― 原著 ―

Cephalometric Study on the Morphology of the First Cervical Vertebra to Craniofacial Structures. (Part 1): Is There Any Relationship ?

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Abstract : The use of cervical vertebrae to evaluate the individual craniofacial development has been considered by some investigators. The first cervical vertebral (atlas) morphology that was reported to reflect the head posture, could be used as an indicator of craniofacial growth and development on Caucasian samples.

The aim of the investigation was to establish a norm of atlas measurements, mean and standard deviation in Japanese school chidren ages' 7, 10, 12 and 15 and to clarify the associations of the atlas morphology with craniofacial structure (CFS) at these ages.

One hundred ninety six lateral head films of 49 school children (30 males and 19 females) at age 7, 10, 12 and 15 were traced and measured at 5 variables for the atlas and 12 variables for CFS. The significance of correlation of the atlas variables with that of CFS was statistically analyzed. Facial diagram of subjects that was divided according to the height of the dorsal arch into high and low group was compared and analyzed.

Data revealed a statistically significant increase in atlas morphological dimension as it undergoes incremental growth change and that a characteristic craniofacial structural differences exist between sex and age. It was observed that a pattern of statistically significant correlation exists on both sexes between the height of the dorsal arch, antero-posterior length and atlas ratio (index) with CFS variables. The association was observed in the vertical position of the mandible among males that was not found among females except on the maxillo-mandibular relations and rotation of the mandible. The pattern of CFS and its association with the atlas morphology were altered with sex and age.

It was established from the results in this study that the association of the atlas morphology with CFS and its growth pattern among Japanese samples, were more vertical mandibular position in males while, in female, a trend of maxillo-mandibular rotation instead of horizontal mandibular position that was reported among Caucasian samples. The association of the first cervical vertebra with CFS and CFS growth pattern itself was different according to race, sex and age. Thus, the factor of sex, race and age should be carefully considered in the application of the atlas morphology as one of the indicator of CFS growth.

抄録：近年，頭位の顎顔面の成長発育に与える影響が注目されており，それに関連してセファログラムで観察できる第一頚椎（アトラス）の形態が，頭位を反映した形態を示し，顎顔面の成長発育の指標となる可能性があることが白人を対象とした研究で報告されている。

この研究の目的は，日本人学童を対象として，各年齢群の男子および女子の第一頚椎セファログラム計測値の基準値を作成し，第一頚椎の形態が各年齢群の顎顔面形態とどのような関連性があるかを明らかにすることである。

学童（男子30名，女子19名）の，7，10，12，15歳時に撮影された側面セファログラムのトレースを行い，5項目の第一頚椎と12項目の顎顔面の形態の計測を行い，第一頚椎の形態と顎顔面形態の各年齢群における関連性について検討し，さらに第一頚椎後弓の高径が高い high dorsal group と，低い，low dorsal group の顎顔面状態を比較検討した。

第一頚椎の，経時的な成長変化が明らかにされ，第一頚椎の後弓の高さと前後径ならびにアトラスレシオ（指数）

と顎顔面形態の計測結果から，いくつかの項目で統計的に有意な相関が認められた。男子では，水平的な項目よりも，垂直的な下顎オトガイ部の位置に相関が認められた。女子では，上下顎の前後的関係と下顎後方部の回転様変化と関連していた。男女間では，異なった傾向を示し，また低年齢群と高年齢群でも関連性が変化する傾向を示した。

日本人学童においても，第一頸椎の形態が，顎顔面形態と何らかの関連性を有することが確認されたが，下顎の水平的な位置と関連した項目で関連がみられる欧米人の報告結果と異なり，男子では下顎の垂直的な成長発育に関連した項目で相関が認められた。一方，女子では上下顎の前後的関係と下顎の後方への回転との関連を示したが，オトガイ部の水平的ならびに垂直的な位置とは関連性が認められなかった。顎顔面成長は，人種や男女間および年齢群によって傾向が変化し，それに伴い第一頸椎と顎顔面形態の関連性も異なるので，臨床的な指標として用いる際にはその点を考慮する必要があると考えられた。

Introduction

A variety of factors such as genetics, sex and function have been reported to influence craniofacial development. Structures of the body such as standing height[1)2)], the hand and wrist[3)], and the cervical vertebrae[4)] have been studied in relation to craniofacial morphology.

Morphological features of the cervical vertebrae have been found to reflect aspects of craniofacial growth changes. Bench[4)], in his study of cervical bone maturation and Houston[5)] in his elaborate review of mandibular growth, showed that the four cervical vertebrae can provide clinically significant information on the progressive movement of the chin, and went further suggesting that the growth of the face height is greatly influenced by the growth of the cervical column. Ogden[6)] mentioned that the first cervical vertebra (atlas) represents the transition between skull and the axial skeleton. The atlas, with its unique feature that supports the cranium has recently gained attention in relation to craniofacial structure because of its relative proximity to the craniofacial complex. Kylämarkula and Huggare[7)] observed that the morphology of the atlas particularly the height of the dorsal arch was associated with head posture and Huggare[8)] reported an association of the height of the dorsal arch with the growth direction of the mandible, while Sandikçioglu et al.[9)] did not find significant correlation with the anterior facial height but found an association with the inclination on the maxilla and the mandible. Therefore, the dimensions of the first cervical vertebra maybe expected to reflect association with craniofacial structures.

Although the morphology of the first cervical vertebra was reported to have an association with the craniofacial morphology, human cephalometric anthropometrical study even among Caucasians seems to be insufficient. Previous cephalometric studies that compared the first cervical morphology with craniofacial dimensions were based on the mean of a collected sample thus, may not be a representative sample of a population in a specific age group.

The aim of this study was to investigate on the association of the first cervical vertebra to craniofacial morphology and to develop a norm of atlas measurements, means and standard deviation in Japanese school-children ages 7, 10, 12 and 15.

Subjects and Methods

A total of 196 lateral head films 30 male and 19 female schoolchildren aged 7 (first grade; Elementary, mean age of 6.8), 10 (fourth grade; Elementary school, mean age of 9.1), 12 (sixth grade; Elementary school, mean age of 11.9) and 15 (third year; Junior high school mean age of 14.1) that was selected from a previously collected sample of the longitudinal epidemiological study at Kawanishi, Niigata Prefecture, in the central part of Japan by the Department of Orthodontics, School of Dentistry, Niigata University.

A series of lateral head films was traced and there were six angular and four linear measurements that was based on the standard cephalometric variables and two linear measurements at point pogonion in relation to the basic cranium to determine the position of the mandible for craniofacial structures, four linear measurements and a mathematical equation for first cervical vertebra (Table 1, Fig. 1 and Fig. 2). The Atlas ratio (AT ratio) was defined as the anteroposterior length over the height of the posterior projection of the first cervical vertebra[10)].

Means and ranges of variation and standard deviations were obtained for all measurements. Correlation between three atlas variables and the craniofacial

Table 1. Definitions of the atlas and the craniofacial morphological variables.

