Original Article

Craniofacial growth of Class III subjects six to sixteen years of age

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ABSTRACT

Objective: To characterize the mixed-longitudinal craniofacial growth of untreated, white, Class III subjects 6 to 16 years of age.

Materials and Methods: Serial cephalograms of 19 females and 23 males with Class III malocclusion were evaluated at three time points (6–8, 10–12, and 14–16 years of age). A similar number of Class I controls were randomly selected and matched for age and sex. The cephalograms were traced and digitized, and 20 variables were evaluated. Growth patterns were quantified, and class and sex differences were evaluated using multi-level analyses.

Results: In comparison with Class I subjects, Class III subjects had significantly ($P \leq .05$) larger mandibular plane angles, gonial angles, mandibular ramus heights, mandibular corpus lengths, and SNB angles, with differences that were maintained between 6 and 16 years of age. Maxillary lengths and ANB angles were significantly smaller and remained smaller in Class III subjects than in Class I subjects. Lower face height, maxillary-mandibular differential, and mandibular body length were also significantly larger and increased significantly more between 6 and 16 years of age in Class III subjects. The WITS appraisal was significantly smaller in Class III subjects and decreased significantly more over time. Most linear measures showed significant sex differences favoring males; the angular measures and anteroposterior (AP) maxillomandibular relationships showed no sex differences.

Conclusions: The AP maxillomandibular relationship of Class III subjects worsens over time. AP discrepancies are primarily due to excessive mandibular growth, which produces a protrusive, hyperdivergent phenotype. The AP discrepancies of males are larger than those of females, with differences increasing over time. (*Angle Orthod.* 2011;81:211–216.)

KEY WORDS: Class III; Cephalometrics; Whites; Growth

INTRODUCTION

Since 1737, when Bourdet first described the skeletal pattern of children with protruding chins, Class III malocclusions have been characterized in various ways. Angle[1] defined Class III malocclusion as "the relation of the jaws with all the lower teeth occluding mesial to normal the width of one premolar or even more in extreme cases." Regardless of the definition used, the orthodontist's understanding of how untreated Class III whites grow has been limited by the low prevalence of Class III malocclusions and the tendency to treat subjects at a younger age. The prevalence of Class III malocclusion has been reported[2,3] to range between 1.6% and 12.2%. National health surveys[4,5] have shown that 4.9% of white children between 6 and 11 years of age and 6% of youths between 12 and 17 years of age display a bilateral mesiocclusion. Using negative overjet to classify Class III subjects, more recent surveys[6,7] indicate a 1–4% prevalence of Class III malocclusion among North Americans.

Previous cross-sectional cephalometric characterizations have shown that when compared to Class I whites, Class III subjects have substantially smaller ANB angles,[8–11] slightly smaller SNA angles,[8,10,12,13] and substantially larger SNB angles.[8,10,11,13] The saddle and cranial base flexure angles have also been shown to be more acute among Class III subjects;[9,14–16] a lack of differences in cranial base angles has also been

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reported.[8,11,13] Similarly, MacDonald and coworkers[16] found no significant differences between Class III and Class I malocclusions for either the SNA angle or the maxillary depth. Larger mandibular dimensions have commonly been cited[8,10,13] as the predominant characteristic in the Class III subject.

While serial data are required to determine actual growth differences associated with untreated Class III malocclusions, relatively few longitudinal studies have been conducted. Baccetti et al.,[17] who evaluated 22 white Class III subjects at two time points, showed that maxillomandibular relationships worsen over time. However, because of the lack of untreated controls, they were not able to determine growth deficiencies or excesses of the craniofacial components. Alexander et al.,[18] who described the longitudinal growth between 4 and 20 years of age of 103 Class III whites, also showed definite worsening of anteroposterior (AP) skeletal relationships, but they were also unable to characterize the differences, again as a result of the lack of controls.

In order to better understand the development of skeletal differences among Class III subjects, this study was designed to evaluate the growth of Class III and matched Class I subjects between 6 and 16 years of age.

