Volume: 26, Issue:2, April 2015 pp: 109-114 ORIGINAL ARTICLE / ORJİNAL MAKALE

EVALUATION OF THE CRANIOCERVICAL JUNCTION OF THE ADOLESCENT PATIENTS WITH CONGENITAL SPINAL DEFORMITY VIA COMPUTERIZED TOMOGRAPHY

KONJENİTAL OMURGA DEFORMİTELİ ADÖLESAN HASTALARDA BİLGİSAYARLI TOMOGRAFİ İLE KRANİOSERVİKAL BİLEŞKENİN DEĞERLENDİRİLMESİ

Mehmet Bülent BALIOGLU[1],
Yunus ATICI[1],
Akif ALBAYRAK[1],
Deniz KARGIN[1],
Yunus Emre AKMAN[1],
Mehmet Akif KAYGUSUZ[2]

[1]*Orthopedics and Traumatology Specialist, Spine Surgery and Arthroplasty Clinic, Metin Sabanci Baltalimani Bone Diseases Training and Research Hospital*

[2]*Prof. Dr., Spine Surgery and Arthroplasty Clinic, Metin Sabanci Baltalimani Bone Diseases Training and Research Hospital*

SUMMARY

Aim: Analysis of the craniocervical junction of adolescent patients with congenital spine deformities with computed tomography (CT) was planned.

Materials and Methods: 23 adolescent patients (15 females and 8 males) with congenital spine pathology and CT of the cervical region were evaluated retrospectively. The mean age was 18.4 years (10-19 years). Basion-axis interval (BAI), basion-dens interval (BDI), Powers ratio, atlanto-occipital interval (AOI), atlantodental interval (ADI) and posterior atlantodental interval (PADI) were measured in CT. Results were compared according to gender, presence or absence of atlantoaxial anomalies and inraspinal anomalies. Mann-Whitney U test was used for comparisons between groups.

Results: The median, minimum and maximum values measured by CT were calculated in all patients. In CT, BAI was found as 2.5 mm (0-7.4 mm), BDI was found as as 4.0 mm (2-7.5 mm), Powers ratio was found as 0.76 (0.63-0.88), AOI was found as 1.2 mm (0-2.8 mm), ADI was found as 1.5 mm (0-3.1 mm) and PADI was found as 17.5 (14.6-23 mm). AOI was found to be significantly different in the patients with congenital anomalies in atlantoaxial junction when compared to the patients without congenital anomalies (P=0.015). In patients with intraspinal anomalies, BDI showed statistically significant differences (P = 0.008).

Conclusion: Being high values of BDI in the patients with AOI and intraspinal anomalies in the presence of atlantoaxial pathology compared to those without could be important when a treatment for craniocervical junction in the adolescent cases accompanied by congenital spinal deformity. The larger number of patients for craniocervical junction is needed for comprehensive detailed studies.

Keywords: Congenital spinal deformity, craniocervical junction, computed tomography, atlantoaxial interval

Level of evidence: Retrospective clinical study, Level III

ÖZET

Amaç: Konjenital omurga deformiteli adölesan hastalarda bilgisayarlı tomografi (BT) ile kranioservikal bileşkenin analizi planlandı.

Materyal ve Metod: Konjenital omurga patolojisi olan ve servikal bölgesine BT çekilen, 23 adölesan hasta (15 kadın, 8 erkek) retrospektif olarak değerlendirildi. Yaş ortalaması 18.4 yıl (10-19 yıl) idi. BT de basion-aksis mesafesi (BAM), basion-dens mesafesi (BDM), Powers ratio, atlanto-oksipital mesafe (AOM), atlantodental mesafe (ADM) ve posterior atlantodental mesafe (PADM) ölçüldü. Sonuçlar cinsiyetlere, atlantoaksiyel anomali ve inraspinal anomali olup olmamasına göre karşılaştırıldı. Gruplar arası karşılaştırma için Mann Whitney U testi kullanıldı.

