The Association Of Anatomical Entities As Applied To Clinical Orthodontics

F. F. SCHUDY, D.D.S.
Houston, Texas

Deep beneath our understanding and high above our imagination lie the inner secrets of biological processes. Here in the regions of the undiscovered and the untested is found the challenge of present day investigation.

A knowledge of the *degree* of association of anatomical entities will sharpen clinical judgment. If we know how consistently two given entities are found to vary together, we may be able to evaluate the significance of their lack of common variance. By ascertaining which factors are consistently associated with each other, we may be able to assign a "cause and effect" relationship. If we can establish cause and effect then we will have a sound basis for attacking associated problems.

The *correlation coefficient* (Pearsonian-r) is a valuable tool when correctly employed to determine the possibility of a significant degree of association between two variables. The term *entity* as used here means (1) an anatomical part, (2) a relationship between two parts, (3) an angle, or (4) a linear measurement.

As we consider correlations it is extremely important to keep in mind that the correlation coefficient per se is of *no value*. It is only through a deep understanding of the growth of the jaws and much experience in clinical practice that a worth-while interpretation can be made. One must be especially cautious in trying to assign cause and effect to two growth increments because almost any two measurements which are increasing in growth are usually well-correlated even though there is no causal relation between them.

Based on a paper read before the Middle Atlantic Society of Orthodontists, January, 1965.

If we expect to better predict future growth and response to treatment, we must acquire a better understanding of basic facial proportions. The calculation of correlation coefficients provides valuable information about how anatomical parts are usually related to each other. They also give us clues regarding which of the many cephalometric measurements are most basically related to the growth of the dentocephalic complex.

The principal value of statistics is to verify what we already know to be true, or at least *think* we know. Information derived from cross-sectional studies must be transmittable to the individual case; otherwise it is of no value.

There is much confusion at the present time about many basic aspects of the orthodontic problem. Some of these are: (1) the amount of surface additions of bone at pogonion, (2) whether anterior teeth can be depressed, (3) whether muscle pressure depresses molar teeth subsequent to treatment, (4) whether the occlusal plane returns to its original inclination after treatment, (5) whether the mandibular plane returns to its original inclination following treatment, (6) the cause of open bites, (7) the cause of vertical overbite, (8) the cause of overbite relapse after treatment and many more.

The profession needs a series of workshops to pool objective information (not opinions) with a view to establishing *sound* precepts on which clinical orthodontics can rely throughout future

generations. As an example, if the growth of the posterior teeth is the primary cause of increase in anterior facial height, we should "nail down" this fact by producing as much evidence as possible. By so doing, we will establish a sound tenet which will stand for all time. One by one, over a period of years, these sound precepts can be established. Thus, we will remove much of the existing confusion and chaos and establish our profession on a firm foundation.

Purpose

The purpose of this study was to try to identify some of these *associations* with a view to making clinical application. Only those associations with known clinical significance will be discussed. There is almost no limit to the number of correlation coefficients which one could conjure, most of which would have no relevance in clinical orthodontics. (We have made 10,000 of these calculations, and only a few will ever be discussed). The author believes very strongly that clinical orthodontics is the only kind of orthodontics that exists, and would never knowingly take up valuable space in a publication with unimportant things. All of the opinions expressed here are based on twenty years of clinical practice and were thought to be valid long before we knew of the existence of these statistical confirmations.

The Association Between Vertical and Horizontal Growth

The association between the vertical growth of the maxilla and the growth of the condyles has significance in clinical practice. There is a discernible time differential between the vertical growth of the posterior alveolar processes and the growth of the condyles. The bulk of the growth of the processes comes earlier than that of the condyles. Of course, it must be recognized that many

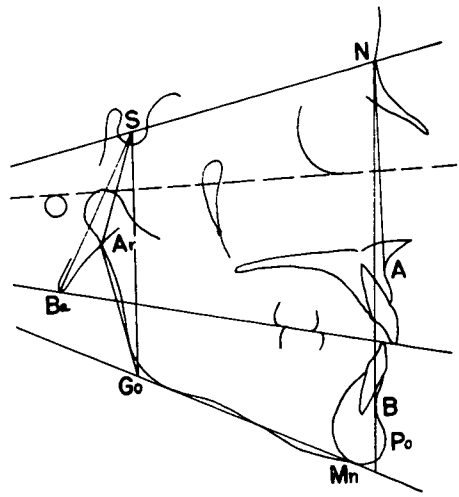

Fig. 1 Landmarks used as reference points in this study. Particular attention is given to the following angles: (1) OM (occlusomandibular), (2) SN-MP, (3) ArGoMn, (4) NSAr, and (5) NSGo.

individuals do not conform to this general rule. The downward descent of the palatal plane usually ceases considerably before the cessation of condylar growth. Phenomenal vertical growth of the maxilla and alveolar processes toward the end of the growing period, in absence of treatment, is indeed rare. Excessive growth of the condyles near the end of the growing period is not rare (Figs. 1 and 2). Such growth usually causes the mandibular plane to flatten and changes the ratio between the mandibular incisor and effective symphysis as related to NB.

What, if any, is the clinical application? We know that during the retention period differential growth at the condyles is likely to thrust pogonion forward ahead of the maxilla (Fig. 3). This may carry all of the maxillary teeth forward, move only the maxillary incisors forward, move the mandibular incisors lingually, or increase the vertical overbite (Fig. 4), depending upon the type of retention, the interincisal angle, amount of overbite, length of cusps, etc.