MATERIALS AND METHODS

Serial cephalometric radiographs were selected from the Bolton-Brush Growth Study Center in Cleveland, Ohio; these radiographs represented white children aged 6–8, 10–12, and 14–16 years of age. Forty-two Class III subjects were selected based on their molar relationships, as determined by the Bolton-Brush Growth Study. Forty age-group and sex-matched Class I controls were randomly selected from the same sample. The subjects were classified as Class III or Class I during the early permanent dentition, based on clinical observations and dental models. Subjects with cleft lip, cleft palate, and other craniofacial syndromes were excluded. The sample was mixed longitudinal; all of the subjects had records at two of the three age groupings; 34% of the sample had complete longitudinal series comprising three records.

Cephalometric Tracing and Analysis

Lateral head films were traced on 0.003-inch frosted acetate. Each film was traced by one investigator and checked for accuracy by one of two investigators. Ten percent of the films were randomly chosen and retraced to assess reliability. All films were then digitized with a Numonics Accugrid Digitizer (Numonics Corp, Montgomeryville, Penn) and analyzed with the Dentofacial Planner software program, version 7.0.2 (Toronto, Ontario, Canada). Sixteen landmarks were identified and digitized. The magnification (approximately 6%) was not corrected.

Cephalometric measures were derived from the analyses of Jarabak and Fizzel,[19] Jacobson,[20] McNamara,[21] and Steiner[22]; they represent a variety of AP and vertical measurements reported to be significant in Class III development.

Statistical Analysis

Data were analyzed using multi-level statistical models.[23] Multi-level statistical analysis does not make the assumption of complete longitudinal data, nor does it require exact intervals between age groups, making it well suited for this mixed-longitudinal study. Growth curves were described as polynomials and estimated using iterative generalized least squares. The regressions consisted of intercept (size) and age (growth velocity at 11 years of age) terms. To center the intercept, 11 was subtracted from the subjects' ages (ie, ages 7, 11, and 15 were changes to −4, 0, and 4, respectively). Separate analyses were performed to evaluate class and sex differences.

Each multi-level model estimated the constant and age terms, as well as group differences in the constant and age terms. The models' constant terms described the size or the angle of either Class I malocclusions or females, depending on the analysis, at 11 years of age. The age terms described the yearly growth changes. The multi-level models also estimated group differences (Class III minus Class I; male minus female) for both the constant and age terms.

Reliability analysis was performed using the Dahlberg method's error statistic [$\sqrt{}$ (Σdeviations^2/2n)]. The method errors of the linear measures ranged between 0.74 mm and 2.1 mm, with mid-face length (Co-A) showing the greatest error. Angular measurement method errors ranged between 0.8° and 2.9°, with the cranial base angle (Ba-S-N) showing the greatest error.

RESULTS

The multi-level models showed significant growth changes for all of the variables except the cranial base angle (Ba-S-N), articular angle (S-Ar-Go), and WITS (Table 1). Eleven of the 20 measures (55%) showed statistically significant differences between Class I and Class III malocclusions. Lower face height (ANS-Me), corpus length (Go-Pg), and the maxillomandibular differential (Mx-Md) were significantly larger in 11 year-old Class III subjects and demonstrated significantly greater growth increases over time than Class I subjects (Figure 1). The WITS appraisal was significantly smaller at 11 years and it decreased significantly more between 6–16 years in Class III's than in

Table 1. Multi-level Growth Estimates for Untreated Class I Subjects and Class Differences (Class III − Class I) Between 6 and 16 Years of Age

