Late Lower Arch Crowding

The Role of Facial Morphology

Margaret E. Richardson

A study of the relationship between dental crowding and facial morphology in 51 individuals studied over the first five years of the permanent dentition, finding some relationships but no strong or consistent pattern.

KEY WORDS: • CROWDING • GROWTH • MANDIBULAR ROTATION • • MORPHOLOGY • SPACE •

The controversy surrounding the etiology of late lower arch crowding has not yet been satisfactorily resolved. The role of the third molar has been studied and debated at some length, and there is evidence to support the view that, in the untreated lower arch, the third molar or lack of space for it may contribute to the development of crowding farther forward (BERGSTRÖM AND JENSEN 1960, VEGO 1962, SCHWARZE 1975, RICHARDSON 1979, 1982, LINDQVIST AND THILANDER 1982).

It is nevertheless obvious that the third molar is not the only factor responsible for the development of such crowding. BJÖRK (1969) suggested that extreme mandibular rotation could result in increased lower arch crowding, and (1972) that complicated facial development may be responsible. SAKUDA ET AL. (1976) claimed that late lower arch crowding was caused by a specific pattern of growth and a type of skeletal pattern that is susceptible to crowding at the beginning of adolescence.

The following investigation was undertaken to elucidate the role of facial morphology and changes in facial morphology brought about by growth or orthodontic treatment in the development of late crowding of the lower dental arch.

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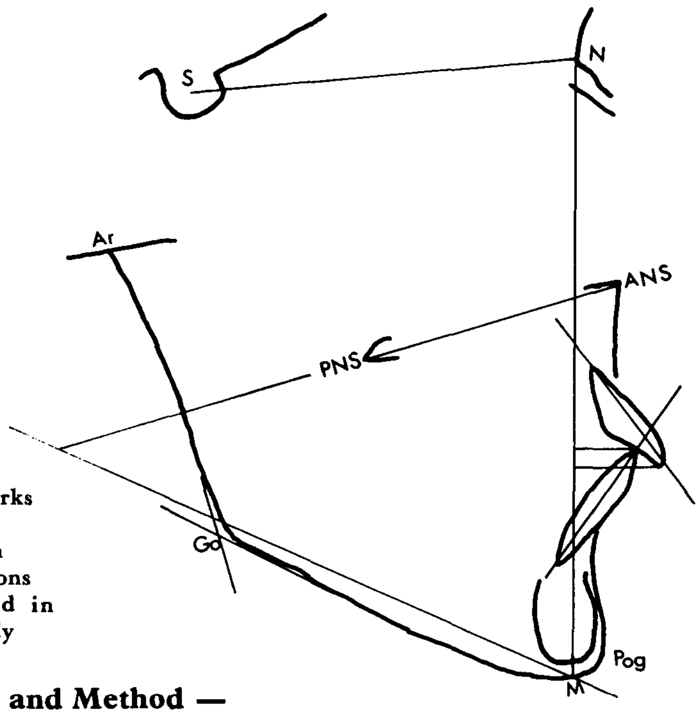

Fig. 1 Landmarks used to establish dimensions 1-8 used in this study

— Material and Method —

A group of 51 subjects, 22 male and 29 female, was selected from the records of a longitudinal study of third molar development (Richardson 1977). All subjects had intact lower arches with third molars present on both sides. Orthodontic treatment was confined to the upper arch, but might be expected to affect some of the variables under consideration, notably the vertical dimension, overbite and interincisal angle.

The first set of records used for this investigation was the earliest set showing a complete permanent dentition anterior to the first permanent molar. The average age was 13 years. The second set of records evaluated for each subject was made five years later.

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Measurements

Radiographs

On tracings of the first 90° left lateral cephalometric radiographs the following dimensions were measured (Fig.1).

