Changes in dentofacial structures in untreated Class II division 1 and normal subjects: A longitudinal study

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The growth potential of individuals with Class II malocclusion is of interest to the practicing orthodontist because these malocclusions constitute a significant percentage of the cases treated. Ast et al.[1] examined 1,413 high school students 15 to 18 years old from upstate New York and found that 23.8% had Class II malocclusion and 69.9% had Class I malocclusion. This ratio, approximately 1:3, was similar to that reported by Goldstein and Stanton[2] for white American children and by Massler and Frankel[3] for children 14 through 18 years old. However, in a group of American blacks evaluated by Altemus,[4] the ratio of Class II to Class I malocclusions was about 1 to 6.

The effects of different types of appliances on the dentofacial relationships of individuals with Class II division 1 malocclusions have been evaluated in a number of studies. In these studies the treated groups were compared with untreated Class II division 1 samples.[5-15] Turloch et al.,[13] after systematically reviewing the literature between 1980 and 1987, identified 50 studies reporting the treatment of young patients with Class II malocclusion. Because of the different limitations in the various studies, Turloch et al. were unable to determine whether orthodontic treatment significantly influenced the growth potential of Class II patients.

Abstract

The purpose of this study was to compare longitudinally the changes that occur in dentofacial structures from the deciduous to the permanent dentitions in untreated Class II division 1 and normal individuals. Complete records were assembled for 65 subjects at three stages of development: at the completion of the deciduous dentition, after the first permanent molars had erupted completely, and after the permanent dentition had erupted completely (third molars excluded). On a cross-sectional basis, only mandibular length (Ar-Pog) differed significantly in the two groups, and then only during the earlier stages of development; by the later stage, the difference was not significant, indicating that some "catch up" growth may occur in Class II individuals. Longitudinal comparisons of the curve profiles, i.e., growth trends between Class II division 1 and normal subjects, indicated that there were no significant differences between the two groups except in upper lip protrusion. Comparisons of the total change from the deciduous to the permanent dentition indicated the presence of a number of significant differences between Class II division 1 and normal subjects, including larger magnitude of maxillary and mandibular lengths in the normal group and greater skeletal and soft tissue convexities in the Class II group.

Key Words

Normal • Class II division 1 • Untreated • Longitudinal • Cephalometrics

Submitted: May 1995 **Revised and accepted:** October 1995 Angle Orthod 1997;67(1):55-66.

Table 1
Descriptive statistics on the ages of individuals with untreated Class II division 1 malocclusion at the different stages evaluated. Normal subjects were matched at 5, 8, and 12 years.

	Males		Females		
Stage	$\bar{x}$	S.D.	$\bar{x}$	S.D.	P
Stage I	5.0	0.5	5.0	0.3	NS
Stage II	7.7	0.8	7.7	0.8	NS
Stage III	12.2	1.0	12.2	1.0	NS

$\bar{x}$ = Mean S.D. = Standard Deviation
NS = Not Significant at $P > 0.05$

Cephalometric characteristics of the Class II division 1 malocclusion

The determination of any dysplasia is usually attempted by comparing the dentofacial characteristics of individuals having a certain class of malocclusion with a group having "normal" occlusion. Using Angle's classification as their criterion, several investigators attempted to describe the cephalometric characteristics of the Class II division 1 malocclusion.[16-25] Fisk[16] described six possible morphological variations in the dentofacial complex: (1) The maxilla and teeth are anteriorly situated in relationship to the cranium; (2) The maxillary teeth are anteriorly placed in the maxilla; (3) The mandible is of normal size, but is posteriorly positioned; (4) The mandible is underdeveloped; (5) The mandibular teeth are posteriorly placed on an adequate base; and (6) Various combinations of the above factors.

The literature review indicates that a Class II malocclusion may or may not be accompanied by a skeletal discrepancy. Furthermore, describing the skeletal dysplasia that may accompany a Class II malocclusion as a "skeletal Class II" is of limited diagnostic value. This is because such a description does not specify whether the mandible is normal or retruded in relation to the maxilla, or whether the maxilla is protruded or normal in relation to the mandible.

The findings from the literature review are still inconclusive partly because most of the studies were cross-sectional in nature. Few longitudinal studies are available in the literature comparing untreated Class II division 1 subjects with untreated normal controls. The purpose of this study is to compare on a longitudinal basis the changes that occur in the dentofacial structures in untreated Class II division 1 and normal individuals between the deciduous and permanent dentitions.

Materials and methods

Subjects

The material for this investigation was obtained from the Facial Growth Study at the University of Iowa. The study was started by Drs. Meredith and Higley in 1946 on 167 subjects.[26,27] The sample for the present investigation were selected based on the availability of records. All subjects had models and cephalograms taken biannually between the ages of 3.5 and 12 years, and annually through age 17. Ninety-seven percent of the subjects were of northwestern European ancestry and all subjects were Caucasians.

Of the 167 subjects (81 males and 86 females) who were initially evaluated, 43 lacked records through the permanent dentition. Of the 121 remaining subjects, (60 males and 61 females) 62.0% (N = 75) developed into a Class I occlusion and 34.0% (N = 41) developed into a Class II occlusion. This assessment was made from records available at the completion of eruption of the permanent dentition.

Class II sample: Of the 41 patients with Class II malocclusion, 7 had an early phase of orthodontic treatment and 4 had Class II division 2 malocclusion and were eliminated from the study. As a result, the Class II division 1 sample consisted of a total of 30 subjects, 15 males and 15 females. None of these subjects had congenitally missing teeth; none had exhibited early loss of deciduous first or second molars nor had they undergone orthodontic therapy.

Each subject had complete sets of data at three stages of dental development: Stage I, after the completion of the deciduous dentition and before the eruption of any permanent teeth; Stage II, at the time the permanent first molars had completely erupted into occlusion, i.e., in the early mixed dentition stage when early treatment is often contemplated; and Stage III, at the completion of eruption of the permanent dentition excluding third molars, i.e., in early adolescence when a significant number of orthodontic patients are treated for malocclusion. After this point most of these cases received comprehensive orthodontic treatment.

Normal sample: Records on 35 normal subjects (20 males and 15 females) were available. The cephalograms for the normal individuals were matched for the ages of the Class II cases at each of the three stages. None of the subjects had an apparent facial disharmony and all had clinically

acceptable occlusion, i.e., a Class I molar and canine relationship with less than 3 mm of crowding and no gross asymmetries in the dental arches. None of the subjects had undergone orthodontic therapy.

The ages of the subjects in each group are presented in Table 1. No significant differences were present in the ages of the Class II division 1 and normal groups at each of the three stages for either males or females.

