SKELETODENTAL CHANGES DURING THE PUBERTAL GROWTH SPURT IN CLASS II DIV I FEMALES: A LONGITUDINAL STUDY

M. Shirazi and Sh. Etemad Moghadam

Department of Orthodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.

Abstract — *This study aimed to determine the quantity and character of growth changes in the skeletodental complex of class II div I malocclusion during the pubertal growth spurt in females. Longitudinal hand-wrist radiographs were obtained from each subject and the onset and end of the pubertal growth spurt was determined. Accordingly two lateral cephalograms were taken, superimposed and analyzed. This sample consisted of 36 girls (18 class I and 18 class II div I malocclusions), with no history of orthodontic treatment. The results indicate that true changes exist during the short period of pubertal growth spurt, which differ in amount and direction, in various parts of the face and cranium; also the pubertal growth spurt may have different effects on identical parameters, when compared between class I and class II div I subjects.*
Acta Medica Iranica 34 (3 & 4): 89-94; 1996

Key words: Skeletodental changes; pubertal growth spurt.

INTRODUCTION

One of the perplexing problems in the field of orthodontics is the prediction of craniofacial growth: the future size of a part, the future facial pattern, and the timing of growth events (1). Since growth does not proceed evenly, certain facial dimensions demonstrate marked changes in their velocity or spurts. The difference in timing of these spurts enhances the difficulty of growth prediction. Knowledge of the onset, duration, and rate of growth during a spurt, especially puberty, constitutes valuable information to the orthodontist (1). According to Nanda the spurt in facial height is similar to the long bones' spurt, but occurs earlier (2,3). Dermaut stated that the best time to initiate treatment is during the increasement of growth and before the maximum growth is over (2). Bishara concluded that the peak height velocity in girls takes place, 2 years earlier than boys, and it ranges from 10 to 14 years of age, therefore the best time to investigate growth changes in girls would be at 9 years (2). Halazonetis and Shapiro performed a longitudinal study on cephalograms of 55 white female and 39 white male subjects, 2 years pre to post pubertal age. The mandibular outline from articulare to gnathion was analyzed into cosine curves, according to the fourier equation. A decrease of the gonial angle was detected, also the female group showed bone deposition in the area posterior to the symphysis and a slight deepening of the antegonial notch with age (4).

Nanda and Ghosh carried out a longitudinal study on growth changes in the sagittal relationship of the maxilla and mandible. Radiographs were taken of 40 girls and 46 boys at ages 6,12,18 and 24. The results showed an increase of 6.07, 7.53 and 11.17 mm at points A, B and pogonion, respectively. The amount of accretion was larger in boys compared to girls (5).

The present study aimed to determine: 1) Whether changes occur in the skeletodental complex during the pubertal spurt in girls. 2) If the skeletodental complex undergoes any changes, what would be the location, magnitude and direction? 3) How would these changes influence the different parts of the skeletodental complex and in what manner could it affect the relationship between various parts of the complex? 4) If the above mentioned facts truely exist, regarding different aspects of change in the skeletodental complex, would there be any difference between skeletal class I and skeletal class II div I malocclusions? 5) If the stated difference is proven, would the probable changes enhance the malocclusion or could they help to improve it? In this case which variable would aggravate and which one would alter the malocclusion? The major goal of this study was to investigate whether the pubertal growth spurt and its related changes were an enhancing or an altering factor, regarding class I and class II div I malocclusions. By obtaining an answer to this question, orthodontic forces can be used to guide the probable changes into a normal path. On the other hand, during orthodontic treatment, considering supposable changes of the pubertal growth spurt, determination of the exact duration of retainer use can be made to minimize any kind of treatment relapses.

MATERIALS AND METHODS

Longitudinal hand-wrist radiographs were taken at 6 month intervals of 36 white females who were 9 to 12 years old. Accordingly 2 lateral cephalograms were also obtained from each subject at the onset and the end of the pubertal growth spurt. The group was chosen from a larger random smaple of 59 school girls, exhibiting class I and class II div I malocclusions.

