

Effect of Dynamic MRI Examination of Cervical Spine on Stability of Three Angles (CPA, CXA, CDA)

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Received: 21 Sep 2021

Accepted: 04 Oct 2021

Published: 11 Oct 2021

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Citation:

Mei Li S. Effect of Dynamic MRI Examination of Cervical Spine on Stability of Three Angles (CPA, CXA, CDA). Clin Surg. 2021; 6(7): 1-5

Keywords:

CPA; CXA; CDA; Craniocervical Junction Malformation; Cervical Mri; Dynamic position

1. Abstract

1.1. Objective: To investigate the influence of cervical dynamic MRI on the stability of CPA Angle, and whether it has more clinical diagnostic value compared with CXA and CDA Angle.

1.2. Methods: 15 healthy clinical subjects underwent MRI examination in neutral position, hyperextension position and hyperflexion position at the same time. The value of three angles (CPA, CXA and CDA) were measured, and the t test was used to compare the changes of different positions.

1.3. Results: The paired T-test showed that CPA had no significant difference in Angle measurement from neutral cervical vertebra to hyperextension cervical vertebra, and was significantly stable to CXA and CDA. Secondly, CPA changed the least from neutral position to overflexion position, followed by CXA, and CDA changed the most.

1.4. Conclusion: CPA is the least sensitive and most stable to cervical curvature. Especially, the difference between neutral position and overextension position is the least, and the stability is obviously better than CXA and CDA.

2. Introduction

Craniocervical Junction (CVJ) malformations include Basilar Invagination (BI), platybasia, Atlanto-Occipital Fusion (AOA), Atlanto-Axial Dislocation (AAD), etc., and sometimes subcerebellar tonsillar hernia and myelomelia (SM) [1], etc. At present, the commonly used diagnostic indicators for CVJ malformation include CPA, CXA, CDA, CAA and CMA [2, 3]. CPA Angle, that is, the Angle formed by the junction of Wackenheim line and hard palatal line in sagittal position, is an indicator that Ma Et al.

proposed to play an important role in MRI diagnosis and treatment of Craniocervical Junction (CVJ) malformation. CXA (Clivoaxial Angle) was defined as the intersection of the baseline of Wackenheim Clivus and the lines drawn along the rear surface of the axial body with the odontoid [2, 3], and CDA (Clivodens Angle) was defined as the Angle formed at the intersection of the lines along the long axis of the slope with the lines along the long axis of the odontoid [5]. Studies have shown that CXA or CDA have high diagnostic value [4, 5]. However, some factors, such as subject position, cervical curvature, hyperosteoegeny, and anatomical changes in the odontoid process, may affect the measurement of CXA and CDA on MRI sagittal view, thus affecting the diagnosis.

MRI in dynamic position of cervical spine is a sagittal imaging technique for patients in neutral, hyperextension and hyperflexion positions, which plays an important role in determining the stability of craniocervical junction malformations [6-8]. However, in the case of multiple malformations at the same time, it will bring difficulties to the diagnosis and differential diagnosis of the disease. The CPA perspective can achieve similar value for diagnosis [9]. The bony base of the hard palate is the palatine process of the maxilla and the horizontal plate of the palatine bone. Compared to the diagnostic anatomy of CXA and CDA, they are stable and unaffected by the above factors, and are clearly visible at the baseline of the Angle in the sagittal MR image. Therefore, we hypothesized that CPA Angle is less affected and more stable by cervical curvature than CXA and CDA. There is no experimental study subjects cervical curvature effect on CPA, so this study recruited 15 subjects without cerebral border zone deformity power by MRI imaging, through neutral and hyperextension, flex-

ion position changes to assess cervical curvature effect on CPA, CXA, CDA, and use SPSS data analysis to verify the stability of the Angle change.

3. Method

3.1. Study Cohort

After approval by the Institutional Review Board, we recruited 15 undergraduate students (1 male, 14 female, age 20-23, mean age 21). None of the subjects recruited in this study had any history of cervical trauma or disease, nor did CT or MRI show evidence of CVJ abnormalities. Subject information was anonymized and de-identified prior to all analysis.

3.2. Use of Instruments

A 1.5 TMRI scanner (Siemens Avanto, Germany) was used to examine each subject in a neutral position. The cervical spine was then fixed in the hyperextension or hyperflexion position at the widest possible Angle (hyperextension $\geq 15^\circ$, hyperflexion $\geq 30^\circ$) using a homemade positioning sponge pad on the head, neck and/or back, respectively. The patient had no obvious discomfort and could cooperate well with the examination. The receiving coils were controlled only by the posterior cervical spine imaging phase coil. Imaging parameters were as follows: sagittal T2-weighted spin echo sequence, repeat time (TR)/echo time (TE) = 2800/107ms, 3mm thick section, FOV of 25cm \times 25cm, acquisition matrix of 230 \times 230. The image quality of all the 15 subjects was evaluated by 2 experienced physicians respectively, and the image quality was satisfactory and unanimous conclusions were reached [7, 8].

