Perspectives in the Clinical Application of Cephalometrics

The first fifty years

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The story of cephalometrics is reviewed from the viewpoint of a clinician seeking the maximum in useful information. The various approaches are traced from early efforts to current frontiers and future prospects. Current applications are presented with full documentation for clinical use.

Roentgenographic cephalometry has made an increasingly notable impact on clinical orthodontics over the past five decades. The first movement initiated by Broadbent as the method developed was for serial study alone. This idea was embraced by Brodie and almost 30 years later, at the second cephalometric workshop,[1] these two still held out for its application to be solely for longitudinal studies, rather than clinical diagnosis.

However, in the same era both Hofrath[2] and Maves,[3] who had developed "teleroentgenography" concurrently with Broadbent, were prescribing it for prosthetic planning and for following operative procedures. Thus, planning of treatment and monitoring of change were inherent potentials of the tool from the beginning, and many new applications have continued to emerge.

It is quite clear that the most significant applications of the cephalometric radiograph have been in clinical orthodontics. Fifty years after its inception, it is a standard procedure for the overwhelming majority of orthodontists.

Many have wondered why it took so long for the radiograph of the head to reach this level of application. Originally limited to the study of changes, it was branded as a research tool only. Then in the 1940's, the conflict of opinion on extraction further polarized the attitudes of clinicians. Conservative non-extraction practitioners were especially reluctant to accept cephalometric evaluation for direct use as an aid in treatment planning. This reluctance grew as those who accepted extraction as a therapeutic alternative derived increasingly valuable diagnostic information from cephalometric radiographs. Differential diagnosis was of no value to those whose minds were already made up.

Second Phase in Clinical Application—Points and Planes

The second major movement was a concern among investigators for establishing reference bases for description of morphology as well as for longitudinal comparison. Broadbent used the Bolton Triangle with "R" registration, while Brodie[4] and Björk[5] concentrated on Sella-Nasion and the anterior cranial base. Tracings were used by Brodie and his colleagues to study treatment results in the 1930's, culminating in a 1938 report.[6] Downs[7] used that information to choose or select treatment for the individual "pattern."

In those years Tweed and his followers were already advocating extraction, and they were bent on placing the lower incisors "over basal bone." Cephalometrics was an obviously useful method for evaluation of the position of the lower incisor relative to the symphysis. The mandibular plane soon became a frame of reference for planning, much to the consternation of the conservative faction.

If the non-extraction group had observed and studied their own results, applied the tool for individual expression and published their objectives, no one could have taken issue with this means for aiding in the decision of where to put teeth. However, they chose to ridicule the method itself.

In retrospect, this was not because of the method but because of the standards and objectives of those extractionists who first embraced the clinical use of the head film during that era. Orthodontics at that time was suffering under the doctrine of limitations in terms of both orthopedics and forecasting. The information in the radiograph was still largely unusable.

Other objections raised were the use of a lateral film on a two-dimensional medium to represent a three-dimensional object, and using such a "static" tool rather than one of "dynamics" which would take growth and physiologic changes into account.

Third Major Phase—Morphologic Description and Typing

The original Downs descriptive analysis[7] was taught to the first reunion meeting of graduates of the University of Illinois orthodontic department in 1948. This was before Steiner[8] and Tweed[9] had presented their own cephalometric interpretations of their clinical ideas.

Wylie[10] divided dimensions along the Frankfort plane into contributing linear components, an approach that was later expanded by Coben[11] measuring from point Basion. The profile describing osing SNA–SNB was developed by Reidel[12] in the "Northwestern" analysis. All of these concepts were applied in various pure and combined approaches.

On going to California in the early 1950's, the author was challenged by colleagues for a direct answer to the question of clinically useful information to be derived from cephalometrics that the practitioner could not also obtain from dental casts and oriented photographs.

This key question, the practical application in terms of helping to determine exactly what to do for the individual patient, continued through the years as Steiner, more than anyone else, refined and taught the application of cephalometrics to clinical problems.

In 1960 the author published two clinical papers in an attempt to answer some of those questions being asked by students and clinicians. The first[13] was a report on the morphologic findings in 1,000 cases consecutively seen in clinical practice. It was an attempt to clarify application, entitled "A Foundation for Cephalometric Communication."

Description of morphology and dental relationships was one aspect. The second was classification, categorizing conditions in terms of their clinical requirements and difficulty. The third was the study of change, comparing the morphology of a single patient at different stages of development or treatment. The fourth was its application in communication of the first three among clinicians and researchers, and between clinician and patient.

The fourth application made the clinician using cephalometrics stand above the rest. With the ability to describe and compare, came the ability to explain things and to find out new information never before available. Above all, was the ability to communicate with the rest of the profession in a sophisticated and meaningful language. The clinician lacking the tool of cephalometrics simply had no sound basis to supplement conjecture in selecting treatment or analyzing changes.

The second 1960 publication by the author was on the analysis of treated cases.[14] The possibilities and the effects of treatment using multibanded orthodontic technique and extraoral traction, the main sources of correction of that day, were explored in depth with cephalometrics. Previous cephalometric and laminagraphic findings published by the author in 1955[15] used no controls. In 1960 one hundred non-treated patients were included as controls.

Fifty of the control occlusions were Class I, and fifty were Class II. As a treatment comparison, three different groups of fifty Class II patients treated by three different modalities were analyzed. One group had been treated with intraoral elastic traction only. Only extraoral (cervical) traction was used in the second group, while for the third group a combination of intraoral and extraoral traction was employed.

Changes were measured in five different areas in a logical sequence. First were the changes in the cranial base. The second area was changes in the lower jaw complex, the third in the upper jaw complex, and the fourth in the upper and lower dentures. The fifth area was soft tissue changes in the nose and lips.

Some 35,000 measurements were

made. Methods of analysis included superpositioning to supply data for natural changes as well as typical behavior in the course of therapy.

The outstanding conclusions were, first, the finding that significant orthopedic change was accomplished. Secondly, tooth movement possibilities and control were more extensive than had previously been believed possible.

At the time of the foregoing publications it had already taken some thirty years for cephalometrics to reach that level of knowledge and utility at the practical level. It had previously been used for numerous "analyses" as compiled by Krogman and Sassouni[16] in 1955. These were mostly descriptive orientations used to evaluate growth. However, the tool had become confusing with endless suggested landmarks and points of orientation for comparisons. That was the situation as we entered the fourth decade of cephalometric practice.

Fourth Phase—Growth Forecasting and Treatment Planning

The fourth major movement in cephalometrics was the attempt at prediction of treatment results. During the previous period the subject of growth forecasting had also been under exploration by the author.[17] This was an outgrowth of cephalometric laminagraphy of the temporomandibular joint. Long-term growth forecasting had not proven trustworthy with the methods of projection used during the years of 1950 to 1965. However, short-term forecasting did prove adequate for the period of actual treatment when combined with the likely effects of the treatment. Treatment designs incorporating growth effects had proven to be quite appropriate, and indeed could be recommended at a clinical level for the establishment of objectives and the planning of anchorage.

This idea was picked up by Holdaway[18] and termed a "Visualized Treatment Objective," which was descriptive of the application. Existing morphology and expected growth in modular increments provided a reference base.[19] Superimposed on this behavior were the requirements for the individual patient, in terms of objectives and the required tooth movement. Desired changes in anterior teeth could be followed by the set-up of the molars, depending on the needs and estimates of anchorage and arch form change. This brings us to approximately 1965.

The Fifth Phase—Confusion of Description with Growth Analysis

It was during this period that two other essential subjects needed to be straightened out. First was a determination of which of all of the possible points and planes of reference were the most useful and dependable for description and, secondly, which were most useful and dependable for evaluation of growth or treatment changes.

Some cephalometric analyses were confusing because they attempted to combine descriptive morphology, analysis of growth and treatment changes, and establishment of treatment objectives without distinction.

Point sella had become popular due more to its ease of identification than to its scientific merit or anatomical dependability. This problem was clearly apparent from the transcripts of the second cephalometric workshop at the Bolton Foundation in 1959,[20] in which it was all but recommended that cephalometrics had no place at the clinical level. Very little agreement was reached regarding specific reference points because no data was available to test one against the other. Clinicians and researchers simply maintained their own personal preferences.

The Third Dimension and Computer Analysis

The second problem prevailing at that time was that cephalometrics at the clinical level had not advanced beyond a two-dimensional application. Transverse three-dimensional morphology and growth were seldom considered.

It was apparent that all of these problems lent themselves to the application of computer technology. While previous attempts had already been made, the author engaged in a new series of computer investigations starting in 1965.[21,22,23,24]

In the research over a five-year period, methods and data from most of the material published in cephalometrics up to that time were incorporated. The idea was to take all of the different methods and test them against each other and arrive at an objective consensus. Correlation test were made for each measurement with all the other measurements. Data from frontal and lateral views of new untreated longitudinal series were used.

One-half of the subjects were males. Half were Class II and half were Class I or normal occlusions. All were followed through the mixed dentition to the permanent dentition. Twenty of the subjects were recorded from the age of five years.

The combined review of all of the current analyses, along with the findings and the data employed for the "master" computer study, provided a new level of knowledge. This was used in reliable composites that were then studied in detail. A system was designed to literally answer any question a clinician could ask with regard to a patient, using reference points and planes *statistically either as good as or superior to any others ever proposed.*

For purposes of descriptive morphology, the nature of the problems makes it useful to divide the information in the "comprehensive analysis" into seven fields. The idea was to:

1. Locate, evaluate or assess the areas of dysplasia.
2. Identify those areas within the complex that were treatable by conventional methods.
3. Identify and evaluate those areas which could work against treatment or be factors which the clinician should take into account in treatment.

Because some 50 to 60 measurements were needed to answer those questions, it required some 2 to 3 days of orientation for a clinician to master the use of the cephalometric language and learn the new points and planes of reference that emerged from the computer study.

As a second application of the computer aimed at clinical and practical application, twelve distinctly superior areas of superimposition emerged for evaluation of *changes* in the jaws, *changes* in the teeth, and *changes* in the soft tissues. For practical application, as a trustworthy base for clinical use, these were reduced to a minimum requirement of four points for serial superimpositioning.[25]

Data was established to aid the clinician in differentiating that part of the correction made by treatment and that part of the change attributable to growth alone. Therefore, three

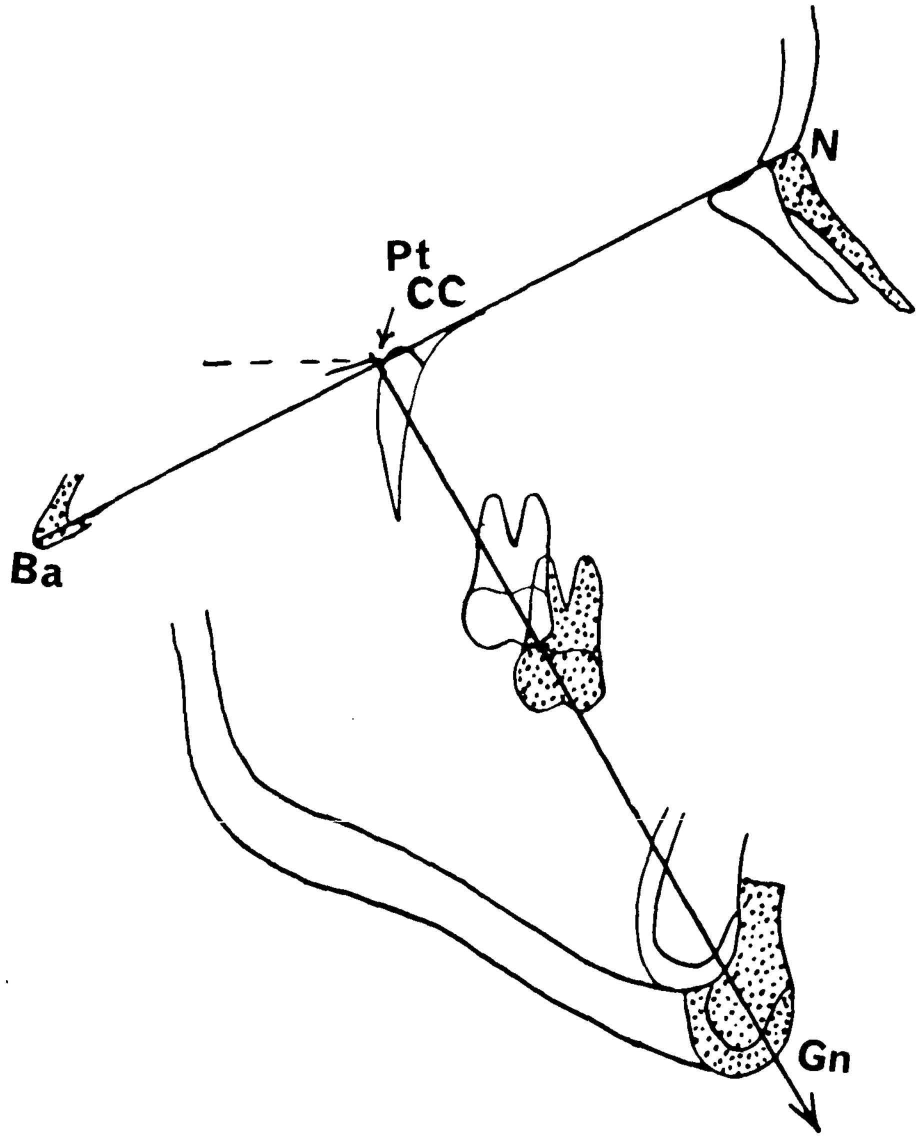


Fig. 1 ***Superimposition 1,*** showing changes in the chin and directional effects of mandibular "rotation." The Ba-N plane is registered at CC, the intersection with the facial axis (Pt-Gn). This axis is the best reference for growth direction, with a mean of 0° and standard deviation of change 1.5° in five years. Note the downward and forward movement of the upper molar with the facial axis (ages 8-13 shown). The long axis of the upper incisor (not shown) is also in general agreement with the facial axis.