1 Mandibular overall length — Articulare to Pogonion (Ar–Pog)
2 Mandibular body length — Gonion to Pogonion (Go–Pog)
3 Ramus height — Articulare to Gonion (Ar–Go)
4 Lower face height — Maxillary plane to Menton (Max–Me)
5 Overbite
6 Gonial angle
7 Maxillary/Mandibular plane angle (ANS–PNS/Go–Me)
8 Interincisal angle (U1/L1)

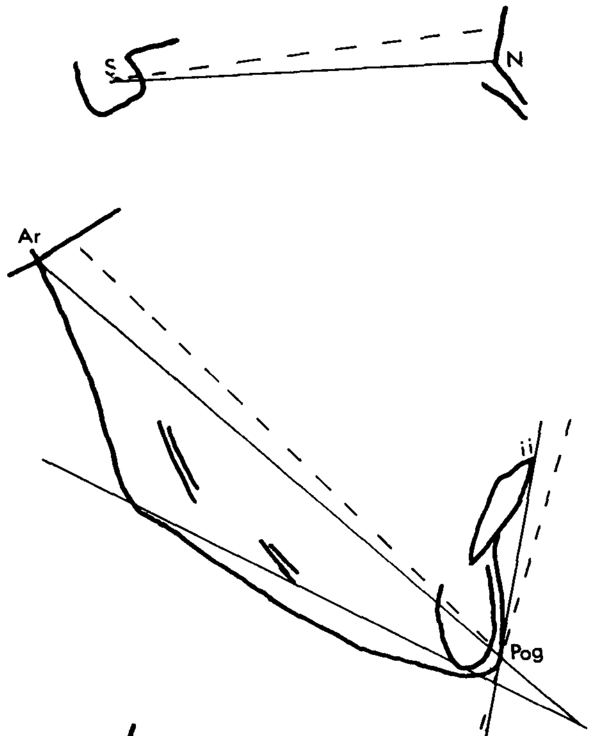

Fig. 2 Landmarks used to establish dimensions 9, 10, 20, 21 and 23.
Also demonstrates the method of measuring changes by superimposition; broken lines show displacement on a second radiograph with registration on the inner outline of the symphysis and the mandibular canal.

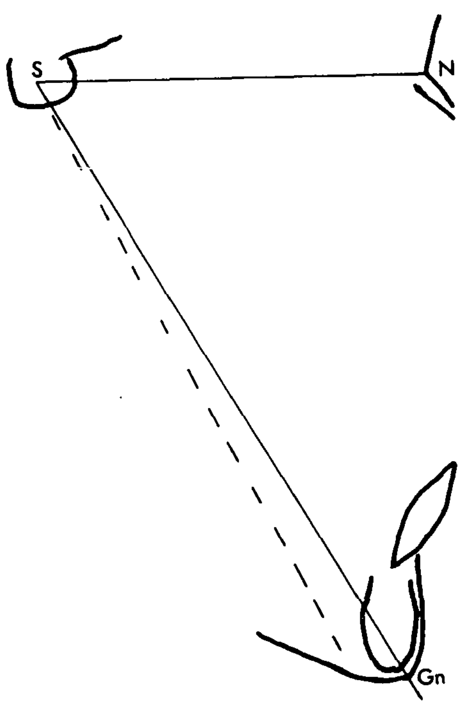

Fig. 3 Dimensions 11 and 22.
Displacement of the S-Gn line on a second radiograph with anterior cranial base registration is shown by the broken line.

9 The angle between Incision Inferius to Pogonion and the Mandibular plane (ii-Pog/Go-Me) (Fig.2)
10 The angle between Articulare-Pogonion and the Mandibular plane (Ar-Pog/Go-Me) (Fig.2)
11 The angle N-S-Gn (Fig.3)

12-22 Changes in dimensions 1-11.

Changes in the above dimensions were measured on the second radiographs taken 5 years later and recorded as variables 12 to 22. In the case of variables 1 to 8, a new tracing was made and the changes (12 to 19) were calculated by subtraction. Changes in variables 9 and 10 (20 and 21) were determined by superimposing the tracing of the first film on the second, registering on the inner outline of the mandibular symphysis and the inferior dental canal. The new positions of incision inferius, articulare and pogonion were then marked (broken lines in Fig.2).

