Changes in overbite and face height from 5 to 45 years of age in normal subjects

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As orthodontists, we are interested in understanding how the face changes from its embryologic form through childhood, adolescence, and adulthood. Of particular interest is an understanding of where growth occurs, in which direction, and how much growth remains in a person who might need orthodontic treatment.

Numerous investigators have described and quantified bodily and facial growth changes at various periods.[1-10] It is generally accepted that growth of various parts of the head neither proceeds at the same rate nor follows the same pattern.[11-12] Meredith[13] found that, on average, indices of upper face depth to upper face width remain practically constant (73%) throughout childhood (between 5 and 11 years), but that this average constancy does not occur in everyone. On the other hand, the corresponding indices for the lower face increase from 80% at age 5 to 82%

Abstract

The purpose of this study was to evaluate changes in overbite over a 40-year span, and to relate these changes to those occurring in vertical skeletal facial relationships. Lateral cephalograms of 20 males and 15 females from the Iowa Facial Growth Study were evaluated at ages 5, 10, 15, 25, and 45 years. Correlation coefficients were computed to determine the relationship between overbite and various skeletal parameters. Analysis of variance and Duncan's multiple-range test were used to compare various periods of growth. Statistical significance was predetermined at the 0.05 level of confidence. No significant correlations were found between the absolute values of overbite and the vertical skeletal parameters in either males or females. Incremental changes in overbite during four growth periods were compared with changes in various vertical parameters and only a few significant correlations were found. In males, the change in overbite was significantly correlated with changes in N-Ans'/N-Me and MP:SN during the 10-to-15-year growth period. In females, the change in overbite was significantly correlated with changes in N-Ans'/N-Me% during the 5-to-10-year period and also with change in Ar'-Go/S-Go% during the 15-to-25-year period. In general, changes in overbite with age are difficult to predict from the initial overbite in the deciduous or mixed dentitions. On the other hand, evaluation of individual curves shows that males who initially had the least amount of overbite maintained that trend during the later stages of development. Although overbite changes were significantly associated with changes in some vertical skeletal parameters, the associations were not of clinical significance for predictive purposes, and overbite changes are probably dependent on concurrent changes in the growth of the alveolar processes.

Key Words

Overbite • Vertical skeletal • Cephalometric • Longitudinal • Normal

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Figure 1
Landmarks used

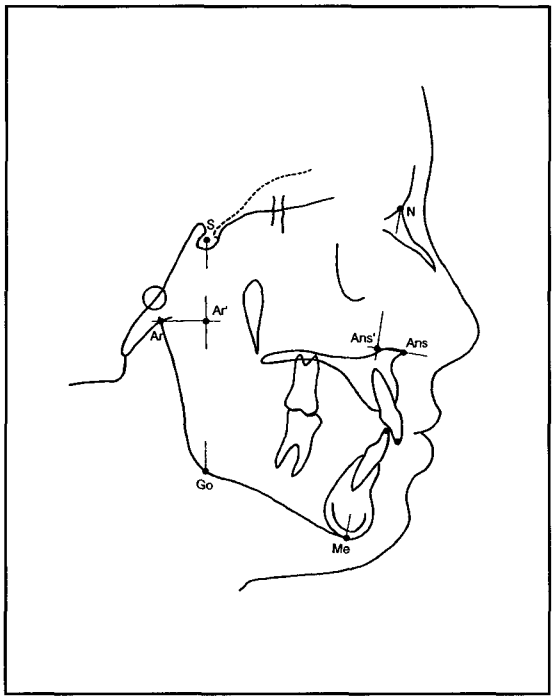

Figure 1

at age 11.

Vertical changes in the face between childhood and early adulthood have been quantified on a longitudinal basis in both normal,[14,15] and extreme facial types.[16]

Snodell et al.[17] evaluated longitudinal normal growth changes in the transverse and vertical dimensions between 4 and 20 years of age and found that vertical growth is much greater than transverse growth. The increase in vertical dimensions ranged from 32% to 40% in males and 19% to 20% in females. The corresponding changes in the transverse dimension ranged from 18% to 27% in males and 13% to 25% in females.