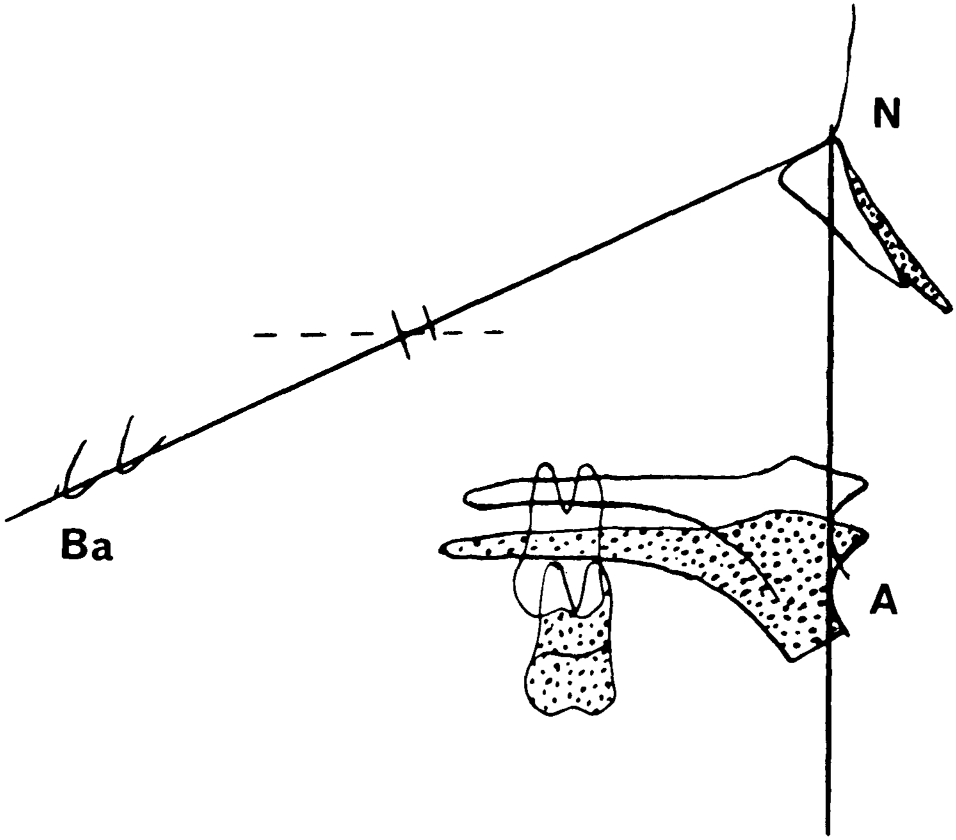


Fig. 2 ***Superimposition 2,*** with Ba-N plane registered at nasion (N). The angle Ba-N-A shows a constant relationship without treatment, with a mean change of 0° and a standard deviation of 1.0° in five years (ages 8-13 shown).

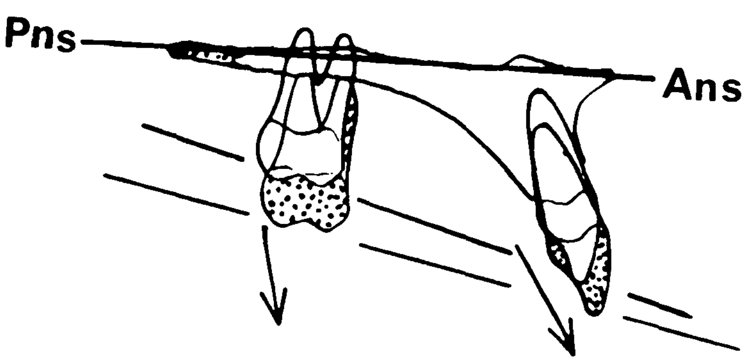


Fig. 3 ***Superimposition 3,*** with palatal plane (ANS-PNS) superimposed and registered for best fit at ANS. Notice greater eruption of molar than incisor, and slow forward drift of the complete denture.

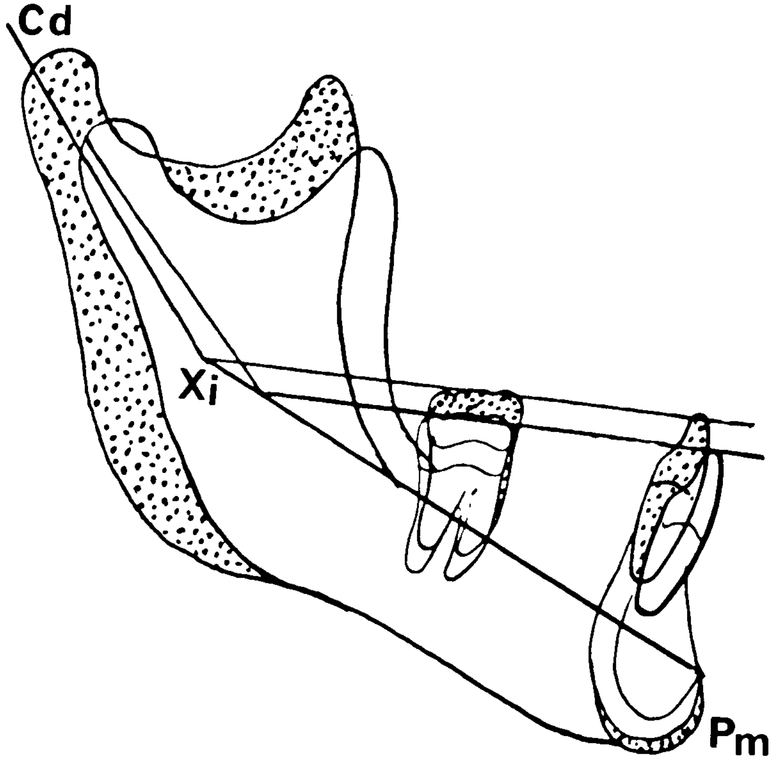


Fig. 4 ***Superimposition 4,*** with Corpus axis (Xi-Pm) superimposed and registered at Pm. Note the parallel elevation of the occlusal plane, direct upward eruption of the molar from the corpus axis, and slight lingual drift of incisor from Pm. Also note the upward bending of the condyle axis (mandibular bend), with more posterior growth at Xi than at the condyle.

new methods of superpositioning were introduced as seen in Figs. 1-4.

One of these was for changes in the chin, Ba-N registered at cc (Fig. 1). A second was for maxillary body change, Ba-N registered at N (Fig. 2). The third method was not changed from the original Brodie-Downs orientation, using the palatal plane registered at ANS for evaluating change in the upper teeth (Fig. 3). The fourth was for changes in the lower teeth, Corpus Axis registered at Pm (Fig. 4). All were proposed as a result of the computer studies of the early 1970's.

The 6th Phase—Increased Data and Confidence for Morphologic Interpretation

The most revealing measurements for communication of a *descriptive analysis of* skeletal and dental dysplasia were chosen by the author for each of the lateral and frontal views. These twenty-three measurements are shown in Figs. 5 and 6 as posted directly on a tracing in routine positioning for convenient interpretation.

The background for the selection of those points and values for actual clinical use is essential to meaningful understanding and interpretation. About the best the unaided individual clinician can do is to memorize those mean values that change with growth and those that remain stable. In this manner different individuals can be assessed for their independent characteristics rather than being compared to one standard value as was done with the Downs, Steiner, and Tweed analyses. A computer adds the capacity for further biological correction, processing each measurement for age, sex, racial type, and actual size.

Lateral Analysis
(see cue sheet)

For clinical application, the most important initial information pertains to chin location. Three factors contribute to this information. One is related to basion-nasion and two to the *true Frankfort horizontal based on the location of true porion rather than the ear rod.*

The Facial Axis

The most useful anatomical construction in both description and growth analysis is a central axis of the face, or the facial axis. This axis is constructed by connecting cephalometric gnathion with cranial point "Pt." This is related to a cranial axis defined by basion and nasion.

Pt point is located at the lower border of foramen rotundum, which is observed at the root of the pterygoid plates at the lower border of the body of the sphenoid bone. This can be a useful reference point for both singular and serial analysis. When Pt point is difficult to identify, a template may be used, as the maxillary nerve that exits from foramen rotundum makes its entrance into the sphenopalatine fossa at the upward and backward curve of the pterygopalatine outline.

As Gn is connected to Pt point and the line extended, it will cross the Basion-Nasion line to form an intersection point called "cc" (for cranial center). Measurements are made at cc. The angle of intersection of the facial and cranial axes is called the facial axis angle.

The mean for the facial axis angle for the general population just happens to be 90°, which is an easy figure to remember. The perfect right angle is perhaps the ultimate in expressing proportionality in angular terms. The standard deviation is only 3°. This measurement provides a frame of reference that will indicate whether the chin is upward and forward or downward and backward. It serves admirably as a central reference axis in the face.

Another convenient use of the facial axis is for determining the overall type of pattern of the patient for whom treatment is being considered. On average, it does not change with growth (change 0° ± 1.5° each five years). It has been *statistically verified to be the most consistent growth axis of any of those proposed and studied thus far.* It should be understood, however, that variations in basion or nasion can occur in extreme pathologic dysplasia. For such conditions further interpretations and secondary methods are needed.

The Facial Angle

The facial angle is well known as the angle formed by the facial line (N-Po) with Frankfort horizontal. Despite repeated publications[26,27] and extensive lecturing on this subject by the author and others, many clinicians still use the ear rod as a representation of porion when in fact, due to

CUE SHEET FOR RICKETTS' SUMMARY DESCRIPTIVE ANALYSIS

Lateral (Sagittal Orientation)

1. **Function:** Indicator for direction of facial development
   Factor: Facial Axis Pt-Gn to Ba-N
   Value: Clinical norm = 90° ± 3°
   Change: 0° (zero) Standard Variation, 1.5° in 5 yrs., 2.0° in 10 yrs.

2. **Function:** Indicator for mandibular prognathism
   Factor: Facial Angle (N-Po to FH) (True Porion not Ear Rod)
   Value: Clinical norm age 3 = 83° ± 3°; age 18 = 88°
   Change: Increases + 1° each 3 yrs. to maturity

3. **Function:** Indicator for proportional ramal height
   Factor: Mandibular plane (FH to Sub. Go.-M.)
   Value: Age 3 = 28° ± 4°
   Change: Reduces one degree each 3 yrs. to maturity; age 18 = 23°

4. **Function:** Indicator for denture height (vertical jaw relation)
   Factor: Oral Gnomon (ANS — Xi — Pm)
   Value: Clinical norm = 46° ± 3°
   Change: None

5. **Function:** Indicator for Nasal Floor
   Factor: Palatal Plane (ANS — PNS — FH)
   Value: Clinical norm = 0° + 2.5°
   Change: None

6. **Function:** Indicator for Horizontal Jaw Relationship
   Factor: Maxillary Convexity (A to Facial Plane)
   Value: Clinical norm age 3 = 4.5 mm; age 18 = 1.0 mm
   Change: Reduces 0.7 mm each 3 yrs.

7. **Function:** Indicator for Protrusion of Lower Denture Incisor
   Factor: Lower incisor edge to APo plane
   Value: Clinical norm = +1 mm
   Change: Tends to follow A-Po plane

8. **Function:** Indicator for Position of Upper Denture (Molar)
   Factor: Upper First Molar to PTV (Pterygoid Vertical)
   Value: Patient's Age + 3 mm
   Change: Increase 1 mm each year to maturity

9. **Function:** Indicator for Relative Incisor Protrusion
   Factor: Interincisal Angle (Upper Incisor to Lower Incisor)
   Value: Clinical norm age 3 = 122° ± 5°
   Change: Increase 2° each 5 yrs.

