Behavior of the Axis of Human Incisor Teeth During Growth[1]

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Since 1936, when Tweed published his philosophy of treatment of malocclusion of the teeth, there has been widespread interest in the axial inclination of the lower incisor teeth. This interest sprang from his contention that the most stable and esthetic results were obtained when these teeth were made to assume an upright position over the body of the mandible, and from his advocacy of extraction of teeth to accomplish this in those cases where there was thought to be too much tooth material to permit such placement by ordinary methods.

A concern over the stability and esthetics of treated malocclusions has appeared periodically in orthodontic writings for over one hundred years and each time that it has attained prominence, it has revived the practice of extraction of teeth as a necessary adjunct to treatment. Most of the ensuing controversy has revolved around the propriety of this practice.

John Hunter, in his "Natural History of the Human Teeth" (1778), held that since the teeth were active agents in the promotion of jaw growth, their loss imposed a handicap on such growth. Delabarre, in 1819, stated a similar conviction in the following words:

> "It is much easier to extract teeth than to determine whether it is absolutely necessary. The extraction of a tooth requires nothing more, on the part of the practitioner, than a degree of facility in the use of instruments that are usually employed in this operation; whilst the knowledge necessary to appreciate the consequences can only be acquired by time and study."

In 1899, Angle announced his "Classification of Malocclusion of the Teeth" and for the first time, functional aspects began to receive attention in place of esthetics. Angle described the normal occlusal relations of the teeth and maintained that orthodontic therapy should be directed solely toward the gaining of such relations.

> "The best balance, the best harmony, the best proportions 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."

Angle recognized that interdental relations were not sufficient unto themselves since the denture was a part of a larger structure, the head, and consequently the relationship between these two would have to be established. He finally accepted the chief chewing tooth of the maxilla as the key to this relation and, in 1905, published his "Upper First Permanent Molar as a Basis for Diagnosis in Orthontia." This was the first attempt to relate the denture to the head through the placement of a single tooth.

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In 1926, Simon published his "Law of the Canine" which held that a perpendicular to the Frankfort Horizontal Plane dropped from the left orbitale passed through the tip of the maxillary canine in normal occlusion. Basing treatment on this, he advocated extraction of teeth in all cases where this plane passed posteriorly to the canine, claiming that such cases exhibited abnormal forward positioning of the maxillary dental arch. Similar views were expressed by Grieve (1941) in his paper "Analysis of Malocclusion, Based upon the Forward Translation Theory."

In 1936, Tweed advanced the relation of the lower incisor teeth to the mandible as the method of choice in relating the teeth to the face, claiming that only when these teeth stood upright over what he termed "basal bone" could stability of results be expected and the best esthetic proportions of the face be obtained.

With the exception of Angle and Grieve, each of these authors advanced methods of determining tooth-face relationships. Thus Simon employed gnathostatics which was a modification of accepted craniometric techniques. The advocacy of the lower incisor led to the employment of a variety of methods aimed at relating this tooth to the mandible as well as to the face as a whole. Tweed himself, used a sagitally sectioned plaster model of the lower dental arch and read the axial inclination of the tooth to the occlusal plane. Salzman introduced the "Maxillator" by means of which various face and jaw measurements and relationships could be taken directly from the patient. Fischer advocated the use of oriented mandibular radiograms and sectioned oriented casts. Margolis suggested composite x-ray photographs. A number of others (Noyes, Rushing, and Sims; Speidel and Stoner; Brodie; Bjork; Downs; Higley and Corlett) employed cephalometric roentgenography in normal lateralis.

In each of these studies, the effort was made to relate the axis of the incisor teeth to certain anatomical planes. Thus Tweed later used a plane "parallel with the lower border or base of the mandible in sagittal view." He declared the mean measurement of this angle gave a value of $90° + 5°$.

Noyes, Rushing and Sims, employing a similar mandibular plane, arrived at mean values of 89.4° on 14 living individuals and 92° on 9 skulls. In 15 malocclusions of the Class II, Division 1 type, their mean was 92° and on Class III, 82.1°. Speidel and Stoner on a sample of 42 young adults obtained a mean of 92.64°. Brodie obtained means of 90.9°, 89.3° and 86.6° on 94 malocclusions of Class I, Class II, Division 1 and Class II, Division 2 types, respectively. Downs reported a mean of 91.4° on a sample of 45 normal occlusions.

All of the above studies were conducted on normal occlusions or on untreated malocclusions and it will be noted that aside from Class III and Class II, Division 2, the mean values obtained by the various investigators are strikingly similar and that all are close to the 90° advanced by Tweed. However, the small range of 10° which he claimed for his clinical findings was not found by any of the others. Those reporting on normal occlusions, Noyes, Rushing and Sims, Speidel and Stoner, and Downs, found ranges of 23°, 28° and 15°, respectively. In the malocclusions, Brodie reported ranges of 28° for Class I, 35° for Class II, Division 1 and 42° for Class II, Division 2. On the basis of these studies, Brodie was led to write:

> "These studies exemplify once more the fallacy of employing a mean as a criterion for the individual. With such a large range in this angle, it would seem impossible to employ it as a basis for clinical judgment. It would seem but logical to conclude that the axial inclination of the lower incisor, like any other anatomic feature, varies greatly and is probably just as much a part of the individual's pattern as are other details of his physiognomy."

Another relationship that has attracted the attention of those concerned with the proportions of the face, and the attention of the orthodontist in particular, is the degree of prognathism of the dental area. Both Case and Cryer were critical of the results of some of Angle's treated cases, claiming that his insistence on placing a full complement of teeth in jaws too small to hold them led to unpleasant toothiness.

