ORIGINAL ARTICLE

Measuring the shape and dimensions of normal the bony structures in the craniovertebral junction from computed tomography images of the pediatric age group

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ABSTRACT

BACKGROUND: The aim of this study is to contribute to the literature by determining the morphometric reference values of the bony structures in the craniovertebral junction (CVJ) from computer tomography (CT) images of the pediatric age group.

METHODS: In this study, CT's of 151 simple trauma patients aged between 3 and 15 years between 2016 and 2020 were evaluated. All CT examinations were performed using a 32-slice CT and included images of the skull base and C1-C2 junction. A total of 10 measurements were obtained from these images, including Wachenheim clivus canal angle (WCA), Welcher basal angle (WBA), Craniocervical tilt angle (CCT), power ratio (PR), Atlantodens interval, McRae Line (MRL), McRae - Dens distance, basion-dens interval (BDI), basion-axis interval (BAI), and atlantooccipital measurement (AOM).

RESULTS: In comparison between gender groups, MRL (p=0.011) and AOM (p<0.001) measurements were found to be significantly higher in males. McRae-Dens distance, BDI, and AOM were significantly higher in patients aged 3–9 years (respectively, p=0005, p=0.003, p<0.001), and BAI (p=0.001) was significantly higher in patients aged 10–15 years. The McRae - Dens distance (p=0.119) was similar between patients with and without terminal ossicle in odontoid apex. But BDI of patients without terminal ossicle was significantly higher (p=0.048). All parameters, except the WCA, WBA, CCT, and PR, were statistically significantly correlated with the patient age (respectively, p=0.21, p=0.13, p=0.70, p=0.99).

CONCLUSION: In this study, the morphometric reference values of the bone structures at the CVJ were determined from the CT images of the pediatric age group.

Keywords: Bony structures; computer tomography images; craniovertebral junction; pediatric age.

INTRODUCTION

Injuries to the pediatric cervical spine are significantly different from those encountered in the adult population.[1] Children have relatively weaker cervical musculature, a larger head size relative to the body, more ligamentous laxity, and a flatter contour of the occipital condyles than adults have.[1–3] These factors make children more predisposed to atlantooccipital dissociation injuries than their adult counterparts.[1]

Imaging of the upper cervical spine after trauma is crucial for injury detection and anatomical description, given the po-

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tential for dire neurological consequences of a missed bone or discoligamentous injury.[4–8] Besides, mobility from ligamentous laxity, epiphyseal variation, unique vertebral architecture, and incomplete ossification of the pediatric cervical spine may further cloud the symptoms of a pathological state after trauma.[4]

Although after the age of 10–12 years, the clinical sequelae of adult and pediatric cervical spine trauma are similar, adult criteria for instability following upper cervical spine trauma have been inappropriately extrapolated to that of the pediatric age group, possibly because of the familiarity with their radiographic measurement techniques.[3] These measurements, although accurate in defining relationships between anatomical structures, do not take into account the complexity and peculiarity of the pediatric spine, especially in very young children.[4]

In the literature, there are many radiography studies covering the occipitocervical region made from past to present. Normal boundaries were tried to be defined with these studies.[9–13] Then the same or quite similar studies were done with computer tomography (CT).[14–18] Very few studies with CT include the pediatric population.[1,4]

The present study aims to contribute to the literature by determining the morphometric reference values of the bony structures in the craniovertebral junction (CVJ) from CT images of the pediatric age group.

MATERIALS AND METHODS

Patient Group

In this study, CTs of 151 simple trauma patients aged between 3 and 15 years between 2016 and 2020 were evaluated. Measurements were made in patients who were admitted for simple trauma, whose osseous and soft tissue structures were evaluated as normal. Those with cervical pathology previously detected due to trauma or other reasons (basilar invagination, Chiari malformation, etc.) were excluded from the study. Artifact CTs that did not have the optimal feature was not taken into consideration. Patients who were evaluated radiologically and clinically as normal at the time of presentation but who subsequently developed persistent neck pain and were treated for this reason were excluded from the study.

Method for the CT of the Cervical Spine

CT measurements were performed simultaneously with a collaborative radiologist and a neurosurgeon (M.K., E.Y.) and all results were recorded. While all data were recorded, the images were taken from the hospital automation system and recorded in another data file. In this way, a systematic review of the study was ensured, while reproducibility was ensured in the previous measurements in case of a possible disagreement during the measurements.

All CT examinations were performed using a 32-slice CT (Model: Somatom Go Now, SIEMENS) and included images of the skull base and C1-C2 junction. Helically acquired axial images were reconstructed in the sagittal and coronal planes. The linear measurement palette in our picture archiving and communications system (CARS) was automatically rounded to the nearest 0.1 mm.

Measurement

In this study, a total of ten measurements were obtained: Wachenheim clivus angle (WCA), Welcher basal angle (WBA), Craniocervical tilt angle (CCT), Power's ratio (PR), atlantodens interval (ADI), McRae line (MRL), McRae - Dens distance, basion-dens interval (BDI), basion-axis interval (BAI), and atlantooccipital measurement (AOM).

WCA

It was obtained by measuring the angle between the line passing through the upper surface of the clivus and the line extending from the back of the odontoid protrusion to the cervical canal (Fig. 1a).