Sonuçlar: Tüm hastalarda BT ile ölçülen ortanca, en küçük ve en yüksek değerler hesaplandı. BT de BAM 2.5 mm (0-7.4 mm), BDM 4.0 mm (2-7.5 mm), Powers ratio 0.76 (0.63-0.88), AOM 1,2 mm (0-2.8 mm), ADM 1.5 mm (0-3.1 mm) ve PADM 17.5 (14.6-23 mm) bulundu. Atlantoaksiyel bileşkede konjenital anomalisi olan hastalarda olmayanlara göre AOM anlamlı olarak farklı bulundu (P=0.015). İntraspinal anomali olan hastalarda BDM istatistiksel olarak anlamlı farklılık gösterdi (P=0.008).

Çıkarım: Atlantoaksiyel patoloji varlığında AOM ve intraspinal anomalisi olan hastalarda BDM değerlerinin olmayanlara göre yüksek olması konjenital omurga deformitelerinin eşlik ettiği adölesan olgularda kranioservikal bileşkeye yönelik bir tedavi planlanırken önemli olabilir. Kranioservikal bileşkeye yönelik daha fazla hasta sayısı ile kapsamlı detaylı çalışmalara ihtiyaç vardır.

Anahtar kelimeler: Konjenital omurga deformitesi, kranioservikal bileşke, bilgisayarlı tomografi, atlantoaksiyel mesafe

Kanıt düzeyi: Retrospektif klinik çalışma, Düzey III

Address: Mehmet Bulent Balioglu, Metin Sabanci Baltalimani Bone Diseases Training and Research Hospital, Rumelihisari cad., 34470, Sariyer / Istanbul.
Tel.: 0532 2521483
E-mail: mbbalibey@gmail.com
Received: 11th December, 2014.
Accepted: 18th March, 2015.

INTRODUCTION:

There are difficulties in defining the craniocervical junction pathologies with conventional radiological methods[2,4]. In the literature, there are studies using direct radiological and computed tomography (CT) which define the various measurement methods for determining the normal values of craniocervical junction radiologically [5-7,9-11]. With congenital spine abnormalities, osseous and intraspinal anomalies can be found together. In our study, investigation of measured values with CT in craniocervical junction of adolescent patients with congenital spinal anomalies was aimed for the analysis of accompanying craniocervical junction and to investigate whether the values is different from the values reported in the literature or not.

MATERIALS AND METHODS:

Twenty-three patients who were imaged with CT due to congenital anomalies of the spine (such as hemivertebra, butterfly vertebrae, block vertebrae) were evaluated. 15 of the patients were female, 8 of the patients were male and mean age was 18.4 years (10-19 years). In our study, craniocervical junction was examined with CT; the patients with no history of cervical spine trauma, bone or ligament injury were included. Basion-axis interval (BAI), basion-dens interval (BDI), Powers ratio, atlanto-occipital interval (AOI), atlantodental interval (ADI) and posterior atlantodental interval (PADI) were measured in every patient. All cases were investigated with magnetic resonance imaging (MRI) in terms of intraspinal anomalies.

Cervical spines were examined with CT device with 16 detectors (Somatom Sensation 16, Siemens AG, Erlanger, Germany). Images in axial and sagittal plan in PACs system were analyzed using bone window. BAI, BDI, Power ratio, AOI, ADI and PADI were measured from CT scans of each patient. For BAI measurements, the interval between basion and the posterior cortical edge of axis was measured according to the method described by Harris[5,6,10] (Figure 1A). BDI measurement was calculated by measuring the interval from most inferior part of the basion to the nearest point of dens superior to the basion[11] (Figure-1B). Powers ratio was calculated by dividing basion type to posterior surface of the spinolaminar line of the atlas and anterior arch of C1 from opisthion type[9] (Figure-1C). AOI was calculated by measuring the average of the interval of perpendicular line extended from mid point of occipital condyle articular surface in sagittal and coronal plan to C1 lateral mass (Figure-1D). ADI was calculated by taking the interval between posterior surface of anterior arch of C1 in sagittal plan and anterior surface of dens in the middle of the arch[7] (Figure-1E). PADI calculation was made by measuring the interval between the most posterior edge of dens in middle sagittal plan and anterior surface of posterior arch of C1 (Figure-1E).

