Volume: 30, Issue: 3, July 2019 pp: 181-186

ORIGINAL ARTICLE

turkishspine

CERVICAL SPINAL ALIGNMENT PARAMETERS

Şahin YÜCELI[1]
Cumhur Kaan YALTIRIK[2]

[1] *Department of Neurosurgery, Neon Hospital, Erzincan, Turkey*
[2] *Department of Neurosurgery, Yeditepe University School of Medicine, İstanbul, Turkey*

ORCID Numbers:
Şahin Yüceli: 0000-0002-9471-3575
Cumhur Kaan Yaltırık:
0000-0002-4312-5685

Address: Şahin Yüceli,
Özel Neon Hastanesi, Erzincan, Turkey
Tel: +90 533 338 01 35
E-mail: sahinyuceli24@gmail.com
Received: 22th January, 2019.
Accepted: 8th May, 2019.
*** There is no conflict of interest between authors.**

ABSTRACT

Aim: The management of complex cervical pathologies could be handled with understanding of cervical biomechanics as well as the baseline data of cervical alignment parameters. The aim of our paper is to support nominative baseline data of the cervical spine alignment parameters to provide guidance for proper surgical treatment.

Material and Methods: We evaluated the lateral cervical radiographs of 347 healthy adult patients between the ages of 18 and 60. We measured cervical lordosis with Cobb angle C0-2 and C2-7, Jackson physiological stress lines, Harrison tangent lines and also sagittal vertical axis with C2-C7 plumb line, cervical tilt and cranial tilt. We analysed measurements according to mean values and genders.

Results: Two hundred and twenty eight patients (65.7%) were female, and 119 patients (34.3%) were males. Mean age was 44.12±16.03 years. Cobb C0-C2 (p=0.307), Jackson (p=0.106), and Harrison (p=0.688) measurements were similar between males and females. But Cobb C2-C7 was significantly different between genders (p=0.017). The comparisons of methods revealed that Cobb C0-C2 had highest values, and Cobb C2-C7 and Jackson was lower than Harrison (CobbC0-C2>Harrison>Cobb C2-C7~Jackson) (p<0.001). SVA (p=0.690) and cervical tilt angle (p=0.538) measurements were similar between males and females but cranial tilt angle was significantly different between genders (p=0.046).

Conclusion: All of these techniques and the standard data must be well understood along with the biomechanical features so that surgeons can choose the best technique for the management of deformities.

Keywords: Cervical spine alignment, cervical lordosis, sagittal vertical axis

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

The cervical spine not only supports the mass of the head, but also undergoes the widest range of motion of the entire spine. It also plays a key role in influencing the subjacent global spinal alignment and pelvic tilt as compensatory changes occur to maintain the horizontal gaze [12].

The major parameters used to define cervical spinal alignment are the Cobb angles, Jackson stress lines, and Harrisons posterior tangent lines for the sagittal curvature, and the gravity line or C2 plumb line for the sagittal vertical axis (SVA) [19]. However, there is no standardized data about the correction limitations of the cervical alignment parameters in the recent literature, and the cervical deformity treatment modalities have yet to be completely published [16].

The management of complex cervical pathologies could be handled by understanding the cervical biomechanics as well as the normative cervical alignment data. However, few studies have defined the baseline values for the cervical spine alignment parameters [4,5]. Therefore, the aim of our paper was to support the nominative baseline data of the cervical spine alignment parameters in order to provide guidance for proper surgical treatment.

MATERIAL AND METHODS

We evaluated the lateral cervical radiographs of 347 healthy adult patients between the ages of 18 and 60. The exclusion criteria were any radiographic pathologies. The cervical radiographs were taken in the standing lateral neutral position, and all of the data was collected and measured by authors. The radiographs were searched using a radiology picture archiving and communication system (PACS) program and the parameter measurements were evaluated with the techniques explained below:

Cobb angle

The Cobb angle is measured from C2 to C7 using a 4-line technique to draw a parallel line to the inferior endplate of C2, to the posterior border of the spinous process, and to the inferior endplate of C7. Two perpendicular lines are then drawn from these lines to measure the angle between them (Figure-1) [4].

The C0–C2 angle, an angle between the McRae line and the C2 lower end plate, was measured using the Cobb method (Figure-2) [4].