	Linear reference variables
1. S-N	Line distance from point Sella to point Nasion
2. Ar-Go	Distance between Articulare to Gonion
3. Go-Me	Distance between Gonion to Menton
4. Ar-Me	Distance between Articulare to Menton
5. S N-Pog (Y)	Distance between Pogonion to point perpendicular to S N
6. Line X	Distance between Pogonion parallel to S N line perpendicular to Y
7. AP	Distance from the most anterior point of the anterior tubercle of the atlas to the most posterior point of the dorsal arch of the atlas
8. D1	Vertical dimension of the radiographic cross-section of the posterior arch of the atlas (Dorsal arch)
9. D2	Horizontal dimension of the radiografic cross-section of the posterior arch of the atlas (Dorsal arch)
10. AA	Vertical dimension of the radiografic cross-section of the anterior arch of the atlas
	Angular reference variables
11. Mp	The angle formed between the Sella-Nasion line and the mandibular plane
12. Go	Gonial angle, the angle between the mandibular plane the and the line through articulare and gonion
13. SNA	Sella-Nasion-point A angle
14. SNB	Sella-Nasion-point B angle
15. ANB	Difference between SNA and SNB angle
16. SN-Gn	Angle between point Nasion and point Gnathion at point Sella

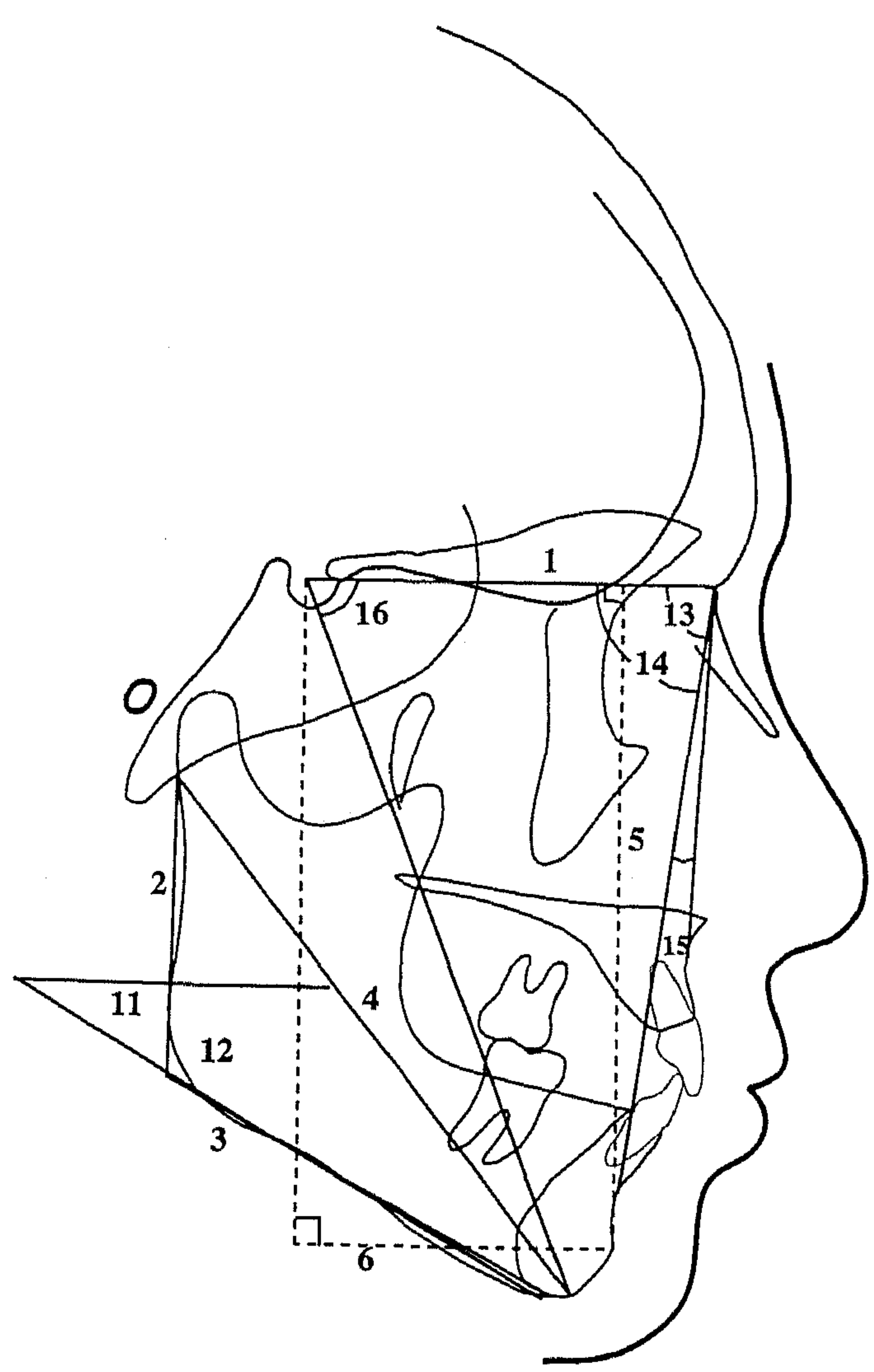


Fig. 1. Cephalometric angular measurements of the craniofacial morphology

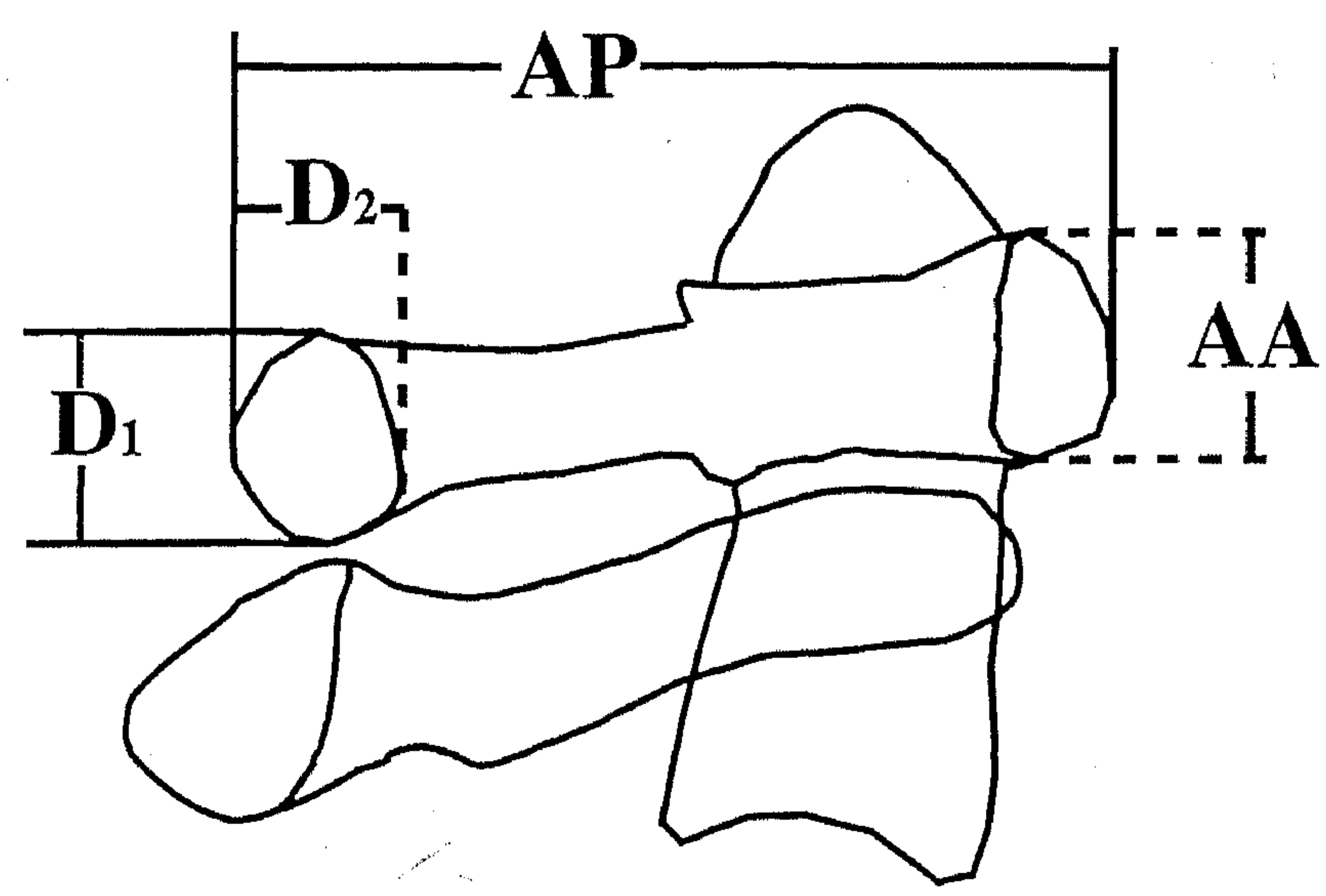


Fig. 2. Diagramatic illustration of the measurements of the first cervical vertebra

