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Association of the Morphology of the Atlas Vertebra with the Morphology of the Mandible

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Abstract

Anatomy and growth of the cervical vertebrae attracted attention, since a number of authors proposed developmental association between different variables indicative of cervical vertebral anatomy and dentofacial build. This study aims to verify the morphology of the atlas vertebra and its relationship with the morphology of the mandible. A total of (41) true lateral radiographs (22 females and 19 males) for subjects with an age range of 18-26 years old were selected and subjected to cephalometric analysis.

The results show that all the measurements are higher in males than in females except that for the gonial angle and there are a statistically significant differences in mean values of atlas ventral height, ramus length, ramus width and body length among the three groups of atlas a-p length (short, average, long) which increased as the atlas a-p length increased. While among the three groups of atlas dorsal height (low, average, high), there are statistically significant differences in the mean values of gonial angle which decreased as the atlas dorsal arch height increased. It is concluded that there is an association between atlas morphology and mandibular growth.

Keywords: True lateral radiograph, Atlas vertebra, Mandibular morphology.

Introduction

It is common practice to take cephalograms where orthodontics or orthognathic assessments of patients are necessary. Generally, such radiographs include a lateral view of the cervical vertebrae (Figure 1a). in addition to the cranium and facial structures.[1] Roentgen-cephalometric studies have shown that anatomical features of the craniocervical junction are associated with head posture, cranial base angulations, mandibular shape and different sagittal and vertical skeletal growth pattern.[2-7]

The first cervical vertebra, the atlas, which forms the connecting element between the head and vertebral column proper, ought to be of particular interest to the orthodontist.[3] The normal anatomy of the atlas when viewed from above is an irregular ring with no body, or centrum, and no spinous process with short anterior and long posterior arches (Figure 1b).. In lateral projections, the fully developed atlas shows variations in shape of the posterior aspect of the superior articular processes. The structure

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which represents the missing body of the atlas forms the odontoid process of the axis. Articulation between the atlas and the occipital condyles permits nodding and articulation between the atlas and the axis allows partial rotary movements of the skul.[1]

The mandible, the largest and lowest bone in the face, has a horizontally curved body, convex forwards, and two broad rami, ascending posteriorly. [8]

The aim of this study was to determine the morphology of the first cervical vertebra (atlas) and to assess its relationship with the shape of the mandible.

Materials and Methods

The sample included cephalometric radiographs of a total of (41) subjects, (22) females and (19) males aged 18-26 years obtained routinely prior to orthodontic treatment.

Three variables related to the morphology of the first cervical vertebra and four for the mandible were measured on the radiographs. The length of the atlas and the height of its ventral and dorsal arches were measured to the nearest millimeter. The variables determined for the mandible (the ramus length, ramus width, body length and gonial angle) were also measured (Figure 2) and the data obtained subjected to statistical analysis. Then the subjects were divided into three groups: short, average, long according to the a-p length of the atlas; and into another three groups: low, average, high according to the atlas dorsal height and the statistical significant differences in the mean values among the groups were calculated using ANOVA test. The average group was one standard deviation around the mean.[8] The mean value of the average atlas a-p is (45.513-55.145) mm, the mean value of the short atlas a-p is $\leq$ 45.513 mm and of the long atlas a-p is $\geq$ 55.145 mm. Whereas the mean value of the average atlas dorsal arch height is (8.145-11.829) mm, the mean value of the low dorsal arch is $\leq$ 8.145 mm and of high dorsal arch is $\geq$ 11.829 mm.

Results

This study shows that all the measurements are higher in males than that in females except that for the gonial angle (Table 1). Statistically high significant differences are found between males and females in the a-p length of the atlas and the ramus length with a significant difference in the body length and gonial angle (Table 2). Table 3 shows that there is a positive correlation of the a-p length with each of ramus length and body length; and of the body length with each of ramus length and ramus width.

Among the three groups of atlas a-p length (short, average, and long) there are statistically significant differences in the mean values of atlas ventral height, ramus length, ramus width and body length. The mean values of these measured variables are increased as the atlas a-p length increased (Table 4).

It is clearly obvious that there is a statistically significant difference in the mean value of the gonial angle among the three groups of the atlas dorsal arch height (low, average, and high). The mean value of this angle is decreased as the atlas dorsal arch height increased (Table 5).

Discussion

Atlas Measurements

Significant sexual dimorphism in cervicovertebral dimensions in general and the first cervical vertebra, atlas, in a special is reported, [4,7,11,12,13,14] with larger measurements in males than females and a highly significant

difference in atlas a-p length only. In the present study, we find the same results (Table 1and 2).

It is also found that in the total sample (Table 1) the mean values of atlas measurements (a-p length, ventral height and dorsal height are nearly similar to others.[4, 7, 9]

In this study, no correlation between atlas measurements is found and this disagreed with Nisayif [7] and Kylämarkula and Huggare [13] (Table3). On the other hand, there are statistically significant differences in the mean values of the atlas ventral height among the three groups of the atlas a-p length (Table 4). This is compatible with Nisayif [7] who also found that the same thing is true for the atlas dorsal height among the three groups of atlas a-p length.