Moorrees[18] evaluated changes in overbite from the deciduous to the permanent dentition. He observed that the amount of overbite in the permanent dentition is not closely related to the amount of overbite in the deciduous dentition for any individual. Furthermore, examination of dental casts failed to reveal an explanation for either the increase or decrease in overbite. Very few studies presented information concerning changes in the dental and facial parameters past the age of 17 or 18 years. Behrents[19] evaluated changes between 25 and 55 years and found no significant changes in the overbite. Bishara et al.[20,21] discussed the changes that occurred in the face between the ages of 5 and 25 years as well as between 25 and 45 years and found a significant increase in overbite in females but not in males between 25 and 45 years of age.

A limited number of longitudinal studies evaluate changes at later stages of maturation, perhaps because such data are difficult to collect and because it is generally thought that facial growth is almost complete by late adolescence. On the other hand, Behrents,[19] Bishara et al.,[21] and Björk[22] have all indicated that a number of facial parameters continue to change past the age of 20 years. Consequently, a better understanding of the normal changes that occur in overbite and the facial skeletal vertical parameters over a prolonged period of time may help elucidate this important clinical dimension.

The purpose of this study was to evaluate and correlate changes in overbite with changes in vertical facial relationships between 5 and 45 years of age. The changes between these ages were arbitrarily divided into four growth periods (GPs): 5 to 10 years (GP I), 10 to 15 (GP II), 15 to 25 years (GP III) and 25 to 45 years (GP IV). These periods correspond roughly to those associated with "early" and "adolescent" treatment as well as to early and late "adult" treatment.

Materials and methods

Subjects

The Iowa Facial Growth Study was started in 1946 by Drs. V. Meredith and L. Higley. Eighty-nine boys and 86 girls "not younger than 3 years" were originally enrolled. Records were taken semiannually until age 12, annually during adolescence, and once during early adulthood.[2,3] Twenty years later, in midadulthood, 16 female and 15 male subjects were located in different parts of the country and they agreed to report for a follow-up examination. The subjects were predominantly of northern European descent, and, at the beginning of the study, were living in or near Iowa City, Iowa. Most were from families of "above average socioeconomic status."[3,4] All subjects used for this investigation had clinically acceptable facial skeletal features and occlusion—that is, Class I molar and canine relationships, anterior crowding of less than 3.0 mm at the time of eruption of the second permanent molars, no congenitally missing teeth or other anomalies, and none had undergone orthodontic therapy. Each subject had a complete set of records at 5, 10, 15, 25, and 45 years of age.

These selection criteria limited the number of people included in the study. On the other hand, the resulting data is purely longitudinal. With mixed longitudinal data, an increase or decrease in the number of persons included at different ages will cause the mean values and standard deviations to fluctuate between consecutive ages. Such variation is not an age-related change in either the size or the relationship of the parameters

Table 1
Descriptive statistics for incremental changes in the various parameters evaluated during four periods of growth–GP I (5 to 10 years), GP II (10 to 15 years), GP III (15 to 25 years), and GP IV (25-45 years)

Parameter	Sex	Change in GP I $\bar{x}$	SD	%	Change in GP II $\bar{x}$	SD	%	Change in GP III $\bar{x}$	SD	%	Change in GP IV $\bar{x}$	SD	%*
Overbite (mm)	M	2.1	1.2	88	0.3	1.3	12	-0.4	0.7	-17	0.4	1.0	17
	F	1.4	1.7	52	0.0	0.8	0	0.3	0.8	11	1.0	0.5	37
Anterior face heights													
N-Ans' (mm)	M	7.2	2.6	45	5.8	1.6	36	2.4	1.2	15	0.6	0.9	4
	F	6.2	1.4	54	3.5	1.2	31	0.9	0.6	8	0.8	0.8	7
N-Me (mm)	M	12.6	6.4	40	11.6	2.9	36	5.6	2.1	18	2.0	1.4	6
	F	10.5	2.9	44	8.2	2.2	34	3.2	1.2	14	1.8	1.0	8
N-Ans' (%)	M	2.5	3.1	156	-0.6	0.9	-38	-0.1	0.7	-6	-0.2	0.6	-12
N-Me	F	1.7	0.8	131	0.0	1.0	0	-0.5	0.3	-38	0.1	0.6	7
Posterior face heights													
Ar-Go (mm)	M	5.6	3.8	26	7.6	2.5	35	7.2	3.4	33	1.3	1.8	6
	F	4.1	1.4	33	5.3	1.9	43	2.2	1.3	18	0.8	1.2	6
S-Go (mm)	M	10.1	4.6	33	10.6	2.5	34	8.3	3.4	27	2.0	1.3	6
	F	8.4	1.7	42	7.4	1.7	38	2.7	1.2	14	1.2	1.2	6
Ar-Go (%)	M	-1.6	2.0	-133	0.9	1.7	75	1.9	1.5	158	0.0	1.2	0
S-Go	F	-2.1	1.8	-140	0.1	1.0	7	0.5	1.0	33	0.0	1.1	0
Anteroposterior face heights													
S-Go (%)	M	1.7	1.8	21	2.4	1.3	30	3.6	2.5	44	0.4	1.0	5
N-Me	F	1.7	2.0	44	1.7	0.9	43	0.5	1.0	13	0.0	1.2	0
MP-SN (º)	M	-1.4	3.0	-21	-2.3	1.7	-34	-3.0	2.3	-45	0.0	0.9	0
	F	-1.8	.8	-58	-1.7	1.3	-55	0.1	0.9	3	0.3	1.3	10

