American Institute for Bioprogressive Education

PROGRESSIVE CEPHALOMETRICS PARADIGM 2000

by Dr. Robert M. Ricketts

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I INTRODUCTION

Statement of Need

In the 1950s, after the acceptance of Downs' Analysis in 1948, a forceful movement toward the clinical use of cephalometrics was witnessed. Many leading clinicians found cephalometric procedures a profound adjunct to their practices. They now had a tool to explain and exhibit the ideas which had developed over their previous careers. But limitations had become a dogma, and the profession was divided.

By the 1960s cephalometrics became expanded due to several developments. Greater possibility of changes with treatment was revealed. The joint area had been uncovered by oriented tomography. Growth was brought into a direct consideration as an adjunct to treatment. Facial typing became a clinical concept. The visualization of treatment objectives (VTO) developed into a part of orthodontic clinical science and art. Computer research led to an advanced state of information and spun off (1) new analyses, (2) new growth revelations, and (3) data for forecasting information in a three-dimensional model.

While the foregoing advancements were made by the 1970s, there was an absence of acceptance by practitioners in the mainstream. Consequently, the clinical use of the tool did not kept pace with that progress. Ironically, an actual decline in use occurred at the same time the orthodontic profession at large sought to further secure the specialty.

Unfortunately, some educators have even belittled the cephalometric approach as an aid for practical decision-making at the chair, still insisting that a static model analysis and photographs will suffice for diagnosis and planning. This idea was held because, first, they think skeletal changes are not significant and, secondly, they believe growth to play only a small role in the outcome of a treatment. This is

despite the fact that 7% of children with Class II have been shown to correct with growth alone. With the vigorous effort on the part of traditional orthodontists to wait for all teeth to be present and then apply old standard straight-wire procedures, the outcome was delegated to the appliance technique alone. Some commercial promoters claim the whole issue in orthodontics is within the wire -- what utter nonsense!

Practices in The New Millenium

In order to further progress, the entire orthodontic profession needs a lift into the new millenium. Great strides have been made in bonding and bracket "preadjustment" designs. However, diagnosis, prognosis, treatment designing, anchorage considerations, the realization of possibilities, and long-term objectives are embarrassingly weak in the common practice of the specialty as determined by surveys as late as 1991. This needs to be changed.

Progressivism in Cephalometric Application

The actual clinical application of the headplate was precipitated by William B. Downs in 1948. His objective was to enable the clinician to "type" the patient's skeletal condition and determine the relations of the teeth within that "pattern". It was proposed as an aid in diagnosis. But also, objectives and treatment plans were to be related to an implied amount of anticipated growth and its direction in Downs' mind.

The author started work with Downs prior to the publication of that analysis. Through the years a series of appropriate changes were made resulting from both controlled investigations and practical experience. It would be difficult now to identify the original scheme because no measurements, methods or interpretations remain as proposed originally.

Downs' method and other schemes focused on the profile. The main interest was directed to chin position, convexity, and denture position. Yet, in Downs' words, in 1950, "the explanation and understanding for conditions that present in the profile comes from effects of the cranial and facial structures **posteriorly**. This is where work is needed."

Since 1970, a frontal analysis has been found useful. Also, in the lateral and frontal, sensible forecasting procedures are proven sufficiently accurate as guides for clinical application. In addition, the **possibilities** of "orthopedics" have been determined as produced by different treatment modalities. Finally, the **computer** has been a breakthrough for research and is being used regularly for clinical information.

All this needs to be taught and adapted for clinical use. Now it is clear that those clinicians waiting for the permanent dentition to start therapy and who work without benefit of the full application of the developments within the cephalometric tool are, unfortunately, being left behind. They may be like Rip Van Winkle . . . awakening to a different world in orthodontics.

The label "progressive" has been employed for two reasons. First, it is used in the sense of modern, contemporary, futuristic and advanced. In fact, Langlade has suggested a new label, "prospective" (or looking toward the future). But more than that, it is associated with the idea that a step-by-step order of application is appropriate for a complete efficient routine clinical regime.

Purpose

The present syllabus, and instructional courses attending it, is an effort to update the specialty of orthodontics as a whole with, if not the schemes presented herein, the cogent use of applications proposed by other cephalometric methods. This teaching is an effort to improve information accessibility and enhance knowledge and skill of application in order to elevate sophistication of the profession.

II THE SEVEN PROCESSES -- The Rough-In of the Idea

In the learning of anything, the mind goes through three stages. The first is the "rough-in" sketch of the idea. The second stage is an abstract process of association and understanding of the idea. The final stage is the concrete, which is the detail of knowledge through correct and routine application.

Rehearsal is required in order to master any idea or technique. It is up to the student to learn. Also, as with any vertical learning process, there are certain baseline values and procedures that simply must be memorized. This will enable the student, or the clinician, to employ the information successfully. It is like a new language that improves with use.

There are essentially seven major operations to the complete contemporary application of the cephalometric X-ray tool for the specialty. For reasons of communication, these are listed first as a rough-in:

1. **Production of the Image**

   Many headfilms are so poor that they do not give the clinician a chance to extract the available information. The technique for taking and processing

of the film should be regarded as seriously as the attention to appliance technique.

2. **Model Data Conversion**

For unification, the information from the orthodontic model is associated with the information from the lateral and frontal headfilm. The amount of enlargement of the cephalometric image needs to be known. (This refers to film-object distance.

Analysis can be started with the teeth and their emplacement, but it can also begin with any part of the skull.

3. **Diagnosis**

The first step toward diagnosis is an adequate description of skeletal, dental, and soft-tissue conditions. This, simply, is anatomical. It requires a scheme for abstraction and reduction in three dimensions. Thus, it entails both lateral (vertical and horizontal) and frontal (transverse and vertical) dimensions in order to be cogent.

4. **Monitoring Base**

The original aim of cephalometrics was to study growth changes in the living child. Comparison techniques were later employed to differentiate treatment changes. **A critical baseline method for separation of normal or natural growth from treatment changes must be available.** Data now is proven and provides a trustworthy reference base.

5. **Prognosis**

Anticipation of the future is one of the basic underlying aims of the whole clinical cephalometric process. This was implicit in the "typing" of facial growth patterns. But the technique offers value far beyond descriptive typing. Predictive techniques, with some rare exceptions, provide good detail of the future untreated face of the child at maturity. Particularly by age 8 the past growth patterns produce a given predictive base. Unfortunately, many educators have given up and spend their time objecting rather than studying and trying to improve present methods of forecasting.

6. **Treatment Planning**

Orthodontic objectives are made for purposes of producing the best esthetics, optimal function and foremost stability. The cephalometric procedure, with a forecast without treatment, may be employed first. Parents often ask what the child's condition will be without treatment. It has been

discovered that between 5% and 10% of early mixed dentition young children may self-correct Class II with growth. The **treatment objectives** are then superimposed on that basic underlying matrix.

Of even greater value, however, **anchorage criteria are calculated and detailed mechanics** are planned for the production of the result.

7. Selling

Any treatment scheme must be agreed upon by the parties involved. The making of a sales contract is a part of management. The cephalometric VTO or VTG process shows something **tangible to sell. It enhances** communication with the patient. It reveals to the patient the objectives and aims of the orthodontic, orthopedic and surgical processes.

THE PROPER USE OF CEPHALOMETRICS PROGRESSES THROUGH THESE SEVEN GROSS STEPS.

III THE TWELVE BRANCHES OF CEPHALOMETRICS -- The Abstract Level

There are essentially twelve (12) major clinical functions of cephalometrics. They fall into four general groups:

The first group pertains to **descriptive** and **diagnostic** parameters and the basis of standards.

The second group contains **sequential** functions which have reference to analysis of change.

The third group is connected with **prognosis.** Forecasting with the **simulation of results** is made to include designing and planning for anchorage for treatment.

The final group of functions is appropriate to **practice management.** Cephalometrics functions for **communication, learning, and selling** of the orthodontic product.

Twelve Functions of Progressive Cephalometrics:

1. Constitutes a tool for **Diagnosis.**
2. Provides access for visual assessment and tracing.
3. Contains references with biologic significance.
4. Yields a basis for a clinical norm.
5. Furnishes a framework for abstraction and reduction.
6. Renders a means for sequential growth analysis.
7. Supplies a **monitoring** process for treatment.
8. Delineates treatment possibilities.
9. Allows **prognosis** and simulation of objectives.
10. Grants a medium for **planning** all treatments.
11. Equips the user for practice management.
12. Manifests a principal tool for education.

* * * * *

Function #1. Constitutes a Tool for Diagnosis

Definition of Diagnosis:

*Diagnosis is the art or act of discrimination of condition and the further distinguising of individual characteristics.

*Diagnosis also includes intuition and experience by the recognition of patterns, but it is first based on science.

*Diagnosis consists of accurate classification and description.

*Diagnosis permits a summary of the symptoms and the conclusions and decisions arrived at.

The Lateral View

A metal head holder, or ear rods, should not cover the joint because that area is a part of present diagnostic consideration. Wooden or thin plastic holders for the ear rods should be used for purposes of radiolucency.

A. The technique for orientation for the lateral is the head in natural posture (not on Frankfort Plane necessarily).
B. The jaws are closed in habitual centric.
C. The lips are closed in order to perceive lip strain needed to seal the lips to swallow, which is diagnostic.
D. A second film may be made at physiologic rest and at lip repose if so desired, but given only one film more information is seen with lip closure because that act also may alter tongue position.

E The film is brought up to the rod holder in order to minimize enlargement, but even then there is still a 6% enlargement of the midline. For instance, arch depth in models actually averages 22.25 ± 1.4", but a 6% enlargement makes it 23.65 mm. from mesial of molar to center of edge to central incisor cephalometrically.

The Frontal View – Orient to Frankfort Plane

A. The technique for orientation on the Frankfort Plane is by alignment of lateral canthus of the eye with a mark on the cephalometer 15 mm. above the ear rod.
B. Teeth are held in occlusion.
C. The film is brought up to the nose to minimize enlargement, but still at the molars a 3% or 1.65 mm. enlargement of the arch may result.

Accessory Views

The Physiologic Rest Position Exposure

A. This is often informative for "joint patients" because it registers the "starting position".
B. The patient is instructed to utter fricative and plosive sounds followed by neutral sounds to acquire rest posture. The word "Boston" works well.
C. The lips may remain at repose.

The 25-Degree Oblique

A. By turning the head 25° the joint of one side is moved out of line of the central beam and the condyle fossa relation can be recorded on the side next to the film. This makes a view of the occlusion on one side for tracing and comparison of the other.

Wide Open

A. Wide open may be diagnostic of a joint or muscle impairment. It will further reveal the morphology and symmetry of the condyles. The right side is enlarged due to film object distance.

Other Functional Conditions

A. Holding the breath may sustain the palate closed.
B. Phonation -- In order to measure functional nasopharyngeal spaces the patient will pronounce the long "u" sound or "oo" as in spoon.
C. Incision possibility can be recorded to measure postures taken for incisive action.

D. A frontal Townes view, with open mouth, may reveal the sinuses and the frontal aspect of the condyles vividly.

Tomography

Body section X-rays provide details in the joint or any section frontally or laterally. (See lateral oblique joint section.)

* * * * *

Function #2. Provides Access for Visual Assessment and Tracing

Candidly, many orthodontists will "eyeball" a film only. Examination without measurement is typical of the practices of radiologists. In general an organized approach will improve the clinician's ability and acumen. A gross interpretation of the X-ray is made from a subjective viewpoint. A self-imposed searching observation followed by unbiased rationalization is required.

Studying the head X-ray film is an adventure. Fragmentary bits are collected from all available sources. The final verdict rests on the sum of the information and not on the X-ray alone.

The Three P's

For purposes of understanding, a searching of the film might be thought of in terms of the **physical** or morphological, the **physiologic**, and the **pathologic** -- hence, for reference, the three P's.

Physical (Form and Size)

A preliminary impression may be rendered by observing the headplates. Experience has shown that initial impressions or use of a photograph may not be borne out with measurement. We divided facial patterns into Brachyfacial, Mesiofacial, and Dolichofacial in terms of chin position. Convexity is assessed farther, and dental emplacement is also viewed.

Physical factors in the lateral film:

1. Cervical vertebrae and cranial base
2. Nasopharyngeal framework
3. Gross facial form
4. Mandibular form
5. Position of teeth
6. Soft tissue morphology

Physical factors in the frontal headfilm:

1. Form and symmetry of the cranium, orbits, nasal cavity, maxilla and mastoids
2. Symmetry of the mandible in form and position
3. Gross tooth displacement and third molar conditions.

Physiologic

Function will vary as based on the skeletal pattern and the muscle conditions. Head posture is a biologic consideration. Breathing spaces may be evaluated and associated with tongue postures and hyoid bone conditions. Strain in the lips may be further assessed as lip tension and tongue function may be factors producing the original malocclusion. Mandibular changes from rest to closure may be further considerations, particularly in a joint dysfunction analysis.

Physiologic factors in both views:

1. Respiratory obstructions
2. Position of the hyoid bone
3. Classification of abnormal lip relationships

Pathologic

1. Congenital deformity of the vertebra or skull base
2. Congenital deformity of the cranial base
3. Fractures
4. Identification of cysts
5. Inflammations of sinuses
6. Adenoids and tonsils proliferation
7. Foreign body identification

Tracing and Digitization

Following the visual assessment a tracing or digitization is performed. Remember that curved surfaces are usually present, and sharp detail is noted in the cross-section of a part. Particular points on the anatomy are sought. The tracing or digitizing into the computer should be considered a piece of art. The pencil line or stylus is placed precisely on the outline of the part not external to it or internal to it.

In order to trace, the analyzer needs to **know detailed anatomy of hard and soft tissues.** A three-dimensional object is projected into a two-dimensional medium. Only areas X-rayed in direct cross-section leave sharp lines of demarcation. Areas of reference require an understanding of their purpose of use.

* * * * *

Function #3. Contains References with Biologic Significance

A. Requirements of Points

Probably no other aspect of cephalometrics is more controversial than methods of superimposing, registering, and measurement. Whatever points are used, they should (1) have biologic significance, (2) be visible or (3) be capable of being constructed repeatedly with dependability.

Two Points Found Misleading

Perhaps at the outset it should be mentioned that two common, and often favorite, points employed in the past have been discovered to present problems or lead to misinterpretation. These are Point Sella and Point B. Because we do not use them, both deserve a discussion as to the reasons for their abandonment.

Point Sella - Found Unreliable

Sella, the center of Sella turcica by inspection, is a convenient point at the center of the hypophyseal fossa and has been the chief point of orientation used with Nasion and Basion by a host of investigators. It was used to form a triangle with Nasion and Basion, Nasion and Bolton Point, or Nasion and Articulare. SN is well associated with the nasal capsule. However, Sella has been found wanting as a mandibular reference and serial reference.

Sella has been dropped because (1) it was not trustworthy for typing, (2) it was questionable for serial reference (in that it is not polar to the face), and (3) it was found to be most unreliable for long-range growth forecasting. Also, (4) references from Sella-Nasion to facial structures correlated essentially not at all to the occlusal plane. Seven references were found useful to the Frankfort plane (when that plane employed true anatomic portion). Finally, (5) the "saddle angle" NSBa or NSAr was not found to be associated with or predictive of maxillo-mandibular relation.

On a current basis, Sella is not employed in this Progressive Cephalometric process except possibly for an angular assessment of the naso-pharyngeal apparatus immediately below it, or may have a usefulness for airway analysis.

Point B -- Alveolar, Not Basalar

Point B in the past has been taken to orient the lower denture, as for instance the lower incisor to the line NB. Downs related the A-B Plane to the Facial Plane and others related it to the occlusal plane. However, Point B develops wherever the lower incisor erupts or drifts as directed by lip and tongue force. A reversal line is found below Point B in development and Point B changes with the movement of the lower incisor. (Finally, Point B disappears when the teeth are lost, and is not present until the incisors erupt.)

The lone exception to the value of B might be to employ the area for evaluation and prediction of soft tissue in the area of supramentale, labial to it. But even then the coronal-root junction of the lower incisor is just as good for reference.

Point B became popular because of the loss of alveolar bone with vigorous orthodontic pressures in the presence of a strong lower lip resistance. It was considered, therefore, a stable basalar point. However, pressures in the range of 0.5 grams per mm.^{2} of labial root surface, **control of needless mandibular rotation** (which increases lip strain), myofunctional therapeutic attention, surgical lip procedures, and finally genioplasty, all can essentially eliminate the fear of introgenic "stripping".

Thus Sella and Point B were found to be unproductive in comparison to other more desirable points.

B. References Employed in Lateral Perspective

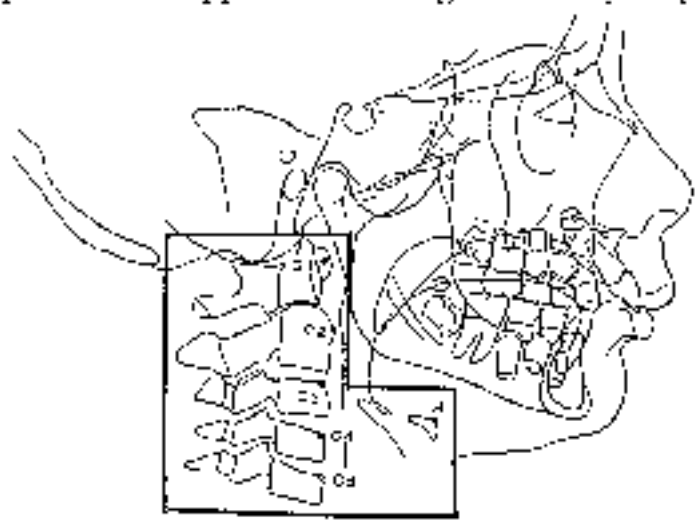
Cervical References

All typical vertebrae need not be traced always. However, dyspiasias of vertebrae and postural problems may be missed if they are not routinely considered. A typical vertebra (C3 to C7) has a body, a lamina, a lateral mass, a pedicle, and a posterior spine. The upper angle of the body can be used for reference. The body center and spine can be used for angulation.

The axis has a large spine and a body possessing a large vertical prop or dens. It also has a large superior facet which fits into the inferior fossa of the Atlas.

The Atlas has large lateral processes which overlap the occipital condyles which it receives. An anterior and posterior arch is present, and the cant or position of the bone may be an issue in physiotherapy. The center of the arches is employed for analysis.

The hyoid bone is traced in cross-section of the body only. Its triangular shape is recorded and a point at the upper anterior angle is the Hyoid point for reference (H).



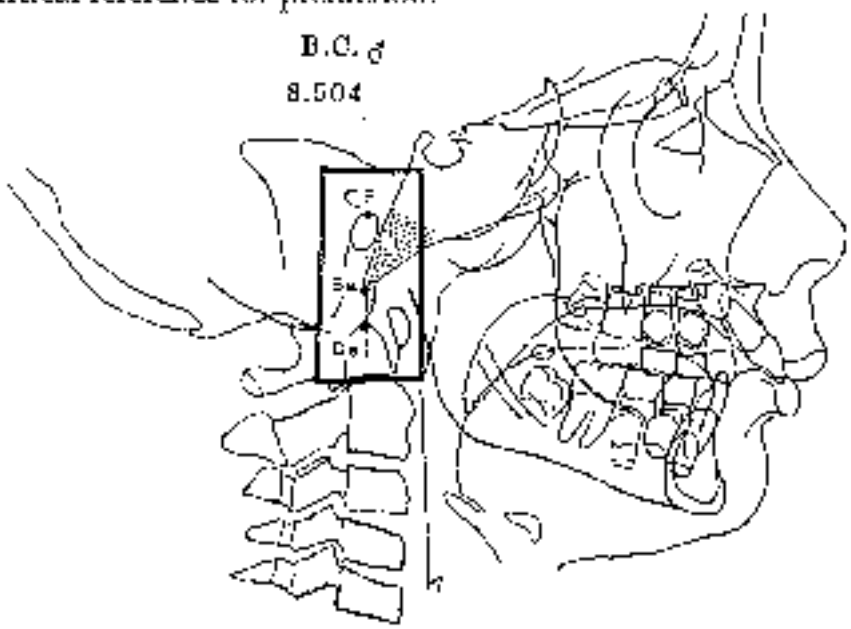
CRANIAL REFERENCES

Basion -- A Biologic Point as an Occipital Bone Center

This point is located at the anterior border of foramen magnum which exits the spinal cord and vessels from the neurocranium. **Basion** is located precisely between the two occipital condyles on which the head is supported and moved. It is a reasonable center for the occipital bone which is a base for support of the brain. Basion to Nasion is synonymous with the **Basi-cranial Axis** of Huxley traditional in anthropology. A plane through these points separates the face from the calvaria.

Basion is usually located immediately superior to the dens and in line vertically with Porion (external auditory canal). Its selection may be confused with the density of the bone of the anterior border of the condyles. It varies from a blunt rounded contour to a more sharp angle formed by lines from the clivus and the basalar portion of the occipital.

Basion is employed for description, for serial superimposing for changes, and provides a critical reference for prediction.



Nasion

The sutures are growth adjustment sites. During growth the nasal bone has been demonstrated to grow away from the frontal bone. The frontal bone houses the forebrain. **Nasion**, selected at the frontal margin of the fronto-nasal suture, represents an area at the junction of squama with the orbital plates and is a useful point for upper facial reference.