Cephalometric landmarks and measurements

Twenty-one hard-tissue and six soft-tissue landmarks were identified on each cephalogram and are presented in Figure 1.

The identification of these landmarks was based upon the classic definitions found in the literature.[28-30] The landmarks were digitized twice by two separate investigators using the Dentofacial Planner 4.22 (Dentofacial Software Inc, Toronto, Canada, 1988).

From these landmarks, 33 anteroposterior and vertical linear and angular measurements were derived and are listed in the various tables and in Figure 1.

All landmarks were identified by one investigator and checked for accuracy of location by a second investigator. The landmarks were measured twice at separate intervals by two investigators. Allowable inter- and intra-investigator errors were 0.5 mm and 0.5°.

Statistics used

Descriptive statistics including the mean, standard deviation, and minimum and maximum values were calculated for each parameter at the three stages. The measurements obtained on the various parameters were evaluated cross-sectionally and longitudinally.

Cross-sectional analysis

The Analysis of Variance General Linear Models procedure was used to compare the dentofacial parameters of Class II division 1 and normal subjects at each stage of development. The incremental changes for the total period were also compared among the various groups examined. The level of significance was predetermined at the 0.05 level of confidence.

Longitudinal comparisons

The individual values at each developmental stage were used to calculate absolute and incremental growth curves. The mean growth profile curves for the normal and Class II division I subjects for each facial parameter were compared by means of the Analysis of Variance General Linear Models procedure.

In the statistical analysis of the growth curves, there were two aspects to be evaluated—the shapes or profiles of the curves and the magnitudes of the curves to be compared. The shape or profile is the slope that describes growth direction. In this respect, the curves might show a parallel relationship indicating that the growth trends are the same. On the other hand, lack of parallelism among curve profiles indicates differences in growth trends. The magnitude of a curve is the height of the curve with age held constant and indicates the amount of change. It needs to be emphasized that if the curve profiles are not parallel, it would not be appropriate to compare the curve magnitudes. The method of analysis used to compare the growth curves was described in detail by Kleinbaum and Kupper.[31]

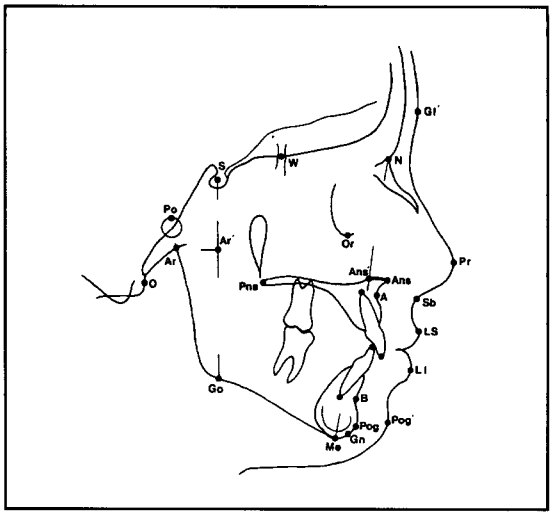

Figure 1

Figure 1
Landmarks used.[27-30]
S = Sella
W = Sphenoid wing point
N = Nasion
Or = Orbitale
Ans = Anterior nasal spine
Ans' = Perpendicular on N-Me at Ans
Pns = Posterior nasal spine
A = Point A or subspinale
B = Point B or supramentale
Pog = Pogonion
Gn = Gnathion
Me = Menton
Go = Gonion
Ar = Articulare
Ar' = Perpendicular on S-Go at Ar
Po = Ponion
O = Occipital condyle
U1 = Long axis of upper incisor
L1 = Long axis of lower incisor
Gl' = Soft tissue glabella
Pr = Prosthion
Sb = Subnasale
Ls = Labrale superior
Li = Labrale inferior
Pog' = Soft tissue pogonion

The level of statistical significance was predetermined at the 0.01 level of confidence for the comparisons of the curve parallelism and at the 0.05 level of confidence for the comparisons of curve magnitude. This variation in the level of significance is suggested by Bonferroni. The Bonferroni method[32] takes into consideration all tests of significance to be examined in one analysis. Since the test for parallelism was part of an analysis that included three variables, the 0.01 level of significance was chosen to keep the overall level of significance relatively high.

Results

Age comparisons

The analysis of variance indicated that no significant differences were present between the Class II division 1 subjects and the normal subjects at each of the three developmental stages.

Changes in cranial base (Figure 2A-B)

Cross-sectional comparisons (Tables 2-5)

All cranial parameters in males and females were not significantly different between the Class II division 1 and normal subjects at any of the

Figure 2A-B
Changes in cranial base angle (NSO) and total cranial base length (N-O) in males and females.

Figure 3A-B
Changes in maxillary relationship (SNA) and maxillary length (ANS-PNS) in males and females.

Figure 4A-C
Changes in SNB, SWPog angles and mandibular length (Ar-Pog) in males and females.

