Cephalometric Patterns of Adults with Normal Occlusion

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Skeletal growth and development of the head has been studied and evaluated by orthodontists more than by any other profession. It has been observed that there develops a sense of balance and harmony between the parts that make up the dentofacial complex in individuals who possess clinically excellent untreated occlusions. Patients with ideal occlusions are believed to represent standards against which malocclusions (which may be of a skeletal or dental etiology) and treated cases may be judged. These values are used to orient the investigator's thinking and are not always considered objectives in treatment.

This report is a survey of the dentofacial cephalometic patterns of adults possessing near ideal occlusions. The cephalometric patterns were measured using the Ricketts analysis by Rocky Mountain Data Systems. Our key objectives are to establish and confirm standards of idealism in facial patterns in adults and to correlate this information to various facial types according to vertical descriptions of growth and ethnic background. The information will be used for re-establishing norms upon which treatment planning can be based.

Literature Review

To critically evaluate findings and to communicate them clearly and accurately, it is necessary to express the structural dimensions of the head and neck in terms of angles and/or linear measurements. As stated by Ricketts,[17] "Thus, the purpose of analysis is objective and encompasses the four 'C's' of cephalometrics. These are: 1) to characterize or describe the conditions that exist, 2) to compare one individual with himself at a later time, 3) to classify certain descriptions into various categories, and 4) to communicate all of these aspects to the clinician, to a fellow research worker, or to the patient."

Dr. Downs'[9] first article encompasses Ricketts' first "C" of cephalometrics by describing a method of analyzing the conditions which exist in a lateral cephalometric roentgenogram. He used a sample of twenty males and females all of whom presented clinically excellent occlusions.

He emphasized that the skeletal framework, the denture, and the overlying musculature are the component parts of the face that constitute balance and harmony. Also, there is a facial pattern that represents an average form in individuals possessing excellent occlusions. The deviations noted on both sides of the mean values show the variations that are encountered when appraising the balance and harmony of the individual being studied. Excessive deviations represent disharmonies between the skeletal and dental parts of the individual being studied.

A second article written by Dr. Downs[10] supplements the first and includes Ricketts' second and third "C's" of cephalometrics. The static analysis is that expression of a condition of relationships at a particular time; a dynamic analysis is a comparison of two or more static analyses and is, therefore, a longitudinal study of growth and/or orthodontic changes. Downs' methods of appraising static and dynamic cephalometric analyses and their bearing on treatment planning and prognosis are discussed.

A third article by Downs[11] supplements the first two. It is noted that if the normal facial pattern and its range of variations could be described, then the abnormal one could be judged by comparison. The Frankfort horizontal is used as the plane for describing the profile; this plane shows a high correlation between radiographs and photographs.

Ricketts[21] has illustrated the stability and advantages of the Frankfort and basicranial planes in all dimensions over other commonly used references. Facial types such as retrognathic, mesognathic, and prognathic are also described. These types are then correlated with the angles of convexity to produce various profile combinations.

This article brings out Ricketts' fourth "C" of cephalometrics. He describes a method of graphing the dentofacial patterns by utilizing the Vorhies and Adams polygon graph. It shows that regularity of an individual pattern is indicative of harmony and balance.

Age differences in the facial complex have been of major interest to researchers in normal occlusion. Brodie,[5] in a study of growth to the eighth year of life, reported, "The morphogenetic pattern of the head is established by the third month of postnatal life, or perhaps earlier, and once attained does not change." This may be true in certain respects, but the statement is misleading. In a later study,[6] of a group of nineteen boys from the ages of 8-17 or beyond, he found that the late stages of growth are accompanied by a continuation of forward and downward movement of pogonion and the anterior nasal spine. The dental arch and the supporting bone tend to drop behind and thus the prominence of the denture appeared to be decreased. He states that this decrease in the prominence of the denture is not necessarily accompanied by a more upright position of the incisors. In the region of the superciliary arches a late outgrowth occurs which carries this portion of the face forward. There is no change in the length of the anterior cranial base during this time. Therefore, this growth is concerned with the face rather than the brain case due to apposition of bone on the external surface. Dr. Brodie states that in spite of these and other changes, there is still a marked constancy and stability of the individual pattern, "One cannot but be impressed with the orderly development of the various types of faces and the adherence to an original proportionality which seems to be characteristic of each." This adherence to an original proportionality will aid the orthodontist when considering growth changes to be anticipated and/or altered orthopedically in his patients, particularly those changes occurring or desired in the profile.