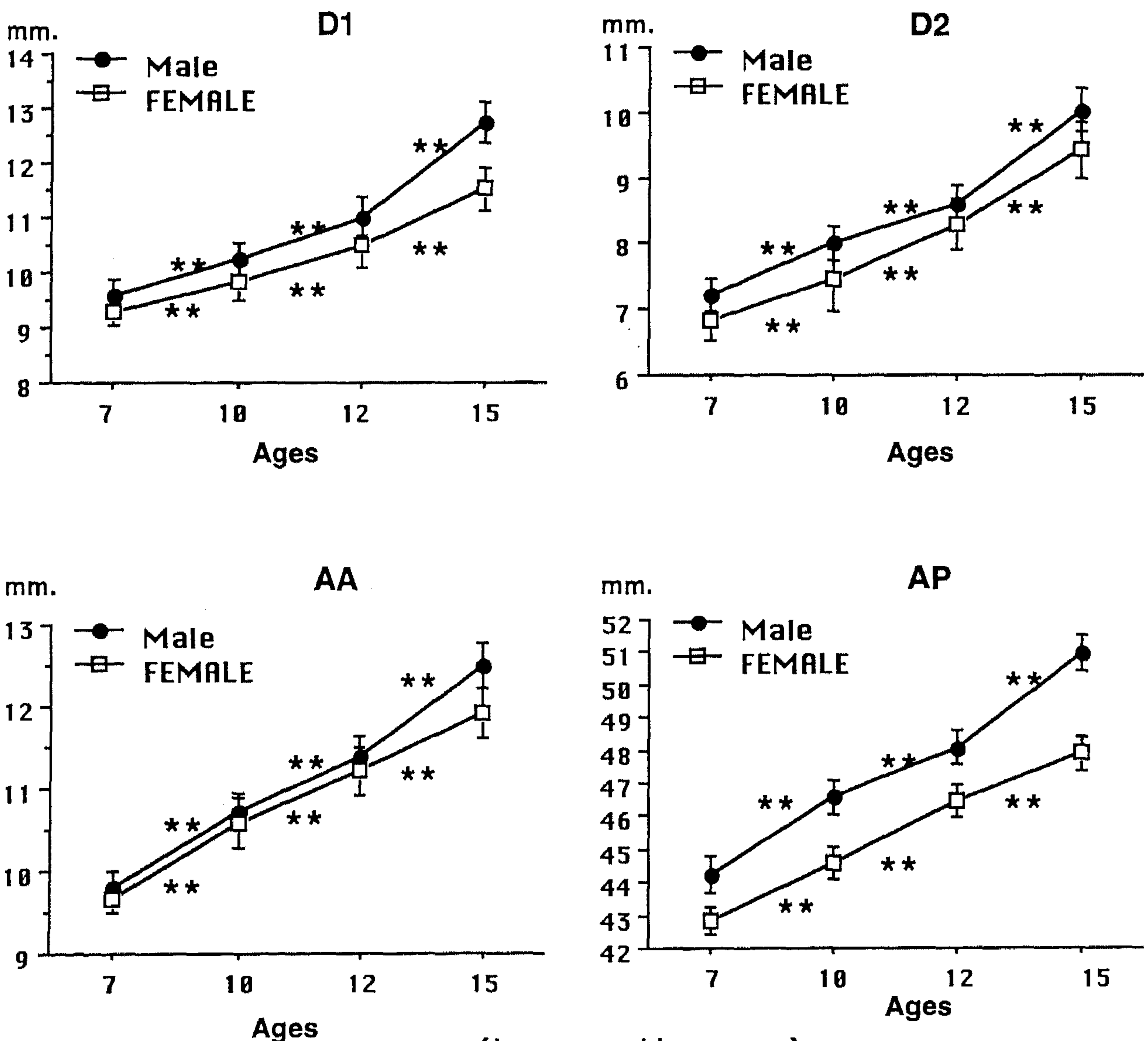
structure variables on each age were statistically analyzed. The measurement of the height the dorsal arch was ranked from highest to lowest at each age and was grouped according to the standard deviation of the mean (±standard deviation). Those that fall below were grouped as low dorsal arch group while those that were beyond the standard deviation were grouped into high dorsal arch group. Accordingly, the classification on the AT ratio was done in this manner. Moreover, facial diagram between high and low dor-

Table 2a. Means and standard deviations of atlas variables among males.

Atlas Variables	7 years		10 years		12 years		15 years	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AP	44.2	3.0	46.6	2.7	48.1	2.8	51.0	3.1
Anterior Arch (Height AA)	9.8	1.1	10.7	1.2	11.3	1.4	12.4	1.5
Dorsal Arch (Height D1)	9.6	1.2	10.2	1.2	11.4	1.3	12.7	1.5
Dorsal Arch (Cross-section D2)	7.2	1.3	8.0	1.4	8.6	1.6	10.0	1.8
AT ratio	4.7	0.7	4.6	0.6	4.5	0.7	4.1	0.5

Table 2b. Means and standard deviations of atlas variables among females.

Atlas Variables	7 years		10 years		12 years		15 years	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AP	42.7	2.6	44.5	2.7	46.4	2.8	47.7	2.8
Anterior Arch (Height AA)	10.1	1.1	11.0	1.3	11.5	1.4	12.2	1.5
Dorsal Arch (Height D1)	9.2	1.1	9.8	1.4	10.5	1.7	11.6	1.6
Dorsal Arch (Cross-section D2)	6.8	1.4	7.5	2.0	8.3	1.7	9.4	1.8
AT ratio	5.0	0.5	4.8	0.7	4.6	0.7	4.1	0.6



(*=p < 0.05, ** =p < 0.01)

Fig. 3. Incremental growth changes of the first cervical vertebra at ages' 7, 10, 12 and 15. Atlas morphologies: **D1** is defined as the height of the posterior tubercle from the most superior point to the most inferior point projected on the gravity determined true vertical; **D2** was defined the antero-posterior width of the whole contour of the radiographic cross section of the posterior arch; **AP** is defined as the antero-posterior lenght from the most anterior tip of the anterior tubercle to the most posterior tip of the posterior arch and **AA** is defined as height of the anterior arch perpendicular to the antero-posterior length of the first cervical vertebra

sal arch and AT ratio groups was set up to illustrate difference or similarities on both sexes at four age periods.

The data obtained included the mean and standard deviation for each parameter measured at each age. Differences between parameters were evaluated with paired t-test. Scatter grams and lines of regression were set up in relation with atlas morphology against the craniofacial variables on each age. Fisher's Z test was used to substantiate the statistical significance of correlation. Two levels of significance were recognized as $p<0.05$ and $p<0.01$ characterized by (*) and (* *) respectively.

Results

The mean and standard deviation of the atlas variables are described in Table 2a and 2b for male and female respectively. From the measurements of the atlas morphology, it would be noticed that there was a significant increase in its dimensions as it undergoes incremental growth change and there was a slight difference in the morphological dimensions between male and female where male exhibited a broader structure than female in the three periods of investigation (Fig. 3a to 3d). While mean and standard deviations of craniofacial morphology (CFS), were described in Table 3a and 3b for male and female respectively. Apparently both sexes showed a significant increase in the craniofacial dimension, but was noticed that a difference of facial pattern between sexes and the direction of growth was altered with age as seen in Fig. 4 and 5.