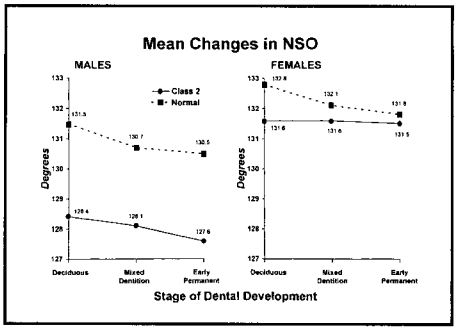

Figure 2A

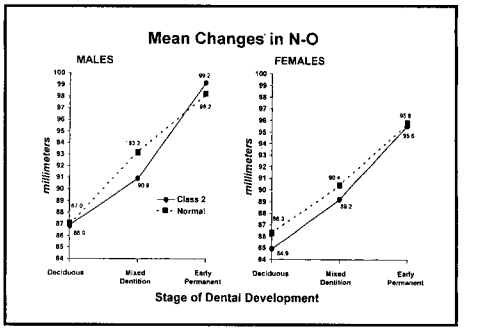

Figure 2B

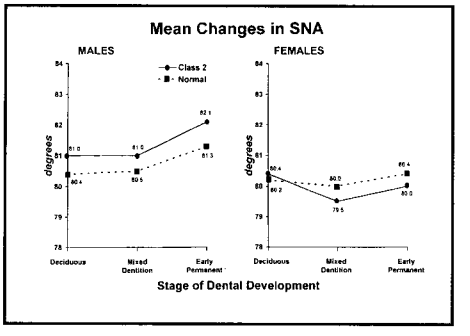

Figure 3A

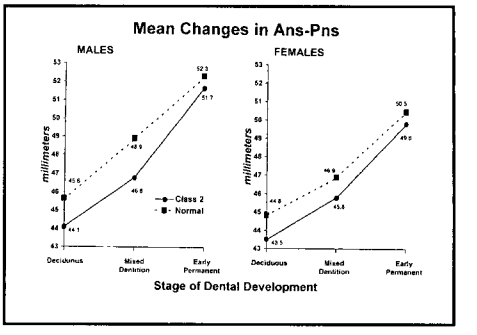

Figure 3B

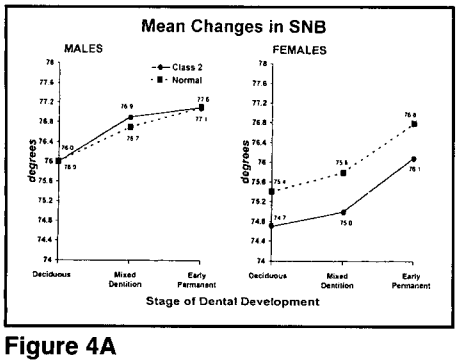

Figure 4A

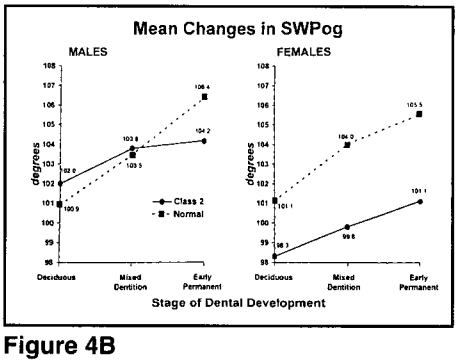

Figure 4B

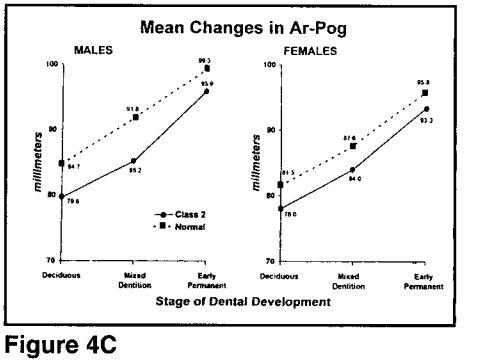

Figure 4C

three stages evaluated. The only significant difference was in the overall change of S-N in females (Table 5), which was larger in the Class II division 1 group than in normals (P<.05).

Longitudinal comparisons (Table 6)

Growth profile: No significant differences were present in the shapes of the curves between the Class II division 1 and normal individuals in either males or females in any cranial base measurement.

Growth magnitude: The curve magnitude for the NSO angle in males was significantly larger in the normals when compared with the Class II division 1 individuals (P < .01).

Changes in the maxillary complex (Figure 3A-B)

Cross-sectional comparisons (Tables 2-5)

There were no significant differences in the comparisons of maxillary relationship (SNA°) and maxillary length (Ans-Pns) between the Class II division 1 and normal subjects in either males or females at the three stages of development. The only exception was maxillary length in males at stage II, which was significantly greater (P < .01) in normals than in the Class II division 1 subjects.

Longitudinal comparisons (Table 6)

Growth profile: There was no significant differences in the shape of the curves between the Class II division 1 and normal individuals in either males or females.

Growth magnitude: The overall magnitude of the curves for maxillary length was significantly greater in normals than in Class II division 1 subjects for both males (P<.01) and females (P<.05).

Changes in the mandible (Figure 4A-C)

Cross-sectional comparisons

Of the five mandibular measurements compared, only two were significantly different between the Class II division 1 and normal subjects. Mandibular length (Ar-Pog) was significantly smaller (P<.01) in the Class II division 1 groups at the earlier stages of development in both males

Table 2
Descriptive statistics and results of analysis of variance comparing Class II division 1 and normal males and females at Stage I (deciduous dentition).

	Males					Females				
	Class II/1		Normals			Class II/1		Normals		
Variable	$\bar{x}$	S.D.	$\bar{x}$	S.D.	P	$\bar{x}$	S.D.	$\bar{x}$	S.D.	P
Cranial base										
NSO°	128.4	4.8	131.5	5.1	NS	131.6	5.7	132.8	4.1	NS
S-N mm	61.6	2.4	60.6	5.0	NS	59.2	1.8	60.2	2.2	NS
S-O mm	34.1	2.0	34.1	3.2	NS	33.2	1.9	33.0	3.6	NS
N-O mm	86.9	3.6	87.0	7.6	NS	84.9	3.5	86.3	3.3	NS
Maxillary complex										
SNA°	81.0	4.3	80.4	4.2	NS	80.4	3.0	80.2	3.2	NS
Ans-Pns mm	44.1	2.3	45.6	3.8	NS	43.5	2.4	44.8	1.8	NS
Mandible										
SNB°	76.0	3.4	76.0	3.8	NS	74.7	2.7	75.4	2.7	NS
SNPog°	75.4	3.4	75.1	4.0	NS	74.1	2.9	74.4	2.8	NS
FH-NPog°	82.8	3.0	81.9	6.9	NS	83.4	2.2	83.5	2.5	NS
SWPog°	102.0	5.2	100.9	5.4	NS	98.3	5.0	101.1	4.7	NS
Ar-Pog mm	79.6	4.2	84.7	4.4	S**	78.0	3.4	81.5	3.7	S**
Maxilla-mandible										
ANB°	5.0	2.2	4.1	2.0	NS	5.7	1.7	4.7	1.7	NS
NAPog°	13.1	6.1	10.8	4.0	NS	14.4	4.4	11.4	3.6	S*
Face heights and relationships										
N-Ans' mm	38.1	2.5	38.8	3.9	NS	36.9	2.2	38.2	1.5	S*
N-Me mm	86.4	4.0	92.1	8.7	S*	86.4	4.2	89.7	3.7	S*
N-Ans'/N-Me%	44.1	2.3	42.1	1.8	S*	42.8	1.7	42.6	1.7	NS
Ar'-Go mm	36.2	2.5	39.3	5.5	S*	35.4	2.7	37.8	2.0	S**
S-Go mm	59.5	3.4	60.8	6.0	NS	57.6	3.2	57.8	2.6	NS
Ar'-Go/S-Go%	60.8	2.2	64.3	4.6	S**	61.4	2.5	65.3	1.7	S**
S-Go/N-Me%	68.9	3.5	66.2	3.4	NS	66.7	3.2	64.4	2.9	S*
MP-SN°	30.5	4.3	34.5	6.0	S*	33.6	4.6	37.0	3.6	S*
Dental relationships										
U1:L1°	145.2	14.0	139.3	13.2	NS	147.1	13.5	146.6	10.9	NS
U1:SN°	92.0	7.2	91.7	8.8	NS	90.0	9.9	89.5	6.4	NS
U1:APog mm	2.5	1.7	3.0	1.2	NS	2.7	1.7	3.0	1.5	NS
L1:MP°	92.2	6.7	88.1	9.0	NS	89.4	7.0	86.7	7.3	NS
L1-NB mm	1.4	1.6	2.1	1.2	NS	1.8	1.6	2.2	1.5	NS
Pog-NB mm	-0.8	1.8	-1.4	1.2	NS	-1.0	1.6	1.3	1.6	NS
Overjet mm	4.4	1.1	2.9	1.3	S*	4.1	1.7	2.5	1.0	S*
Overbite mm	1.9	1.2	1.1	1.1	S*	2.6	2.0	1.6	1.1	NS
Soft tissue relationship										
NB:Ls-Pog'°	18.5	3.8	15.0	3.9	S*	18.1	4.8	14.5	5.0	S*
Gl-SLs-Pog'°	168.4	3.8	169.7	4.1	NS	166.6	4.2	170.3	4.0	S*
Ls:Pr-Pog' mm	1.9	1.8	-0.3	1.9	S**	1.2	1.8	-0.2	1.6	NS
Li:Pr-Pog' mm	-0.8	1.4	0.1	1.5	NS	1.1	2.1	0.2	1.8	S*