10. **Function:** Indicator for Relative Protrusion of Lower Lip
    Factor: Lower Lip to Esthetic Plane
    Value: Clinical norm age 3 = 0 mm ± 2 mm; age 15 = −3.0 mm ± 2 mm
    Change: Decreases 0.25 per year or 1.25 each 5 yrs.

11. **Function:** Indicator for Internal Form of the Mandible
    Factor: Bend of Mandible — Corpus Axis — Condyle Axis Reflex Angle
    Value: Clinical norm age 3 = 19.0°; age 8 ± 22.0°; Age 13 = 25°; age 18 = 28°
    Change: Increases 0.6° each year

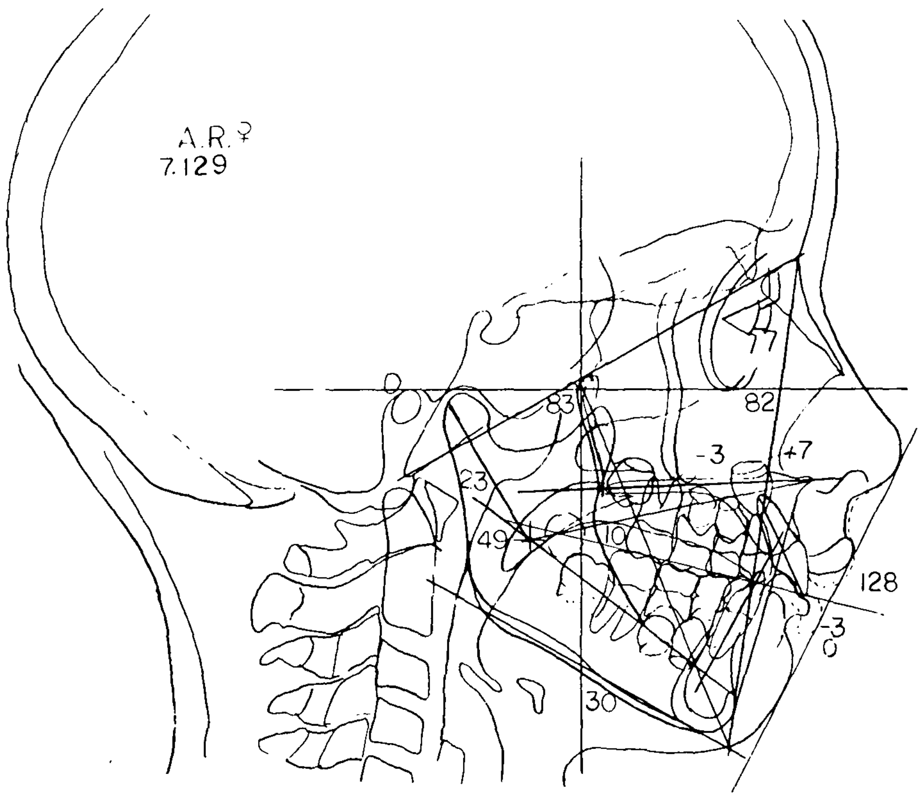


Fig. 5 Tracing of lateral radiograph, with typical critical measurements posted. Facial axis 83°, facial angle 82°, convexity ±7 mm, mandibular plane 30°, oral gnomon 49°, mandibular bend 23°, palatal plane −3°, interincisal angle 128°, lower incisor to A-Po −3mm, lower lip to esthetic line 0 mm, and upper molar to PTV 10 mm.

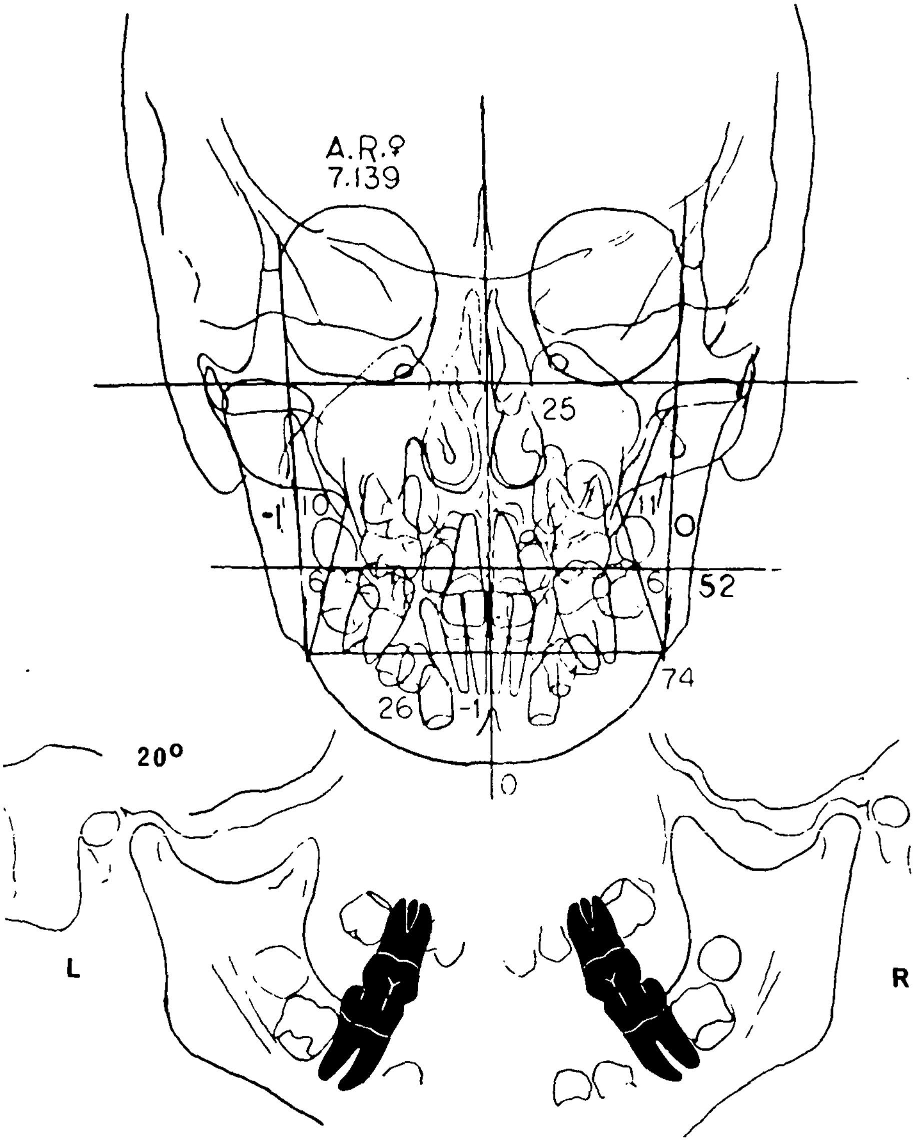


Fig. 6 Tracing of frontal radiograph and laminagraphs of patient shown in Fig. 5. Nasal width 25 mm, left maxilla 10 mm, right maxilla 11 mm, mandibular width 74 mm, mandibular midline deviation 0 mm, molar positions left 6 mm and right 6 mm, intermolar width 52 mm, intercuspid width 26 mm, denture midline −1 mm, upper to lower molar left −1 mm and right 0 mm. Lower tracings show 20° laminagraphs as used for evaluation of orthodontic patients.

error in technique and variation of the soft tissue around the ear, *the ear rod has been noted to be located well over 1 cm from the true ear hole* (Fig. 7).

It is unthinkable to introduce this kind of error unnecessarily. For example, consider the folly of using the Tweed analysis to precisely locate the lower incisor in relation to a Frankfort plane that is in error by ½ inch! The image of true porion is usually located directly over that of basion and directly over the dens. It is about 3 to 4 mm downward and forward from the internal auditory canal.

The top of the condyle head is usually very close to the level of true porion (Fig. 8C). Class III patients often display the condyles well above above the Frankfort plane (Fig. 8B). In some Class II, Division 2, and rarely in Class II, Division 1 they may be located somewhat inferior to the Frankfort plane [28] (Fig. 8A).

With all of these considerations in view, a repeatable selection of true porion can be made. This has been shown by clinical testing to be as accurate and repeatable as selecting the arbitrary visual center of Sella turcica. By bisecting the two external canals and bisecting the two orbital rims for orbitale, a true Frankfort plane can be constructed.

TABLE 1

Mean Behavior of Facial Angle for American, Californian, Caucasian Population Increase of 1 each 3 yrs.

Age 3		83°
Age 6		84°
Age 9		85°
Age 12		86°
Age 15		87°
Age 18	Males	88°
Age 21	Males	89°
Age 24	Males	90°

The Facial "plane" is described as a line connecting Nasion with Pogonion, located on the anterior curve of the outline of the chin. The Facial plane crosses an extension of the true Frankfort to form the Facial angle. By adulthood, in the male particularly, this angle also reaches about 90°. However, during growth it is usually less, increasing about 1° every three years. Table 1 shows the mean values and the practical values for the Facial angle for clinical interpretation. The morphological standard deviation is 3°. *The Facial angle is the most statistically reliable descriptor of chin depth.* It expresses the forward or backward position of the chin and is both useful and dependable for a representation of relative mandibular prognathism.

The Mandibular Plane

A mandibular plane has been popularized in orthodontics as long as cephalometrics has existed. Various points have been used to define the lower border of the mandible, but the most common and most useful are the inferior border of the angle and menton at the midline of the symphysis, as described by Downs.

In effect, once the symphysis position is defined by the facial axis and facial angle, the mandibular plane represents, more than anything else, *the vertical height of the ramus.* What has been typically interpreted clinically as a high mandibular plane angle is often no more than a relatively short vertical height of the ramus. In turn, a short ramus height is often caused by a diseased condyle head, or a short condyle head with an altered growth potential, or by inadequate musculature.

Low mandibular planes, on the other hand, represent adequate ramus height and are usually associated with

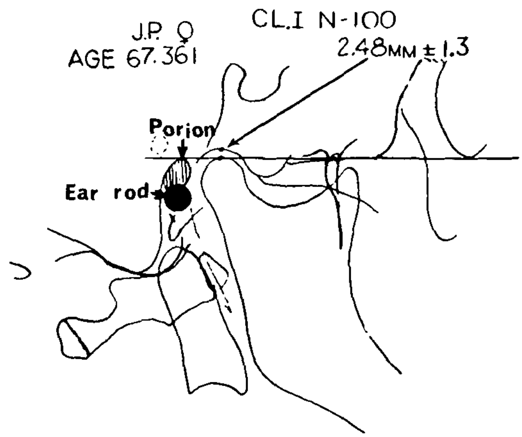


Fig. 7A Tracing of lateral radiograph showing typical relation of joint to Frankfort plane, with ear rod shown in solid black. The mean value for fossa position in 100 patients was 2.48 mm ±1.3 mm above true porion.