Not all nasal sutures are parallel to the central beam of the X-ray. The eyelid may confuse the Nasion selection, particularly in the Mongoloid race. Nasion must consequently be selected with precision. It may appear to be nothing more than a

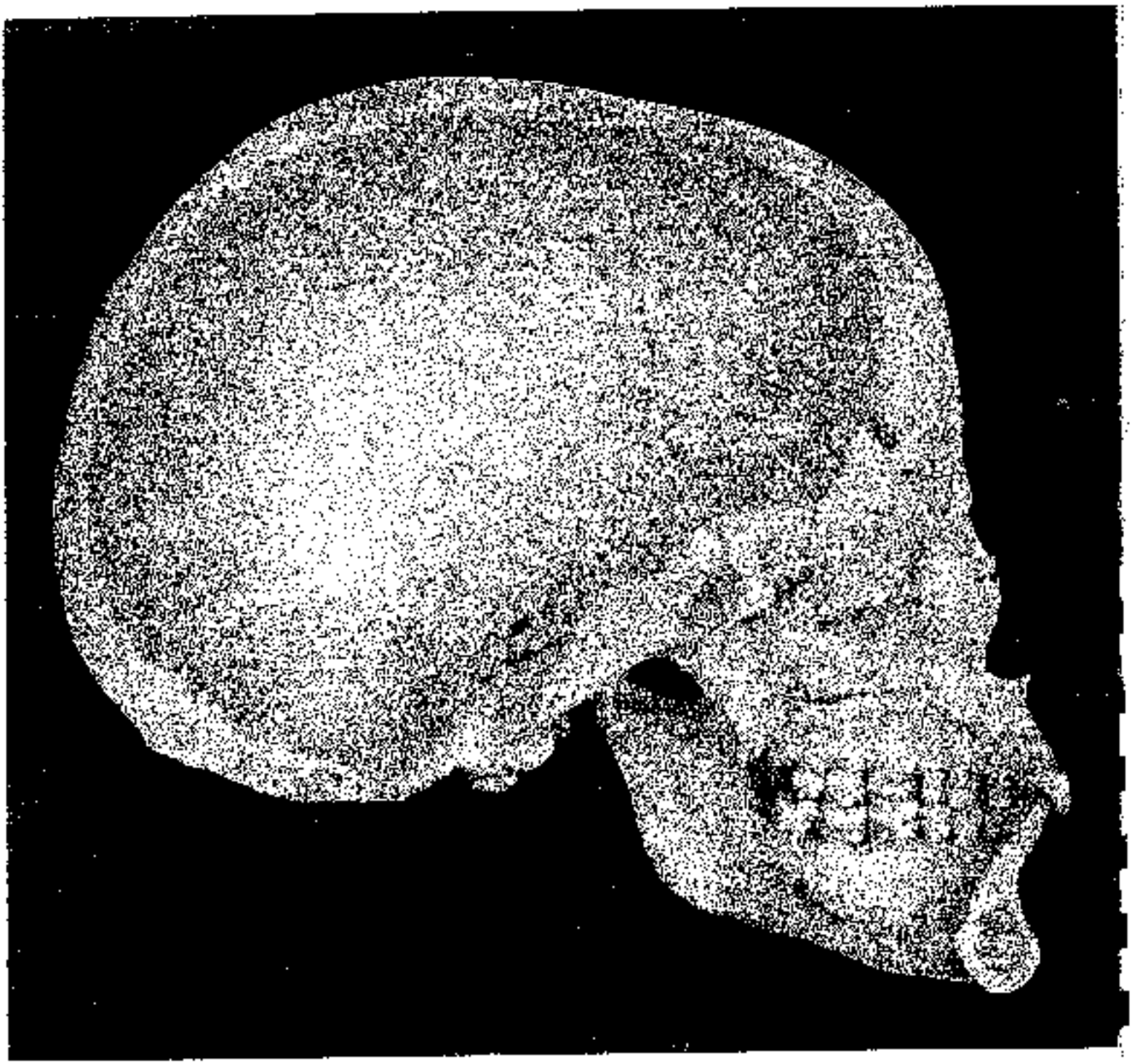
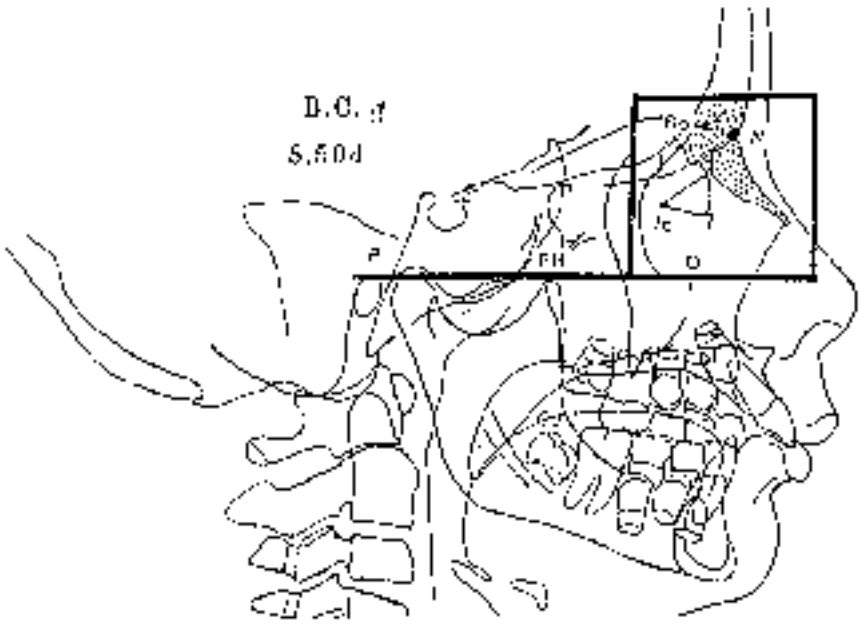


Photo of a sagittal section of a skull

slight indentation. It serves to help form the basi-cranial axis and has remarkable order with the forward development of Point A or the maxilla.



Porion -- A Temporal Bone Center and Historically the Most Common Anthropometric Point

Porion, selected at the center of the superior border of the ear canal, has traditionally been used for description of cranial and facial relationships. It represents the center of the temporal bone, the housing of the fossa, Nature's articulator. While visible in the dry skull it presents a slight problem of identification in the radiograph.

The ear rod of the cephalometer cannot be used with accuracy. In addition, the ear canal itself will vary in the image rendered because the canal will lie in the skull at different directions. The meatus is oval-shaped and not round.

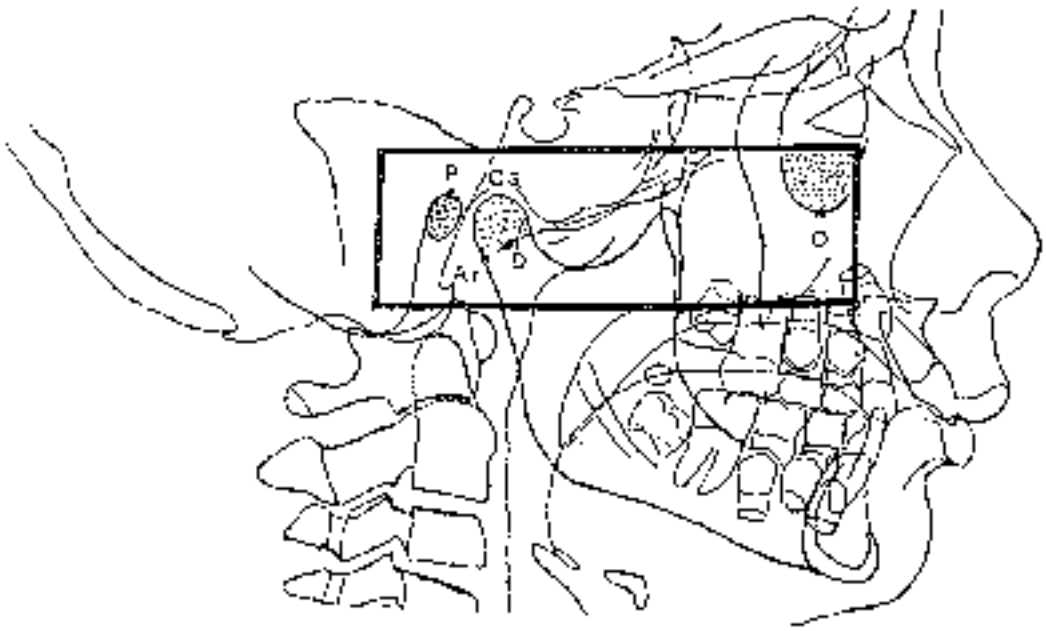
The external meatus further may be confused with the internal meatus which lies above it and behind it while remaining in a consistent orientation to it with growth. The canals also may not be symmetrical in position in the film due to either posturing or asymmetry. It therefore needs a **differential selection**, particularly for height. Both sides are bisected for one common reference.

The following aids are recommended for its selection:

1. Look for it in line with the dens, and Basion.
2. Orient also from the glenoid fossa which is almost bisected; i.e., from the eminence to the root of the fossa but may be confused in the child with the spheno-occipital synchondrosis.
3. Orient from the eminence or lateral tubercle.
4. The top of the condyle is remarkably consistent with the Frankfort Plane in dry skulls. (If the condyle is too far above or too far below the

FH Plane, something is probably wrong in the selection.)

5. The end of the post-glenoid process is very consistent with Frankfort Plane in the human.
6. Identify the internal canal and eliminate that image.
7. Trace both joints with a very soft lead pencil directly on the film (rub off with fingers, do not erase).
8. Identify the condyles and then compose a common joint area for the central reference from Time I onward.
9. Horizontally the posterior margin (condylion posterior) of the normally positioned condyle is used as a reference.
10. Three points on the condyle are Condylion (Co), Condylion posterior (Cp), and Condylion superior (Cs).



Orbitale (O)

The eye is a neurologic organ which develops relatively early. Because the orbital cavity is related to sight, which is in turn oriented to the true horizontal, the lower rim of the orbit (or Orbitale), when employed with Porion, has proven useful for facial orientation. Although Orbitale is located in the face due to its neural nature and early maturation (it is so basic it is thought of as "cranial").

The lateral border of the orbit is formed by the zygomatic bone. In fact, it can be debated that Orbitale point is actually based on the zygomatic bone. Selection may be at times difficult, and the right and left sides are bisected for critical longitudinal use. The selection should not be confused with the lacrimal canal, the infraorbital canal, or air cells in the ethmoid.

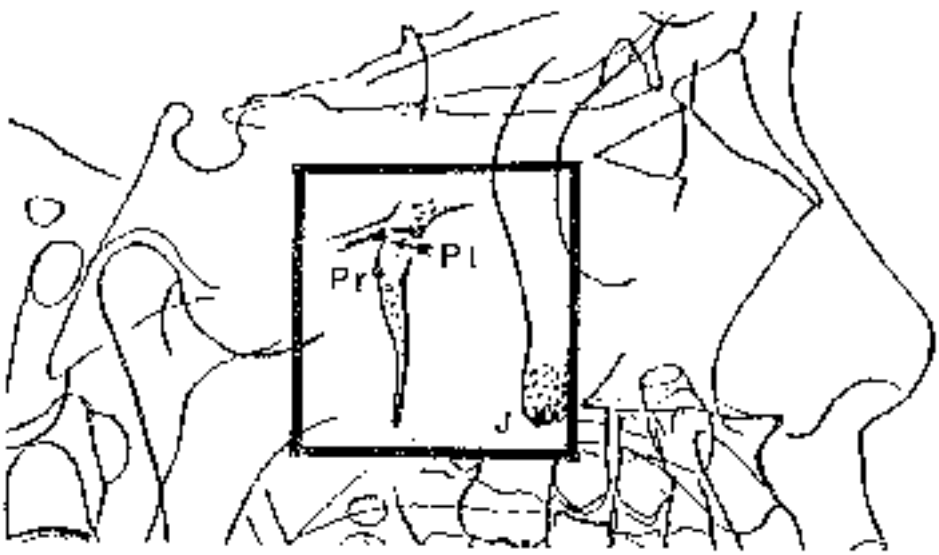
Quite consistently the Frankfort Plane precisely bisects the zygomatic arch. By examining the anatomy closely, Orbitale can be selected with confidence. It has, however, been observed to be influenced downward and backward with cervical traction in a growing child.

Pterygoid Reference (Pr)

The narrow Pterygomaxillary fissure was formerly employed for reference with the assumption that it was stable. However, on seeing that it was influenced by treatment, a higher point at the posteriormost border of the sphenopalatine fossa was employed for reference and labelled pterygoid reference (Pr). No treatment at the "root" of the pterygoid plates was found. A point at the posteriormost curvature of the fossa is selected. This area is close to a stable center. Point Pr is employed to drop a perpendicular from Frankfort. The outlines of both fossae are bisected for the selection of Pr. This crossing forms the best coordinate for entering data into the computer although, of course, any point can be used.

Pterygoid Point (Pt)

A polar center, from which lines to facial parts disperse in an orderly manner, has been sought from the beginning of growth studies. It is logical that the phenomenon would be related to neural distribution. The large trigeminal cranial nerve has both sensory and motor components which feed the facial cavities. The sphenoid bone is the central bone in the make-up of the skull. An exhaustive study with the computer revealed that a central point was essentially found near Foramen Rotundum -- the exit of the maxillary nerve, or second division of the trigeminal nerve.



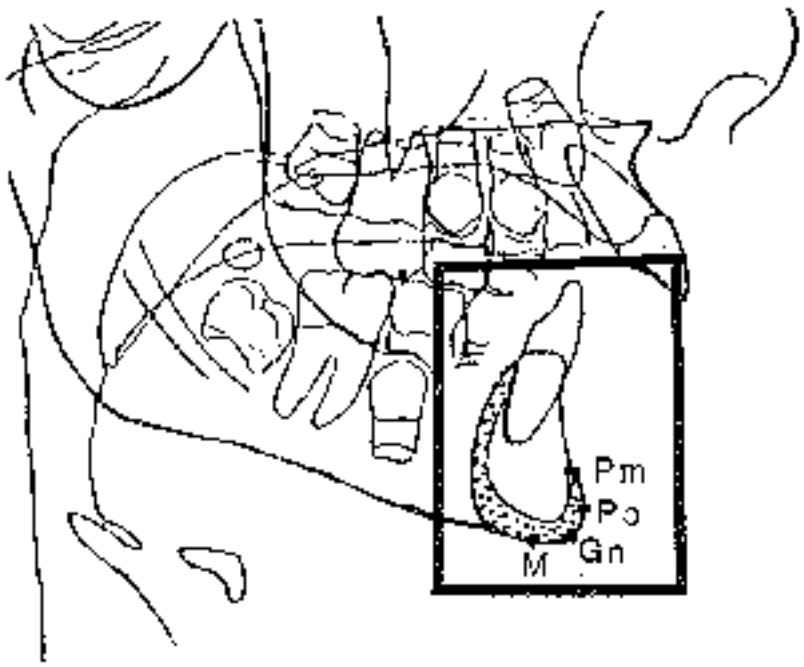
With the discovery of this central area, studies with leaded skulls showed that the lower border of the foramen could be identified as a point, and hence labeled Pt (for the origin of the pterygoid buttress).

Biologically, this area as a reference location is highly rational. Architecturally, at this area the great wings swing upward and outward, the pterygoid plates extend downward and the rostrum of the sphenoid supports the vomer downward and forward. From a neurotrophic standpoint (at this spheno-palatine location) the maxillary nerve enters, ganglia are contained, internal maxillary blood vessels branch, and it is a bracing area mechanically. Both Pr and Pt points have been highly successful sources of reference.

Thus in summary, our "cranial" references are **Ba, N, P, O, Pr** and **Pt**, with Sella relegated only for nasopharyngeal analysis.

MANDIBULAR REFERENCES

Greatest attention is needed for the mandible in facial typing and serial work. The lower jaw is more variable and has greater limitations structurally with treatment than the midface in the growing child. The thought form, in facial type and direction of growth, is the chin. Thus the mandible as a whole is assumed to be influenced when the behavior of the chin is studied. Several points of reference on the mandible are employed.



Pogonion (Po)

The most anterior point on the outline of the chin has long been used as a horizontal reference for chin position (**Po**). However, that surface can be relatively

flat and not specific for a vertical reference.

Protuberance Menti (Pm)

For a stable vertical reference, for the measurement of tooth eruption and growth change, a reversal line has been found at the top of the trigonum mentali (protuberance and mental tubercles). **Pm** is selected where the cortical plate ends and where the supramental contour starts to recede into the alveolar process. Metal implant markers at this point do not change during normal growth. Care should be exercised to select the same point in a series of tracings. Boys have additions of bone circumferentially below Pm point.

Gnathion (Gn)

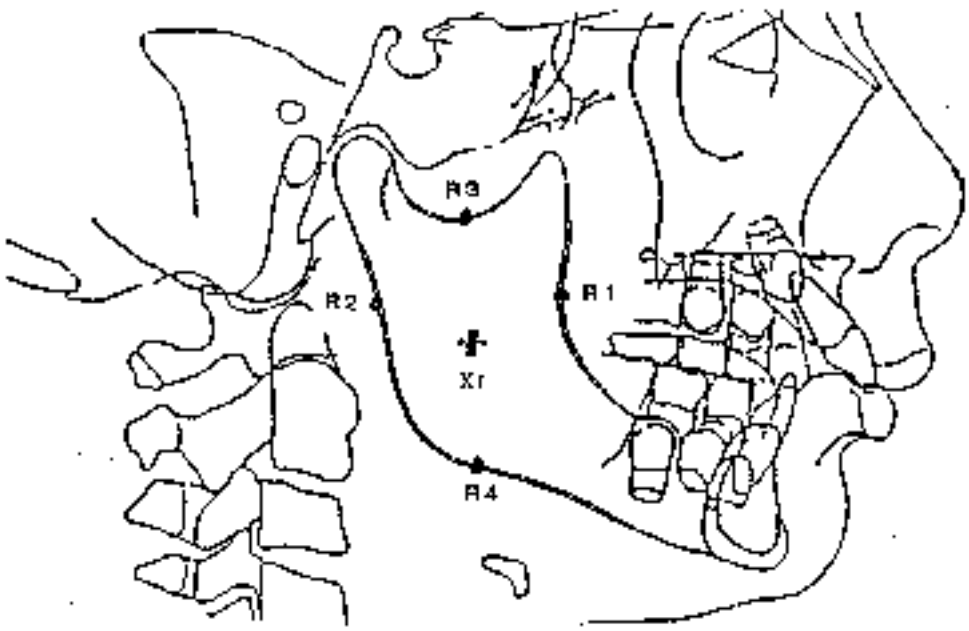
Technically, **Gn** was the most downward and forward point on the chin for anthropometrics. Practically, it is selected cephalometrically and constructed by the intersection of the Facial Plane with the Mandibular Plane which becomes the Gn reference. The crossing of the Facial Axis depicts the working gnathion point on the chin. Cephalometric Gn is used for the Facial Axis as it connects to Pt.

Menton (M)

Simply the lowest point on the inferior border of the symphysis.

Xi Point - R1 to R4

One of the most useful references ever discovered is Xi Point. It was selected as a centroid reference for the ramus and was a true break-through in research and clinical science.



Four points on the ramus are used for **Xi** selection. R1 is located at the anterior border at the narrowest point on the ramus. R1 is thus selected at the deepest curve on the sub-coronoid incisure. R2 is at the same level as R1 on the posterior border. R3 is the lowest point on the sigmoid notch. R4 is directly below R3 on the inferior point of the ramus. Thus, the height and depth of the ramus are bisected and the common point is Xi Point.

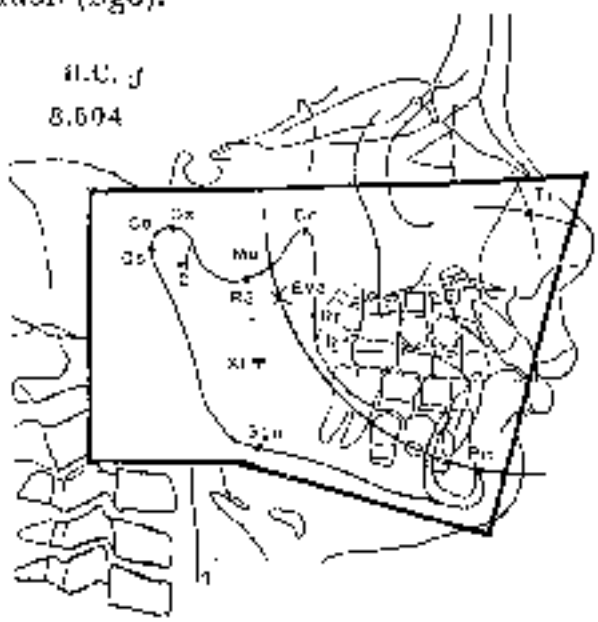
Although measured for its selection, Xi Point is strongly biological for several reasons. It is (1) found at the mandibular foramen funnel. It is (2) highly regular with the True Buccal Occlusal Plane. Its (3) diagnostic position is relative to PTV. It is (4) employed to locate points for the growth arc.

Xi Point is also (5) used for description of the size and form of the mandible. It is (6) used for the analysis of the Divine Proportion. It is (7) employed for facial typing. With growth it is (8) a vertex center for the oral cavity height. It is (9) used for description of both total facial and dental height. Finally, (10), it is used for prediction of development of occlusion and for the assessment of eruption and tooth changes clinically.

With ten applications, the selection of Xi needs care. The sigmoid notch is thin bone. Both external oblique ridges are often superimposed and confused with the medial temporalis crest. The margins of both sides of the ramus need to be bisected. In severe asymmetry, two Xi points -- one for each side -- may be useful for calculations.