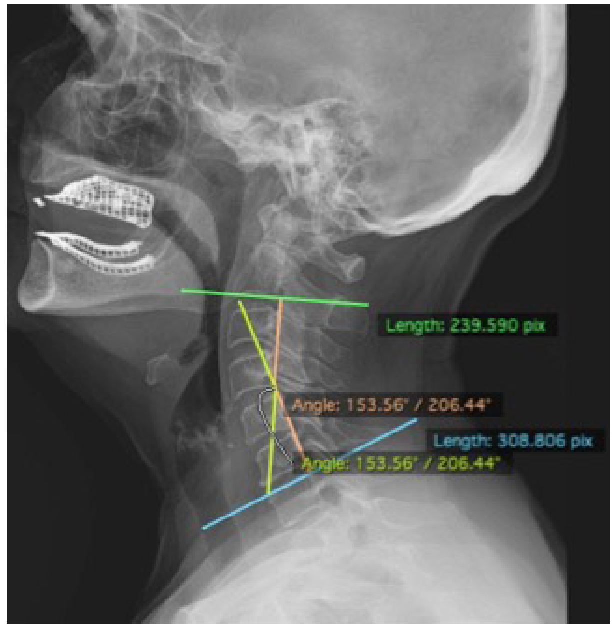

Figure-1. C2-7 4-line Cobb angle measurement technique with lateral X-ray graphy

Jackson physiological stress lines

Two lines are drawn parallel to the posterior margins of the C7 and C2 bodies, and the angle between them is then measured (Figure-3) [11].

Harrison posterior tangent method

Lines are drawn parallel to the posterior margins of C2–C7, and all of the angles are added to obtain the cervical curvature results (Figure-4) [10].

Sagittal vertical axis

A plumb line is drawn from the center of C2, and the distance from this line to the posterior corner of the upper endplate of C7 is obtained (Figure-5) [17].

Cervical tilt

A line is drawn from the center point of the upper endplate of the T1 vertebra to the tip of dens, and another line is drawn perpendicular to the same center. The angle between them is then measured (Figure-6) [14].

Figure-2. C0-2 Cobb angle measurement technique with lateral X-ray graphy

Figure-3. Jackson stress line technique with lateral X-ray graphy

Figure-5. SVA measurement C2-7 plumb line technique with lateral X-ray graphy

Figure-4. Harrison tangent technique with lateral X-ray graphy

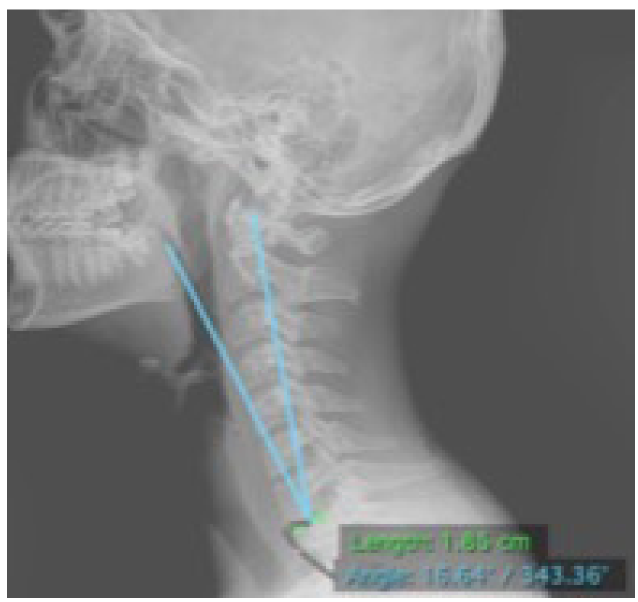

Figure-6. Cervical tilt angle measurement technique with lateral X-ray graphy

Cranial tilt

A line is drawn from the center of the T1 upper endplate to the tip of dens, and then a vertical line is drawn to the same center (Figure-7) [3].