Dental prognathism can be determined quite objectively by measuring the angular relation of the upper to the lower incisor in the sagittal plane. With increasing prognathism, these teeth become more procumbent and the angle between their axes decreases. This relation has been studied by several authors, the present one included. Bjork, on a sample of 322 boys, 12 years of age, obtained a mean of 128.45° ± .49° with a standard deviation of 8.8° and one of 137.44° ± .70° with a standard deviation of 11.76° on a sample of 281 conscripts between 21 and 23 years of age. In a group of 40 normal occlusions, Downs obtained a mean of 135.4° with a standard deviation of 5.76° and a range of 20.5°.

Cole (1947) reporting on 21 treated cases in which four first bicuspids had been extracted found that there was a strong tendency for the mandibular incisors to return to their original axial inclination after the removal of retention.

Litowitz (1947) studied 20 treated cases which had remained clinically stable following the removal of all retention and found that there was some tendency for the lower incisors to return to their original position. In those cases where treatment had resulted in an increase in axial inclination, half tended to regain their former inclination and half became more procumbent. In others, where treatment had resulted in a decrease in axial inclination, the majority continued to decrease after retention.

The demonstration of changes in axial inclination following the treatment of malocclusion presented the question of whether or not such changes might be found in all growing individuals. This could only be studied by a longitudinal type of investigation in which growth changes of individuals could be followed. The present study was the result.

Method

This study is based on serial cephalometric roentgenology, the technique of which has been adequately described in the literature.

Inasmuch as this work was to concern itself with the behavior of the maxillary and mandibular incisors in relation to certain planes and to each other, it was necessary to select planes which could be determined easily and which had been shown to be the least affected by the processes of growth.

The points and lines used in this investigation are indicated on Fig. 1.

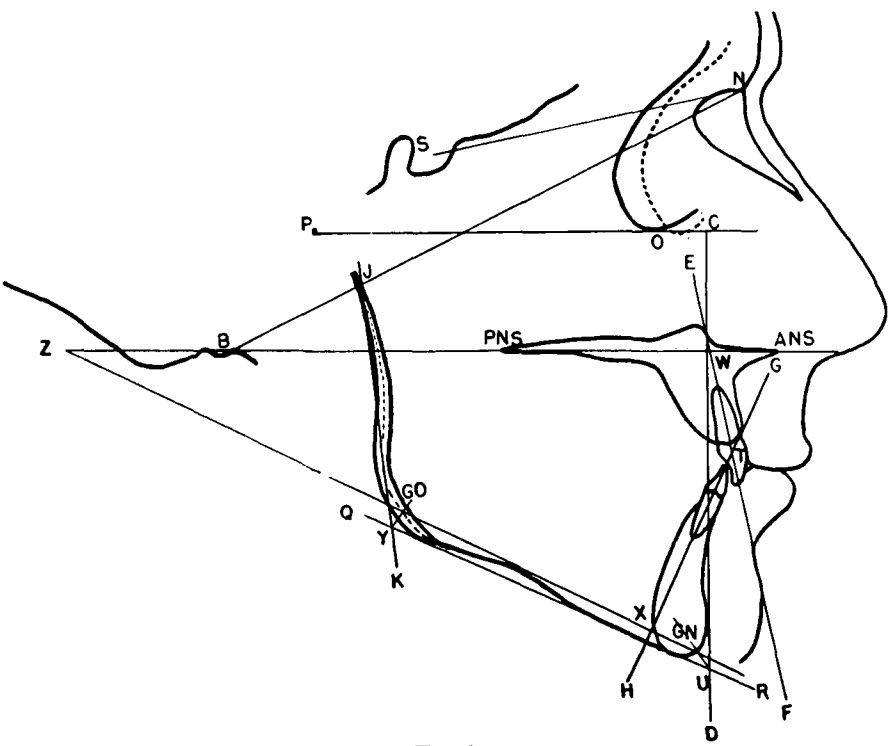


Fig. 1
Diagram to indicate points and planes used in this study.

Whenever two shadows appeared on the headplate, e.g., the posterior borders of both right and left rami, one line was drawn between them indicating the mean and it was this line which was used in the investigation.

The palatal plane has been accepted by investigators as one which descends with little or no change in its angular relation to cranial planes. Consequently, it was decided to relate the maxillary incisor to the palatal plane, determined by drawing a line through the points representing the anterior nasal spine (ANS) and the posterior nasal spine (PNS).

Most investigators have related the mandibular incisor teeth to the mandibular plane, a line drawn tangent to the lowest points on the body of the mandible. In a recent paper by Downs, however, it was pointed out that appositional growth on the lower border of the mandible introduced an error which could be avoided by using a line drawn tangent to the gonial angle and the profile image of the symphysis. Although this was an improvement, a comparison of the symphysis on the first and last of many long series of roentgenograms showed a very vivid remodeling in the form of the symphysis which caused a shifting of the lowest point on its profile. To minimize this error, it was decided to relate the lower incisor teeth to a plane drawn through gonion (GO) and gnathion (GN). This plane is not a new one, for it was used by Brodie in 1941 as a base for superimposing mandibles of different ages. The method of locating the points, however, is probably a little different from that described in the literature.

The mandibular plane was drawn as described by Downs (Q-R). The Bolton plane, a line joining nasion (N) and Bolton point (B) was drawn, intersecting the posterior border of the ramus at J. A tangent (J-K) was drawn from J to the greatest bulge on the posterior border of the ramus, intersecting the mandibular plane (Q-R) at Y. The intersection of these lines formed the angle J-Y-R. This angle was bisected and the point at which the bisector crossed the outline of the mandible was designated as gonion (GO).