WBA

It was obtained by measuring the wide angle between the straight line drawn from the nasion tuberculum sellae and the straight line drawn from the basion tuberculum sellae (Fig. 1a).

CCT

Chandra et al.[19] defined the craniocervical tilt angle as the

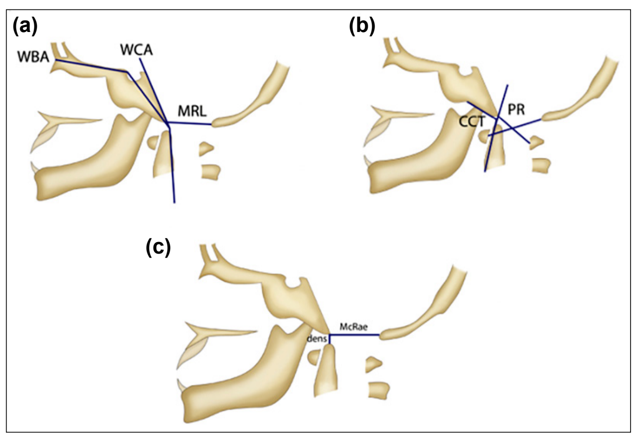

Figure 1. Major craniometric lines drawn on sagittal illustration. **(a)** Wachenheim clivus angle (WCA): It turns tangentially at the level of the sellar ridge and clivus, reaching the basion; Welcher basal angle: The angle between the straight line drawn from the nasion tuberculum sella and the straight line drawn from the basion tuberculum sella; McRae Line (MRL): Basion to opisthion. **(b)** Power ratio: The distance between the tip of the basion and the spinolaminar line of the atlas and the midpoint of the posterior aspect of the anterior arch of the anterior arch of the C1 vertebrae between the tip of the opisthion; Craniocervical tilt angle: Angle between the anterior border of the axis and the anterior border of the clivus. **(c)** McRae-Dens distance: The length of the vertical line drawn from the MRL closest to the dens.

angle between the line drawn upward from the anterior side of the odontoid protrusion and the line drawn from the anterior border of the clivus. The angle between the anterior border of the axis and the anterior border of the clivus (Fig. 1b).

PR

The PR was calculated by dividing the distance between the tip of the basion and the spinolaminar line of the atlas by the distance between the tip of the opisthion and the midpoint of the posterior aspect of the anterior arch of the C1 vertebra (Fig. 1b).[18] No measurement was performed in cases where the C1 vertebra anterior or posterior arch was not ossified or partially ossified. (This measurement was not performed if the anterior or posterior arches of C1 were not visualized in the midsagittal plane either because of lack of ossification of the anterior arch of C1 or, less likely, because of incomplete fusion of the posterior neural arches.).

ADI was measured in cases where C1 anterior arch was ossified. The distance between the middle of the posterior side of the C1 anterior arch and the anterior side of the dens was measured (Fig. 2a).

MRL

The line drawn from the lower end (basion) of the clivus to the posterosuperior of the foramen magnum (opisthion). Basion to the opisthion (anteroposterior dimension of the foramen magnum is shown in Fig. 1a).

McRae-dens (Odontoid Process [OP]) Distance

The length of the vertical line drawn from the MRL closest to the OP (Fig. 1c).

BDI

BDI was obtained by measuring the highest point where dens could be seen from the basion (Fig. 2a). In cases where the OS terminal was visualized, the measurement was made considering the upper point of the OS terminal closest to the basion and in cases where it could not be visualized, the measurement was made from the closest point of the axis to the basion.

BAI

BAI was measured in this study, taking Harris' fundamental principles for radiography (1994) into account (Fig. 2a). It is the perpendicular distance between the basion and the rostral extension of the posterior cortical margin of the body of the axis. The posterior axial line is a line drawn along the posterior cortex of the body of the axis and extended cranially. The basion–axial interval is the distance between the basion and this line. It was measured in the midsagittal plane.[8]

AOM

AOM was obtained by measuring the line between the lower side of the occipital condyle and the upper side of the C1 mass after confirming the midlines of the occipital condyle and C1 lateral masses in the sagittal and coronal planes (Fig. 2b). The mean of the four readings was obtained for both the sagittal and coronal images of each side.

Statistical Analysis

Descriptive statistics were presented as mean and standard deviation, and the upper limit of 95% confidence interval for continuous variables, and frequency and percent for categorical variables. Continuous variables were evaluated regarding normal distribution characteristics. The Mann–Whitney U test was used for the comparisons of non-normally distributed parameters between independent study groups. Correlation between the patient age and the radiographic measurements were analyzed using the Spearman's Rho test. A Type-I error level of 5% was considered as the statistical significance cut-off. All analyses were performed using the SPSS 21 software (IBM Inc., Armonk, NY, USA).