Subgonion (Sgo)

Gonion is by definition the most inferior-posterior point on the angle of the mandible. The lower border of the angle is used for selection of the mandibular plane and hence is labeled subgonion (**Sgo**).



Condylion (Co)

Technically, by description, it is the most superior point on the condylar head. Practically, as used, it is often the most upward and backward point. Essentially, it can be located by use of Point D which has been selected by bisecting the width of the condyle neck near the Basion-Nasion plane.

Condylion Superior (Cs)

When the most superior aspect of the condyle is used we call it Condylion Superior (Cs). It is used in forecasting.

Condylion Posterior (Cp)

In order to locate a reliable horizontal reference for the condyle and the joint, the most posterior point is selected on the condyle border. Care should be exercised in checking mandibular posture. The condyle need not be seated "terminally".

Articulare (Ar)

Articulare has been employed as the highest visible point on the posterior border of the condyloid process beneath the shadow of the cranial base. Conveniently, it can be selected on the Basion-Nasion plane at the posterior margin of the condyle neck.

Ramus Reference (Rr)

The top half of the ramus (Xi to R3) is bisected, and a horizontal line is drawn to the anterior border which determines the Ramus reference. This is used for prediction.

Eva Point (Eva)

By connecting Rr point to R3 (the center of the sigmoid notch) a line depicting the coronoid process is formed. By bisecting that line, point Eva is selected, which is used to construct an arc together with Pm point.

Murray Point (Mu)

This is a reference point employed for forecasting at the crossing of the arc with the sigmoid notch outline.

Thus, in summary, the seventeen mandibular references are employed. On the symphysis are **Pm, Po, Gn**, and **M**. For the ramus they are **Sg, R1** to **R4, Rr, Xi, Eva** and **Mu**. For the condyle they are **D, Co, Cs** and **Cp**.

MAXILLARY REFERENCES

Compared to the references for the mandible, the references for the midface are few and simple, but are sometimes difficult to identify.

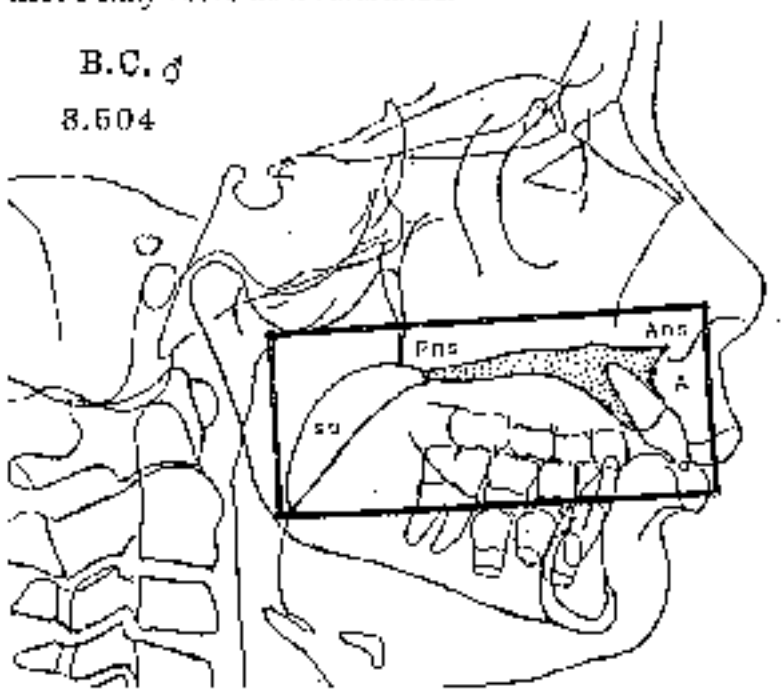
Anterior Nasal Spine (ANS)

Anteriormost on the two maxillae is a spine which acts as a shelf to support the nasal cartilaginous septum. The anterior nasal spine is therefore related to the nasal cavity and is not alveolar process. It is sometimes difficult to locate precisely. With an overexposed, or unshaded X-ray technique, it may be visible only in spotted light. It also varies in length. Rarely is it not present, but in long noses it may be larger than in short noses. Along with the spine, a heavy bony ridge, which runs transversely between the two maxillae, may be identified together with the foramen for the incisive canal medial to the erupting canines which may obscure it.

Posterior Nasal Spine (PNS)

The posterior nasal spine is actually on the palatine bone, not the maxilla. It is an extention of the maxillary hard palate and usually is revealed as a tip. It is plainly visible in cross-section in adults. It may, however, be superimposed by the developing molar crowns in children.

When it is difficult to locate, the attachment of the soft palate can be used to find it. The superior border immediately at the tip usually serves as the upper velar attachment, while the velum has a broader base inferiorly. In bilateral cleft palate conditions there is no posterior spine but in surgically closed soft cleft palates the cross section of scar tissue may serve as a reference.



Point A (A)

By definition Point A is usually selected at the deepest curvature of the contour below the anterior nasal spine. It is often considered to be the junction of alveolar process with basal bone. In long lower face height the maxillary incisors supra-erupt. This may extend the alveolus downward and the deepest contour may be low and away from the base of the spine. In normal adult conditions, Point A is almost exactly parallel to the height of the root tip of the central incisor. Point A is thus selected at the base of a triangular form for the anterior nasal spine (see illustration).

In extreme gummy smile patients with a long alveolus present, and in which surgical maxillary impaction is planned, an artificial Point A is selected at the level of the incisor tip for planning reference. This is employed for the Divine Proportion in planning in order to locate the palate and the lower incisor edge at a golden point between A and Pm. The artificial A point is employed to locate Point A in a golden relation to Frankfort Plane and Pm.

Thus, in summary, the maxillary points are **Ans, Pns,** and **Point A.**

TEETH

We have found the use of the Ricketts template to be a vast aid for drawing teeth! In order to record for greatest detail, all teeth may be traced. However, the first molars and the central incisors are references usually employed as keys to denture emplacement. The lower buccal teeth are employed for the **True Buccal Occlusal Plane.** When the right and left molar teeth are directly superimposed, tracings are easy. But when asymmetry exists, all dental structures are bisected for a single representation for measurement and planning.

Without much ado we quietly calculated molar relationship for classification from the lower molar rather than the upper. Strangely, no one objected, which meant perhaps that most clinicians actually think from the lower molar.

The Lower Incisor ($\overline{1|}\vec{1}$) (B1)

Selection of the most representative position of the common lower central incisor is attempted. If one lower central incisor is displaced forward it does not represent the position of the entire lower anterior section. In general, the mean of the two lower central incisors represents a working position. Hence, the template is of good value for accuracy and efficiency in tracing.

The Upper Central Incisor ($\underline{1|}1$) (A1)

As in the lower, a common position between the two upper centrals represents a working relationship. Again, the template offers the best consistency and accuracy.

The Lower First Molar ($\overline{6|6}$) (B6)

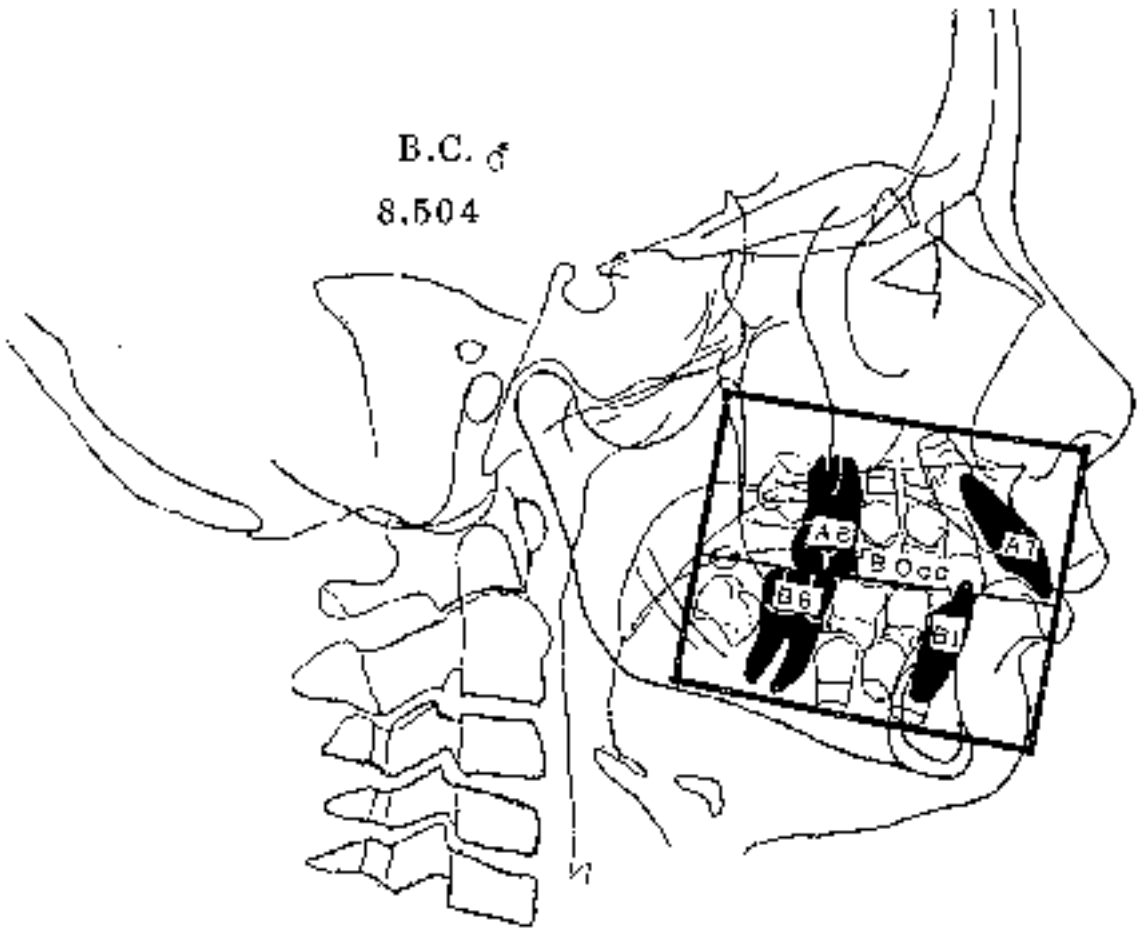
The lower molar serves as a base reference for diagnosis, planning, and anchorage consideration. Its position in the two sides is bisected for a common reference. It serves to calculate arch depth. It is used for measuring arch emplacement vertically as well as horizontally. The lower molar tends to behave vertically with Xi Point during development. The posterior margin is used for distal references and the mesial margin for anterior reference, and the bisection of the molar occlusion is used for measurements vertically.

The Upper First Molar ($\underline{6|6}$) (A6)

The upper molar also is bisected. A problem may occur in its position in subdivision situations. Still, a bisection will yield a mean position.

Canines

All four canines are problems clinically, and the canine cusp tips are references for the comprehensive analysis.



SOFT TISSUE TRACING AND REFERENCES

In soft tissues, small letters are employed for reference.

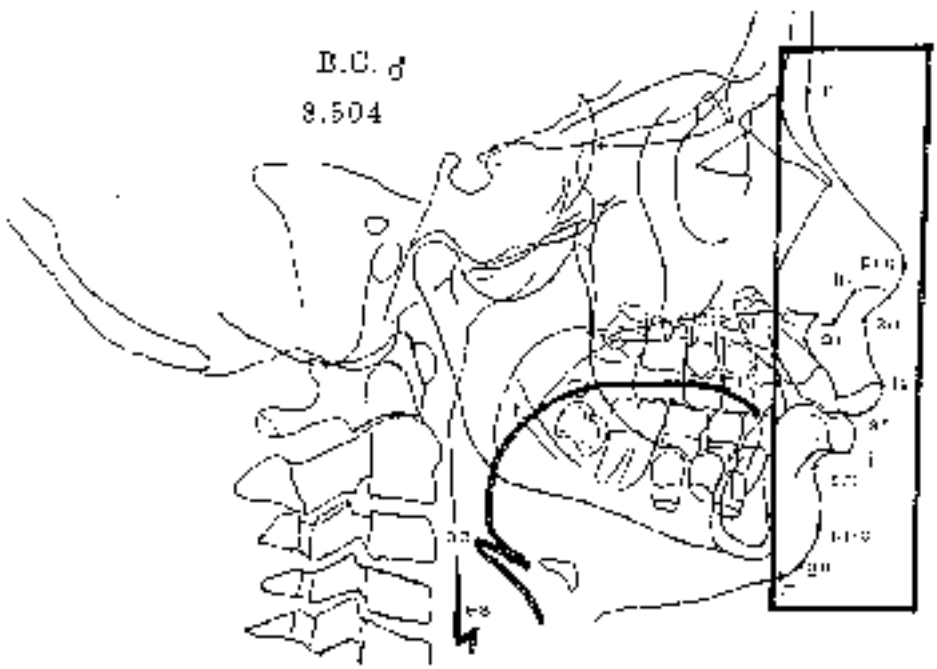
The Profile

The contours of all the tissue on the profile are useful for the visualization of esthetics and function. (**prn**) is pronasalis. **ppo** is propogonion., n is soft tissue nasion, **gn** is gnathion, and **m** is menton.)

Discussed previously was the manner in which the lips are positioned for the film exposure. Some clinicians become emotional about this issue. We prefer the jaws and lips be held together **for a functional diagnosis.** A closed lip position in a lip seal will indicate the treatment problem.

However, a second film can be made with patients at physiologic rest and lip repose and can be traced and compared. Also, barium swallows may indicate the tongue and lip behavior in deglutition.

Lip contours and demarcation of vermillion borders also help reveal soft tissue detail (**ls** is superior lip, li is inferior lip). The curve of the ala of the nose (al) also may be diagnostic. The right and left eyelids and globes of the eyes are also visible and sometimes a useful reference at the lateral canthus (lc). **Sn** is subnasale, b or **sm** is supramental.



The Tongue and Hyoid (H)

The outline of the tongue is mostly quite visible posteriorly, but sometimes difficult to locate because it is thin anteriorly. The tongue dorsum and posterior border should be traced down to and including the epiglottis.

The hyoid bone is traced in cross-section of the body only. Its triangular shape is

recorded, and a point at the upper anterior angle is the Hyoid point for reference (H).

The Soft Palate

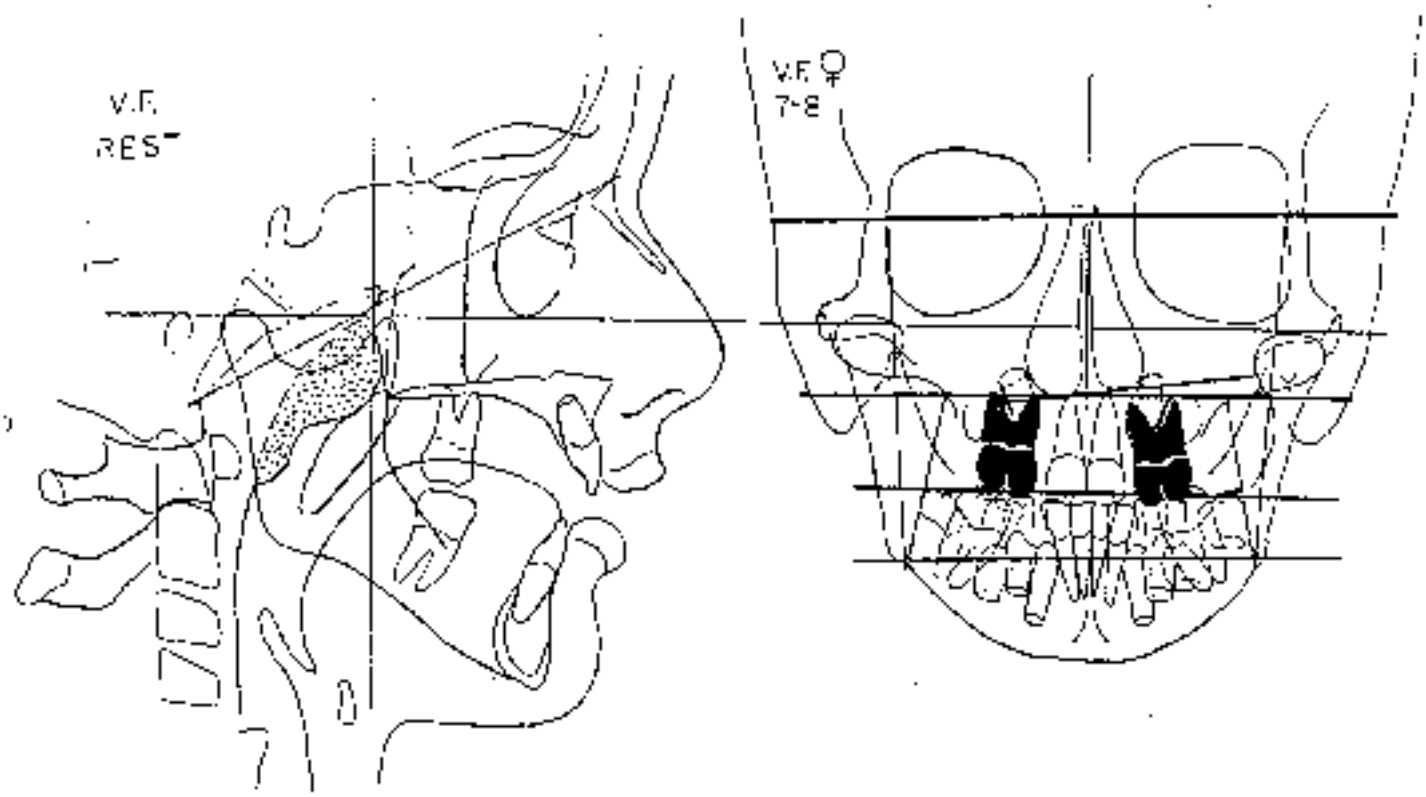
Normally, the posterior margin of the tongue lies in contact with the soft palate. When a space exists, the possibility of mouth breathing should be investigated. Changes occur, and these can be evaluated with tracings. The soft palate is traced in cross section and has been studied in length, thickness, and position from the hard palate and in function during swallowing and speech.

The Nasopharyngeal and Pharyngeal Wall

Adenoid extent and position is an issue. Therefore, starting with the soft tissue posterior to the superior choanal area, the tracing is continued downward to the level of the esophagus.

Foreign Bodies and Pathology

Artifacts, objects in the nose, gunshot wounds, cysts, fractures and tumors may further be identified and when traced will force a detailed inspection.



Patient with adenoid blockage and bilateral lingual cross-bite

FRONTAL PERSPECTIVE

The frontal has not become popular despite the common palatal splitting practices and attempts to expand lower arches by the mainstream of orthodontists. It wasn't until parameters and data were available from the computer that it reached cogent application.

References Employed in Frontal Perspective

Cranial and Basalar Points

Zygomatic Frontal Point (Zf)

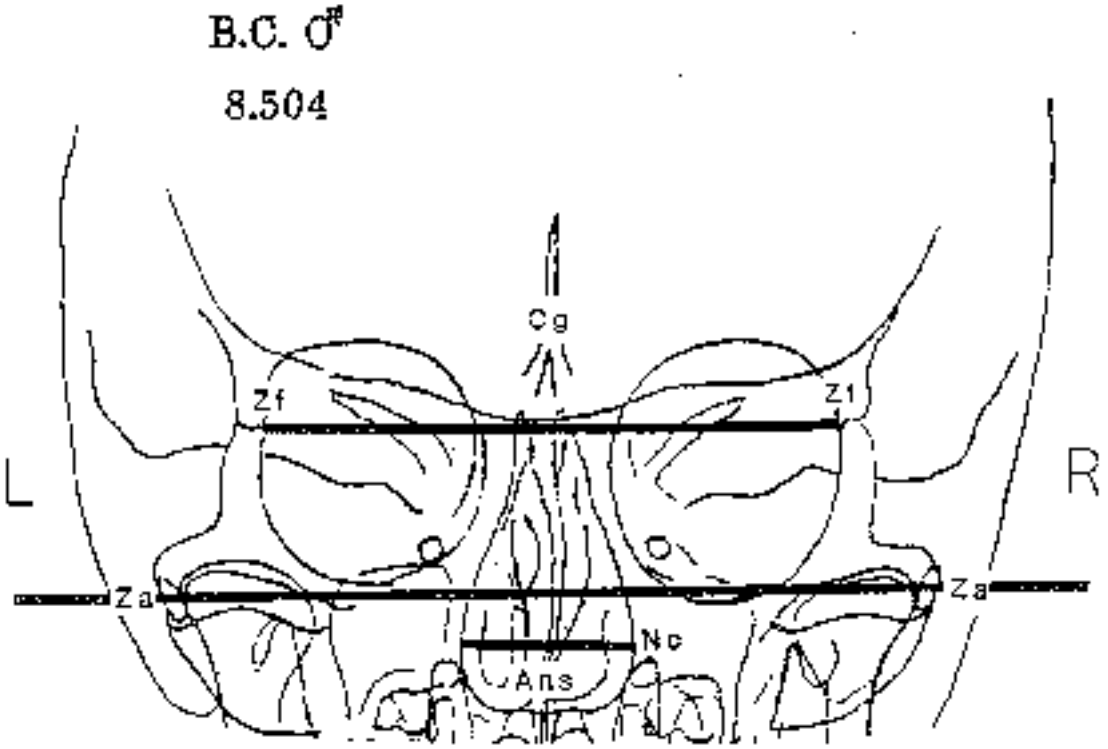
The two zygomatico frontal sutures are sought and if not plainly visible may be identified as a lateral notch at the approximate height of Nasion. The inside margin at the orbit is selected bilaterally as Zg points.