The Frankfort Horizontal plane was constructed by connecting porion (P) with orbitale (O). A line C-D was drawn perpendicular to the Frankfort Horizontal plane and tangent to the most anterior point on the symphysis. This line (C-D) was permitted to intersect the mandibular plane at U, forming the angle C-U-Q. This angle was bisected. The point at which the bisector crossed the outline of the symphysis was designated as gnathion (GN). A line was drawn through the points GO and GN, forming the GO-GN plane.

The axes of the maxillary and mandibular incisor teeth were indicated by drawing lines through the apices of the roots and the tips of the incisal edges as indicated by the profiles of the respective teeth. Line E-F represents the axis of the maxillary incisor tooth. Line G-H represents the axis of the mandibular tooth. These axes (E-F and G-H) intersect at point T, forming the angle E-T-H. Henceforth, this angle will be called the angle of the upper left central to the lower left central or the angle of the maxillary incisor to the mandibular incisor. Line E-F crosses the palatal plane at W, forming the angle PNS-W-F. Henceforth, this angle will be called the angle of the upper left central to the palatal plane or the angle of the maxillary incisor to the palatal plane. Line G-H crosses the GO-GN plane at X, forming the angle G-X-GO. Henceforth, this angle will be called the angle of the lower left central to the GO-GN plane or the angle of the mandibular incisor to the GO-GN plane.

The palatal plane was extended to intersect the GO-GN plane at Z. This formed the angle ANS-Z-GN. Henceforth, this angle will be called the angle of the GO-GN plane to the palatal plane.

All angles in this study were measured with a transparent protractor to one-half of one degree.

Material

The material for this investigation consisted of forty-seven series of lateral head roentgenograms of untreated cases. Forty-five were secured from the Bolton Foundation, Department of Anatomy, Western Reserve University, Cleveland, Ohio, and two, from the Department of Orthodontia, University of Illinois.

The selection was made at random except that an effort was made to secure series which extended for at least eight years beyond the roentgenogram which first showed the incisors in occlusion. Only three series did not extend for that period of time, one continuing for six years, and two, for seven years.

All of the cases except six were Class I. Of the six, five were Class II, Division 1, and one was Class II, Division 2. Eighteen of the series were female, twenty-nine, male (Table 1).

All of the serial numbers, except AGB and AB, are the actual Bolton Foundation case numbers.

Findings

Relationship of Mandibular Incisor to GO-GN Plane

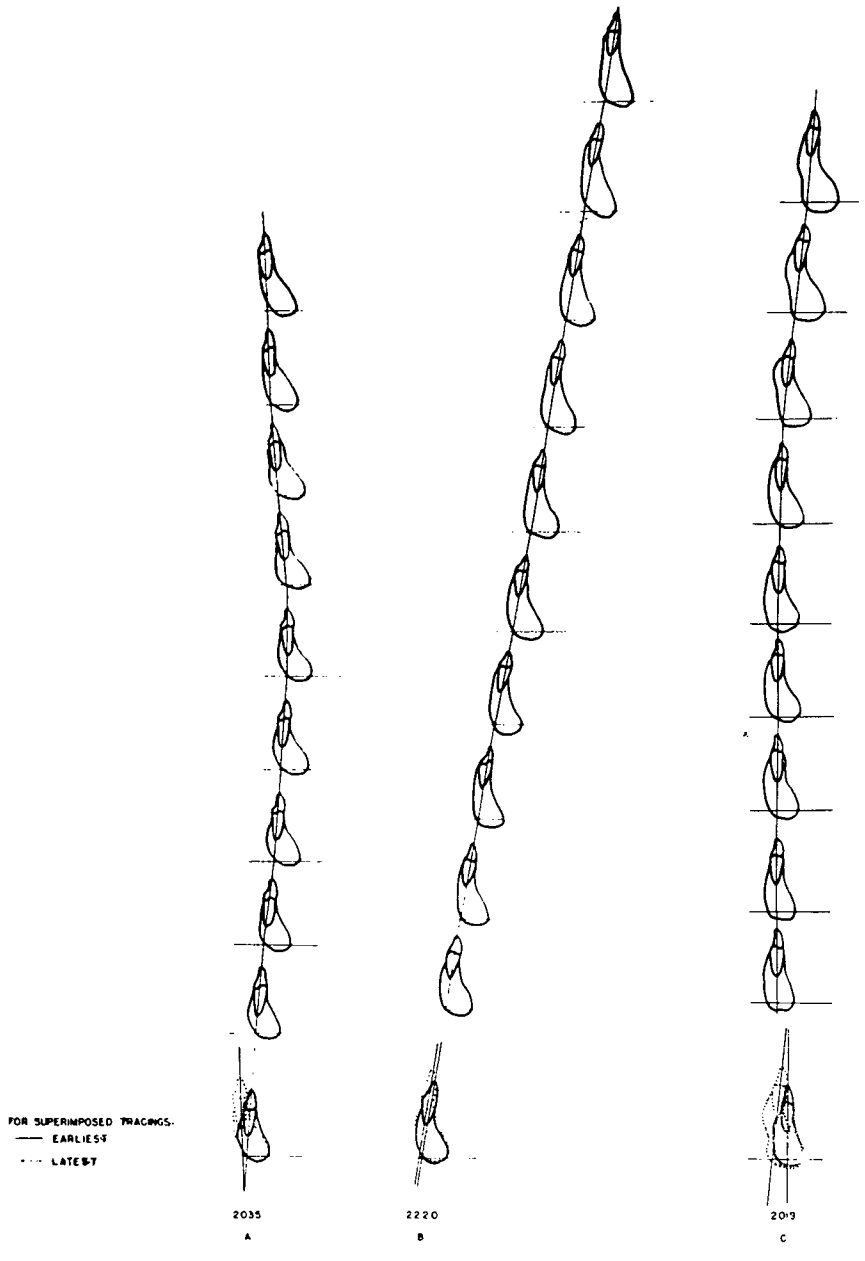
The angle of the mandibular incisor to the GO-GN plane was measured from each roentgenogram for each of the 47 series and tabulated.