The results of Björk's[3] study do not entirely agree with Brodie. His is a cross-sectional investigation of the facial structures based on cephalometric X-rays of twelve year old boys and an approximately equal number of adult males. It showed that the facial structure is subject to considerable growth changes in pattern during adolescence.

Other studies that examined changes occurring through normal growth were conducted by Williams,[24] Merow,[14] Lande,[13] and Coben.[8]

The changes in the pattern are discussed by Dr. Downs.[11] His evidence shows that in normal growth the mandible moves forward faster than the maxilla. The facial angle increases from a norm in the deciduous age of 82° to 88° in the 14.5 year-old sample. The angle of convexity decreases from 10 to 0 degrees. Vertical growth is greater in the area of the ramus than the profile. The mandibular plane angle decreases from 28° to 22. The AB plane, which expresses the anteroposterior relationship of the maxillary and mandibular denture bases, and the Y axis show the least difference for the two age groups.

It should be noted that with the eruption of the permanent incisors, the denture suddenly becomes very protrusive. It is at this time that the child's face, particularly in the oral area, becomes full and is often mistaken for an abnormal dental protrusion.

Downs' third article includes a section on sex differences in growth and the effect of these differences on the soft tissues, as well as the "profile arc" which passes through nasion, point A, and pogonion.

The lower incisor to the point A-pogonion plane as described by Ricketts[17] is believed to be a descriptive and useful measurement. Dr. Downs' sample gave a mean angle of 23° with a standard deviation of 3 degrees. The distance of the incisal edge to the A-Po plane was also measured and showed a variation of —2 to + 3 mm and a mean of .5 mm according to type and soft tissue balance.

Baum,[2] in a review of the literature on growth, points out that the sex and age of the individual must be considered. They must be coordinated with the level of maturation of the individual. He summarizes with a "three L" postulate of boys' growth pattern, "Boys grow later, longer, and larger than girls." In other words, boys achieve more growth over a longer period of time and they begin this growth at a later time relative to chronological age.

Methods and Materials

Patient records for this project were submitted by members of the Foundation for Orthodontic Research. Complete diagnostic records were obtained on 90 Caucasian adults with near ideal untreated occlusions. Of those submitted, 82 were selected for the most ideal occlusions, 43 females and 39 males. The criterion for selection was the basis of normal and healthy occlusion as described by Ricketts.[19] The facial musculature of these individuals displayed physiologic balance and harmony. The material included the following complete orthodontic records: models, photographs, headplates in occlusion (frontal and lateral) and full-mouth X-rays, panorex, and/or laminagraphs if available.

The tracings were made by the Rocky Mountain Data System.[28] Complete cephalometric descriptions including 68 measurements from two dimensions were analyzed using their computer system.

The individual's facial pattern may be considered a key determinant of treatment selection. A single number is assigned which separates the degree to which the face is a vertical (dolicofacial) pattern or horizontal (brachyfacial) pattern.

To calculate this, number the *clinical deviations* from the normal six key measurements: the lower face height, facial axis, mandibular plane angle, posterior facial height, facial width and mandibular arc, are added and averaged with the proper sign to divide individuals into five groups: severe dolicofacial, dolicofacial, mild vertical, normal or standard, and brachyfacial (Table I).

The vertical description is a number expressed in clinical deviations so that negative numbers indicate vertical patterns, between —1 and + 1 standard and numbers greater than + 1 indicate brachyfacial patterns.

The word standard is used rather than normal because we are describing the facial type. Any of the five categories of vertical description of growth may have near ideal or "normal" occlusion.

TABLE I

CALCULATION OF FACIAL PATTERN VERTICAL DESCRIPTION

Measurement	*Clinical Norm*	*Clinical Deviation*	*Sign Indicating Brachyfacial*
Lower Face Height	47° Stays constant with age.	±4.0°	— (minus)
Facial Axis	90°	3.5°	+ (plus)
Mandibular Plane Angle	26° at age 9. Decreases 0.3° per year.	4.5°	—
Posterior Facial Height	55 mm for a patient of average size at age 8.5. Should be corrected for size.	3.3 mm	+
Facial Width	115.7 mm at age 9, increases 2.4 mm per year.	3.0 mm	+
Mandibular Arc	26° at age 8.5. Increases 0.5° per year.	4.0°	+

$$\text{Clinical Deviation from Norm} = \frac{\textit{Measured Value — Norm}}{\text{Clinical Deviation}}$$

FACIAL PATTERNS NUMERICAL RANGES

Severe Dolicofacial	*Dolicofacial*	*Mild Vertical*	*Standard*	*Brachyfacial*
less than —2	—2 to —.99	—1 to —.49	—.5 to +.99	+1 or greater

Results

Our sample in terms of overall facial pattern was composed of 39 brachyfacials, 39 standards and 4 dolicofacials.