Several statistically significant correlation between

Table 3a Means and standard deviations of CFS among male subjects.

CFS Variables	Male							
	7 yrs	SD	10 yrs	SD	12 yrs	SD	15 yrs	SD
SNA	80.9	2.7	80.9	2.8	81.6	3.2	82.5	2.7
SNB	76.3	2.6	76.4	3.1	77.8	3.6	82.5	2.7
ANB	4.6	1.6	4.0	1.9	3.8	2.1	0.0	2.8
MP	36.9	4.5	36.2	4.6	35.6	4.2	34.0	4.8
Go	128.5	4.8	126.4	5.7	126.3	6.5	123.6	8.0
SN	65.5	2.7	67.5	3.0	68.8	2.7	71.4	3.2
SN-Gn	71.0	2.5	70.5	2.8	70.7	2.8	70.0	3.3
Ar-Go	40.3	2.9	42.5	3.0	44.6	3.8	50.0	3.6
Go-Me	62.6	3.1	67.1	3.9	70.4	4.2	76.4	5.5
Ar-Me	92.1	4.4	99.0	4.8	102.7	4.9	111.9	5.1
SN-Pog (Y)	100.0	4.4	105.0	4.7	109.6	5.5	119.5	6.2
Line X	40.9	5.2	43.1	5.5	45.8	5.8	49.2	7.5

Table 3b. Means and standard deviations of CFS among female subjects.

CFS Variables	Female							
	7 yrs	SD	10 yrs	SD	12 yrs	SD	15 yrs	SD
SNA	82.0	3.3	81.6	3.1	82.4	3.7	82.3	2.9
SNB	77.7	2.6	77.9	2.6	48.1	2.9	78.8	3.0
ANB	4.3	2.3	3.9	1.9	4.3	2.4	3.5	2.1
MP	38.2	3.7	37.6	4.1	37.0	4.1	36.2	4.7
Go	128.4	5.6	127.0	5.4	126.5	6.1	124.8	7.0
SN	64.3	2.8	66.0	1.9	67.5	2.2	68.0	2.7
SN-Gn	70.0	1.9	70.0	2.0	69.9	2.0	70.2	3.5
Ar-Go	39.2	2.6	41.3	3.1	43.5	3.4	46.2	3.5
Go-Me	61.1	5.4	66.7	2.4	70.0	3.8	71.1	5.7
Ar-Me	92.9	3.6	98.3	3.8	102.5	3.8	106.0	4.5
SN-Pog (Y)	98.7	3.7	104.9	4.9	109.3	4.6	113.0	4.7
Line X	41.1	5.8	42.9	5.4	45.8	6.0	47.9	5.9

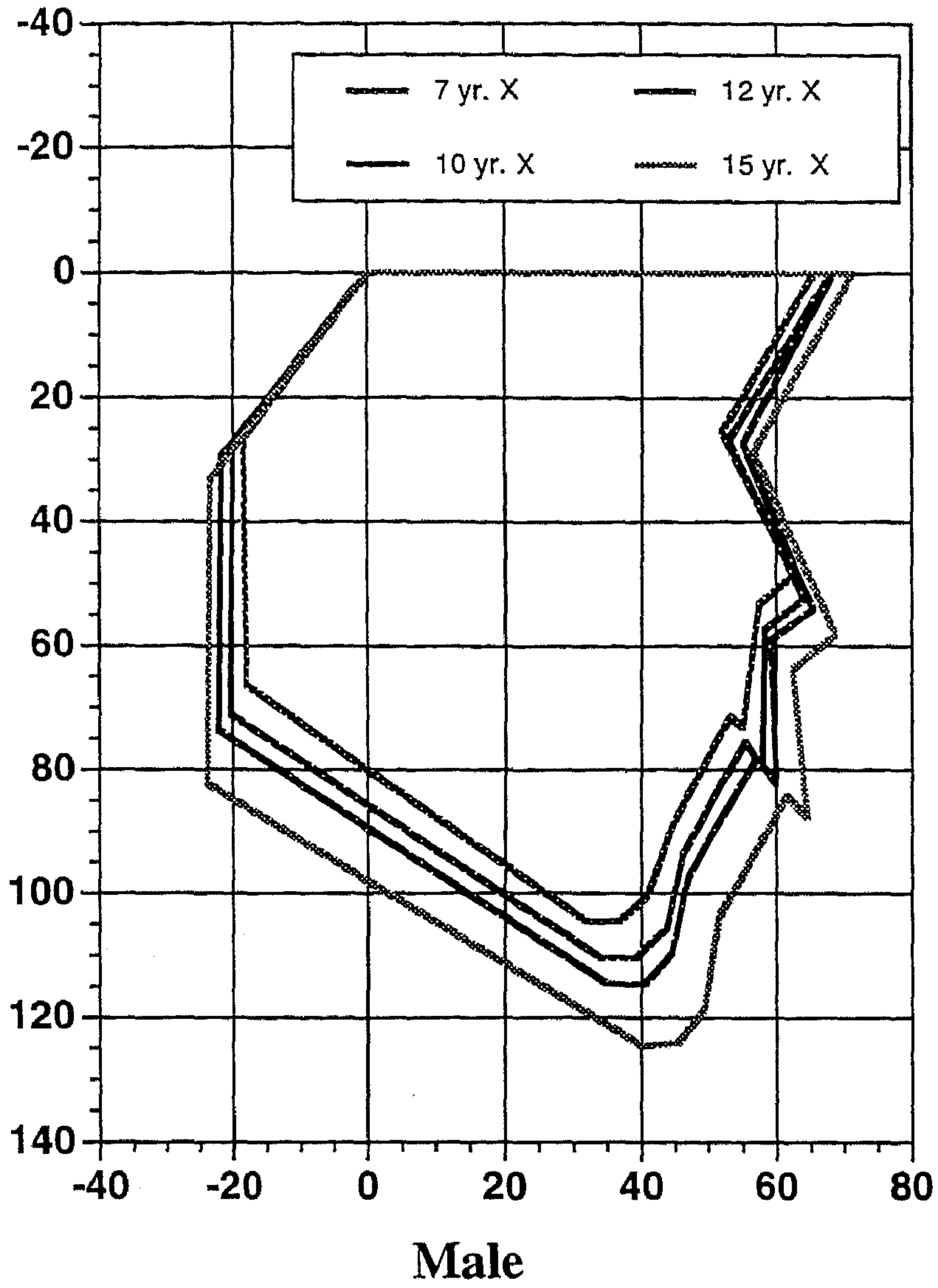


Fig. 4. Mean incremental growth pattern and changes of the craniofacial structures as seen on the facial diagram among male subjects