The mean was calculated for each age (Table 1) and, in all those in which there was an adequate sample, the mean was found to be very close to 96°. Age stages 7, 19, 20 and 21, which contained five cases each or less, showed variations. The range for the larger samples was quite high with a minimum of 22½° and a maximum of 30°.

The original tabulation of data had revealed that not all cases were behaving similarly, i.e., some showed a decreasing angle; some showed an increasing angle; and still others showed a remarkably stable angle. This raised the question of whether the stability of the mean values was the result of equal and opposite trends in the behavior of the different cases. In order to examine each series individually, each angle was traced (Fig. 2). Each horizontal, parallel line on the paper was made to represent a GO-GN plane. The GO-GN plane of the first film was made to coincide with the lowest horizontal line on the tracings, and the symphysis and lower incisor were traced. The line representing the axis of the tooth was drawn and extended upwards until it intersected the next horizontal line. At that point, the next drawing was placed, superimposing GO-GN with the horizontal line and permitting the line drawn through the long axis of that tooth to cross the horizontal line at the point of intersection with the line drawn through the long axis of the first tooth. This was continued until all the stages for that one series had been exhausted. Individual graphs of this sort were made for each of the 47 series.

ANGLE OF LOWER LEFT CENTRAL TO GO-GN PLANE				
Age	Number Of Series	Mean	Range	Total Range
7	5	94	89 - 98	9
8	27	96.07	81 - 111	30
9	44	96	80½ - 110½	30
10	45	96.13	81 - 110½	29½
11	47	96.13	84 - 109	25
12	46	95	83 - 108½	25½
13	47	95.7	85 - 107½	22½
14	44	95.13	84½ - 109	24½
15	41	95.57	85½ - 108½	23
16	39	96.19	85 - 108	23
17	39	95.43	87 - 107½	20½
18	19	96.94	87 - 109½	22½
19	5	99.3	90 - 107	17
20	5	93.7	88½ - 106	17½
21	1	90.5		

TABLE 1



ANGULAR PATTERNS FORMED BY MANDIBULAR INCISOR TO GO-GN PLANE

FIG. 2

Scrutiny of the graphs showed that the angle of the lower incisor to the GO-GN plane followed three different trends. In the first pattern (Fig. 2B), the angle remained stable and presented a relatively straight line. In the second pattern (Fig. 2A), the angle decreased and resulted in a curve which was concave on its left side. In the third pattern (Fig. 2C), the angle increased and formed a curve with a concavity on its right side. Of the 47 cases studied, the angle remained stable in 20, decreased in 15 and increased in 12.

Of equal interest to the change in axial inclination of the incisor and of possibly greater significance was the change in the relationship of this tooth to the body of the mandible. Scrutiny of the tracings revealed that regardless of whether the incisor maintained its original axial inclination, became more upright or more procumbent, it had assumed a more posterior position on the body of the bone than it had held originally. (Fig. 3)

Relationship of Maxillary Incisor to Palatal Plane

The angle of the maxillary incisor to the palatal plane was measured for each headplate in a manner similar to that employed for the lower, and the mean for each age was calculated (Table 2). Once again, eliminating ages 7, 19, 20 and 21 because of smallness of sample, this angle proved to be very constant, although not quite as constant as the mean angle of the lower left central to the GO-GN plane. Furthermore, the total ranges were larger, extending from a minimum of 26½° to a maximum of 37½°.

These angles were depicted graphically in a manner similar to that already described except that here the horizontal, parallel lines of the tracing represented the palatal plane. Instead of starting from the lowest horizontal line as before, the first film was superimposed on the top horizontal line and the successive films progressed downward.

Again the series fell into three distinct groups. In one (Fig. 4B), the angle of the maxillary incisor to the palatal plane remained constant and a straight line developed. In another, the angle decreased and a curve was formed with a concavity on its left side (Fig. 4A). In the last, the angle increased and a curve was formed with a concavity on its right side (Fig. 4C). Of the 47 cases studied, the angle remained stable in 19, decreased in 18 and increased in 10. (Fig. 5)

The anterior nasal spines and the palatal planes for the first and last headplate of each series were superimposed and it was found that the maxillary incisor on the roentgenogram of five series was in a very marked posterior position in comparison to its original position. (Fig. 8)

Relationship of Maxillary Incisor to Mandibular Incisor

The angle between the upper left central incisor and the lower left central incisor was measured for each headplate and the means calculated (Table 3).

By not taking ages 7, 19, 20 and 21 into consideration, the mean angle here was about as constant as that of the upper left central to the palatal plane. The total range here, as might be expected, was by far the greatest, extending from a low of 27½° to a high of 44°.

