# A Cephalometric Study of Cranial, Mandibular, and Lower Incisor Morphology in the Adult Face

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In the practice of orthodontics a knowledge of what constitutes normal growth and development is of great importance. Throughout the orthodontic literature, frequent reference is made to the growth processes which ultimately result in adult face morphology. Understanding of normal development has enabled us to accurately predict cranial and upper face growth and to separate those portions of the growing face which deviate from the normal. Unfortunately, prediction of mandibular growth is not completely reliable. Only through understanding what constitutes a "normal" face are we able to make diagnostic predictions.

The mandible is believed to play a dominant role in the development of a well-balanced face. The location of the mandible with respect to the remaining craniofacial complex gives us much of the diagnostic information upon which we build treatment plans. The angulation and positioning of the mandibular incisors sometimes determine the course and type of treatment patients receive.

The purpose of this study was to determine the morphology of the mandible and the cranial base, and then relate this information to the position of the mandibular incisors in untreated Class I individuals with full dentitions.

The data in this study were used to calculate mean values for each measurement observed. Methods were employed to discover basic differences, similarities, and correlations. The observations were tested for statistical probability.

## Literature Review

With the introduction of the Downs analysis,[10-12] a universally acceptable means of communication concerning skeletal and dental patterns was established. This analysis provides an excellent means of appraising the facial pattern.

Coben[8] studied headplates of 25 males and 22 females at 8 years, plus or minus 1 year; and at 16 years, plus or minus 1 year. He suspected that correlations existed between the morphology of the cranial base, the mandibular plane angle, and the mandibular incisor positioning. One of his findings was that the mean gonial angle of 126.2 degrees at 8 years of age decreases an average of 4.6 degrees for males and an average of 4.8 degrees for females by the age of 16.

Björk[2] found the gonial angle in 45 males to decrease from the fifth year to the twenty-second year of age. The reduction averaged 6 degrees, changing the average from 129 degrees to 123.

Brodie[4,5] noticed that when the serial tracings of an individual were superimposed on the mandibular plane, which is known to be relatively stable, the gonial angle remained in a relatively constant relationship.

Changes in the form of the ramus, gonial angle, and the condyloid and coronoid processes of the mandible give us clues concerning the expected changes in the growth of the mandible. Ricketts[18] has suggested that an increase in the depth of the ramus will be accompanied by the development of the more acute gonial angle.

Based on a master's thesis at the Ohio State Univ., March 1974.

Both Johnson[16] and Schudy[21] have shown a direct relationship between the size of the gonial angle and the size of the Frankfort mandibular plane angle. As the gonial angle tends to open, the mandibular plane angle increases. This results in more than average vertical development. They believed that the height of the alveolar process is adaptive to the inherited gonial angle.

Richardson[17] has shown high degrees of significance in the relationship of the sella-articulare-gonion (S-Ar-Go) angular measurements and articulare-gonion-menton (Ar-Go-Me) to the degree of anterior open bite and deep overbite. As S-Ar-Go and Ar-Go-Me increase there is more tendency to open bite. The linear measurement nasion to sella showed relationship to open and deep bites; as the measurement decreased, a tendency to open bite developed.

Hunter, Balbach, and Lamphiear[15] investigated the heritability of certain features. They found the most significant correlations occur between the measurements of fathers and offspring.

Avery[1] studied the gonial angle and found the strongest similarity to be between mother and son, with the similarity increasing with age change. This suggests influence of the maternal x-chromosome being expressed only with the son.

For making predictions concerning mandibular growth, Ricketts[20] considers the mandibular plane angle, the inclination of the gonial angle, the width of the ramus and synthesis, condylar thickness and angulation, and the corpus mandibular length. He believes the past growth of the mandible indicates its future growth possibilities.

A conflict of opinion exists concerning the positioning of the mandibular incisors relative to the mandibular plane. Downs found a mean angle of 91.4 degrees. Tweed[23] analyzed the work of Brodie and of Broadbent and found considerable variation in the mean measurements of the relationship of the mandibular incisor to the mandibular plane. Brodie's subjects had a mean angle of 88.3 degrees; Broadbent's children of 14 years of age had a mean angle of 89.5 degrees. Tweed found a mean angle of 87.88 degrees in subjects with facial esthetics that he considered good or excellent.

In a study by Cottrill[9] the mandibular incisor was found to become more protrusive with age. A 4 degree labial tip was noted from the average age of 15 years to the average age of 23.5 years.

Tweed[24] related the mandibular incisor to the Frankfort plane and believed the incisor angulation (FMA) should be approximately 65 degrees in cases with a Frankfort mandibular angulation of 25 degrees. The location of the incisor with respect to the mandibular plane will vary as the mandibular plane varies if the incisor is to be kept at 65 degrees to the Frankfort plane.

Ricketts[19] advocates use of the A point-pogonion (APog) plane or a corrected (synthesized) APog plane in locating the final position of the mandibular incisor. The location of the mandibular incisor to this plane is 1,000 treated orthodontic cases was found by Ricketts to average 0.5 mm at 21 degrees.