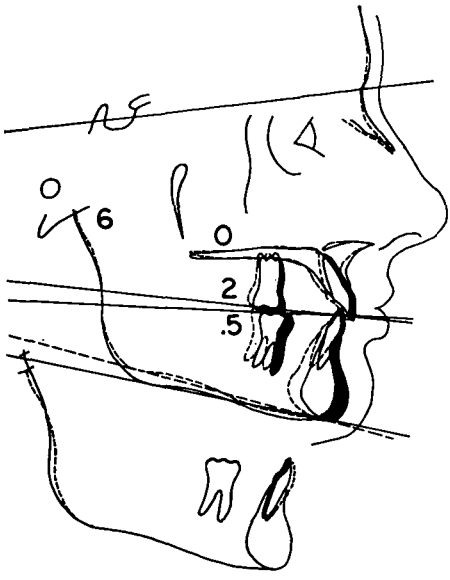

Fig. 2 Showing posttreatment growth in a female from age 14 to 18 years. It may be noted that the mandibular plane became flatter. Also the occlusal plane became flatter with relation to SN but remained constant with relation to the mandibular plane. There was a marked forward swing of the chin but no increase in anterior dental height (ANS to Mn). The entire maxillary denture moved forward, the mandibular incisors moved lingually and the overbite increased. All of these changes were brought about by an imbalance between vertical and horizontal growth increments. The condyles grew 6 mm, while the body of the maxilla grew none, the maxillary alveolar process grew 2 mm and the mandibular alveolar process grew .5 mm, producing a 6 to 2.5 ratio. This was very unfavorable growth from the standpoint of retention, as the mandibular incisors became crowded due to the fact that they were forced lingually as the bite closed. A cuspid to cuspid retainer should have been used during this period; it would have prevented lingual displacement of the incisors, but would have caused more labial displacement of maxillary incisors.

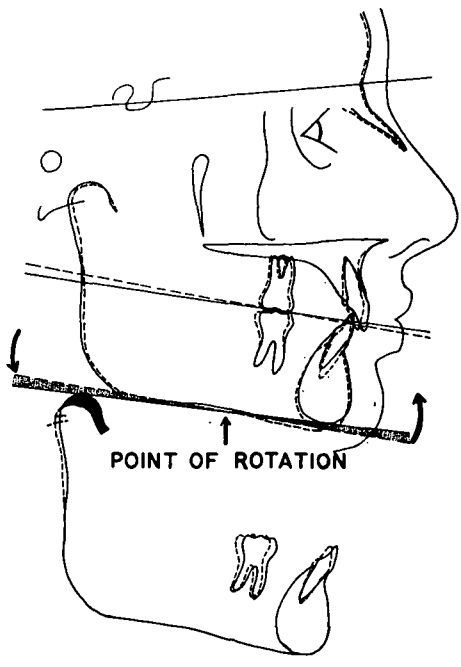

Fig. 3 Showing posttreatment growth in a female from age 14 to 17 years. This is the only case that the author has ever found in which the distance from ANS to Mn has decreased. This was *not* due to intrusion of molars but instead to a rotation of the mandible resulting from late growth at the condyles.

Overbite Correlations

Many aspects of these studies are quite puzzling and require much thought to arrive at a reasonable degree of understanding. For example, the correlation of the SN-MP angle with vertical overbite has an insignificant reading ($r = -.27$), while the reading for the FM angle with overbite is very significant, ($r = -.48$). At first this was an enigma. In 1964 the author[15] stated, "The low correlation coefficient (—.274) for the SN-MP angle with vertical overbite was a surprise and a disappointment."

After reading the findings of Hapak,[4] a much better understanding began to emerge. In a study of fifty open-bite cases Hapak found that the upward growth of the mandibular incisor has a much higher correlation coefficient with the SN-MP angle than with the FM angle. ($\overline{1}$ to menton distance correlated with SN-GoGn angle showed an r of .81, while with the FM angle the reading was .69). This, of course, means

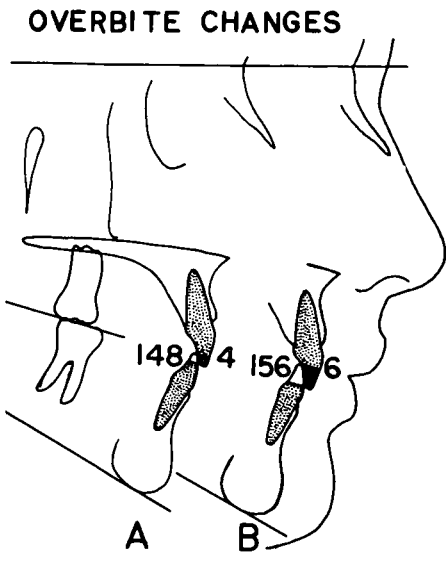

Fig. 4 This is a three year growth study in a female from 9 to 12 years of age, (A and B, respectively). The vertical overbite increased from 4 mm to 6 mm, and the interincisal angle increased from 148° to 156°. The large interincisal angle was thought to be the principal causal factor in the increase of overbite.

that the vertical growth of the mandibular incisors varies more in accordance with the variation of the SN-MP than the FM angle. This seems to account for the lower correlation of the SN-MP with overbite. The additional growth of the mandibular anterior alveolar process which accompanies high SN-MP angles appears to be compensatory. It reduces the open bite if there is one or increases the overbite if there is an overbite, and thereby lowers the inverse reading of the SN-MP angle with the vertical overbite to —.27. Were it not for this phenomenon nearly all individuals with high SN-MP angles would have open bites. The SN-MP angle takes into account whatever vertical dysplasia there may be between the glenoid fossa and sella turcica, while the FM angle, of course, does not.