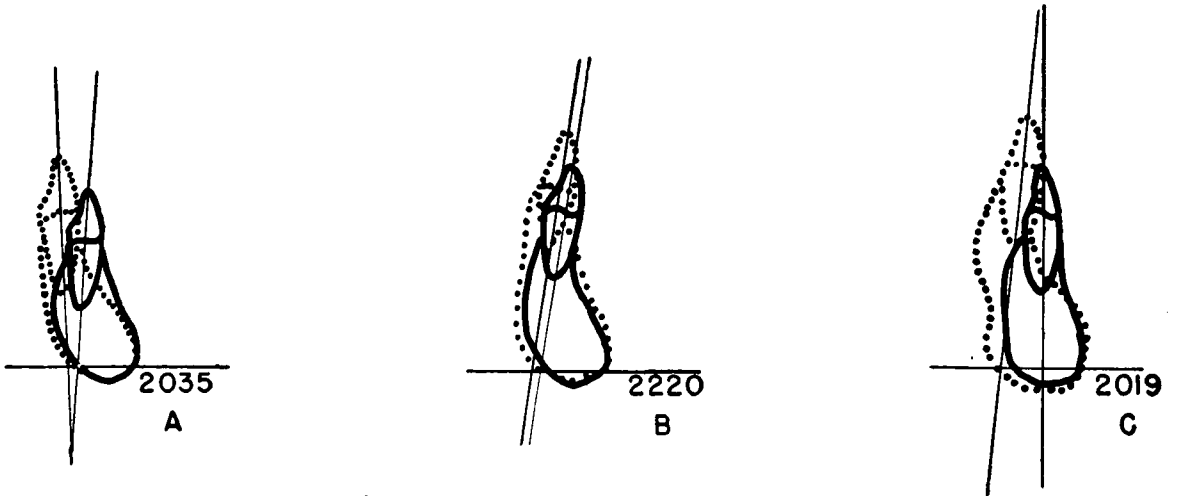


FIG. 3

This illustration is an enlargement of the superinposed tracings on Fig. 2 with some additional information.

ANGLE OF UPPER LEFT CENTRAL TO PALATAL PLANE				
Age	Number Of Series	Mean	Range	Total Range
7	4	109.37	103 - 114½	11½
8	28	106.07	92 - 121½	29½
9	43	110.86	95 - 128	33
10	46	110.48	98 - 131	33
11	47	109.57	99 - 127	28
12	46	109.31	90½ - 128	37½
13	47	109.5	93½ - 127½	34
14	41	108.8	93½ - 128½	35
15	41	110.29	94 - 128	34
16	39	108.88	93 - 129½	36½
17	39	109.69	95 - 130	35
18	18	111.05	94 - 120½	26½
19	5	110.4	107 - 113	6
20	5	104.4	100 - 110	10
21	1	100		

TABLE 2

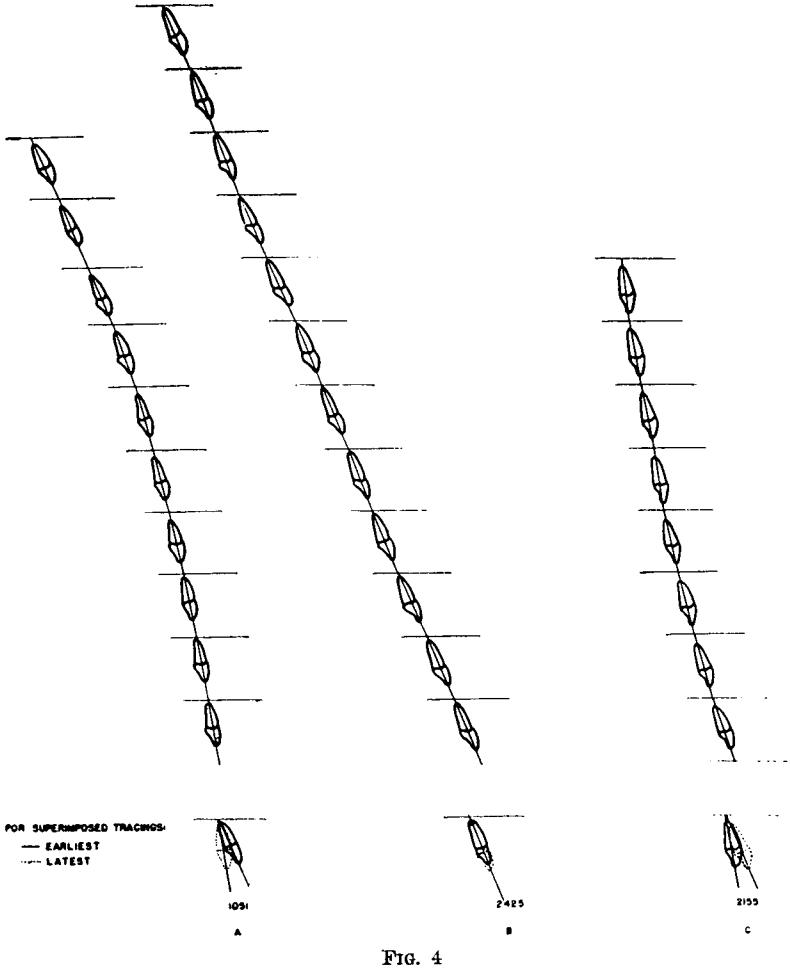
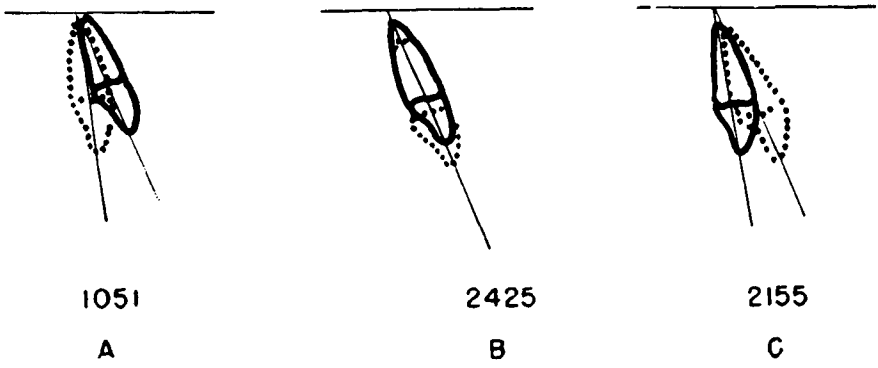