	Class I Subjects				Class III − Class I Differences			
	Intercept		Age Effects		Intercept		Age Effects	
	At 11 y of Age	Standard Error	Change Over Time	Standard Error	Differences	Standard Error	Differences in Change Over Time	Standard Error
N-Me*	112.58	0.58	2.27	0.07	—	—	—	—
ANS-Me*	63.06	0.72	1.08	0.08	1.64	1.01	0.22	0.10
N-ANS*	50.08	0.28	1.01	0.04	—	—	—	—
N-ANS/ANS-Me*	78.66	0.73	0.18	0.08	—	—	—	—
MPA*	30.84	0.84	−0.31	0.05	2.44	1.14	—	—
S-N*	68.37	0.33	0.80	0.03	—	—	—	—
Ba-S-N	130.10	0.56	−0.08	0.07	—	—	—	—
N-S-Ar*	123.12	0.55	0.17	0.08	—	—	—	—
S-Ar-Go	139.20	0.60	−0.07	0.10	—	—	—	—
Ar-Go-Me*	131.97	0.75	−0.38	0.05	2.23	1.02	—	—
Co-A*	84.09	0.43	1.34	0.06	—	—	—	—
ANS-PNS*	51.17	0.39	0.73	0.05	−1.55	0.53	—	—
Ar-Go*	44.81	0.45	1.18	0.06	1.37	0.59	—	—
Go-Pg*	66.56	0.69	1.56	0.08	2.07	0.97	0.34	0.10
Co-Gn*	108.25	0.75	2.60	0.07	3.91	1.04	—	—
ANB*	3.24	0.36	−0.25	0.03	−2.29	0.49	—	—
SNA*	80.28	0.46	0.10	0.04	—	—	—	—
SNB*	76.92	0.58	0.37	0.04	2.46	0.82	—	—
Mx-Md*	23.50	0.60	1.11	0.09	5.29	0.85	0.25	0.12
WITS*	−0.81	0.35	0.02	0.08	−3.93	0.49	−0.27	0.11

* Significant ($P < .05$) growth changes; — = Not statistically significant; Mx-Md = Co-Gn minus Co-A; Wits = A ⊥ functional occlusal plane minus B ⊥ functional occlusal plane.

Class I's. The mandibular plane angle (MPA), gonial angle (Ar-Go-Me), ramus height (Ar-Go), mandibular length (Co-Gn), and the SNB angle were all significantly larger in the Class III group at 11 years of age; maxillary length (ANS-PNS) and ANB angle were significantly smaller in Class III malocclusions, Figure 2.

The multi-level models showed statistically significant sex differences for eight measures (Table 2). The gonial

