A Cephalometric Evaluation of the Normal Skeletal and Dental Pattern of Children With Excellent Occlusions*

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Perhaps the most basic problem in any diagnostic system is the establishment of a range of Normality. In order to determine the very existence of an abnormality — in this case malocclusion — we must first be able to demonstrate the cardinal sign of pathology, "changes in structure."[1] Thus in order to demonstrate changes we obviously must first establish a normal range from which to measure and evaluate these changes.

The Nomenclature Committee of the American Association of Orthodontics[2] has proposed the following definition of normal occlusion: "The type of occlusal contact that helps to maintain the health of the supporting structures of the teeth and favors the physical and mental adjustment of the individual." In the proposition of this broad definition of an often used but nebulous term, the Committee has recognized the broadening scope of the field of orthodontics, the esthetic and cosmetic considerations of the relationship of the teeth to the rest of the face.

Angle's[3] basic concept of malocclusion was formulated only upon the relationships of the teeth to each other and their opponents. "We will define occlusion as being *the normal relations of the occlusal inclined planes of the teeth when the jaws are closed. Malocclusion* of the teeth is but the perversion of their normal relations."

The modern concept of malocclusion has exceeded in scope the rather pragmatic definition of the term as set down by the American Dental Association:[4] "Such malposition of the teeth as will interfere with the highest efficiency during the excursive movements of the jaw which are essential to the function of mastication."

Calvin Case[5] was one of the first to recognize the importance of esthetic considerations. He stated that the term malocclusion "not only applies to every form of dental irregularity, but to all imperfections in facial outline that are caused from malpositions of the teeth and jaw. He further stated that "the only true basis of diagnosis and treatment is *dento-facial harmony* — harmony in the occlusal relations of the dentures to each other for purposes of mastication, and harmony in the dento-facial area and its relations to the other features." Again in his definition of the terms "protrude" and "retrude" Case says, "Teeth are in a protruded or retruded position only in respect to the esthetic standard of dento-facial relation, and in no instance can this be determined by the occlusal relation."

Thus, the possibility of influencing "facial harmony" was recognized and various attempts were made to establish an esthetic ideal.

Edmund H. Wuerpel,[6] the director of the School of Fine Arts of Washington University exerted a great influence over Angle's concepts of beauty of face. In an article in the first issue of *The Angle Orthodontist,* Wuerpel said: "There is no 'most beautiful person.' There is a most perfect type and in

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one type there may be just as much beauty as in another . . . Every era creates its type."

Wuerpel[3] expressed his standard of normality in terms of "balances" an imponderable intellectuality that "only one in two or three hundred of even art students ever succeed in mastering."

Dr. Angle[3] interpreted this concept of balance — again a normality standard — as follows: "There is a law for determining the best balance of features, or at least the best balance of the mouth with the rest of the features. It is that the best balance, the best harmony, the best proportion of the mouth in its relations to the other features require that there shall be *the full complement of teeth and that each tooth shall be made to occupy its normal position — normal occlusion.*"

The concept of the nature of normality, however, is not an esthetic consideration but a scientific and mathematical entity. Dorland defines normal as "agreeing with the regular and established type."[4]

It therefore became necessary to devise methods and techniques of relating the teeth to the facial skeleton and of measuring and expressing these relationships to determine the "regular and established type." It became immediately obvious that absolute measurements were inappropriate because of differences in size of individuals so various systems of angular relationships and measurements have been proposed.

Riedel[7] in the introduction to his thesis says of these early investigators: "One of the first investigations was that of Camper, in 1768, wherein he measured a facial angle constructed by drawing a line through the ear hole and the wing of the nose and bisecting it with a second line joining the most prominent point on the forehead to the alveolar margin of the maxilla.

"The use of Camper's angle was gradually abandoned as it became evident that it varied considerably from race to race and within individuals of the same race without providing a true picture of facial type.

"Probably the most extensively used of the planes to evaluate facial profile has been that introduced by Von Ihering, in 1872. It was accepted by the Anthropological Congress in Frankfort in 1884 and named the Frankfort plane."