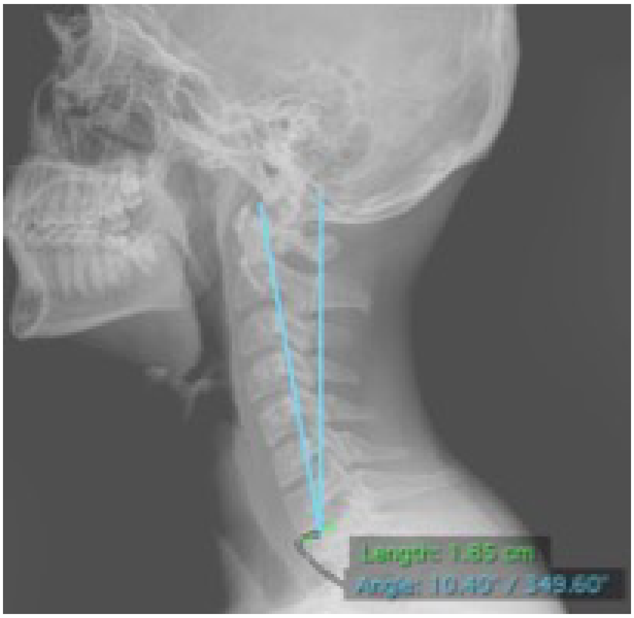

Figure-7. Cranial angle measurement technique with lateral X-ray graphy

Statistical Analysis

The descriptive data were presented as the means and standard deviations for the numerical variables, and the frequencies and percentages for the categorical variables. The independent group comparisons were conducted using the Mann-Whitney U test between the genders. A type I error level of 5% was considered to be statistically significant in the analyses. SPSS Statistics version 18 (IBM Inc., Armonk, NY, USA) was used for the statistical assessments.

RESULTS

Table-1 shows the patients' demographics; 228 patients (65.7 %) were female, 119 patients (34.3 %) were male, and the mean age was 44.12±16.03 years old (Table-1).

Table-1. Patient demographics

		Count	%
GENDER	Female	228	65.7%
	Male	119	34.3%
		Mean	SD
AGE (year)		44.12	16.03

The measurements according to gender are presented in Table-2. The Cobb C0–C2 (p=0.307), Jackson (p=0.106), and Harrison (p=0.688) measurements were similar between the males and females. However, the Cobb C2–C7 measurement was significantly different between the genders (p=0.017), with the males having significantly higher Cobb C2–C7 values. In addition, the C2–C7 plumb line (p=0.690) and cervical tilt angle (p=0.538) measurements were similar between the males and females. However, the cranial tilt angle was significantly different between the genders (p=0.046), with the males having significantly higher cranial tilt angle values.

The method comparisons (Table-3) revealed that the Cobb C0–C2 measurement exhibited the highest values, while the Cobb C2–C7 and Jackson measurements were lower than the Harrison measurement (Cobb C0–C2 > Harrison > Cobb C2–C7 ~ Jackson) (p<0.001).

Table-2. Measurement comparison between genders

	Female		Male		p
	Mean	SD	Mean	SD	
Cobb C0-C2 angle	31,43	7,12	29,57	8,72	0,307
Cobb C2-C7 angle	16,30	9,18	21,73	9,01	0,017
Jackson angle	17,43	11,02	21,33	10,66	0,106
Harrison angle	22,43	9,48	23,69	8,14	0,688
C2-C7 plumb line (mm)	3.81	2.75	3.58	1.89	0.690
Cervical tilt angle	17.69	5.46	18.68	5.89	0.538
Cranial tilt angle	8.62	2.54	9.52	2.18	0.046

Table-3. Comparison of cervical lordosis measurement methods

	Mean	SD	p
COBB_C0_C2	30,72	7,76	p<0.001
COBB_C2_C7	18,37	9,44	
JACKSON	18,92	10,98	
HARRISON	22,91	8,96	

DISCUSSION

The cervical spine carries the load of the head and neck using a 3-column model unlike the 3-column model in the thoracolumbar spine, which consists of an anterior and 2 posterior columns [5]. The major parameters used to assess the cervical spine alignment include the Cobb angles, Jackson stress lines, and Harrison posterior tangent lines for the sagittal curvature, and the gravity line or C2 plumb line for the SVA [11]. In asymptomatic normal volunteers, cervical lordosis (CL) is settled in C1–C2 at a ratio of 75 %–80 % [9,11]. Lippman reported a procedure consisting of drawing lines to measure the scoliosis curves on anterio-posterior radiographs in 1945, which was later developed by Cobb in 1948 [4,18]. The Cobb angles were drawn to measure the sagittal spinal curves of the cervical, thoracic, and lumbar regions on lateral radiographs [4]. In 1957, Jackson reported the physiological stress lines [11]; while in 1986, Gore et al. used Jackson's stress lines and Harrison began to use the posterior tangents technique [7,10].