$\bar{x}$ = mean; SD = standard deviation
GP I = Changes between 5 and 10 years
GP II = Changes between 10 and 15 years
GP III = Changes period between 15 and 25 years
GP IV = Changes period between 25 and 45 years

* Percentage change in the growth period in relation to the total change between 4 and 45 years of age.

measured. The cause of such random variation can be eliminated by examining those subjects for whom complete sets of data are available. Of the original 175 children enrolled in the study, 20 males and 15 females had complete records up to young adulthood (25 years) and only 15 males and 15 females presented themselves at midadulthood (45 years).

Landmarks and measurements

The following landmarks were identified on each cephalogram (Figure 1): sella turcica (S); nasion (N); menton (Me); anterior nasal spine (Ans); anterior nasal spine prime (Ans'), which is the point at which a perpendicular from Ans intersects N-Me; gonion (Go); articulare (Ar); and articulare prime (Ar'), which is the point at which a perpendicular from articulare intersects S-Go. The definitions of the various landmarks have been published elsewhere.[23,24] From these landmarks, various linear and angular measurements have been derived, including:

1. Overbite
2. Anterior face heights: N-Ans', N-Me and N-Ans'/N-Me
3. Posterior face heights: Ar'-Go, S-Go, and Ar'-Go/S-Go
4. Anterior to posterior face: S-Go/N-Me, and MP-SN.

The selection of these variables was based on the fact that they are used by orthodontists to evaluate vertical skeletal and dental relationships before, during, and after orthodontic treatment. All linear measurements were multiplied by the appropriate magnification factors and actual sizes are reported in the tables.

Reliability

The landmarks on each cephalogram were located by one investigator and checked by another. When possible, all the cephalograms belonging to an individual subject were located at the same sitting. Two investigators independently measured each parameter on each

Table 2
Results of paired *t*-tests comparing changes between different periods of growth for each of the parameters evaluated

Variable	Sex	GP I vs. GP II	GP II vs. GP III	GP III vs. GP IV
Overbite	M	S	S	NS
	F	S	NS	S
Anterior face heights				
N-Ans'	M	S	S	S
	F	S	S	S
N-Me	M	NS	S	S
	F	S	S	S
A-Ans'/N-Me	M	S	NS	NS
	F	S	NS	NS
Posterior face heights				
Ar-Go	M	NS	NS	S
	F	NS	S	S
S-Go	M	NS	NS	S
	F	NS	S	S
Ar-Go/S-Go	M	S	NS	NS
	F	S	NS	NS
Anterior-posterior face heights				
S-Go/N-Me	M	NS	NS	NS
	F	NS	S	NS
MP-SN	M	NS	NS	NS
	F	NS	S	NS

S = Significant at the 0.05 level of confidence. NS = Not significant
GP I = Changes between 5 and 10 years
GP II = Changes between 10 and 15 years
GP III = Changes period between 15 and 25 years
GP IV = Changes period between 25 and 45 years

cephalogram twice. Permissible intra- and interinvestigator disagreements were predetermined at 0.5° and 0.5 mm.

Statistics

The descriptive statistics for the absolute dimensions of each parameter at 5, 10, 15, 25, and 45 years were calculated, as were the incremental changes during various growth periods: 5 to 10 years (GP I); 10 to 15 years (GP II); 15 to 25 years (GP III); and, 25 to 45 years of age (GP IV).