The Frankfort plane was originally determined by bony landmarks. It was located by drawing straight lines through the lowest points in the margins of the orbits and the highest points in the margins of the auditory meatuses. On the living subject soft tissue landmarks equivalent to these points were located.[8]

Many investigators have used this plane as a basis for angular measurements on skulls and on living subjects. With the advent of cephalometric techniques the Frankfort plane remained one of the most important orientation landmarks.[9]

In 1948 Downs[10] presented on excellent paper which he says was "undertaken to determine the range of the facial and dental pattern within which one might expect to find the normal." This paper consisted of a series of values derived from linear and angular measurements of cephalometric roentgenograms of twenty individuals who possessed clinically excellent occlusions. The individuals used in this study ranged in age from twelve to seventeen years and were equally divided as to sex. This set of values has come to be known as Downs' Analysis and has been accepted as a standard by which the skeletal and denture pattern of an orthodontic patient may be evaluated.

However, Moore[11] has shown in a serial study of a group of ten growing individuals with excellent occlusion that between the eighth year and the sixteenth year the chin point tends to become more prominent and that horizontal growth exceeds vertical growth.

Bjork[12] compared a large group of twelve-year-old boys to a large group of men between the ages of twenty-one and twenty-three. He demonstrated the following changes in facial skeleton between these ages: The lower jaw is displaced forward relative to the upper jaw. The facial profile straightens and the angle of prognathism is increased by 4.4 degrees. (The angle of prognathism is drawn from nasion to prothion to pogonion.) He also describes changes in occlusion which result in a more upright position of the incisors or at least an increase in the angle formed by the intersection of the axes of the upper and lower central incisors.

Schaeffer[13] in a serial study of forty-seven individuals was able to show that the angles of the axes of incisors might increase, decrease, or remain stable. However, in every case regardless of the behavior of their axes the incisor teeth came to occupy a relatively more posterior relation to their supporting bones with growth of the facial skeleton.

It is apparent, therefore, that changes do occur in the skeletal and denture pattern of a growing individual. It is necessary then to establish a series of progressive normals, one for each age group throughout the growth period and perhaps even throughout the entire life span of the individual.

This study is an attempt to establish the normal skeletal and denture patterns of children possessing excellent occlusions during the ages when orthodontic treatment is usually undertaken.

Methods and Material

The method employed in this study was roentgenographic cephalometry. The Broadbent-Bolton cephalometer was used to position the head and cassette. The cephalometric technique was that which was described by Broadbent[9] and others. The subjects were sixty-two children of the Seattle public schools equally divided as to sex. They had clinically excellent occlusions, considering tooth relationships only. An attempt was made to cover the eleventh, twelfth, and thirteenth years. However, shed deciduous teeth and erupting permanent teeth made excellent occlusion difficult to recognize during the eleventh year so that the bulk of the children fell between the twelfth and fourteenth years. The mean age of the males was 12 years, 8½ months ±1.289 months. The mean age of the females was 12 years, 7½ months ±1.556 months. All of the subjects were white children.

Two lateral head films were made of each subject, one with the mandible in rest position and one with the teeth in occlusion. Measurements were made on tracings of the occlusion head films. The rest position head films were used to determine position of individual teeth and the occlusal plane.

The landmarks and planes used were those employed by Downs,[10] and were located as described by him. (Figs. 1 and 2.) Certain of the angles measured and discussed by Riedel[7] have also been included in this analysis.

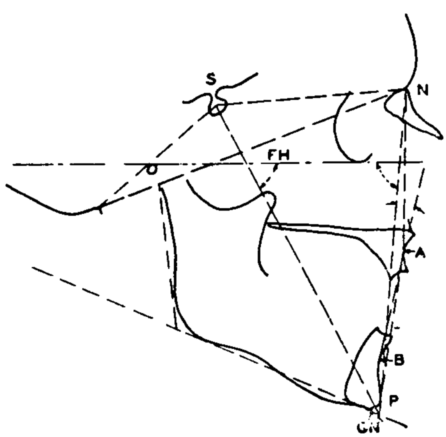

Fig. 1—The skeletal pattern (after Downs)

GLOSSARY

Nasion-N: The suture between the frontal and nasal bones.

