Components of Class III Malocclusion in Juveniles and Adolescents

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A statistical comparison of cross-sectional cephalometric records of Class III malocclusion subjects from ages 5–15 with serial Class I controls, finding strong tendencies for early appearance of distinctive characteristics.

KEY WORDS: • Cephalometrics • Growth and Development • • Malocclusion, Class III • Prognathism, mandibular •

Little definitive information is available on the dentofacial components of Class III malocclusion, and what has been reported remains controversial. The terms "mandibular prognathism" and "Angle Class III malocclusion" are generally regarded as similar if not synonymous in the dental literature, which has tended to overemphasize the importance of occlusal relationships by using occlusal terms in describing skeletal relationships.

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A Class III malocclusion may often be present in mandibular prognathism, but those occlusal relationships comprise only one part of a much larger syndrome. Similarly, mandibular prognathism may be present in many individuals with Class III malocclusion. Previous investigations have shown that various types of skeletal patterns may exist in those with Class III malocclusion.

Sanborn (1955) found that 45.2% of his class III sample had actual mandibular protrusion, with the maxilla within the normal range of protrusion and the mandible beyond. Maxillary retrusion was present without mandibular prognathism in 33%, 9.5% had both maxillary and mandibular positions within normal range, and 9.5% had a combination of maxillary retrusion and mandibular protrusion.

Dietrich (1970) found that 37.5% of his permanent dentition Class III sample had maxillary retrusion without mandibular prognathism, 31% had mandibular protrusion with normal maxilla, and 24% had both maxilla and mandible within the normal range of prominence. Further, in this Class III sample he also found 6% with both maxillary and mandibular retrusion, and 1.5% with maxillary retrusion combined with mandibular protrusion.

Jacobson et al. (1974) reported on sex differences and differences between child and adult Class III samples. They found the largest percentage of adults with Class III malocclusions (49%) had mandibular protrusion with normal maxillae, 26% had maxillary retrusion with a normal mandible, and 14% normal protrusion of maxilla and mandible.

Ellis and McNamara (1984) found a combination of maxillary retrusion and mandibular protrusion to be the most common skeletal relationships, being present in 30% of their adult Class III subjects. Maxillary retrusion with normal mandibular prominence was found in 19.5%, and normal maxilla with mandibular protrusion in 19.1% of the subjects.

Others have noted differences in the Class III adult population compared to the Class I controls, in both the relative positions of the teeth and jaws and in other skeletal areas such as the cranial base, the morphology of the maxilla and mandible, and vertical dimensions (Hemley 1944, Stapf 1948, Björk 1950, Maj et al. 1958, Pascoe et al. 1960, Alling 1961, Smith and Chambers 1962, Hopkin et al. 1968, Horowitz et al. 1969, Ahlgren 1970, Bimler 1970, Rakosi 1970, Ridell et al. 1971, Droel and Isaacson 1972 and Rakosi and Schilli 1981).

One area which has not received much attention is the skeletal relationships at the time when a Class III malocclusion first becomes apparent.

Does a young child with a Class III deciduous dentition have a different skeletal pattern than one with a Class I dentition? Does the skeleton in a Class III child grow differently than that of a Class I child? Are the typical skeletal and dental characteristics of an adult with a class III malocclusion already present in the growing child?

Dietrich (1970) divided a sample of patients who had negative A–N–B angles into three maturation levels based on tooth eruption. Deciduous, mixed, and permanent dentition Class III samples were compared to Class I subjects of corresponding maturation levels. The results showed that almost half of the deciduous dentition sample had neutral maxillary and mandibular positions, whereas only one-fourth of the mixed dentition and permanent dentition samples presented neutral relationships. This indicates that the skeletal aberrations grew worse with time.

Incidence of mandibular protrusion increased with age from 23% in the deciduous dentition and 20% in the mixed dentition sample to 34% in the permanent dentition sample. Maxillary retrusion was present in 26% of the deciduous dentition sample, 44% of the mixed dentition sample, and 37% of the permanent dentition sample.

Although the results of Dietrich's study indicate that skeletal changes occur in different dentition levels, the results are difficult to interpret because his criterion for inclusion of a subject in the study was a negative A–N–B angle, rather than tooth relationships. This has the effect of preselecting subjects with skeletal aberrations while probably excluding some Class III malocclusions.

Jacobson et al. (1974) conducted a similar study using the presence of a Class III dental relationship as the criterion for selection of a "Class III" subject. No skeletal criteria were used. The subjects were subdivided into adult and child samples, with the child sample ranging from 6 to 16 years. There was no further subdivision of this sample into smaller age groups. Comparisons were made with Class I samples of similar ages. More than half of this child sample presented normal maxillary and mandibular positions, which were much less common in the adult sample.

They also found mandibular protrusion in many more adults than in the children, indicating a change in craniofacial morphology from childhood to adulthood, but it was impossible from this study to determine exactly when this change occurred. They found these differences to be primarily due to mandibular morphology.

The purpose of this study is twofold. *The first* is to compare the skeletal and dental characteristics of subjects with Class III and Class I malocclusion in four consecutive developmental age groups. Admittedly, the most suitable design for a study of this nature would be to follow individuals longitudinally through development. However, this was not possible for the Class III sample; only the Class I norms are based on individuals who were followed longitudinally through time.

The second purpose of this study is to evaluate the skeletal variability among Class III subjects in each of four developmental age groups.

— Materials and Methods —

The sole anatomic criterion for inclusion of a subject in this study sample was the presence of a Class III molar relationship as determined from a lateral cephalograph.

The sample included males and females in selected age brackets between 5 and 15 years of age, without cleft palate or craniofacial syndrome, selected from eleven private orthodontic practices. Records of 30 individuals with Class III malocclusion whose ages did not fall within the ranges selected for study were not included. Lateral cephalographs of 144 Class III children were used in the final study sample.

Each film was traced by one investigator and checked by a second to verify the accuracy of anatomic structures and landmark placement. Landmarks were then digitized in an X-Y coordinate system by a single operator at the Center for Human Growth and Development, the University of Michigan. Radiographic enlargement was standardized at 8% by computer.

The control sample of Class I individuals with well-balanced faces (Bolton Standard Faces) was derived from the Bolton-Brush Growth Study at Case Western Reserve University (Broadbent et al. 1975). Records were available on 16 males and 16 females who had been radiographed annually. The films were retraced and digitized in a manner similar to that used for the Class III sample.

Measures of craniofacial structural relationships were divided into several categories for analysis; cranial base, maxillary skeletal, mandibular skeletal, intermaxillary, dentoalveolar, and vertical facial relationships. The measures used were standard cephalometric measures adopted from the analyses of Downs (1948, 1952 and 1956), Steiner (1953, 1959 and 1960), Riedel (1952 and 1957), Tweed (1953 and 1954), Ricketts (1960, 1972 and 1981), and McNamara (1983 and 1984).

The two samples were divided into four age groups prior to analysis; from 5yr 0mo to 7yr 0mo (5–7), 8yr 0mo to 10yr 0mo (8–10), 11yr 0mo to 13yr 0mo (11–13), and 13yr 1mo to 15yr 0mo (13–15). The sample sizes and sex distribution are shown in Table 1.