3.3. Image Analysis

CPA, CDA, and CXA were measured on sagittal MR images of all 15 subjects by 2 imaging investigators, regardless of subjects' demographic characteristics and clinical history. Software used: RadiAnt DICOM Viewer (64-bit). First, the following anatomical markers were identified: dorsal margin of the hard palate, dorsal margin of the base of the slope, dorsal margin of the dentate process, median axis of the base of the slope, and median axis of the odontoid process [7, 8] FIG. 1. Then, to assess inter-observer consistency, two investigators independently measured CPA, CXA, and CDA for all subjects (Table 1, Figure 1).

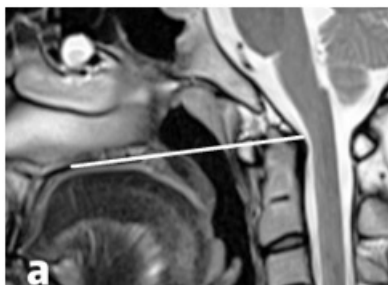


Figure 1: Straight lines and angles for evaluating basilar invagination
Figure A: Chamberlain's line, dorsal margin of the hard palate to the occipital point
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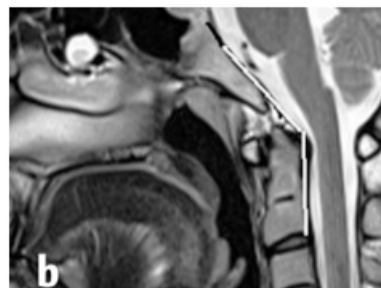


Figure B: CXA: Angle formed by the intersection of Wackenheim's line (from the spheno-occipital joint to the tip of the odontoid) and the odontoid along the posterior surface of the axon

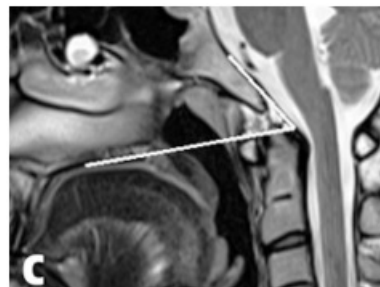


Figure C: CPA: Angle formed by Wackenheim line and hard palate extension

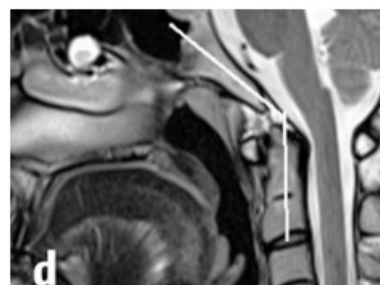


Figure D: CDA: Angle formed by a straight line along the long axis of the ramp and a straight line along the long axis of the odontoid

Table 1: Data distribution of the three angles under the dynamic position of the subject

	Mean (range)			ICCvalue
	Neutral position	Hyperextension	Flexion-extension	
CPA	60.8 \pm 2.1 $^\circ$ (51.4 $^\circ$ —67.6 $^\circ$)	61.7 \pm 1.9 $^\circ$ (54.0 $^\circ$ —71.9 $^\circ$)	59.7 \pm 1.5 $^\circ$ (52.6 $^\circ$ —66.6 $^\circ$)	0.726
CXA	147.5 \pm 2.4 $^\circ$ (129.8 $^\circ$ —160.7 $^\circ$)	153.6 \pm 3.7 $^\circ$ (131.8 $^\circ$ —169.8 $^\circ$)	144.6 \pm 2.5 $^\circ$ (127.1 $^\circ$ —156.4 $^\circ$)	0.942
CDA	135.9 \pm 2.8 $^\circ$ (116.1 $^\circ$ —150.7 $^\circ$)	141.9 \pm 4.4 $^\circ$ (115.2 $^\circ$ —162.5 $^\circ$)	130.7 \pm 2.9 $^\circ$ (108.7 $^\circ$ —144.5 $^\circ$)	0.92

3.4. Data Analysis

SPSS software (IBM SPSS Statistic, version 24) was used to evaluate the stability of CPA, CXA and CDA at the cervical dynamic position using the paired T-test. In paired T test, intra-group correlation coefficient (ICC) was used to determine intra-observer repeatability and inter-observer consistency according to whether P value <0.05, indicating whether the mean difference between

two correlated (paired) groups was statistically significant [11]. The results of similar correlation between 0.41 and 0.60 indicated moderate agreement, 0.61-0.80 indicated substantial agreement, and 0.81-1.00 indicated close to perfect agreement.