Sella Turcica-S: The center of the profile image of the fossa.

Orbitale: The lowest point on the left infraorbital margin.

Porion: (Cephalometric) the highest point on the superior surface of the soft tissue of the external auditory meatus.

Pogonion: The most anterior point on the mandible in the midline.

Point A - subspinale: The deepest midline point on the premaxillae between the anterior nasal spine and prosthion.

Point B - supramentale: The deepest midline point on the mandible between infradentale and pogonion.

Gnathion: A point on the chin determined by bisecting the angle formed by the facial and mandibular planes.

Frankfort horizontal: (*Cephalometric*) a horizontal plane running through the right and the left cephalometric porion and the left orbitale.

Mandibular plane: A line at the lower border of the mandible tangent to the gonion angle and profile image of symphysis.

Facial plane: A line from nasion to pogonion.

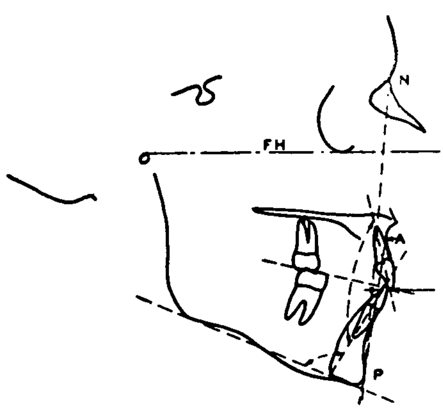

Fig. 2—The denture to the skeletal pattern (after Downs)

Denture base limit: A line drawn through points A and B.

Occlusal plane: A line bisecting the occlusion of the first molars and central incisors.

Y axis: A line from sella turcica to gnathion.

Angle of Convexity: Formed by the intersection of a line from nasion to point A with a line from point A to pogonion.

Facial angle: The inside inferior angle formed by the intersection of the Frankfort Horizontal and Facial Plane.

OBSERVATION AND SUMMARY OF STATISTICAL EVIDENCE

The following tables have been prepared from the data accumulated in this study:

Table 1 is a comparison by means of critical ratio of the values observed in males to those observed in females. It is divided into three sections, Skeletal Pattern (Downs); Denture Pattern (Downs); and Denture Analysis (Riedel).

Comparison of the skeletal pattern of the male to that of the female in this age group showed that the Angle of Convexity of the male was higher (more acute) than that of the female. No other significant differences were shown.

In a comparison of the denture patterns, there could be shown no significant differences.

In Riedel's denture analysis, angle ANB, a measure of roughly the same characteristics as the Angle of Convexity, also approaches significance.

Table 2 is a comparison by means of the "t" test of the combined group of males and females used in this study considered as a single mixed group, to Downs' mixed group.

In the comparison of the skeletal pattern of the combined group to that of Downs' group, the Angle of Con-