The selection was based on the following criteria:

1) No history of orthodontic treatment and no extractions, proximal caries or missing teeth mesial to the second molars (diagnosis was assessed by panoramic radiogaphy and physical examination).

2) Total absence of dental or skeletal cross bite, crowding and oral habits.

3) No history of general or congenital disease.

4) All were born and living in Tehran for 3 generations and were Muslims.

Estimation of the onset of pubertal growth spurt was made by identifying, ossification of the carpal sesamoid (adductor sesamoid) and the end of pubertal growth spurt was evaluated by fusion of the epiphysis and diaphysis of the third finger's distal phalanx (Figs. 1,2 and 3) (6,7).

Lateral cephalometric radiographs were traced with a soft 0.5 mm pencil on acetate tracing papers, and a thorough combination analysis (as described by Tweed, Down, Steiner, Hold Away, Bjork) was conducted for each radiograph (2 films for each subject). The mean for each measurement at the onset and end of the pubertal growth spurt, growth changes and its standard deviations were calculated and the results of a t-test were shown as significant or nonsignificant ($p<0.05$, $p<0.01$). In addition a comparison was made between growth changes in class I and class II div I malocclusions, and an evaluation was made to see if the pubertal growth spurt has various effects on different malocclusions.

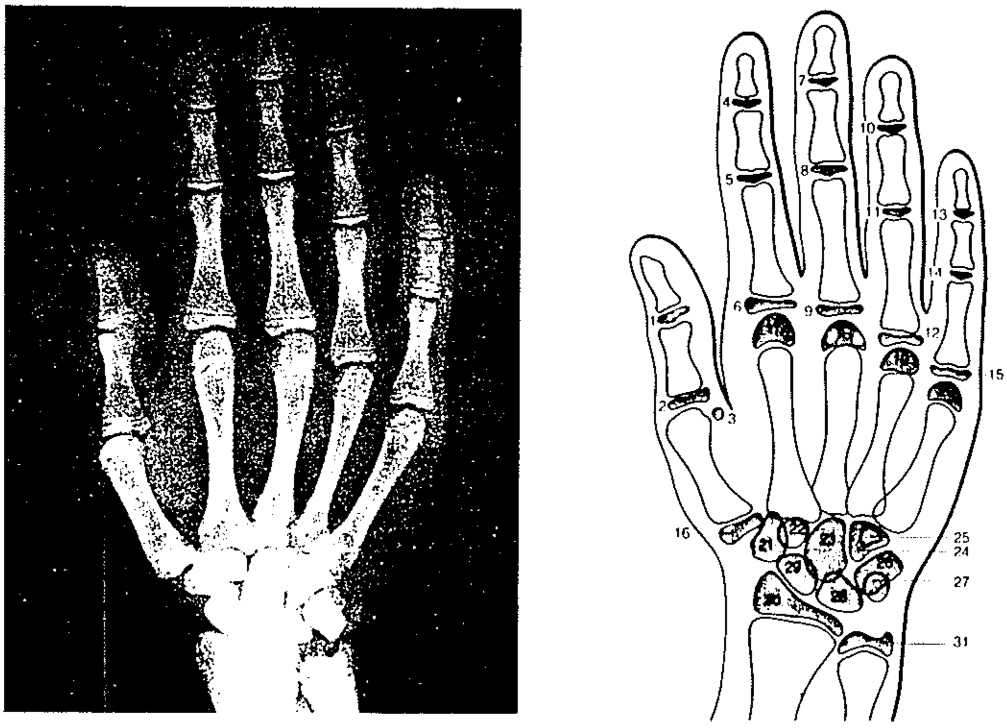

Fig. 1. Ossification events of the hand-wrist roentgenogram and the approximate timing of fusion.