Change in variable 11 (22) was determined by superimposing the tracing of the first film on the second, registering on the anterior cranial base. The new position of gnathion was then marked as shown by the broken line in Fig.3.

These procedures eliminated changes due to alterations in the angulation of the mandibular plane or S-N. Negative values for changes in variables 12 to 22 indicate an increase.

23 Jaw rotation was measured directly as the change in angulation of S-N when the tracing of the first film was superimposed on the second with mandibular structures in register (Björk 1969) (Fig.2). Positive values indicate forward rotation.

Dental Casts

24 Change in total space condition was calculated as the difference in space condition between the first and second sets of casts. Space condition was calculated as the difference between arch length and total tooth size from first molar to first molar, as measured on plaster casts with a vernier microscope. A positive change indicates an increase in crowding.

25 Change in anterior space condition was calculated in a similar way, measuring between the mesial surfaces of the cuspids.

All measurements were made twice by the same observer to the nearest 0.5° or 0.5mm.

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Statistical Analysis

Means and standard deviations for the original measurements are shown in Table 1. Changes in measurements over the five-year period for the whole group of 51 and the male and female subgroups are shown in Table 2.

Zero-order correlation analyses were carried out for the change in total space condition and the change in anterior space condition on all of the other original variables and changes in variables. The resultant significant correlation coefficients are shown in Table 3.

Multiple regression analyses were performed, using the change in total space condition and the change in anterior space condition as the dependent variables and all other original measurements (and changes) as independent variables. These are shown in Tables 4-7.

— Results —

Lower face height (maxillary plane to menton) and overbite were larger in the males than in the females (Table 1). None of the other original measurements was significantly different in the male and female groups.

There was, on average, no significant change in overbite, gonial angle, or the angle N-S-Gn (Table 2). In the group as a whole, all of the other variables changed significantly during the five-year period.

Table 1

Means and Standard Deviations for the Variables Measured on the First set of Records

Variable	All Subjects Mean	All Subjects S.D.	Males Mean	Males S.D.	Females Mean	Females S.D.	Diff M–F
1 Ar–Pog(mm)	105.21	6.52	106.88	5.98	103.94	6.73	2.94
2 Go–Pog(mm)	73.79	5.02	75.26	4.60	72.67	5.11	2.59
3 Ar–Go(mm)	44.15	3.34	44.50	3.09	43.88	3.55	0.62
4 Max Pl–Me(mm)	63.43	4.57	65.41	3.91	61.93	4.52	3.48
5 Overbite(mm)	4.02	2.56	4.86	2.28	3.38	2.61	1.48
6 Gonial Angle(°)	115.53	8.61	116.72	8.60	114.64	8.66	2.08
7 Max/Mand Angle(°)	27.92	4.08	28.08	3.58	27.80	4.48	0.28
8 Incisor Angle(°)	130.15	12.23	128.44	12.74	131.44	11.89	−3.00
9 ii–Pog/Go–Me(°)	72.72	5.41	72.72	5.78	72.72	5.21	0.00
10 Ar–Pog./Go–Me(°)	15.24	2.26	15.16	2.38	15.30	2.21	−0.14
11 N–S–Gn(°)	67.15	3.46	67.32	3.13	67.03	3.73	0.29
						r<0.05	r<0.01

Table 2

Means and Standard Deviations for the Changes in Variables Over a Five-Year Period