There are at least two ways that these facts about relationships may be interpreted. (1) A high SN-MP angle may represent the greater vertical dysplasia and may therefore call forth a greater compensatory response, which results in more vertical growth of the mandibular incisors. (2) A high FM angle may represent the greater vertical dysplasia; thus, the overbite cannot adjust to it, but must vary inversely as does this angle. In other words, the compensatory action is less adequate in coping with the situation. However, it must be remembered that Hapak's study included only open bites while the work of Schudy[14,15,16] was a cross section of the population which included both open and closed bites.

Certain things seem quite clear. We know that increased height of the mandibular incisors cannot possibly cause an increase in facial height as they are not contacting the teeth in the maxillary arch. We also know that this common variance did not come about by chance; our statistical calculations tell us that. Hence, we know there must be a reason, in other words, a cause and an effect.

This leads us to only one conclusion, namely that the large SN-MP angle causes the open-bite tendency which in turn induces mandibular incisor growth. This incisor growth occurs despite the presence of a tongue thrust which presumably exerts pressure in a downward direction. Also, it seems logical that the vertical growth of the lips has difficulty in keeping pace with the increase in anterior dental height. The result is that the mentalis muscle has greater and greater difficulty in closing the mouth orifice and swallowing becomes more and more strained. The tongue appears to have greater and greater difficulty filling the oral cavity and, as a result, it functions lower and lower in the mouth and thrusts farther and farther between

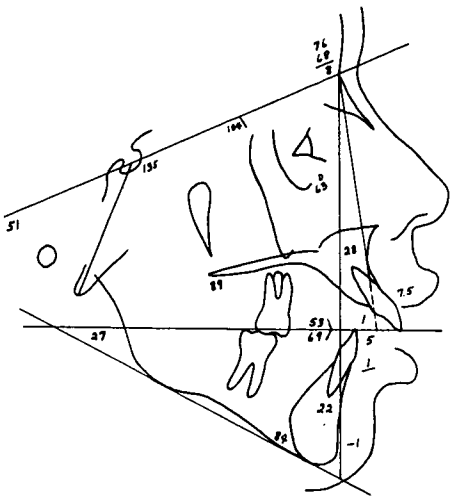

Fig. 5 A severe vertical dysplasia with very large SN-MP and OM angles (51° and 27°, respectively). This very unfavorable morphological pattern is accompanied by a severe open bite, a tongue thrust and mentalis muscle strain.

the teeth. As a result of these anatomical changes the mandibular incisors seem to be drawn and/or forced upward by functional pressures.

After pondering the above observations a biological principle becomes quite clear. First an imbalance between condylar growth and vertical molar growth, sometimes aided by a large gonion angle, produces a large SN-MP angle (Fig. 5). This in turn forces menton to move away from anterior nasal spine and throws a functional strain upon the integumental tissues and tongue. This malfunction of the soft tissues calls forth a compensatory vertical growth of the mandibular anterior alveolar process trying to relieve the strain. Thus, the incisors grow vertically and the OM angle increases. This is why this angle is an objective criterion for identifying vertical dysplasias, and why it has a very significant correlation at the one percent level with vertical overbite. This also tells us why a large OM angle is often associated with mentalis muscle strain and tongue thrust. It may be a reasonable explanation why the OM angle is more closely associated with the SN-MP than with the MP angle.

The Gonial Angle

The gonial angle of the mandible is the angle formed by a line tangent to the ramus and a line from menton to the lowest point on the lower border at the angle. Gonion is a point on the surface of the mandible at which a line bisecting the gonial angle intersects the outline of the mandible. On an average the growth ratio between the corpus and the ramus is about 7 to 6: the corpus grows 7 mm while the ramus is growing 6.[5] The ramus was measured from articulare. However, it must be remembered that there is much variation of this growth ratio.

In 126 correlation coefficients of the changes of the angle N-S-Ar none were found to be statistically significant. This included 63 readings for the "growth" group of 62 subjects and 63 readings for the treated group of 50. This could be interpreted to mean that the position of the glenoid fossa is not subject to change by treatment. However, this is not offered as proof.

When we considered the angle N-S-Go we found quite a *different* story. This angle obviously measures the anteroposterior position of gonion as related to sella. Many of the readings were highly significant and some were considerably altered by treatment, as may be seen in Fig. 6.

In Figure 10 of a 1964 article[15] it was pointed out that increasing molar height causes gonion to move posteriorly. This is verified in the table of correlations in Figure 6. There is a moderate consistency between the posterior movement of gonion and a closure of the gonial angle ($r = -.36$ in growth and $-.22$ in treatment). The lack of forward growth of pogonion is highly

Correlations of Nasion-Sella-Gonion Angle

Changes of N-S-Go with ↓

Variable	Growth	Treatment
Gonial Angle Changes (Ar-Go-Mn)	-.36	-.22
Forward Growth of Pogonion	-.64	-.50
Changes in S-N-B Angle	-.54	-.68
Changes in SN-MP Angle	.38	.51
Forward Growth of $\overline{1}$	-.49	-.31
Vertical Growth in Molar Region	-.03	-.41
Vertical Change of $\overline{1}$	.12	.42
Horizontal Component of Condyle	-.40	-.12

1% level = .35

Fig. 6

correlated with the posterior movement of gonion ($r = -.64$ in growth and $-.50$ in treatment). This obviously means that as gonion moves posteriorly pogonion fails to move forward. A similar consistency was found with changes in the SNB angle. There, $r = -.54$ in growth and $-.68$ in treatment. This was interpreted to mean that the change of the reading from $-.54$ to $-.68$ reflects the lingual movement of point B during treatment. The repositioning of point B would also explain why the forward growth of pogonion has a reading of $-.64$ and B point has a reading of only $-.54$.