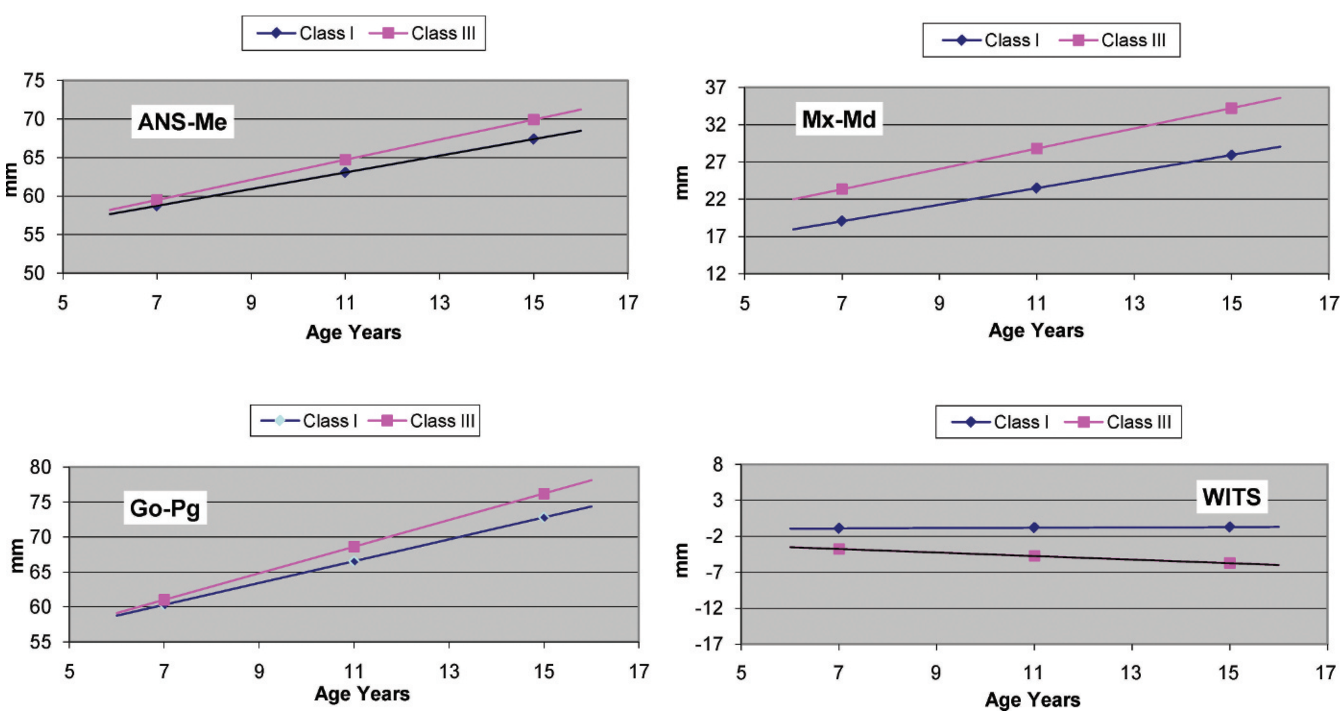

Figure 1. Measures demonstrating significant size differences at 11 years and significant growth differences between Class I subjects and Class III subjects 6–16 years of age.