FIG. 4
Angular patterns formed by maxillary incisor to palatal plane.



ANGULAR PATTERNS FORMED BY MAXILLARY INCISOR TO PALATAL PLANE

FIG. 5

This illustration is an enlargement of the superimposed tracings on Fig. 4 with some additional information.

The fact that two teeth and two reference planes were involved in this part of the study made it necessary to utilize a graphic representation different from the previous two. It was decided to show the first, middle and last tracing of each series and to indicate the angular reading between the long axes of the maxillary and mandibular incisors (Fig. 6). A graphic representation of the amount of change or the degree of stability of the angles was made by superimposing the first and last tracing of each series (Fig. 7).

Once more the angles fell into three categories. In 18 of the 47 series the angle of the upper to the lower incisor remained stable, in 8 it decreased and in 21 it increased.

GO-GN Plane to Palatal Plane

The next part of the investigation was carried on to determine whether or not a changing relationship between the upper and lower incisors could be attributed to changes between the reference planes, viz., the angle between the GO-GN plane and the palatal plane.

The angle between the GO-GN plane and the palatal plane was measured for each headplate in the series. A comparison of these results with the measurements of the angle between the maxillary and mandibular incisors, case for case, revealed the following facts:

1. There were 13 cases in which there was no change in either angle, that is, the angle between the upper and lower incisors remained stable and the angle between the GO-GN plane and the palatal plane remained stable.

2. There were 5 cases in which the angle between the upper and lower incisors remained stable and the angle of the GO-GN plane to the palatal plane decreased.

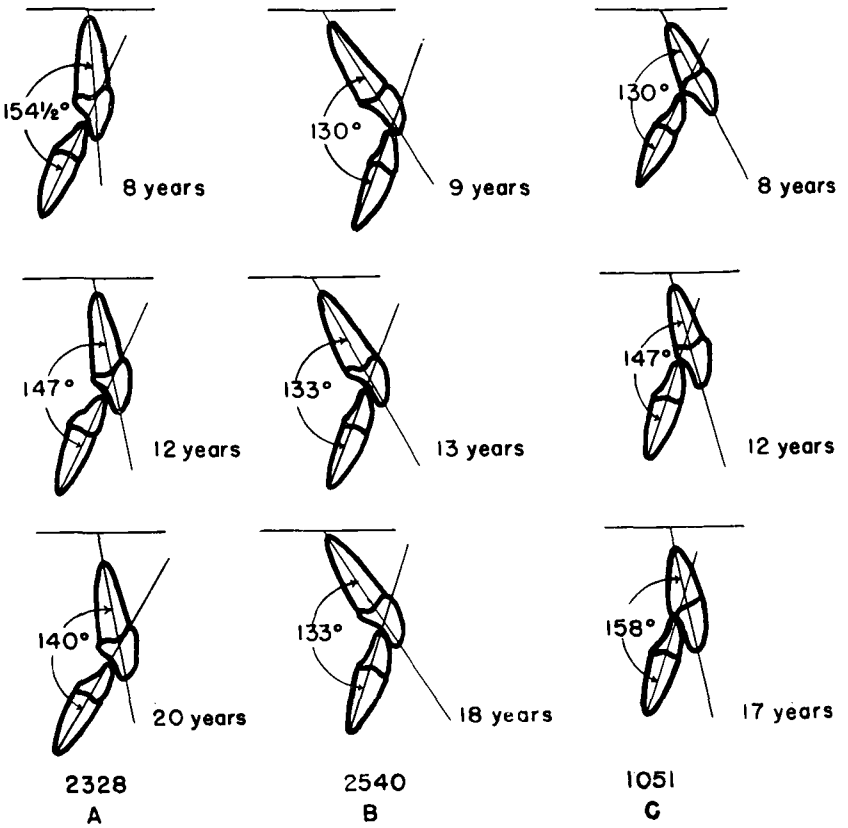


FIG. 6
Angular patterns formed by maxillary incisor to mandibular incisor

3. There were 21 cases in which the angle between the upper and lower incisors increased. The angle of the GO-GN plane to the palatal plane decreased in 12 of those cases and remained stable in 9.

4. There were 8 cases in which the angle between the upper and lower incisors decreased. The angle between the GO-GN plane and the palatal plane remained stable in 3 of those cases, decreased in 4 and increased in 1.

Findings in Class II Malocclusion

It was interesting to note the following facts about the six cases of Class II malocclusion:

(1) In five of the cases, the angle of the maxillary incisor to the palatal plane decreased and in the sixth it remained stable.

(2) In four of the cases, the angle of the mandibular incisor to the GO-GN plane remained stable. In one case it decreased; in the other it increased.

(3) In four cases, the angle of the maxillary incisor to the mandibular incisor increased. In two cases it remained stable.