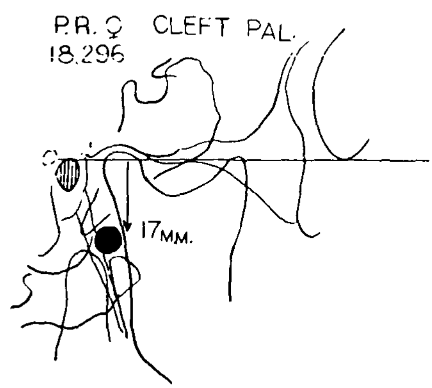
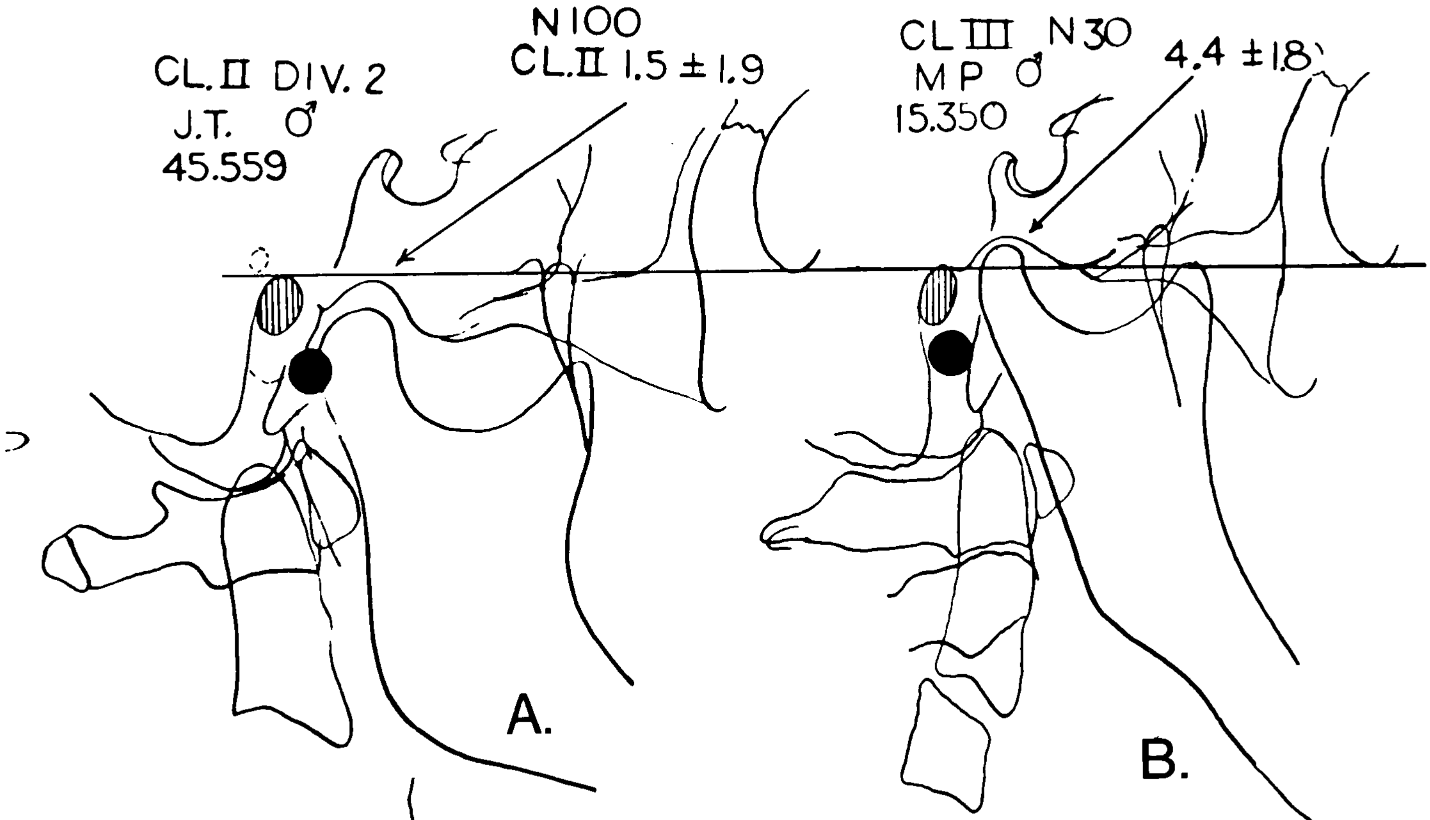


Fig. 7B Tracing of lateral radiograph of female cleft palate patient, showing ear rod 17 mm from true porion. This film was exposed in a second attempt to seat the patient as low as possible on the ear rods, demonstrating the extreme variability of this soft-tissue landmark. Similar discrepancies have been noted in otherwise normal patients.



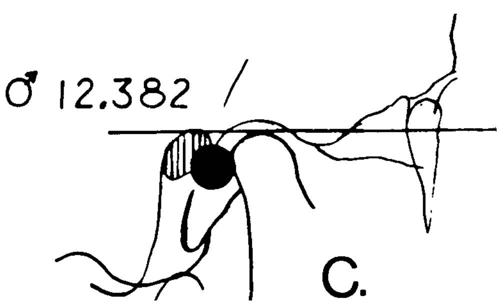


Fig. 8A A Class II division 2 patient, showing depth of fossa closer to Frankfort plane as is often found in such cases (mean 1.5 mm ±1.9 mm).

Fig. 8B A Class III patient showing fossa above Frankfort. The mean value for Class III is 4.4 mm ±1.8 mm.

Fig. 8C Top of condyle head located exactly on the Frankfort plane, which is the usual expectation with the fossa positioned as shown in 7A.

strong healthy condyle heads and musculature in patients with a history of good growth of the mandible. So-called "low-angle cases" are those who will more effectively resist treatment of a deep bite by eruption of posterior teeth, while high-angle cases with "weaker mandibles" tend to open up with little resistance. "Weak" and "strong" mandibles are generally associated with weak or strong musculature.[29] These are probably the factors which have led to the wide use of the mandibular plane as clinicians express intuitive perceptions regarding the plane and related structure and function.

However, the angle itself as measured from any cranial base or facial base is not the accurate predictor that many assume. Its standard deviation is greater than those of the facial axis and facial angle. Like the facial angle, the mandibular plane changes with age and the arcial progress of growth. Therefore, any appraisal of the mandibular plane must likewise be age- and sex-related. (See table 2 for data for age corrections.)

The Mandibular Bend

The "mandibular bend" angle measures the angulation of the condylar process to the body of the mandible. It is measured as the angle of the condyle axis (Xi through the center of the condyle neck) to the posterior extension of the corpus axis (Pm to Xi). This angle tends to increase about three degrees every five years (0.6°/yr.) as the mandible grows, for a total increase of about ten degrees from age three to maturity (Table 3).

The change with growth is largely an effect of vertical growth of the ramus, so the change will be negligible with no ramus growth and above average with large growth increments.

This change aslo reflects the "mandibular rotation" or "condyle rotation" with growth, providing an objective measure of that visualization.

Maxillary Dysplasia—Point A to the Facial Plane

The anterior-posterior position of the maxilla is of great clinical significance from both functional and esthetic points of view. Because the upper jaw is central to the profile, the simplest and best expression of the location of the maxilla is a direct linear measurement from Point A to the Facial Plane.

This is a measure of convexity, and of all the measurements in the face, convexity is one of the most controversial. Establishing meaningful definitive values is most difficult. This

TABLE 2

Mandibular Plane to True FH Decreases with Age (Changes Essentially with Facial Angle).

Age 3	28°
Age 6	27°
Age 9	26°
Age 12	25°
Age 15	24°
Age 18 } Males	23°
Age 21 } Males	22°
Age 24 } Males	21°

TABLE 3

Average values of the mandibular bend angle for the growing years. The standard deviation at eight years of age is 4.7 degrees. An increasing angle indicates "forward rotation" of the condyle, generally associated with forward growth of the chin.

Years	Degrees	Years	Degrees
3	19.0	13	25.0
4	19.6	14	25.6
5	20.2	15	26.2
6	20.8	16	26.8
7	21.4	17	27.4
8	22.0	males	
9	22.5	18	28.0
10	23.2	19	28.6
11	23.8	20	29.2
12	24.4		

TABLE 4

Convexity (Horizontal Jaw Relationship)
Decreases 0.7 mm each 3 yrs.

Age 3		4.5 mm
Age 6		3.8 mm
Age 9		3.1 mm
Age 12		2.4 mm
Age 15		1.7 mm
Age 18	Males	1.0 mm
Age 21	Males	0.3 mm
Age 24	Males	−0.4 mm

difficulty is compounded by the fact that convexity can also change with age, with mandibular growth, and with treatment. Convexity is also somewhat dependent on racial type, further challenging orthodontic objectivity.

Therefore, values used as indicators of functional and esthetic relations must be quite sophisticated. By adulthood the usual objective in many orthodontic practices is something close to a straight profile. However, in the small face of a pre-school child the normal convexity may approach ½ cm. Values gleaned from various studies and clinical findings over the years are shown in chart form in table 4.

Palatal Plane to FH

The palatal plane is constructed by connecting the anterior nasal spine and posterior nasal spine.

In the interest of vertical analysis, and in the interest of recognition of the nasal capsule as a part of orthodontic objectivity, the palatal plane has loomed into significant importance. This is particularly true since the plane is recognizably variable. When relating the nasal floor to harmony and balance with the remainder of the face (despite its relation to the anterior cranial base), the objective in orthodontic treatment has come to be one of a palatal plane reasonably parallel to the Frankfort horizontal plane. Therefore, we again come back to the true Frankfort plane for this evaluation. The desired value is 0° or 180°, with a standard deviation of 3°

Denture Height—The Oral Gnomon

For this contemporary measurement, two new points are required beyond the traditional early points selected (Fig. 5 and 9B).

One of these is Xi-point, at the centroid of the ramus, derived by bisecting the vertical height and the horizontal depth of the ramus. It is a very useful and strong biologic point, almost always located immediately over the mandibular foramen where the mandibular nerve enters into the mandible.

The second point is a vertical point on the symphysis called PM or protuberance menti. While pogonion is easily discernible on the anterior curvature, it is not precisely defined vertically. PM is selected at the upper termination of the heavy cortical bone of the symphysis, at the start of the recess for the incisive, fossa. This essentially coincides with the lower limit of the resorptive area above the chin. A line from PM to Xi-point represents the corpus axis and can be taken as another measure of length of the mandible.

A useful measure clinically, particularly in open- and closed-bite individuals, is what has come to be called the oral gnomon. It is the angle made by connecting anterior nasal spine (ANS), Xi, and PM points. It effecttively represents the denture height, or lower facial height, or vertical relationships between the maxilla and the chin (Figs. 9 and 10).

Dental Relationships

In the more comprehensive analysis, the relationships of the teeth are

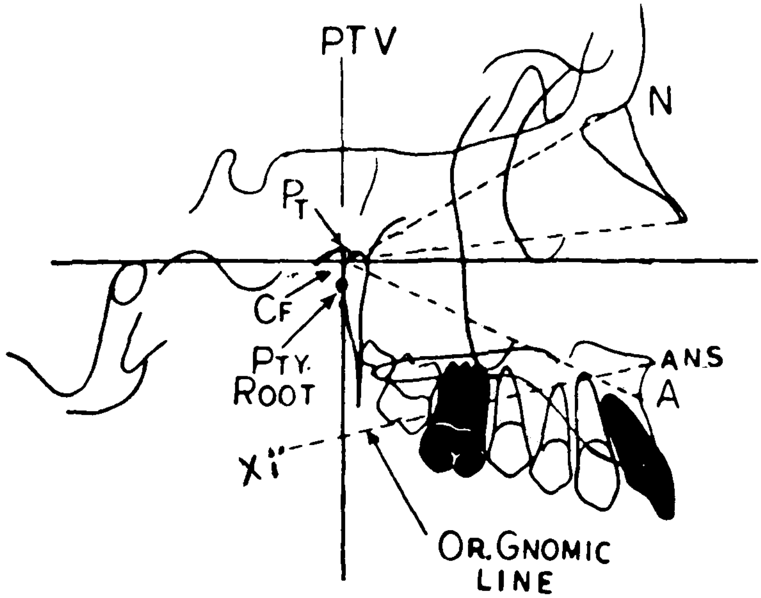


Fig. 9A Points and planes in pterygoid area. Vertical is erected to true Frankfort plane from PR point (dot) off base of pterygoid wings; this line is called the pterygoid root vertical. The intersection is called CF point (Frankfort Center). The position of the upper molar is measured forward from this PTV line to the distal of the crown. Pterygoid point (PT) is located on the lower border of foramen rotundum, above and behind the outline of the pterygopalatine fossa.

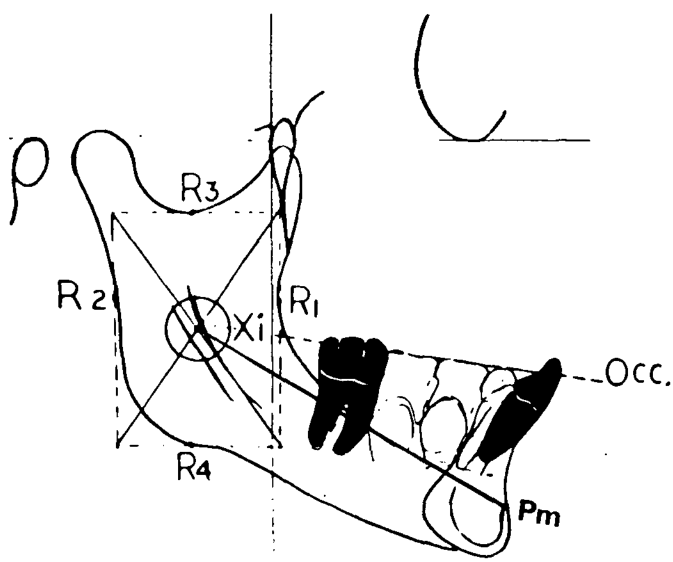


Fig. 9B One method of locating Xi point at the center of the ramus. Protruberance menti (Pm), located at the recessive area above pogonion, is joined with Xi to form the corpus axis. Note the proximity of the extension of the occlusal plane to Xi point.