Beier et al. reported that CL is localized to C1–C2, with only 15 % of lordosis cases being measured below in the rest of the region [2]. Most often, hyperlordosis is the result of occiput–C2 fusion surgery, as reported in the literature [20,21]. Hardacker et al. reported a mean CL of 40.0° ± 9.7° that exhibited a significant correlation with thoracic kyphosis [9]. In addition, Lee et al. reported that the mean value of the C0–C2 angle was 22.4±8.5° and that of the C2–C7 angle was 9.9±12.5° [14]. The ratios of the C0–C2 angle and the C2–C7 angle were 77 % and 23 % of the total CL, respectively [14]. Gore et al. reported C2–C7 CL angles of 16° for males and 15° for females [7].

Harrison et al. conducted a comparison of the 4-line Cobb method and Harrison tangents to measure CL, and they found that the Cobb technique overestimated the cervical curvature at C1–C7 and underestimated the cervical curve at C2–C7 [10]. They also suggested that the posterior tangent method could calculate the cervical curvature better than the Cobb method [10]. We found that the mean values of the C0–C2 and C2–C7 Jackson stress lines and Harrison tangents were 30.72° ± 7.76°, 18.37° ± 9.44°, 18.92° ± 10.98°, and 22.91° ± 8.96°, respectively. Our results are similar to those of Harrison. Overall, the Harrison tangent technique is difficult to measure, but we thought its results were better for determining the values because the tangents can also measure the internal curve.

Lee et al. reported the widest range of nominative data for cervical spine alignment, with mean values of 18° ± 6.6° for cervical tilting and 7.7° ± 5° for cranial tilting [14]. In their study, Hardacker et al. reported a C7 SVA mean value of 15.6 mm [9]. Gore et al. reported a mean SVA of 16.8 mm, and also suggested that CL increased with age, but did not address the adjacent spinal alignment measurements or segmental cervical values [7].

The sagittal balance of the cervical spine may affect the clinical outcomes of the fusion or deformity corrections of cervical degenerative disc diseases [8,15]. In recent studies, the criteria for the physiological reconstruction of CL remains unclear [1,13,22]. However, only a few studies have defined the nominative alignment parameter data [3,6].

CONCLUSION

All of these techniques and the standard data must be well understood along with the biomechanical features so that surgeons can choose the best technique for the management of deformities. However, further investigations with an increased amount of cervical spine nominative data are needed.

In addition, these data must be used to define the relationships between the cervical, thoracic, and lumbar spine alignment parameters for more standardized indications for the surgical correction of deformities.

REFERENCES

1. Ailon T, Shaffrey C, Lenke LG, Harrop JS, Smith JS. Progressive spinal kyphosis in the aging population. *Neurosurgery* 2015; 77(Suppl.-4): S164–S172.
2. Beier G, Schuck M, Schuller E, Spann W. *Determination of Physical Data of the Head I. Center of Gravity and Moments of Inertia of Human Heads*. Munich: Institute of Forensic Medicine, University of Munich, 1979, p44.
3. Chen Y, Luo J, Pan Z, Yu L, Pang L, Zhong J, Li Z, Han Z, Cao K. The change of cervical spine alignment along with aging in asymptomatic population: a preliminary analysis. *Eur Spine J* 2017; Jul 6. doi: 10.1007/s00586-017-5209-1.
4. Cobb JR. Outlines for the Study of Scoliosis.. In: Edwards JW (Ed.). *Instructional Course Lecture*. Vol 5. American Academy of Orthopedic Surgeons, Ann Arbor 1948; pp: 261–275.
5. Diebo BG, Varghese JJ, Lafage R, Schwab FJ, Lafage V. Sagittal alignment of the spine: what do you need to know? *Clin Neurol Neurosurg* 2015; 139: 295–301.