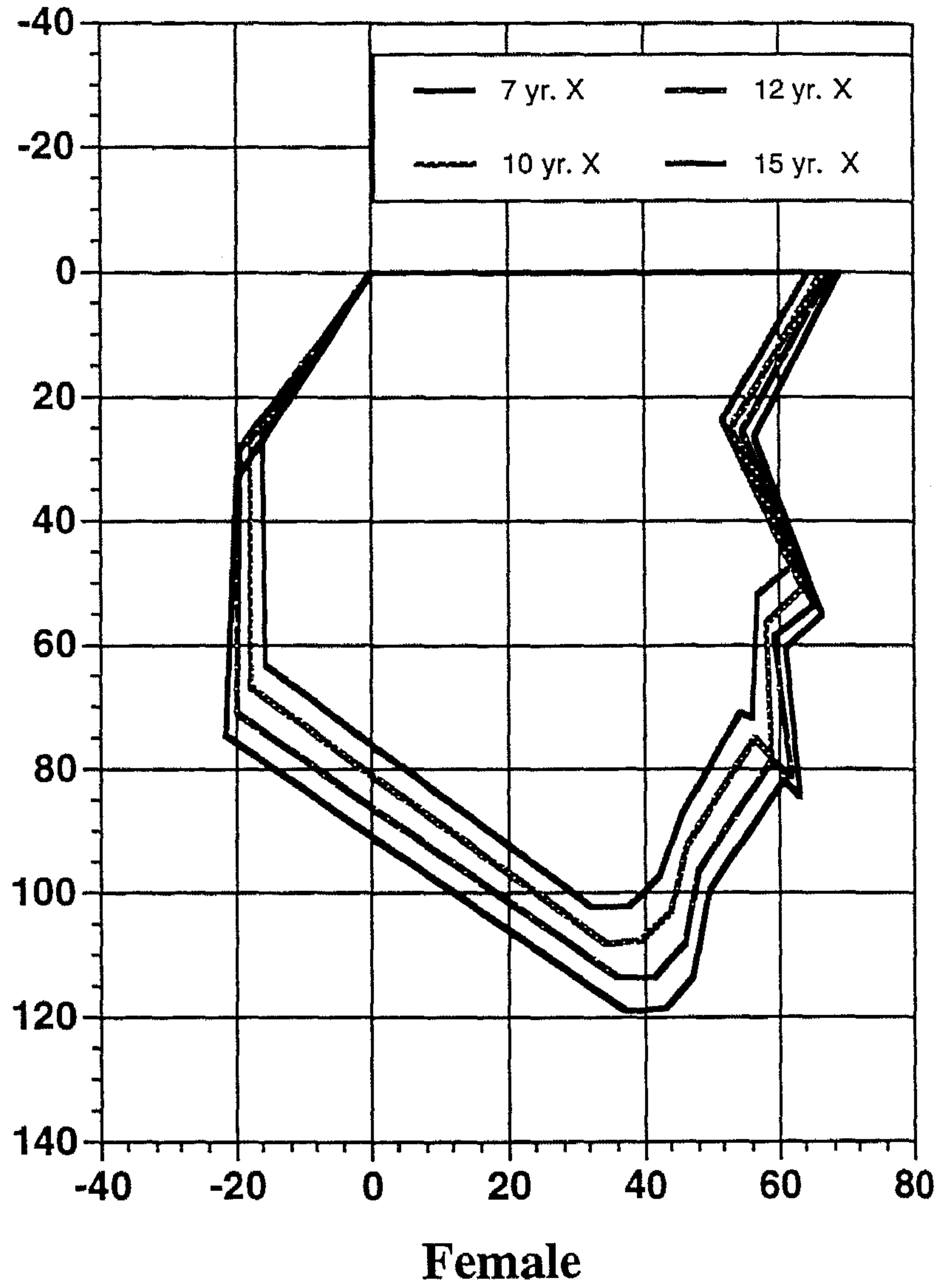


Fig. 5. Mean incremental growth pattern and changes of the craniofacial structures as seen on the facial diagram among female subjects

the first cervical morphology and CFS was observed that varies among sexes. The correlation coefficients between the atlas morphology and the CFS morphology were expressed in Table 4a to 4d. The height of the dorsal arch of the atlas showed a low significant positive correlation with anterior facial height (Y) at ages' 10, 12 and 15 respectively and strong positive correlation with length of the mandible (Ar-Me) at ages' 10 and 15 for male. The difference between point A and B (ANB angle) revealed a positive correlation at ages' 7 and 12, while the gonial angle showed a pattern of strong negative correlation at ages' 10, 12 and 15 respectively along with negative correlation was observed among female at age 15 with the height of the dorsal arch of the atlas.

The antero-posterior length of the atlas showed a varying degree of correlation on both sexes but the male revealed a consistent pattern of correlation with mandibular length (Ar-Me) and anterior facial height (Y) from age 7-15. Female, on the other hand, exhibited a strong negative correlation with anterior cranial base SN at ages' 7 and 10, and positive correlation with mandibular length (Go-Me and Ar-Me) at ages' 12 and 15 respectively.

The AT ratio that was conceived initially to be similar to the height of the dorsal arch showed a negative correlation with the difference between A and B (ANB angle) at age 12 and mandibular length (Ar-Me) at age 15. While a pattern of significant positive correlation with gonial angle (Go) was presented at ages' 10, 12 and 15.

From the facial diagram, there was a remarkable difference between the high and low dorsal arch groups as well as that of the AT ratios on both sexes. The high dorsal arch group tended to have a broader facial structure compared with the low dorsal arch group among male, while the high dorsal arch group had as a smaller and seemingly retracted mandibular configuration than the low dorsal arch group among female at four periods of investigation as seen in Fig. 6 and 7.

Table 4a. Statistical significant coefficient of correlation between atlas morphology and craniofacial morphology at age 7.

Craniofacial Variables	Male				Female			
	D1	D2	AP	AT ratio	D	D2	AP	AT ratio
SNA								
SNB								
ANB					0.45*			−0.49
MP								
Go								
SN						−0.51*	−0.61**	
SN-Gn								
Ar-Men			0.46*					
Ar-Go								
Go-Men			0.38*					
X		0.38*	0.41*					
Y						−0.48*		

Table 4b. Statistical significant coefficient of correlation between atlas morphology and craniofacial morphology at age 10.

Craniofacial Variables	Male				Female			
	D	D2	AP	AT ratio	D	D2	AP	AT ratio
SNA								
SNB								
ANB								
MP			0.41*					
Go					−0.62**			0.65**
SN								−0.47*
SN-Gn								
Ar-Men	0.43**		0.42**					
Ar-Go								
Go-Men								
X		0.39*						
Y	0.34*		0.53**					

Discussion

There are studies suggesting that both head posture and cervico-vertebral anatomy[8,11-13] are associated with CFS. Experimentally and clinically, it has been demonstrated that head posture and the atlas morphology correlate[7,13]. A cephalometric study of 72 young Caucasian adults showed that the difference of the height of the dorsal arch of the first cervical vertebra correlated with head posture in relation to the cranio-cervical angulation of the head[7]. Again it was reported, in a similarly designed study of 39 young Caucasian adults, that the difference in the dorsal arch height correlated with CFS. The head posture were found to be raised among low dorsal arch subjects[13,14].

The subjects was chosen from the files of a cephalometric epidemiological study represent samples that include several kinds of malocclusions but had not undergone orthodontic treatment. Cephalograms of each subject were taken at standing position with the absence of a standardized head posture. It was reported that methods used to determine the natural head position has varied, they included the use of mirror[15], a light source placed in front of the patients[16,17] and no external reference[18,19] and in some studies the subjects were placed in sitting or standing position. It was believed then that the standardized head posture on cephalometry was technique sensitive and up to the

Table 4c. Statistical significant regression coefficient of correlation between atlas morphology and craniofacial morphology at age 12.

Craniofacial Variables	Male				Female			
	D	D2	AP	AT ratio	D	D2	AP	AT ratio
SNA								
SNB	0.39*			−0.38*				
ANB					0.48*			−0.52*
MP								
Go					−0.63**			0.59**
SN			0.47**					
SN-Gn								
Ar-Men			0.37*					
Ar-Go								
Go-Men							0.46*	
X								
Y	0.36*		0.51*					

Table 4d. Statistical significant regression coefficient of correlation between atlas morphology and craniofacial morphology at age 15.