Correlation coefficients (r) were performed to determine the relationship between overbite and the various vertical skeletal parameters in both males and females. Paired t-tests were used to compare the changes between the various periods of growth for each parameter.[25] The level of statistical significance was predetermined at the 0.05 level of confidence.

Results

The descriptive statistics for changes in the parameters evaluated at each developmental stage for both males and females are presented in Table 1. Comparisons between various stages are presented in Table 2.

Changes in overbite (Figure 2): Most of the significant increases in overbite occurred in GP I, i.e., between 5 and 10 years in both males ($\bar{x}$= 2.1 ± 1.2), and females ($\bar{x}$=1.4 ± 1.7 mm). The changes in the other periods of growth were relatively smaller in magnitude.

Changes in anterior face height (Figure 3): The increase in upper face height (N-Ans') was significantly greater in GP I in both males and females, while there were relatively larger increases in lower face height (Ans'-Me) in the subsequent periods of growth. As a result, there was an increase in the ratio of anterior face height (N-Ans'/N-Me) in GP I in both males and females. The ratio then decreased slightly in the subsequent growth periods (Table 1).

Changes in posterior face height (Figure 4): In males, the magnitude of the increases in posterior face heights (Ar'-Go and S-Go) were not significantly different in the first three growth periods (GPs I, II, and III). In females, however, there was a significantly greater increase in these parameters only in the first two periods of growth, GP I and II.

The changes in the ratio of posterior face height (Ar'-Go/S-Go) were similar in males and females; that is, the ratio decreased in GP I and increased in GP II and GP III.

Changes in anteroposterior face heights (Figures 5 and 6): The ratio of S-Go/N-Me and the SN:MP angle described similar changes in males and females during GP I and II. During GP III, males changed the most and females the least.

Changes between 25 and 45 years of age (GP IV): There were significant but relatively small changes in all vertical linear dimensions of face heights between 25 and 45 years of age. The changes did not significantly alter the various ratios of face heights.

Correlation coefficients (r) of the absolute values: The absolute values of overbite were correlated with each of the eight cephalometric measures of vertical relationships at the various ages, namely: 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 25, and 45 years. The results indicated the absence of significant correlations ($p > 0.05$) between overbite and these parameters in both males and females.

Correlation coefficients (r) of the incremental values: The changes in overbite during each of the four growth periods (GP I to IV) were correlated with the changes in various vertical skeletal parameters. The results indicated that only