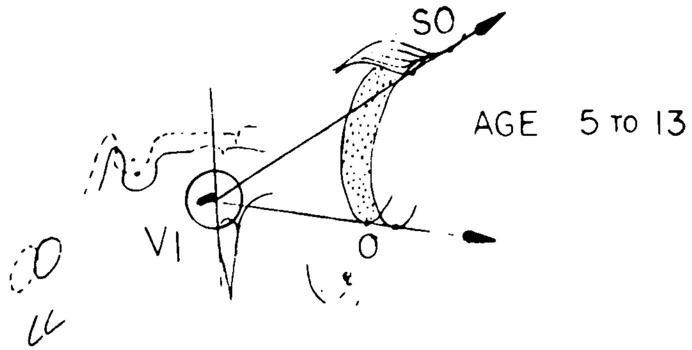


Fig. 10A Growth of orbit with vertex center at the base of superior orbital fissure at entrance of V1 (first division of 5th nerve).

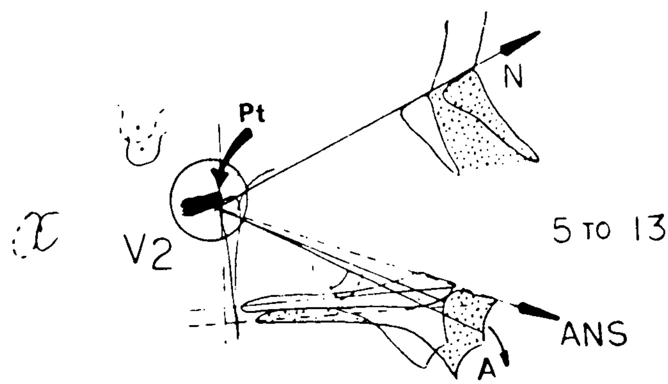


Fig. 10B Growth of nasal capsule based on Pt to nasion, site of V2 (second division of 5th nerve). Note parallel dropping of the palate. Shape is allometric but not a gnomic triangle.

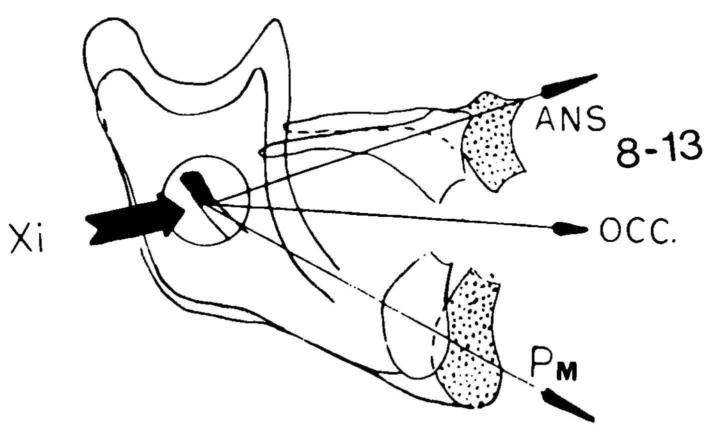


Fig. 10C Mean behavior of growth in denture height, age 8-13. Site of Xi is the entrance of V3, the third division of the 5th nerve. The ANS-Xi-Pm angle is highly regular in growth. Note the orderly orientation of the occlusal plane. This oral capsular behavior is referred to as the oral gnomon.

described in the lateral head film in both horizontal and vertical directions. The molars, cuspids and incisors are related similar to the image that can be extracted from viewing a dental cast. For a survey type analysis, however, it is assumed that dental casts are available and the clinician is primarily interested in locating the denture relative to the skeletal parts.

Lower Incisor to A-Po Line

Treatment planning starts around the lower incisor. In the construction of a treatment objective, or the analysis of arch length for possible expansion or extraction, interest is immediately focused on the lower incisors. The relation of the tips of the incisors to the anterior-most extensions of the maxilla and mandible (or the A-Po line) has proven through several decades to be a most practical method of assessing lower incisor position.

A clinician has the option of either correcting the lower incisor to the existing A-Po line or changing the A-Po line itself with growth and facial orthopedic treatment. This is where the application of the A-Po line becomes complicated to those not thinking it all the way through. Nevertheless, the A-Po line is a very useful basis for assessment of the antero-posterior location of the lower denture, or the so-called sagittal positioning of the lower incisor and lower denture in relation to the existing skeleton.

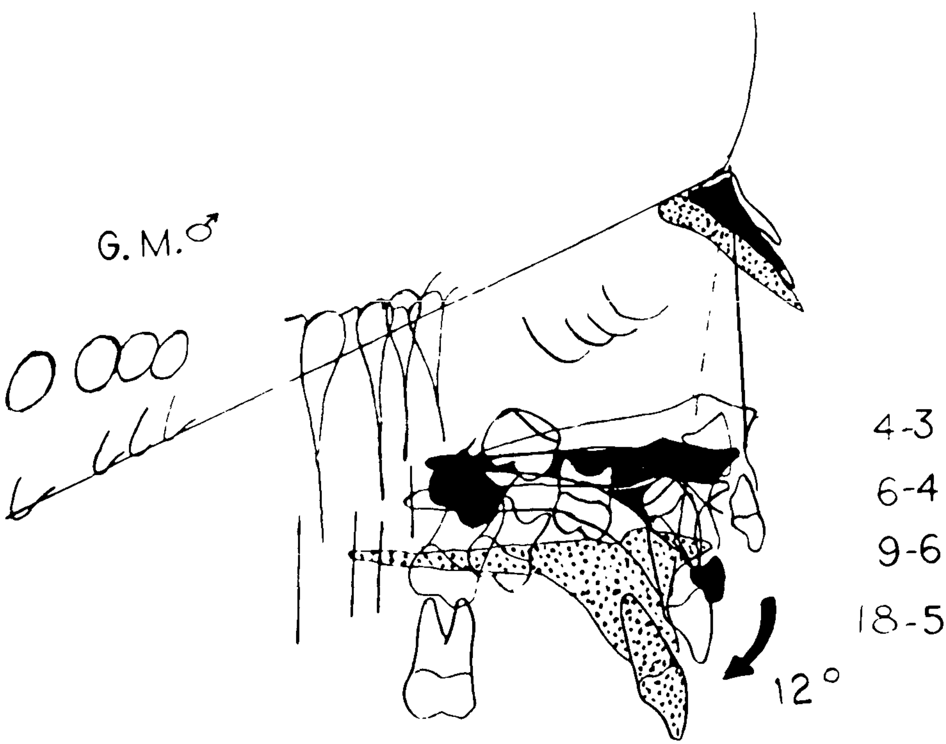


Fig. 11A Growth behavior in a male patient treated for Brodie syndrome. Treated with two stages of extraoral traction. Note 12° backward change in point A and distal movement of deciduous and permanent molars from age 4-3 to 18-5. Compare with normal growth shown in Fig. 2.

One interesting feature of relating the lower incisor to the A-Po line is that the mean value changes very little with growth. The norm values change only slightly from the deciduous dentition right on through to maturity. Most all of the studies of normal and natural dentitions find the position of the lower incisors about 2 mm ahead of the A-Po line, with a standard deviation of 2 mm.

In the early 1950's, studies of stable cases and consideration for lip relationship of most pleasing proportion led the author to accept the lower incisor at +1 mm to the A-Po line, with a variation of ±2.5 mm as his clinical objective. This can place the lower incisor as far as 3.5 mm ahead or 1.5 mm behind the A-Po line. It is found that outside these limits there is great risk of esthetically protrusive or retrusive denture and lip relationships. Treatment options in such patients are selected on other functional and esthetic factors. Of significance is the fact that the A-Po line itself changes with treatment and with growth, as was discussed previously in relation to convexity of the face.

Individual patients have been seen in which the Basion-Nasion-point A angle has been reduced 12° with extraoral traction treatment (Fig. 11). Patients have been seen in which mandibular posturing devices successfully brought the chin forward 5 mm. In theory, therefore, changes in con-

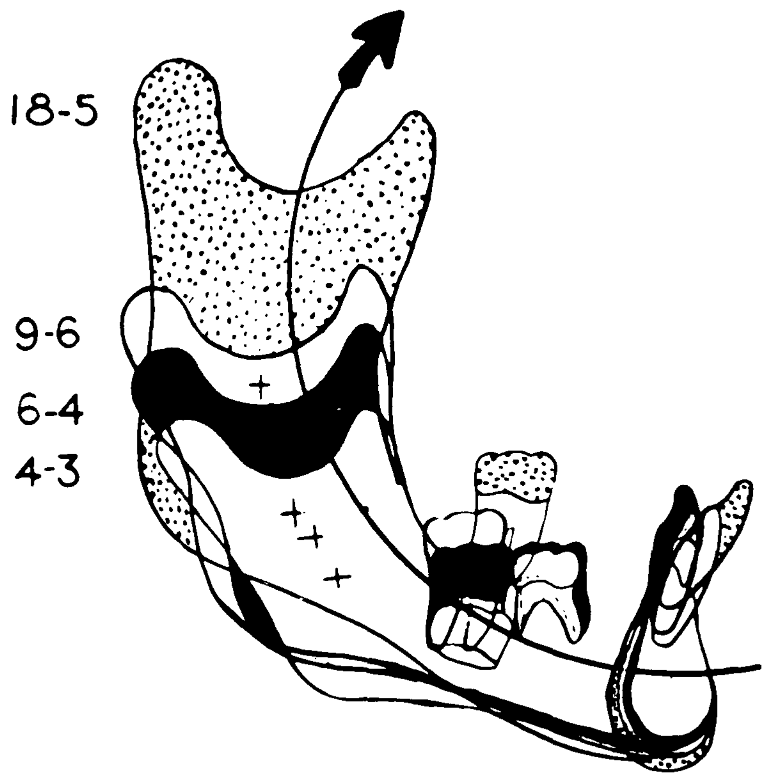


Fig. 11B Mandibular change in the same patient shown in 11A, oriented on arcial growth line described in Fig. 13. Note the behavior of lower molars and incisors in two stages of treatment, and occlusal plane moving with Xi point from deciduous through mixed to permanent dentition.

vexity of the face (A to Facial line) in the range of 1.5 cm (or 15 mm) might be accomplished.

Upper Molar to PTV

After assessing the relation of the lower denture to the profile, the next major interest is the space available for the upper molars. The best assessment found for this dimension is based on a perpendicular line from the Frankfort plane to the anterior-most margin of the cranial base of the pterygoid plates. From a point (PR) selected at the most posterior outline of the pterygo-palatine fossa, the line drawn perpendicularly to Frankfort is called the Pterygoid Root Vertical or PTV (Fig. 9A).

In contradistinction to the measurement from lower incisor to A-Po line, this value does change with growth. As a rule of thumb, 3 mm plus the patient's age is used, with an accepted deviation of ±3 mm. The upper first molar can be moved distally to the millimeter equivalent of the patient's age with no serious increase in the risks of impaction of posterior teeth. Table 5 shows the first molar position at various age levels.

The Interincisal Angle

Interincisal angles of around 135° were described by Downs in his original analysis. However, that normal sample was chosen with some bias against protrusion of anterior teeth. Most normal samples of adult Caucasian individuals show average angles closer to 130°.

However, the interincisal angle does change with time. As the jaws grow in height, the teeth upright slightly. As the lower incisor tends to follow the A-Po line, the upper incisor is contained by the lower lip. A lower angle may be the result.

In many malocclusions interincisal angles may fall within normal limits and the incisor relationship still be badly deranged. Therefore, it is reasonable to question the value of the angle on a routine basis. The answer is that it is particularly meaningful for Class II Division 2 cases, extremely deep bite cases, and severely open bites, but must be evaluated in relationship to other relationships.

Table 6 shows values of interincisal angle change. It is the author's objective to achieve 125° to 126° angles in therapy, overtreating this relationship to allow for retention uprighting, which is quite common. This lower angle will provide a good plateau on the upper incisor for articulation of the lower incisor and smooth incisal guidance.

Thus, three main measurements are noted in the denture: lower incisor to A-Po for the lower arch, molar to

TABLE 5

Upper First Molar Position (from PTV) Increases 1 mm Each Year with Maxillary Growth and Eruption.

Age 3	Unerupted
Age 6	9 mm
Age 9	12 mm
Age 12	15 mm
Age 15	18 mm
Age 18 } Males	21 mm
Age 21 } Males	24 mm
Age 24 } Males	

TABLE 6

Interincisor Inclination. Uprights 2° Each 5 Years with Vertical Development. Upper Incisor Tends to Follow Behavior of Facial Axis.

Age 3	122°
Age 8	124°
Age 13	126°
Age 18 } Males	128°
Age 23 } Males	130°

PTV for the upper arch, and inter-incisal angle for inter-arch relations.

Lower Lip to E Line

The last factor in the lateral film is soft tissue, especially the relationship of the lower lip to the esthetic plane. The problems in evaluating esthetics are compounded by differences in racial types and in constitutional types within races. However, a start must be made somewhere to evaluate esthetics, and the lower lip to the E line (nose to chin) has proven to be highly satisfactory in the author's experience. The labial surface of the lower lip is influenced by both lower and upper incisors, while the upper lip is influenced only by the upper incisor.