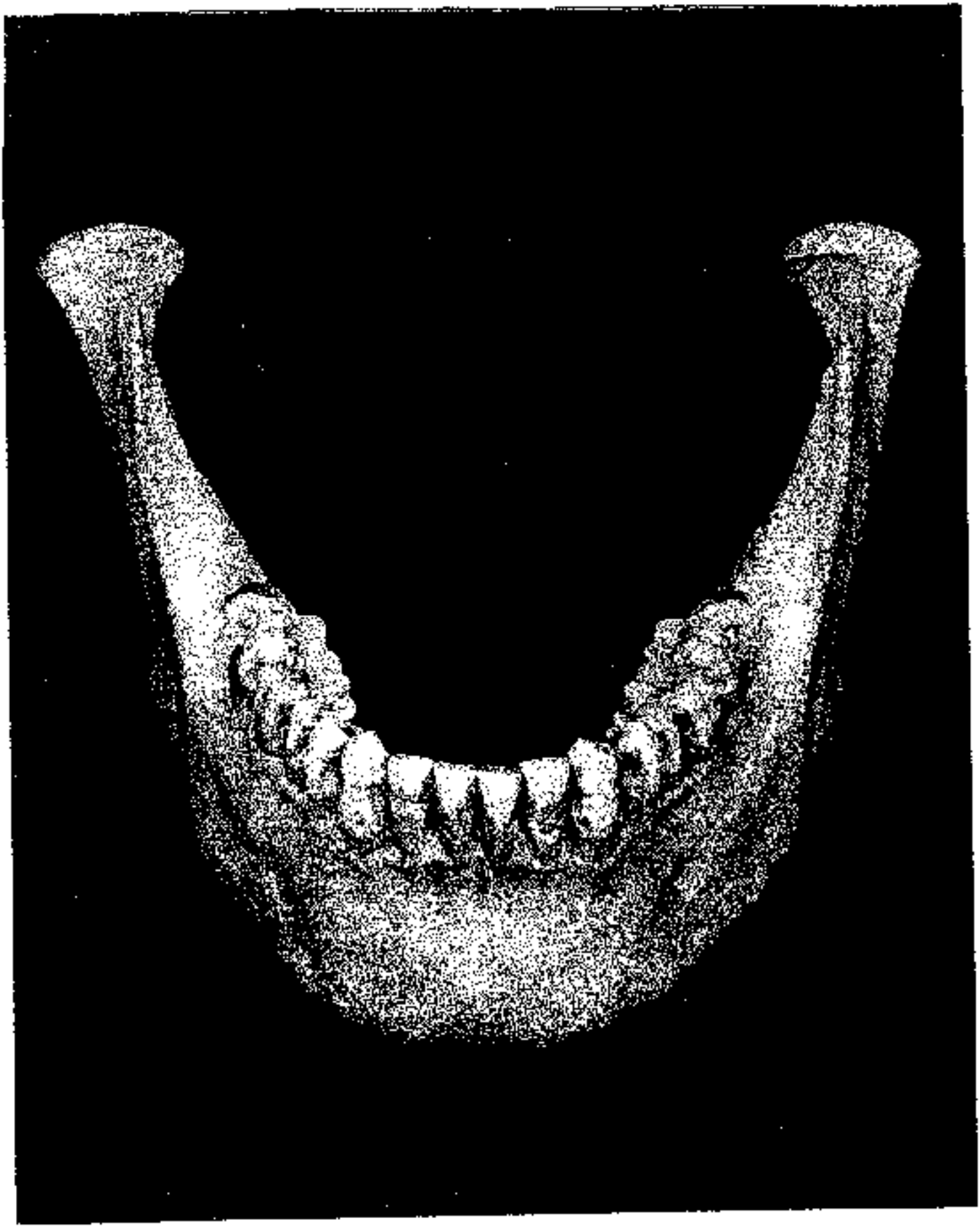
Zygomatic Arch Point (Za)

Careful examination will reveal the cross section of the zygomatic arches. The center is selected by inspection. Za stands for Zygomatic arch center.

Crista Galli Point (Cg)

Crista Galli is dense and commonly shows on the frontal film. The tip is employed for a point. When it is not visible the base or top of the septum is employed for a midline point.





Mandibular Basalar Points

Ag Points

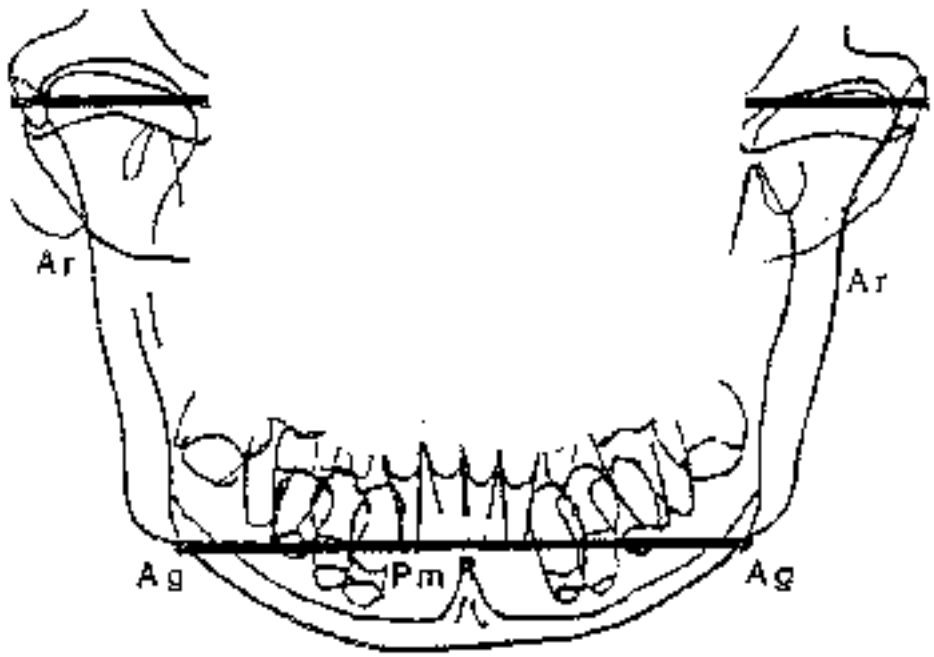
The gonial angle may flare outward and is posterior to the denture. Thick cortical bone is located at the termination of the external oblique ridge anterior to the mandibular notch. Technically, this is called the trihedral eminence. It was called the Antegonial Tubercle and labelled Ag as a mandibular base reference. It is one key to the successful use of the Frontal Analysis.

Protuberance menti (Pm)

In the frontal view a triangle of bone is often quite visible at the symphysis. The top of the triangle is chosen as Pm point. It represents the midline of the symphysis.

Lateral Articulare (Ar)

This is selected on the lateral border of the mandible at the crossing of a transverse line through points Jugale.



Maxillary References

Nc Points

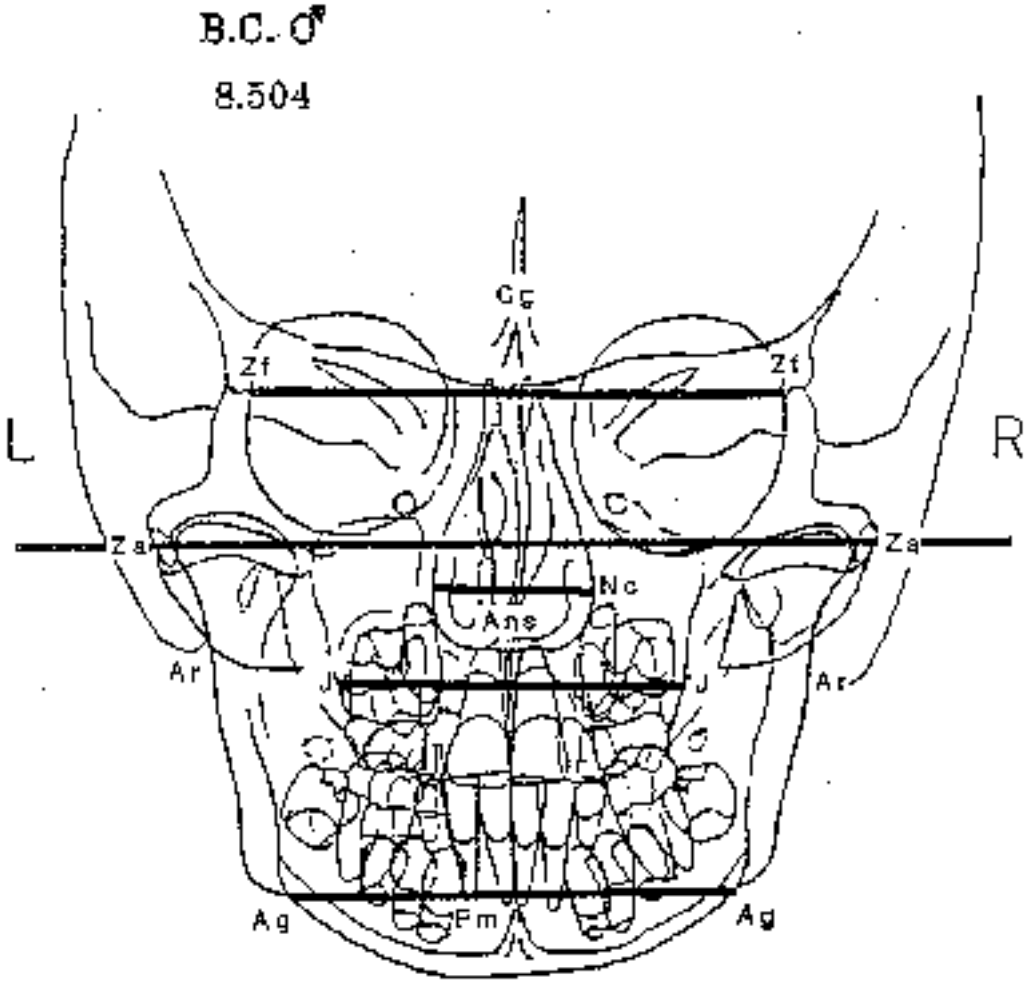
The lateralmost margin of the inside margin of the nasal cavity is selected and labelled Nc.

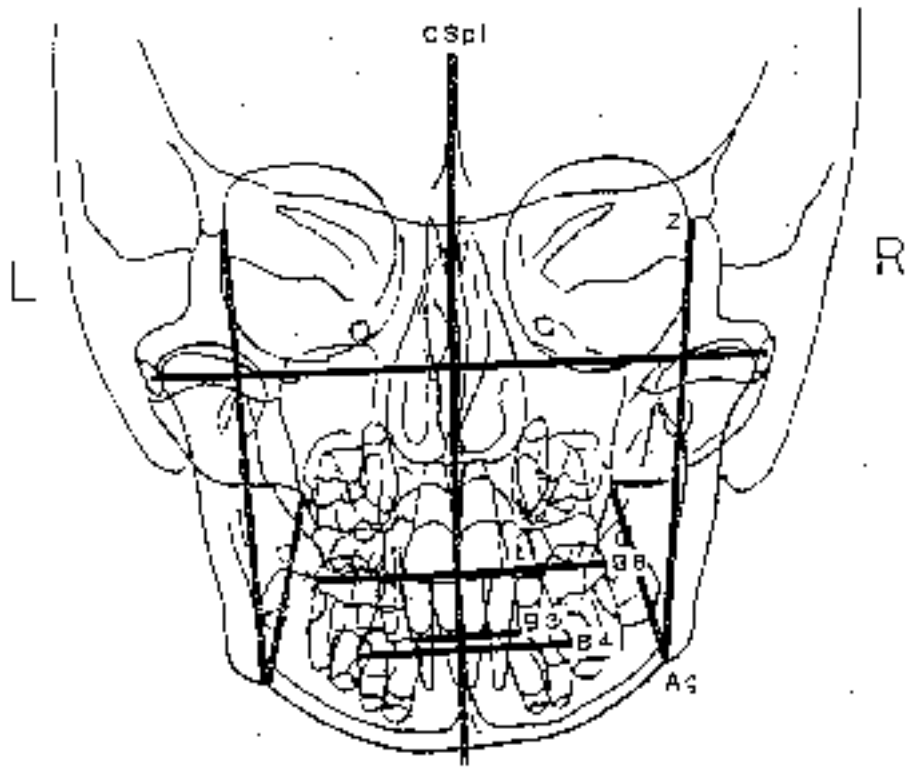
Jugale (J)

At the crossing on the zygomatic process on the maxillary with the outline of the tuberosity a point is selected to represent the basal bone of the maxilla. It is point Jugale and it is selected for width of the maxillary base.

Anterior Nasal Spine (ANS)

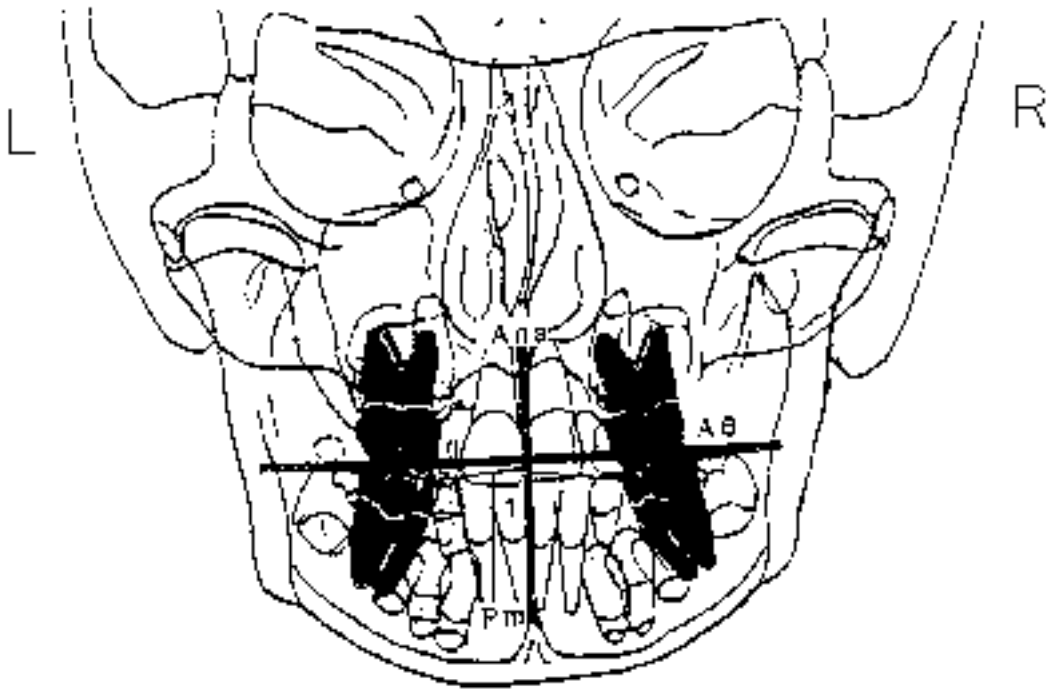
The actual spine is not visible, but a center of the hard palate at the junction with the septum can be selected. The mid-maxillary suture identification will help mark the center also.





DENTAL

The buccalmost points are selected for molars A6L, A6R, B6L, and B6R, and premolars B4L and B4R. The bisection of the molar occlusion is selected for the Fronto-occlusal Plane. The tips of the canine cusps are selected as A3L and A3R, and B3L and B3R.



PLANES AND LINES OF REFERENCE AND PARAMETERS

A line simply joins two points and can serve for other points to be measured to it. A **plane** is likened to a flat surface or three-dimensional as a thought form. Both are employed in cephalometry. Some very basic and useful planes and lines have proven to be of the most substantial value and are now described.

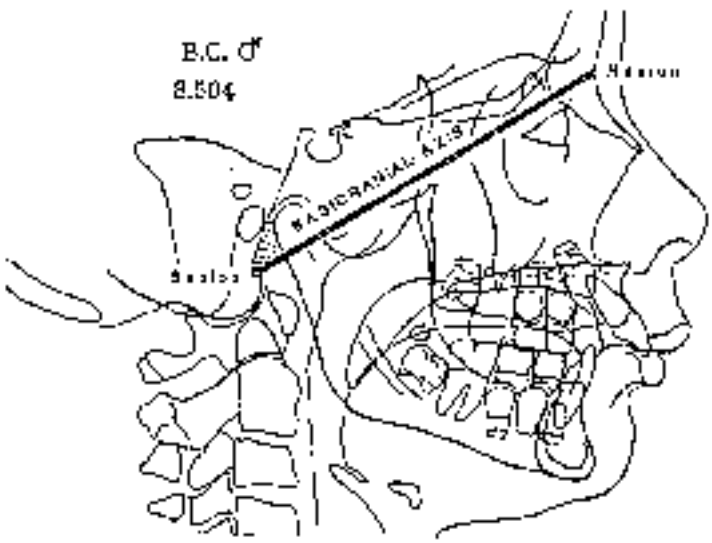
Lateral Cranial Planes

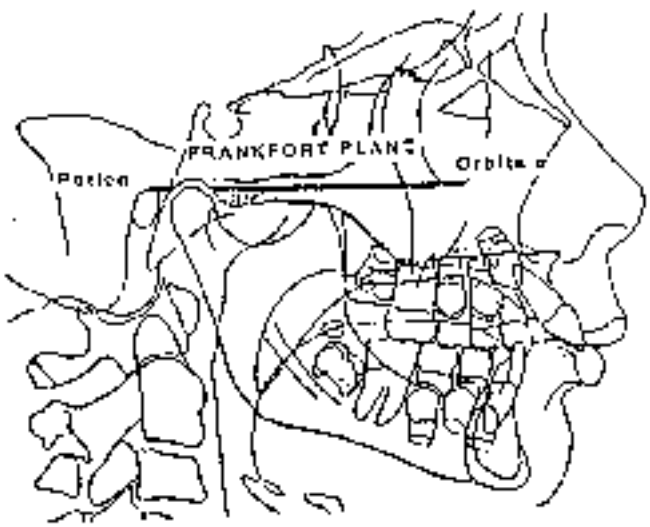
Basion-Nasion Plane

The teeth were glued together on skulls and a saw cut was made from Basion to Nasion. This plane cuts off the base of the pterygoid plates, is parallel to the zygomatico-temporal suture and sections off the mandibular condyle. It truly can be thought of as a facial separation plane. With experience it has become a remarkably useful plane for both descriptive and sequential functions.

Frankfort Plane

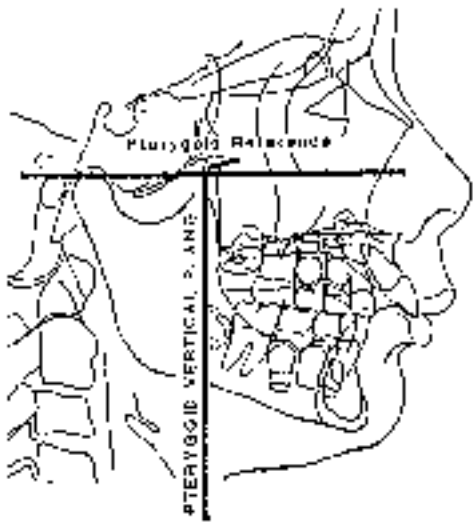
This is perhaps the best plane to start with for the study of head posture. From Porion, as the temporal bone center, it essentially orients the center of hearing and equilibrium to the orbit, the organ of sight. This plane from P to O bisects the zygomatic arch, and is a perpendicular to the coronal suture in general.





Pterygoid Vertical Plane

A perpendicular to Frankfort acts as a separation line for the face away from the base of the pterygoid plates. It reasonably forms a representation of the coronal suture. The hyoid bone also tends to orient to it. This plane labeled PTV (for the pterygoid not vertical) forms an excellent coordinate for entrance of data for the computer. The point of crossing of this line with Frankfort has been labelled Cf.

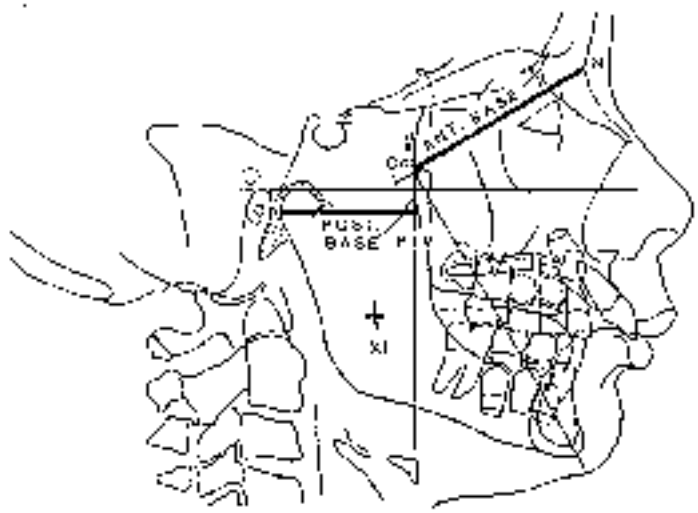


The Cranial Base

The whole cranium for practical purposes is reduced to two parameters.

The **Anterior Base** is measured on BaN from Cc to N.