The numerical results of each Angle were measured twice by two researchers, and then the final average was taken.

The results of the two researchers were in complete agreement ($P < 0.001$) across all three angles, with a high degree of interobserver agreement between CPA, CXA, and CDA

4. Influence of Cervical Curvature Changes on the Three Angles

Three angles (CPA, CXA and CDA) were affected to varying degrees in the course of cervical curvature changes (Table 2, Figure 2). There was no significant difference in CPA from neutral po-

sition to overextension position ($P = 0.278$), but significant difference in CXA and CDA ($P = 0.003$ and 0.018 , respectively). When neutral position changed to overflexion position, CPA, CDA and CXA all changed significantly ($P = 0.039$, 0.003 and 0.000 , respectively). In order to further compare the difference of the variation amplitude of the three angles in neutral to overflexion position, we applied paired T-test for analysis. We also examined the significance of CPA Angle from hyperextension to hyperflexion and found a difference ($P = 0.028$)

The paired T test was applied to compare the change amplitude of the three angles with the postures. The results showed that CPA had the smallest change amplitude when neutral position changed to overflexion position, followed by CXA, and CDA had the largest change amplitude.

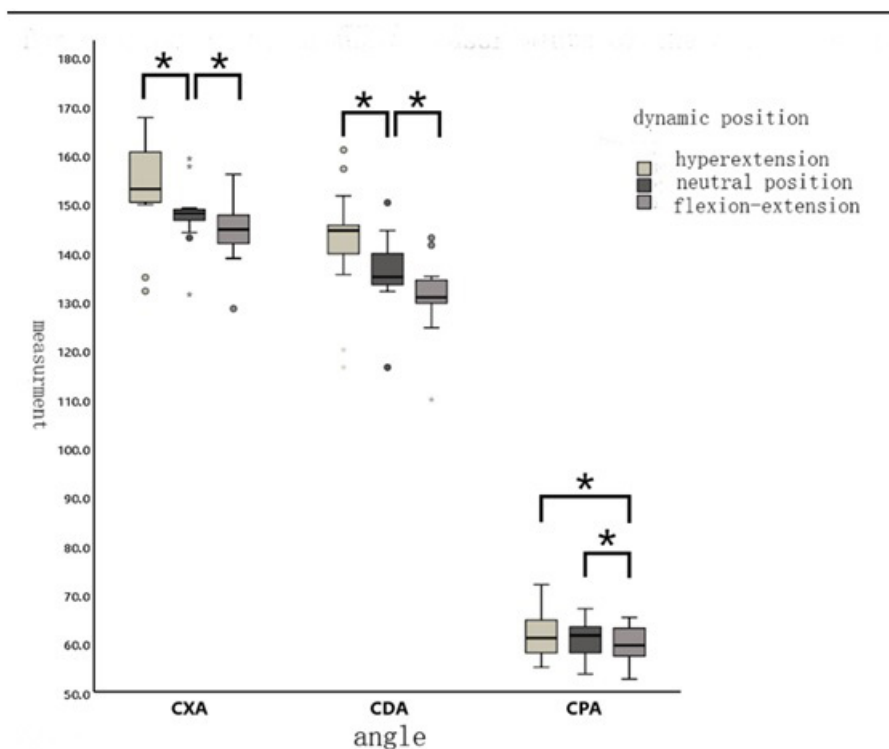


Figure 2: Data distribution of the three angles under the dynamic position of the subject

Table 2: Analysis of the influence degree of neutral and overflexion position changes on the three angles

	Mean	Standard deviation	difference 95% confi dence		P value
			Lower limit	Upper limit	
CPA -	-	3.2134	-3.5995	-0.0405	0.046
CXA	1.82				
CPA -	-	2.7887	-5.5926	-2.504	0
CDA	4.0483				
CXA -	-	2.9411	-3.8571	-0.5996	0.011
CDA	2.2283				

5. Conversation

This study of the three angles under different cervical curvature change difference significance test, proved in MRI dynamic check cervical by neutral position shift for stretching, CPA's point of clinicsofsurgery.com

view change there was no significant difference in statistics, we can think of CPA Angle stability, while the CXA, CDA are affected, this is obviously better than the CPA CXA and CDA. When neutral position changed to overflexion position, CPA had the

smallest change value, that is, the measurement stability of CPA was significantly better than CDA and CXA. Therefore, CPA can provide supplementary information for measuring CXA or CDA during the diagnosis of craniocervical junction malformation and improve diagnostic performance.