$\bar{x}$ = Mean; S.D. = Standard deviation; P = probability; NS = Not significant; S* = Significant at ≤ 0.05 and S** at ≤ .01

and females (Tables 2 and 3). But the differences were not significant at the later stage of development, i.e., following the eruption of the permanent dentition (Table 4). The total change in mandibular length was not significantly different between the groups (Table 5).

Longitudinal comparisons (Table 6)

Growth profile: No significant differences were present in the growth profiles of any of the mandibular parameters.

Growth magnitude: The overall magnitude of the curve for mandibular length was significantly greater (P<.01) in the normal subjects than for the Class II division 1 subjects in both males and females. In females the curve magnitude for SWPog was significantly greater for the normal subjects when compared with the Class II division 1 subjects (P < .01).

Table 3
Descriptive statistics and results of analysis of variance comparing Class II division 1 and normal males and females at Stage II (mixed dentition).

	Males					Females				
	Class II/1		Normals			Class II/1		Normals		
Variable	x	S.D.	x	S.D.	P	x	S.D.	x	S.D.	P
Face heights and relationships										
Cranial base										
NSO°	128.1	5.0	130.7	4.9	NS	131.6	6.2	132.1	4.5	NS
S-N mm	63.9	2.8	64.4	2.0	NS	61.7	2.0	62.4	2.7	NS
S-O mm	36.2	2.0	37.4	2.2	NS	35.5	2.0	35.6	3.7	NS
N-O mm	90.9	4.0	93.2	3.9	NS	89.2	4.1	90.4	4.0	NS
Maxillary complex										
SNA°	81.0	4.4	80.5	4.3	NS	79.5	3.2	80.0	3.6	NS
Ans-Pns mm	46.8	1.7	48.9	2.2	S**	45.8	2.3	46.9	2.1	NS
Mandible										
SNB°	76.9	4.0	76.8	3.7	NS	75.0	3.0	75.3	3.0	NS
SNPog°	77.0	4.2	76.6	3.9	NS	75.1	3.0	75.3	3.0	NS
FH-NPog°	84.2	4.2	83.4	3.2	NS	83.1	2.6	83.5	2.2	NS
SWPog°	103.8	5.3	103.5	5.6	NS	99.8	5.4	104.0	4.8	S*
Ar-Pog mm	85.2	4.1	91.8	4.6	S**	84.0	3.9	87.6	3.8	S**
Maxilla-mandible										
ANB°	4.1	1.8	3.7	1.5	NS	4.5	1.5	4.2	1.6	NS
NAPog°	9.0	4.8	8.2	3.7	NS	9.8	3.6	9.4	3.8	NS
Face heights and relationships										
N-Ans' mm	41.5	2.7	43.7	2.4	S*	41.0	2.7	42.1	2.0	NS
N-Me mm	92.1	3.4	100.8	4.0	S**	93.1	5.0	96.2	5.4	NS
N-Ans'/N-Me%	45.1	2.4	43.4	1.5	S*	44.0	1.4	43.8	1.6	NS
Ar'-Go mm	39.5	2.7	43.7	3.3	S**	37.9	3.5	40.0	2.2	S*
S-Go mm	64.6	3.5	67.6	4.7	S*	61.9	3.3	62.8	2.7	NS
Ar'-Go/S-Go%	61.1	2.3	64.7	2.1	S*	61.1	3.2	63.7	2.0	S**
S-Go/N-Me%	70.2	4.1	67.1	4.6	S*	66.6	3.5	65.3	3.2	NS
MP-SN°	29.1	4.3	33.9	5.0	S**	33.8	4.4	35.8	3.9	NS
Dental relationships										
U1:L1°	130.5	9.1	131.3	7.8	NS	131.0	9.5	130.1	6.9	NS
U1:SN°	101.9	3.5	101.1	4.1	NS	100.2	6.8	101.1	5.4	NS
U1:APog mm	3.4	2.0	4.2	1.5	NS	4.6	1.5	4.9	1.6	NS
L1:MP°	98.4	5.2	93.9	5.2	S*	95.0	6.8	93.0	5.2	NS
L1-NB mm	2.5	1.8	3.4	1.2	NS	2.8	1.7	3.6	1.3	NS
Pog-NB mm	0.1	1.7	-0.3	1.6	NS	0.2	1.2	-0.6	1.4	NS
Overjet mm	3.9	1.4	2.9	1.2	S*	4.7	1.3	3.3	1.4	S*
Overbite mm	2.0	2.0	2.1	1.7	NS	3.1	2.0	2.3	1.2	NS
Soft tissue relationships										
NB:Ls-Pog'°	14.6	4.2	13.6	3.7	NS	15.2	3.8	13.7	4.5	NS
Gl-SLs-Pog'	168.1	4.1	168.8	3.4	NS	165.6	4.7	168.2	3.6	NS
Ls:Pr-Pog' mm	-0.5	1.5	-0.6	1.9	NS	0.1	1.6	-1.0	1.5	NS
Li:Pr-Pog' mm	0.3	1.8	-0.2	1.6	NS	0.4	2.1	0.0	1.4	NS

$\bar{x}$ = Mean; S.D. = Standard deviation; P = probability; NS = Not significant; S* = Significant at ≤ 0.05 and S** at ≤ .01

Changes in maxillary-mandibular relationships (Figure 5A-B)

Cross-sectional comparisons (Tables 2-5)

The angle of skeletal convexity (NAPog) in females at Stage I and the ANB angle in males at Stage III were larger in the Class II division 1 subjects than in normals ($P < .05$). There was a significantly greater reduction in the NAPog angle over the total period of observation in the Class II division 1 females than in normals ($P<.01$).