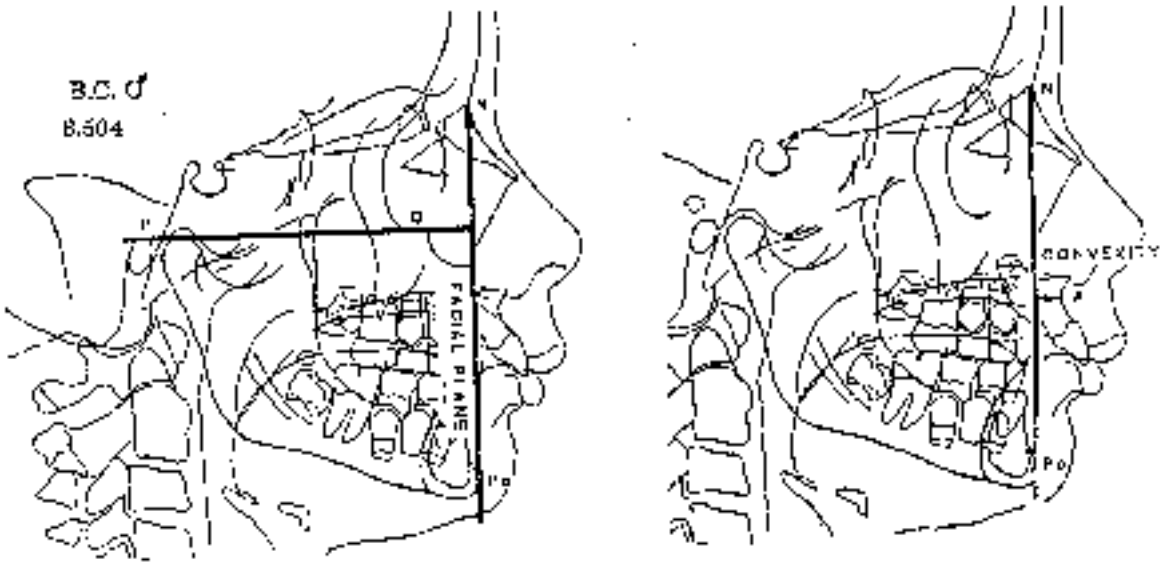
The **Posterior Base** has been more difficult because it is not easy to find the center of the ear canal for Porion as a horizontal reference. After years of trial, the posteriormost margin of the condyle (bisected for right and left sides) was taken as a reference (Condylion Posterior) for depth from the Pterygoid Vertical.



Planes and Lines for the Face

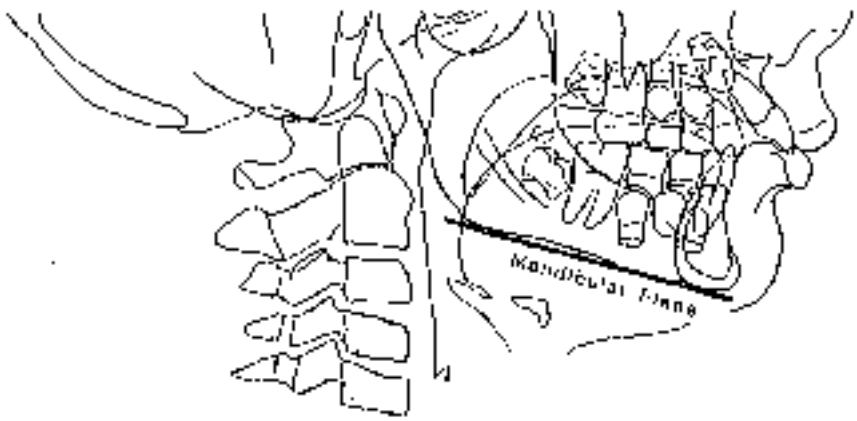
Facial Plane

This traditional plane is formed by connecting Nasion with Pogonion. Measured from Frankfort the angle (Facial angle) is perhaps the single best expression of chin depth in facial typing. It changes with typical growth. Point A from this plane serves to measure skeletal convexity.



Mandibular Plane

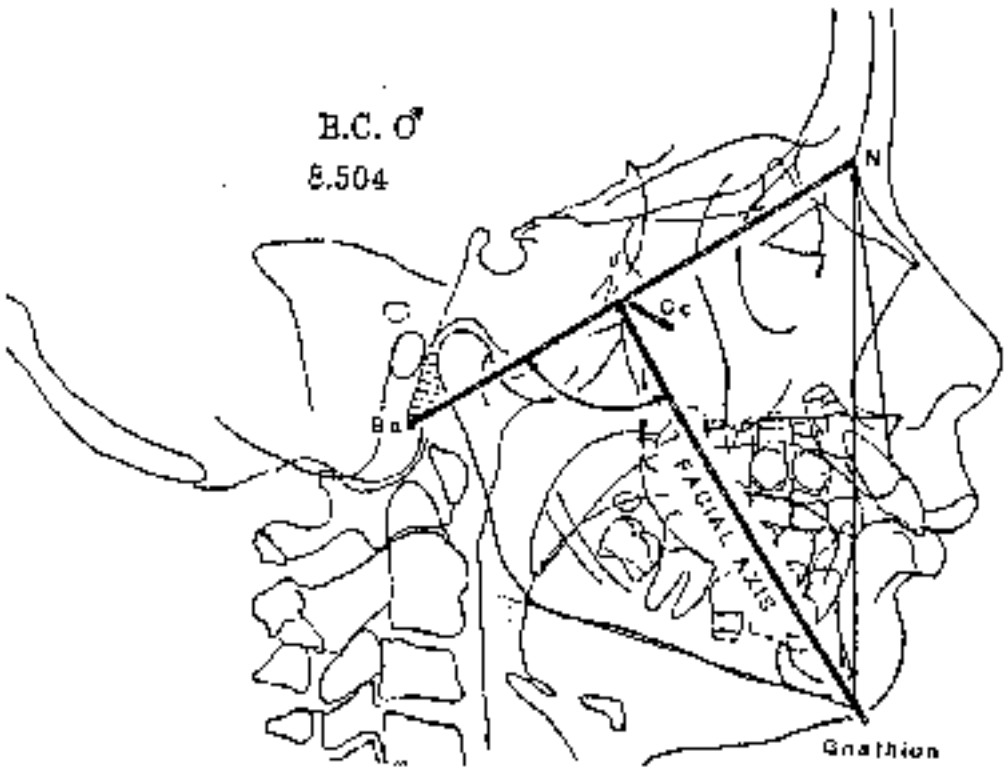
Different mandibular planes have been employed, but the most simple and useful is the lower border of the angle of the ramus (Subgonion)(Sg) to the lower border of the symphysis (Menton) (M). It has been used erroneously as a growth forecaster. However, the angle of the mandibular plane can be an indicator of a sick condyle. The intersection of the Facial and Mandibular Planes is used to construct cephalometric Gnathion (Gn).



Facial Axis

The most central axis of the face discovered is the line from Pterygoid Point (Pt) to Gnathion. It is measured relative to the Basion-Nasion Plane and forms, on average, almost a perfect right angle in the Caucasian population. The point of crossing of these lines is labelled Cc (for Cranial center). In some patients Pt may fall below the Basicranial axis and thus the Facial axis is extended upward to form Cc. The Facial axis closes only slightly with average normal growth (about one degre every five years). This crossing is **Position One** base in the summary growth analysis.

Incidentally, the Basion-Nasion at Nasion becomes the registration for assessment of the position of Point A or the maxilla. The NA line can be thought of as the **Nasal Plane**.

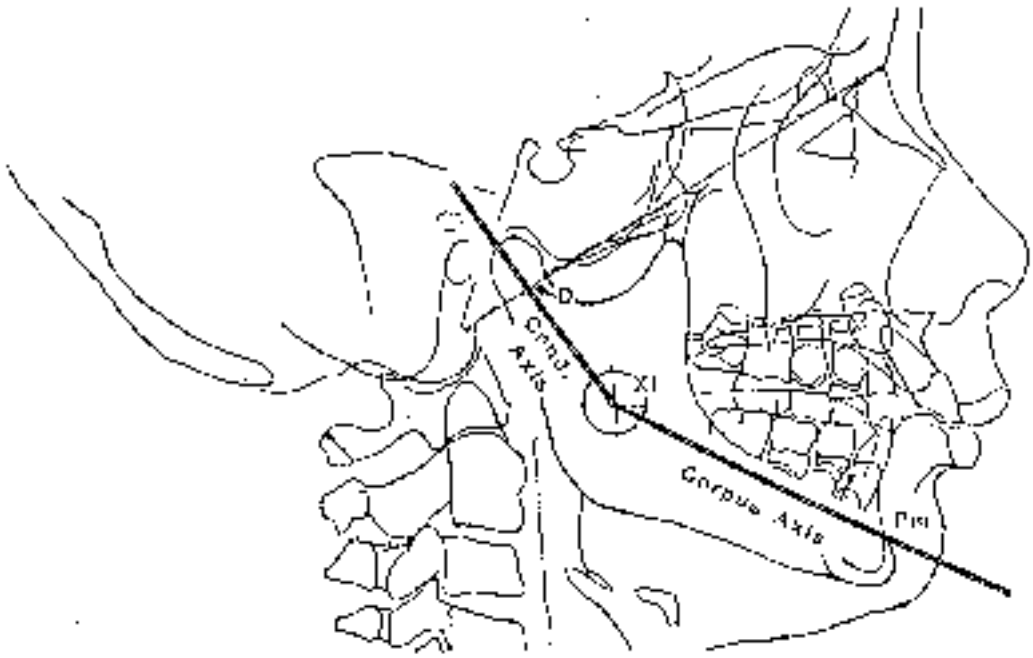


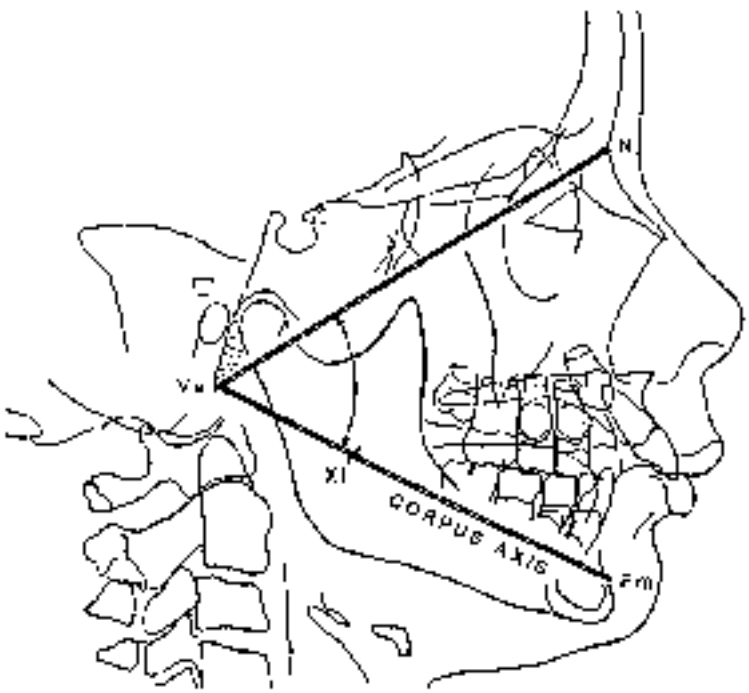
Condyle Axis

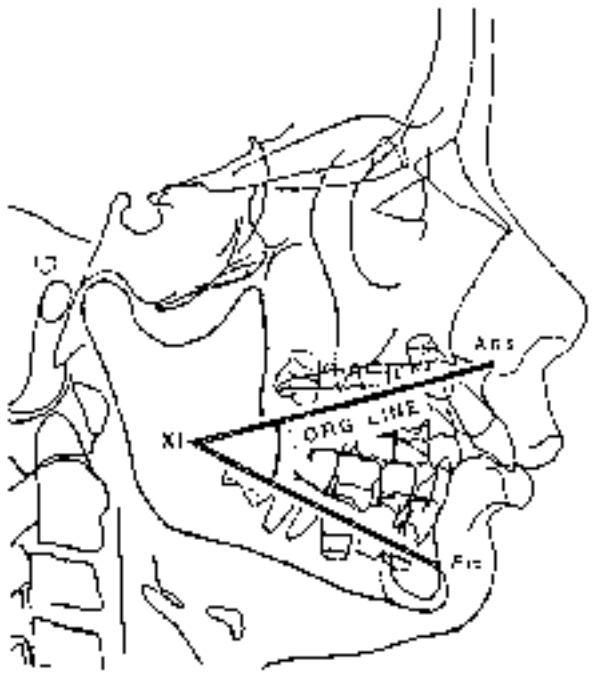
A line from Xi Point extended through Point D to Condylion (Co) forms the Condyle Axis. It is measured for morphologic analysis and growth or treatment change from the corpus axis. It becomes critical in the analysis of treatment changes.

Corpus Axis

This plane is formed from Protuberance Menti (Pm) through Xi Point. Extended to cross BaN, it forms Vertigon (Ve). The angle formed is a representation of total facial height, which is 60° ± 3°. Anteriorly, when superimposed at Pm the Corpus Axis becomes a superb reference for denture behavior and is **Position** Four in the summary growth analysis.



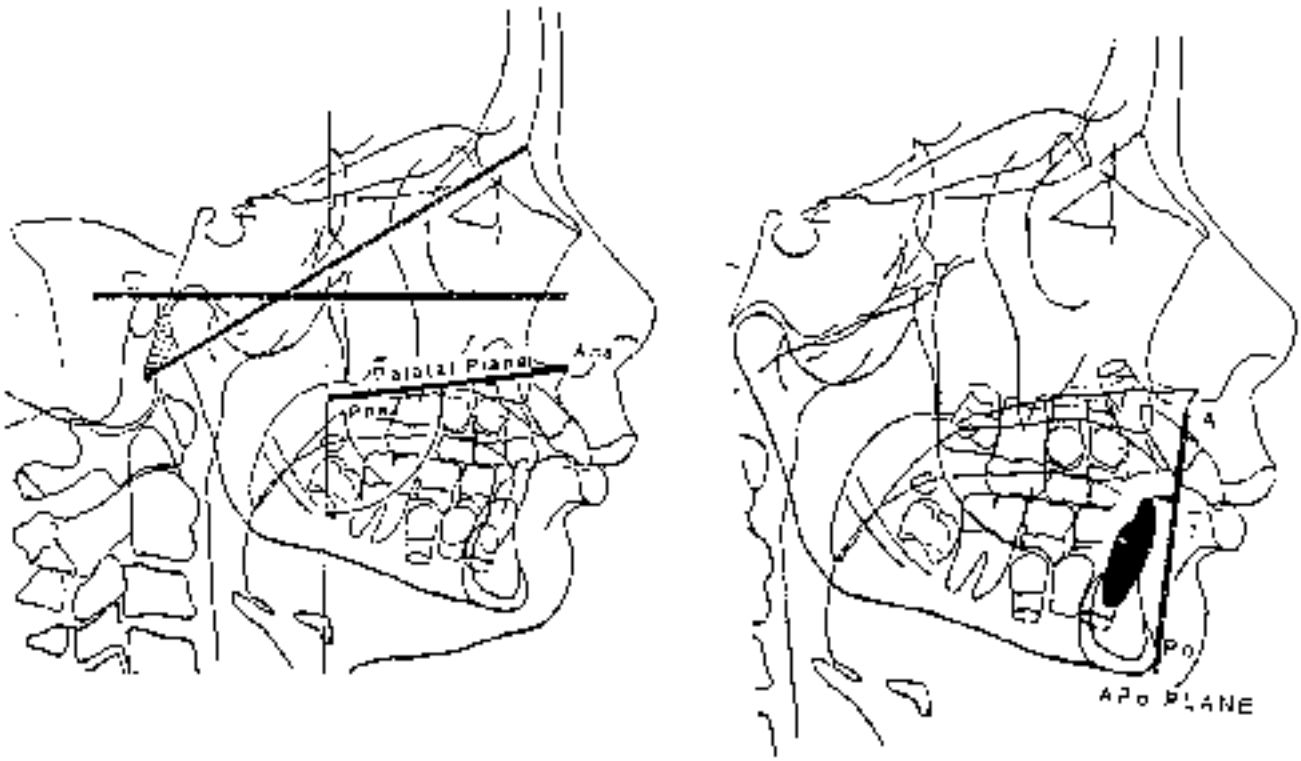




Thus, **Xi Point** is, in a sense, a radiation point for the chin, the condyle, the anterior nasal spine, and a line to Cc serves as an aid in growth forecasting as the Xi Axis. In addition, a line from Xi to the incisal point represents the Divine Occlusal Plane for reference. Further, the Xi is employed to determine points for the growth arc and for measuring denture location as well as mandibular position. **Thus**, eight structures in all are related from Xi Point!

Palatal Plane

A line from anterior to posterior nasal spine represents the plane of the hard palate, which is the floor of the nose and roof of the mouth. It changes little in angulation from Basion Nasion during natural growth, but can be influenced several degrees with treatment, particularly with extraoral traction. At ANS the palatal plane is **Position Three** for the maxillafry teeth reference in the summary growth analysis.



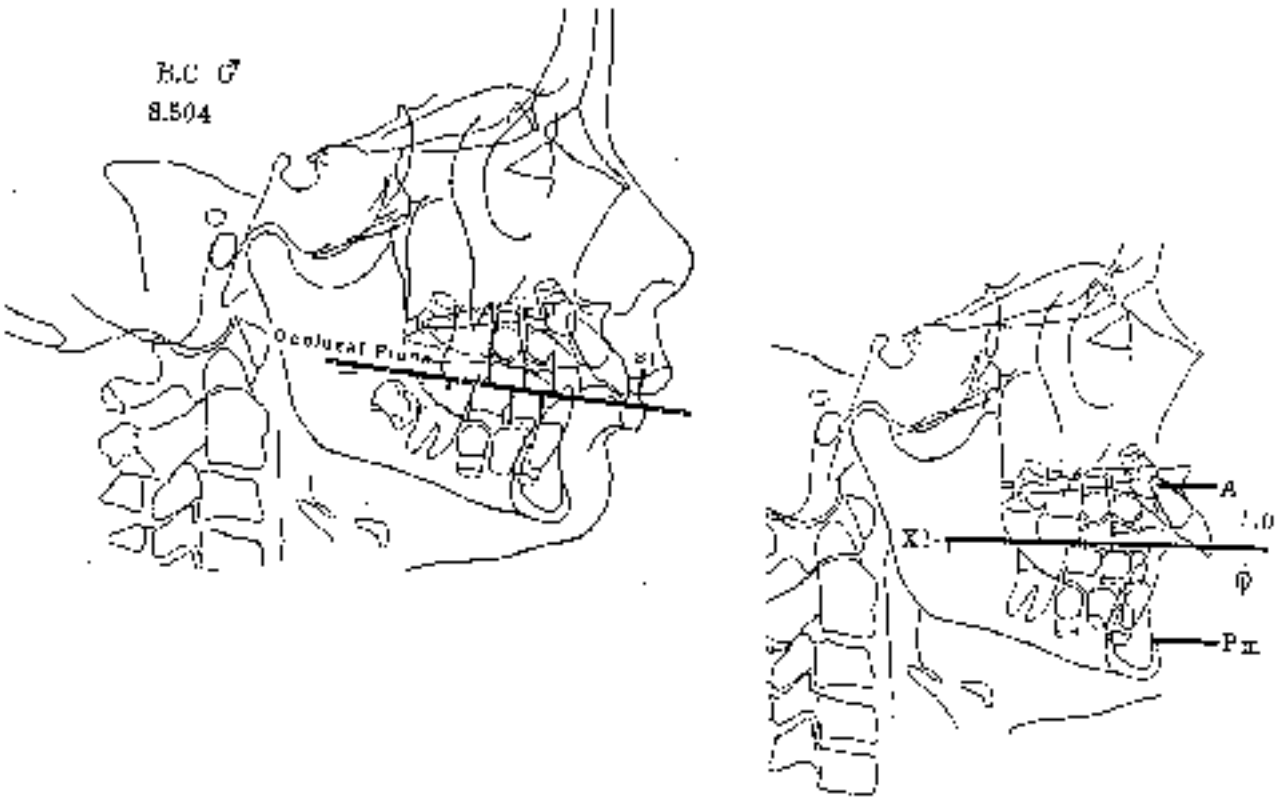
The APo Plane

Point A to Pogonion becomes a line of reference for the protrusion or retrusion of the anterior teeth. The angle of this plane to the facial plane uprights with growth. Both Point A and Pogonion positions are influenced by treatment. It forms the best reference to reason about in diagnosis, and is the best reference for planning. It is a line to which the teeth can be related reciprocally. The lower incisor to the APo Plane is a critical issue.

REFERENCES FOR THE TEETH

Buccal Occlusal Plane

A line through the bisection of the cusps of the buccal teeth represents a plane uninfluenced by a lip and tongue abnormality. It is therefore diagnostic of supra or infra eruption of anterior teeth. In cases of posterior open bite the space is bisected. It tends to have high order with the corpus axis.



Divine Occlusal Plane

The golden section contains two parts which are proportionally related to 1.0 to 1.618. This is also called a divine proportion, and referred to with the symbol Φ. When a particular point is located relative to the two endpoints it will be called divinely oriented, or a divine point. If the whole line is considered, the longer portion is 0.618 the total length.

A lower incisor divine point is selected between Point A and Pm. The height from incisal edge to Pm should be 0.618, the total height from A to Pm. That point connected to Xi becomes a reference line for planning orthodontics in the long range. The lower incisor tip will be on the line, and the lower molar 1 to 2 mm. below it for the natural occlusal curve.