The upper lip is located ideally approximately 2 mm farther behind the line than the lower lip. This tends to hold true for most patients. As the nose grows and the chin develops, the lips gradually appear to contract into the face (table 7). Starting with the lips slightly ahead of the esthetic line in the juvenile stages, the lower lip has dropped behind this line by adolescence and continues to retract in adults. This can occur especially rapidly with maturation of males in the late teens or early twenties.

In the Oriental and Black races, the nose tends to be proportionally shorter and slightly wider and, particularly in the Black, the lips are somewhat thicker than seen in White populations, The author feels that a good objective is easy closure of the mouth with little or no strain, pursing or excessive mentalis action. This will achieve a most relaxed expression and graceful, healthy, harmonious relationships.

TABLE 7

Relative Protrusion of Lower Lip. Mouth Flattens 0.25 mm Each Year with Natural Development.

Age 3		0 mm
Age 8		−1.25 mm
Age 13		−2.50 mm
Age 18	Males	−3.75 mm
Age 23	Males	−5.00 mm

The Frontal Analysis

The frontal head film has been used for growth studies but until computer research in 1968 detailed objectivity for the clinician was not forthcoming. Lack of interest and experience combined with difficulty in attaining consistently satisfactory orientation in the frontal positioning in the head holder at the time of exposure limited progress in the frontal analysis (Fig. 12). Another factor was the lack of accepted reference points and the acquisition of enough clinical data in both normal and treated patients to enable establishment of standards for actual clinical use.

New horizons developed the need for orthodontic criteria in terms of transverse assessment. The development of palatal widening and maxillary orthopedics, the demonstration of mandibular posturing devices such as the Fränkel appliance, the characteristic changes that occurred in the frontal dimension with extraoral traction, and an awakening awareness of the relationships between respiration and growth all expanded that need. The measurements were selected in the frontal for a routine survey. These can be memorized and taken into account by those desiring this level of information in their clinical knowledge and diagnosis (See Cue Sheet for frontal analysis).

Nasal Width

One of the primary points of interest is the width of the nasal cavity,

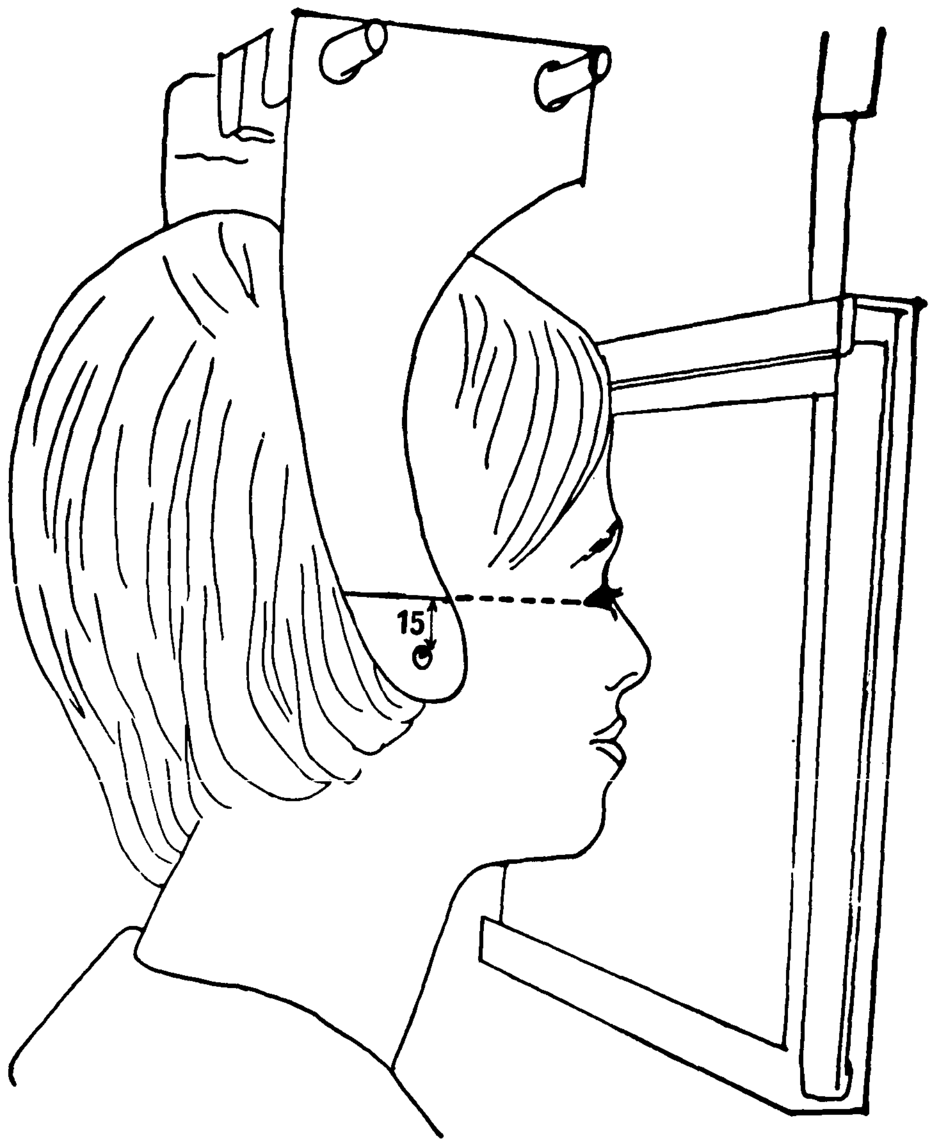


Fig. 12 Method of positioning for consistent orientation of Frankfort plane. The head is lowered to fit the ear rod to the top of the ear canal, and the lateral canthus of the eye oriented level with a line scribed 15 mm above the ear rod. Note the variation in positioning on the ear rod in Figs. 7 and 8, which can cause significant changes in the frontal view if not corrected.

CUE SHEET FOR RICKETTS' SUMMARY DESCRIPTIVE ANALYSIS

Frontal Orientation

1. Function: Indicator for Effective Nasal Width
Factor: Nasal Cavity Width N.C. — N.C. (Widest Points in Nasal Capsule)
Value: Clinical norm age 8 = 24.5 mm ± 2.0 mm
Change: Increase 0.5 mm each yr.; age 3 = 22 mm, 18 = 29.5

2, 3. Function: Indicator for Maxillo-Mandibular Transverse Relation
Factor: Maxillary Relation (Maxillary Concavity) (J to Frontal Facial Plane)
Value: Clinical norm = 10 mm ± 1.5 mm
Change: None

4. Function: Indicator for Effective Mandibular Width
Factor: Mandibular Width Ag — Ag (At Trihedral Eminence above Notch)
Value: Clinical norm age 3 = 68.25 ± 3.0
Change: Increase 1.25 each yr.; 8 yrs. = 75 mm 13 yrs. = 81.25
18 yrs. = 88.50

5. Function: Indicator for Skeletal Symmetry
Factor: Points ANS and Po to Central Sagittal Plane
Value: Clinical norm = 0 mm ± 2 mm
Change: No Change with Symmetry; Increases in Asymmetry

6. Function: Indicator for Arch Width at the First Permanent Molar
Factor: Intermolar Width (Buccal Surfaces of First Molars Transversely)
Value: Clinical norm B6 to B6 = 56 mm ±2.0 mm
Change: May narrow slightly with mesial drift but essentially no change

7. Function: Indicator for Arch Width at Lower Cuspids
Factor: Intercuspid Width (From Incisal Tips)
Value: Clinical norm B3 to B3 age 13 = 26.0 mm ± 1.5 mm; age 3 = 25 mm; age 8 = 22.5 ± 2 mm
Change: Crowns converge, then diverge in eruption

8, 9. Function: Indicator for Harmony of Arch Width with Jaws
Factor: Lower Molar to Fronto Denture Plane (B6 to J Ag)
Value: Clinical norm age 8 = 6.0 ± 2.0 mm
Change: Increase with age 0.8 mm each yr.; age 6 = about 5, 13 = 10 mm, 18 = 14.2 mm

10. Function: Indicator for the Midline Drift of the Lower Arch
Factor: Midpoint of Lower Incisors to Fronto A-Po Plane
Value: 1/1 = 0 mm = ±1 mm
Change: No change in normal symmetry; worsening in asymmetry

11, 12. Function: Indicator of Molar Crossbite
Factor: Buccal surface of upper molar to lower molar
Value: Upper more buccal by 1 mm ± 1 mm
Change: None

TABLE 8

Nasal Cavity Width
Increases 0.5 mm each year

Age 3—22.0	Age 10—25.5	Age 17—29.0
4—22.5	11—26.0	18—29.5
5—23.0	12—26.5	19—30.0
6—23.5	13—27.0	20—31.5
7—24.0	14—27.5	21—32.0
8—24.5	15—28.0	22—32.5
9—25.0	16—28.5	23—33.0

because of the importance of attaining normal respiration in the orthodontic patient. The accompanying table 8 shows the normal dimensions and growth changes in nasal width. This measurement is used in combination with the palatal plane in clinical diagnosis, and while treatment changes cannot be covered in the scope of this discussion, the nasal cavity can be altered with extraoral traction and attention to the nasal capsule has come to be a major concern of the astute orthodontic clinician (See Fig. 6).

Mandibular Width

One reason for difficulty with the frontal head film was attributable to the continued efforts to evaluate the mandible from the gonial angles and condyles, and the midface from the zygomatic arches. These points are all far removed from the teeth, and their variability resulted in low correlations. Values useful enough to be practical at a clinical level could not be derived until points closer to the molar teeth were selected.

Basal mandibular width is better described by points just below the trihedral eminence, called Ag (for antegonial tubercle). This is a much more stable area, undistorted by muscle attachments. The standard values with growth are noted in table 9.

TABLE 9

Mandibular Width
Increases 1.35 mm each year at Antegonial Trihedral Area (Ag)

		Males
Age 3—68.25	Age 10—77.70	Age 17—87.15
4—69.6	11—79.05	18—88.50
5—70.95	12—80.40	19—89.85
6—72.30	13—81.75	20—91.20
7—73.65	14—83.10	
8—75.0	15—84.45	
9—76.35	16—85.80	

Maxillary Width

Maxillary width is evaluated from the mandible, just as convexity or maxillary relation is measured from the mandible. Because there are two sides and two maxillae, a measurement is made for each side. In order to establish a line from which to measure, "Frontal Facial Lines" (actually two lateral lines) are constructed from the inside margins of the zygomatico-frontal sutures to the aforementioned Ag points. This is related to "J" point or point jugale, which is defined as the crossing of the outline of the tuberosity with that of the jugal process as viewed in the frontal film. About a 10 mm distance from J point to the fronto-lateral facial line is desirable.

Symmetry

The next measurement in skeletal relation is the maxillary and mandibular midlines. By relating point A and Pogonion to the midsagittal plane, symmetry of the skeletal midlines can be assessed. A midsagittal plane is dropped through the top of the nasal septum or crista galli, perpendicular to the line through the centers of the zygomatic arches. By this method, asymmetries can be located within the maxilla or the mandible, or in combination. This information assists in the diagnosis of unilateral conditions and severe midline deviations.

Thus, of the ten measurements for the frontal, the skeletal parts are represented by five, i.e., the nasal width, mandibular width, maxilla to mandible on each side, and midline deviations.

Denture Relations in the Frontal—Molar Width

In the denture pattern a primary interest is the lower molar width relative to the skeleton. Just as the lower incisor was evaluated from basal points in the upper and lower jaws, so is the molar related to basal bone near its position. In this instance, however, the lower molar measurement changes with age. Table 10 is used as a reference. Both the right and left sides should be evaluated.

Actual Intermolar Width

In addition to the molar relation to the jaws, the intermolar width can be measured from the buccal surface as portrayed on the radiograph. There is a 5% to 10% enlargement which should be considered when relating the measurement from the film to the dental cast, but this is unimportant for relationships within the radiograph.

TABLE 10

First Molar to Jaws

Increases due to Lateral Jaw growth 0.8 each year

Age 6—4.4 mm	Age 13	10.0
7—5.2	14	10.8
8—6.0	15	11.6
9—6.8	16 Males	12.4
10—7.6	17 Males	13.6
11—8.4	18 Males	14.2
12—9.2	19 Males	15.0

Intercuspid Width

In addition to the width at the lower molars, the width between the tips of the lower cuspids can also be assessed. These teeth also change relationships during the time of eruption, requiring the appraisal of age effects in any evaluation.

Denture Symmetry

Similar to basal midlines, the denture midline is assessed from points between the upper and lower central incisor roots. The ideal, of course, is that the central sagittal plane falls on all these midline points.

Upper to Lower Molar Relation

Width differences between upper and lower molars are useful in identifying actual and potential crossbites as well as asymmetries. The measurement is made at the most prominent buccal contour of each tooth as seen in the P-A view, and recorded as the buccal overjet of right and left upper molars.