Craniofacial Variables	Male				Female			
	D	D2	AP	AT ratio	D	D2	AP	AT ratio
SNA								
SNB								
ANB								0.49*
MP								
Go					−0.57**			0.57**
SN								
SN-Gn								
Ar-Men	0.44**		0.46**	−0.34*	−0.55**		0.48**	0.52*
Ar-Go								
Go-Men								
X								
Y	0.34*		0.45*					

Variables with no significant correlations have been deleted from the table, and non-significant corrlations have been deleted from the remaining variables.

present a controversial issue, thus slightly differs with the methods employed by previous researchers who utilized the natural head (mirror) position[20]. Although postural variables were not included in this study, the relationship with CFS of the atlas variable alone that may not be dependent on the head posture were evaluated. Since most of the orthodontist, until recently, uses the conventional method in cephalometry. Therefore, it may be expected that it could be used in the evaluation.

Several investigators that studied on the relationship of the atlas with CFS have used the common lateral cephalometric landmarks and seem to agree on the principle of their use. However, although the first cervical morphology has been used on some studies, investigators seem to differ in the definition of reference points and lines. Huggare[8] measured the posterior arch perpendicularly to the antero-posterior axis of the atlas and considered the whole contour of the arches. Kylämarkula and Huggare[14] measured and studied the height of the posterior arch of the atlas, both directly and projected parallel to the gravity determined true vertical and did not find any statistical significant difference on both methods. Again, Kylämarkula and Huggare[7] measured the height of the posterior arch of the atlas projected on the gravity-determined true vertical, while Sandikçioglu et al.[9] measured the cross-sections of the anterior and posterior arches and the antero-posterior axis of the atlas.

In the present study, we measured the antero-posterior length and posterior arch height projected on the gravity-determined true vertical and length of the radiographic cross-section of the dorsal arch that considers its whole contour and the vertical dimension of the anterior tubercle of the first cervical vertebra. The definitions of the heights of the anterior and posterior arches of the atlas used in the present study therefore slightly resemble those that were described by Sandikçioglu et al.[9] and Kylämarkula and Huggare[8),14] and supplement it with the antero-posterior radiographic cross-section of the dorsal arch.

Earlier studies on the morphological changes of the face were observed using initial or mean of a collective age group sample of the atlas morphology as a variable for comparision. The present study compared the morphology of the atlas at age seven until fifteen years old. Data were analyzed and compared with the craniofacial dimension of the same age, therefore differs with the report of Kylämarkula and Huggare[7], Shiokawa et al.[10] and Sandikçioglu et al.[9] So far, however, the incremental growth change of the atlas itself has not been documented. Our results may establish the association of the atlas variables with CFS, however a standard model for the atlas varibables at ages' 7, 10, 12 and 15 were deemed necessary as reference.

Studies who have reported measuring the atlas presented some variety of results. The individual morphological parts of the atlas that correlated with CFS may be described in three sections according to its anatomical part.

In the antero-posterior portion, some investigators did not find any correlation between the antero-posterior length of the atlas and CFS. While in the present study, a pattern of positive correlation with mandibular length (Ar-Me), and anterior facial height (Y) seems to suggest that as the antero-posterior length of the atlas increases, an increase in facial height and mandibular length is inevitable. Thus it may present a downward-forward mandibular growth direction among male. As for the female, although a pattern of correlation was not established, a significant positive correlation with mandibular length (Go-Me and Ar-Me) and difference of points A and B

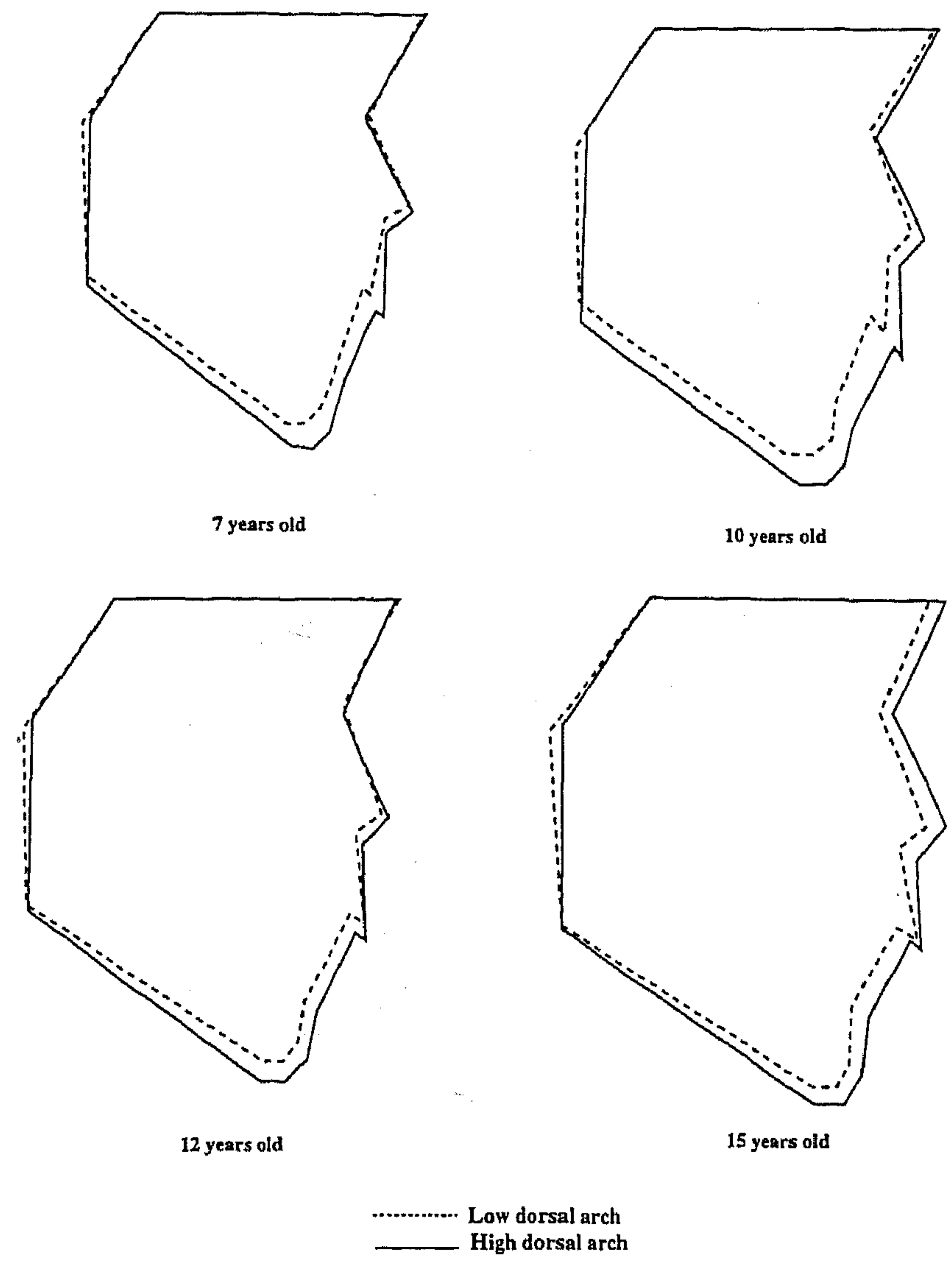


Fig. 6. Facial diagrams of male subjects with high and low dorsal arch group at four age stage