Longitudinal comparisons (Table 6)

Growth profile: No significant differences were present in the growth profiles of males and females for the changes in maxillary - mandibular relationships.

Growth magnitude: In both males and females the magnitude of the curves for ANB and NAPog angles were greater in the Class II division 1 than in the normal subjects ($P < .05$).

Table 4
Descriptive statistics and results of analysis of variance comparing Class II division 1 and normal males and females at Stage III (permanent dentition).

	Males					Females				
	Class II/1		Normals			Class II/1		Normals		
Variable	x	S.D.	x	S.D.	P	x	S.D.	x	S.D.	P
Cranial base										
NSO° 127.6	5.2		130.5	4.9	NS	131.5	5.9	131.8	4.8	NS
S-N mm	68.8	4.2	67.1	2.2	NS	65.4	2.2	65.2	3.2	NS
S-O mm	40.8	3.6	40.5	2.1	NS	38.9	2.5	38.7	3.9	NS
N-O mm	99.2	7.4	98.2	3.9	NS	95.6	4.5	95.8	4.9	NS
Maxillary complex										
SNA°	82.1	4.2	81.3	3.8	NS	80.0	3.5	80.4	3.6	NS
Ans-Pns mm	51.7	3.2	52.3	2.2	NS	49.8	2.8	50.5	2.4	NS
Mandible										
SNB°	77.1	3.8	77.6	3.3	NS	76.1	3.3	76.8	3.0	NS
SNPog°	78.1	4.2	78.0	3.7	NS	76.8	3.2	76.8	3.1	NS
FH-NPog°	83.8	4.1	83.0	4.7	NS	84.0	3.0	83.2	2.5	NS
SWPog°	104.2	6.7	106.4	5.5	NS	101.0	5.4	105.5	5.5	S*
Ar-Pog mm	95.9	5.6	99.3	5.1	NS	93.3	4.8	95.8	5.1	NS
Maxilla-mandible										
ANB°	5.0	1.7	3.8	1.7	S*	3.9	1.8	3.6	1.9	NS
NAPog°	9.3	4.8	6.9	4.3	NS	7.2	4.7	7.3	5.1	NS
Face heights and relationships										
N-Ans' mm	47.6	4.6	48.0	2.4	NS	46.3	2.8	46.2	2.2	NS
N-Me mm	103.9	8.0	108.2	4.4	NS	102.9	6.1	104.0	5.4	NS
N-Ans'/N-Me%	45.8	2.2	44.4	1.5	S*	45.0	1.8	44.4	1.9	NS
Ar'-Go mm	44.3	4.2	47.0	3.5	NS	42.9	4.3	43.8	2.5	NS
S-Go mm	73.4	5.4	74.2	4.9	NS	70.0	4.8	69.8	3.4	NS
Ar'-Go/S-Go%	60.2	2.9	63.3	1.9	S*	61.2	3.2	62.8	1.8	NS
S-Go/N-Me%	70.8	4.4	68.6	4.7	NS	68.1	3.7	67.2	3.4	NS
MP-SN°	29.1	5.4	32.4	5.2	NS	33.0	4.6	34.2	4.0	NS
Dental relationships										
U1:L1°	126.5	11.6	128.0	6.7	NS	125.2	8.4	127.7	7.9	NS
U1:SN°	102.9	6.0	102.2	4.9	NS	102.3	7.1	102.2	4.7	NS
U1:APog mm	5.2	2.5	5.3	1.6	NS	6.0	1.4	5.8	1.6	NS
L1:MP°	101.5	8.0	97.5	5.2	NS	99.5	6.7	96.0	5.0	NS
L1-NB mm	4.2	2.4	4.6	1.2	NS	4.3	1.7	4.4	1.7	NS
Pog-NB mm	1.7	1.6	0.7	1.8	NS	1.2	1.3	0.3	1.4	NS
Overjet mm	4.2	1.4	3.1	1.0	S*	4.9	1.5	3.0	0.7	S*
Overbite mm	4.2	1.5	3.6	1.3	NS	3.8	1.7	3.2	1.5	NS
Soft tissue relationships										
NB:Ls-Pog'°	15.4	4.8	14.0	4.2	NS	14.5	4.2	13.0	5.8	NS
Gl-SLs-Pog'°	165.5	3.6	167.4	3.7	NS	163.5	4.8	167.5	4.8	S*
Ls:Pr-Pog' mm	1.4	2.3	-1.0	1.9	NS	-0.9	1.8	-2.3	2.2	S*
Li:Pr-Pog' mm	1.2	2.2	-0.5	1.7	NS	0.5	1.5	-0.4	2.3	NS

$\bar{x}$ = Mean; S.D. = Standard deviation; P = probability; NS = Not significant; S* = Significant at ≤ 0.05 and S** at ≤ .01

Changes in face heights and relationships (Figure 6A-C)

Cross-sectional comparisons (Tables 2-5)

At Stage I in both males and females, most of the parameters describing the vertical relationships of the face were significantly greater in normals than in Class II division 1 subjects. At Stage II, normal males still had significantly larger measurements than Class II division 1 males. On the other hand, females had fewer differences (Ar'-Go and Ar-Go/S-Go%). At Stage III, there were no significant differences between females in any of the parameters and only two ratios (N-Ans'/N-Me% and Ar'-Go/S-Go%) were significantly different in males, indicating a relatively shorter lower anterior face and longer lower posterior face in the Class II division 1 subjects.

Table 5
Descriptive statistics and results of analysis of variance comparing total changes in Class II division 1 and normal males and females from deciduous to permanent dentitions.