(1) Epiphysis of thumb (2) Epiphysis of the proximal phalanx of the thumb (3) Sesamoid of the adductor brevis muscle at the metacarpophalangeal joint of the thumb (4) Epiphysis of the distal phalanx of the index finger (5) Epiphysis of the middle phalanx of the index finger (6) Epiphysis of the proximal phalanx of the index finger (7) Epiphysis of the distal phalanx of the middle finger (8) Epiphysis of the middle phalanx of the middle finger (9) Epiphysis of the proximal phalanx of the ring finger (10) Epiphysis of the distal phalanx of the ring finger (11) Epiphysis of the middle phalanx of the ring finger (12) Epiphysis of the proximal phalanx of the ring finger (13) Epiphysis of the distal phalanx of the little finger (14) Epiphysis of the middle phalanx of the small finger (15) Epiphysis of the proximal phalanx of the little finger (16) Epiphysis of the first metacarpal bone (17) Epiphysis of the second metacarpal bone (18) Epiphysis of the third metacarpal bone (19) Epiphysis of the fourth metacarpal bone (20) Epiphysis of the fifth metacarpal bone (21) Trapezium (22) Trapezoid bone (23) Capitate bone (24) Hamate bone (25) Hamular process of the hamate bone (26) Triquetral bone (27) Pisiform bone (28) Lunate bone (29) Scaphoid bone (30) Distal epiphysis of the radius (31) Distal epiphysis of the ulna

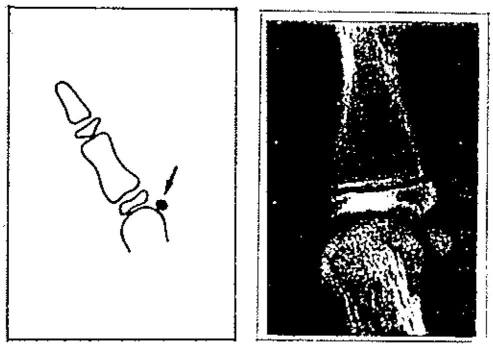

Fig. 2. Ossification of the adductor sesamoid of the thumb

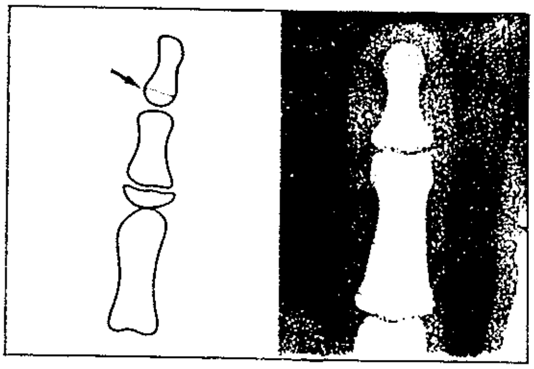

Fig. 3. Union of the distal phalanx of the third finger.

RESULTS

The skeletodental changes for each of the parameters in class I and class II div I subjects are shown repectively in Tables 1 and 2. In order to compare the influence of the pubertal growth spurt on the changes seen during this period between class I and class II div I malocclusions, Table 3 was conducted.

In Tables 1 and 2 "Significance" shows an obvious effect of the pubertal growth spurt on the related variable. In Table 3 "Significance" shows a marked difference of the effect of the pubertal growth spurt on identical parameters between class I and class II div I, malocclusions.

Table 1. The effect of pubertal growth spurt on different parameters in class I malocclusion