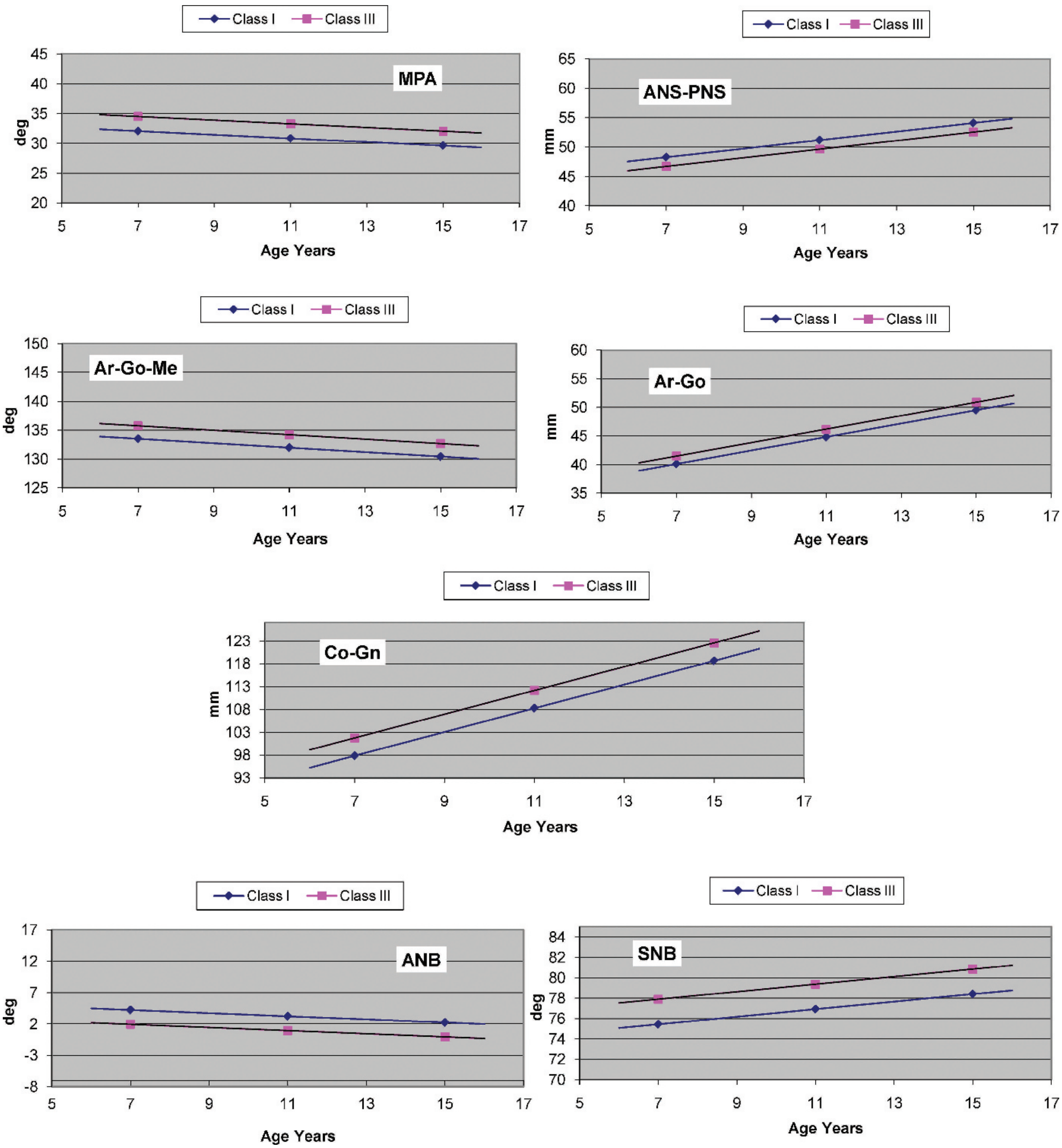

Figure 2. Measures demonstrating significant size differences at 11 years of age between Class I subjects and Class III subjects.

angle (Ar-Go-Me) was significantly greater in males than in females at age 11, with no significant growth differences. Total face height (N-Me), lower face height (ANS-Me), upper face height (N-ANS), anterior cranial base length (S-N), mid-face length (Co-A), mandibular body length (Go-Pg), and mandibular length (Co-Gn) were all significantly larger in males and demonstrated significantly greater growth increases over time compared with females. Mandibular ramus height (Ar-Go) was significantly smaller in 11-year-old males but showed significantly greater increases for males than for females.

Table 2. Multi-level Growth Estimates of Female Growth Changes and Sex Differences (male − females) Between 6 and 16 Years of Age

	Female				Male − Female Differences			
	Intercept		Age Effects		Intercept		Age Effects	
	At 11 y of Age	Standard Error	Change Over Time	Standard Error	Differences	Standard Error	Differences in Change Over Time	Standard Error
N-Me*	111.11	0.81	1.95	0.06	2.98	1.13	0.64	0.12
ANS-Me*	62.56	0.70	1.02	0.07	2.66	0.99	0.35	0.10
N-ANS*	49.81	0.41	0.86	0.06	0.54	0.57	0.28	0.08
N-ANS/ANS-Me*	78.66	0.73	0.18	0.08	—	—	—	—
MPA*	32.08	0.62	−0.31	0.05	—	—	—	—
S-N*	67.95	0.46	0.70	0.04	0.83	0.65	0.20	0.06
Ba-S-N	130.11	0.56	−0.08	0.06	—	—	—	—
N-S-Ar*	123.12	0.55	0.17	0.08	—	—	—	—
S-Ar-Go	139.20	0.60	−0.07	0.10	—	—	—	—
Ar-Go-Me*	133.13	0.57	−0.40	0.05	—	—	—	—
Co-A*	83.13	0.60	1.20	0.09	1.91	0.84	0.30	0.12
ANS-PNS*	50.39	0.29	0.73	0.06	—	—	—	—
Ar-Go*	45.59	0.49	1.03	0.08	−0.12	0.69	0.29	0.12
Go-Pg*	66.56	0.69	1.56	0.08	2.07	0.97	0.34	0.10
Co-Gn*	109.13	0.82	2.34	0.09	2.27	1.15	0.53	0.13
ANB*	2.09	0.29	−0.25	0.03	—	—	—	—
SNA*	80.28	0.46	0.10	0.04	—	—	—	—
SNB*	78.17	0.43	0.37	0.04	—	—	—	—
Mx-Md*	26.17	0.52	1.24	0.06	—	—	—	—
WITS*	−2.79	0.33	−0.13	0.06	—	—	—	—

* Significant ($P < .05$) growth changes; — = Not statistically significant; Mx-Md = Co-Gn minus Co-A; Wits = A ⊥ functional occlusal plane minus B ⊥ functional occlusal plane.