RESULTS

A total of 152 patients were included in the study. Of these patients, 101 (66.4%) were male and 51 (33.6%) were fe-

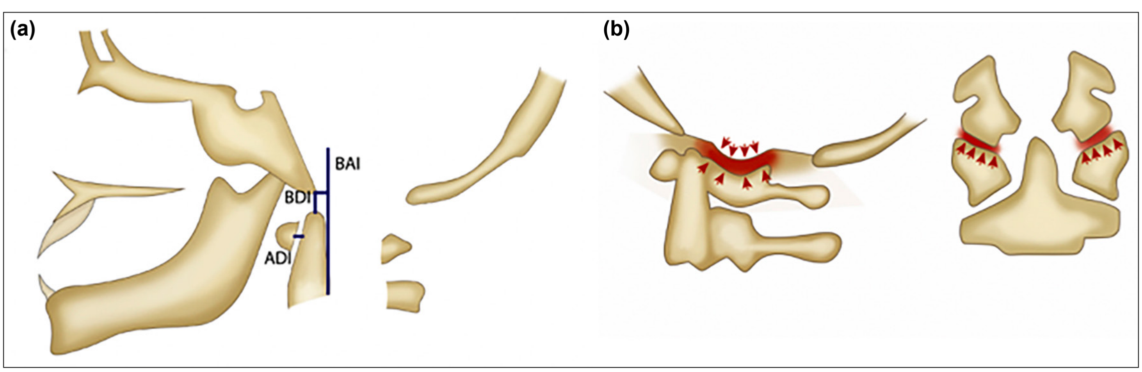

Figure 2. (a) Atlantodens interval: Distance between C1 front arch and front of dens; Basion-dens interval: İt was obtained by measuring the highest point where a dens could be seen from the basion; Basion-axis interval: It is the perpendicular distance between the basion and the rostral extension of the posterior cortical margin of the body of the axis; **(b)** atlantooccipital measurement: The distance the midline of the occipital condyle and C1 lateral mass in the sagittal and coronal planes (red arrows).

Table 1. Radiographic measurements in all patients

	All patients		
	Mean	SD	95% ULCI
Wachenheim clivus (°)	156.8	9.9	176.6
Welcher basal angle (°)	133.4	8.0	149.4
Craniocervical tilt angle (°)	56.7	11.0	78.7
Power's ratio (%)	0.7	0.1	0.9
ADI (mm)	2.7	0.7	4.2
McRae (mm)	36.2	2.9	42.1
McRae - Dens distance (mm)	4.7	1.7	8.2
BDI (mm)	6.0	1.6	9.2
BAI (mm)	6.1	2.5	11.2
AOM (mm)	0.2	0.1	0.4

ULCI: Upper limit of Confidence Interval; SD: Standard deviation; ADI: Atlantodens interval; BDI: Basion-dens interval; BAI: Basion-axis interval; AOM: Atlantooccipital measurement.

male. The radiographic measurements of all patients were presented in Table 1. The comparisons between the gender groups are shown in Table 2. The comparisons of the indexes between males and females revealed that MRL (p=0.011, Table 2), and AOM (p<0.001, Table 2) measurement were significantly higher in males. Of the patients, 85 (55.9%) were aged 3–9 years, and 67 (44.1%) 10–15 years. Comparisons of selected indexes between the age groups revealed that all but the craniocervical tilt angles were significantly different between the groups (p=0.656, Table 3). Accordingly, MRe-Dens distance, BDI, and AOM were significantly higher in patients aged 3–9 years (respectively, p=0005, p=0.003, p<0.001, Table 3), and BAI (p=0.001, Table 3) was significantly higher in patients aged 10–15 years (Table 3).

The terminal ossicle was present in 52 patients (34.2%) among patients aged 3–9 years. The MRe - Dens distance (p=0.119, Table 4) was similar between patients with and without terminal ossicle in odontoid apex. But BDI of patients without terminal ossicle was significantly higher (p=0.048, Table 4). The correlations of radiographic measurements with patient age were presented in Table 5. All parameters, except the WCA, WBA, CCT and PR, were statistically significantly correlated with the patient age (respectively, p=0.21, p=0.13, p=0.70, p=0.99, Table 5, Fig. 3). Accordingly, there was a positive and moderate correlation between patients' age and MRL (r=0.44, p<0.001, Table 5, Fig. 4), and BAI (r=0.39, p<0.001, Table 5, Fig. 4). These indexes were increased when the patient's age increased. Meanwhile, patient's age was negatively and moderately correlated with ADI (r=−0.39, p<0.001, Table 5, Fig. 5) and AOM (r=−0.55, p<0.001, Table 5, Fig. 5), and negatively and weakly correlated with MRe-Dens distance (r=−0.29, p<0.001, Table 5, Fig. 5) and BDI (r=−0.24, p<0.001, Table 5, Fig. 5). These indexes were decreased when patient's age increased.