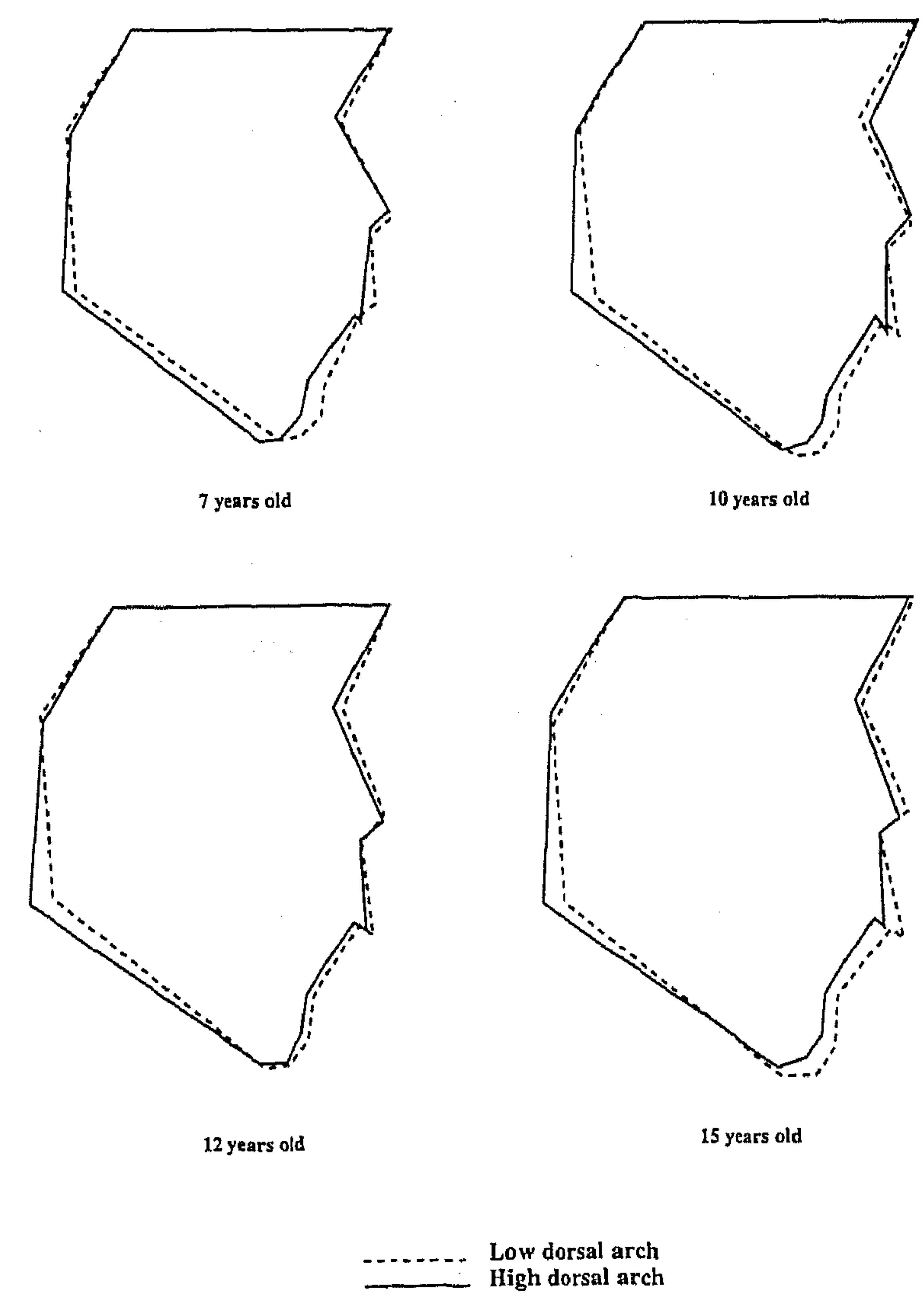


Fig. 7. Facial diagrams of female subjects with high and low dorsal arch group at four age stage

from sella-nasion line were observed at age 12 and 15 respectively that may suggest a variable pattern of growth.

As for the posterior arch of the atlas in relation to CFS, certain craniofacial characteristics have been observed between the high dorsal arch group and low dorsal arch group that were distinct on each sex. The significant positive correlation observed with anterior facial height at age 10, 12 and 15 could be explained by general pattern of large craniofacial structure and vertical growth pattern in the anterior facial height among male subjects as seen in Fig. 6 for those subjects with high dorsal arch contrary to the report of Huggare[8] in a sample of 18 Finnish children of mixed sexual orientation ages eight and ten years where they found a reduced vertical growth of the pogonion point in subjects with large height of the posterior arch of the atlas. Difference in the correlation might be attributed to factors such as racial difference[21], where it was pointed out that the growth direction of the mandible among Japanese is more vertical than Caucasian. Moreover, in the previous studies, subjects were of composite sex orientation, while the current study categorized the gender accordingly that perhaps observed distinctively different results. Nevertheless, it could be hypothesized that these could be a reflection of a general association between the vertical development of the cervical column and that of the face as proposed by Bench[4].

The female exhibited a seemingly inverse craniofacial characteristic than male. The negative correlation between the height of the dorsal arch and the gonial angle interpreted as a decrease in the gonial angle and increase in ANB angle that was observed could be associated with the directional trend of the maxilla and the mandible that could be seen in Fig. 7 at age 10, 12 and 15. The correlation in the study by Sandikçioglu et al.[9] of young adults with age range of 22 that included both sexes did not find significant correlation between the height of the posterior arch of the atlas and the anterior facial height instead found an association with the cranio-maxillary and cranio-mandibular direction (r = −0.22 to −0.30) compared with this current study were low and the significance of correlation was observed only among females. Seemingly, the significant correlation observed in this study suggest a maxillo-mandibular rotation. The high dorsal arch group apparently shows a