The cephalometric values for males and females in each age group in the Class I sample were subjected to the Student t-test to determine sex dimorphism. There was only one measure, the distance from sella to nasion in the 5–7, 8–10, and 11–13yr age groups, which showed significant sex differences. The 11–13yr age group also showed marginally significant sex differences in many of the longer linear measures.

As the male and female sample sizes for the Class III and Class I samples in each age group were similar, the cephalometric values for combined sexes for the two samples in each age group were also subjected to the Student t-test to identify significant differences between the Class III and Class I samples.

— Results —

Mean composite facial polygons for the Class III and Class I samples for each age group are shown in Fig. 1. These provide patterns which can be readily compared visually to illustrate relative overall differences between the two samples.

Cranial Base Relationships
Table 2

The anterior cranial base length (S-N) was similar in all age groups except the 5–7yr group, where the mean length of S-N in the Class III group was significantly larger.

The posterior cranial base length (S-Ba), however, was significantly longer in the Class III sample in all four age groups.

There was no significant difference in the cranial base angle (N-S-Ba) between the two samples in any age group.

The angle between S-N and the Frankfort horizontal plane was significantly larger in the the Class III sample in the 8–10 and the 13–15yr groups, but it was similar in the 5–7 and 11–13yr age groups.

Table 1

Age and Sex Distribution of Samples

	5–7			8–10			11–13			13–15		
Age	N	♂	♀	N	♂	♀	N	♂	♀	N	♂	♀
Class III	38	15	22	40	22	18	31	19	12	35	16	19
Class I	32	16	16	32	16	16	32	16	16	32	16	16

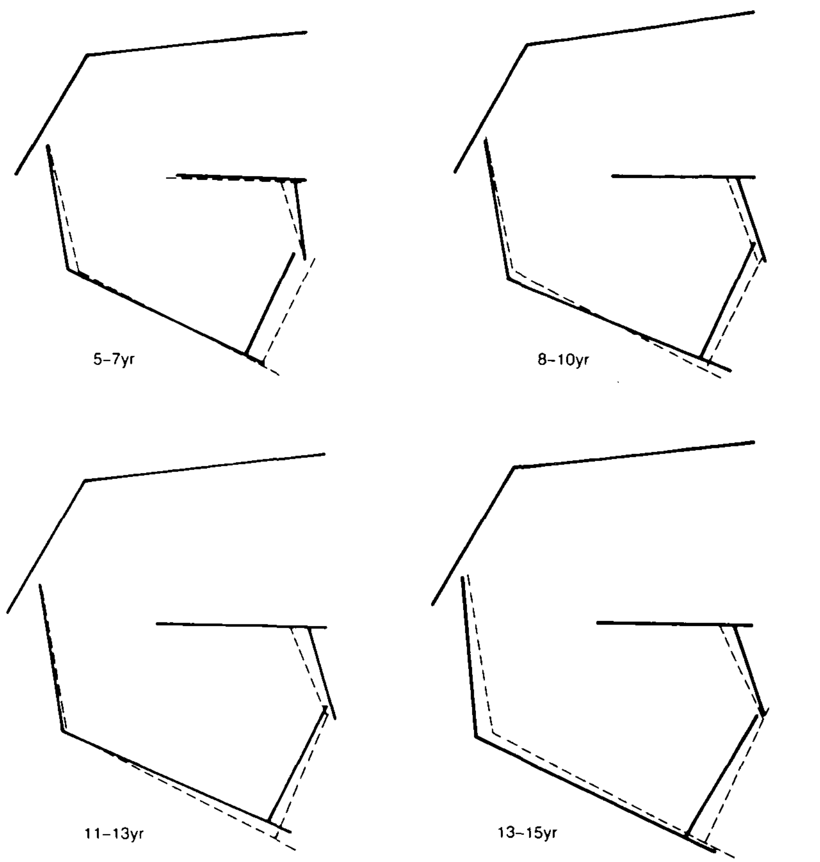

Fig. 1 Composite polygons for the mean Class I (solid lines) and Class III (broken lines) samples. The Class III sample shows similar differences from the Class I sample in all age groups.

Maxillary Skeletal Relationships
Table 3

On the basis of mean S-N-A value, the Class III sample exhibited a maxilla which was significantly more retrusive than the Class I sample in all except the 11-13yr age group (Fig. 2).

Using the linear measure from point A to the nasion perpendicular (A-N⊥) to relate the maxilla to the cranial base, the maxillae of the Class III sample were significantly more retrusive only in the 5-7yr group, yet mean effective maxillary length (Co-A) of the Class III sample was significantly shorter than in the Class I sample in all except the 5-7yr age group (Fig. 3).

Palatal plane angles showed different results with different cranial bases of orientation. The angle between the palatal plane (ANS-PNS) and S-N was not significantly different between the two samples at any age. However, the angles between the palate and Frankfort horizontal (PP/FH) for the Class III sample

Table 2

Cranial Base Relationships
Mean values ± Standard Deviations

Craniofacial Variable	5–7 Class III n=38	5–7 Class I n=32	8–10 Class III n=40	8–10 Class I n=32	11–13 Class III n=31	11–13 Class I n=32	13–15 Class III n=35	13–15 Class I n=32
S-N (mm)	68.4±4.1	66.3±2.6	68.3±3.8	69.0±2.8	70.8±4.6	71.7±2.8	72.5±5.2	72.6±2.6
S–Ba (mm)	42.0±3.7	38.5±1.9	43.7±2.8	42.2±2.6	46.1±2.3	44.4±2.4	47.9±4.0	45.0±2.5
N–S–Ba (°)	126.9±5.5	127.3±3.7	127.4±4.8	126.3±2.6	126.8±5.2	127.3±3.8	126.7±6.1	126.8±4.4
S–N/FH (°)	6.9±2.9	6.2±3.2	9.2±2.8	6.4±2.3	7.1±3.2	6.0±2.8	7.4±3.2	5.5±3.0

Significance of differences between Class I and Class II: P<.05 P<.01 P<.001

Table 2

were significantly smaller in all but the 5-7yr group.

The posterior nasal spine (PNS) of the Class III sample was found to be at a more inferior level in some age groups, also varying with the measurement used.

Mandibular Skeletal Relationships
Table 4

Most of the measures of horizontal mandibular skeletal position show the Class III sample to have significantly more protrusive mandibles than the Class I sample at all ages. The facial plane angle (N-Pog/FH) and pogonion to nasion perpendicular (Pog-N⊥) values showed the greatest statistical significance, exceeding the 0.001 level of confidence for all age groups.

The mean N-Pog/FH angle was about 3° greater in the Class III group (Fig. 4), and Pog-N⊥ was more than 5mm more prognathic than in the Class I sample in most age groups. The angles S-N-B and S-N-Pog were inconsistent, although they were greater than in the control group in most subjects throughout growth.

The saddle angle (S-N-Ar) was similar in all age groups, indicating a similar anteroposterior position of the temporomandibular joint.