Mandibular Measurements

In our study it is found that the mean values of mandibular measurements are similar to that of Rakosi [10] and Bishara,[15] and that all these measurements are larger in males than females except that for gonial angle. This can be explained according to the differences in muscular mass and force which are greater in males than females.[16]

The positive correlation of the body length with each of ramus length and ramus width (Table 3) is so expected because the mandible is a single bone and its dimensions are to be proportional to be of normal size.

The association of atlas measurements with mandibular measurements

This study demonstrates that there is a significant correlation of the a-p length of the atlas vertebra with each of the ramus length and body length of the mandible (Table 3), and there are significant differences in the mean value of the ramus length, ramus width and body length among the three groups of the a-p length (Table 4). This may indicate that a short atlas is associated with short mandible and long atlas is associated with long mandible, which may give an indication to the association between mandibular growth and atlas morphology since Bergersen [17]stated that all the facial landmarks migrates during growth in a forward and downward direction.

For the three groups of atlas dorsal height, the gonial angle only shows significant differences in its mean values which decrease as the atlas dorsal height increase (Table 5). This comes in agreement with others.[3,5,7] Thus, in general, a high dorsal arch is seen in conjunction with square shaped mandible (i.e. small gonial angle), whereas, a low arch is usually found together with a mandible characterized by an obtuse jaw angle.

Conclusion

Evaluation of certain morphological features, even at some distance from the face, may further elucidate the relationship between form and function in human craniofacial morphogenesis.

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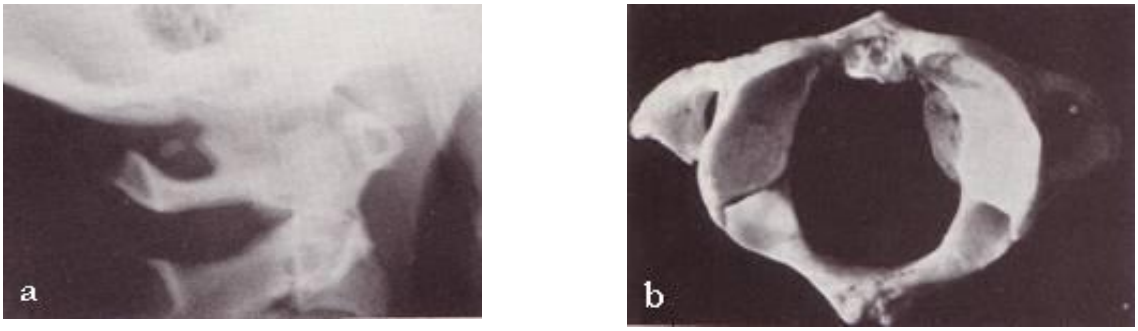
Figure (1): Atlas Vertebra (Farman and Escobar, 1982) [1]
a: lateral aspect b: upper aspect of a typical mature first cervical vertebra



For the first cervical vertebra, atlas, according to Huggare and Kylämarkula (1985) [9]: a, is the most anterior point on the atlas ventral arch; p, is the most posterior point on the atlas dorsal arch; atlas a-p, is the maximum anterioposterior extent of the atlas; atlas venter, is the maximum vertical extent of the atlas ventral arch perpendicular to the length of the atlas a-p; atlas dors, is the maximum vertical extent of the atlas dorsal arch perpendicular to the length of the atlas a-p. *For* the *mandible* according to Rakosi (1982) [10]: Ar-Go (ramus length); Me-Go (extent of the mandibular base- body length); APOcc-PPOcc (occlusal plane); ramus width (determined at the height of the occlusal plane); Ar-Go-Me (gonial angle).

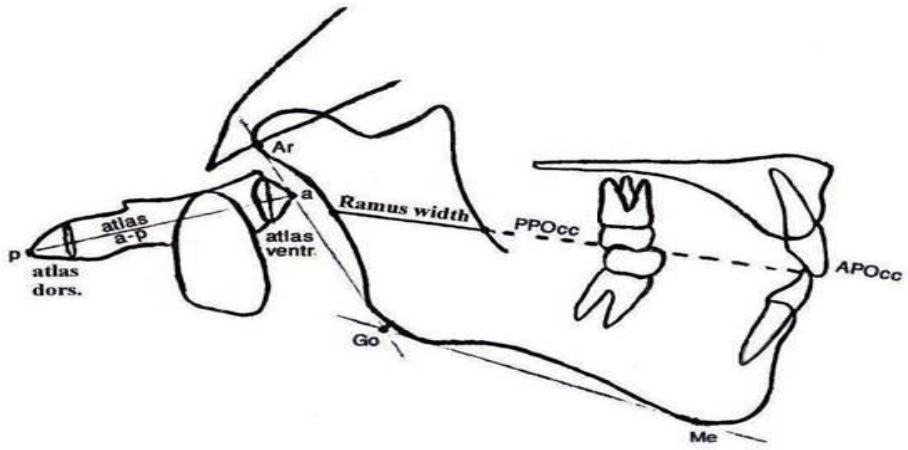


Figure (2): Cephalometric measurements

Table (1): Mean and standard deviation of the variables for females, males and total sample.