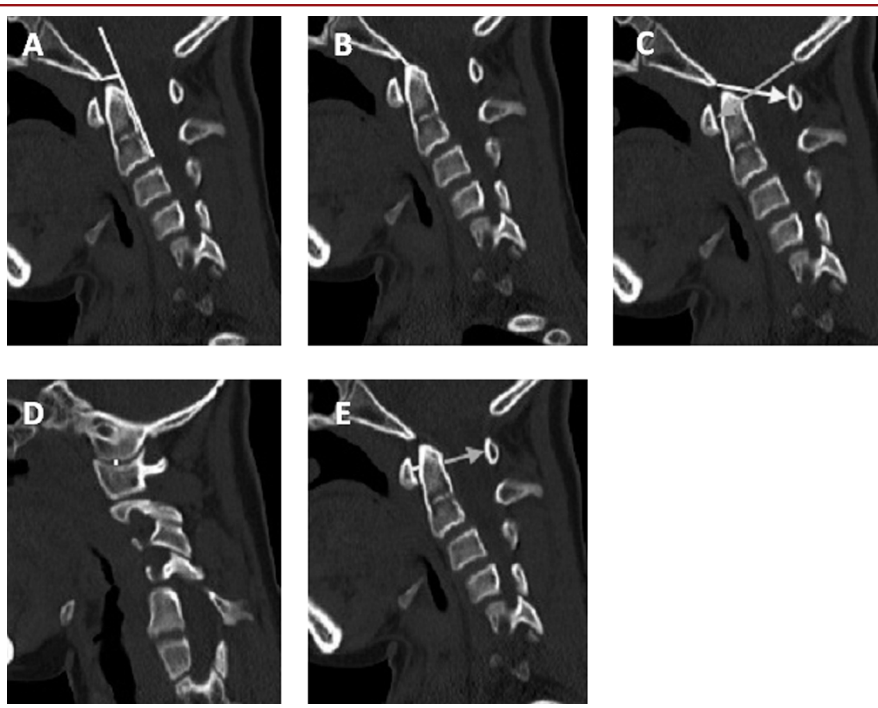

Figure-1. Measurement of **(A)** basion-axial interval (BAI), **(B)** basion-dens interval (BDI), **(C)** Powers ratio, **(D)** atlanto-occipital interval (AOI), **(E)** atlantodental interval (ADI) and **(F)** posterior atlantodental interval (PADI) in CT.

Since the data measured by each method showed nonparametric distribution, they were expressed as median, the minimum value and the maximum value. Mann Withney-U test was used in pairwise comparisons. Each measured distance was statistically compared in terms of gender, atlantoaxial pathology and intraspinal anomalies.

RESULTS:

All parameters measured in the patients were calculated in sequence of median, the minimum and the maximum. When all patients were evaluated, BAI was found as 2.5 mm (0-7.4 mm), BDI was found as 4.0 mm (2-7.5 mm), Powers ratio was found as 0.76 (0.63-0.88), AOI was found as 1.2 mm (0-2.8 mm), ADI was found as 1.5 mm (0-3.1 mm) and PADI was found as 17.5 (14.6-23 mm) (Table-1).

When the distribution of obtained results according to gender were statistically compared, no significant differences were found between both sexes ($p<0.05$) (Table -2).

When the patients were compared in terms of atlantoaxial pathology, only AOI was found to be significantly different between the patients with pathology (n=5) and the patients with congenital anomalies in other parts of the spine but no cervical pathology (n=18) ($P=0.015$). There were no significant differences in other parameters ($p <0.05$) (Table-3).

Table-1. Median values (minimum-maximum) of basion-axial interval (BAI), basion-dens interval (BDI), Powers ratio, atlanto-occipital interval (AOI), atlantodental interval (ADI) and posterior atlantodental interval (PADI) in all patients via CT

N=23	Median	Minimum	Maximum
BAI (mm)	2.50	0.00	7.40
BDI (mm)	4.00	2.00	7.50
Powers Ratio	0.76	0.63	0.88
AOI (mm)	1.20	0.00	2.80
ADI (mm)	1.50	0.00	3.10
PADI (mm)	17.50	14.60	23.00

Table-2. Distribution of the patients according to gender and comparison of kranioserkal junction angles. Significant difference was not found among both genders ($P>0.05$).