DISCUSSION

Few measurement norms have been established for the pediatric upper cervical spine based on CT scans.[20] In pediatric spinal injuries, the same measurement and normal-abnormal threshold values are used, ignoring the anatomical and biomechanical differences of the pediatric spine from those of adult individuals.[4] Since there are normal variants such as incomplete ossification, synchondrosis, and pseudosubluxation in pediatric ages, it is especially difficult to detect abnormalities in trauma.[4]

Table 2. Radiographic measurements according to gender groups

	Gender				p
	Male (n=101)		Female (n=51)		
	Mean	SD	Mean	SD	
Wachenheim clivus (°)	157.33	10.17	155.76	9.33	0.440
Welcher basal angle (°)	134.14	7.23	132.15	9.10	0.251
Craniocervical tilt angle (°)	56.42	10.38	57.26	12.17	0.554
Power's ratio (%)	0.72	0.06	0.72	0.07	0.459
ADI (mm)	2.81	0.74	2.60	0.65	0.079
McRae (mm)	36.59	3.07	35.55	2.53	0.011
McRae - Dens distance (mm)	4.73	1.69	4.77	1.89	0.997
BDI (mm)	6.09	1.67	6.18	1.74	0.630
BAI (mm)	5.96	2.69	6.50	2.12	0.346
AOM (mm)	0.24	0.07	0.19	0.07	<0.001

SD: Standard deviation; ADI: Atlantodens interval; BDI: Basion-dens interval; BAI: Basion-axis interval; AOM: Atlantooccipital measurement.

Table 3. Comparisons of indexes between age groups

	Age Group				p
	3–9 years (n=85)		10–15 yeas (n=67)		
	Mean	SD	Mean	SD	
Craniocervical tilt angle (°)	56.77	10.66	56.62	11.46	0.656
McRae - Dens distance (mm)	5.09	1.68	4.30	1.76	0.005
BDI (mm)	6.50	1.52	5.64	1.77	0.003
BAI (mm)	5.56	2.55	6.88	2.30	0.001
AOM (mm)	0.25	0.07	0.18	0.07	<0.001

SD: Standard deviation; ADI: Atlantodens interval; BDI: Basion-dens interval; BAI: Basion-axis interval; AOM: Atlantooccipital measurement.

Table 4. Comparisons of indexes according to the presence of terminal ossicle

	Odontoid apex (ossiculum terminale)				p
	- (n=32)		+ (n=53)		
	Mean	SD	Mean	SD	
McRae - Dens distance (mm)	5.51	1.61	4.78	1.61	0.119
BDI (mm)	6.86	1.49	6.02	1.29	0.048

SD: Standard deviation; BDI: Basion-dens interval.

The published plain radiographic normal values are larger than the values obtained for CT images. Thus, the use of plain radiographic normal values could result in failure to identify pathologically increased measurements and subsequently missed injuries. Magnification in standard plain radiographic technique and limitations in the accuracy of radiographic measurements are probably the causes of the bulk of the differences between the two techniques.[1] Performing CT-based measurements reduces misdiagnosis in pediatric spinal trauma cases. There are many published studies on this subject.[21–23] However, the normal value measurements of the pediatric age group and the number of patients with pathological measurements done are quite limited. Moreover, instead of the "normal" imaging, some measurements defining the upper range of the normal value measurements have been based on pathological analyses.[24]

Table 5. Correlations of radiographic measurements with patient age

	Age	
	r	p
Wachenheim clivus (°)	-0.102	0.21
Welcher basal angle (°)	0.14	0.13
Craniocervical tilt angle (°)	-0.03	0.70
Power's ratio (%)	0.00	0.99
ADI (mm)	-0.39	<0.001
McRae (mm)	0.44	<0.001
McRae - Dens distance (mm)	-0.29	<0.001
BDI (mm)	-0.24	0.003
BAI (mm)	0.39	<0.001
AOM (mm)	-0.55	<0.001

ADI: Atlantodens interval; BDI: Basion-dens interval; BAI: Basion-axis interval; AOM: Atlantooccipital measurement.

BDI

BDI was first described on X-ray images by Wholey et al.[25] in 1958. This measurement was investigated in many studies in the following years.[10,26–30] Lee et al.[11] stated that a BDI value higher than 15 mm in adults and 12 mm in children could be interpreted as atlantooccipital dislocation and these criteria would provide a reliable diagnosis for atlantooccipital dislocation. Lee made this work necessary with direct radiography measurements. Gonzalez et al.[26] stated in measurements on CT that this value, >9 mm, likely indicated the possibility of the traumatic disruption of the CVJ. In his study, Gonzalez found the mean value as 4.7±1.7 mm in adults, and as 11.9±3.2 mm in limited numbers of pediatric cases.

Vachhrajani et al.[4] state that since the tip of the odontoid does not ossify until the age of 12 years, applying the adult