The facial axis angle of the Class III sample was significantly smaller in the 8-10 and 13-15yr groups, indicating a backward and downward position of gnathion in the Class III mandible. The mandibular plane angles showed varying results, depending on the cranial plane of orientation. The mean MP/S-N angle of the Class III sample was significantly higher than in the Class I sample for all but the 5-7yr group. The mean MP/FH angle in the Class III sample was significantly higher for the 8-10 and the 13-15yr groups. In all instances, mean man-

Table 3

Maxillary Skeletal Relationships
Mean values ± Standard Deviation

Craniofacial Variable	5–7 Class III n=38	5–7 Class I n=32	8–10 Class III n=40	8–10 Class I n=32	11–13 Class III n=31	11–13 Class I n=32	13–15 Class III n=35	13–15 Class I n=32
Anteroposterior								
S–N–A (°)	79.7±3.5	81.9±3.3	79.1±2.7	81.8±3.0	80.5±4.8	82.0±2.7	80.8±4.3	83.2±2.7
A–Na⊥ (mm)	−3.0±3.1	−1.6±2.9	−1.6±2.6	−1.7±2.4	−2.4±3.5	−2.0±3.2	−1.8±3.6	−1.3±1.9
Co–A (mm)	79.8±5.1	78.8±3.0	81.2±4.3	84.4±3.5	86.2±6.9	89.1±3.5	88.6±6.4	91.8±3.3
Vertical								
PP/S–N (°)	6.6±3.0	7.4±2.6	8.1±3.3	7.9±2.5	7.3±4.1	8.3±2.7	6.6±3.2	7.7±3.1
PP/FH (°)	−.29±3.5	1.2±3.5	−1.2±3.3	1.5±3.0	0.2±3.3	2.3±2.9	−0.8±3.2	2.2±2.8
PNS–S (mm)	42.9±4.1	41.2±2.4	44.3±2.8	44.6±2.6	47.5±4.7	46.8±2.7	50.1±4.2	48.8±2.9
PNS–⊥	39.2±4.2	37.8±2.0	41.5±2.8	41.6±2.4	44.6±4.0	44.2±2.4	47.2±3.8	46.3±2.7
PNS–FH⊥	18.8±3.0	17.4±2.4	20.9±2.1	20.0±2.0	23.3±2.9	21.3±2.3	24.3±2.5	22.7±2.3

Significance of differences between Class I and Class II — P<.05 P<.01 P<.001

Table 4

Mandibular Skeletal Relationhips
Mean values ± Standard Deviation

Craniofacial Variable	5–7 Class III n=38	5–7 Class I n=32	8–10 Class III n=40	8–10 Class I n=32	11–13 Class III n=31	11–13 Class I n=32	13–15 Class III n=35	13–15 Class I n=32
Anteroposterior								
S–N–D (°)	80.4±3.3	78.1±3.0	79.1±3.0	78.6±2.7	81.6±4.3	78.8±2.6	82.1±4.2	80.2±2.6
Facial Angle	87.1±2.7	84.4±2.8	88.4±2.4	85.9±2.0	89.4±3.7	86.1±2.4	90.5±3.4	87.1±1.9
Po–Na⊥	−4.9±4.6	−9.0±4.5	−2.8±4.4	−7.0±3.6	−1.3±7.0	−7.1±4.5	0.9±6.9	−5.4±3.6
S–N–Po (°)	80.2±3.3	78.2±2.8	79.3±3.2	79.6±2.7	82.3±4.3	80.1±2.6	83.0±3.9	81.6±2.8
N–S–Ar(°)	120.1±4.7	119.7±4.2	121.9±5.7	120.9±4.2	120.7±4.7	122.2±3.2	120.0±5.9	122.3±3.5
Vertical								
Facial Axis (°)	1.9±3.6	1.6±2.9	−1.4±4.3	1.2±2.6	0.8±5.5	1.4±2.6	0.5±3.8	2.4±2.9
MP/SN (°)	32.8±5.1	31.8±3.3	35.6±5.4	30.6±3.1	33.1±6.4	30.4±3.2	33.2±5.4	29.0±3.8
MP/FH (°)	25.9±3.9	25.6±2.8	26.4±4.7	24.2±3.2	26.0±5.9	24.3±3.3	25.8±4.7	23.5±4.0
Mandible								
Gonial Angle	130.2±5.7	125.2±4.1	128.1±6.0	123.2±4.6	127.6±6.3	122.9±4.6	126.1±6.4	120.9±5.2
Ar–Go/S–N (°)	82.6±4.7	86.5±4.7	87.4±5.2	87.4±4.4	85.5±5.5	87.5±4.4	87.2±5.0	88.1±4.3
Ar–Go/S–N (°)	75.7±4.3	80.4±4.7	78.1±4.7	81.0±4.5	78.3±5.4	81.5±4.4	79.7±4.8	82.6±3.7
Co–Gn (mm)	103.3±7.5	96.1±3.5	107.8±5.8	104.6±3.7	117.2±6.8	111.5±3.9	123.4±7.6	117.3±4.5
Co–Go (mm)	47.9±5.3	44.9±2.4	50.1±3.8	48.8±2.3	55.7±4.1	52.7±3.4	58.4±4.7	56.6±3.4
Ar–Go	39.5±5.7	38.2±2.2	40.5±3.2	40.8±2.1	45.4±3.6	44.2±2.9	47.7±4.5	47.8±3.3
Go–Po	69.3±6.4	65.4±2.6	72.4±5.0	72.0±3.3	77.4±5.6	76.2±3.5	82.4±5.4	80.1±3.8
Go–Gn	68.4±6.5	65.1±2.7	71.7±4.9	71.7±3.3	76.8±5.6	75.9±3.5	81.9±5.3	80.3±3.7

Significance of differences between Class I and Class II   P<.05   P<.01   P<.001

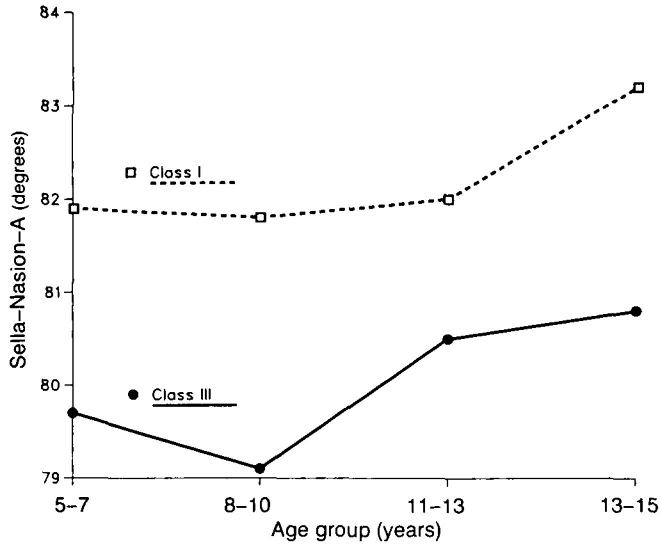

Fig. 2 Plot of the mean S-N-A values for the Class I and Class III samples in each age group. The mean Class III S-N-A values are lower than those of the Class I sample in all age groups, indicating more retrusive maxillae.