ANGLE OF UPPER LEFT CENTRAL TO LOWER LEFT CENTRAL				
Age	Number Of Series	Mean	Range	Total Range
7	1	139		
8	22	130.27	113½ - 154½	41
9	39	129.17	115 - 154	39
10	40	128.81	108 - 148½	40½
11	43	129.59	111 - 147	36
12	45	130.7	113½ - 147	33½
13	46	131.39	115 - 152	37
14	41	131.90	115 - 151½	36½
15	38	131.65	115 - 155	40
16	37	132.52	116 - 155	39
17	38	132.51	114 - 158	44
18	18	130.72	114 - 141½	27½
19	5	128.4	119 - 141	22
20	4	132.62	121 - 140	19
21	1	146		

TABLE 3

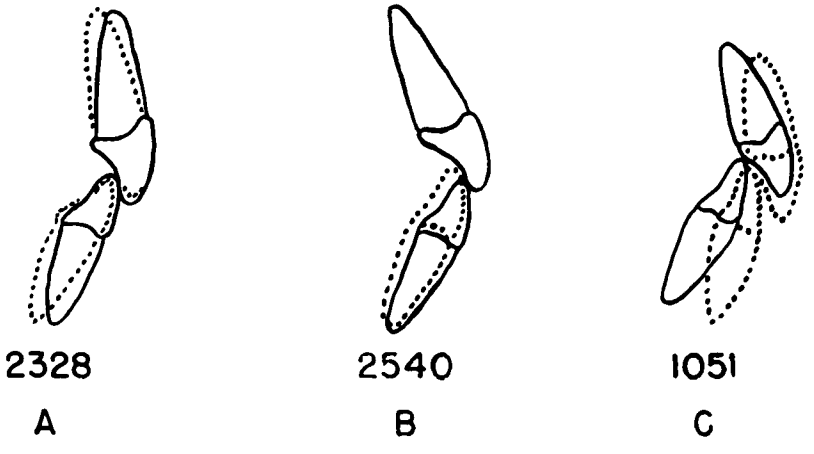
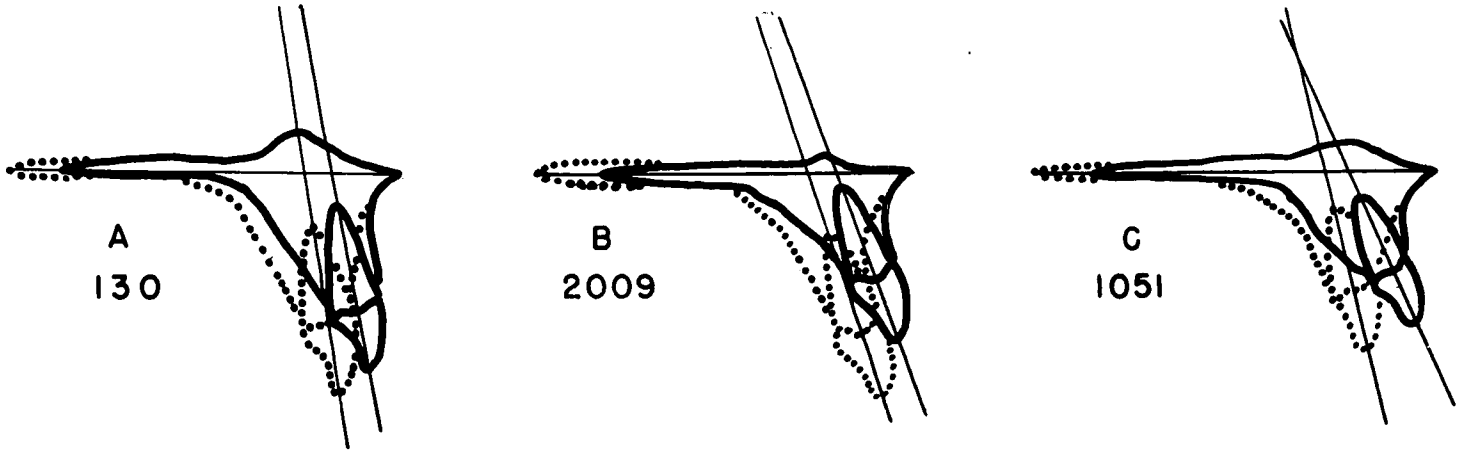


FIG. 7

In this illustration the first and last tracings of each series shown in Fig. 6 have been superimposed to show the three developmental patterns of the angle between the maxillary and mandibular incisors (A, decreasing; B, stable; C, increasing) and the manner in which the changes took place.

Influence of Sex

Apparently sex had no influence on the patterns described by the incisors, the series of both males and females were equally scattered among the different types.



POSTERIOR POSITION OF MAXILLARY INCISOR AFTER A PERIOD OF GROWTH

FIG. 8

Discussion

The mean values found in this investigation compare closely with those of other investigations.

The mean values obtained by them for the relation of the lower incisor to the mandibular plane differ slightly for the reason that the planes of reference were slightly different. If the usual mandibular plane had been used in this problem, the values would probably have been almost identical. Opportunity was not afforded to compare the means of most of the other angles calculated in this work, but the few that were available showed great similarity.

More important than the closeness of the means are the ranges. In all work reported, including the present one, the ranges are very great. When one considers the constancy of the mean, in the face of such ranges, one can only conclude that it is folly to employ a mean as a criterion for a single individual.