VARIABLE	X1	X2	d	SD	R.	P<	%d
SADDLE ANGLE	127.91	127.75	-0.16	2.17	NS	-	
ARTICULAR ANGLE	140.91	140.61	-0.3	3.09	NS	-	
GONIAL ANGLE	131.30	129.86	-1.44	1.19	S	0.01	-1.09
SUM	400.14	398.08	-1.91	3.26	NS	-	
ANT. CRANIAL BASE	70.86	70.94	0.083	0.17	NS	-	
POST. CRANIAL BASE	30.69	31.02	0.33	1.16	NS	-	
RAMUS HEIGHT	40.22	41.97	1.75	1.34	S	0.01	4.35
BODY LENGTH	71.61	73.42	1.81	1.25	S	0.01	2.5
SNA	79.706	80.4	0.694	0.55	S	0.01	0.8
SNB	76.66	77.35	0.69	0.52	S	0.01	1.03
ANB	3.06	3.05	0	0.2	NS	-	
GO-GN-SN	34.83	34.36	-0.47	1.43	NS	-	
U1 TO NA	21.47	22.55	1.083	2.09	NS	-	
U1 TO NA (mm)	2.44	2.66	0.19	0.82	NS	-	
L1 TO NB	24.58	25.13	0.55	1.70	NS	-	
L1 TO NB (mm)	4.19	4.47	0.27	0.6	NS	-	
Y-AXIS	60.36	59.8	-0.55	1.44	NS	-	
NA TO POG (CONVEXITY)	+2.77	+3.05	0.27	0.47	NS	-	
U1 TO FH	110.69	111.75	1.05	2.24	NS	-	
U1 TO SN	103.13	105.19	2.05	3.44	NS	-	
INTERINCISAL ANGLE	131.47	103.97	-0.5	3.07	NS	-	
POG TO NB (HOLD AWAY)	1.58	1.83	0.25	0.49	NS	-	
FMA	27.61	26.72	-1.1	1.55	S	0.05	-3.2
IMPA	93.38	93.88	0.5	2.24	NS	-	
FMIA	59.72	59.66	-0.05	2.51	NS	-	
N-POG TO FH (FACIAL ANGLE)	84.83	86	1.16	0.82	S	0.01	1.36
ANT. FACIAL HEIGHT	108.83	112.16	3.33	3.47	S	0.05	3
POST. FACIAL HEIGHT	69.09	72.16	3.07	1.3	S	0.01	4.4
JARABAK INDEX	%63.4	%64.3	%0.9	2.17	NS	-	

x_1 = The mean measurement of a variable at the onset of the pubertal growth spurt.
x_2 = The mean measurement of a variable at the end of the pubertal growth spurt.
d = The mean measurement of growth changes produced by the pubertal growth spurt.
SD = Standard deviation of growth changes.
R = Result { S = Significant; NS = Nonsignificant.
%d = The percentage of growth changes during the pubertal growth spurt.

Table 2. The effect of pubertal growth spurt on different parameters in class II div I malocclusion

VARIABLE	X1	X2	d	SD	R	P<	%d
SADDLE ANGLE	123.13	124.02	0.88	2.76	NS	-	
ARTICULAR ANGLE	142.77	143.33	0.55	1.91	NS	-	
GONIAL ANGLE	131.72	131.02	-0.69	1.94	NS	-	
SUM	397.61	398.38	0.75	2.42	NS	-	
ANT. CRANIAL BASE	69.69	70.3	0.61	0.78	S	0.05	0.87
POST. CRANIAL BASE	33.52	33.69	0.16	0.33	NS	-	
RAMUS HEIGHT	38.72	42.19	3.47	2.04	S	0.01	8.96
BODY LENGTH	70.16	72.02	1.86	1.17	S	0.01	2.6
SNA	84.73	85.36	0.63	0.67	S	0.05	0.7
SNB	78.19	78.72	0.527	0.63	S	0.05	0.67
ANB	6.43	6.64	0.21	0.1	S	0.01	3.2
GO-GN-SN	36.01	35.63	-0.37	0.68	NS	-	
U1 TO NA	16.36	19.41	3.11	4.4	S	0.05	18.6
U1 TO NA (mm)	1.61	2.19	0.58	0.96	NS	-	
L1 TO NB	26.8	28.05	1.25	2.11	NS	-	
L1 TO NB (mm)	5.25	6.08	0.83	0.91	S	0.05	15.8
Y-AXIS	60.80	61.52	0.72	1.31	NS	-	
NA TO POG (CONVEXITY)	+6.44	+6.21	-0.22	0.87	NS	-	
U1 TO FH	109.63	112.19	2.55	3.62	S	0.05	2.32
U1 TO SN	102.13	105.19	3.05	4.38	S	0.05	2.98
INTERINCISAL ANGLE	131.5	128.38	-3.11	4.66	S	0.05	-2.36
POG TO NB (HOLD AWAY)	0.63	0.77	0.138	0.517	NS	-	
FMA	28.66	28.38	-0.27	1.46	NS	-	
IMPA	94.97	95.86	0.88	2.25	NS	-	
FMIA	58.94	57.72	-1.22	2.2	NS	-	
N-POG TO FH (FACIAL ANGLE)	86.75	86.35	-0.38	1.09	NS	-	
ANT. FACIAL HEIGHT	111.33	115	3.67	1.95	S	0.01	3.2
POST. FACIAL HEIGHT	65.72	66.55	0.83	1.1	S	0.05	1.1
JARABAK INDEX	%59.03	%57.8	%-0.45	1.4	NS	-	