Variable	All Subjects Mean	All Subjects S.D.	Males Mean	Males S.D.	Females Mean	Females S.D.	Diff M–F
12 Ar–Pog(mm)	−9.55	4.30	−11.96	3.83	−7.23	3.76	4.22
13 Go–Pog(mm)	−5.66	2.39	−6.98	2.04	−4.66	2.18	2.31
14 Ar–Go(mm)	−6.23	3.52	−7.41	3.58	−5.34	3.26	2.07
15 Max Pl–Me(mm)	−5.49	4.05	−7.66	3.18	−3.84	3.90	3.82
16 Overbite(mm)	0.28	1.99	0.47	2.12	0.13	1.91	0.34
17 Gonial Angle(°)	−0.06	5.61	0.64	5.61	−0.59	5.65	1.22
18 Max/Mand Angle(°)	1.08	2.51	0.61	2.29	1.44	2.66	−0.83
19 Incisor Angle(°)	−5.76	9.84	−6.98	10.62	−4.82	9.29	2.16
20 ii–Pog./Go–Me(°)	−1.03	2.41	−1.26	2.58	−0.86	2.31	0.40
21 Ar–Pog./Go–Me(°)	−2.68	2.30	−3.21	2.05	−2.29	2.44	0.92
22 N–S–Gn(°)	−0.23	2.13	−0.11	2.18	−0.32	2.12	−0.21
23 Rotation(°)	2.78	2.92	3.24	2.76	2.44	3.04	0.80
24 Total Space Condition(mm)	2.33	1.32	2.67	1.40	2.07	1.21	0.60
25 Ant. Space Condition(mm)	0.93	0.94	1.10	1.21	0.81	0.67	0.29
					r<0.05	r<0.01	r<0.001

Table 3

Significant Zero Order Correlation Coefficients

Variable	Subgroup	N	Change in Total Space Condition	Change in Anterior Space Condition
4 Max Pl–Me	Male	22	−0.47	—
7 Max/Mand Angle	Male	22	−0.61	—
9 ii–Pog/Go–Me	Female	29	—	0.40
11 N–S–Gn	Female	29	−0.45	—
17 Gonial angle change	Female	29	—	0.39
19 Incisor angle change	Female	29	—	−0.42
				r<0.05 r<0.01

Table 4

Multiple Regression Analyses of the
Change in Total Space Condition
with the *Original Measurements* as Independent Variables

Individual Variable	All Subjects (51) Partial Regression Coefficient	F	Males (22) Partial Regression Coefficient	F	Females (29) Partial Regression Coefficient	F
1 Ar–Pog	—	—	—	—	—	—
2 Go–Pog	−0.12	5.37	0.12	7.06	−0.08	1.64
3 Ar–Go	−0.21	7.48	−0.35	19.15	—	—
4 Max Pl–Me	0.22	8.43	—	—	0.15	4.09
5 Overbite	0.07	0.63	−0.13	2.05	0.16	2.19
6 Gonial Angle	—	—	—	—	—	—
7 Max/Mand Angle	−0.31	16.01	−0.47	39.51	−0.15	4.68
8 Incisor Angle	−0.04	3.36	—	—	−0.06	6.17
9 ii–Pog/Go–Me	−0.07	2.31	—	—	—	—
10 Ar–Pog/Go–Me	0.06	0.30	—	—	—	—
11 N–S–Gn	0.06	1.00	0.11	2.68	0.16	5.05
		R=0.60		R=0.85		R=0.66
		F=2.59		F=8.45		F=2.79

Table 5

Multiple Regression Analyses of the Change In Total Space Condition with *Changes* in Measurements as Independent Variables