	Female (n=15)			Male (n=8)			P
	Median	Minimum	Maximum	Median	Minimum	Maximum	
BAI (mm)	1.80	0.00	6.80	3.15	0.00	7.40	0.357
BDI (mm)	4.40	2.00	7.50	3.85	2.00	7.00	0.925
Powers Ratio	0.76	0.63	0.88	0.77	0.65	0.85	>0.05
AOI (mm)	1.20	0.00	1.70	1.55	1.00	2.80	0.115
ADI (mm)	1.50	0.80	2.40	1.60	0.00	3.10	0.925
PADI (mm)	17.50	14.80	23.00	18.25	14.60	22.60	0.548

Table-3. According to the presence or absence of craniocervical junction pathology, AOI was found to be significantly different in the patients with atlantoaxial pathology compared to the patients without atlantoaxial pathology ($P=0.015$). There were no significant differences in other parameters ($P> 0.05$).

	Atlantoaxial pathology						P
	Absent (n=18)			Present (n=5)			
	Median	Minimum	Maximum	Median	Minimum	Maximum	
BAI (mm)	2.20	0.00	6.80	2.60	0.00	7.40	0.691
BDI (mm)	3.90	2.00	7.50	5.10	2.00	6.60	0.691
Powers Ratio	.75	.63	.88	.79	.73	.82	0.446
AOI (mm)	1.10	0.00	1.70	1.60	1.30	2.80	***0.015***
ADI (mm)	1.50	.80	3.10	1.50	0.00	2.60	>0.05
PADI (mm)	17.25	14.60	23.00	19.10	17.00	21.50	0.290

When the patients with both detected congenital anomalies of the spine and intraspinal pathology (n=15) were compared to the patients without intraspinal pathology (n=8), only BDI was found to be significantly different (p=0.008); there were no significant differences in other parameters between the two groups (p> 0.05) (Table-4).

Table-4. The patients with detected intraspinal pathology were compared to the patients without intraspinal pathology. BDI displays significant difference (P=0.008), while there were no significant differences in other parameters between the two groups (P> 0.05).

	Intraspinal anomalies						P
	Absent (n=8)			Present (n=15)			
	Median	Minimum	Maximum	Median	Minimum	Maximum	
BAI (mm)	2.95	0.00	6.80	1.90	0.00	7.40	0.357
BDI (mm)	3.50	2.00	4.40	5.50	3.00	7.50	***0.008***
Powers Ratio	0.73	0.68	0.82	0.76	0.63	0.88	0.392
AOI (mm)	1.30	0.90	1.70	1.10	0.00	2.80	0.681
ADI (mm)	1.65	0.80	2.40	1.40	0.00	3.10	0.506
PADI (mm)	17.50	15.20	23.00	17.50	14.60	22.60	0.975

DISCUSSION:

The evaluation of the problems of craniocervical region (e.g., trauma or other pathologies) is not always possible with conventional lateral radiological examinations[2,4]. It is possible to evaluate craniocervical region particularly with CT[10].

It is recommended to measure from the sections of midline to accurately assess the contour of the posterior cortex, since BAI gives the erroneous results in the different sections of axis[10]. In their study, Rojas et al. measured the BAI as 3.4 cm in average with CT [10]. In our study, BAI was measured as 2.5 mm.

The normal upper limit of BDI was reported as 12 mm in the literature[5,6]. Gonzalez et al. published the average as 4.7 mm and the maximum as 9 mm[3]. Rojas et al. showed the maximum as 9.1 mm in 200 patients with the age of 20-40 years with CT, and up to 8.5 mm for >95% [10]. In our study, we found the median value of BDI as 4.9 mm, the maximum as 7.5 mm in the adolescent patients with congenital spine anomalies. We found our results consistent with the normal values reported in the literature.

In our study, median of BDI value was measured as 4 mm (2-7.5 mm) in all patients with CT. The value was found to be significantly high in patients detected with intraspinal anomalies in MRI compared to ones without intraspinal pathology (P=0.008) (Table-4).

Power ratio was shown as <0.9 mm for more than 95% of normal population[9]. In our study, we found the power ratio in our patients as 0.76 which is compatible with the normal values in the literature (Table-1).

The normal values for AOI in 95% of the adults were reported as 1 mm in average (0.6-1.4 mm) with CT[10]. In our study, the median value of AOI measured with CT was found as 1.2 mm (0-2.8 mm). When the patients with atlantoaxial pathology were compared the ones without atlantoaxial pathology, AOI values of the patients with atlantoaxial pathology was found to be significantly high (P = 0.015) (Table-3).