x_1 = The mean measurement of a variable at the onset of the pubertal growth spurt.
x_2 = The mean measurement of a variable at the end of the pubertal growth spurt.
d = The mean measurement of growth changes produced by the pubertal growth spurt.
SD = Standard deviation of growth changes.
R = Result { S = Significant; NS = Nonsignificant
%d = The percentage of growth changes during the pubertal growth spurt.

Table 3. Comparison of the effect of pubertal growth spurt on different parameters between class I and class II div I malocclusions

VARIABLE	d_1	S_1	d_2	S_2	R	P<
SADDLE ANGLE	-0.16	2.17	0.88	2.76	NS	-
ARTICULAR ANGLE	-0.3	3.09	0.55	1.91	NS	-
GONIAL ANGLE	-1.44	1.19	-0.69	1.94	NS	-
SUM	-1.19	3.26	0.75	2.42	NS	-
ANT. CRANIAL BASE	0.08	0.17	0.61	0.78	S	0.05
POST. CRANIAL BASE	0.33	1.16	0.16	0.33	NS	-
RAMUS HEIGHT	1.75	1.34	3.47	2.04	S	0.05
BODY LENGTH	1.81	1.25	1.86	1.17	NS	-
SNA	0.694	0.55	0.63	0.67	NS	-
SNB	0.79	0.52	0.527	0.63	NS	-
ANB	0	0.2	0.21	0.1	S	0.05
GO-GN-SN	-0.47	1.43	-0.37	0.68	NS	-
U1 TO NA	1.083	2.09	3.11	4.4	NS	-
U1 TO NA (mm)	0.19	0.82	0.58	0.96	NS	-
L1 TO NB	0.55	1.7	1.25	2.11	NS	-
L1 TO NB (mm)	0.27	0.6	0.83	0.91	NS	-
Y-AXIS	-0.55	1.44	0.72	1.31	NS	-
NA TO POG (CONVEXITY)	0.27	0.47	-0.22	0.87	NS	-
U1 TO FH	1.05	2.24	2.55	3.62	NS	-
U1 TO SN	2.05	3.44	3.05	4.38	NS	-
INTERINCISAL ANGLE	-0.5	3.07	-3.11	4.66	NS	-
POG TO NB (HOLD AWAY)	0.25	0.49	0.138	0.517	NS	-
FMA	-1.1	1.55	-0.27	1.46	NS	-
IMPA	0.5	2.24	0.88	2.25	NS	-
FMIA	-0.05	2.51	-1.22	2.2	NS	-
N-POG TO FH (FACIAL ANGLE)	1.16	0.82	-0.38	1.09	S	0.01
ANT. FACIAL HEIGHT	3.33	3.47	3.67	1.95	NS	-
POST. FACIAL HEIGHT	3.07	1.3	0.83	1.1	NS	-
JARABAK INDEX	%0.9	2.17	%-0.45	1.4	NS	-

d_1 = The mean measurement of growth changes related to the pubertal growth spurt for class I subjects.
d_2 = The mean measurement of growth changes related to the pubertal growth spurt for class II div I subjects.
S_1 = Standard deviation of d_1
S_2 = Standard deviation of d_2