Independent Variable	All Subjects (51) Partial Regression Coefficient	F	Males (22) Partial Regression Coefficient	F	Females (29) Partial Regression Coefficient	F
12 Ar–Pog(mm)	−0.07	0.54	−0.13	0.57	0.72	12.72
13 Go–Pog(mm)	−0.01	0.01	0.04	0.03	−0.76	13.12
14 Ar–Go(mm)	0.08	0.81	0.12	0.51	−0.55	10.59
15 Max Pl–Me(mm)	—	—	0.18	0.75	−0.04	0.39
16 Overbite(mm)	—	—	0.22	0.45	—	—
17 Gonial Angle(°)	—	—	0.77	0.29	−0.09	4.72
18 Max/Mand Angle(°)	−0.04	0.22	−0.33	1.50	−0.16	2.82
19 Incisor Angle(°)	−0.04	3.77	−0.04	0.71	−0.07	8.59
20 ii–Pog./Go–Me(°)	−0.09	0.78	−0.08	0.10	−0.15	1.81
21 Ar–Pog./Go–Me(°)	0.09	0.72	−0.20	0.52	0.36	10.57
22 N–S–Gn(°)	−0.18	2.86	−0.19	0.68	−0.13	1.57
23 Rotation(°)	0.14	2.83	0.07	0.08	0.06	0.80
		R=0.46		R=0.65		R=0.82
		F=1.24		F=0.56		F=3.12

Table 6

Multiple Regression Analyses of the Change in the Anterior Space Condition with the *Original Measurements* as Indepedent Variables

Independent Variable	All Subjects (51) Partial Regression Coefficient	F	Males (22) Partial Regression Coefficient	F	Females (29) Partial Regression Coefficient	F
1 Ar–Pog(mm)	−0.18	1.59	−0.50	1.07	−0.01	0.06
2 Go–Pog(mm)	0.13	1.40	0.22	0.50	−0.03	0.14
3 Ar–Go(mm)	0.22	1.45	0.35	0.38	−0.01	0.01
4 Max Pl–Me(mm)	0.04	0.29	0.25	1.24	0.08	1.74
5 Overbite(mm)	0.03	0.20	−0.22	1.04	0.10	1.84
6 Gonial Angle(°)	0.01	0.21	0.03	0.33	−0.02	0.53
7 Max/Mand Angle(°)	−0.04	0.32	−0.30	2.00	−0.01	0.03
8 Incisor Angle(°)	−0.01	0.42	0.00	0.00	−0.02	1.34
9 ii–Pog/Go–Me(°)	0.02	0.22	−0.04	0.08	0.04	0.73
10 Ar–Pog./Go—Me(°)	−0.18	1.12	−0.56	1.15	—	—
11 N–S–Gn(°)	0.06	1.09	0.26	4.29	−0.08	1.47
		R=0.37		R=0.65		R=0.66
		F=0.56		F=0.68		F=1.36

Table 7

Multiple Regression Analyses of the Change in Anterior Space Condition with the *Changes in Measurements* as Independent Variables

Independent Variable	All Subjects (51) Partial Regression Coefficient	F	Males (22) Partial Regression Coefficient	F	Females (29) Partial Regression Coefficient	F
12 Ar–Pog(mm)	—	—	—	—	0.21	2.72
13 Go–Pog(mm)	−0.04	0.42	—	—	−0.25	3.18
14 Ar–Go(mm)	0.03	0.46	0.18	8.50	−0.25	5.64
15 Max Pl–Me(mm)	—	—	—	—	—	—
16 Overbite(mm)	−0.05	0.51	−0.14	0.89	−0.17	2.60
17 Gonial Angle(°)	0.06	7.23	0.12	3.87	0.06	6.11
18 Max/Mand Angle(°)	−0.13	5.41	−0.32	6.32	−0.12	4.84
19 Incisor Angle(°)	—	—	0.02	0.52	0.00	0.00
20 ii–Pog./Go–Me(°)	0.09	1.68	0.21	2.95	—	—
21 Ar–Pog./Go–Me(°)	0.05	0.46	−0.14	1.41	0.13	4.44
22 N–S–Gn(°)	−0.13	4.00	−0.32	9.75	−0.09	2.24
23 Rotation(°)	0.17	9.89	0.25	5.13	0.05	1.23
		R=0.58		R=0.86		R=0.77
		F=2.29		F=3.76		F=2.58

There was a significant increase in the overall length (articulare to pogonion), body length (gonion to pogonion), in ramus height (articulare to gonion) and in lower face height (maxillary plane to menton). There was an average decrease in the maxillary/mandibular plane angle and an average forward rotation of the jaw.