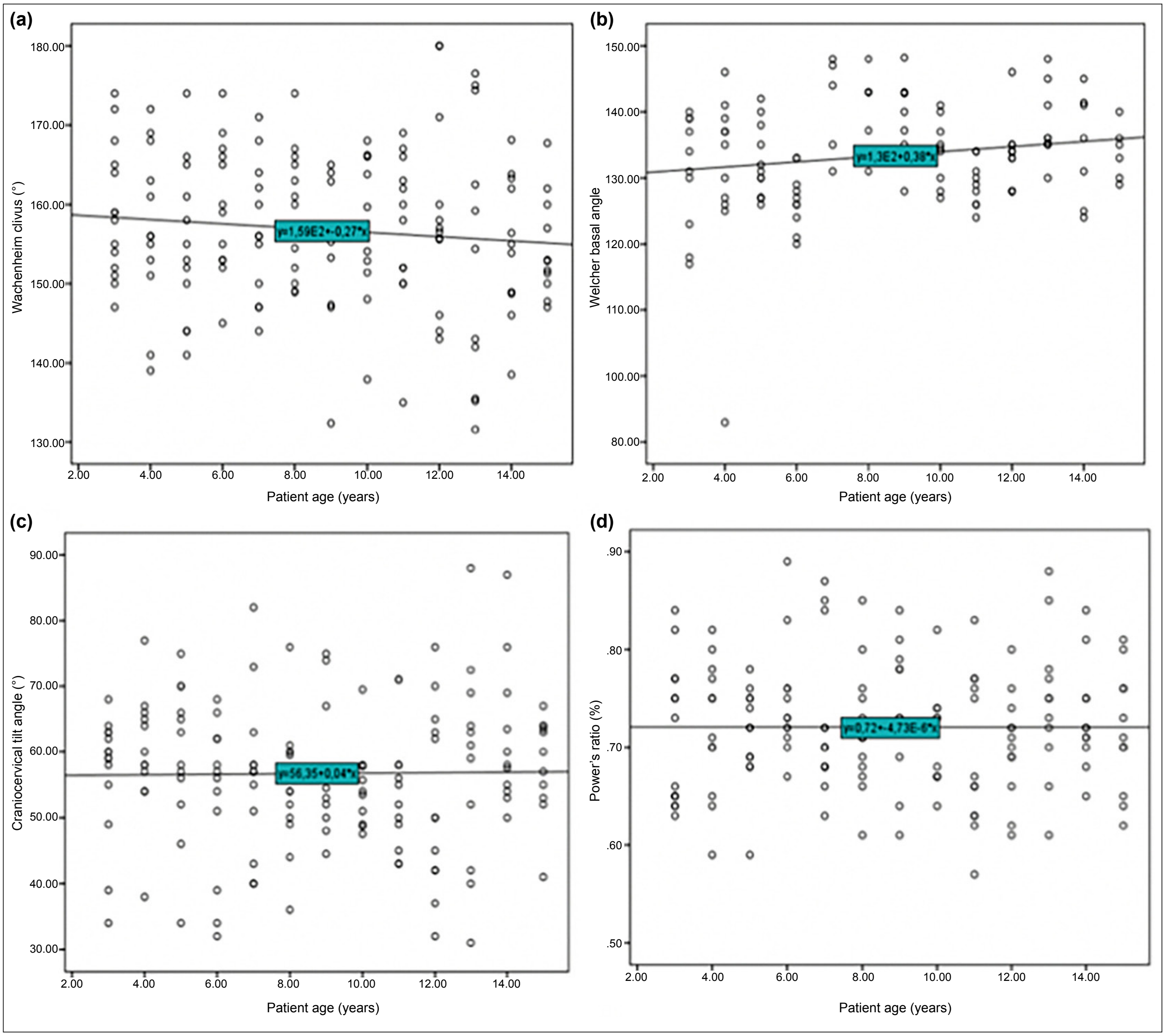

Figure 3. Correlation of Wachenheim clivus angle **(a)**, Welcher basal angle **(b)**, Craniocervical tilt angle **(c)** and power ratio **(d)** with patient age.

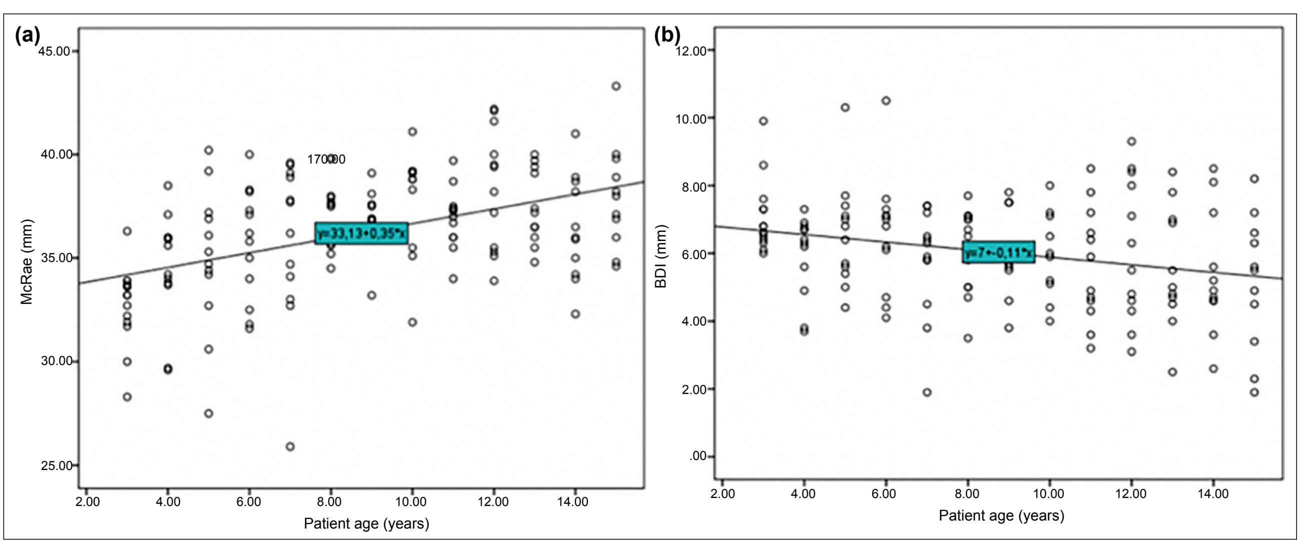

Figure 4. Correlation of McRae Line **(a)** and Basion-axis interval **(b)** with patient age.