Arch Depth and Model Conversion

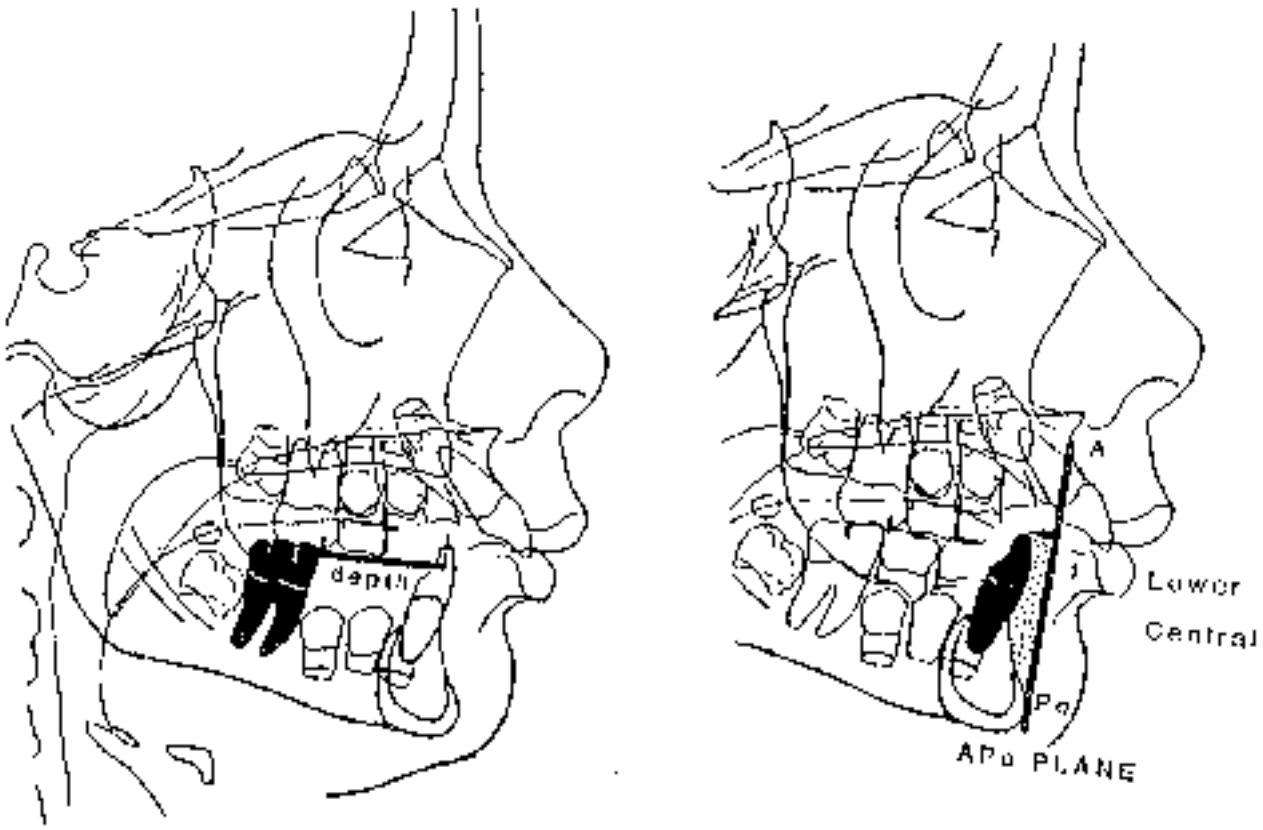
The actual model analysis is also a part of the Progressive cephalometric process. Normal dimensions with standard deviations form the base for evaluation.

Arch depth is measured from the mesial of the lower molar to the center of the incisal edge of the mean lower central incisor. It is a critical measurement transferred from the model and employed for diagnosis forecasting and planning mechanics. A 6% (or about 1 mm.) enlargement is present in the usually lateral headplate.

Arch depth and arch width are both associated. Width is taken from the canine tips and the buccal of the first premolar and first molar (see next page).

Lower Incisor Position

The lower incisor is measured from the Denture Plane (APo) but is planned from the APo relationship **produced with treatment**. (See APo Plane.)



(See also APPENDIX for illustration of normal dimensions as compared to G.A.)

Upper Molar Position

The upper molar is measured from the distal of the crown directly to PTV. It has long been established to lie typically at age plus three millimeters. When closer than average it does not mean it cannot or should not be moved distally, but it does suggest lack of space ultimately for the upper third molar.

Interincisal Angle

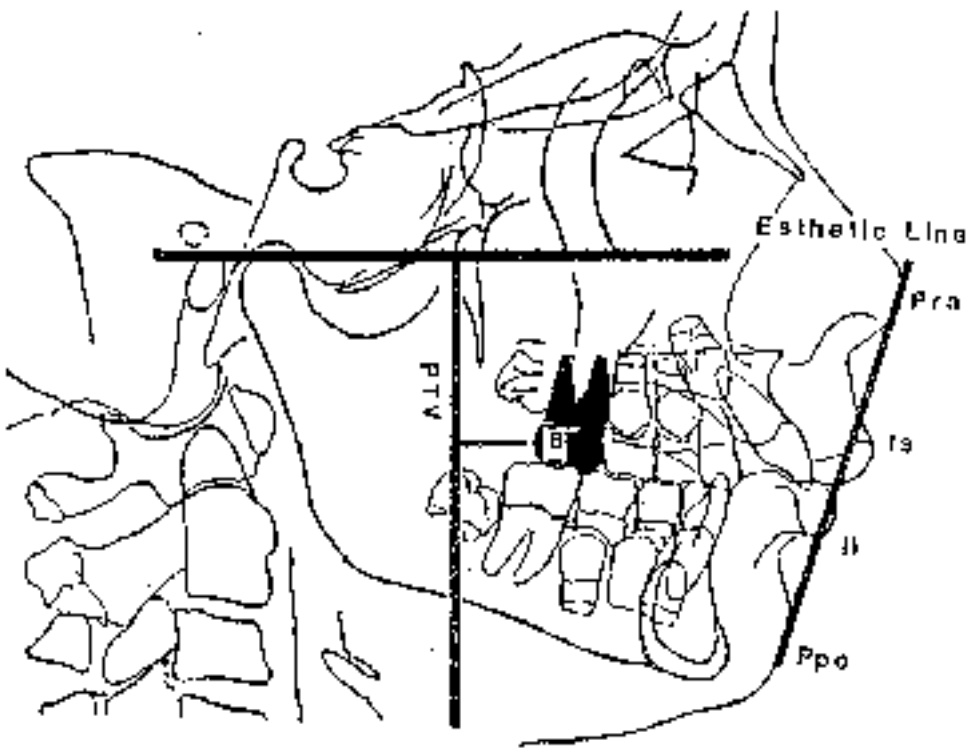
The principal concern for this relation at a normal mean of 130° in the adult caucasoid populations is after treatment. In finishing, a 126° angle is preferable. In both negroid and mongoloid populations the mean angle by adulthood is below 125°.

Soft Tissue

The Esthetic Line (E Line)

The nose tip point is called pronasli (prn). The most prominent chin point is labelled propogonion (ppo). The E line (Esthetic line) serves as a reference for protrusion of the lips. The lower lip is a reference to which the upper is compared.

Several other planes are of use in the Harmonic Equation, but are dealt with elsewhere.



FRONTAL PLANES

Cranial

Transverse lines are drawn through common points.

ZA - ZA a Frontal Frankfort plane

Zf - Zf a Frontal basal plane on the Frontal bone

Cg-Vertical a perpendicular dropped through Frontal Frankfort from Crista Galli represents the midsagittal plane

Facial

Mandibular

Ag - Ag a Frontal mandibular plane

Maxillary

J - J a Frontal maxillary plane

Cranio-Mandibular

Zf - Ag (bilateral) a line from Zf point to Ag represents the fronto-facial planes

Za - Ag (bilateral) a line from the zygomatic arch center to the mandible represents form and posture of the mandible.

Maxillo-Mandibular

J - Ag (bilateral) a line from Jugale to antegonion represents a frontal denture plane

ANS to Pm a line from Anterior Nasal Spine to Pm represents a plane between the maxillary and mandibular midlines

Dental

B6L to B6R a bisection of the molar occlusion connection represents a fronto-occlusal plane.

* * * * *

Function #4. Yields a Basis for a Clinical Norm

The Scientific Basis of Clinical Standards for Reference -- the Clinical Norm Application

The idea of a clinical norm for orthodontics was proposed by Simon prior to radiologic cephalometry. His goal was to establish a standard for comparison of the abnormal or the extent of dysplastic irregularity. It was proposed to provide a basis for order in correction toward the norm or "the ideal".

The same conception was proposed by Downs and Steiner. The question, however, became the rigidity by which the clinician was supposed to adhere to the prototype, or a particular model of perfection. The basis for Downs' norm was twenty young normal full dentition subjects without what he judged to be protrusive occlusion. Hence, there was some bias in his selection. The basis of Steiner's norm was only one subject, a full dentition female selected as his objective from his clinical experience, from which he derived his "ideal" -- a flagrant bias.

It was obvious that clinical norm references needed improvement for several reasons. First, a range needed to be established, not a single point. Second, values for ages needed to be provided. Third, sex differences were necessary in establishing objectives. Fourth, racial and constitution types needed description. Fifth, the analysis needed to be more in depth in order to provide insight into responsible anatomic variables. Sixth, there needed to be a consideration for the transverse dimension. Seventh, a three-dimensional atlas of normal morphologic variation and an atlas for normal growth needed to be available for reference. Eighth, a method should be available for the biologic correction of values due to overall size. Ninth, a method of display for description of extreme dysplasia would be helpful. Tenth, a matrix for prognostication was desired.

Computer Study (1966 to 1969)

All the foregoing became objectives for a computer study protocol of 1966.

Material

Five collections of material were employed for the study. Recall of 70 untreated and normal subjects was conducted and headfilms in lateral and frontal views were obtained. From those, forty (40) subjects were selected for study serially. Twenty (20) were males and twenty (20) were females. Twenty (20) were moderate Class II, and twenty (20) were normal, or Class I. In twenty (20) children the mean

time differences were from 5 to 13 years of age (8 years duration). In twenty (20) the time difference was 5 years (from 8 to 13 years of age).

The second collection was from past Ricketts studies. This consisted of the data for one thousand (1000) consecutive patients from the orthodontic files, and two hundred fifty (250) serial records from 1960 modality studies. This included longitudinal data of fifty (50) subjects treated with edgewise mechanics.

The third collection was a cross section of three-year-old children to extend the data back to age three . The fourth collection was a group of thirty (30) near-adult males in order to extend the data to age 18 years. The fifth collection was data from the literature up until 1966 when the working standards were determined. Particular reference was made to publications of Sassouni and Krogman, Broadbent and Bowden.

Method

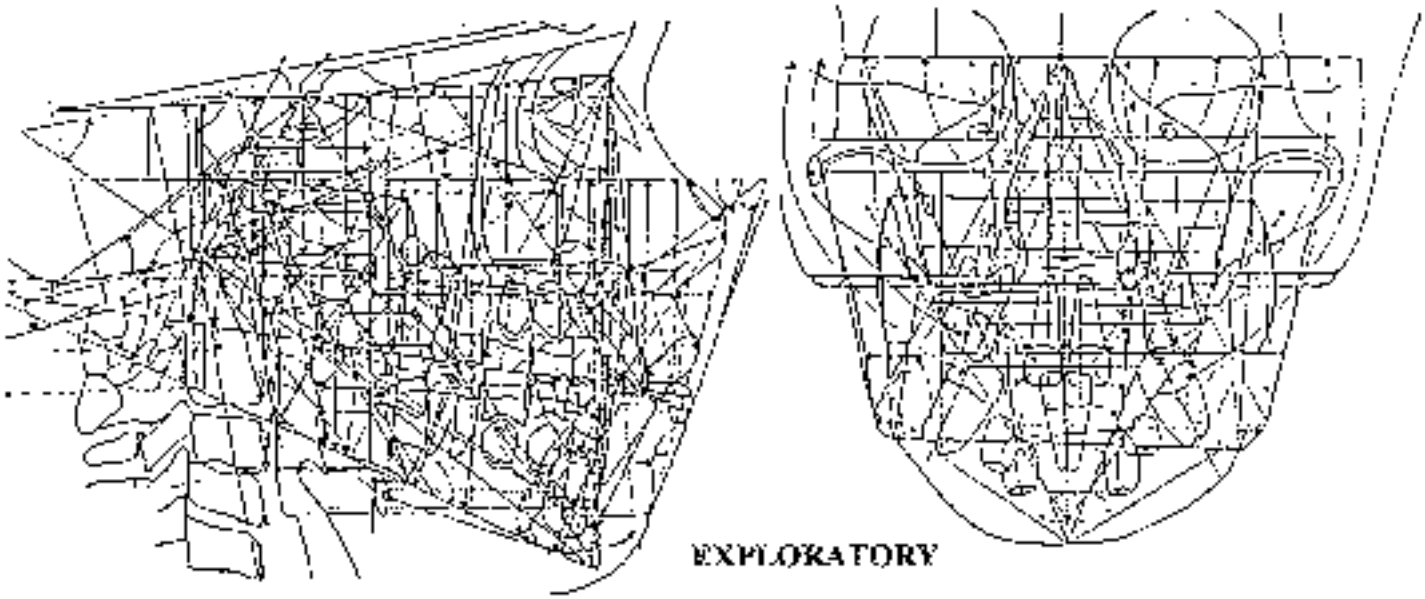
Literally every sensible measurement or angle ever proposed was subjected to comparison, and many points were triangulated for control of error. Three hundred sixty-two (362) linear or angular measurements were recorded in Time I and Time II for each patient. For the five-year-olds three age periods were studied, which meant Time III tracings had to be made. All measurements were recorded in the computer to include the calculations of growth changes. Means, standard deviations, and extreme values were computed. Every measurement was cross-correlated with every other, and the growth gradient was correlated as well. In all, over 400,000 coefficients of correlation were tabulated.

For an investigation for polar phenomenon, manual composites were made from the mean data in both lateral and frontal for visual growth comparison and study with a metric polar grid.

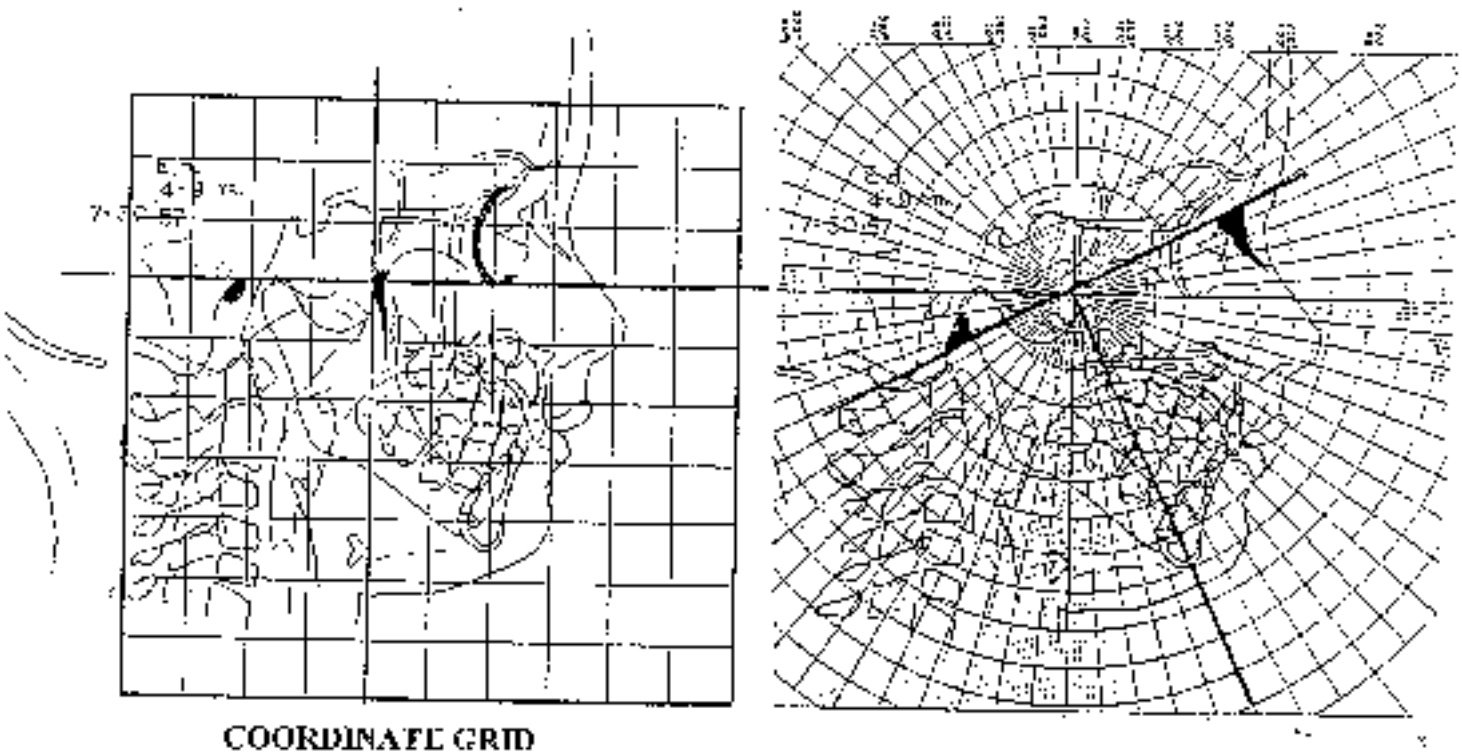
Results

The result was some forty contributions to the body of knowledge for the profession. An atlas of normal morphology and normal growth was established for the computer. A cube-root index was devised for corrections for size. Corrections were made as well for age, sex, and racial types.

A comprehensive analysis was deduced in 1969 that has stood essentially unchanged now for more than 25 years. Minor adjustments have been made in only two or three parameters. Every effort to test the data with normal material has resulted in a reconfirmation of the program.



EXPLORATORY



COORDINATE GRID

POLAR GRID

A Summary Descriptive Analysis was selected and popularized. For a summary growth and treatment base, a critical four-position analysis was devised. This proved to be the most trustworthy method for procuring treatment information for the clinician wishing to know the different results with various techniques.

Spin-offs

From the findings further research led, by 1971, to the discovery of an arc of growth of the mandible, described later. This led in turn to methods for sensible long-range forecasting to maturity. This also led to changes in beliefs and practices regarding treatment mechanics.

The Second Major Computer Study (1989-1990)

The arcial method of forecasting was improved, retested, and further refined, based on empirical feedback. After nineteen years of use, both statistical and trial-and-error testing had been conducted. Concrete data sufficient to satisfy the scientific community was sought. Therefore, a new long-term sequential study was started in 1989 and completed in 1990.

Material

One hundred thirty-three (133) subjects were used. Beginning lateral headplates were collected from seven institutions. Seventy-three (73) had had no orthodontic attention at all. Ten (10) were serially extracted without further intervention. Fifty (50) patients were treated for a variety of malocclusions. Of these 25 were males and 25 were females. The seventy-three (73) untreated children were from age 6 to age 18. Some X-rays were from age 5 to as much as 28 years of age.

Method

All beginning headplates were traced by Ricketts and digitized. Forecasts without treatment were made for each subject either to a maturity cut-off or to the age of the last headplate. Those were also digitized and entered into the computer.

After the forecasts were completed, the final lateral headplates were collected and traced. These were also digitized and recorded. All forecasts were compared to the actual. The 133 subjects were broken down for sex and individual types. Twenty-eight (28) normal occlusion untreated subjects were studied. Seventeen groups were composited for comparison.

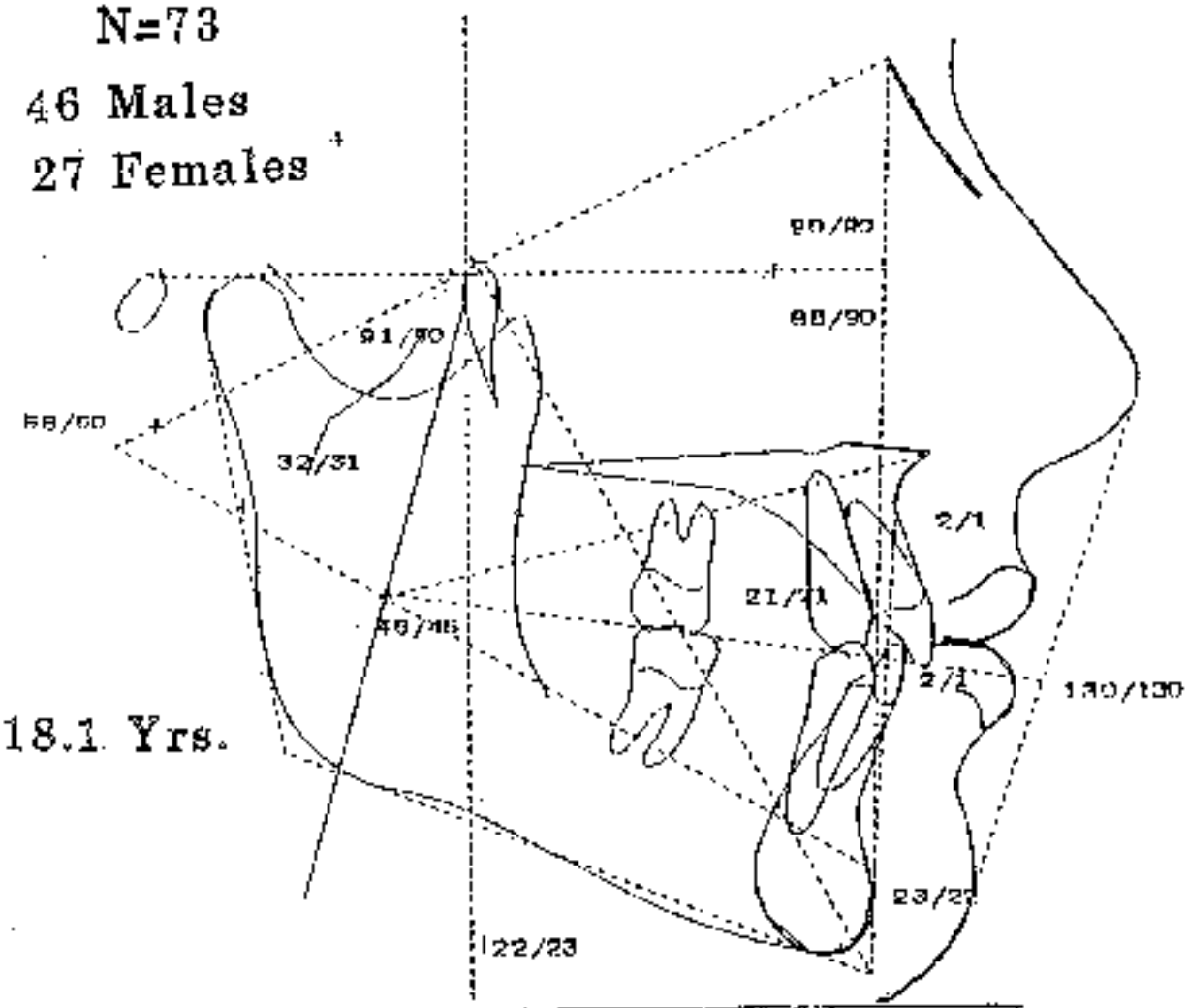
For statistical analysis, a "bars and whiskers" test was conducted for the samples to compare statistically the actual against the prediction.