The dorsal movement of gonion is

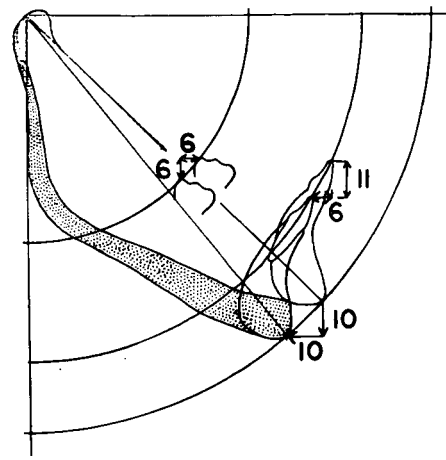

Fig. 7 In average facial proportions, when we increase mandibular molar height 6 mm the chin moves about 10 mm. In this case the ratio for the mandibular incisor was 11 to 6. These ratios will change with different facial types. Thus, when we increase molar height 1 mm, in the presence of nongrowing condyles, the chin will move backward almost 2 mm.

well correlated with changes in the SN-MP angle ($r = .38$ in growth and .51 in treatment). This means that, as the mandibular plane steepens, gonion tends to move posteriorly. A moderate inverse reading was found between the dorsal movement of gonion and the forward movement of the mandibular incisor ($r = -.49$ in growth and $-.31$ in treatment). At first it seemed impossible for these readings to vary in an opposite manner from those of the SNB angle. Please note that treatment increased the correlation with B point while treatment reduced the reading for lower $\overline{1}$. However, this can be explained by three factors: (1) the rotation of the mandible (Fig. 7), (2) the fact that in treatment the mandibular incisor apices usually move lingually more than in growth; this also repositions B point lingually, and (3) mandibular incisor apices frequently move lingually more than the crowns during treatment.

The most important observation in

Figure 6 is the correlation of gonion change and the vertical movement of the mandibular molar ($r = -.03$ in growth and $-.41$ in treatment). This has tremendous implications. This reading is an important causative factor in the marked changes of the other readings. It means that treatment causes the mandibular molar to move occlusally and this in turn causes the chin to move downward and backward, the mandibular plane to become steeper and gonion to move backward. This phenomenon is further verified by the last two readings in the figure. The mandibular incisor is caused to move downward (with relation to SN) and the gonial angle to move posteriorly as a result of vertical molar change. ($r = .12$ in growth and .42 in treatment). The vertical molar change caused by treatment obliterates the normal consistency between the horizontal component of condylar growth and lack of dorsal movement of gonion. ($r = -.40$ in growth and changes to $r = -.12$ in treatment.)

The gonial angle changes exhibit some interesting correlations, (Fig. 8). As the table shows, the overall linear growth of the mandible is not well correlated with angle changes ($r = .05$ and $-.11$). Also the growth of the ramus is not consistent with angular changes ($r = -.02$ and $-.15$). However, the growth of the corpus is very significantly related to gonial angle changes ($r = -.51$ in growth and increases to $-.57$ in treatment). It would be most difficult if not impossible to discover this phenomenon by any other means. This shows that when the mandible grows markedly in the body the gonial angle tends to become more acute. It should be reasonable to assume that corpus growth more than growth elsewhere causes the gonial angle to change in the direction of acuteness. In a previous report it was pointed out that in comparable periods of time growth closed the gonial angle an average of .5 of a degree while treatment opened it an average of 1.5 degrees. This suggests that treatment tends to cause this angle to become more obtuse. This is further verified by the last two variables.

Gonial Angle Correlations

Changes of Ar-Go-Mn with ↓

Variable	Growth	Treatment
Linear Growth of Mandible (Ar · Po)	.05	-.11
Linear Growth of Ramus	-.02	-.15
Linear Growth of Corpus	-.51	-.57
Horizontal Component of Condyles	.32	.48
SN-MP Changes	.26	48
Forward Growth of Po	-.03	-.34

1% Level = .35

Fig. 8

All of the above changes may be summed up in a broad sense by saying that the *position* and *size* of the gonion angle is subject to environmental influences. This is particularly true of the anteroposterior position of gonion. This study aided by three previous reports has established beyond any doubt the existence of an important biological truth, namely, that too much molar height prevents a forward positioning of the chin and thereby prevents a reduction of the ANB angle. This in turn renders Class II correction much more difficult. Moreover, these combined studies have made abundantly clear the

nature of the mechanism of growth of the jaws. They have shown that vertical and horizontal facial changes affect vertical overbite (Fig. 9), that they are inseparable and that they must always be considered together. The clinical application is that since molar height, both maxillary and mandibular, in most instances, is readily influenced by treatment, we must be cautious about inducing too much molar height in open-bite cases and in hyperdivergent (retrognathic) individuals.