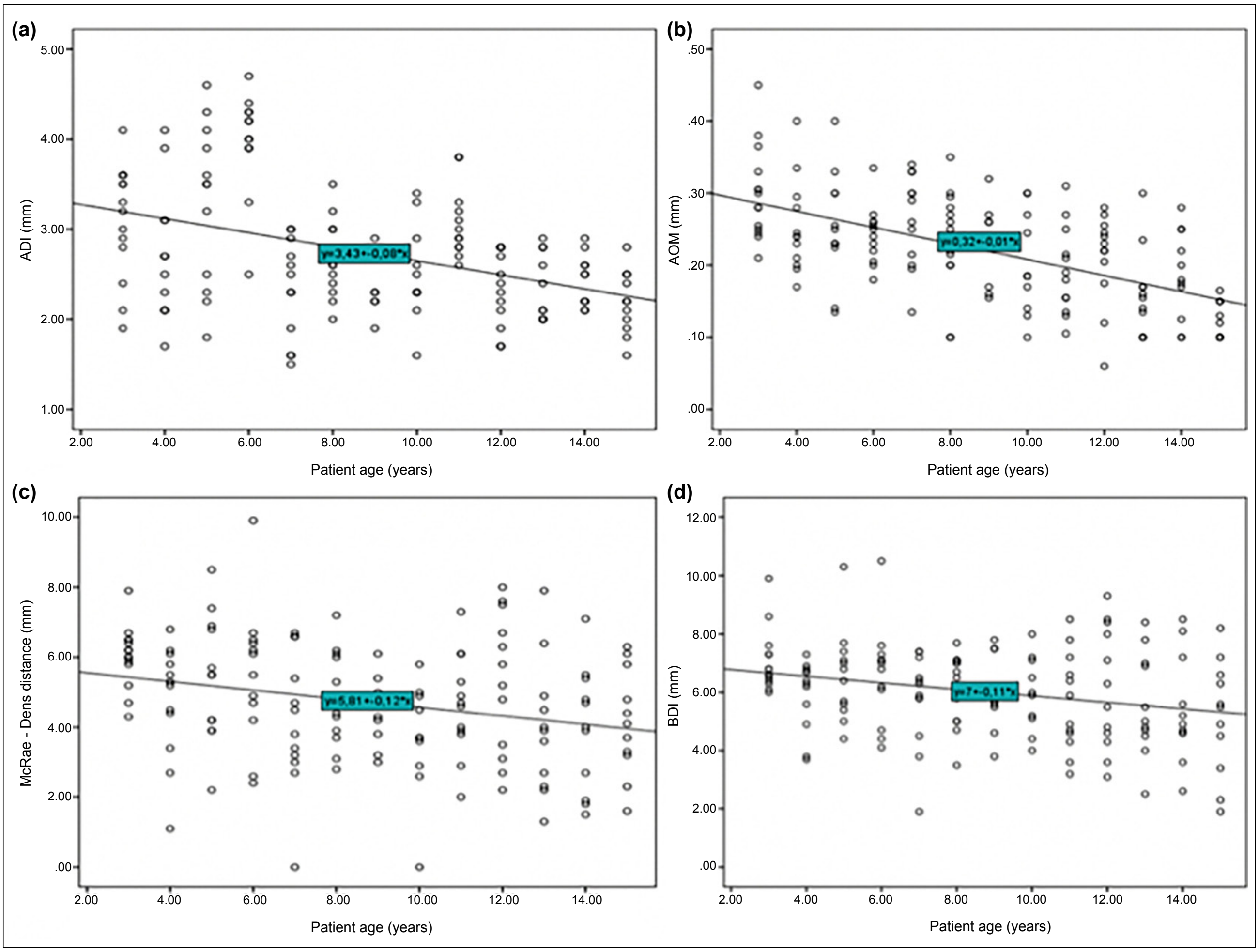

Figure 5. Correlation of correlation of atlantodens interval **(a)**, atlantooccipital measurement **(b)**, McRae-Dens distance **(c)**, and basion-dens interval **(d)** with patient age.

definition of BDI to the immature pediatric cervical spine may result in an overdiagnosis of distraction injuries and a high incidence of false-positive results. They found the mean BDI as 7.28 mm and determined a 0.02 mm reduction in BDI with each monthly increase of age.

Bertozzi et al.[1] obtained more precise results by separating the patient population into those at whom the ossiculum terminale is present and those at whom it is absent. They found that the age range of patients with ossification of the ossiculum terminale was between 21 months and 10 years (n=81), whereas the age range of patients without ossification was between 6 months and 4 years (n=36). In patients with ossification of the ossiculum terminale, the maximum value obtained was 9.9 mm, and the mean value was 6.2±1.66 mm. In those patients at whom the ossiculum terminale is not yet ossified, the maximum value obtained in their study was 11 mm, and the mean value was 7.8±1.90 mm.