Atlantodental ligament, alar ligaments and transverse Atlanta ligaments were evaluated by measuring the predental interval with ADI. Abnormal enlargement of predental interval shows the injury of craniocervical ligaments, especially transverse atlantal ligament[1]. Normal value was shown as 3 mm for males, 2.5 mm for females[7]. Rojas et al. reported the normal value as ≤ 2 mm for both genders with CT [10]. In the study of Ozdogan et al, ADI was found as 1.47 mm for males and 1.51 for females with CT in the study of 50 males and 50 females; if it is measured more than 2 mm, it was emphasized that should be investigated in terms of craniocervical region pathologies[8]. In our study, the median value of ADI of adolescent patients was fount as 1.5 mm in males (≤2.4) and 1.6 mm for females (≤3.1) which were compatible withe normal literature. Medain value of PADI in our patients was found as 17.5 mm (14.6-23 mm) (Table 2).

Knowing the distance between each of the anatomical structure of the craniocervical junction can be necessary for the treatment and follow-up of adolescent cases especially accompanied by congenital spinal deformity. In the presence of atlantoaxial pathology, higher value of AOI and BDI in the patients with intraspinal anomalies compared to the patients without intraspinal anomalies can be important in planning the treatment for craniocervical junction in the adolescent cases accompanied by congenital spinal deformity. In the cases with congenital spinal pathology, further studies are needed with more number of patients to better evaluate craniocervical junction.

REFERENCES:

1. Deliganis AV, Baxter AB, Hanson JA, Fisher DJ, Cohen WA, Wilson AJ, Mann FA. Radiologic spectrum of craniocervical distraction injuries. *Radiographics* 2000; 20: 237–250.

2. Gale SC, Gracias VH, Reilly PM, Schwab CW. The inefficiency of plain radiography to evaluate the cervical spine after blunt trauma. *J Trauma* 2005; 59: 1121–1125.

3. Gonzalez LF, Fiorella D, Crawford NR, Wallace RC, Feiz-Erfan I, Drumm D, Papadopoulos SM, Sonntag VK. Vertical atlantoaxial distraction injuries: radiological criteria and clinical implications. *J Neurosurg Spine* 2004; 1: 273–280.

4. Harris J Jr. The cervicocranium: its radiographic assessment. *Radiology* 2001; 218: 337–351.

5. Harris JH Jr., Carson GC, Wagner LK. Radiologic diagnosis of traumatic occipitovertebral dissociation: 1. Normal occipitovertebral relationships on lateral radiographs of supine subjects. *AJR Am J Roentgenol* 1994; 162: 881-886.

6. Harris JH Jr, Carson GC, Wagner LK, Kerr N. Radiologic diagnosis of traumatic occipitovertebral dissociation: 2. Comparison of three methods of detecting occipitovertebral relationships on lateral radiographs of supine subjects. *AJR Am J Roentgenol* 1994; 162: 887–892.

7. Hinck VC, Hopkins CE. Measurement of the atlanto-dental interval in the adult. *Am J Roentgenol Radium Ther Nucl Med* 1960; 84: 945–951.

8. Özdoğan S, Köken M, Gergin YE, Aydın SO, Yüce E, Tiryaki M, Tatarlı N, Süslü HT, Hiçdönmez T. Erişkinlerde ön atlantodental mesafenin bilgisayarlı tomografi ile ölçümü. *J Turk Spinal Surg* 2014; 25(3): 193-197.

9. Powers B, Miller MD, Kramer RS, Martinez S, Gehweiler JA Jr. Traumatic anterior atlanto-occipital dislocation. *Neurosurgery* 1979; 4: 12–17.

10. Rojas CA, Bertozzi JC, Martinez CR, Whitlow J. Reassessment of the craniocervical junction: normal values on CT. *Am J Neurorad* 2007; 28(9): 1819-1823.

11. Wholey MH, Bruwer AJ, Baker HL Jr. The lateral roentgenogram of the neck; with comments on the atlanto-odontoid-basion relationship. *Radiology* 1958; 71: 350–356.