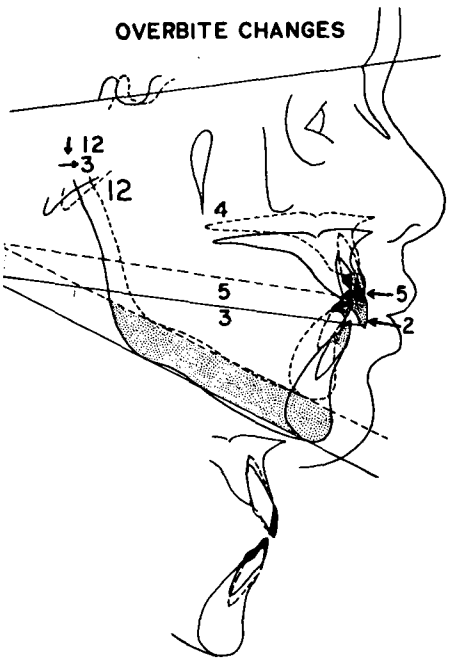

Fig. 9 This shows a three year growth study in a male from age 11 to 14. It will be noted that pogonion did not move ahead of nasion and that growth was predominantly in a vertical direction. The point of special interest is that the vertical overbite *decreased* from 5 to 2 mm. The condyles grew 12 mm and combined vertical growth in the molar region was 12 mm (4+5+3). The condyles grew 12 mm vertically and 3 mm horizontally. This helps confirm the thought that vertical growth tends to reduce overbite.

The Gonial Complex

The gonial, SN-MP, and OM angles all have one common side, the mandibular plane; hence, they of necessity have a close association. Since they have important mutual ingredients, it seems logical to consider them together as the "gonial complex".

Basically these angles are tied up with (1) the ratio between corpus and ramus growth, (2) the vertical growth of the maxilla, (3) the relative vertical growth of posterior and anterior mandibular teeth, and (4) the amount of vertical overbite. The average for the gonial angle is 125°, for SN-MP 33°, and for OM 16°.

When these three angles are near average, we usually find good facial proportion in vertical dimension with good potential for harmonizing maxillary and mandibular base relationship. When they are all proportionately high or low it is an indication that nature has made favorable compensations. However, when any member of the complex is out of proportion to the others, we may suspect insufficient compensations suggesting an inharmony of growth increments, and should proceed with caution. When an obtuse SN-MP angle accompanies an acute gonion angle, we may expect to find a relatively short ramus and long corpus; the converse is also true. A large OM angle is consistent with a large gonion angle. When a marked disproportion exists between these two angles the vertical growth of the maxilla must compensate to bring about harmony. When the OM angle is disproportionately high with relation to the SN-MP, we usually find open-bite tendencies and vice versâ. There is good reason to believe that disproportions of the OM angle with either of the other angles constitute our most serious disharmonies, as we shall see later. The OM angle is, to a considerable extent, a function of the gonial and SN-MP angles.

To determine the most "basic" of these three related variables we are interested in how one varies in conjunction with changes in the others. Ezekial[2] states it this way, "We want to determine what proportion of the variation of the dependent variable can be explained by the particular independent variable considered, according to the relation observed. The square of the correlation coefficient gives the proportion of variation in Y associated with variations in X. Where both X and Y are assumed to be built up of simple elements of equal variability, all of which are present in Y but some of which are lacking in X, it can be proved mathematically that r^2 measures the proportion of all the elements (of variability) in Y which are also present in X. For that reason, in cases where the dependent variable is known to be causally related to the independent variable, r^2 may be called the coefficient of determination. It may be said to measure the percentage to which the variance in Y is determined by X, since it measures that proportion of all the elements of variance in Y which are also present in X."

"Since the coefficient of determination is the most direct and unequivocal way of stating the proportion of the variance in the dependent factor which is associated with the differences in the other variable independent factor, it should be used in preference to the correlation coefficient. In the case of variables causally related, it measures the proportion of variance in one which is 'caused by' variations in the other."

In the specific case of the three variables in the gonial complex, let: OM = X, Gonial angle = Y, and SN-MP = Z.

Given $r_{xy} = .74$, $r_{xz} = .66$, and $r_{yz} = .61$

To get the coefficients of determination (d) we square the r values. We then have: $d_{xy} = .5476$, $d_{xz} = .4356$, and $d_{yz} = .3721$

Thus the proportion of variance in X associated with the variance in Y is 55%, or the variance in Y associated with the variance in X is 55%, and similarly for the other two relationships, X with Z is 44%, and Y with Z is 37%.

If X is the independent variable, then the proportion of the variance in Y associated with X is 55%, and the proportion of the variance in Z associated with X is 44%, giving a total of 99% out of a possible 200% association of X with its two related variables, or an average relationship of 49.5%. If Y is the independent variable, then the figures are 55 and 37% for a total of 92%, or an average 46%. If Z is the independent variable, then the figures are 44 and 37% for a total of 81%, or an average of 40.5%. Thus X is the most closely related to its fellows. This may indicate either stronger independence, or dependence, but it does show which is the most involved or "related" variable. A comprehensive study of growth and treatment reveals that the vertical movement of mandibular teeth is readily subject to environmental influences. Since OM angle changes are caused by vertical movement of mandibular teeth, we are quite certain that the above observed relationship indicates greater *dependence* of the OM angle in the gonial complex.

Multiple regression is a reliable statistical method which may be used to test the "basic nature" of the three angles of the gonial complex. The multiple correlation coefficients for the three angles are found in Figure 10.