	Males					Females				
	Class II/1		Normals			Class II/1		Normals		
Variable	$\bar{x}$	S.D.	$\bar{x}$	S.D.	P	$\bar{x}$	S.D.	$\bar{x}$	S.D.	P
Cranial base										
NSO°	-0.8	2.0	-1.0	2.1	NS	-0.1	2.9	-1.0	2.2	NS
S-N mm	7.2	3.1	6.5	4.8	NS	6.2	1.6	5.0	1.5	S*
S-O mm	6.8	2.8	6.4	2.4	NS	5.6	1.9	5.7	1.3	NS
N-O mm	12.2	5.2	11.2	6.6	NS	10.7	2.5	9.4	2.3	NS
Maxillary complex										
SNA°	1.1	1.6	1.0	0.9	NS	-0.4	1.5	0.2	1.6	NS
Ans-Pns mm	7.6	2.8	6.7	4.1	NS	6.4	1.8	5.7	1.6	NS
Mandible										
SNB°	1.2	1.8	1.6	1.3	NS	1.4	2.3	1.4	1.8	NS
SNPog°	2.7	1.9	2.9	1.1	NS	2.7	1.9	2.4	2.1	NS
FH-NPog°	1.0	3.2	1.1	6.3	NS	0.6	2.5	-0.3	2.5	NS
SWPog°	2.2	3.7	5.5	2.6	S**	2.7	3.9	4.3	4.2	NS
Ar-Pog mm	16.4	5.1	14.7	2.4	NS	15.2	3.4	14.3	2.3	NS
Maxilla-mandible										
ANB°	0.0	1.5	-0.4	1.5	NS	-1.8	1.4	-1.2	1.3	NS
NAPog°	-3.8	4.3	-3.8	2.8	NS	-7.2	3.2	-4.1	3.3	S**
Face heights and relationships										
N-Ans' mm	9.5	3.0	9.2	2.8	NS	9.4	1.6	8.0	1.6	S*
N-Me mm	17.5	6.9	16.1	6.8	NS	16.6	3.6	14.3	2.8	S*
N-Ans'/N-Me%	1.7	1.7	2.2	1.1	NS	2.3	1.2	1.8	1.2	NS
Ar'-Go mm	8.1	3.3	7.7	1.2	NS	7.5	3.4	6.1	2.0	NS
S-Go mm	13.9	4.1	13.4	4.9	NS	12.4	3.3	12.0	2.3	NS
Ar'-Go/S-Go%	-0.6	2.3	-0.9	5.0	NS	-0.2	2.6	-2.6	1.7	S**
S-Go/N-Me%	1.4	2.1	0.9	1.2	NS	1.4	2.4	2.8	2.2	NS
MP-SN°	-1.4	3.7	-2.1	3.2	NS	-0.6	2.8	-2.8	2.4	S*
Dental relationships										
U1:L1°	-18.7	12.8	-11.3	12.5	NS	-21.9	11.7	-18.9	8.9	NS
U1:SN°	10.9	6.6	10.5	9.5	NS	12.3	9.7	12.7	3.6	NS
U1:APog mm	2.7	2.0	2.3	1.6	NS	3.4	1.4	2.7	1.2	NS
L1:MP°	9.3	9.4	9.5	9.8	NS	10.1	5.2	9.3	6.1	NS
L1-NB mm	2.8	2.0	2.5	1.3	NS	2.5	1.1	2.1	1.3	NS
Pog-NB mm	2.5	1.2	2.1	1.1	NS	2.1	1.6	1.5	1.1	NS
Overjet mm	-0.2	0.8	0.1	1.3	S*	-0.8	1.3	0.9	1.1	S*
Overbite mm	2.3	1.8	-2.5	1.1	S*	1.2	2.2	-1.7	1.7	S**
Soft tissue relationships										
NB:Ls-Pog'°	-3.1	4.0	-1.0	2.8	NS	-3.6	4.0	-1.5	3.0	NS
Gl-SLs-Pog'	2.9	2.9	-2.3	3.7	S**	3.2	4.2	-2.8	3.1	S**
Ls:Pr-Pog' mm	0.5	1.7	-1.3	1.1	S**	-1.3	1.8	-2.1	1.4	S**
Li:Pr-Pog' mm	0.4	1.9	-0.5	1.6	NS	-0.6	2.0	-0.5	1.6	NS

$\bar{x}$ = Mean; S.D. = Standard deviation; P = probability; NS = Not significant; S* = Significant at ≤ 0.05 and S** at ≤ .01

Longitudinal comparisons (Table 6)

Growth profile: No significant differences were present in the shapes of the curves between the Class II division 1 and normal individuals in either males or females in all measurements of face heights and relationships.

Growth magnitude: In both males and females the magnitude of the growth curves of the vertical linear dimensions were larger in normals than in Class II division 1 subjects. The corresponding ratios also reflected these differences.

Changes in dental relationships (Figure 7A-B)

Cross-sectional comparisons (Tables 2-5)

Of the six parameters describing the dental relationship at each of the three stages, only overjet was significantly larger in the Class II division 1 males and females when compared with the corresponding normals. No other parameter was significantly different. When the total changes between Stages I and III were compared, there

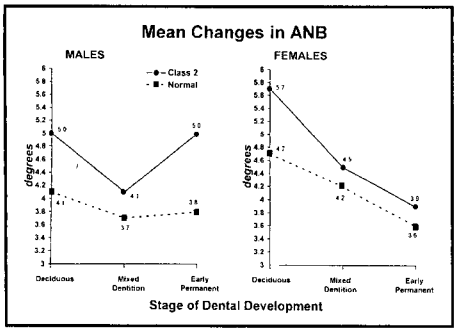

Figure 5A

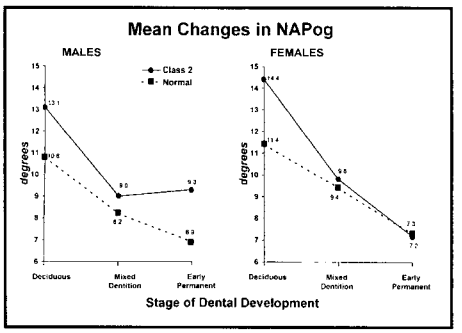

Figure 5B

Figure 5A-B
Changes in ANB and skeletal facial convexity (NAPog) angles in males and females.