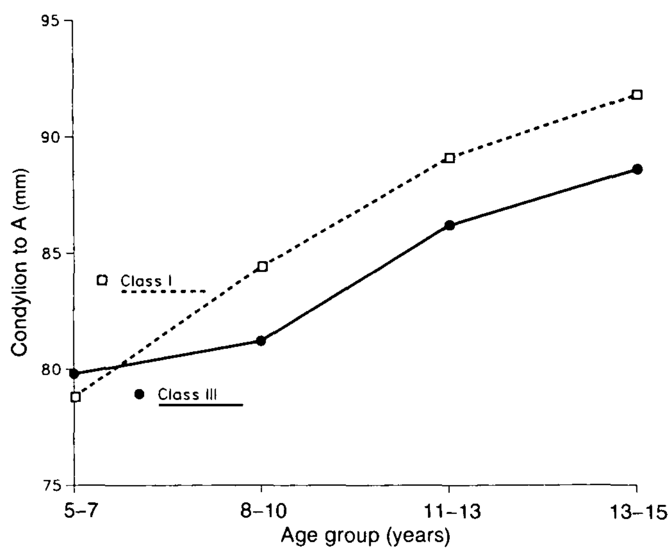

Fig. 3 Plot of the mean effective maxillary length (Condylion to Point A) for the Class I and Class III samples in each age group. With the exception of the 5-7yr group, the Class III sample had lower values than the Class I sample.

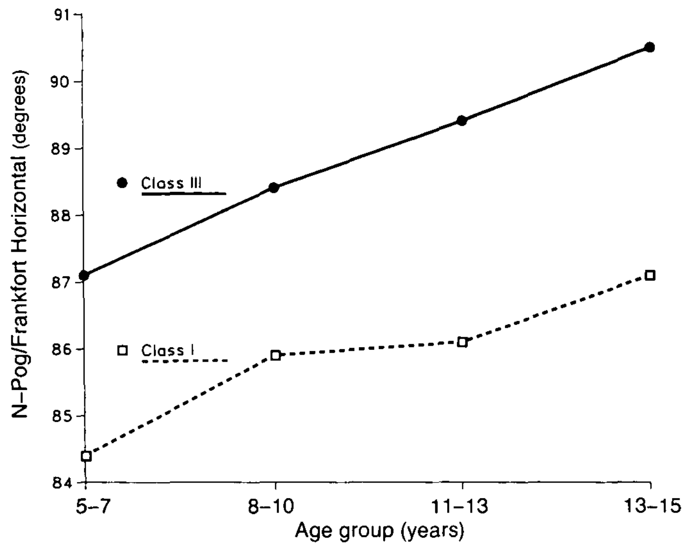

Fig. 4 Plot of the mean facial plane angles for the Class I and Class III samples in each age group. The Class III values were higher in each age group than the Class I values, indicating more protrusive mandibles.

dibular plane angles were greater in the Class III sample than in the Class I sample.

Mean mandibular length (Co-Gn) in the Class III sample was between 3mm and 6mm longer than in Class I, *a highly significant finding* in all age groups (Fig. 5). Although ramus (Co-Go and Ar-Go) and corpus (Go-Pog and Go-Gn) in the Class III sample were generally longer, statistical significance was only reached in the 5–7yr age group.

The mean Class III gonial angle was about 5° more obtuse in all age groups (Fig. 6). This may account for the finding of a greater average mandibular length in Class III mandibles without a corresponding difference in ramus or body length.

The angles between the posterior border of the mandibular ramus (Ar-Go) and S-N and the Frankfort plane were considerably smaller in most age groups, indicating a more forward position of gonion in the Class III sample.

Intermaxillary Relationships

Table 5

Both measures of relative maxillary and mandibular horizontal positions (A-N-B and Maxillomandibular Differential) showed highly significant differences between the Class III and Class I samples in all age groups. The mean A-N-B angles were all negative in the Class III sample, whereas they averaged about +3° in the Class I sample. Similarly, the difference between the average effective mandibular length (Co-Gn) and average effective maxillary length (Co-A) was at least 6mm greater in the Class III sample at all ages (Fig. 7).

The angle between the palatal plane and the mandibular plane (PP/MP) was significantly greater in the Class III sam-

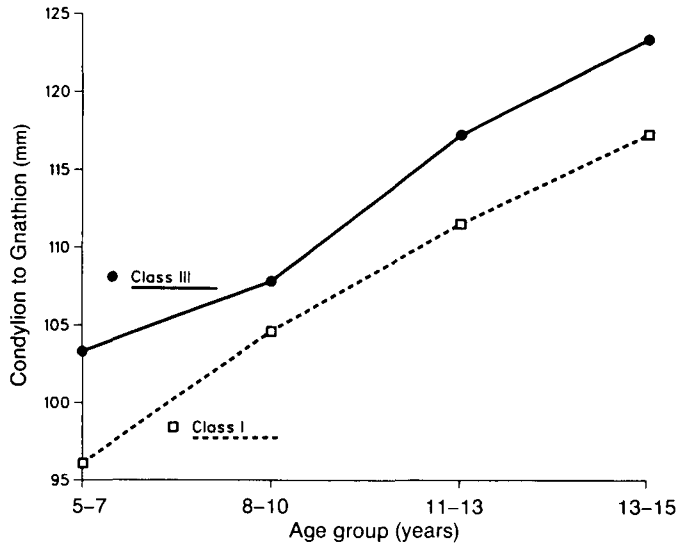

Fig. 5 Plot of the mean effective mandibular length (Condylion to Gnathion) for the Class I and Class III samples in each age group. The Class III sample had larger values in each age group.

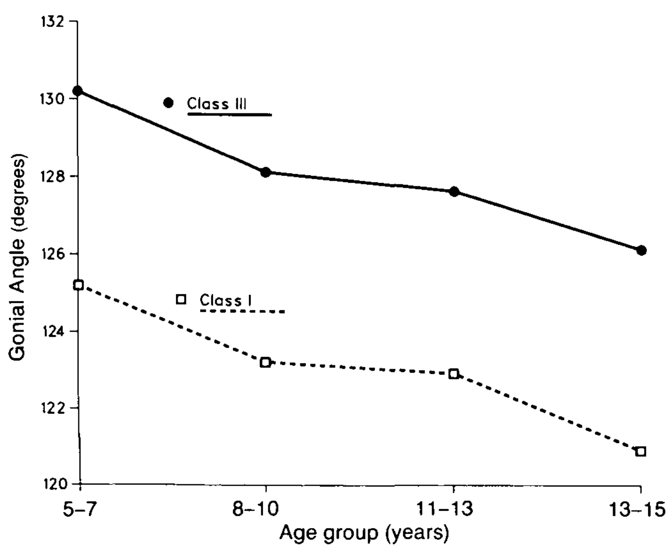

Fig. 6 Plot of the mean gonial angle for the Class I and Class III samples in each age group. The mean Class III gonial angle is more obtuse in all age groups.

Table 5

Intermaxillary Relationships
Mean values ± Standard Deviation

Craniofacial Variable	5–7 Class III n=38	5–7 Class I n=32	8–10 Class III n=40	8–10 Class I n=32	11–13 Class III n=31	11–13 Class I n=32	13–15 Class III n=35	13–15 Class I n=32
A–N–B (°)	−0.7±2.3	3.9±1.6	−0.0±1.7	3.3±1.4	−1.1±2.7	3.1±1.7	−1.3±2.1	3.1±1.8
Mand–Max Diff (mm)	23.4±3.5	17.3±2.1	26.6±3.7	20.2±2.5	31.0±3.9	22.4±3.0	34.9±5.0	25.5±3.8
Pal Pl/Mand Pl (°)	26.2±4.7	24.4±3.5	27.5±5.1	22.7±3.1	25.8±5.0	22.1±3.2	26.6±5.1	21.3±3.8

Significance of differences between Class I and Class II: P<.05 P<.01 P<.001

ple for all except the 5–7yr age group, indicating more vertical development in the Class III sample.