The coefficient of multiple determination (r^2) for the OM angle is .61611. Thus, approximately 62% of the vari-

Angles	R.	P.
OM-(gonial-SN-MP)	.7849	P<.001
GONIAL-(om-sn-mp)	.7533	P<.001
SN-MP-(om-gonial)	.6838	P<.001

Fig. 10 R = Multiple correlation coefficient.
P = Probability of this R. happening by chance alone if this correlation does *not* exist in the parent population of which this sample is a part. Heavy type indicates the variable which is being estimated in terms of the other two.

ance in OM is associated with the variance in gonial and SN-MP angles. This is the proportion of variance in OM which has been mathematically accounted for by the other two factors together. Using the same method of calculation we find that 57% of the variance in the gonial angle and 47% of that of the SN-MP angle is mathematically accounted for by the other two factors together.

Thus, it has been shown by both the *coefficient* of *determination* and *multiple determination* that the OM angle is influenced most and that the SN-MP angle is influenced least by the other members of the group. These findings also further confirm the "biological truth" referred to earlier in this paper.

Facial Esthetics

How do the observed associations affect facial esthetics? The correct inclination and position of the mandibular incisor teeth are associated with: (1) the size of SN-MP angle, (2) changes in the inclination of mandibular plane, (3) the relative length of the mandible, (4) the size of the ANB angle, and (5) the size of effective symphysis (Fig. 11). The "steepness" of the mandibular plane is an important function of the effect a given change of the mandibular incisor position will

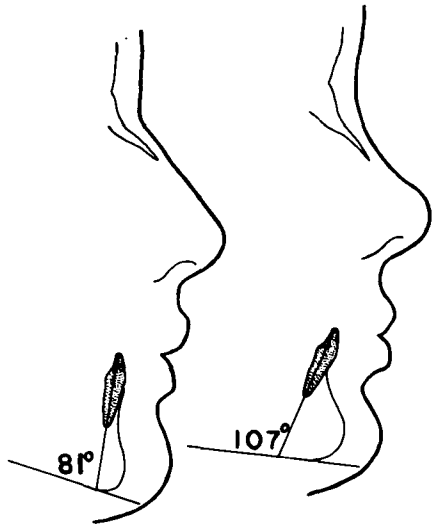

Fig. 11 This shows that it is the *position*, not the inclination, of the mandibular incisor which determines its effect on facial contour. Here we have a 26° variation with reasonably good facial profiles in both cases.

have upon facial esthetics. Within reasonable limits the steeper the mandibular plane, the less effect a given amount of lingual movement of these teeth will have upon facial contours. The flatter this plane, the more effect this same amount of lingual movement will have upon facial contour. Thus, when the SN-MP angle is acute, lingual movement of the mandibular incisor may have a marked adverse effect on facial esthetics. This is why, in hypodivergent (low angle) cases, the positioning of this tooth is so critical and why these cases should *not* have dental units removed if it can be avoided. This is also why, in hyperdivergent individuals with steep mandibular planes, we must be cautious about moving molars occlusally for fear the chin will be forced downward and backward (Fig. 12). In this connection it must also be remembered that increase in anterior dental height or lack of it is a factor to be considered.

It may be noted in (A) of Figure 13, that 3 mm of lingual movement

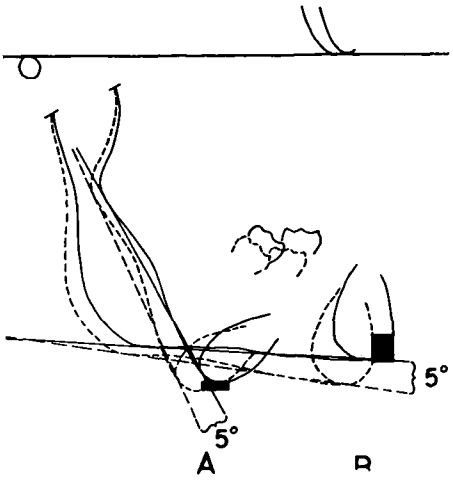

Fig. 12 Illustrating the effects of rotation of the mandible in different facial types. One is extremely retrognathic and the other extremely prognathic. Note that in A the chin moves backward two and a half times as fast as it moves downward. In B the chin moves downward more than it moves backward with the same 5° of rotation. This explains why we must use a different set of diagnostic and treatment rules for these two facial types.

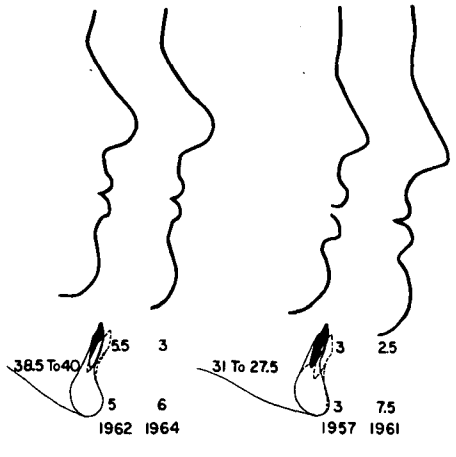

Fig. 13 Here we have the profiles of two before and after treatment records. In the individual on the left the profile was not discernibly changed, while on the right the profile was adversely changed. The reasons are to be found in the text.

of the incisor had almost no effect on lip contours, while in (B) 1.5 mm of lingual movement had a marked adverse effect. How can this be true? It may be noted further that in (A) the SN-MP angle was 38.5°, and increased to 40°; in other words the mandible was steep and became steeper. In (B), this angle was 31°, and decreased to 27.5°; it was flat and became flatter. Thus, the size of the original SN-MP angle, plus the amount and direction of rotation had more effect on facial esthetics than the actual repositioning of the incisors on their bases. This is why we must use a different set of diagnostic rules in dealing with individuals with high and low SN-MP angles.