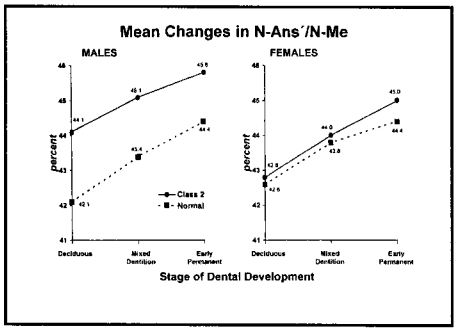

Figure 6A

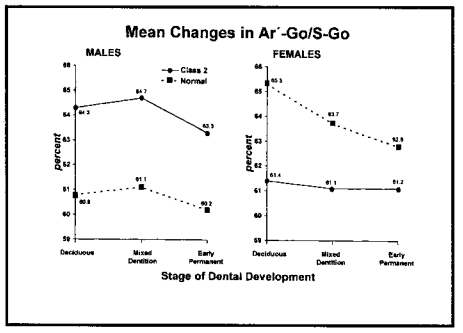

Figure 6B

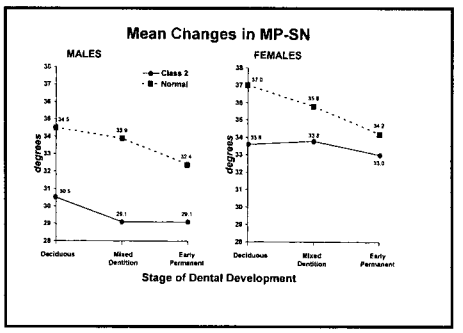

Figure 6C

Figure 6A-C
Changes in anterior face heights (N-Ans'/N-Me%) posterior face heights (Ar'-Go/S-Go%) and mandibular plane inclination (MP:SN°).

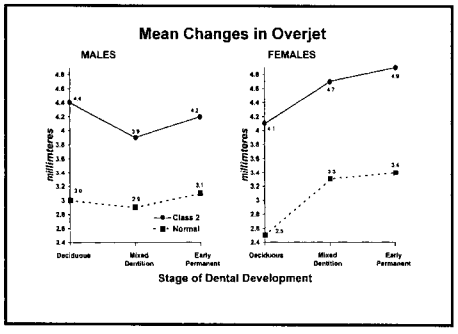

Figure 7A

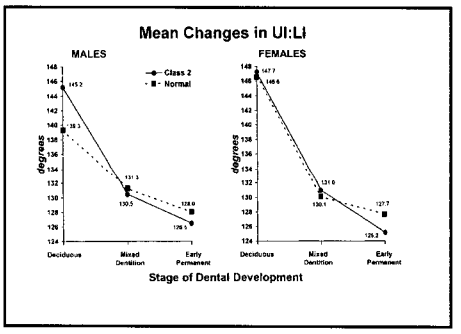

Figure 7B

Figure 7A-B
Changes in overjet and interincisal angle (U1:L1) in males and females.

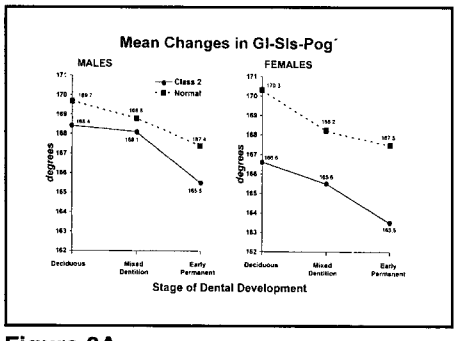

Figure 8A

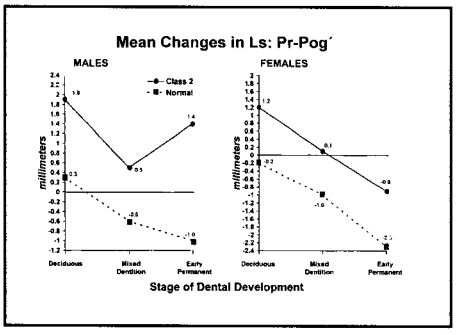

Figure 8B

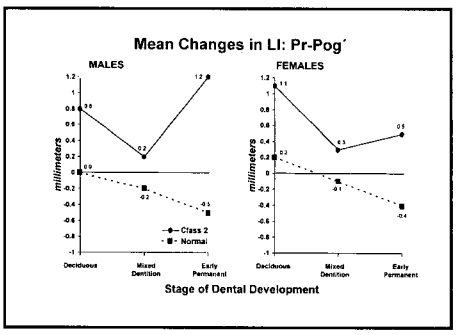

Figure 8C

Figure 8A-C
Changes in the angle of soft tissue convexity (Gl-Sls-Pog'), upper (Ls:Pr-Pog') and lower (Li:Pr-Pog') lip protrusion.

was a small but significant decrease in overjet in the Class II division 1 group accompanied by a significant increase in overbite in both males and females.

Longitudinal comparisons (Table 6)

Growth profile: No significant differences were present in the shapes of the curves between the Class II division 1 and normal individuals in either males or females in all dental relationships.

Growth magnitude: In both males and females the magnitude of the curves for overjet and Pog:NB were larger in Class II division 1 individuals than in normals. The curve for overbite was larger in Class II females and the curve for L1:NB was larger in normals.

Soft tissue relationships (Figure 8A-C)

Cross-sectional comparisons (Tables 2-5)

At Stage I in both males and females the Holdaway soft tissue angle (NB:Ls-Pog) was larger in Class II division 1 subjects than in

Table 6
Results of longitudinal comparisons of curve profile and magnitude between Class II division 1 and normal males and females

	Males		Females	
Variable	Parallelism	Magnitude	Parallelism	Magnitude
Cranial base				
NSO°	NS	N > II (S**)	NS	NS
SN mm	NS	NS	NS	NS
SO mm	NS	NS	NS	NS
NO mm	NS	NS	NS	NS
Maxillary complex				
SNA°	NS	NS	NS	NS
Ans-Pns mm	NS	N > II (S**)	NS	N > II (S*)
Mandible				
SNB°	NS	NS	NS	NS
SNPog°	NS	NS	NS	NS
FH:N-Pog°	NS	NS	NS	NS
SWPog°	NS	NS	NS	N > II (S**)
Ar-Pog mm	NS	N > II (S**)	NS	N > II (S**)
Maxilla-mandible				
ANB°	NS	II > N (S*)	NS	II > N (S*)
NAPog°	NS	II > N (S*)	NS	II < N (S*)
N-Ans' mm	NS	NS	NS	NS
N-Me mm	NS	N > II (S**)	NS	N>II (S**)
N-Ans'/N-Me%	NS	II > N (S**))	NS	NS
Ar'-Go mm	NS	N > II (S**)	NS	N>II (S**)
S-Go mm	NS	NS	NS	NS
Ar'-Go/S-Go%	NS	N > II (S**)	NS	N>II (S**)
S-Go/N-Me%	NS	II > N (S**)	NS	II>N (S**)
MP-SN°	NS	N > II (S**)	NS	N>II (S**)
Dental relationships				
U1:L1°	NS	NS	NS	NS
U1:SN°	NS	NS	NS	NS
U1:APog mm	NS	NS	NS	NS
L1:MP°	NS	NS	NS	NS
L1-NB mm	NS	N>II (S*)	NS	NS
Pog-NB mm	NS	II>N (S*)	NS	II>N (S*)
Overjet mm	NS	II>N (S*)	NS	II>N (S*)
Overbite mm	NS	NS	NS	II>N (S*)
Soft tissue relationships				
NB:Ls-Pog'°	NS	II>N (S*)	NS	II>N (S*)
Gl-SLs-Pog'	NS	NS	NS	N>II (S**)
Ls:Pr-Pog' mm	S*	—	0.0010	—
Li:Pr-Pog' mm	NS	NS	NS	NS