The average value is 1.0 mm + 1.0 mm.

Class II malocclusions may show a negative value suggesting a crossbite even when no crossbite exists. This is a result of mesial rotation and positioning of the upper molar into a region where the arch width is narrower. Such cases require expansion in conjunction with any retraction therapy to produce compatible arch forms without crossbite.

THE 7TH PHASE—CONTEMPORARY SERIAL ANALYSIS (See Figs 1-4, 10, 13)

While the Steiner analysis was a great step in the advancement of cephalometrics for the clinician, it still proved to be inadequate, particularly for longer-term growth analysis and specifics in the details of treatment.

It focused on changes from the anterior cranial base alone, without any central facial axis. For analysis, broad interpretations in directions of facial development could not be reliably made from such unstable indicators as a mandibular plane that is known to undergo extensive remodeling with growth, and a point B that does not represent true basal bone and is influenced by movement of the incisors.

A more complete cranial base is preferable: one near the interface between the face and the entire floor of the brain case. The Ba-N plane has proven to be the most reliable longitudinal clinical reference. Ironically, the small standard deviation of change in the facial axis (from the Pt to Gnathion) with growth narrows the frame of reference to a point where the orthodontist can learn directly the degree to which treatment or normal growth are accountable for an observed change (see Figs. 1 and 14).

Again, the research with the computer was responsible for the development of some of these measurements now thought to be critical in the four-

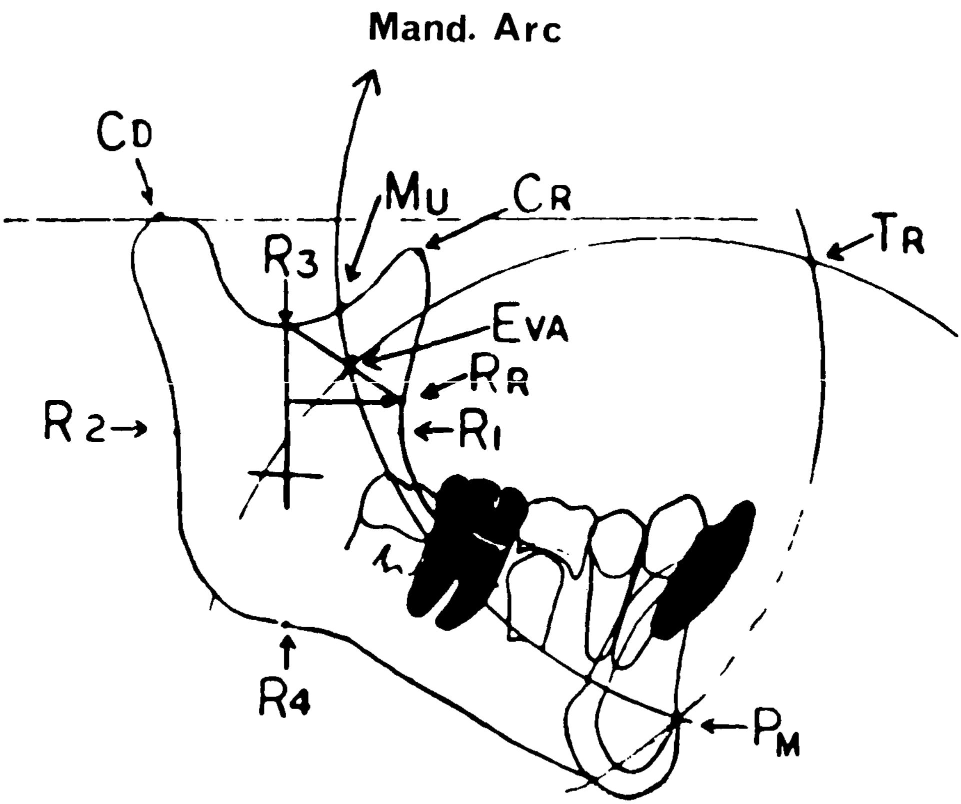


Fig. 13 Construction of the mandibular growth arc. The upper half of the ramus is bisected horizontally and the ramus reference (Rr) located on the anterior margin. This is connected to R3, the lowest point on the sigmoid notch of the ramus, and the line bisected to locate point Eva. Eva and Pm identify the base of the equilateral triangle that is then constructed with its apex at Tr (true radius). The growth arc is struck with Tr as the center, simultaneously locating point Murray where it crosses the sigmoid notch.

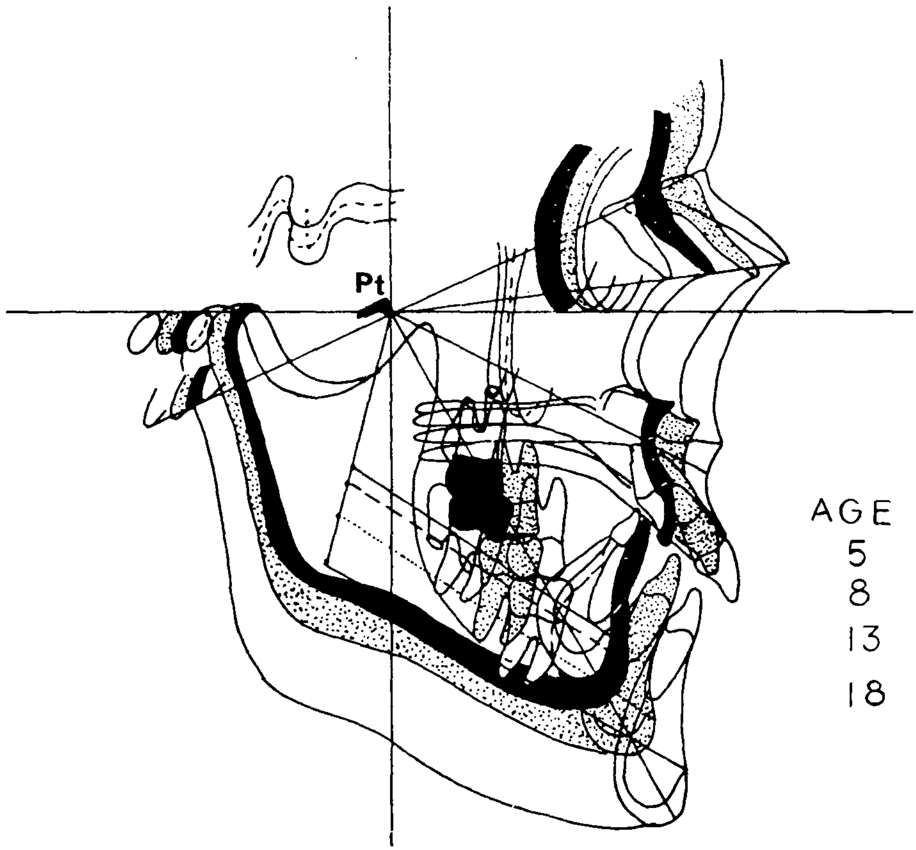


Fig. 14 Polar view of growth, based on a center located on Basion-Nasion plane registered at the point (cranial center, CC) where a perpendicular from Pt point intersects Ba-N. Note the orderly apparently radial outward movement of almost all facial structures with growth. Porion, Basion, Orbitale, Nasion, Gonial angle, Xi point, Gnathion and both molar and incisor teeth follow this pattern. The pattern is not shared by Sella, which is located in the neural cavity, or by the anterior nasal spine and point A.

position analysis discussed earlier. This may be considered a major breakthrough for the clinician seeking confidence in the clinical use of cephalometrics.[25]

For simplification of analysis for changes in the mandible, maxilla, and upper and lower teeth, pertinent data is shown in tabular form, together with the extent of change which might lead the orthodontist to suspect that a change was accomplished by therapy. There are always rare extremes, however, as the values were reduced to standard deviations of change or standard variation between time one and time two.

As familiarity with the technique is gained, the clinician's ability to monitor the course of therapy is greatly enhanced. Further, results can be assessed both in the short range and the long range. This detailed and critical type of analysis is something that our field has sought for fifty years.

The 8th Phase—Biologic Growth of the Mandible and Face

The 8th movement in cephalometrics has been the recognition of the arcial course of mandibular growth. While Moss[30] envisioned the growth of the mandible as a logarithmic spiral reasonably constructed via the path of the mandibular nerve, Ricketts found that the mandibular segment of such a spiral is closely approximated by a circular arc.[31] This can be easily constructed for assistance in long-range forecasting of the size and form of the mandible (Figs. 13 and 11B).

While data in terms of blind studies are not yet published, the arcial method of prediction works with uncanny accuracy and is quite trustworthy for clinical use in the absence of growth-related pathology.

In addition to superimposing on arcial forms for analysis, the location of vital centers from which growth appears to radiate in an orderly manner is another concept. These vertex centers seem to be identified with the growth of other oral, nasal, and orbital capsules in the face and indeed with the brain itself (See oral gnomon). Thus, as an eighth move in cephalometrics, departure from the traditional points and planes is required for a better understanding of the biologic nature of morphology and growth.[32] Those classical points merely identify parts of the complex curves that are the real pattern of living things (Figs. 9, 10, 13).

The 9th Phase

We are just at the threshold of the 9th movement in cephalometrics. While the Golden Section and Phi relationships have been known to artists and mathematicians for centuries, their direct application to the face from a therapeutic viewpoint, has only recently come under inspection. The Golden Section and Fibonacci numbers seem to be compatible with both the fields of mathematics and biology.[33] The Golden Section is not a mere mathematical presence—scientific investigations in the field find that proportion of 1.618, or its reciprocal 0.618, as a basis of beauty, harmony, balance, unity, and grace (Figs. 15-19).

Several composites of normal and well-treated patients all point to the fact that in normal facial morphology there are several places where these divine proportions can be recognized (table 11). When the skeleton and the denture are in normal arrangement and normal function and beauty, these relations even transcend racial differences.[34]

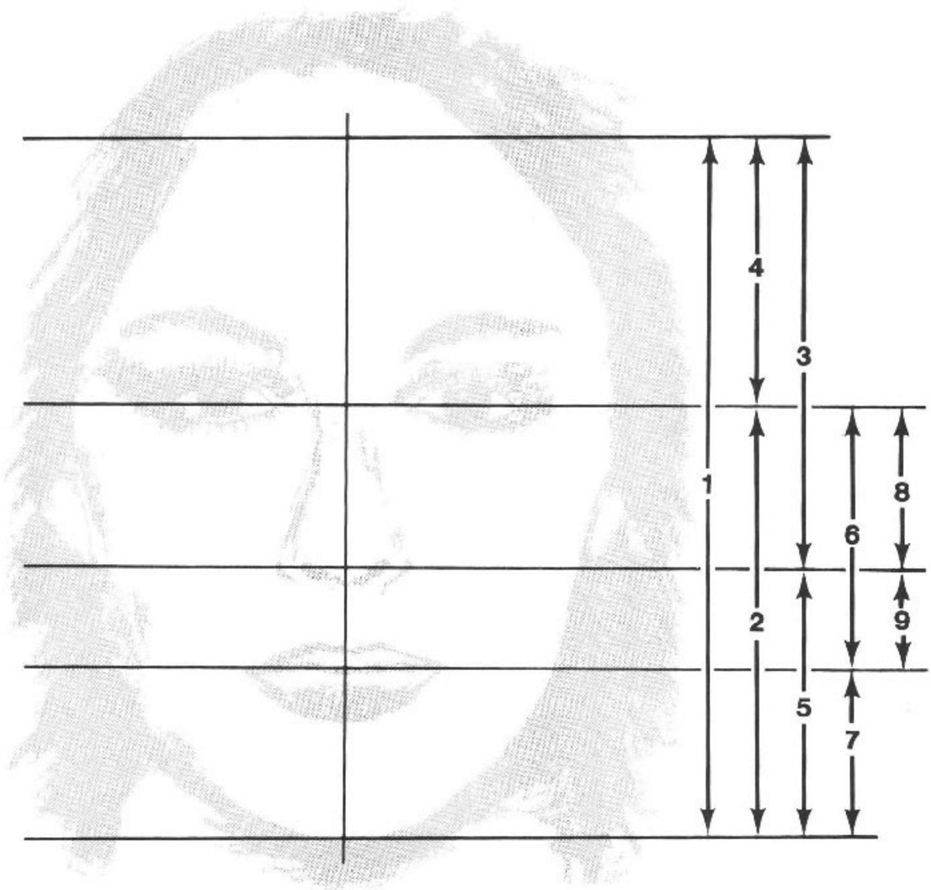


Fig. 15 Soft tissue proportional analysis of an esthetically pleasing face traced from an advertisement. The divine proportion is 1.618, or 1.62 in this scale of accuracy. Facial height from Trigion to menton (1) is divided into the height from eye to chin (2) which is 1.62 times the distance from eye to Trigion (4). Trigion to alar rim of nose (3) is 1.62 times the distance from nose to chin (5). Eye to mouth (6) is 1.62 times mouth to chin (7). Nose to chin (5) is 1.62 times nose to eye (8). Eye to nose (8) is 1.62 times nose to mouth (9). Chin to mouth (7) is 1.62 times mouth to nose (9). Chin to nose (5), mouth to eye (6) and eye to Trigion (4) are about equal.