Dentoalveolar Relationships
Table 6

Several measures of maxillary incisor position were used in this study. The Class III sample generally showed significantly more maxillary incisor prominence in all age groups than the Class I controls (Fig. 8).

In contrast, most measures of mandibular incisor position showed highly significant mandibular incisor retrusion in the Class III sample in all except the 5–7yr age group (Fig. 9). In the 5–7yr group, the mean mandibular incisor protrusion was greater in the Class III than in the Class I sample.

The interincisal angle (U1/L1) was significantly smaller in the Class III sample at 5–7yrs and 13–15yrs. Although smaller in the other age groups, the differences between Class I and Class III values were not significant.

The vertical relation between the upper incisor and the maxilla was not significantly different between the two samples in any age group. The linear measurement between the incisal edge of the upper incisor and ANS, and the perpendicular distance to the palatal plane were very similar in magnitude in Class I and in Class III, and both increased approximately 1.5mm each year.

The linear distance between the lower incisor edge and menton also was very similar in the two samples.

Vertical Facial Relationships
Table 7

The upper anterior face height measures (N–Me and N–A) for the two samples were very similar in all age groups, whereas the lower anterior face measures

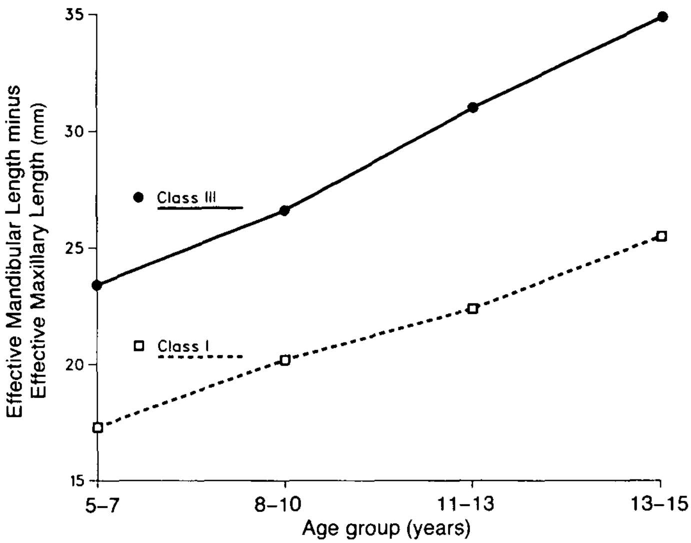

Fig. 7 Plot of the maxillomandibular differentials (effective mandibular length minus effective maxillary length) for the Class I and Class III samples in each age group. The Class III values are greater in all age groups.

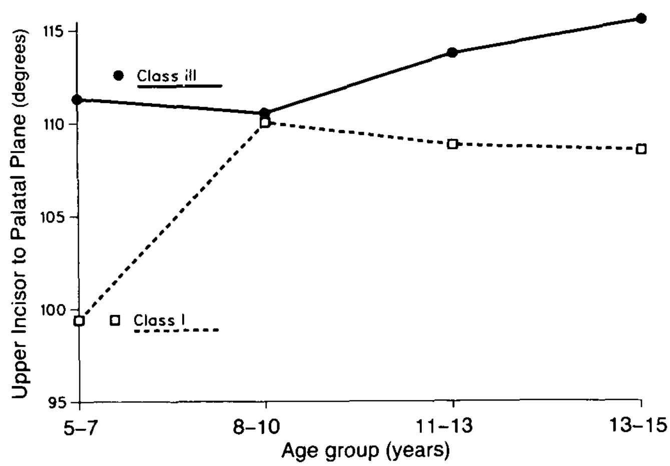

Fig. 8 Plot of the angle between the maxillary incisor axis and the palatal plane (U1/PP) for the Class I and Class III samples in each age group. The maxillary incisor in the average Class III individual is more procumbent than in Class I, except in the 8-10yr age range.

Table 6

Dentoalveolar Relationships

Mean values ± Standard Deviation

Craniofacial Variable	5–7 Class III n=38	5–7 Class I n=32	8–10 Class III n=40	8–10 Class I n=32	11–13 Class III n=31	11–13 Class I n=32	13–15 Class III n=35	13–15 Class I n=32
Anteroposterior								
U1/S–N (°)	104.0±4.2	91.6±6.0	102.6±8.5	102.0±4.7	106.4±6.5	100.4±5.4	108.9±7.7	100.9±5.6
U1/FH (°)	110.0±3.6	97.3±6.5	111.8±7.6	108.4±4.1	113.5±6.2	106.5±3.8	116.3±6.8	106.4±5.0
U1/N–A (°)	24.9±4.5	10.1±6.8	23.7±7.8	20.1±4.5	25.8±6.3	18.5±5.1	28.1±6.4	17.6±5.6
U1 to N–A (mm)	3.0±2.4	1.3±1.6	4.0±2.3	3.5±1.3	5.5±1.9	4.0±1.5	6.6±2.4	4.3±1.6
U1 to Pt A Vert (mm)	2.0±2.0	0.6±1.5	3.6±2.4	3.1±1.1	4.8±1.8	3.5±1.2	6.1±2.4	4.0±1.4
U1 to A–Po (mm)	1.4±2.1	2.1±1.6	2.8±2.5	3.9±1.4	3.1±2.3	4.2±1.5	4.0±3.1	4.2±1.9
U1 to N–Po (mm)	1.2±2.5	3.9±1.7	2.7±2.9	5.1±1.9	2.1±3.5	5.3±1.9	2.6±4.3	5.1±2.5
U1 to Pal Pl (°)	111.3±5.0	99.4±6.1	110.5±7.3	110.0±4.8	113.7±5.7	108.8±4.7	115.5±6.8	108.5±6.0
U1/L1 (°)	134.5±6.7	149.2±9.0	132.9±11.	134.9±6.9	134.7±8.9	136.3±5.3	131.2±10.	136.3±8.3
L1/N–B (°)	21.7±4.2	17.0±5.2	23.5±5.6	21.7±4.9	20.5±7.7	22.1±4.4	22.0±6.6	23.0±5.7
L1 to N–B (mmm)	3.1±1.7	2.3±1.1	4.5±2.2	3.6±1.3	4.2±2.4	4.1±1.1	4.6±2.2	4.4±1.6
L1/MP (IMPA) (°)	89.7±7.0	87.5±4.8	88.6±6.3	92.6±5.4	85.8±7.0	92.8±5.4	86.6±6.7	93.8±5.7
L1/FH (FMIA) (°)	65.1±5.3	66.6±5.2	64.7±5.6	63.2±5.8	68.2±8.9	62.8±4.5	67.6±6.6	62.7±6.1
L1 to A–Po (mm)	2.9±2.1	−0.7±1.6	3.4±2.4	0.4±1.4	3.3±2.8	0.6±1.3	3.8±2.9	0.9±1.8
Vertical								
U1 to ANS (mm)	23.5±2.8	24.2±2.4	25.3±2.9	25.8±2.5	26.7±3.0	27.1±2.7	28.5±2.9	28.2±3.0
U1 to Pal Pl Vert (mm)	23.2±2.8	23.7±2.2	25.0±2.9	25.5±2.4	26.5±3.0	26.9±2.6	28.3±2.9	28.0±2.9
L1 to Me (mm)	35.5±4.1	34.2±2.4	37.4±2.9	37.5±2.0	39.9±3.2	39.7±2.2	42.2±2.9	41.2±2.4