Since there were only four dolicofacial patterns in our entire normal occlusion sample, our tables of measurements included only the standard and brachyfacial categories, Tables II and III.

Our findings illustrate that individuals with a more brachyfacial pattern have a better chance than other facial types of having a normal occlusion. The averaged facial axis is forward at 93° and the mandibular plane 19 degrees. The sample also has a short averaged anterior lower facial height. Although these cases have a long posterior facial height, they are saved from being pseudo Class III by having a short corpus length. The convexity of 1.3 mm is less than in the standard facial pattern which is 2 mm. Viewing the skeletal frontally, it is seen that the nasal cavity and the maxilla are wider.

The dentition also tends to what would be expected in a brachyfacial person. The interincisal angle is smaller leaving the incisors more protrusive with the mandibular first molars 1 mm wider. There is greater distance from the upper first molar to the PTV. The lower incisor is more than 2 mm anterior to the A-Pog plane; this measurement is consistent in all facial patterns and vertical descriptions of growth in our sample.

There are large differences in the sizes of the skeletal structures between males and females. Some important indications of this are found in males with a 5 mm greater corpus length, an 8 mm longer posterior facial height and a 5 mm greater anterior cranial length. The mandibular plane is one degree less in males than in females. The facial plane, facial axis and convexity do not vary significantly with sex in our sample. In the frontal dimension, males have a 4 mm larger maxillary width, a 1 mm wider nasal cavity, and a 5 mm wider mandible.

The dentition of females is slightly more upright and less protrusive. The lower first molars are 3 mm wider in males as would be expected with the wider mandible. Also, the upper molar

TABLE II

LATERAL COMPREHENSIVE CEPHALOMETRIC DESCRIPTION

Occlusal Relation	*Standard Males*	*Standard Females*	*Brachy Males*	*Brachy Females*
01 Molar Relation, mm	— 2.0	— 2.4	— 1.8	— 1.8
03 Canine Relation	— 0.4	— 0.4	— 1.2	— 0.3
05 Incisor overjet	2.9	3.2	2.9	3.0
07 Incisor overbite	2.2	3.2	2.4	3.5
09 Lower incisor extrusion	1.7	1.9	2.1	2.3
11 Interincisal angle, deg.	127.9	129.6	128.7	127.5
Maxillo.-Mand. Relation				
13 Convexity	2.4	1.9	— 0.1	0.4
15 Lower facial height, deg.	45.0	45.5	42.1	40.6
Denture to Skeleton				
18 Upper Molar position	22.3	20.3	28.7	23.7
20 Mand. Incisor protrusion	3.0	2.3	2.6	2.0
22 Max. Incisor protrusion	5.8	5.3	5.3	4.6
24 Mand. Incisor inclin, deg.	24.8	25.8	25.6	27.6
26 Max. Incisor inclin., deg.	27.4	24.6	25.7	24.9
27 Occlusal Pl Ramus (XI)	— 1.2	— 0.8	0.4	— 1.0
28 Occlusal Pl. inclin. deg.	23.5	23.6	21.1	20.8
Esthetic Problem Lip Relation				
29 Lip Protrusion	— 2.8	— 3.0	— 5.3	— 4.4
30 Upper lip length	28.9	26.2	28.3	25.1
31 Lip Em.—Occl. Pl.	— 2.5	— 3.0	— 2.7	— 2.6
Cranio-Facial Relation				
32 Facial Depth, deg.	91.2	90.3	92.8	93.1
34 Facial Axis	90.8	90.7	95.5	95.4
35 Facial Taper	67.8	67.4	71.9	71.1
36 Maxillary Depth	93.4	92.1	92.6	93.5
37 Maxillary Height	56.3	56.1	53.3	54.1
38 Palatal Plane (FH)	3.2	1.8	1.9	4.2
39 Mand. Plane (FH)	21.1	22.3	15.3	15.8
Deep Structure				
40 Cranial Deflection	29.0	28.4	27.5	28.4
42 Cranial Length Anterior	62.5	59.3	65.9	60.3
44 Posterior Facial height	71.3	66.4	78.6	68.0
46 Ramus Position, deg.	77.5	78.5	80.4	79.2
48 Porion Location (TMJ)	—41.5	—39.8	—42.8	—39.3
50 Mandibular Arc, deg.	34.7	31.8	38.4	37.5
51 Corpus Length	77.7	72.4	80.9	74.8