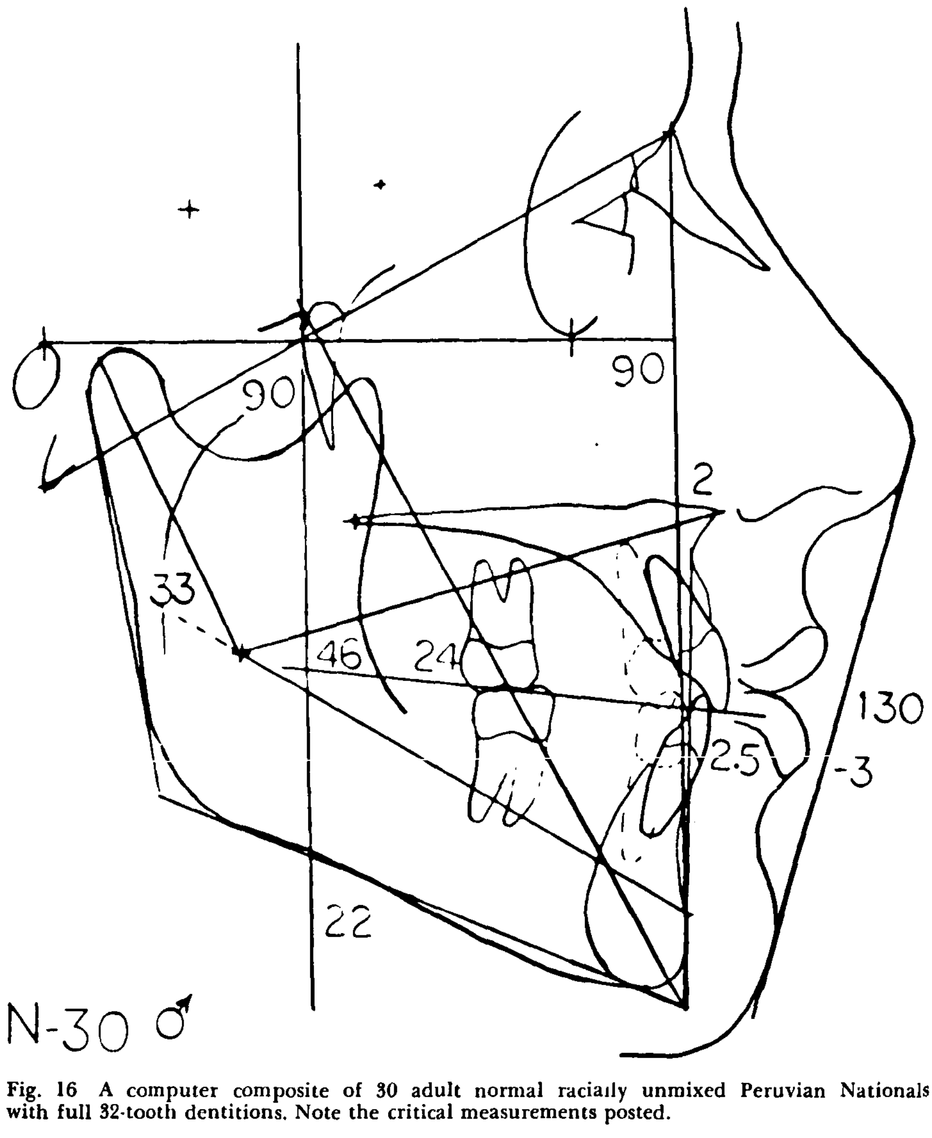


Fig. 16 A computer composite of 30 adult normal racially unmixed Peruvian Nationals with full 32-tooth dentitions. Note the critical measurements posted.

TABLE 11

Values in Divine Proportion Study

N 10 Photographic Models

	x Measurement *Actual*	*1.618 Proportion*				
1. TR-M	144.3 ÷ 89.18 ÷ 55.12 ÷ 34.06 ÷ 21.05					
2. LC-M	89.3	89.3 × 1.618 =				144.5
		89.3 ÷ 1.618 =		55.2		
3. TR-AL	88.6	88.6 × 1.618 =				143.4
		88.6 ÷ 1.618 =		54.8		
4. TR-LC	52.1	52.1 × 1.618 =			84.3	136.4
		52.1 ÷ 1.618 =	32.2			
5. AL-M	54.5	54.5 × 1.618 =			88.2	142.7
		54.5 ÷ 1.618 =	33.7			
6. LC-CH	55.6	55.6 × 1.618 =			90.0	145.6
		55.6 ÷ 1.618 =	34.7			
7. CH-M	33.7	33.7 × 1.618 =		54.5	88.2	142.7
		33.7 ÷ 1.618 = 20.8				
8. LC-AL	34.7	34.7 × 1.618 =		56.1	90.8	147.0
		34.7 ÷ 1.618 = 21.4				
9. AL-CH	21.3	21.3 × 1.618 =	34.5	55.8	90.2	146.0

5 Points

TR = Trichion
LC = Lateral Canthus
AL = Alar Rim
CH = Cheilion (Lip Embrasure)
M = Menton

Note recurrence of values in right-hand columns. Successive divisions of TR-M produce values in range of other dimensions.

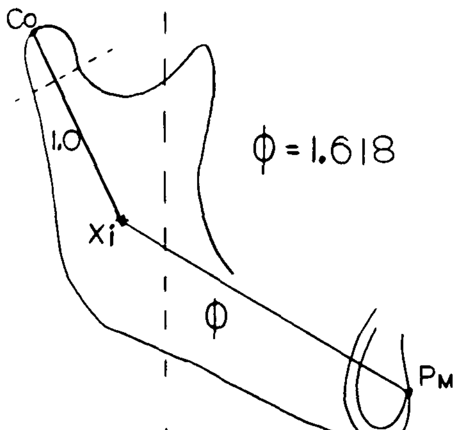


Fig. 17 Golden cut or divine proportion analysis of the mandible shown in the composite in Fig. 16. Corpus axis (Xi-Pm) is 1.62 times the condyle axis (Xi-Cd).

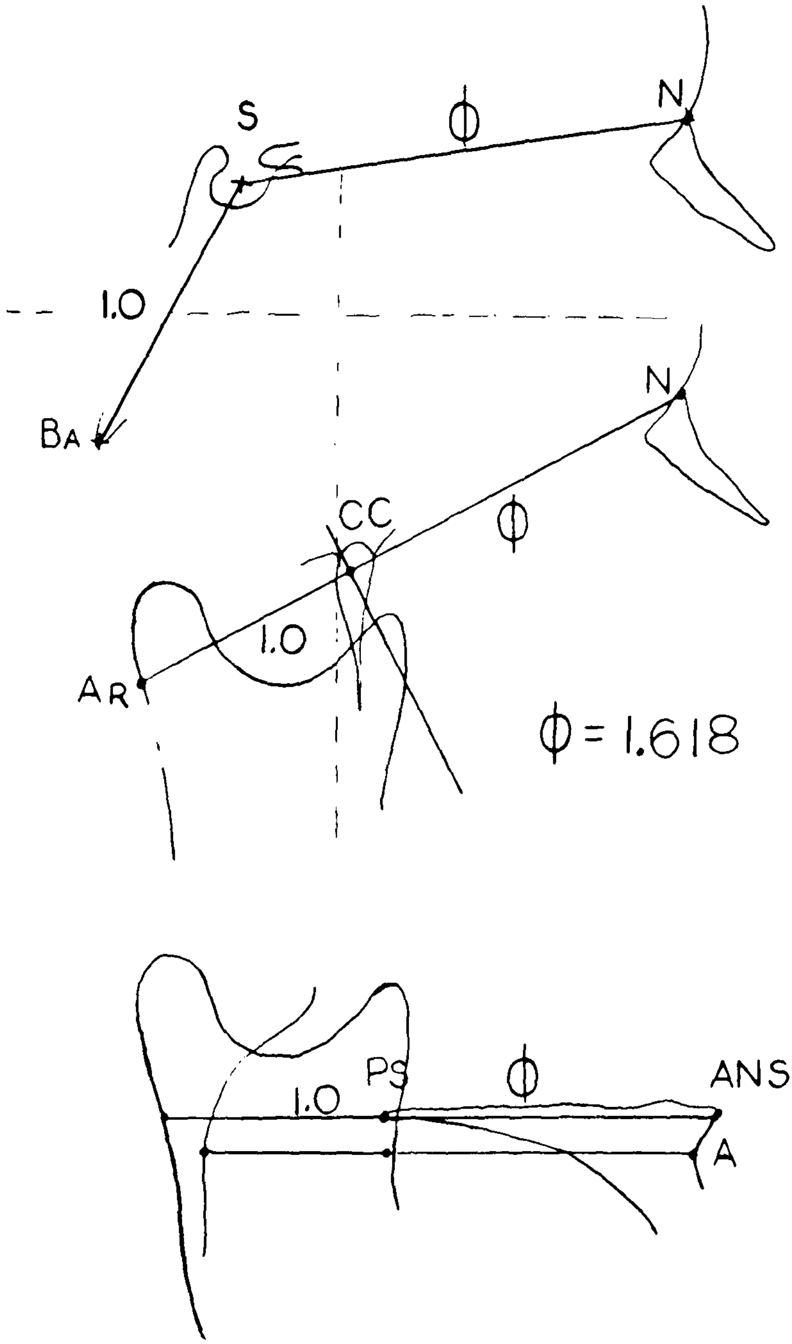


Fig. 18 Other divine proportions from Fig. 16. S-N is 1.62 times S-Ba. CC-N is 1.62 times CC-Ar. ANS-PNS is 1.62 times PNS to the ramus base of the condyloid process. A-PNS is 1.62 times PNS to the soft-tissue wall of the posterior pharynx.

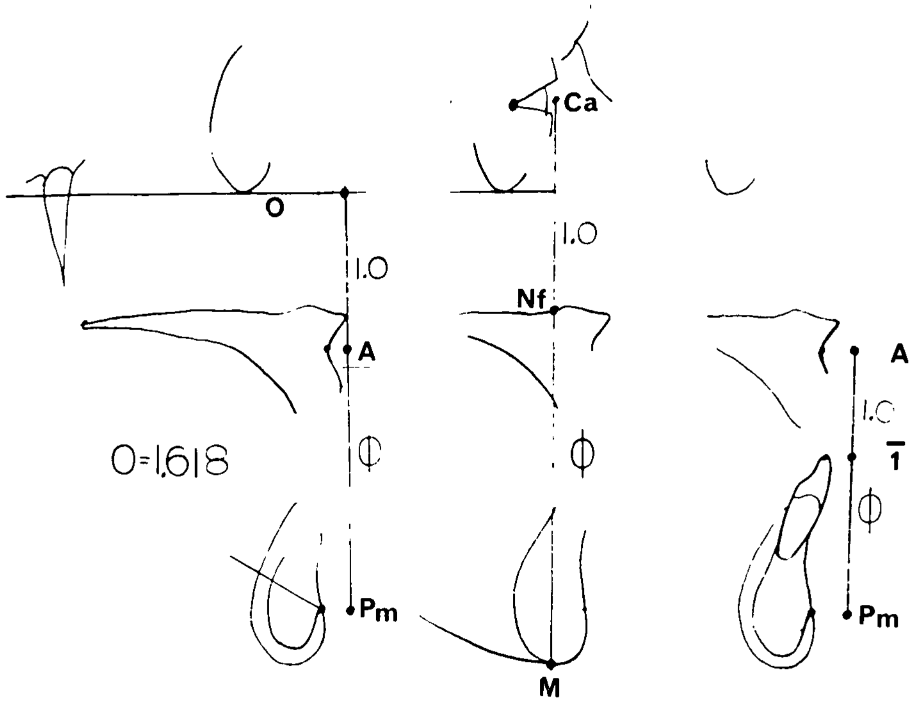


Fig. 19 Additional proportions are: A-Pm 1.62 times A-Frankfort plane. Menton-nasal floor 1.62 times nasal floor to canthus of the eye. Lower incisor—Pm 1.62 times lower incisor-point A.

These relations probably go back to basic cellular division, and to expand this new movement would take more explanation than can be offered here. However, composites of normal occlusions seem to point to the relationships outlined in the accompanying illustration (Figs. 16-19).

These arrangements and relationships are quite useful in patients with extreme dysplasia, and particularly in those requiring surgical correction; ugly patients are indeed made quite beautiful when the skeletal arrangement follows this principle.

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