Discussion

While our profession can take justifiable pride in our progress and in our contribution to the field of medical science still we must not become self satisfied. Most other disciplines have also made outstanding progress.

Perhaps the greatest obstacle to more rapid progress is the unresolved differences of opinion among our leaders. It is not uncommon to observe diametrically opposite opinions held by two top echelon authorities on basic biological processes. Both cannot be right, and there is a good possibility that one is right and the other is wrong; of course, both may be wrong. Yet, these men seldom sit down to present evidence to show why they believe what they believe. To defend an invalid tenet of yesteryear is to do a great disservice to the progress of our profession. Men sometimes prefer to rest on the time-worn prerogative, "I just don't see it that way." There is no place among us for unsupported opinions regardless of professional stature. Only objective information deserves an audience. To allow unresolved differences to exist year after year, decade after decade, is

to impede progress.

Biological processes simply cannot be interpreted by man's logic. We must first find out what happened and, having done that, we then may use our processes of deduction to find out why it happened. It is dangerous to formulate tenets on the sole basis of subjective observation and logic. As an example Dr. John Mershon in 1937 wrote a treatise on the subject of overbite correction.[8] In this paper he stated, "Elongation of the posterior teeth throws a constant strain upon the muscles of mastication and destroys the interrelated harmony of parts. The pull of the muscles drives the teeth back into the alveoli until a slight space is present between the upper and lower teeth when the muscles are at equilibrium." He further states, "The only permanent change which can be brought about by the use of a bite plate is the depression of the anterior teeth into the alveoli." This work of Mershon was so astute and received such wide acclaim that it was referred to as a classic of the day. Dr. Mershon's deductions were quite logical and indeed classical; however, they were contrary to the facts—not only contrary but diametrically *opposite* to the facts.[7,14,15,16,19]

Merritt made a study of vertical overbite in 30 treated cases.[7] Measurements were made before treatment, after treatment, and from two to three years posttreatment. He found a high correlation between depression of mandibular incisors and relapse of vertical overbite. He also found a high correlation between vertical movement of mandibular molars and stability of overbite. He selected the ten individuals in which the overbite correction was most stable and the ten in which overbite was least stable leaving out the "middle" ten. Paired "t" tests were then done on the twenty cases. For mandibular molar elevation between the two groups he found a "t" test reading of 8.69 with a probability of .001. For mandibular incisor intrusion the "t" test reading was 4.62 with a probability of .001. In other words, when mandibular incisors are intruded, they usually tend to extrude subsequent to treatment inviting a return of the overbite; and when molars are moved occlusally, they remain at this level and prevent a relapse of overbite (Figs. 14 and 15). These findings of Merritt confirm the author's observations on hundreds of cases. Thus, it can be said that molars almost never are intruded into the bone by muscle pressure, and if they can be induced to

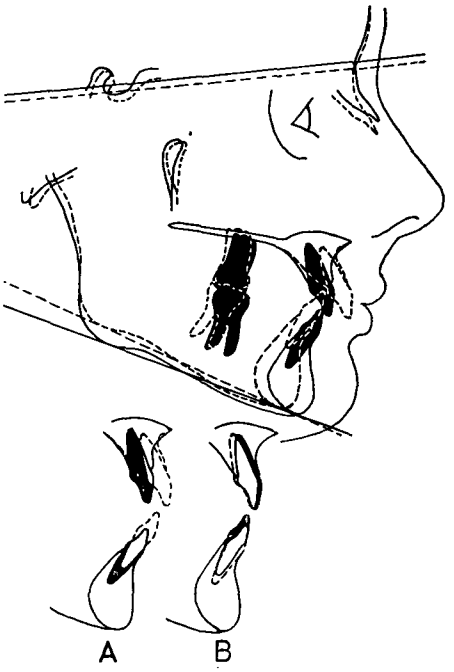

Fig. 14 Pretreatment and posttreatment tracings superimposed on the palatal plane. There was no increase in anterior dental height but considerable growth at the condyles. A shows that mandibular incisors were excessively intruded and that the maxillary incisors were moderately intruded. B shows the posttreatment reactions. Note that the mandibular incisors again moved up and closed the bite accordingly.

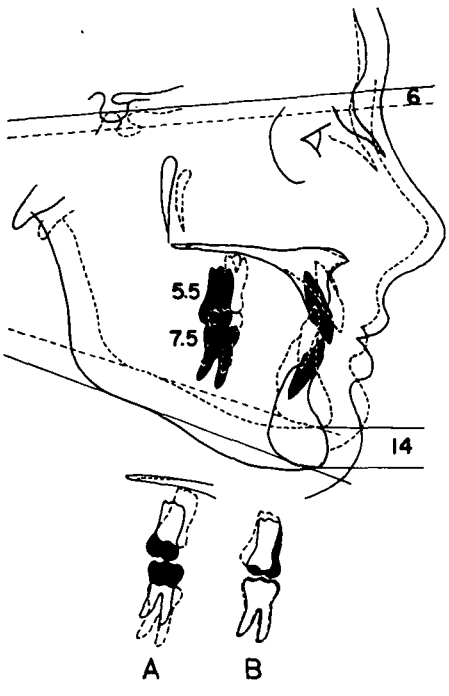

Fig. 15. Pretreatment and posttreatment tracings superimposed on the palatal plane. During treatment anterior dental height increased 14 mm and has remained the same through 4 years of posttreatment observation. This vertical change was due to 5.5 mm of maxillary molar growth and 7.5 mm of mandibular molar growth. This is shown in A. In B note that during the posttreatment period the mandibular molar remained at the same level and the maxillary molar grew downward *even more.*

move occlusally, they will remain at this level in almost all instances. If during treatment anterior dental height (ANS to menton) is increased at least the amount of the vertical overbite (Fig. 15), we may be assured of a successful overbite correction in most instances. When this dimension is not appreciably increased (Fig. 14), we may expect a return of the overbite.