DISCUSSION

AP relationships of Class III subjects clearly worsen between 6 and 16 years of age. Compared to Class I subjects, Class III subjects had smaller ANB and larger SNB angles, as previously reported[9,11,13] for samples evaluated cross sectionally. As expected, the Class III subjects in the present study also exhibited a significantly larger maxillomandibular differential and a smaller WITS differential. Importantly, both of these differentials worsened over time, indicating a worsening of the Class III malocclusion. Decreases in the WITS measures and increases in the maxillomandibular differential have been previously reported[17] for Class III subjects followed longitudinally. The ANB angle in the present study probably did not worsen over time as a result of the greater-than-expected increases in lower facial height exhibited by Class III subjects. Similar increases in lower face height of Class III subjects have been reported[18] between 4 and 20 years in age. It is possible that the ANB angle maintained the same growth rates in Class I subjects and Class III subjects because the anterior movements of point B were masked by the inferior movements of point B. The WITS better represents the true AP changes because it is measured from the occlusal plane and is unaffected by the vertical changes that occur.

In contrast to those of Class I subjects, the mandibles of Class III subjects were more hyperdivergent and substantially larger. The angular differences identified among Class III subjects in the present study, including the increased mandibular plane and larger gonial angles, have been previously well established.[8,10,12] Supporting the present findings, greater ramus heights have been reported[13] for Class III than for Class I subjects. Total mandibular length has also been previously shown[8,9] to be significantly larger in Class III subjects of similar ages. Increased corpus length among Class III subjects compared with Class I subjects has been previously identified by Jacobson and coworkers.[10] The greater growth increases in corpus length identified in the present study have not been previously shown. This indicates that it is the remodeling pattern (ie, a development of a more obtuse gonial angle and increases in corpus length associated with deposition of bone at the lower posterior aspect of the ramus), rather than condylar growth, that is the primary determinant of overall mandibular excess among Class III subjects.

In contrast to their large, prognathic mandibles, the maxillas of the Class III subjects in the present study were orthognathic. MacDonald et al.[16] also showed no significant differences between Class III subjects and Class I subjects for either SNA or maxillary depth. While most other cross-sectional studies[8,10,12,13] have reported maxillary retrusion among Class III subjects, their results tend to be limited and inconsistent. For example, Guyer et al.[8] reported significant differences in the SNA angle between Class I subjects and Class III subjects for three of the four age groups evaluated; Battagel[11] only found differences after all of the group data had been combined; Tollaro et al.[13] did not find significant differences among their 4- and 5-year-old subsamples, but they did report differences for the 6-year-olds and for the entire sample combined. Taken together, the present and previous studies indicate that even though the maxillas of Class III subjects are smaller, maxillary retrusion is relatively mild and represents only a minor contribution to the development of AP discrepancies.

Sex differences, which increased over time, were evident for most of the linear measures. Males were larger than females, and the differences increased with age. These results are consistent with an understanding of craniofacial and somatic growth. Sex differences in maxillary and mandibular growth favoring males have been previously established.[24,25] Sex differences are small during childhood and become pronounced during adolescence, as a result of the two extra years of childhood growth among males as well as the greater intensity of the male adolescent spurt.

CONCLUSIONS

- Maxillomandibular relationships of Class III subjects progressively worsen between 6 and 16 years of age.
- Class III subjects have a somewhat smaller, but not more recessive, maxilla than do Class I subjects; maxillary size differences are established early and maintained through 16 years of age.
- Class III subjects have larger, more protrusive mandibles than Class I subjects, with AP growth excesses that accumulate over time. Class III subjects also have hyperdivergent mandibles and excessive growth of lower facial height.
- Males are larger than females, with size differences increasing between 6 and 16 years of age. There were no significant sex differences in AP maxillomandibular and angular relationships.

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