Significance of differences between Class I and Class II — P<.05 P<.01 P<.001

Table 7

Vertical Relationshhips

Mean values ± Standard Deviation

Craniofacial Variable	5–7 Class III n=38	5–7 Class I n=32	8–10 Class III n=40	8–10 Class I n=32	11–13 Class III n=31	11–13 Class I n=32	13–15 Class III n=35	13–15 Class I n=32
Upper Facial Ht (mm)	44.9±4.6	44.2±2.4	48.6±3.4	48.8±2.4	51.4±4.6	52.2±2.4	53.5±3.6	53.9±2.8
Lower Facial Ht (mm)	58.4±6.0	56.8±3.3	61.2±5.3	59.3±3.2	64.5±5.9	62.2±4.1	69.4±5.3	64.9±4.3
Ant Facial Ht (mm)	102.5±9.6	99.1±3.9	108.8±7.0	106.3±4.3	115.0±7.7	112.7±4.8	122.2±7.5	117.1±5.6
Post Facial Ht (mm)	65.7±8.8	64.4±3.2	67.6±4.8	70.3±3.7	74.4±5.2	75.1±4.4	79.1±6.1	79.9±4.4
UFH:AFH	0.4±0.0	0.5±0.0	0.5±0.0	0.5±0.0	0.5±0.0	0.5±0.0	0.4±0.0	0.5±0.0
LFH:AFH	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0
PFH:AFH	0.6±0.0	0.7±0.0	0.6±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0	0.7±0.0
UFH:LFH	0.8±0.0	0.8±0.1	0.8±0.1	0.8±0.0	0.8±0.0	0.8±0.1	0.8±0.1	0.8±0.1
N–A (mm)	49.6±5.0	48.8±2.5	53.3±3.7	54.0±2.7	56.5±4.3	57.3±2.8	59.5±4.3	59.0±3.0
A–Gn	52.0±5.7	48.8±2.9	54.5±4.7	50.6±2.9	57.5±5.2	53.5±3.0	61.8±4.2	56.2±3.6
N–Gn	101.5±9.5	97.2±3.9	107.8±7.1	104.4±4.1	113.9±7.8	110.6±4.5	121.2±7.4	115.0±5.5
N to A–Gn (mm)	1.0±0.1	1.0±0.0	1.0±0.0	1.1±0.8	1.0±0.1	1.1±0.1	0.9±0.1	1.1±0.1

Significance of differences between Class I and Class II   P<.05   P<.01   P<.001

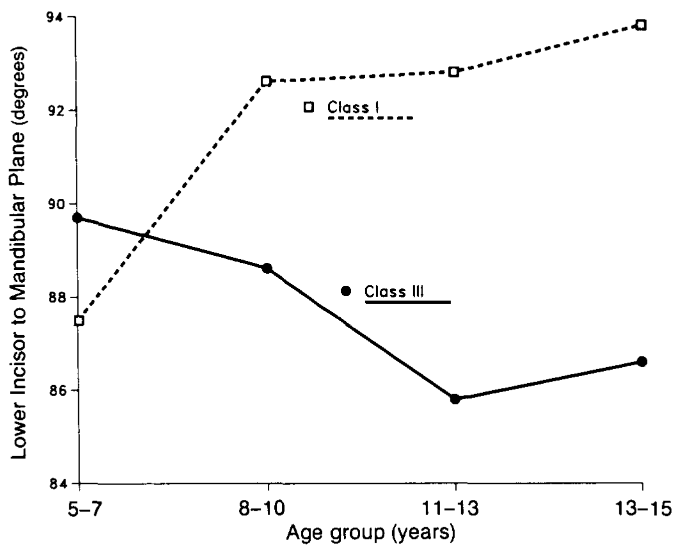

Fig. 9 Plot of the angle between the mandibular incisor axis and the mandibular plane (IMPA) for the Class I and Class III samples in each age group. With the exception of the 5–7yr group, the lower incisor is more recumbent in the average Class III subject.

(ANS–Me and A–Gn) were significantly different in several of the age groups (Fig. 10). This has a similar effect on total anterior facial dimensions.

The ANS–Me value, although approximately 2mm greater in the Class III sample at all ages, was greater by a statistically significant amount only in the 13–15yr group. On the other hand, the mean A–Gn value was significantly larger in the Class III sample in all age groups.

These measures seem to indicate that the Class III sample differs most from the Class I sample in the lower part of the face.

Analysis of Component Combinations

To determine the frequency of occurrence of *combinations* of skeletal components of the Class III sample, a neutral range for individual measures of maxillary and mandibular skeletal position and vertical facial dimension was selected for each age group.

The neutral ranges for S–N–A, facial plane angle, and lower face height were established from the Bolton Class I sample as the mean value ± one standard deviation.

Values below the neutral range indicate a retrusive position for the maxilla or mandible, or a short vertical development for the lower anterior face height. Values greater than the neutral range indicate a protrusive position of the maxilla or mandible, or a long lower anterior face height.

This reduces each measurement to a trichotomy into which all subjects can be classified as low, neutral or high. From these three trichotomies, 27 combinations are possible.

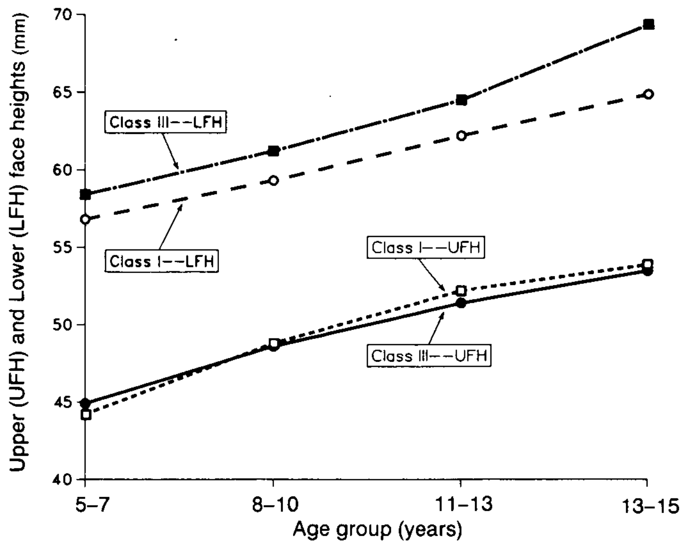

Fig. 10 Plot of the upper anterior facial height (UFH, Nasion to ANS) and lower anterior facial height (LFH, ANS to Menton) for the Class I and Class III samples in each age group. The Class III and Class I samples had similar upper anterior facial height values, but the Class III values for lower anterior facial height values are larger in each age range.