N=73

46 Males

27 Females

Age 18.1 Yrs.



FACIAL PATTERN: MILD BRACHYFACIAL						
# FACTORS	MEASURED VALUE		NORM		CLINICAL DEVIATION	
Interincisal Angle	130.1	dg	130.0	dg	0.0	
Convexity	2.1	mm	0.0	mm	0.2	
Lower Facial Height	45.7	dg	45.0	dg	0.2	
A6 Molar Position to PTV	21.0	mm	21.0	mm	0.0	
U1 to A-Po Plane	1.5	mm	1.0	mm	0.2	
B1 Inclination to A-Po	23.5	dg	22.0	dg	0.4	
Facial Depth	88.3	dg	89.0	dg	-0.4	
Facial Axis	90.7	dg	90.0	dg	0.2	
Maxillary Depth	90.3	dg	90.0	dg	0.1	
Mandibular Plane to FH	21.9	dg	23.3	dg	-0.3	
Mandibular Arc	32.1	dg	30.7	dg	0.4	
Total Facial Height	57.7	dg	60.0	dg	-0.6	

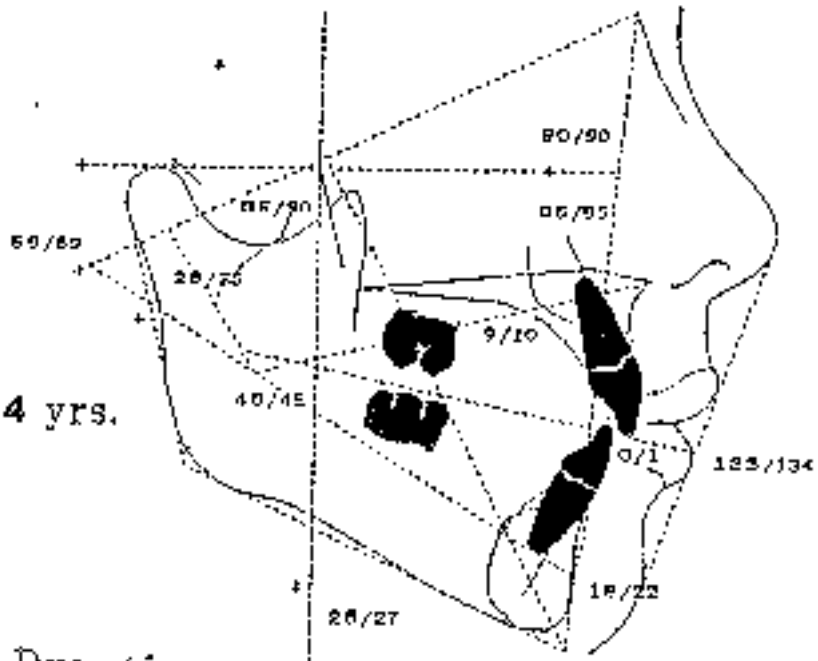
Tulin 1993

Confirmation of original computer data.

N=73

non

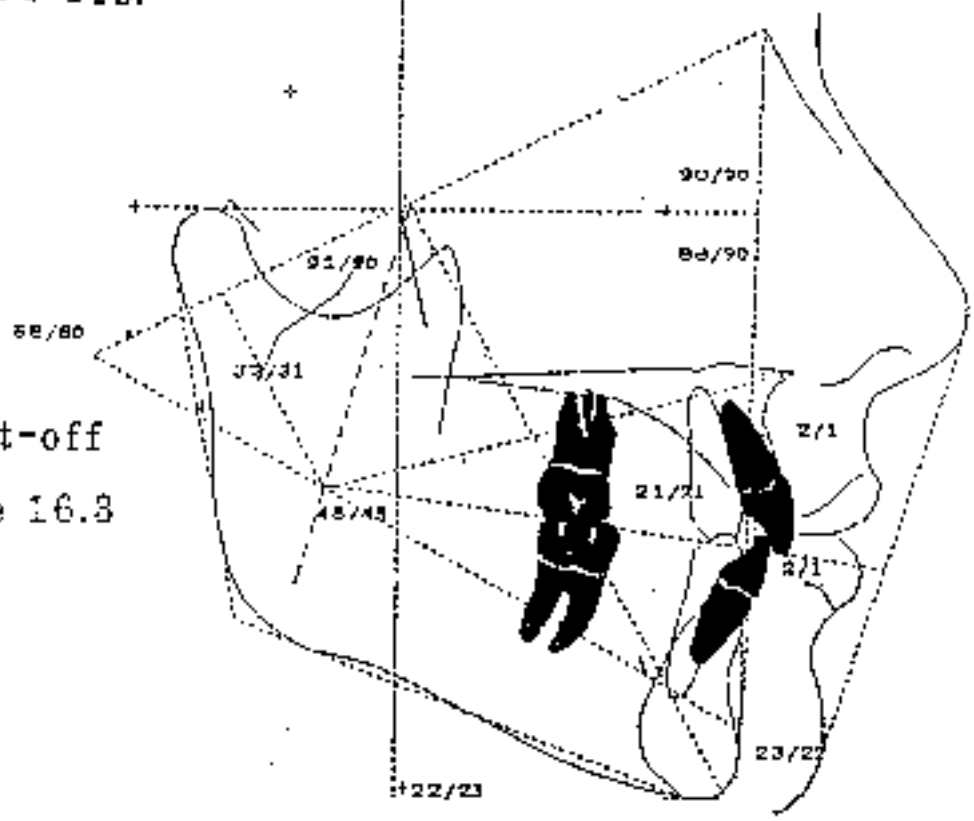
46/27



Age 6.64 yrs.

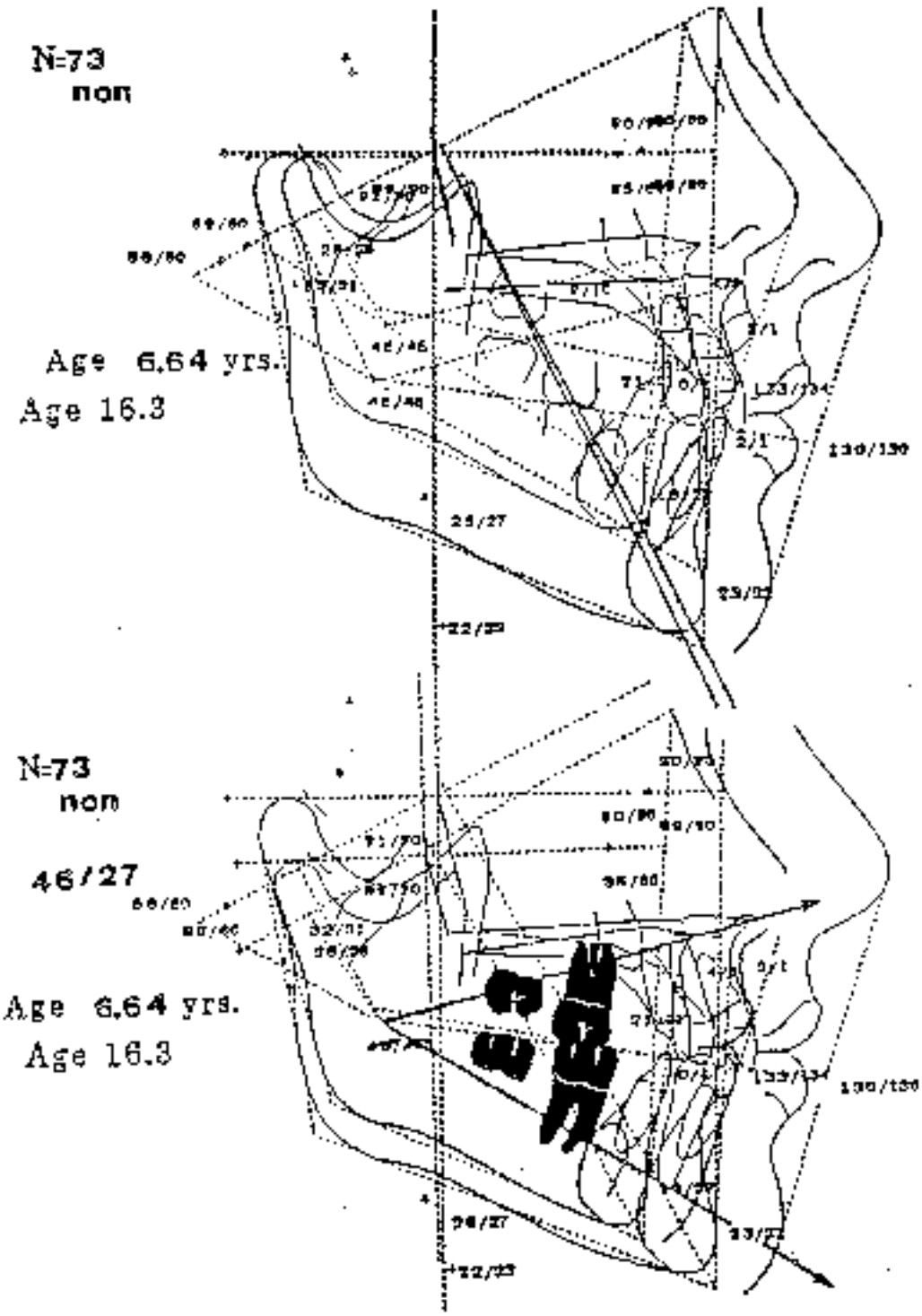
Growth Duration

9.64 Yrs.



Cut-off

Age 16.3


N=73
non
Age 6.64 yrs.
Age 16.3
N=73
non
46/27
Age 6.64 yrs.
Age 16.3

Findings

The findings were so voluminous that they are yet to be published in book form. The data were collected in the routine sequence, i.e., the cranial base, mandible, maxilla, teeth, and soft tissue.

The results cannot be reported herein for reasons of space. However, the following can be stated:

1. Boys' head and face measurements are about one year's growth larger than girls already at the juvenile ages.

2. Girls' cut-off is a mean of 14.8 years.

3. Boys' cut-off is a mean of 19 years.

4. The facial axis closed slightly in every sample (1.5° in 10 years).

5. Point A moved forward about one degree in 10 years.

6. The previous computer data was corroborated.

7. Growth forecasts proved, as expected, to be in the 90% range -- many almost absolute.

8. The composite became a brilliant source for research, similar to the VTO for clinical work.

9. Data was employed to improve further the forecasting procedures.

10. The issue of size and form growth gain loomed again.

11. The research experience reinforced the summary analysis and stimulated certain modifications.

12. Patients "missed" in the forecast led to a further search for hidden variables.

Current Confidence

Thus the original manual clinical data, the 1966 computer work, and the 1990 computer confirmation has led to better confidence levels.

The Precipitation of the Summary Analysis

In summary, as explained before, this Progressive program for cephalometrics has been an evolution extending for half a century. In the face of so much controversy, exhaustive computer study was conducted from 1965 to 1969. Studies continued thereafter with further refinements up until 1995. For the 1969 study all the analyses proposed until then were combined and cross-correlated, which may explain its remarkable dependability.

Comprehensive for Completeness

The result of the original work was the selection of a "comprehensive" analysis to supply information both frontally and laterally to answer almost any question sought by a clinician. Families of measurements were an advantage for clinical order. However, the comprehensive is remarkable for the detailed analysis of exceptional conditions. For cogency, a selection was suggested for a "Summary" form by Gugino originally and became modified through experience since 1970.

RMO Diagnostic Services

RMO Case Number: [illegible] RMO Run date: [illegible] X-Ray date: 11/29/90 Birthdate: unknown Age: [illegible] Sex: Male Reference: [illegible]

CCD - ORTHODONTIC CONDITIONS

LATERAL BEFORE TREATMENT

- Appears on tracing

FACTOR	MEASURED VALUE	CLINICAL NORM	CLINICAL DEVIATIONS FROM NORM	
DENTAL RELATIONS				
01 Molar Relation	-1.1 mm	-2.0 mm	0.6	
03 Canine Relation	3.2 mm	-2.0 mm	0.7	
05 Incisor Overjet	4.1 mm	5.3 mm	0.7	
07 Incisor Overbite	2.7 mm	2.5 mm	0.1	
07 Lower Incisor Extrusion	2.4 mm	1.5 mm	0.6	
#10 Interincisal Angle	130.1 dg	130.0 dg	0.0	
DENTAL TO SKELETON				
#19 A6 Molar Position to PTV	22.0 mm	21.0 mm	0.0	
#23 B1 to A-Po Plane	1.6 mm	1.5 mm	0.2	
22 A1 to A-Po Plane	5.5 mm	3.6 mm	0.5	
#24 B1 Inclination to A-Po	23.6 dg	22.0 dg	0.4	
26 A1 Inclination to A-Po	26.6 dg	28.0 dg	-0.4	
27 Occlusal Plane to Xi	0.6 mm	-3.7 mm	1.4	*
29 Inclination of Occl Plane	22.8 dg	27.2 dg	-1.2	*
54 B1 [illegible] to FH	62.5 dg	65.0 dg	-0.5	
ESTHETICS				
29 Lower Lip to Esthetic Plane	-3.3 mm	-2.9 mm	-0.2	
23 Upper Lip Length	26.6 mm	27.0 mm	-0.1	
31 Lip Embrasure to Occl Plane	-4.4 mm	-3.0 mm	-0.7	
58 [illegible] Angle	116.7 dg	115.0 dg	0.3	
NASOPHARYNGEAL AIRWAY				
52 N-S-Ba	132.8 dg	129.8 dg	1.0	
53 Ba-S-PNS	50.8 dg	63.0 dg	-2.5	*
95 Airway Percent	51.9 %	66.1 %	-3.3	
96 Linear-Adenoid AD1	27.1 mm	27.6 mm	-0.1	
97 Linear-Adenoid AD2	21.9 mm	21.6 mm	-0.6	
99 Distance PTV to Adenoid	17.8 mm	15.2 mm	0.3	

CCD - SKELETAL CONDITIONS

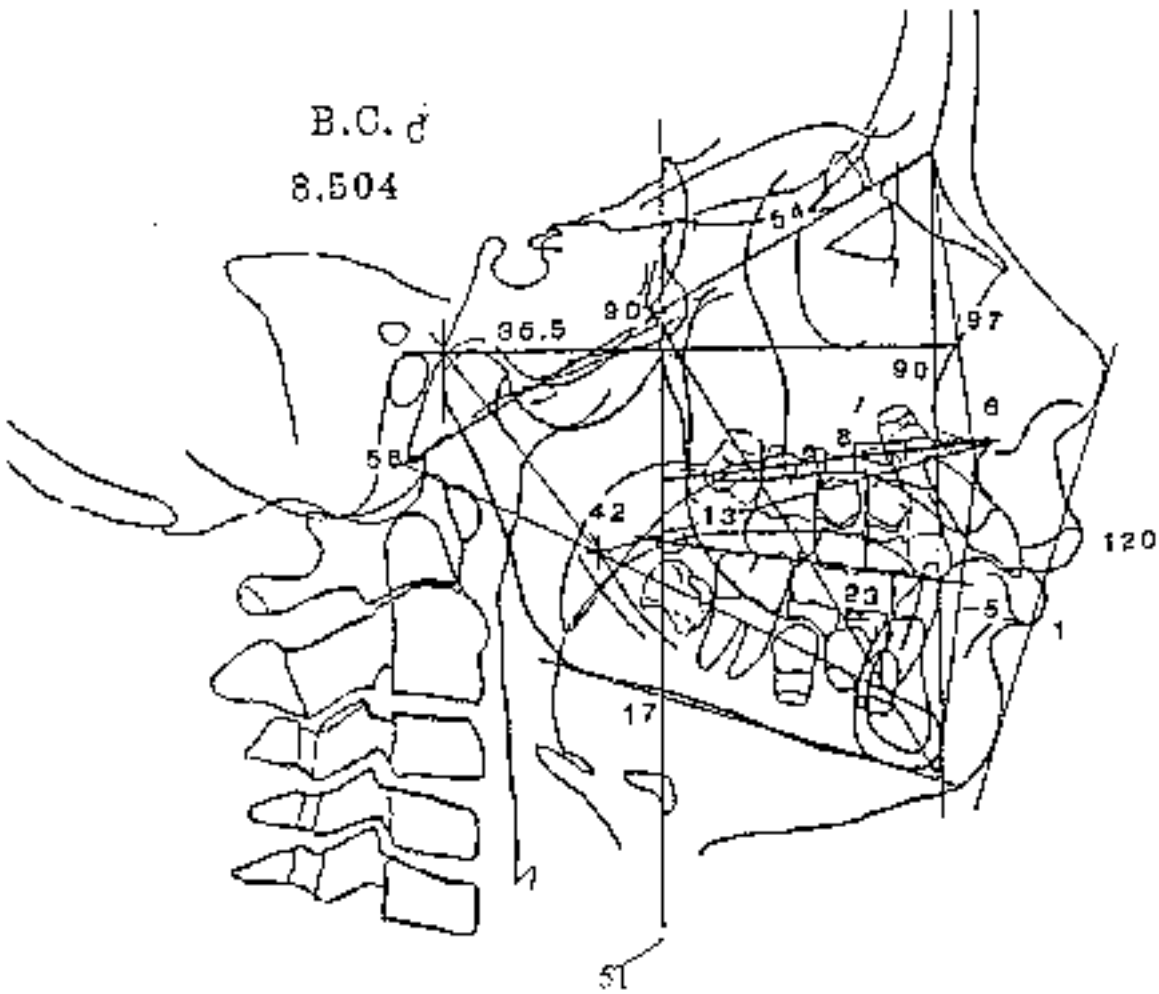
LATERAL BEFORE TREATMENT

- Appears on tracing

FACTOR	MEASURED VALUE	CLINICAL NORM	CLINICAL DEVIATIONS FROM NORM	
SKELETAL RELATIONS				
#13 Convexity	2.1 mm	0.6 mm	0.8	
#15 Lower Facial Height	45.7 dg	45.0 dg	0.2	
84 Present [illegible] height	NOT AVAILABLE			
51 Posterior face height	85.6 mm			
92 Anterior face height	124.2 mm			
52 Posterior/Anterior ratio	68.8 %			
91 Saddle Angle	123.8 dg	123.0 dg	0.2	
95 Condylion-A point	92.8 mm	96.7 mm	-0.8	
97 Condylion-Gnathion	123.1 mm	127.2 mm	-0.7	
85 Max-Mand Differential	30.2 mm	30.0 mm	0.1	
89 Menton-ANS	70.9 mm	73.1 mm	-0.5	
JAW TO CRANIUM				
#32 Facial Depth	88.3 dg	89.6 dg	-0.4	
#34 Facial Axis	90.7 dg	90.0 dg	0.2	
#20 Maxillary Depth	90.3 dg	90.0 dg	0.1	
37 Maxillary Height	57.5 dg	55.7 dg	0.7	
30 Palatal Plane to FH	1.2 dg	1.0 dg	0.0	
#35 Mandibular Plane to FH	21.5 dg	23.9 dg	-0.5	
77 Ba-N-A	63.4 dg	63.0 dg	0.0	
75 S-N-A	83.5 dg	82.0 dg	0.1	
79 S-N-B	78.1 dg	80.0 dg	-0.3	
69 A-N-B Difference	3.2 dg	2.9 dg	0.4	
#75 Total Facial Height	57.7 dg	60.0 dg	-0.6	
INTERNAL STRUCTURE				
40 Cranial Deflection	27.0 dg	27.0 dg	0.0	
45 Cranial Length Anterior	62.2 mm	63.4 mm	-0.5	
44 Ramus Height (CF-Go)	70.8 mm	64.5 mm	1.5	*
46 Ramus X Position	76.0 dg	76.0 dg	0.0	
43 Porion Location (Por to PTV)	-41.1 mm	-43.5 mm	1.1	*
#56 Mandibular Arc	33.1 dg	30.7 dg	0.4	
51 Corpus Length	75.3 mm	75.0 mm	-0.2	