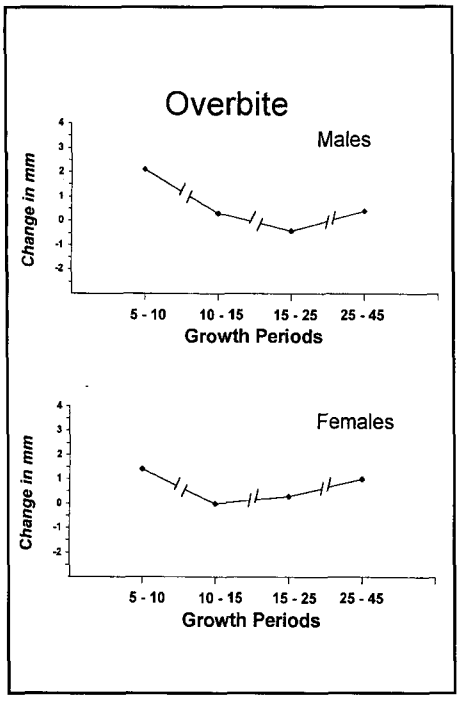

Figure 2

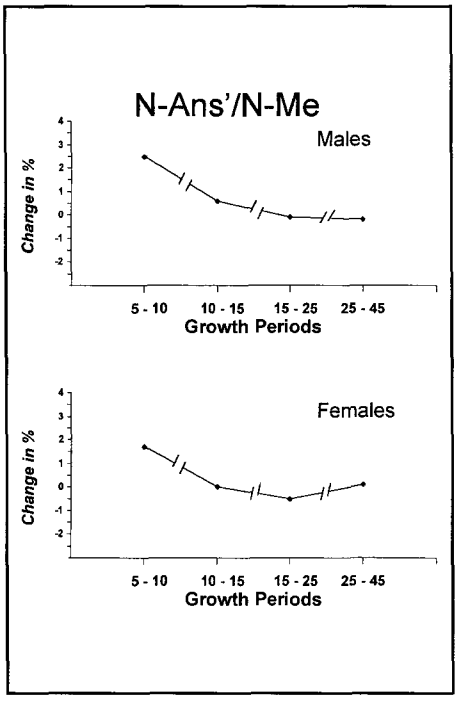

Figure 3

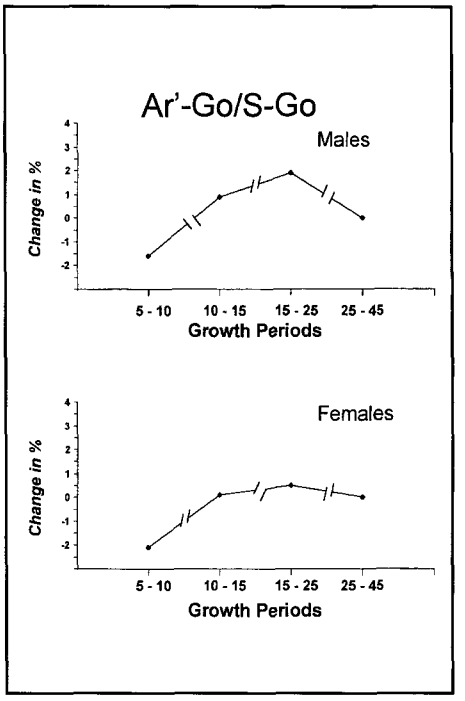

Figure 4

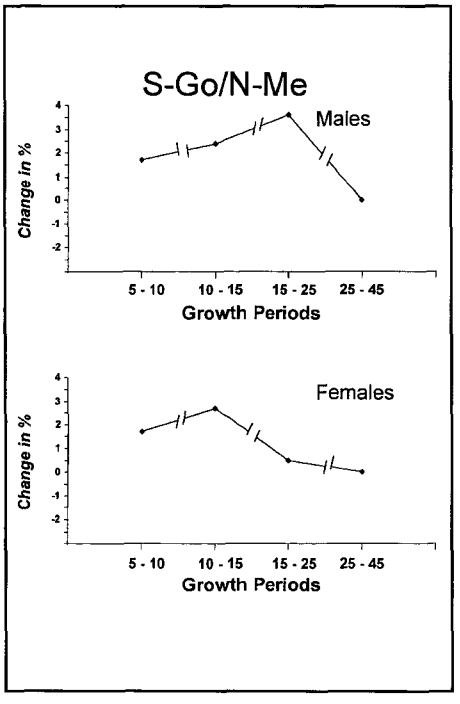

Figure 5

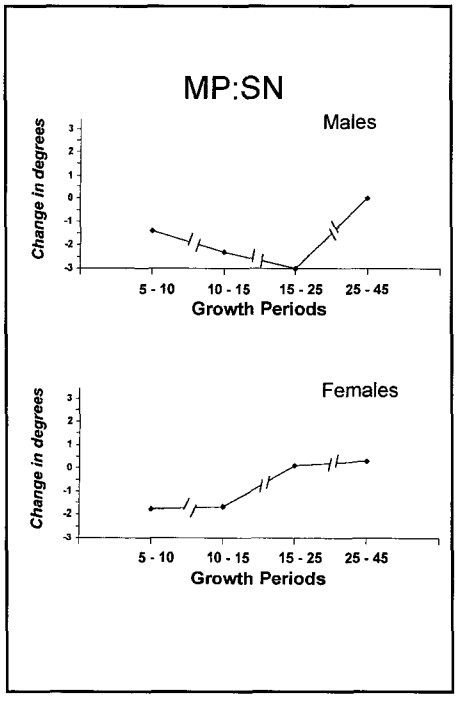

Figure 6

Figure 2
Incremental changes in overbite at different periods of growth

Figure 3
Incremental changes in the ratio of anterior face heights during different periods of growth

Figure 4
Incremental changes in the ratio of posterior face heights during different periods of growth

Figure 5
Incremental changes in the ratio of posterior to anterior face height during different periods of growth

Figure 6
Incremental changes in the MP:SN angle during different periods of growth

a few significant correlations were present. Specifically, in males, the changes in overbite were significantly correlated with changes in N-Ans'/N-Me (r = 0.6749, p = 0.0011) and MP:SN (r = 0.469, p = 0.0369) in GP II. In females, the changes in overbite were significantly correlated with the changes in N-Ans'/N-Me% at GP I (r = 0.5554, p = 0.0316) and to the changes in Ar'-Go/S-Go% at GP III (r = 0.5301, p = 0.0421).