As we ponder the possible cause and effect aspect of the many anatomical relationships of the human head, we are constantly reminded of the old adage, "fools rush in where angels fear to tread". Yet, if our generation meets its responsibility of continued progress, we must face these issues without flinching. We must probe deeper and deeper and be satisfied with small additions to the total body of useful knowledge.

Summary

1. The correlation coefficient, when properly employed, is a valuable tool in assigning cause and effect by identifying common variances of anatomical parts as well as other entities.
2. The purpose of this study was to try to establish new precepts, strengthen old ones, and point out cause and effect. This, we hoped, would be a contribution to clinical orthodontics.
3. The association of vertical with horizontal growth has an important effect on vertical overbite as well as overjet.
4. The type of terminal growth will indicate the best retention procedures.
5. Inharmonies of growth between the condyles and molars resulting in high SN-MP angles were shown to be the cause of many open bites. This was held to be a basic biological principle.
6. An attempt was made to show why the OM angle is associated with mentalis muscle strain.
7. The size and position of the gonial angle were shown to be subject to environmental changes.
8. The gonial complex composed of the SN-MP, OM and gonial angles was discussed in a fairly comprehensive manner. Clinical implications were pointed out.
9. Facial esthetics is significantly affected by the rotation of the mandi-

ble and the degree of facial divergence (the size of the SN-MP).

10. It was pointed out that, when molars are moved occlusally in treatment resulting in an adequate increase in anterior dental height, overbite correction is nearly always successful.
11. It was also pointed out that when mandibular incisors are markedly intruded, they usually extrude subsequently and result in a return of the vertical overbite. The clinical implication is, "do not intrude mandibular incisors."

2615 Cameron

ACKNOWLEDGMENT

The author wishes to express appreciation to Dr. Tom Creekmore for preparation of the data and illustrations. Also, gratitude is here expressed to Mrs. Dorothy Wellington for assistance in the preparation of the statistics.

BIBLIOGRAPHY

1. Creekmore, T. D.: Inhibition or Stimulation of Vertical Growth of the Facial Complex. Unpublished.
2. Ezekial and Fox: Methods of Correlation and Regression Analysis. *John Wiley and Sons, Inc.*, New York.
3. Garn, Stanley M.: Statistics: A Review. *Angle Ortho.*, July, 1958.
4. Hapak, F. M.: Cephalometric Appraisal of the Open-Bite Case. *Angle Ortho.*, Vol. 34, Jan. 1964.
5. Maj, Giorgio, and Luzi, C.: Longitudinal Study of Mandibular Growth Between Nine and Thirteen Years As A Basis For An Attempt of Its Prediction. *Angle Ortho.*, July, 1964.
6. Merow, William W.: A Cephalometric Statistical Appraisal of Dentofacial Growth. *Angle Ortho.*, October, 1962.
7. Merritt, Jerald Louis, Jr.: A Cephalometric Study of the Treatment and Retention of Deep Overbite Cases. Unpublished.
8. Mershon, John V.: Possibilities and Limitations in the Treatment of Closed Bites. *Int. J. of Ortho. and Oral Surgery*, Vol. 23, 1937.
9. Poulton, Donald R.: Changes in Class II Malocclusions with and without Occipital Headgear Therapy. *Angle Ortho.*, Oct. 1959.
10. Ricketts, R. M.: Facial and Denture Changes During Orthodontic Treatment as Analyzed from the Temporomandibular Joint. *A. J. Ortho.*, 41: 163-179, 1955.
11. Ricketts, R. M.: The Keystone Triad. *A. J. Ortho.*, April, 1964.
12. ————: The Influence of Orthodontic Treatment on Facial Growth and Development. *Angle Ortho.*, 30: July, 1960.
13. Sarnat, Bernard G.: Postnatal Growth of the Upper Face: Some Experimental Considerations. *Angle Ortho.*, July, 1963.
14. Schudy, Fred F.: The Cant of the Occlusal Plane and the Axial Inclinations of Teeth as Related to Diagnosis and Treatment. *Angle Ortho.*, April, 1963.
15. ————: Vertical Growth Versus Anteroposterior Growth as Related to Function and Treatment. *Angle Ortho.*, Vol. 34: April, 1964.
16. ————: The Rotation of the Mandible Resulting from Growth: Its Implications in Orthodontic Treatment. *Angle Ortho.*, January, 1965.
17. Steiner, C.: Cephalometrics for You and Me. *A. J. Ortho.*, 39: 729-755, 1953.
18. ————: Cephalometrics in Clinical Practice. *Angle Ortho.*, 22: 8-29, January, 1959.
19. Zingeser, Maurice R.: Vertical Response to Class II, Division 1 Therapy. *Angle Ortho.*, Vol. 34, 1964.