Enlow et al.[13,14] point out the number of variables which exist in the face. An alteration in any portion of the craniofacial complex produces an equal, and sometimes opposite, alteration in another part of the craniofacial complex. Because of the intrinsic ability of the individual to compensate for regional growth alterations, a marked change in one anatomic part does not necessarily prevent the development of a face of natural proportions.

TABLE I

| | | Entire Sample | Group B | Group W | Group A |
|---|---|---|---|---|---|
| Frankfort Mandibular Angle | Mean | 23.53 | 14.62 | 23.03 | 32.95 |
| | S.D. | 7.46 | 3.88 | 2.90 | 5.02 |
| Incisor Mandibular Plane Angle | Mean | 96.32 | 102.21 | 96.42 | 92.95 |
| | S.D. | 7.25 | 6.73 | 4.71 | 5.02 |
| Gonial Angle | Mean | 122.34 | 115.32 | 122.07 | 128.43 |
| | S.D. | 6.31 | 5.83 | 5.83 | 5.39 |
| Articular Angle | Mean | 143.29 | 142.10 | 143.37 | 144.42 |
| | S.D. | 6.92 | 6.88 | 5.71 | 7.42 |
| Cranial Articular Angle | Mean | 125.76 | 125.90 | 126.38 | 125.00 |
| | S.D. | 5.29 | 4.22 | 5.89 | 5.52 |
| Sum of Articular and Cranial Articular Angles | Mean | 269.27 | 268.33 | 269.75 | 269.73 |
| | S.D. | 5.95 | 4.00 | 3.81 | 7.75 |

## Methods and Materials

A study sample of 90 with ages ranging from 12 years 6 months to 27 years 6 months (mean 18.5) consisted of 43 males and 47 females taken from the records of the orthodontic department of Ohio State University.

The total sample was divided into three groups: (B) individuals with FMA less than 18 degrees, (W) those with angles 18.5 to 27.5, and those (A) with FMA angles 28 degrees and over.

The points nasion (N), sella turcica center (S), Bolton (Bo), articulare (Ar), gonion (Go), and menton (Me) were recorded. The following planes were constructed: NS, N-Bo (Bolton), SAr, ramal (Ar-tangent to posterior border of mandible), mandibular (Me tangent to lower border of mandible), and long axis of the mandibular incisors. The Frankfort plane was arbitrarily placed 22.5 degrees to N-Bo.

NS intersected with SAr formed the cranial articular angle; SAr crossing the ramal plane at Ar formed the articular angle; the gonial angle was constructed by the ramal and mandibular planes; the intersection of the long axis of the lower incisors and mandibular plane formed the IMPA angle. A combination measurement was also utilized, the sum of the articular and cranial articular angles.

Statistical data obtained were means, standard deviations (S.D.), standard errors (S.E.), 95% confidence ranges, students "t" tests, and correlation analyses.

## Results

A summary of the various angles of the total sample and the different groups is detailed in Table I.

Table I reveals that only small differences exist in the measurement of the articular and cranial articular angles. However, when the raw data were viewed it could be seen that variations in the angulations do exist. It was thought that compensations in the angular measurements were being viewed. This was true. The sum of the value of the two angles shows such compensation (Table I). These findings indicate only slight differences between the ninety subjects.

## Discussion

The mean of 23.53 degrees, gathered from our group of ninety individuals with Class I occlusion, regardless of tooth crowding or facial esthetics, together with Downs' and Tweed's figures represents a true total population mean.

Mandibular incisor positioning showed the greatest variation when compared with previous works. Downs' mean of 91.4 degrees, reported for individuals 14.6 years of age with ideal occlusion, was 4.92 degrees less than ours. Table I shows that IMPA value is higher than indicated by previous studies done on younger age groups. This increased angulation was expected and has been reported by other investigators. The lower incisor was shown to be related to the increasing or decreasing FMA in an inverse manner.

Measurements of the gonial angle agreed with the means found by previous researchers. Our mean for the ninety individuals was 122.34 degrees. Coben's subjects at 16 years of age showed a mean of 121.5 degrees and Björk's sample had a mean of 123.0 degrees. This angle relates directly with the FMA and inversely with the mandibular.

When FMA is used to separate the ninety individuals into groups, variations in the gonial angle can be demonstrated. The student "t" test indicated ($P < 0.01$) that the differences observed in our study are statistically significant. As the FMA increases, the gonial angle opens and vice versa. These findings tend to indicate that the gonial angle may be of much greater importance in growth predictions than previously thought.

The articular angle assumed a relatively constant mean value throughout the entire sample. The cranial articular angle behaved similarly.

Viewed individually, the articular and cranial articular angles show considerable variation; however, when variations in the angles exist, the sum of the two angles totals a remarkably constant value. To test their inverse relationship, a correlation analysis was performed. Since the mean value for each group was closely related, the groups were combined into the total sample of ninety individuals. The "r" has significance at the 5.0% level if the value calculated reaches 0.268 for a sample of ninety. In this study the "r" value was minus 0.5285 indicating that the relationship between the articular angle and the cranial articular angle is inversely related ($P < 0.01$). It is thought the finding further substantiates craniofacial compensation.

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