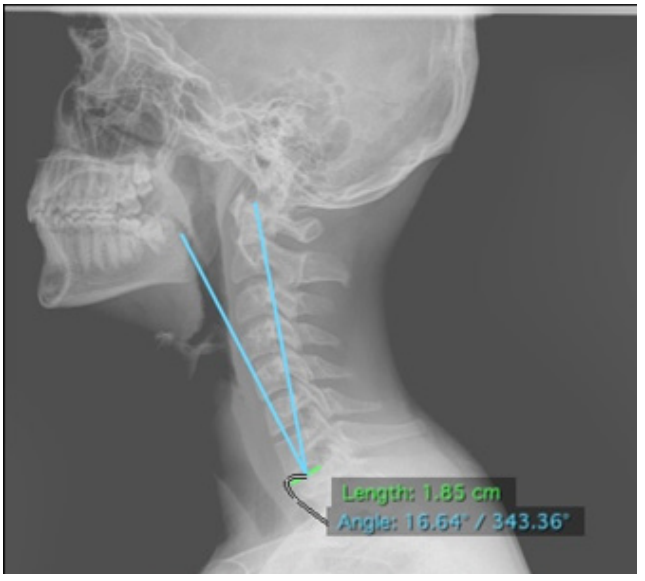

Figure-9. Cervical tilt

Cranial Tilt

Cranial tilt was defined as the angle between 2 lines, both originating from the center of the T_1 upper endplate, with 1 passing through the dens (same as the second line in cervical tilt) and the other being a vertical line **(Figure-10)** [14].

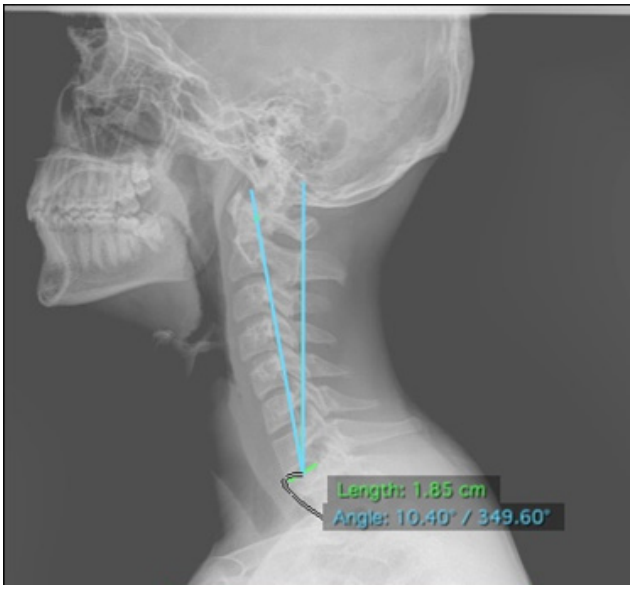

Figure-10. Cranial tilt

Cervical Lordosis Measurement with (C_0) - (C_{0-2}) - (C_{2-7}) Angles

C_0 angle was defined as an angle formed between the Frankfort plane and the McRae line **(Figure-11).** C_{0-2} angle, an angle between the McRae line and the C_2 lower end plate was measured using Cobb method. For the C_{2-7} angle, an angle between the posterior wall of the C_2 vertebral body and the C_7 vertebral body was measured using Gore method [6].

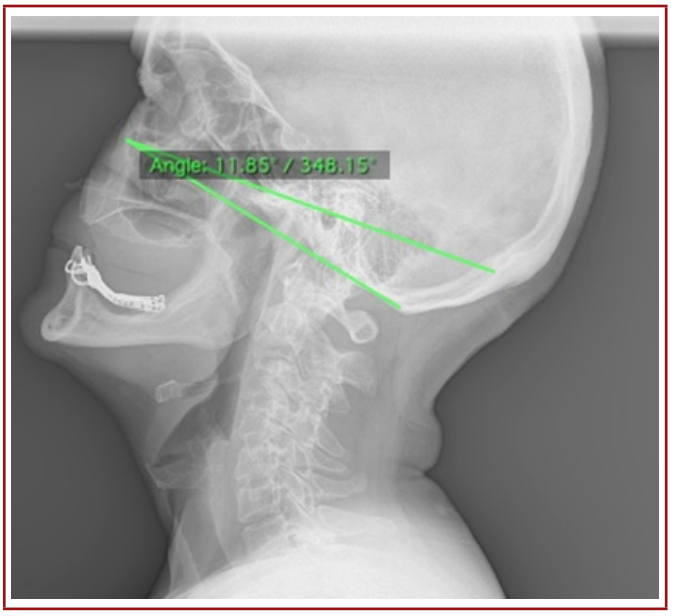

Figure-11. C_0 angle

DISCUSSION

Sagittal balance of the cervical spine may affect the clinical outcomes of fusion or deformity correction of cervical spine diseases such as cervical degenerative disc diseases [7,15]. In the recent studies criteria for physiological reconstruction of cervical spine lordosis remains unclear. Only a few studies define the nominative data's of alignment parameters.

Lee et al. reported the widest range of nominative data for cervical spine alignment in their study [14]. They found that the mean values of TIA was 69.5° ± 8.6° and T1S was 25.7° ± 6.4°; neck tiling was 43.7° ± 6.1°; C_{0-2} angle was 22.4° ± 8.5° and C_{2-7} angle was 9.9° ± 12.5°. The ratio of the C_{0-2} angle and the C_{2-7} angle was 77 % and 23 %, respectively, of the total cervical lordosis (CL). The mean C_0 angle was 9.3° ± 7.3° and cranial offset was 20.9 ± 11.7mm. The mean cervical tilting was 18±6.6 degrees and cranial tilting was 7.7° ± 5°. On the basis of the formula, T_1 slope=cervical tilt + cranial tilt, the ratio of cervical tilting to cranial tilting was 70.2 % : 29.8 % [14].

Harrison et al. made a comparison of two techniques which were 4 line Cobb method and Harrison Tangents to measure cervical lordosis[9]. They found that Cobb method at C_1–C_7

overestimated the cervical curvature (-54°) and, at C_2–C_7 it underestimated the cervical curve (-17°), whereas the posterior Harrison tangents were the slopes along the curve (-26° from C_2 to C_7) [9].

Hardacker et al. reported a mean value of C_1-C_7 lordosis angle -41.8 degree, C_7 sagittal vertical axis mean value 15.6 mm in their study [8].

Gore et al. reported C_2-C_7 cervical lordosis angles of 16 degrees for men and 15° for women [5]. The mean SVA was reported 16.8 mm. They also suggested that cervical lordosis increased with age but did not address adjacent spinal alignment measures or segmental cervical values [5].

The cervical spine carries the load of the head and neck with a 3-column model unlike the 3-column model in the thoracolumbar spine consisting of an anterior and 2 posterior columns. The major parameters used to assess cervical spine alignment include Cobb angles, Jackson stress lines, and Harrison posterior tangent lines for sagittal curvature; gravity line or C_2 plumb line for SVA; and the CBVA for horizontal gaze [10].

Thoracic inlet angle, cervical tilt, neck tilt, and cranial tilt are new parameters that being discussed in the literature for cervical alignment. It has been shown that these parameters affect the alignment of the cervical spine like T_1 slope and thoracic inlet angle, as they relate to cervical lordosis, are important parameters to consider in optimizing cervical deformity correction [13].

Further investigation with increased number of nominative data of the cervical spine is needed especially the relationship between the thoracic and lumbar alignment parameters and more standardized indications for correction of deformities with surgery.

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