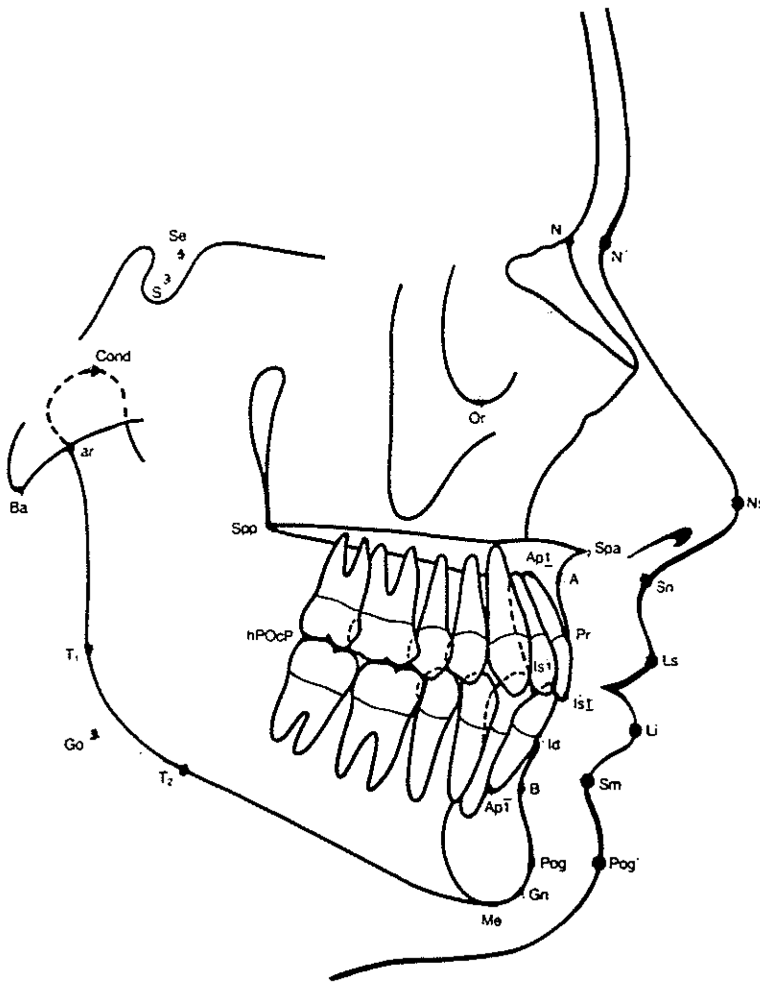

Fig. 4. Cephalometric Reference Points.
N = Nasion; the most anterior point of the frontonasal suture in the midsagittal plane
S = Midpoint of sella; sella point (S) is defined as the center of the sella turcica. It is a constructed (radiologic) point in the median plane
Se = Midpoint of the entrance to the sella
Cond = Condylion; the most posterior superior point of the condyle
ar = Articulare; a constructed point at the intersection of the images of the posterior margin of the ramus and the outer margin of the cranial base
Ba = Basion; lowest point on the anterior margin of the foramen magnum in the median plane
T1 = Most posterior point on the ramus in the region of the angle of the mandible
Go = Gonion; a constructed point at the intersection of the lines tangent to the posterior border of the ramus and the lower border of the mandible.
T2 = Most posterior inferior point on the body of the mandible
Me = Menton; the most inferior point of the outline of the symphysis in the midsagittal plane
Gn = Gnathion; the most anterior inferior point on the bony chin in the midsagittal plane
B = Point B, supramentale; the deepest point on the outer contour of the mandibular alveolar process between infradentale and pogonion
Id = Infradentale; the most anterior superior point on the alveolar process between the mandibular central incisors in the median plane
Pr = Prosthion; the most anterior inferior point on the alveolar portion of the premaxilla between the upper central incisors in the median plane

DISCUSSION*

Saddle Angle and Articular Angle

These angles decreased in class I and increased in class II subjects, which show a more posterior position of the mandible in relation to the base of the skull, in class II div I malocclusion and also a clockwise rotation in this group, but neither of the subjects showed significant changes.

Gonial Angle

This angle reduced in both classes, which shows similar results with a research done by Halazonetis and coworkers (4). The decrease is more pronounced in class I subjects and is significant up to 99%.

Anterior Cranial Base

Incremental changes are seen in both classes but significance is shown only in class II div I subjects. Table 3 demonstrates a more dramatic effect of the pubertal growth spurt on class II div I, compared to class I malocclusions.