TABLE III

FRONTAL COMPREHENSIVE CEPHALOMETRIC DESCRIPTION

Occlusal Relation	*Standard Males*	*Standard Females*	*Brachy Males*	*Brachy Females*
02 Molar Relation, Left	1.0	1.8	2.3	1.5
04 Molar Relation, Right	0.8	1.5	1.2	1.3
06 Intermolar width, Mand.	58.0	55.0	58.5	56.5
08 Intercanine width, Mand.	26.3	25.7	26.0	26.0
10 Denture Midline	— 0.2	— 0.3	0.0	0.0
Maxillo.-Mand. Relation				
14 Max-Mand width, left	—14.1	—13.0	—13.2	—13.4
16 Max-Mand width, right	—13.0	—13.1	—12.9	—12.9
17 Max-Mand midline, deg.	0.0	0.6	0.4	0.0
Denture to Skeleton				
19 Molar to jaw left, Mand.	8.3	8.3	10.7	7.3
21 Molar to jaw right, Mand.	8.2	8.5	9.2	7.5
23 Denture, jaw midline	— 0.2	0.2	— 0.0	0.0
25 Occlusal plane tilt	— 0.5	— 0.6	0.2	— 0.2
Cranio-Facial Relation				
33 Postural Symmetry, deg.	— 0.8	0.5	— 0.0	0.1
Deep Structure				
41 Nasal Width	29.7	29.5	32.3	29.9
43 Nasal Height	49.9	49.0	51.4	48.7
45 Maxillary Width	64.2	62.0	68.2	62.3
47 Mandibular Width	86.9	83.3	90.3	83.2
49 Facial Width	134.7	127.7	138.5	130.7

is 4 mm farther from the PTV in males than in females.

Discussion

The major finding of this sample was that normal occlusions occur more commonly in people who tend to have brachyfacial skeletal patterns. In fact, there is a clear trend that the more brachyfacial a person, the greater the likelihood of having a normal occlusion. On the other hand, the more severely dolicofacial a person is, the smaller the chance of a normal occlusion. The explanation is rather simple; the brachyfacial person has more room for his or her teeth.

The brachyfacial cases have greater distance from the upper first molar to the central incisor than the cases with standard facial patterns. In addition, there is greater distance from the pterygoid vertical to the upper molars. Consequently, since the brachyfacial people experience more horizontal growth in the jaws, they have larger arches which make more space available for the teeth. The contention that there is less crowding in brachyfacial persons is further supported by an increase in their intercanine and intermolar widths. This wider dentition occurs in a wider maxilla and mandible.

This finding has profound implications to treatment planning. In brachyfacial patients there may be less need to extract teeth to achieve good occlusion. This is not an all or nothing situation; there are dolicofacial people who have normal occlusion. Rather, it means the more brachyfacial a patient is, the greater the likelihood they can be treated successfully with nonextraction because there will be, in the long range of the growth forecast, more available arch length.

The concept of treatment norms must be reconsidered in the light of the findings from this study. It is not possible to apply the same norms and treatment objectives to cases with different facial patterns. The brachyfacial cases have much less convexity than the cases with standard facial patterns. In treatment planning this must be taken into consideration in setting objectives; a person with a "normal" facial structure needs more convexity to get all the teeth into good occlusion. Similarly, the brachyfacial person has a flatter occlusal plane and mandibular plane angle. The key norms used by clinicians in setting treatment objectives should be reassessed to determine whether they are affected by varying facial structures.

Esthetics is a function of the lower lip to the esthetic plane. Of the norms germane to esthetics, those that vary with facial pattern cannot readily be controlled by the clinician. An example of this is lower facial height. The lower facial height is much smaller in brachyfacial than in standard or dolicofacial cases.

Oral gnomons in brachyfacial patterns have a smaller lower facial height and therefore require less muscular stress to allow the lips to rest comfortably over the teeth while remaining in muscular equilibrium with the tongue.

A gnomon is that part added to the size of a form without change in shape, like a sea shell growing larger in proportional increments. It illustrates the "constancy" of the pattern. The points describing the oral gnomon for this description are from the anterior nasal spine to Xi point to super pogonion or DM point.