TABLE 1

Means, Ranges, and Critical Ratios

Measurement		Males		Females	Critical Ratio
		Skeletal Pattern (Downs)			
Facial Angle	M[a] =	88.7 ± 0.58	M =	90.2 ± 0.60	SEDiff[d] = 0.83
	SD[b] =	3.23	SD =	3.32	CR[e] = 1.75
	R[c] =	83.5 to 96.0	R =	82.0 to 95.5	
Mandibular Plane Angle	M =	23.3 ± 0.92	M =	22.2 ± 0.75	SEDiff = 1.19
	SD =	5.12	SD =	4.20	CR = 0.92
	R =	14.5 to 33.5	R =	11.5 to 31.5	
Y Axis	M =	57.5 ± 0.53	M =	56.9 ± 0.65	SEDiff = 0.84
	SD =	2.93	SD =	3.64	CR = 0.71
	R =	51.03 to 63.0	R =	50.5 to 67.0	
Angle of Convexity	M =	+4.9 ± 0.84	M =	+2.5 ± 0.83	SEDiff = 1.112
	SD =	4.70	SD =	4.62	CR = 2.03
	R =	—5.0 to +12.0	R =	—6.0 to +16.5	
Angle of AB Plane to Facial Plane	M =	—6.2 ± 0.45	M =	—5.7 ± 0.48	SEDiff = 0.67
	SD =	2.51	SD =	2.75	CR = 0.76
	R =	—9.0 to +1.0	R =	12.0 to —1.0	
		Denture Pattern (Downs)			
Cant of Occlusal Plane	M =	+7.3 ± 0.63	M =	6.6 ± 0.71	SEDiff = 0.95
	SD =	3.47	SD =	3.95	CR = 0.76
	R =	—0.5 to +12.5	R =	—1.5 to 16.0	
Angle of Axis of Upper to Axis of Lower Incisor	M =	125.8 ± 1.43	M =	128.8 ± 1.49	SEDiff = 2.07
	SD =	7.95	SD =	8.28	CR = 1.45
	R =	111.5 to 143.0	R =	116.0 to 142.5	
Angle of Axis of Lower Incisor to Occlusal Plane	M =	+22.4 ± 1.04	M =	+20.5 ± 1.02	SEDiff = 1.46
	SD =	5.79	SD =	5.66	CR = 1.31
	R =	+12.0 to +32.0	R =	+7.0 to 29.5	
Angle of Axis of Lower Incisor to Mandibular Plane	M =	+7.3 ± 0.89	M =	+5.0 ± 1.12	SEDiff = 1.43
	SD =	4.98	SD =	6.24	CR = 1.58
	R =	—3.5 to +19.0	R =	—6.0 to +18.0	
Distance from Upper Incisor to AP Plane	M =	+5.3 ± 0.38	M =	+4.5 ± 0.25	SEDiff = 0.45
	SD =	2.13	SD =	1.37	CR = 1.69
	R =	+1.0 to 9.0	R =	+1.5 to +7.0	
		Denture Analysis (Riedel)			
Angle of Upper Incisor to Frankfort Horizontal	M =	114.9 ± 1.07	M =	113.7 ± 0.97	SEDiff = 1.44
	SD =	5.94	SD =	5.43	CR = 0.79
	R =	101.5 to 130.5	R =	106 to 127.0	
Angle ANB	M =	+3.6 ± 0.27	M =	+2.7 ± 0.32	SEDiff = 0.42
	SB =	1.53	SD =	1.81	CR = 1.95
	R =	—3.0 to +6.0	R =	0.0 to +7.5	
Angle of Frankfort Horizontal to NA	M =	91.2 ± 0.64	MU =	91.4 ± 0.71	SEDiff = 0.96
	SD =	3.55	SD =	3.94	CR = 0.11
	R =	86.0 to 100.5	R =	82.5 to 98.5	
Angle of AB Plane to Occlusal Plane	M =	90.1 ± 0.62	M =	91.5 ± 0.41	SEDiff = 0.74
	SD =	3.48	SD =	2.30	CR = 1.88
	R =	82.0 to 96.0	R =	85.0 to 96.0	

a Mean
b Standard Deviation
c Range
d Standard error of the Differences
e Critical Ratio