The interincisal angle increased significantly. The angles ii–Pog/Go–Me and Ar–Pog/Go–Me both increased significantly, indicating an average forward direction of eruption and vertical direction of mandibular growth or treatment change.

There were significant average changes in total space condition and in anterior space condition, indicating an increase in crowding.

Similar changes were found in the male and female groups, although there were some differences in the degree of change. Changes in Ar–Pog, Go–Pog, Ar–Go, and lower face height were significantly greater in the male group. Changes in maxillary/mandibular plane angle in the male group and the angle ii–Pog/Go–Me in the female group were below the level of statistical significance. There were no statistically significant differences between changes in the other variables in males and females.

None of the zero-order correlation coefficients for the group as a whole were significant.

In the male group there were significant negative correlations between the change in total space condition and lower face height (−0.47), and between the change in total space condition and the maxillary/mandibular plane angle (−0.61) (Table 3).

In the female group, there was a significant positive correlation between the change in total space condition and the angle N–S–Gn (0.45). The change in anterior space condition was significantly correlated in the female group with the angle ii–Pog/Go–Me (0.40), the change in gonial angle (0.39), and the change in interincisal angle (−0.42) (Table 3).

The regression analysis of the change in total space condition on the original measurements for the group as a whole gave a significant multiple correlation coefficient of 0.60 (Table 4). Mandibular body length (Go–Pog), ramus height (Ar–Go), lower anterior face height (Max–Me) and the maxillary/mandibular plane angle (ANS–PNS/Go–Me) all contributed significantly to the prediction of change in total space condition.

In the male group, the multiple correlation coefficient for the change in total space condition on the original variables was 0.85, with only the mandibular body length (Go–Pog), ramus height (Ar–Go), and the maxillary/mandibular plane angle contributing significantly to the regression equation.

In the female group, the multiple correlation coefficient for the change in total space condition on the original variables was 0.66, with the maxillary–mandibular plane angle, interincisal angle and N–S–Gn angle, contributing significantly to the regression equation (Table 4).

The regression analysis of the change in total space condition on the changes in measurements gave nonsignificant multiple correlation coefficients for the whole group and for the male group (Table 5). In the female group, there was a significant multiple correlation coefficient for the change in total space condition on the changes in measurements (0.82), with the changes in mandibular overall length (Ar–Pog), mandibular body length (Go–Pog), ramus height (Ar–Go), gonial angle, interincisal angle and the Ar–Pog/Go–Me angle contributing significantly to the regression equation.

None of the multiple correlation coefficients for the change in anterior space condition on the original measurements were significant (Table 6).

The multiple correlation coefficients for the change in anterior space condition on the changes in measurements were significant (whole group 0.58, males 0.86, females 0.77) (Table 7). In the whole group, the changes in gonial angle, maxillary–mandibular plane angle, N–S–Gn angle and rotation contributed significantly to the regression equation.

In the male group, the ramus height (Ar–Go), maxillary–mandibular plane angle, N–S–Gn angle and rotation, and in the female group the ramus height (Ar–Go), gonial angle, maxillary/mandibular plane angle and Ar–Pog/Go–Me angle contributed significantly to the regression equations.

— Discussion —

No firm conclusions can be drawn from these results. None of the zero-order correlation coefficients for the group as a whole were significant, which indicates that no single variable had a very strong connection with the change in space condition in the lower arch. Although there were some significant zero-order correlation coefficients in the male and female subgroups, it is to be expected that about 5% will be significant merely by chance.

Total Space Condition

The multiple correlation coefficients for the change in total space condition with the original measurements were significant, suggesting that some of the morphological features in the early permanent dentition were weakly associated with an increase in lower arch crowding.

The multiple correlation coefficient of 0.85 in the male group means that 72% of the variation in change in total space condition can be explained by the three variables contributing significantly to this regression equation (Table 4). However, in view of the lower multiple correlation coefficients for the whole group and for the female group, and the fact that different variables contributed significantly to those regression equations, it would be unrealistic to attach much predictive importance to this finding.