NS = Not significant; N = Normals; I = Class II/1; S* = Significant at ≤ 0.05 and S** at ≤ 0.01

normals. The upper lip (Ls:Pr-Pog') was more protrusive in Class II division 1 males, while the lower lip (Li:Pr-Pog') was more protrusive in females. At Stage II there were no significant differences between Class II division 1 and normals in both males and females. At Stage III, Class II division 1 females had a significantly larger angle of convexity (Gl-SLs-Pog') and a more protrusive upper lip (Ls:Pr-Pog'). Comparisons of the total change from Stage I to III indicated that the soft tissue facial convexity and upper lip protrusion increased significantly in the Class II division 1 individuals while it decreased in the normals. This occurred in both males and females.

Longitudinal comparisons (Table 6)

Growth profile: All the growth profile comparisons were not significantly different between the Class II division 1 and normal individuals, with the exception of the growth profile for upper lip protrusion (Ls:Pr-Pog'). These differences were present in both males and females.

Growth magnitude: In both males and females the magnitude of the growth curves for the Holdaway soft tissue angle (NB:Ls-Pog') and soft tissue angle of convexity (Gl:Sls:Pog') were significantly larger in Class II division 1 than normal individuals.

Discussion

The findings from the literature indicated that the presence of a Class II division 1 malocclusion can be associated with any one or combination of the following conditions:[16-25]

1. Maxillary skeletal protrusion with or without a long maxilla;
2. Maxillary dental protrusion;
3. Mandibular skeletal retrusion with or without a short mandible;
4. Mandibular dental retrusion; and
5. Obtuse cranial base angle.

This lack of consensus regarding the dentofacial characteristics of Class II division 1 subjects is an indication of the large variation within this population.[16-25] Such variation is understandable because of the dental, skeletal and soft tissue interactions that can lead to a discrepancy that is often described solely in terms of the dental occlusal relationship.

As a result, the possibility exists that either randomly or by design, the different studies on Class II division 1 individuals might have more or less of one type of skeletal and/or dental malrelationships. This is because the only common denominator between the individuals evaluated in these studies was based on the dental classification of the Class II division 1 malocclusion.

In addition, most of these studies are cross-sectional in nature, which further complicates the clinical picture. The findings in the present investigation point to the fact that when the same parameter is evaluated on a cross-sectional basis at different ages, the results may indicate significant differences at one age but not at another (Tables 2-5). Therefore, when possible, it is im-

portant to evaluate "growth trends" on a longitudinal basis. The advantage of such longitudinal evaluations is that they provide for a more comprehensive understanding of whether the growth trends in Class II division 1 untreated subjects are significantly different from those of untreated normal subjects.

Another factor that confounds the evaluation of untreated Class II division 1 individuals is that the more severe cases often seek treatment at an earlier age. In the present study, 7 out of 41 patients in the original Class II sample were treated for their malocclusion before the complete eruption of the permanent dentition, i.e., in the mixed dentition. As a result, one might assume that the present sample does not include the full range of Class II division 1 malocclusions, i.e., the relatively more severe cases. Obviously not treating these individuals just to study their growth trends would have posed a serious ethical problem. As a result, the reader needs to consider this potential limitation when interpreting the present findings.

Cross-sectional comparisons (Tables 2-5)

The present findings indicate that, on a cross-sectional basis, there were very few consistent significant differences from one stage of development to the other when the Class II division 1 and normal subjects were compared. Of interest, mandibular length (Ar-Pog) was significantly shorter in the Class II division 1 subjects when compared with the normal subjects, only in the earlier stages of development. By the time the permanent dentition has completely erupted, the differences in mandibular length were not significant. This finding might suggest the possibility of a late "catch up" growth period occurring in the Class II division 1 subjects.

Longitudinal comparisons (Table 6, Figures 2-8)

As detailed earlier, the growth trends can be described in two ways: growth profile, i.e., direction of change, and growth magnitude, i.e., amount of change.

Growth profiles: One of the most interesting findings in the present study was that the longitudinal comparisons of the growth profiles of the various dentofacial structures in Class II division 1 and normal subjects were essentially similar. In other words, the general growth direction of the cranial base, maxillary, mandibular, dental and soft tissue structures describe similar growth trends. The only exception was in upper lip protrusion, which had significantly different growth profiles in the two groups.

Growth magnitude: Comparisons of the total amount of growth changes indicated that there were numerous significant differences between the Class II division 1 and the normal subjects. The overall changes in maxillary and mandibular lengths were larger in normal males and females when compared with the corresponding Class II division 1 subjects, while the curve magnitude for SWPog for Class II females was significantly smaller. On the other hand, the curve magnitudes for the ANB angle, the angles of skeletal and soft tissue convexities (NAPog, NB:Ls-Pog', Gl-SLs-Pog') were significantly larger in the Class II division 1 subjects when compared with normals.

These findings indicate that, in general, Class II division 1 and normal subjects have essentially similar growth trends, but the overall magnitude of the growth changes may differ in a few parameters.

Conclusions

The findings from the present study indicate that:

1. In the cross-sectional comparisons there were few consistent differences between the Class II division 1 and normal subjects. The differences in mandibular length and position were more evident in the early stages of development than at the later stages. This may indicate the possibility of a "catch up" period in mandibular growth in Class II division 1 subjects at the later stages of development.
2. The longitudinal comparisons of the growth profiles indicated that the growth trends are essentially similar between Class II division 1 and normal subjects in the various dentofacial parameters compared except for upper lip protrusion.
3. The comparisons of growth magnitude (amount of growth) pointed to a number of significant differences indicating the presence of greater skeletal and soft tissue convexities in Class II division 1 subjects accompanied by a tendency for a more retruded mandible.
4. The growth of the cranial base parameters evaluated were essentially similar in Class II division 1 and normal subjects.
5. In Class II division 1 subjects, the angle of skeletal convexity decreased with growth, while the soft tissue convexity increased with growth when compared with normal subjects.
6. Describing the skeletal dysplasia that might accompany the Class II division 1 malocclusion as a "skeletal Class II" is of limited diagnostic value and does not help in treatment planning. This is because of the presence of a broad range of skeletal as well as dental maxillary/mandibular relationships.

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