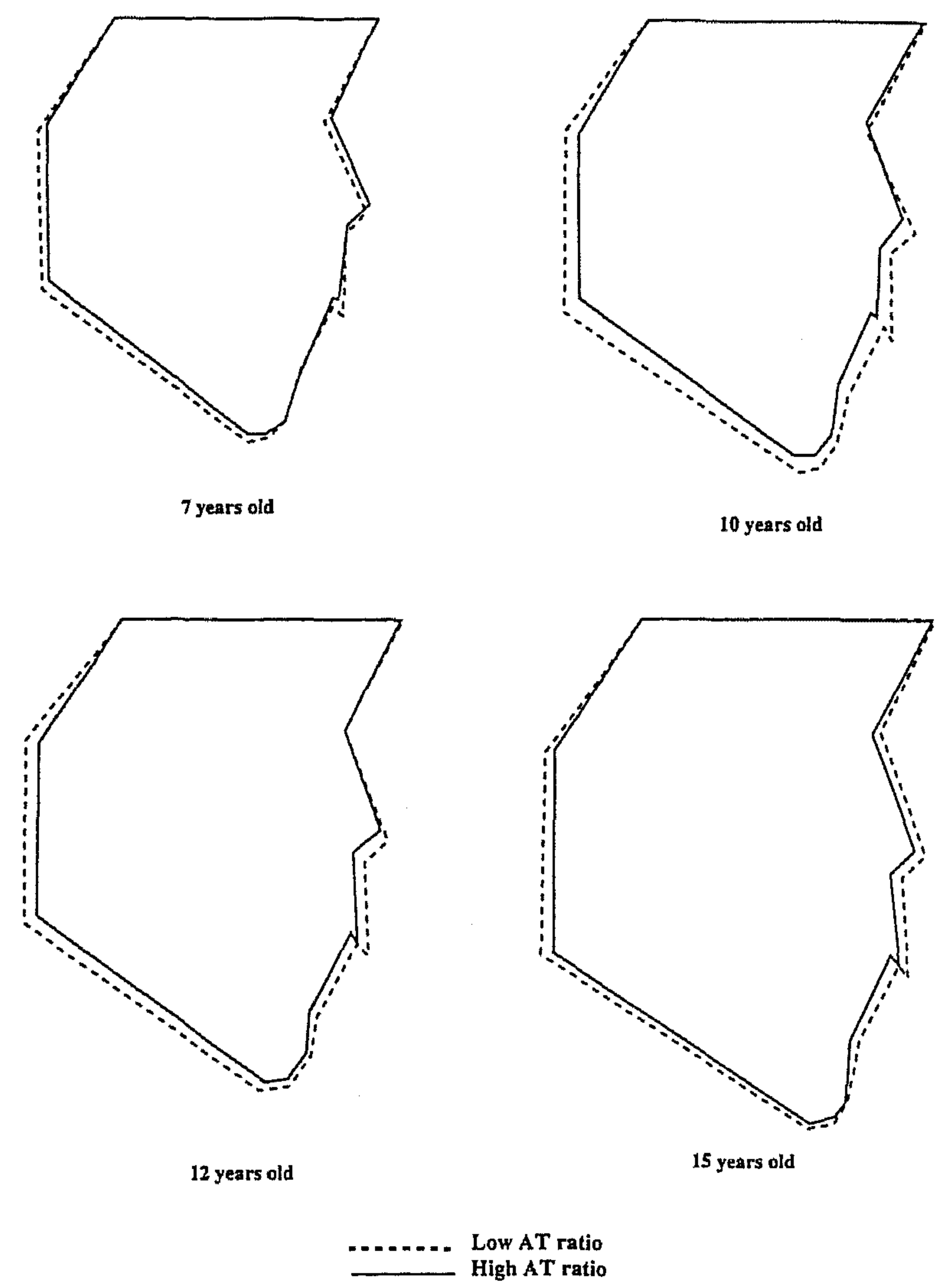


Fig. 8. Facial diagrams of male subjects with and low AT ratio group at four age stage

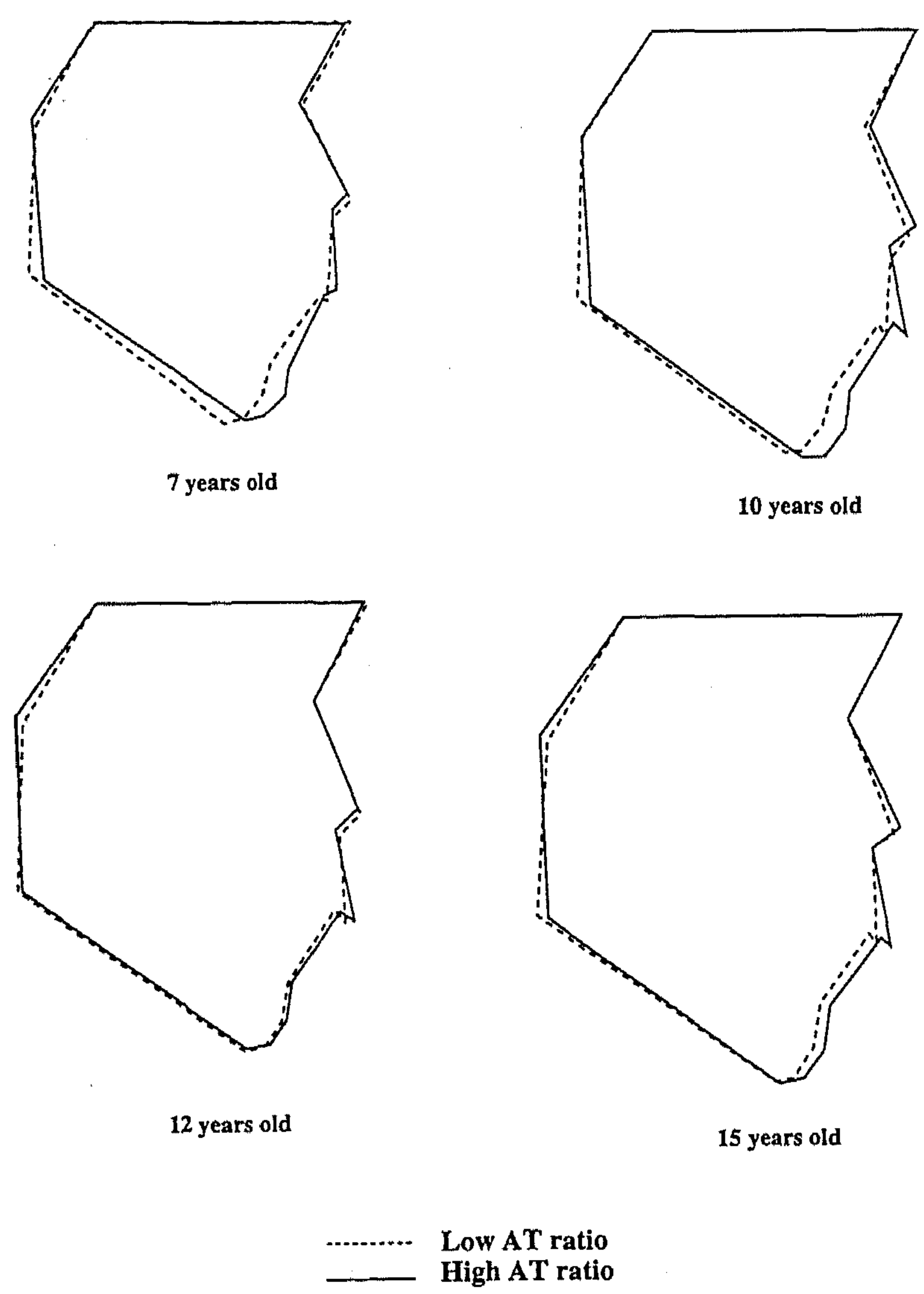


Fig. 9. Facial diagrams of female subjects with high and low AT ratio group at four age stage

retracted mandible, and a counterclockwise directional pattern with seemingly small facial height than those subjects with low dorsal arch, that may suggest a Class III skeletal tendency.

Concerning the AT ratio, both male and female exhibited some statistically significant correlation, however, the female showed a pattern of strong positive correlation between the AT ratio and the Gonial angle at ages' 10, 12 and 15 respectively that could be interpreted as increase in the AT ratio conformed with the increase of the gonial angle. Shiokawa et al.[10] in a sample of 30 females ages' 8 to 14, who initiated the use of atlas ratio, observed a correlation with SN-Gn angle and the horizontal growth direction of the mandible and speculated that the result suggests a counterclockwise rotational growth. From the facial diagram (Fig. 9), a seemingly forward rotational trend could be observed in for those subjects with high AT ratio among females, while males seem to have unremarkable difference between high and low group as seen in Fig. 8. This common finding may suggest that the AT ratio may at certain extent be a parameter in predicting facial growth. However, it is difficult to make any definite conclusion of its applicability since the prognostic effect was only seen among females thus, in order to analyze the relationship between the AT ratio and facial morphology, a more comprehensive study seems necessary.

From the various significant correlation results in this study among Japanese samples, a pattern of correlation between the atlas morphology and the craniofacial structure would suggest that first cervical vertebra in its strategic position supporting the cranium, has a clear association with craniofacial structure in that, there were more vertical mandibular position in males while, in females, a trend of maxillo-mandibular rotation instead of horizontal mandibular position that was reported among Caucasian samples Although, a clear relationship of the atlas morphology with CFS was revealed in this study, further investigation should be undertaken to determine whether its dimension at initial period of evaluation would correlate with CFS and mandibular growth change with age.

In addition, the conflict in association between previous reports and the current study may be attributed to the difference in racial origin, the composition of subjects that incorporates both sexes and the age of the subject.

In conclusion, the present study has presented evidence of relationship between the first cervical morphology and craniofacial structures. The association of the first cervical vertebra with CFS and CFS growth pattern itself is different according to race, sex and age. Thus, the factor of sex, race and age should be carefully considered in the application of the atlas morphology as one of the indicator of CFS growth.

Note

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