Gender Variable	Female n=22		Male n=19		Total n=41	
	Mean	SD	Mean	SD	Mean	SD
a-p length	47.6591	3.4757	53.4211	4.3181	50.3293	4.8161
Venteral height	10.6818	1.7151	11.2895	1.3470	10.9634	1.5668
Dorsal height	9.7727	1.5791	10.2368	2.1237	9.9878	1.8422
Ramus length	49.6591	3.7013	56.6579	5.8572	52.9024	5.9258
Ramus width	35.0682	2.3770	35.9474	3.5742	35.4756	2.9853
Body length	78.4091	6.2595	84.6316	7.6045	81.2927	7.5141
Gonial angle	130.2727	6.0054	124.7895	8.0179	127.7317	7.4516

Table (2): Differences in variables between females and males.

Variable	t-test	p-value	Sig
a-p length	4.608	0.000	HS**
Venteral height	0.938	0.361	NS
Dorsal height	0.426	0.675	NS
Ramus length	3.841	0.001	HS**
Ramus width	0.552	0.588	NS
Body length	2.277	o.035	S*
Gonial angle	1.993	0.049	S*

p>0.05 = NS = Non significant , *P<0.05 = S = Significant , **P<0.01 = HS = High significant

Table (3): Correlation of the variables for the total sample.

Variable	a-p length	Ventral height	Dorsal height	Ramus length	Ramus width	Body length	Gonial angle
a-p length	1.000						
Venteral height	0.269	1.000					
Dorsal height	0.297	0.221	1.000				
Ramus length	0.504*	0.286	0.175	1.000			
Ramus width	0.381	0.055	0.322	0.321	1.000		
Body length	0.617*	0.313	0.189	0.599*	0.570*	1.000	
Gonial angle	-0.279	-0.040	-0.420	-0.466	-0.348	-0.389	1.000

Table (4): Mean, standard deviation and ANOVA test of the short, average and long according to atlas a-p length.

Variable	Groups	Atlas a-p length		ANOVA test		
		Mean	SD	F-test	P-value	Sig
a-p length	Short	43.5714	1.2724	60.77	0.000	HS
	Average	50.5517	3.0483			
	Long	58.5000	0.8660			
Ventral height	Short	10.5000	2.5981	5.646	0.029	S
	Average	11.0517	1.3716			
	Long	11.1000	0.8944			
Dorsal height	Short	9.4286	1.3973	1.856	0.217	NS
	Average	9.9138	1.7681			
	Long	11.2000	2.5884			
Ramus length	Short	48.7857	3.2385	4.891	0.041	S
	Average	53.3448	6.0298			
	Long	56.1000	6.0869			
Ramus width	Short	33.0714	1.3671	6.384	0.022	S
	Average	35.5172	2.8331			
	Long	38.6000	2.7928			
Body length	Short	75.2857	5.8656	21.730	0.006	S
	Average	80.9483	6.4964			
	Long	91.7000	4.2661			
Gonial angle	Short	129.2857	8.5579	0.542	0.601	NS
	Average	128.1724	6.8820			
	Long	123.4000	9.1269			

Table (5): Mean, standard deviation and ANOVA test of the low, average and high according to atlas dorsal height.

Variable	Groups	Atlas dorsal height		ANOVA test		
		Mean	SD	F-test	P-value	Sig
a-p length	Low	51.0000	5.2281	0.743	0.514	NS
	Average	49.6250	4.4755			
	High	52.2222	5.6685			
Ventral height	Low	10.2500	0.9574	0.417	0.676	NS
	Average	11.0536	1.7498			
	High	11.0000	1.1456			
Dorsal height	Low	7.0000	0.0000	29.936	0.000	HS
	Average	9.5893	0.9818			
	High	12.5556	1.1304			
Ramus length	Low	53.7500	6.5000	0.417	0.676	NS
	Average	53.0357	5.0478			
	High	52.5558	8.5748			
Ramus width	Low	34.3750	3.3510	2.206	0.192	NS
	Average	35,2857	2.8167			
	High	36.5556	3.3953			
Body length	Low	79.1250	7.5540	0.826	0.481	NS
	Average	81.3393	6.9203			
	High	82.1111	9.9068			
Gonial angle	Low	133.8750	10.2825	4.369	0.049	S
	Average	127.9464	6.2647			
	High	124.3333	8.5732			