6. Donk RD, Fehlings MG, Verhagen WI, Arnts H, Groenewoud H, Verbeek AL, Bartels RH. An assessment of the most reliable method to estimate the sagittal alignment of the cervical spine: analysis of a prospective cohort of 138 cases. *J Neurosurg Spine* 2017; 26(5): 572–576.
7. Gore DR, Sepic SB, Gardner GM. Roentgenographic findings of the cervical spine in asymptomatic people. *Spine* 1986; 11: 521–524.
8. Gwinn DE, Iannotti C, Benzel EC. Effective lordosis: analysis of sagittal spinal canal alignment in cervical spondylotic myelopathy. *J Neurosurg Spine* 2009; 11: 667–672.
9. Hardacker JW, Shuford RF, Capicotto PN, Pryor PW. Radiographic standing cervical segmental alignment in adult volunteers without neck symptoms. *Spine* 1997; 22: 1472–1480.
10. Harrison DE, Harrison DD, Cailliet R, Troyanovich SJ, Janik TJ, Holland B. Cobb method or Harrison posterior tangent method: which to choose for lateral cervical radiographic analysis. *Spine* 2000; 25: 2072–2078.
11. Jackson RP, McManus AC. Radiographic analysis of sagittal plane alignment and balance in standing volunteers and patients with low back pain matched for age, sex, and size. A prospective controlled clinical study. *Spine* 1994; 19: 1611–1618.
12. Lee SH, Son ES, Seo EM, Suk KS, Kim KT. Factors determining cervical spine sagittal balance in asymptomatic adults: correlation with spinopelvic balance and thoracic inlet alignment. *Spine J* 2015; 15(4): 705–712.
13. Lee JS, Youn MS, Shin JK, Goh TS, Kang SS. Relationship between cervical sagittal alignment and quality of life in ankylosing spondylitis. *Eur Spine J* 2015; 24(6): 1199–1203.
14. Lee SH, Kim KT, Seo EM, Suk KS, Kwack YH, Son ES. The influence of thoracic inlet alignment on the craniocervical sagittal balance in asymptomatic adults. *J Spinal Disord Tech* 2012; 25: E41–E47.
15. Legaye J, Duval-Beaupere G, Hecquet J. Pelvic incidence: a fundamental pelvic parameter for three dimensional regulation of spinal sagittal curves. *Eur Spine J* 1998; 7: 99–103.
16. Protopsaltis TS, Scheer JK, Terran JS, Smith JS, Hamilton DK, Kim HJ, Mundis GM Jr, Hart RA, McCarthy IM, Klineberg E, Lafage V, Bess S, Schwab F, Shaffrey CI, Ames CP, International Spine Study Group. How the neck affects the back: changes in regional cervical sagittal alignment correlate to HRQOL improvement in adult thoracolumbar deformity patients at 2-year follow-up. *J Neurosurg Spine* 2015; 23(2): 153–158.
17. Scheer JK, Tang JA, Smith JS, Acosta FL Jr, Protopsaltis TS, Blondel B, Bess S, Shaffrey CI, Deviren V, Lafage V, Schwab F, Ames CP; International Spine Study Group. Cervical spine alignment, sagittal deformity, and clinical implications. *J Neurosurg Spine* 2013; 19(2): 141-159.
18. Sevastikoglou JA, Bergquist E. Evaluation of the reliability of radiological methods for registration of scoliosis. *Acta Orthop Scand* 1969; 40: 608–613.
19. Yokoyama K, Kawanishi M, Yamada M, Tanaka H, Ito Y, Kawabata S, Kuroiwa T. Age-related variations in global spinal alignment and sagittal balance in asymptomatic Japanese adults. *Neurol Res* 2017; 39(5): 414–418.
20. Yoshida G, Kamiya M, Yoshihara H, Kanemura T, Kato F, Yukawa Y. Subaxial sagittal alignment and adjacentsegment degeneration after atlantoaxial fixation performed using C-1 lateral mass and C-2 pedicle screws or transarticular screws. Clinical article. *J Neurosurg Spine* 2010; 13:443–450.
21. Yoshimoto H, Ito M, Abumi K, Kotani Y, Shono Y, Takada T. A retrospective radiographic analysis of subaxial sagittal alignment after posterior C1-C2 fusion. *Spine* 2004; 29: 175–181.
22. Youn MS, Shin JK, Goh TS, Kang SS, Jeon WK, Lee JS. Relationship between cervical sagittal alignment and health-related quality of life in adolescent idiopathic scoliosis. *Eur Spine J* 2016; 25(10): 3114–3119.