TABLE 2

Combined Group to Downs' Group — "t" Test

Measurement	Combined Group	Downs' Group	"t"
	Skeletal Pattern (Downs)		
Facial Angle	M = +89.4 ± 0.43	M = +87.9 ± 0.80	1.704
	SD = 3.35	SD = 3.57	
	R = 82.0 to 96.0	R = 82.0 to 95.0	
Mandibular Plane Angle	M = 22.7 ± 0.60	M = +22.9 ± 0.72	0.175
	SD = 4.71	SD = 3.24	
	R = 11.5 to 33.5	R = 17.0 to 28.0	
Y Axis	M = +57.2 ± 0.42	M = +59.3 ± 0.85	2.356
	SD = 3.32	SD = 3.82	
	R = 50.5 to 67.0	R = 53.0 to 66.0	
Angle of Convexity	M = +3.7 ± 0.61	M = 0.0 ± 1.14	2.934
	SD = 4.81	SD = 5.09	
	R = —6.0 to +16.5	R = —8.5 to +10.0	
Angle of AB Plâne to Facial	M = —5.9 ± 0.32	M = —4.7 ± 0.60	1.826
	SD = 2.50	SD = 2.67	
	R = —12.0 to +1.0	R = —0.0 to —9.0	
	Denture Pattern (Downs)		
Cant of Occlusal Plane	M = +6 9 ± 0.47	M = +9.2 ± 0.86	2.363
	SD = 3.74	SD = 3.83	
	R = —1.5 to +16.0	R = +1.5 to 14.0	
Angle of Axis of Upper Incisor to Axis of Lower Incisor	M = +127.3 ± 1.05	M = +137.5 ± 1.29	5.092
	SD = 8.26	SD = 5.76	
	R = 111.5 to 143.0	R = 130.0 to 150.5	
Angle of Axis of Lower Incisor to Occlusal Plane	M = +21.5 ± 0.74	M = +14.5 ± 0.80	5.061
	SD = 5.80	SD = 3.48	
	R = +7.0 to +32.0	R = +3.5 to 20.0	
Angle of Axis of Lower Incisor to Mandibular Plane	M = +6.2 ± 0.73	M = +1.5 ± 0.85	3.388
	SD = 5.76	SD = 3.78	
	R = —6.0 to +19.0	R = —8.5 to +7.0	
Distance from Incisor to AP Plane	M = +4.9 ± 0.23	M = +3.1 ± 0.39	3.870
	SD = 1.82	SD = 1.73	
	R = +1.0 to +9.0	R = —1.0 to +5.0	

vexity can be shown to be significantly larger (more acute) in the younger age group. No other significant differences could be shown.

In comparison of the denture pattern of the combined group to Downs' group the following significant differences could be shown: The angle of the axis of the upper incisor to the axis of the lower incisor was more acute in the younger age group; the angle of the axis of the lower incisor to the occlusal plane more acute, and to the mandibular plane more obtuse; and the distance from the incisal edge to the upper incisor to the AP plane was greater in the younger age group.

DISCUSSION

In view of the foregoing data, it can

be said that in the age group studied, the male has a more convex face than the female, as the critical ratio between the mean angles of convexity of the male and female groups is greater than two. This finding is in some measure corroborated by the work of Yellen,[14] who compared mandibular and maxillary length in males and females in this age group. He showed that both the maxilla and mandible are significantly larger in the male, but that the critical ratio between the maxillae of the two groups is greater than the critical ratio between the mandibles. Thus, although the maxilla and mandible is larger in the male, the size gradient is greater in maxilliary size. This tends to produce a more protrusive middle third of the face and hence, a more acute angle of convexity.

Another explanation of the angle of convexity being larger in males than in females in the group studied is that the mean facial angle of the male group is less although not significantly different from the female group. This would place the chin point in a more posterior relation in males than in females. A combination of both of these factors would explain our findings.

It can also be said that in comparison to an older group, the younger group have more convex faces, less upright incisors measured from either occlusal plane or mandibular plane, and a more protrusive denture measured from the incisal edge of the upper incisor to the AP plane. These differences are shown by the significant values obtained when the "t" test was applied in comparing the combined male and female groups to Downs' group. The distance from the incisal edge of the upper incisor to the facial plane is also significantly greater in the younger age group, showing a more protrusive denture.

It is important, therefore, that we appreciate the differences in the skeletal and denture patterns of children and those of adults. The child must be compared to a normal range compiled for his own age group and not to one of an adult or older age group. Similarly, the ideal of treatment should be a denture pattern within the normal range for the particular age group of the patient, within the limits of the skeletal pattern, again evaluated by comparison to a normal range for that particular age group.

Consideration should also be given to the fact that at least in the age group studied the males have a higher angle of convexity than the females.

Summary and Conclusions

1. A cephalometric evaluation of the normal skeletal and dental pattern of children with excellent occlusions has been made.
2. It was shown that in this age group the males had more convex faces than the females. (Greater Angle of Convexity).
3. It was also shown that compared to an older age group, the group studied in this work had a more convex face, less upright incisors measured from either occlusal plane or mandibular plane and a more protrusive denture measured from the incisal edge of the upper incisor to the AP plane.
4. The importance of comparing a child to a normal range for his own age group is discussed.

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