In the measurements made in the present study, BDI was found to be 6.0±1.6 mm. There was no difference between the genders.

Comparisons of selected indexes between age groups revealed that it was significantly different between groups. Accordingly, BDI was significantly higher in patients aged 3–9 years (p=0.003, Table 3), (id est., when the age groups of 3–9 and 10–15 were compared).

In the measurements performed, the ossiculum terminal was found to be ossified in all patients over 10 years of age. Comparing the patients with and without the ossiculum terminale, BDI was found to be more extended in the non-ossified group (p=0.048, Table 4).

ADI

ADI, also known as the predental space, is very small and maintained by the transverse atlantal, alar, and atlantodental ligaments. Therefore, an abnormally widened ADI indirectly indicates CVJ ligament injury and particularly transverse atlantal ligament injury ADI in children are 3–6 mm on plain radiographs.[30] Any ADI measurement >6 mm in children suggests ligamentous rupture. However, this value may be excessive (>6 mm) in children with ligament laxity (down syndrome etc.) without any clinical signs. In a CT-based study, the instability threshold value was reported as 3 mm.[4] Menezes[31] defined the presence of a predental interval >3 mm in patients under the age of 8 and 5 mm in patients over the age of 8 as the instability configuration in the CVJ.[32] In the measurements made in the present study, ADI was found to be 2.7±0.7 mm (Table 1). It was calculated that the interval decreased with increasing age (r=−0.39, p<0.001, Table 5).

AOM

Pang et al.[32] found the mean value as 1.28 mm in their CT-based occipital condyle-C1 interval in 89 children with minor trauma and no trauma history. The same group of authors reported that this measurement had 100% sensitivity in atlantooccipital dissociation injuries.[19,32] The structure called "synchondrosis intraoccipitalis anterior" previously defined as wedge-shaped depression in the atlantooccipital joint surface interval was detected during the measurements performed in the present study.[33,34] In accordance with the literature, measurements were not made over wedge-shape to avoid incorrect values in the measurements. (It is important to note this structure and refrain from including this depression in measurements of the atlantooccipital interval because doing so would falsely increase the value obtained.) In the AOM performed, the mean value was found to be 0.2±0.1 mm (Table 1). It was significantly wider in the male gender (p<0.001, Table 2), and the 3–9 age group compared to the 10–15 age group (p<0.001, Table 3). It was calculated that AOM decreased with increasing age (r=−0.55, p<0.001, Table 5, Fig. 5b).

PR

This ratio was first described by Powers in 1979.[18] PR is the most widely used method for the diagnosis of anterior atlantooccipital dislocation.[35] A PR >1 should be interpreted in favor of atlantooccipital dislocation. PR could not be calculated in children due to the challenges in identifying the opisthion on direct radiographs.[11] It is easier to detect landmarks in CT-based measurements. PR measurements are difficult when C1 anterior and posterior arches are not ossified. In adult patients, PR were found to be compatible with direct radiography measurements (<0.9). Rojas et al.[30] found it compatible with direct radiography measurements in pediatric cases and gave an average value of <0.9. The value of the PR increased slightly with age. The values of all patients were within the normal range (<0.9).[36] The average value in the PR measurements required in the current study was measured as 0.7±0.1 mm (Table 1).

CCT

Chandra et al.[19] defined it as the angle between the line drawn from the anterior border of the clivus of the line drawn upward from the anterior face of the odontoid protrusion. They found the sagittal inclination angle as 60.2±9.2° in the control group, and the basilar intussusception and atlantoaxial dislocation as 84.0±15.1°. Tanrisever et al. found it as 126.98°±12.24° similar to Chandra et al.[9,19] In the current study, the CCT angle was found to be 56.7°±11.0° (Table 1).

MRL

The MRL's line is the line drawn from the lower end (basion) of clivus and to the posterosuperior of the foramen magnum (opisthion). No part of the odontoid should be above this line and it gives the correct result in the diagnosis of basilar impression. MRL's line is generally longer than 30 mm in normal individuals. A diameter of <25 mm is almost always associated with neurological symptoms.[37] Al Kaissi et al.[38] measured the MRL as 19.6 mm in a 5 year-old male child diagnosed with arthrogryposis multiplex congenital, who had severe central nervous system dysfunction. According to a study by Dash et al.[15] (conducted in adults), the MR was found to be 36.48 mm in males and 35.97 mm in females. In the study by Tanrisever et al.[9] the minimum MRL was found to be 29.60 mm in measurements in adults. Lee et al.[36] found that the MRL value increased from 31.7 mm in the 0–2 years, 33.4 mm in 2–5 years with statistical significance; however, the value did not increase statistically significantly after 5 years.

In the present study, the MRL was measured as 36.2±2.9 mm (Table 1). This value was measured statistically significantly higher in males (36.59±3.07 mm, p=0.011, Table 2). There was a positive and moderate correlation between patients' ages and MRL (r=0.44, Table 5, Fig. 4a).