The multiple correlation coefficients for the change in total space condition with the changes in measurements were nonsignificant for the whole group and the male group (Table 5). Although the correlation coefficient in the female group was significant, this is not a clear indication that growth or treatment changes play an important part in the development of, or increase in, crowding of the lower arch as a whole.

Anterior Space Condition

The multiple correlation coefficients for the change in anterior space condition with the original measurements were nonsignificant and lower than those for the change in total space condition (Table 6). This is at variance with the observations of SAKUDA ET AL. (1976), who found a closer association between the change in anterior crowding and cephalometric measurements at age 12 years than between change in total crowding and the same measurements. Although the variables in the present study were not all exactly the same as those used by Sakuda et al., there are enough similarities for like trends to be expected.

In contrast, the multiple correlation coefficients for the change in anterior space condition with the changes in measurements were significant, indicating that certain growth and treatment changes may be associated to some extent with increased lower anterior crowding (Table 7). This is in agreement with the findings of SAKUDA ET AL. (1976), but should nevertheless be interpreted with a degree of caution.

In the male group, over 70% of the variation in change in anterior space condition can be accounted for by the variables contributing significantly to the regression equation, but only 60% in the female group, and 40% in the combined group can be so explained (Table 7). In addition, the direction of the correlation is not always consistent between males, females and both sexes combined.

Among the factors which contribute significantly to these regression equations are the change in maxillary/mandibular plane angle and the change in N-S-Gn, indicating that a downward direction of growth or treatment change of the mandible is associated with an increase in lower anterior crowding.

SAKUDA ET AL. (1976) presented tracings of 2 subjects, one of whom showed an increase in lower arch crowding and the other with little change in crowding. The striking difference between these 2 subjects, to which they drew attention, was the direction of mandibular growth; the crowded subject grew mainly downward in contrast to the mainly forward growth of the noncrowded subject. However, according to their interpretation of their regression equation, " . . . individuals showing less procumbency of upper central incisors, less maxillary growth, larger vertical growth in upper posterior segments, and decreased intermolar angle had a tendency toward a large increase in the lower anterior crowding score." A measure of mandibular growth direction did not contribute to their regression equation.

Other factors which contributed significantly to the regression of the change in anterior space condition on the changes in other variables in the present investigation were the change in gonial angle and jaw rotation. This suggests that a forward rotation of the jaws may be associated with increased lower anterior crowding and complements BJÖRK'S (1969) finding, although Björk observed that extremes of mandibular rotation in either a forward or backward direction could result in increased lower arch crowding.

Third Molars

SAKUDA ET AL. (1976) dismissed the mandibular third molars as important etiologic factors in the crowding of the lower dental arch. Previous investigations on the material used in the present study produced significant zero-order correlation coefficients between the change in total space condition and forward movement of the first molar (0.47), original molar space condition (−0.33), and change in molar space condition (0.34) (RICHARDSON 1979, 1982). Although these correlations reached levels of statistical significance only on the left side, they appear to be more important in the etiology of lower arch crowding than any of the factors examined in the present investigation.

Growth Pattern

The present findings do not support the conclusions of SAKUDA ET AL. (1976) that "... the specific pattern of growth during adolescence and the specific type of skeleton at the beginning of adolescence are ... important aetiologic factors of secondary crowding." Nevertheless, they do not exclude the possibility that these factors play a minor role in the development of such crowding, and it is also possible that molar crowding may be more active in the etiology of late lower arch crowding in the presence of certain morphological features or changes due to growth or treatment.

— Conclusions —

- Some morphological features in the early permanent dentition may predispose to increased crowding of the lower arch, but the pattern of association is variable and unclear.
- Downwardly-directed mandibular growth or treatment change and forward mandibular rotation are among the factors which may contribute to late crowding of the anterior part of the lower arch.

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