Although it was found that each angle measured either remained stable, increased or decreased, the total pattern could not be described in such simple terms because in any one individual there might be a combination of differing tendencies. For example, the angle of the mandibular incisor to the GO-GN plane might remain stable, the angle between the maxillary and the mandibular incisors might decrease and the angle between the maxillary incisor and the palatal plane might increase. This was actually found to be the condition in one series.

In order to summarize the varied tendencies that might exist in any one individual, a chart was constructed of all the possible combinations of changes in the three angles (Table 4). A survey was made of the 47 cases and each series was placed in its proper category. Of the 13 possible combinations, only 4 failed to find representation among the 47 series. With a greater number of cases, it seems likely that every combination would be found to exist.

The fact that there are 9 series in one combination and 5 in another has very little significance, for several were border-line cases which were extremely difficult to classify. It is important that the overwhelming number of cases were easy to classify and fell into many different categories, emphasizing the anatomic variation among the individuals.

The work of both Litowitz and Cole accentuated the above point. They found that although the position of the lower incisors had been changed during treatment and the denture had remained clinically stable, these teeth tended to change following the removal of rention. They became either more or less procumbent. On the basis of the present work, the explanation could be offered that the developing pattern of the individual had been interferred with during treatment and when relieved of all restraining influences the teeth returned to their predetermined positions in the pattern.

From all the evidence, it would seem impossible to employ limited angular measurements as absolute criteria in either prognosis or treatment planning. It does seem to be within the realm of possibility to determine, by a series of roentgenograms taken over a number of years, the combination into which an individual might be expected to fall and, on the basis of such findings, to plan the treatment.

NUMBER OF SERIES IN EACH CLASS	ANGLE OF LOWER LEFT CENTRAL TO GO-GN PLANE			ANGLE OF UPPER LEFT CENTRAL TO LOWER LEFT CENTRAL			ANGLE OF UPPER LEFT CENTRAL TO PALATAL PLANE		
	Stable	Decrease	Increase	Stable	Decrease	Increase	Stable	Decrease	Increase
9	X			X			X		
9	X					X		X	
1	X				X				X
3		X		X					X
		X			X				X
6		X				X		X	
6		X				X	X		
		X				X			X
5			X	X				X	
6			X		X				X
			X			X		X	
1			X		X		X		
			X		X			X	

TABLE 4

Combinations of changes of three angles which might exist in one individual.

Although this study was not laid out to show it, the absolute change in the position of the lower incisor to the body of the mandible was strikingly demonstrated when the tracing of the symphysis of the last roentgenogram of a series was superimposed on a tracing of the first. Regardless of whether the angle of the lower incisor to the GO-GN plane had remained stable, increased or decreased, the final film invariably showed the incisor in a more posterior position than in which it had originally been found. (Fig.3)

When this changing relationship of the lower incisor had been noted, it was decided to investigate the possible existence of a similar developmental pattern between the upper incisor and its maxillary base. This was done by superimposing the anterior nasal spines and palatal planes for the first and last headplate of each series. When this was done, the maxillary incisor on the final film of five series showed a very marked

posterior position in comparion to its original position. Other series would have probably shown a similar change except that the method of superposing tracings was too crude and did not permit an easy determination of change. A more refined method would probably detect a greater proportion of cases in which the maxillary incisor was in a relatively more posterior position after a number of years of growth. (Fig. 8)

The changing relationship between the teeth and their supporting bones in the later stages of growth furnishes an explanation of the clinical observation that dental prognathism is not as prevalent in the adult as it is in the child. It would appear that the dentition, i.e., the teeth and the alveolar processes, do not keep pace with the facial skeleton in its post-adolescent forward growth. This point suggests further studies directed toward an analysis of these later changes.

The results of a comparison between the angle of the GO-GN plane the palatal plane and the angle of the maxillary incisor to the mandibular incisor point out the two manners in which the relationships may change: (1) there may be a movement of the teeth in relation to their reference planes or (2) there may be movement of the reference planes in relation to the teeth. This comparison does not, however, show a direct cause and effect relationship.

Conclusions

I. Whether derived from mixed age samples or from specific age groupings, the mean angle of the maxillary incisor to the palatal plane, the mean angle of the mandibular incisor to the GO-GN plane and the mean angle of the maxillary to the mandibular incisor are found to be quite constant. The ranges, however, are large.

II. Each of these three angles may increase, decrease or remain stable during growth.

III. There is no correlation between the behavior of one of these angles and that of another. Any one of thirteen possible combinations might exist in an individual and all but four such combinations were found in this sample of 47 individuals.

IV. There appears to be no cause and effect relationship in changes between the angle of the upper to the lower incisor and the angle between their reference planes; either movement of the teeth in relation to the reference planes or movement of the reference planes in relation to the teeth may occur.

V. Regardless of the behavior of their axes, the incisor teeth come to occupy a relatively more posterior relation to their supporting bones with growth of the facial skeleton. This is advanced as a possible explanation for the progressive esthetic improvement observed in individuals exhibiting dental prognathism in their earlier years.

SUMMARY

The reasons for the prevailing interest in the axial relation of human incisor teeth to their supporting bone have been pointed out and a review has been made of the various methods that have been employed to study those relations.

The fact has been emphasized that all previous methods have been of a cross-sectional or averaging nature and that the derived means have shown a close similarity to each other.

The wide extent of the ranges reported by all investigators, except Tweed, indicated that the constancy of the mean was making an almost equal and opposite divergence of incisal position within the samples. No previous study has been directed toward a determination of possible age changes in these incisal relationships.

The method of conducting a longitudinal study of detenofacial relations by means of roentgenographic cephalometry has been described and the findings of such a study set forth in tables and graphs.

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