Magnitude of changes in overbite vs. corresponding skeletal changes: In order to determine whether the magnitude of change in overbite is influenced by the skeletal vertical changes, male and female subjects were divided into two groups according to the total change in overbite. In one group the overbite change from 5 to 45 years was 2.0 mm or greater, while in the second group the total overbite change was less than 2.0 mm. The various dentofacial parameters

Table 3
Change from 25 to 45 years

		$\bar{x}$	SD	*p*	
Overbite	M	0.4	1.0	0.1635	NS
	F	1.0	0.5	0.0001	S**
N-Ans'	M	0.6	0.9	0.0181	S*
	F	0.8	0.8	0.0007	S**
N-Me	M	2.0	1.4	0.0001	S**
	F	1.8	1.0	0.0001	S**
N-Ans'/NMe	M	-0.2	0.6	0.2956	NS
	F	0.1	0.6	0.2810	NS
Ar'-Go	M	1.3	1.8	0.0146	S*
	F	0.8	1.2	0.0273	S*
S-Go	M	2.0	1.3	0.0001	S**
	F	1.2	1.2	0.0011	S**
Ar'-Go/S-Go	M	0.0	1.2	0.9414	NS
	F	0.0	1.1	0.9175	NS
S-Go/N-Me	M	0.4	1.0	0.1391	NS
	F	0.0	1.2	0.9119	NS
MP:SN	M	0.0	0.9	0.9670	NS
	F	0.3	1.3	0.3124	NS
MP:FH	M	0.9	4.3	0.4246	NS
	F	0.2	2.6	0.7259	NS

$\bar{x}$ = mean; SD = standard deviation
p = probability; S* = significant ≤0.05; S** = significant ≤0.01
NS = not significant
M = males; F = females

for the two groups were compared using Student *t*-tests at each of the four growth periods. The only parameter that was significantly different between the two groups was overbite ($p = 0.0173$). In other words, in both males and females, there were no significant differences in any of the skeletal vertical parameters between the groups with the most and least changes in overbite.

Discussion

Orthodontists are interested in learning about the growth of the various parts of the face, not only where growth occurs but also when it occurs or ceases to occur. Traditionally, the emphasis was on periods of maximum growth changes, i.e., the adolescent years. More recently, the number of adults undergoing orthodontic treatment has increased significantly, and so it has become important to also evaluate the changes that occur in the face during later periods of growth.

The findings from the present investigation indicate that the greatest increase in overbite occurs during the transition from the deciduous to the permanent dentitions, i.e., in the mixed dentition. Changes still occurred in the subsequent periods of growth, but were essentially of smaller magnitude and not statistically significant. Comparisons of vertical skeletal changes between the four growth periods indicated that, in females, most of the changes occurred in GP I, whereas in males the changes were more evenly distributed over two or three growth periods.

Correlations between overbite and other skeletal vertical parameters: Only a few correlations were significant between the incremental changes in overbite and the other skeletal parameters evaluated, but all the correlations were below 0.7. According to Horowitz and Hixon,[26] correlation coefficients of less than 0.7 or 0.8 are of dubious predictive value, particularly when applied to the clinical situation of an individual patient.

Although it is important for clinicians to be aware of the average changes, it is also important to realize that the normal changes in overbite with age cannot be accurately predicted from the changes in the vertical skeletal parameters. The correlation coefficients (*r*) were low even when the associations were significant ($p \leq .05$).

Individual variation in overbite changes (Figures 7A-C): In an attempt to better explain the changes in overbite from childhood to adulthood, individual curves were evaluated. Male and female curves were divided according to the magnitude of the overbite in the deciduous dentition into three groups, least overbite (≤0.7 mm), average overbite (0.8 to 1.3 mm), and most overbite (>1.7 mm) in males. The corresponding values in females were <0.8, 1.1 to 1.9, and ≥2.4 mm, respectively.

In the majority of the cases (33 out of 35 cases), overbite increased from the deciduous to the mixed dentition. Following the mixed dentition stage, there was no consistent pattern in the changes in overbite with age, i.e., the overbite tended to either increase, decrease, or exhibit little change (Figures 7A-C).