Ramus Height

As seen in Tables 1 and 2 the pubertal growth spurt has an augmentative affect on both malocclusions ($p<0.01$). Table 3 shows a more pronounced effect on class II div I subjects.

Bone formation takes place in the proliferative layer

* All the mentioned cephalometric reference points are shown in Fig. 4.

of the cartilagenous cells in the condyle during growth. As we know these cells proliferate in different directions (superior and posterior), thereby the direction of increasement of the ramus height will depend on the advancement of one of the vectors to the other. In class II div I, accretion will be superiorly, resulting in a more posterior position of the mandible compared to the maxilla and a clockwise rotation of the mandible.

Body Length

The body length of the mandible increases in both groups (P<0.01). As seen in Table 2 the t-test result, related to this parameter, turned out to be nonsignificant, so the effect of the pubertal growth spurt is equal on both malocclusions.

Considering this and the angle changes that are mentioned above, we can reach the conclusion that the main difference between class I and class II div I malocclusions is because of a change in the position of the mandible in relation to the base of the skull and the body length of the mandible is not entirely responsible. In a similar research it was concluded that the change in the position of pogonion on a cephalogram during growth was due to the direction of condylar growth, but not an expression of growth, yet still affecting the amount of the measurements obtained in the study (8).

SNA and SNB

The pubertal growth spurt has an incremental effect on both angles in class I and class II div I malocclusions, but according to Table 3, both groups are evenly affected.

ANB

In class I malocclusion this angle remains unchanged, but strongly increases in class II div I subjects (p<0.01), showing that the pubertal growth spurt has a powerful effect only in class II div I malocclusions.

U1 TO NA/U1 to FH/U1 to SN

Incremental changes are more pronounced in class II div I malocclusions (P<0.05). In this group proclination of the upper incisors is induced by the pubertal growth spurt.

L1 to NB (mm)

Increasement is seen in both groups, but more dramtic in class II div I subjects.

Interincisal Angle

This angle is reduced in both groups but the decrease is much stronger in class II div I malocclusions.

N-Pog to FH (Facial Angle)

The facial angle is increased in class I and decreased in class II div I subjects.

This shows a tendency towards a convexer profile during growth and according to Table 2 the pubertal growth spurt has a stronger effect on this angle in class II div I, compared to class I malocclusions.

In conclusion we suggest that during the pubertal growth spurt, specific skeletodental changes take place in class II div I malocclusions.

By determination of these changes, arrangements can be made to guide them in a direction similar and harmonious with class I malocclusions therefore prevention of a problem (malocclusion) can be made.

By knowing the various growth sites and the timing of growth, advantage can be taken to minimize or maximize different aspects of change in the skeletodental complex, in order to achieve an ideal occlusion and facial proportions.

Orthodontic treatment might take place before the pubertal growth spurt, considering the changes that occur in different areas, a potential for relapse exists, thereby regarding the quantity and quality of the changes, an accurate plan can be made to diminish treatment relapses.

REFERENCES

1. Dermaut L.R, O'Reilly MJJ/Changes in anterior facial height in girls, during puberty. Angle orthod 48 (2): 163-71; 1978.

2. Bishara. Prediction of growth spurt. AM. J. Orthod 1981.

3. Proffit, W.R. Contemporary Orthodontics 1986.

4. Halazonetis D.J., Shapiro F. Quantitative description of the shape of the mandible. AM. J. Orthod; 99: 49-56, 1991.

5. Nanda R.S., Ghosh J. Longitudinal growth changes in the sagittal relationship of maxilla and mandible. AM. J. Orthod; 107: 79-90, 1995.

6. Fishman L.S. Maturational patterns and prediction during adolescence. Angle orthod; 178-93, 1987.

7. Hosseinzaadeh Niek T. The journal of Islamic dental association of Iran, 1:27-42; 1995.

8. Hagg U. Attstrom K. Mandibular growth estimated by four cephalaometric measurements. AM J Orthd; 102: 146-52, 1992.