McRae-dens (OP) Distance

OP located above the McRae is considered pathologic and it is indicative of basilar invagination.[39] In the literature, there are many studies that evaluate the McRae-Dens where none of the individuals had the tip of the OP above. In the previous studies (all conducted in adults), the mean value of OP-McRae in the control group was reported in a range of 4.60–5.80 mm.[9,14–17] Lee et al.[36] made CT measurements in 247 children. They measured the McRae-OP distance in children aged 0–2 years, 2–5 years, and over 5 years. The mean McRae-OP line was 8.5 mm in 0–2 years, 8 mm in 2–5 years, and 7.5 mm over 5 years. They reported that this value decreased moderately with age. In our measurements, McRae-Dens length was measured as 4.7±1.7 mm (Table 1). The 3–9 age group was significantly higher compared to the 10–15 age group (p=0.005, Table 3). When patients with positive and negative ossiculum terminal were compared, there was no significant difference between the two Groups (p=0.119, Table 4).

WBA

It is the angle formed by the line extending from the nasal tubercle to the tuberculum sellae and the line passing parallel from the basion to the clivus. WBA increased when the skull base is abnormally flattened with or without basilar impression.[40] WBA should normally be <140°. In the literature, there are many studies that evaluate the WBA.[9,15,41–45] In the literature review, no pediatric measurements were found in the studies. Measurement results in the present study (133.4°±8.0°, Table 1) increased with age, but the relationship between age and increase was found to be very weak (r=0.14, Table 5, Fig. 3b).

WCA

WCA was first described by Bundschuh et al.[46] The clivus spinal canal angle is the angle that is formed at the junction of Wackenheim's line (along the dorsal surface of the clivus) and the posterior vertebral body line. The clivus canal angle normally ranges from 150° in flexion to 180° in extension, and if this angle is <150° the angle is considered to be pathological and may result in spinal cord compression in the general population.[47,48] In the present study, it was measured as 156.8°±9.9° (Table 1).

Limitation of Study

Due to the dynamic nature of the CVJ, measurements to be made will differ depending on the degree of extension or flexion of the neck. For this reason, our evaluation with CT taken only in the neutral position of the head constituted an important limitation for our study in most of the measurements. In our study, other factors such as race and height that may affect CVJ craniometry were not discussed, but we think that this issue should be taken into account in future studies.

Conclusion

We reported the results of our study on normal CVJ values obtained from cervical CT of 151 children (3–15 years old) with simple trauma. The data we obtained may be useful for the comparative evaluation of childhood CVJ pathologies with normal parameters. In addition, our study highlights the need for surgeons to consider normal ranges based on CT scanning rather than data from plain radiographs.

Ethics Approval

All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Ethics Committee Approval: This study was approved by the Sakarya University Faculty of Medicine Non-Interventional Research Ethics Committee (Date: 03.01.2022, Decision No: 92656).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Pediatrik yaş grubunun bilgisayarlı tomografi görüntülerinden kraniyovertebral bileşkedeki normal kemik yapıların şekil ve boyutlarının ölçülmesi

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AMAÇ: Bu çalışma, pediatrik yaş grubunun bilgisayarlı tomografi (BT) görüntülerinden kraniyovertebral bileşkedeki kemikli yapıların morfometrik referans değerlerini belirleyerek literatüre katkıda bulunmayı amaçlamaktadır.
GEREÇ VE YÖNTEM: Bu çalışmada, 2016–2020 yılları arasında yaşları 3–15 arasında değişen, 151 basit travmalı çocuk hastanın servikal BT'leri değerlendirildi. Tüm BT incelemelerinde 32-kesitli bir BT kullanılarak, kafa tabanı ve C1-C2 bileşkesinin görüntüleri değerlendirildi. Bu görüntülerden Wachenheim clivus kanal açısı (WKA), Welcher bazal açısı (WBA), kraniyoservikal tilt açısı (KST), Power oranı (PO), Atlantodens intervali (ADI), McRae Line (MRL), McRae - Dens mesafesi, Bazion-Dens aralığı (BDA), Bazion-aksis aralığı (BAA), Atlantooksipital mesafe (AOM) olmak üzere toplam 10 ölçüm elde edildi.
BULGULAR: Cinsiyet grupları karşılaştırıldığında MRL (p=0.011) ve AOM (p<0.001) ölçümleri erkeklerde anlamlı olarak yüksek bulundu. McRae-Dens mesafesi, BDA ve AOM 3–9 yaş arası hastalarda anlamlı olarak daha yüksekti (sırasıyla, p=0005, p=0.003, p<0.001) ve BAA (p=0.001) anlamlı olarak 10–15 yaşındaki hastalarda daha yüksekti. McRae - Dens mesafesi (p=0.119) odontoid apeksinde terminal kemikçik olan ve olmayan hastalar arasında benzerdi. Ancak terminal kemiği olmayan hastalarda BDA anlamlı olarak daha yüksekti (p=0.048). WKA, WBA, KST ve PO dışındaki tüm parametreler, hasta yaşı ile istatistiksel olarak anlamlı şekilde ilişkiliydi (sırasıyla, p=0.21, p=0.13, p=0.70, p=0.99).
TARTIŞMA: Bu çalışmada, pediatrik yaş grubunun BT görüntülerinden kraniyovertebral bileşkedeki kemik yapılarının morfometrik referans değerleri belirlendi.

Anahtar sözcükler: Bilgisayarlı tomografi; kraniovertebral bileşke; kemik yapılar; pediatrik yaş.

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