In an effort to more closely evaluate the frequencies with which the maxillary and mandibular skeletal components of Class III occur in the various age groups irrespective of lower anterior face height, an evaluation of only the maxillary and mandibular skeletal positions for the Class III sample was also computed for each age group. The neutral ranges for S-N-A and facial angle were established as described above. From these two trichotomies, 9 combinations are possible.

Skeletal Components of Class III in the 5-7yr Age Group

Table 8 lists the combinations of skeletal components for the 5-7yr age group. Fourteen out of the 27 possible combinations of components occurred. Groups I and II both had retrusive maxillae and neutral lower anterior face heights. Group I was characterized by a neutral position of the mandible, while the mandible was protrusive in group II.

The values for lower anterior face heights were within the neutral range in over half of the subjects in this age group, larger in approximately 32%, and shorter in 16%.

Table 9 lists the combinations of maxillary and mandibular skeletal positions in the 5-7yr age group. Six of the 9 possible combinations occurred. Once again, the two most common groups showed maxillary retrusion with a neutral mandibular position, and mandibular protrusion with a neutral maxilla. The next most frequent combination was that in which both jaws were within the neutral range.

The combination of maxillary retrusion with mandibular protrusion was the fourth group in terms of frequency of occurrence at 5–7 years of age.

Skeletal Components of Class III in the 8–10yr Age Group

Table 8 lists the combinations of skeletal components for the 8–10yr age group. Thirteen combinations of components occurred in this age range.

The two most frequent included protrusive mandibles. The most common combination consisted of maxillary skeletal neutrality, mandibular skeletal protrusion and a long lower anterior face height. The next most frequent combination was a protrusive mandible with maxillary protrusion and lower face height in the neutral range.

Unlike the 5–7yr age group, in which more than half exhibited neutral lower anterior face height, the lower anterior face height in this group was almost

Table 8

The Fourteen Combinations of Horizontal and Vertical Maxillary and Mandibular Skeletal Components found in the Class III Sample

Ranked by frequency of occurrence (27 Possible combinations)

Group	Age 5–7 n=38					Age 8–10 n=40					Age 11–13 n=31					Age 13–15 n=35				
	N	%	Mx	Md	LF	N	%	Mx	Md	LF	N	%	Mx	Md	LF	N	%	Mx	Md	LF
1	5	13.2	←			6	15.0		→	≡	5	16.1	←		≡	8	22.8	←	→	≡
2	5	13.2	←	→		5	12.5		→		4	12.9	←	→		6	17.1		→	
3	4	10.5	←		≡	4	10.0	←			3	9.7		→	=	5	14.3	←		≡
4	4	10.5		→		4	10.0	←	→		3	9.7	←			4	11.4	←	→	
5	4	10.5			≡	4	10.0			≡	3	9.7	→	→		3	8.6	→	→	
6	3	7.9		→	=	3	7.5	←		=	3	9.7	→		≡	2	5.7	←		
7	3	7.9				3	7.5		→	=	2	6.5	←	→	=	2	5.7	←	←	≡
8	3	7.9		→	≡	3	7.5	←		≡	2	6.5		→		1	2.9	←		=
9	2	5.3	←	←		2	5.0			=	2	6.5			≡	1	2.9		←	
10	1	2.6	←		=	2	5.0	←	→	=	1	3.2			=	1	2.9	→		≡
11	1	2.6			=	2	5.0	←	→	≡	1	3.2	←	←	≡	1	2.9		→	≡
12	1	2.6	←	→	=	1	2.5	←	←	≡	1	3.2		→	≡	1	2.9	→	→	≡
13	1	2.6	→	→		1	2.5	→	→	≡	1	3.2	→	→	≡					
14	1	2.6	→	→	≡															

Mx — Maxillary skeletal length
Md — Mandibular skeletal length

LF — Lower Face Height

← More Retrusive than normal
→ More Protrusive than normal

= Short Lower Face Height
≡ Long Lower Face Height

Blank spaces indicate "normal" values, with a neutral effect equally distributed among 32.5% neutral, 37.5% long and 30% short.

Table 9 lists the six combinations of maxillary and mandibular positions present in this sample. The most common group was characterized by mandibular protrusion with a neutral maxilla. The next most common group was the opposite, with retrusive maxilla and neutral mandible. Group 3 was characterized by maxillary retrusion and mandibular protrusion.

Skeletal Components of Class III in the 11-13yr Age Group

Table 8 lists the 13 combinations of skeletal components found in the 11–13yr age group. The most common combination of components in this age group was maxillary retrusion, neutral mandibular position, and longer lower anterior face height. The second most frequent combination was maxillary retrusion, mandibular protrusion and neutral lower anterior face height.

There was an almost equal division of lower anterior face height values into short, neutral and high in this age range.

Table 9 lists the 7 combinations of maxillary and mandibular positions in the members of this age group. The most frequent combination of horizontal maxillary and mandibular position was maxillary retrusion combined with a neutral mandibular position. The second, third and fourth groups were all characterized by a protrusive mandible with the maxilla covering the entire range from retrusive through neutral to protrusive.

The maxilla was retrusive in over half of the subjects in this age group, and the mandible was protrusive in over half.

Table 9

Seven Combinations of Horizontal Maxillary and Mandibular Components found in the Class III Sample
Ranked by frequency of occurrence
9 Possible combinations

	Age 5–7 n=38				Age 8–10 n=40				Age 11–13 n=31				Age 13–15 n=35			
Group	N	%	Mx	Md	N	%	Mx	Md	N	%	Mx	Md	N	%	Mx	Md
1	10	26.3	←		14	35.0		→	8	25.8	←		12	34.3	←	→
2	10	26.3		→	10	25.0	←		6	19.3	←	→	8	22.8	←	
3	8	21.0			8	20.0	←	→	6	19.3		→	7	20.0		→
4	6	15.8	←	→	6	15.0			4	12.9	→	→	4	11.4	→	→
5	2	5.3	←	←	1	2.5	←	←	3	9.7			2	5.7	←	←
6	2	5.3	→	→	1	2.5	→	→	3	9.7	→		1	2.9		←
7									1	3.3	←	←	1	2.9	→	

Mx — Maxillary skeletal length
Md — Mandibular skeletal length

← More Retrusive than normal
→ More Protrusive than normal
Blank spaces indicate "normal" values, with a neutral effect

Skeletal Components of Class III in the 13-15yr Age Group

Table 8 lists the 12 combinations of skeletal components for the 13–15yr group. The most common combination of components was maxillary retrusion, mandibular protrusion, and a long anterior face height. The next most common combination was mandibular protrusion associated with neutral maxillary and anterior face height values.

More than half of the sample had long lower anterior face height values, and only one had a short lower anterior face height.

Table 9 lists the 7 combinations of maxillary and mandibular skeletal positions. Group 1, representing 34% of the sample, had maxillary retrusion and protrusion of the mandible. Group 2, representing an additional 23% of the sample, had maxillary retrusion and a neutral mandibular position. It is not until Group 3 that mandibular protrusion is associated with a neutral maxillary position.