MRI is the necessary means of diagnosis of cranial neck border area abnormalities, its main advantage is that is multi-parameter imaging and comprehensive display, especially in the sagittal position can be clearly showed foramen magnum osseous margin before and after the nadir, saddle back vertex and pillow tuberosity in order the osseous marks, provide accurate anatomic location for accurate measurement, and without the influence of the bony artifact. Dynamic MRI can not only dynamically reflect the stability of craniocervical junction, but also provide clinical guidance for the diagnosis and treatment of atlantoaxial dislocation and classification [12]. In our study, dynamic MRI was used to test the stability of the three angles of the cranio-cervical junction, which not only ensured that the subjects were not affected by ionizing radiation, but also provided image clarity for Angle measurement.

The diagnostic value of CDA and CXA in craniocervical junction deformity has been confirmed. However, the results of this study showed that when CDA changed from neutral position to overflexion position, the value change was greater than that of CPA and CXA, which was inconsistent with previous studies [5]. This may be due to the change in the relationship between the slope and the long axis of the odontoid process, resulting in inaccurate measurement. In addition, MRI examination in dynamic position showed cervical flexion, widening of spinal canal, shorter distance between slope and odontoid process, and narrowing of spinal canal in cervical extension position. The slope is far from the odontoid process [13, 14], which adversely affects the measurement of CPA or CXA. Malformation or morphological variation of the odontoid process is quite common, and the integrity of the odontoid process is essential for the stability and proper function of the atlantoaxial joint [15, 16]. All above indicated that the measurement of CXA and CPA was greatly affected by dynamic MRI examination and had poor stability.

CPA is mentioned in this study by the hard palate and Wackenheim line slope line from the perspective of natural existence, by contrast, hard palate of palatal process is based on the upper jaw bone and the level of the palatine bone plate, dynamic MRI imaging, due to changes in the subject's position does not cause the change of the structure, therefore, the stability of the CPA Angle is not affected. In addition, CPA changes in the neutral-over-extension position were more stable than those in the neutral-over-flexion position, possibly because the contact area between tongue and palate increased in the over-flexion position [17], which affected the stability of CPA Angle measurement. In order to control the influence caused by other factors, we need to ensure that the sponge pad height of the subjects during the MAGNETIC resonance examination

is consistent, and the Angle of the two researchers should be measured several times to reduce the measurement error, so as to ensure the stability of CPA itself rather than the error caused by the examination and measurement.

The limitations of this study are as follows: First, the dynamic position imaging method adopted in this study does not accurately control the Angle of cervical hyperflexion and hyperextension of each subject, which results in poor reliability of the experimental results. Due to the long time of MRI examination, some patients' body position is limited and cannot be well combined with dynamic examination, which also brings difficulties in practical clinical application. Second, we measured the range values of CXA, CDA and CPA in cervical MRI dynamic position of volunteers. The measurement of CXA and CDA can be affected by the upward movement of odontoid process in patients with common basilar indentation, the backward movement of odontoid process in patients with atlantoaxial dislocation, and other congenital malformations, alveolar fracture or dislocation, and posterior axis osteosclerosis [13]. Third, Magnetic Resonance Imaging (MRI) for assessing maxillary gap and the subluxation and occipital - cervical spine in the C2 region with CT tomography as well as a variety of subluxation, in evaluating slope - dentate clearance, the erosion of spines and atlas occipital aspects, MR than CT tomography [20] effectively, this measuring Angle may be produced for us check technical error. Finally, this experiment is not CMA, CCA Angle stability affected by cervical curvature change, and we think the CPA Angle stability is good, but the results show that neutral - a bend in the cervical vertebrae, there are differences between the CPA's point of view change, in addition to the above factors influence, may be associated with this study sample size is too small, this is the deficiency of this study.

6. conclusion

Dynamic MRI examination has varying degrees of influence on the measurement stability of the three angles. As can be seen from the data distribution diagram of the three angles of the subjects' dynamic position, the measured data distribution of CPA is the most concentrated, indicating that the value of multiple measurements of CPA is stable. The stability of CXA and CDA in cervical hyperextension and flexion is not as good as that of CPA, indicating that the measurement of CPA is less affected by examination technology, which provides a new examination technology and measurement Angle choice for clinical diagnosis of craniocervical junction malformation

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