A significant point in this study was that the sample size was not large enough in all the various vertical descriptions of growth. We assume, therefore, that there are fewer normal occlusions with vertical, dolico, or severe dolicofacial descriptions of growth because of their low incidence in our sample.

Summary and Conclusions

1. People with normal occlusion tend to have more brachyfacial than dolicofacial patterns.

2. Many of the norms vary significantly with the different facial patterns. When treating a patient, the norms used should reflect differences associated with the various facial patterns and sex. This will enable us to treat with fewer extractions with the confidence that the teeth and bony structure will remain stable.

3. Our findings re-establish and reconfirm our cephalometric standards for adults based on the individual's facial type as described by his or her vertical description of growth and ethnic type. We can be accurate in treating the patient to the clinical normal for that individual and not to an overall composite of the average.

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Bibliography

1. Abrams, Isaac N.: Oral muscular forces, *Angle Orthod.* 33:83-104, 1963.
2. Baum, A. T.: Age and sex difference in dentofacial changes following orthodontic treatment, *Am. J. Orthod.* 47:335, 1964.
3. Björk, A.: *The Face in Profile*, Berlinska Bok Trycheriet, Lund 1947.
4. Broadbent, B. Holly: Notes from lecture material presented at the Bolton Foundation, Western Reserve Univ., Nov. 1963.
5. Brodie, Allan G.: Growth pattern of the human head from the third month to the eighth year of life, *Am. J. Anat.* 68:209-62, 1941.
6. ———: Late growth changes in the human face. *Angle Orthod.* 23:146-57, 1953.
7. ———: Facial patterns, a theme on variation, *Am. J. Orthod.* 16:75-87, 1947.
8. Coben, Eugene: Growth concepts, *Angle Orthod.* 31:194, 1961.
9. Downs, William B.: Variations in facial relationships, their significance in treatment and prognosis, *Am. J. Orthod.* 34:812-840, 1948.
10. ———: The role of cephalometrics in orthodontic case analysis and diagnosis, *Am. J. Orthod.* 38:162-182, 1952.
11. ———: Analysis of the dentofacial profile, *Angle Orthod.* 26:191-212, 1956.
12. Hellman, Milo: Introduction to growth of the human face from infancy to adulthood, *Int. J. Ortho. and Oral Surg.* 18:777-98, 1932.
13. Lande, Milton: Growth behavior of human bony facial profile as revealed by serial cephalometric roentgenology, *Angle Orthod.* 22:78-90, 1952.
14. Merow, W. W.: A cephalometric statistical appraisal of dentofacial growth, *Angle Orthod.* 32:205-13, 1962.
15. Riedel, Richard A.: The relation of maxillary structure to cranium in malocclusion and in normal occlusion, *Angle Orthod.* 23:142-145, 1952.
16. Ricketts, Robert M.: A foundation for cephalometric communication, *Am. J. Orthod.* 46:330-357, 1960.
17. ———: Cephalometric analysis and synthesis, *Angle Orthod.* 21:141-156, 1961.
18. ———: New perspectives in orientation and their benefits to clinical orthodontics. Part I. *Angle Orthod.* 45: 1975.
19. ———: Occlusion—the medium of dentistry, *J. Pros. Dent.* Vol. 21, No. 1. 39-60.
20. ———: The keystone trend, *Am. J. Orthod.* 50:244-264, 728-750, 1964.
21. ———: The influence of orthodontic treatment on facial growth and development, *Angle Orthod.* 30:103-133, 1960.
22. Schulof, Robert: Data-bits, profiles from RMDS, Jan. 1976.
23. Steiner, Cecil C.: Cephalometrics for you and me, *Am. J. Orthod.* 39:729-755, 1953.
24. Williams, B. H.: Craniofacial proportionality in horizontal and vertical plane. *Angle Orthod.* 23:26-34, 1963.
25. Winders, Robert V.: Recent findings in myometric research, *Angle Orthod.* 32:38-43, 1962.
26. Wylie, Wendell: Assessment of anterior-posterior dysplasia, *Angle Orthod.* 17:97-109, 1947.
27. Ricketts, Robert M.: New perspectives in orientation and their benefits to clinical orthodontics—Part II, *Angle Orthod.* 46:26-37, 1976.
28. Rocky Mountain Data Systems, Inc.: Computerized cephalometrics manual revised edition, June 1973.