Maxillary skeletal retrusion was present in 63% of this sample, and mandibular protrusion in 66%.

— Discussion —

Not long ago, an individual exhibiting a Class III malocclusion was routinely diagnosed as having mandibular prognathism. This designation *ipso facto* labelled the mandible as the aberrant component of the patient's craniofacial anomaly.

As diagnostic capabilities have advanced, cephalometric investigations have demonstrated that some Class III patients do not fit this "classic" pattern (Sanborn 1955, Ahlgren 1970, Dietrich 1970, Rakosi 1970, Jacobson et al. 1974, Ellis and McNamara 1984).

These investigations show that individuals who exhibit a Class III malocclusion present a spectrum of abnormalities. A Class III malocclusion can exist with any number of combinations of skeletal and dental variations within the facial skeleton.

In a recent investigation of 302 adult Class III individuals, Ellis and McNamara (1984) reported that almost one third of the sample had a combination of maxillary retrusion and mandibular protrusion. Maxillary skeletal retrusion with a normally-positioned mandible was found in 19.5% of the sample, and mandibular protrusion with a normally positioned maxilla in 19.1%.

The present investigation reinforces the view that Class III malocclusions can be present with various combinations of skeletal and dental components.

Simple maxillary retrusion was found in 25% of the total sample in the present study. This agrees closely with other investigations in adults by Sanborn (1955), Jacobson et al. (1974) and Ellis and McNamara (1984), as well as the investigation of patients with deciduous dentitions by Dietrich (1970). However, Jacobson et al. (1974) found simple maxillary retrusion in only 8% of their sample of children.

Mandibular protrusion, commonly cited as the major skeletal aberration in individuals with Class III malocclusion, was found in *only 18.7%* of the total sample. This finding is very similar to the deciduous and mixed dentition samples of Dietrich (1970) and the adult sample cited above (Ellis and McNamara 1984). It is slightly higher than the child sample of Jacobson et al. (1974).

A combination of maxillary retrusion and mandibular protrusion was found in 22.2% of this sample. Dietrich (1970) found no such subjects in his deciduous dentition sample, and only 3% of his mixed dentitions. Similarly, JACOBSON ET AL. (1974) found none in their child sample.

Forty-one percent of this entire sample (59 of 144) also had long lower face height.

Clearly, even in children and adolescents, a Class III malocclusion does not indicate some typical facial skeletal pattern. Rather, it can be the result of any of several combinations of aberrations in the craniofacial complex.

A brief listing of other areas within the face of the Class III individuals who exhibited consistently significant differences from the Class I sample in this study include longer posterior cranial bases, larger mandibular plane angles, larger gonial angles, longer mandibles, maxillary incisor protrusion, and mandibular incisor retrusion.

Several investigators have commented on the developmental nature of Class III malocclusion. ANGLE (1907) noticed that Class III malocclusion, if allowed to develop, always progressed and became more severe. Others (SEIPEL 1946, BJÖRK 1951, LANDE 1952, TWEED 1966 AND GRABER 1969) also suggest that the growth of the mandible exceeds that of the maxilla and mandibular prognathism results.

JACOBSON ET AL. (1974) found 60% of their Class III children to have maxillae and mandibles positioned within the range of normal, and attributed this to the premise that the growth aberrations which lead to discrepancies between the maxilla and mandible had not as yet occurred. They surmised that with continued growth, the mandible would outgrow the maxilla, producing maxillomandibular disharmony later. Evidence for this was offered by the fact that only 14% of their adult Class III sample exhibited maxillae and mandibles within the range of normal, compared to 60% in the children. This was further substantiated by the fact that the proportion of individuals who exhibited mandibular protrusion increased from childhood to adulthood.

The present investigation compares a cross-sectional sample of Class III individuals with a longitudinal Class I sample. Perhaps the most interesting finding is that most of the characteristic aberrations associated with adult Class III malocclusion are already present at an early age. Few of the measures within the Class III population which were found to be significantly different from the Class I population in the oldest age group were not already present in the youngest age group.

Even though several measures were found to increase at a faster rate in the Class III samples, the related differences were already present in the young children. Thus, the maxilla was found to be retrusive, and the mandible protrusive, from age 5 to age 15.

Another example is the gonial angle. Several investigators (HEMLEY 1944, MAJ ET AL. 1958, ALLING 1961 AND JACOBSON ET AL. 1974) indicate that the gonial angles of Class III individuals are frequently larger than in Class I individuals. The present investigation found this to be the case in all age groups from 5 to 15 years at the 0.001 level of significance (Fig. 6).

Further, the significantly greater length of the mandible (condylion to gnathion) without a correspondingly larger length of the ramus or body indicate that the greater total length is the result of the more obtuse gonial angle in the Class III sample.

These findings suggest a tendency for a morphological difference between the mandible of Class III and Class I individuals, and that this difference occurs early.

Only a few of the distinctive measures in the Class III group were not already significantly different from the Class I group before the 8–10yr age period.

Mean effective maxillary length (Co-A) in the Class III group at age 5–7 was actually longer than in the class I sample, although not significantly so. In all of the other age groups, this dimension was significantly shorter in the Class III group.

Similar results were found with the facial axis, mandibular plane, and PP/MP values.

It was also found that the vertical development of the lower anterior face reached excessive values later in the Class III sample. In the 5–7yr age group, the mean lower face height in the Class III sample was 1.6mm greater than the control sample. In succeeding age categories this difference was 1.9mm, 2.3mm and 4.5mm (Fig. 10). This difference was statistically significant only in the last age group, where significance exceeded the 0.001 level. This indicates that the increase in vertical lower anterior facial growth occurs later, and that it is not typically present in early childhood.

— Summary and Conclusions —

Mandibular prognathism and Angle Class III malocclusion are not synonymous. When treating Class III patients orthodontically, whether they are growing children or mature adults, anteroposterior and vertical positions of facial components as well as dental relationships must be considered, so that the excess or deficiency may be treated where it actually exists.

This study was undertaken to compare Class III skeletal and dental relations to Class I norms. The findings support the following conclusions regarding the average characteristics of class III subjects:

- Posterior cranial base length (S–Ba) was significantly longer in Class III subjects.
- Although there was not total agreement between the two measures used to indicate anteroposterior maxillary position (S–N–A and A to nasion perpendicular), the Class III maxillae were generally retrusive.
- The effective length of the Class III maxillae (Co–A) was significantly shorter.
- The Class III sagittal mandibular skeletal position was prognathic.
- The Class III mandibular length (Co-Gn) was 3–6mm longer.
- The mean difference between effective maxillary length (Co–A) and mandibular length (Go–A) in Class III was at least 6mm greater than in Class I in all age groups.
- The gonial angle in Class III subjects was more obtuse and anteriorly positioned.
- The mandibular plane angle tended to be greater in the Class III subjects.
- There was greater vertical lower face height in Class III.
- Class III maxillary incisors were significantly protrusive.
- Class III mandibular incisors were significantly retroclined, except in the youngest (5–7) age group.

Most of the above differences were found in all four age groups, indicating that patients with Class III malocclusion exhibit unique skeletal and dental aberrations from an early age. Although they may grow worse with age, these aberrations do not usually begin their development later in life. AO

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