In another attempt to evaluate these individual trends, the severity of overbite at 25 years of age was used to subdivide the sample into least overbite (≤2.4 mm), average overbite (2.6 to 3.9 mm), and most overbite (≥4.0 mm) and retrospectively determine the variation in the original overbite (Figures 8A-C). Again, there was no consistent pattern of change, with one interesting exception: Males who ended with the least amount of overbite also had minimal overbite in the deciduous

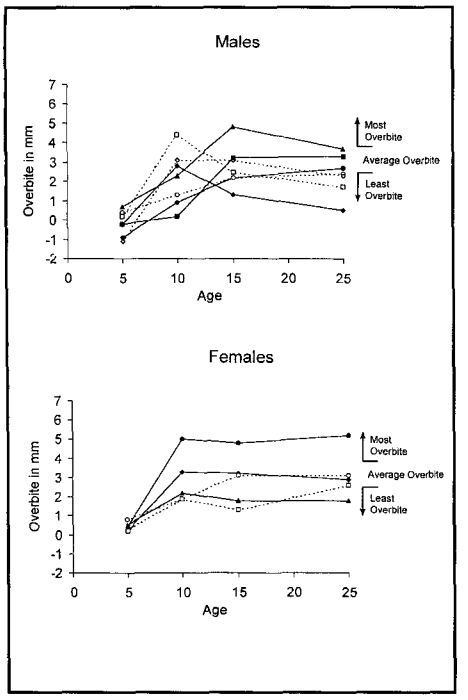

Figure 7A

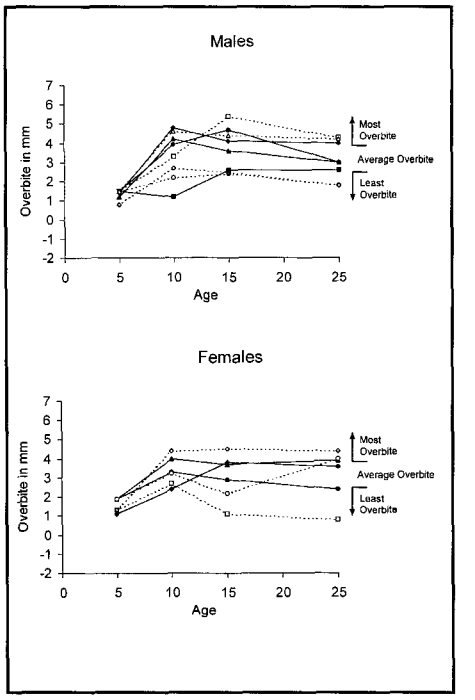

Figure 7B

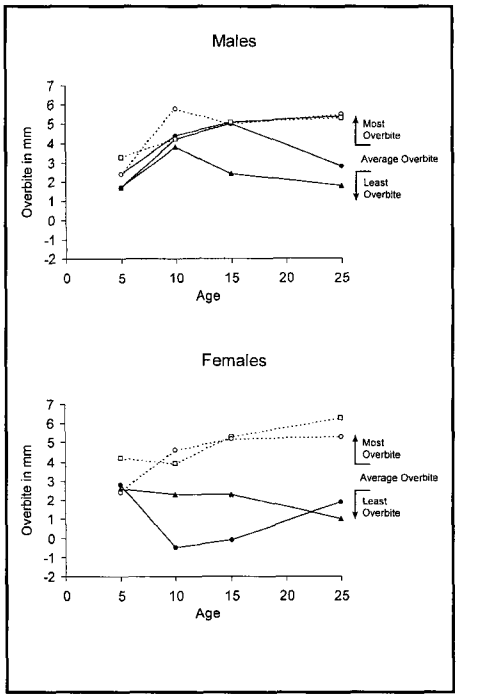

Figure 7C

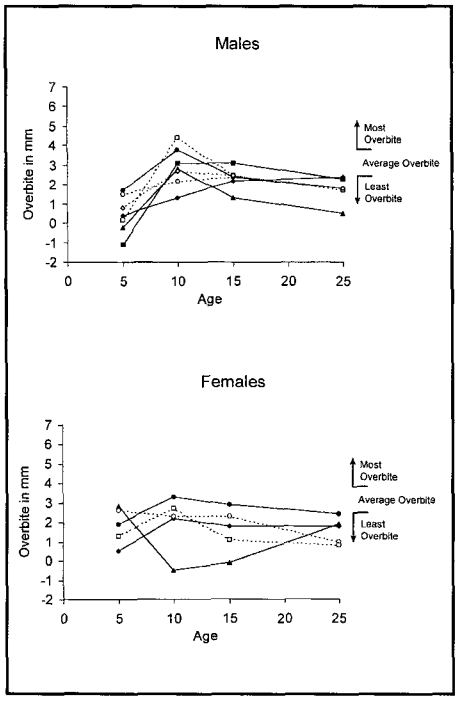

Figure 8A

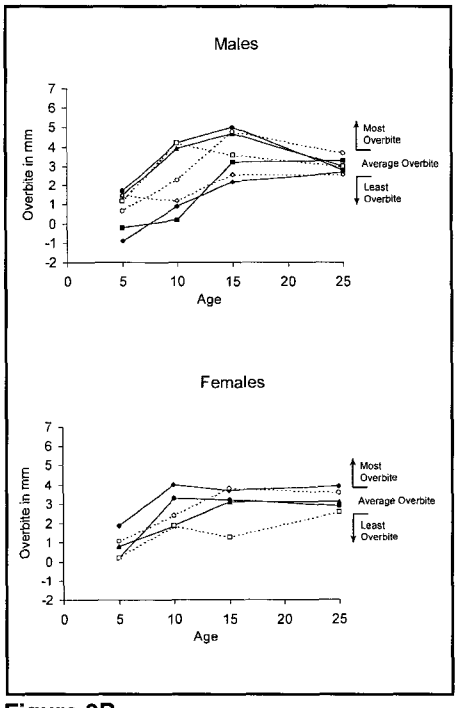

Figure 8B

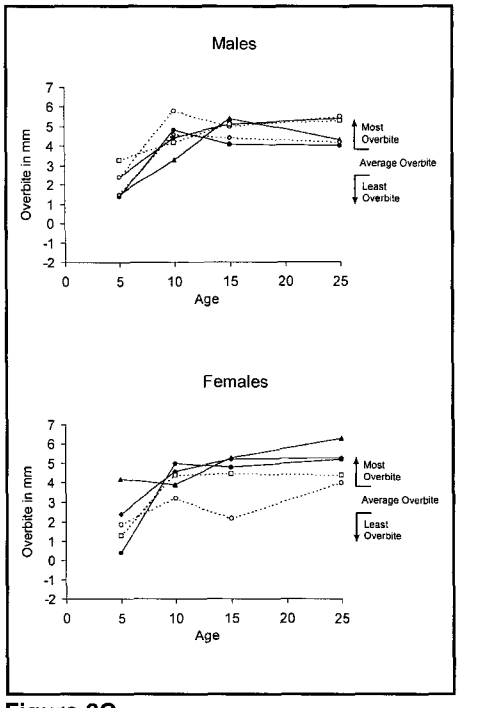

Figure 8C

Figure 7A
Changes in overbite from 5 to 20 years of age in males and females with the least overbite in the deciduous dentition

Figure 7B
Changes in overbite from 5 to 20 years of age in males and females with average overbite in the deciduous dentition

Figure 7C
Changes in overbite from 5 to 20 years of age in males and females with the most overbite in the deciduous dentition

Figure 8A
Changes in overbite from 5 to 25 years of age in males and females with the least overbite in the permanent dentition

Figure 8B
Changes in overbite from 5 to 25 years of age in males and females with average overbite in the permanent dentition

Figure 8C
Changes in overbite from 5 to 25 years of age in males and females with the most overbite in the permanent dentition

dentition (Figure 8A).

The present findings indicate that, in general, changes in overbite with age are difficult to predict from the initial overbite in the deciduous or mixed dentition. On the other hand, evaluation of the individual curves illustrated that, in males, those individuals who initially had the least overbite maintained that trend at the later stages of development.

Conclusions

The findings from this study indicate that although there are statistically significant correlations between changes in overbite and changes in face heights, the correlations are low and not clinically useful for predictive purposes.

As a result, it seems that normal growth changes in the skeletal vertical parameters do not play a clinically significant role in determining the amount of overbite for an individual. Other factors, such as growth of the alveolar processes, might also influence changes in overbite.

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