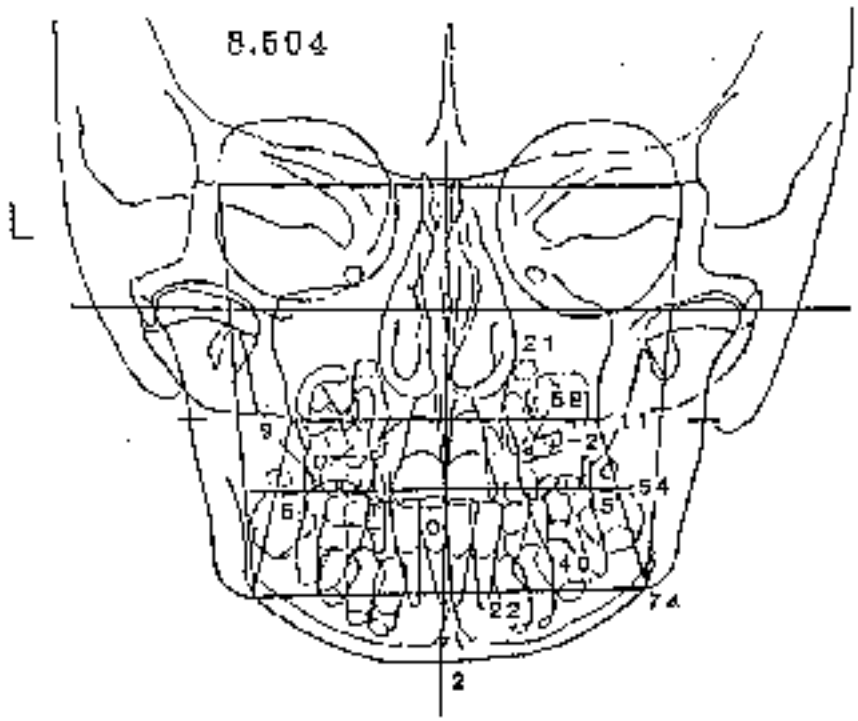
THE LATERAL SUMMARY ANALYSIS

Purpose	Parameter
1. Total facial height	Corpus Axis to BaN
2. Lower facial height	Corpus Axis to Org line
3. Central facial direction	Facial Axis to BaN
4. Facial depth	Facial Plane to Frankfort
5. Convexity	Point A to Facial Plane
6. Ramus height	Mandibular Plane to Frankfort
7. Palatal Plane Position	Palatal Plane to Frankfurt
8. Posterior Cranial length	Posterior Condylion to PTV
9. Anterior Cranial length	Cranial center to Nasion
10. Lower incisor position (horizontally)	Incisor tip to APo
11. Lower incisor position (vertically)	Incisor tip to Buccal Occlusal Plane
12. Upper molar position	Distal of upper molar to PTV
13. Depth of lower arch	Mesial of molar to incisor tip
14. Upper to lower incisor	Inter-incisal angle
15. Lower lip protrusion	Lower lip to E line



THE FRONTAL SUMMARY ANALYSIS

Purpose	Parameter
1. Nasal cavity width	Nc to Nc
2. Maxillary width	Jugale to Jugale
3. Mandibular width	Antegonion to Antegonian
4. Maxillo-mandibular width (L)	Jugale to Fronto-Facial Plane
5. Maxillo-mandibular width (R)	Jugale to Fronto-Facial Plane
6. Mandibular symmetry	Protuberance Menti to Mid Plane
7. Maxillary symmetry	Point ans to Mid Plane
Dental Frontal	
8. Molar width	Trans-buccal of lower molars
9. First premolar width	Trans-buccal of lower first premolar
10. Intercanine width	Trans-canine tips
11. Molar position (L)	Molar buccal to Fronto-Dental Plane
12. Molar position (R)	Molar buccal to Fronto-Dental Plane
13. Molar bite (L)	Buccal of A6 to B6
14. Molar bite (R)	Buccal of A6 to B6
15. Midline of lower	Embrasure of lower incisor to Mid Pl.



For explanation of each parameter, see Appendix.

The frontal provides information for the transverse dimensions. For the frontal, fifteen measurements are employed; seven skeletal and eight dental measurements are made. Thus, thirty measurements can be evaluated even for the "Summary Analysis", when both views are considered and a sophistication is sought.

Function #5. Furnishes a Framework for Abstraction and Reduction

Abstractionism

An abstraction is a summarized statement of a major composition. If the anatomy and physiology of the whole head is to be considered, a great bewildering complexity would result in its measurement and description. But through a selection of baseline points and planes of reference an organized method and the parameters can be selected. These references should have, first, **biologic significance** and, secondly, **availability of perception** in the X-ray view. With a valid process the best abstraction for description can be achieved.

For the best procedure for the evaluation of growth or treatment change, the **most stable or unchanging references are employed.** Such is the orientation for the polar phenomenon of growth. Also, points on the jaws serve for analysis of tooth changes. Standard values for changes are available for reference in the computer.

For the forecasting of growth, an arc of growth for the mandible was abstracted. Secondly, phenomena for the association of mandibular growth with the growth of the cranial base and mid-face also follow. This in turn became the base for plotting dental and soft tissue changes.

In effect, these procedures are all abstractive and their use may be likened to a short-hand method for the taking of dictation.

Reductionism

Reductionism is simplification. It is a process that permits not only a summarization but provides a means for the **selection** of the most significant or important aspects of something complex.

Thus, a proper cephalometric analysis will permit a "summary form". Even if a scheme be more comprehensive in content, such as that available with the computer, it still represents an abstraction. But effectively, by comparison a program can **reduce** the summary form by the selection of the most meaningful and significant measurements for the clinician's attention and the amount of importance to be attached to a measurement. This is the beauty of application by the computer because the detail and rating of data it affords

With the computer analysis also the process is **abstracted** by division of the analysis into fields of interest or families of measurements. **Reduction** is accomplished by the use of indices for weighting and by the use of symbols (or

asterisks) to denote severity. Both abstraction and reduction help to determine the degree of difficulty in a given situation.

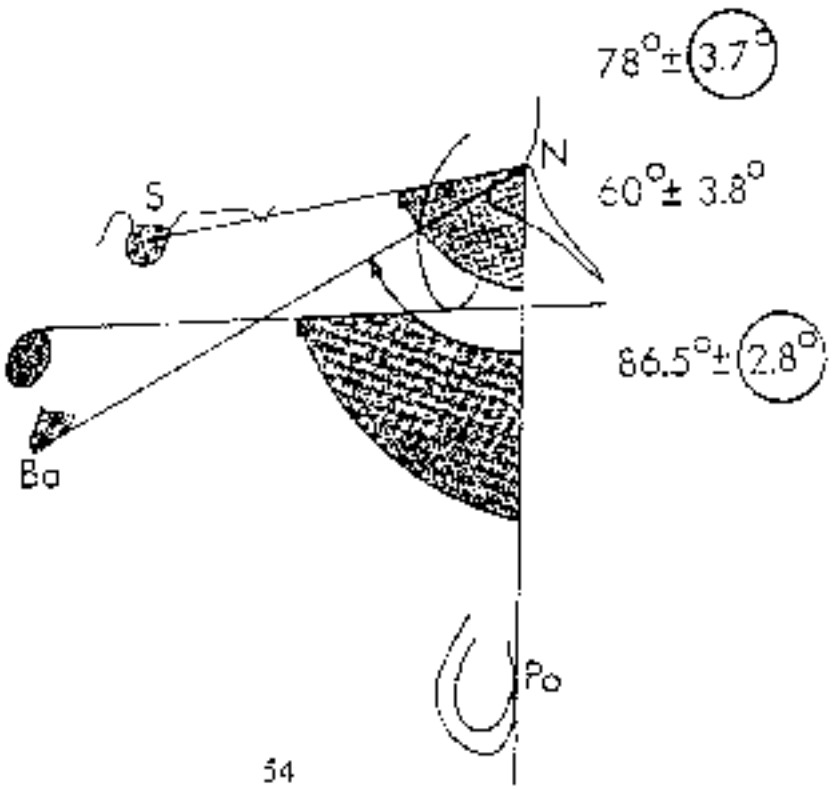
The routine standard deviation is understood. In order to improve its application a clinical deviation concept was introduced? This rounded out numbers for ease of memory, graded values for clinical application, and improved communication.

Brief Statistics

Description

It has been contended herein that the Frankfort plane provides the most useful orientation for description but that the Basion-Nasion plane is the most cogent for serial work. In support of this thesis, aside from the practical everyday value gained with its use, some simple data are offered.

The superiority of Frankfort for "typing" of the face was seen in the first computer sample of N=40 subjects at age 8 years. For testing of the cranial reference, for relating facial points, the SN plane, FH plane and BaN plane were measured from the Facial plane (Nasion-Pogonion). The Standard Deviation from S-N and Ba-N was almost identical, at $\pm 3.7°$ to $\pm 3.8°$ respectively. From Frankfort plane (P-O) (with true Porion) the S.D. was $\pm 2.8°$. Frankfort therefore showed the best order for describing prognathism of the chin.



Sequential Change

For a tight order for assessment of directional change the average values and standard errors of the mean were calculated, using the same three basic planes (SN, FH, and BaN). The chin (Po), the maxilla (A), the ramus (Xi), the nose tip (e) and the lower molar 36 were compared (see Table 1).

Table I.

	Frankfort average change		*Frankfort RMS*		*S -N average change*		*S -N RMS*		*BA-N average change*		*BA-N RMS*	
Point	*X*	*Y*	*X*	*Y*	*X*	*Y*	*X*	*Y*	*X*	*Y*	*X*	*Y*
Xi	−0.14	−1.34	0.26	0.26	−0.47	−1.43	0.35	0.32	−0.90	−0.80	0.27	0.24
PO	1.59	−1.92	0.35	0.40	0.99	−2.48	0.55	0.47	0.05	−2.32	0.48	0.36
A	0.88	−0.95	0.20	0.22	0.60	−1.43	0.34	0.30	0.09	−1.25	0.25	0.24
E	1.89	−0.50	0.48	0.34	1.71	−1.26	0.59	0.41	1.19	−1.49	0.47	0.39
36	1.55	−1.76	0.27	0.21	1.10	−2.23	0.38	0.29	0.31	−2.10	0.27	0.25

Calculations were made to determine the average change in the X and Y directions as well as the root mean-squared errors. It is obvious that in every incidence the reference frame which utilized the Frankfort horizontal was appreciably better than that which utilized sella-nasion.

For Pogonion, from the BaN coordinate, the mean change in millimeters horizontally was 0.05 mm. At 0.48 standard error, it would suggest that the true mean for a sample would be between 0.43 mm. and 0.53 mm. almost 70% of the time. This would suggest that chin growth varies essentially from a perpendicular to the BaN plane.

From SN the mean horizontal change was .99 (or 1 mm.) per year rather than 0.05 per year as measured from BaN coordinate. From FH the change was 1.59 mm. horizontally. The BaN reference was thus a superior base for longitudinal analysis of horizontal behavior of the chin. (See illustration on page 56.)

For vertical (downward and forward) change (of Po) the mean was 2.32 mm. and the standard error was 0.36 mm. We have established a hypothesis of 2.5 mm. per year at Gnathion. The vertical change of Pogonion from SN was 2.48 mm. but from F.H. was only 1.92 mm. The larger value reflects the internal changes of the cranium. In the 1990 study of 73 children, the mean facial axis closed while the old Y axis from SN opened.

Because Co and CF points are close together the amount of change for Xi Point would be reflected only in direction.

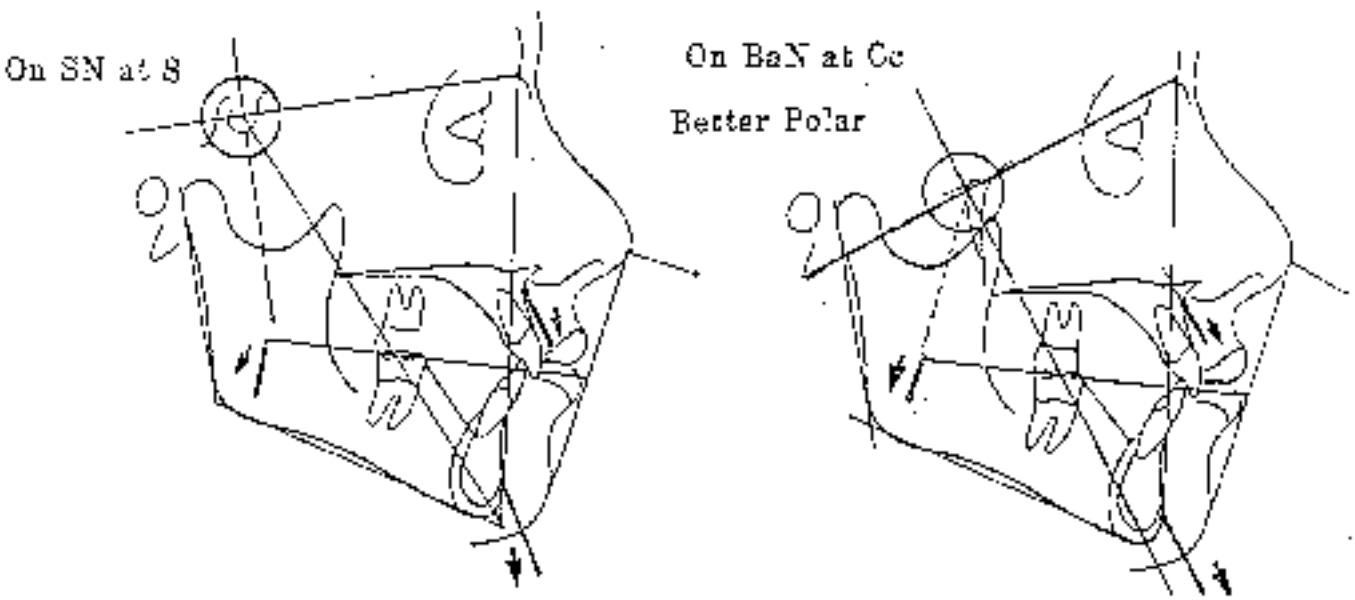
From BaN at Pt, the Xi Point moved backward 0.9 mm. and downward 0.8 mm., showing a straight downward and backward tendency from the Facial Axis coordinate (see sample N=50 of 1970 below, and N=73 of 1990 on following page). Thus it was concluded that for longitudinal analysis the BaN reference was superior for the mandibular points on the chin and ramus.

Further, when Point A was considered from SN it moved forward 0.6 mm. and downward 1.43 mm. From **FH**, Point A moved forward 0.88 mm. and downward 0.95 mm. From BaN reference it moved forward only .09 mm. yearly and downward 1.25 mm. almost parallel to the behavior of the lower incisor.

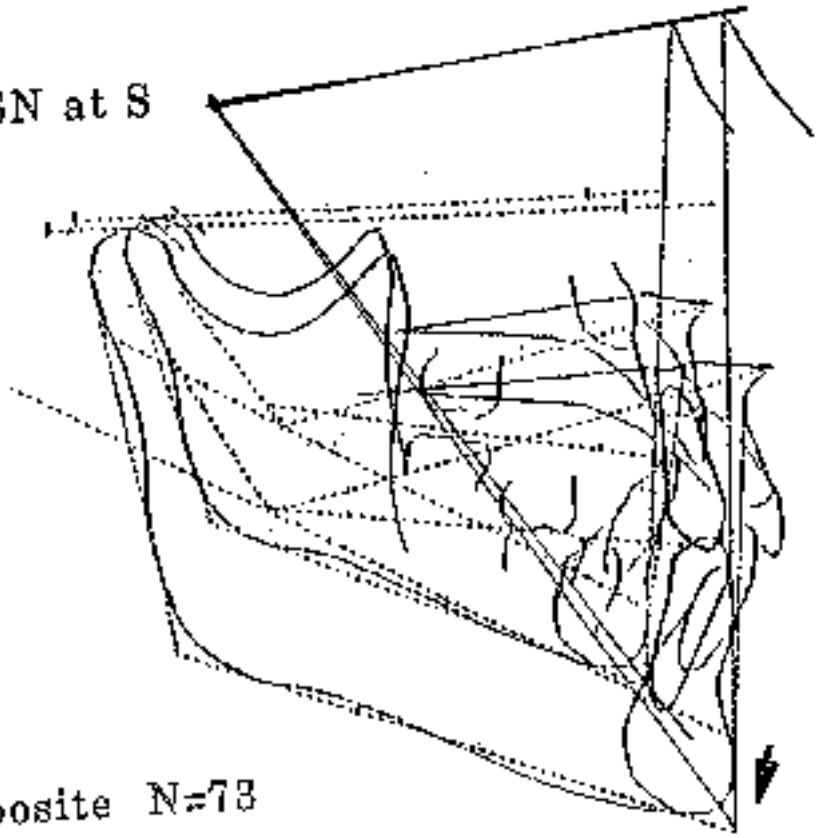
In visual analyses the nose tip (e) and behavior of the lower molar (B6) will be noted.

* * * * *

1970 Michigan Sample N=50



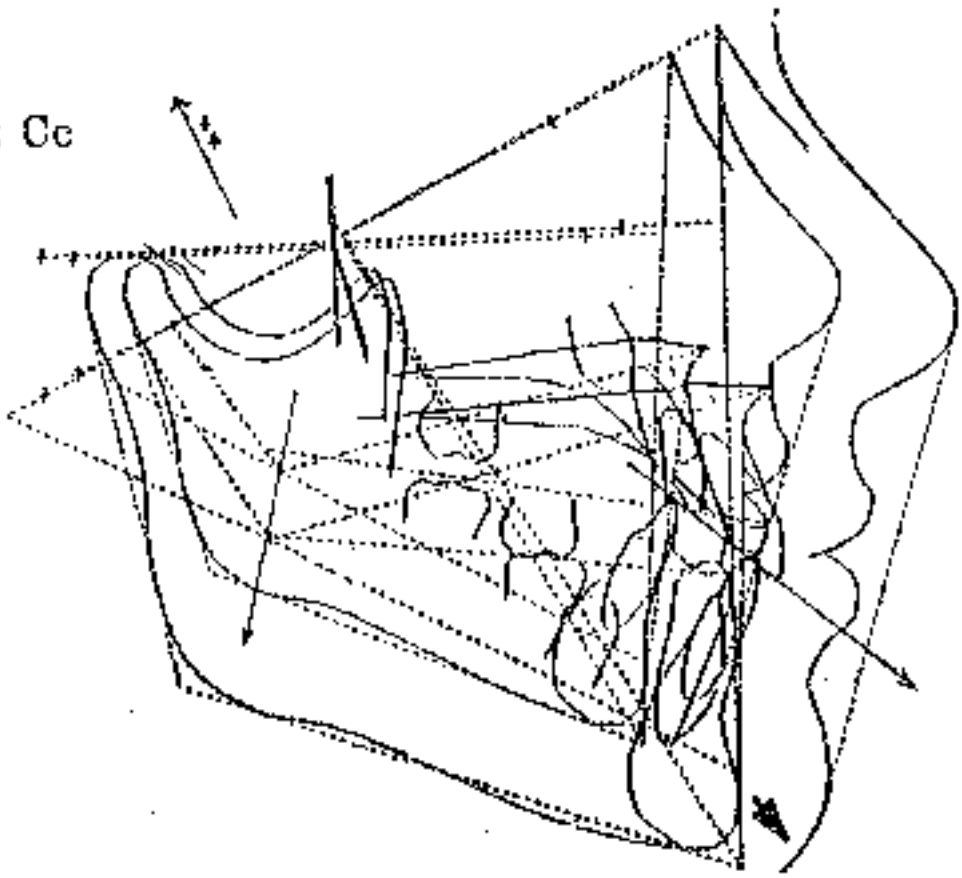
On SN at S



1990

Composite N=73

BaN at Cc



Function #6. Renders a Means for Sequential Growth Analysis

Interest in Growth

Growth has been a continued interest since the beginning of orthodontics. Development is usually associated with growth to include all change. Development toward senility continues after growth in size stops. Early in orthodontic theory growth was assumed to be essentially controlled by the treatment mechanisms.

Roentgenographic cephalometry was developed first for growth research. Later it was used for specific detail of treatment change. Three main divisions of head growth of concern are skeletal, dental and soft tissue.

Mandibular growth is of great significance clinically. The clinician desires to determine its participation in the correction of Class II, the treatment of deep bite, and the processes encountered in the management of Class III conditions.

No one questions the ability to alter the development of dental apparatus or the influence of teeth or the soft tissues. But of more interest is the question of possible treatment influences on growth and development of the basal skeleton.

Controversies

Both in anthropology and cephalometry progress has been hampered by differences of opinion regarding references to be used for assessing growth change. Studies of reversal lines by Enlow and implant studies by Bjork have helped to select stable sites for analysis of changes and have clarified some arguments regarding growth. Computer research and the availability of composites have helped immensely to provide growth data and growth variability.

Original studies on dry skulls were conducted from Porion. With analysis, however, it became recognized that growth occurred on both sides of the coronal suture complex. The ear canal (and Porion) had been convenient and easy points from which to measure skulls. With headplates Sella Turcica was also plainly visible and convenient. In its favor, Sella lies in proximity to the anterior cranial references or the superstructure for the nasal cavity. Also, the Sella-Nasion line is reasonably oriented to the upper and mid-face.

However, Sella has several limitations for growth analysis. It (1) lies behind the coronal suture, it (2) is related to brain or neuro-cranial growth, and it (3) lies above the principal bracing of the face at the Basi-Cranial Axis. Sella also (4) is a poor reference for the mandible which is supported laterally in the temporal bone. In

growth it (5) has a poor expression of polar phenomenon with the oral cavity. It was (6) found wanting in reliability for growth forecasting. (Fifteen to twenty percent of growth on the Y axis was cranial and not mandibular.) For all these reasons we were forced to abandon it for growth analysis and prediction.

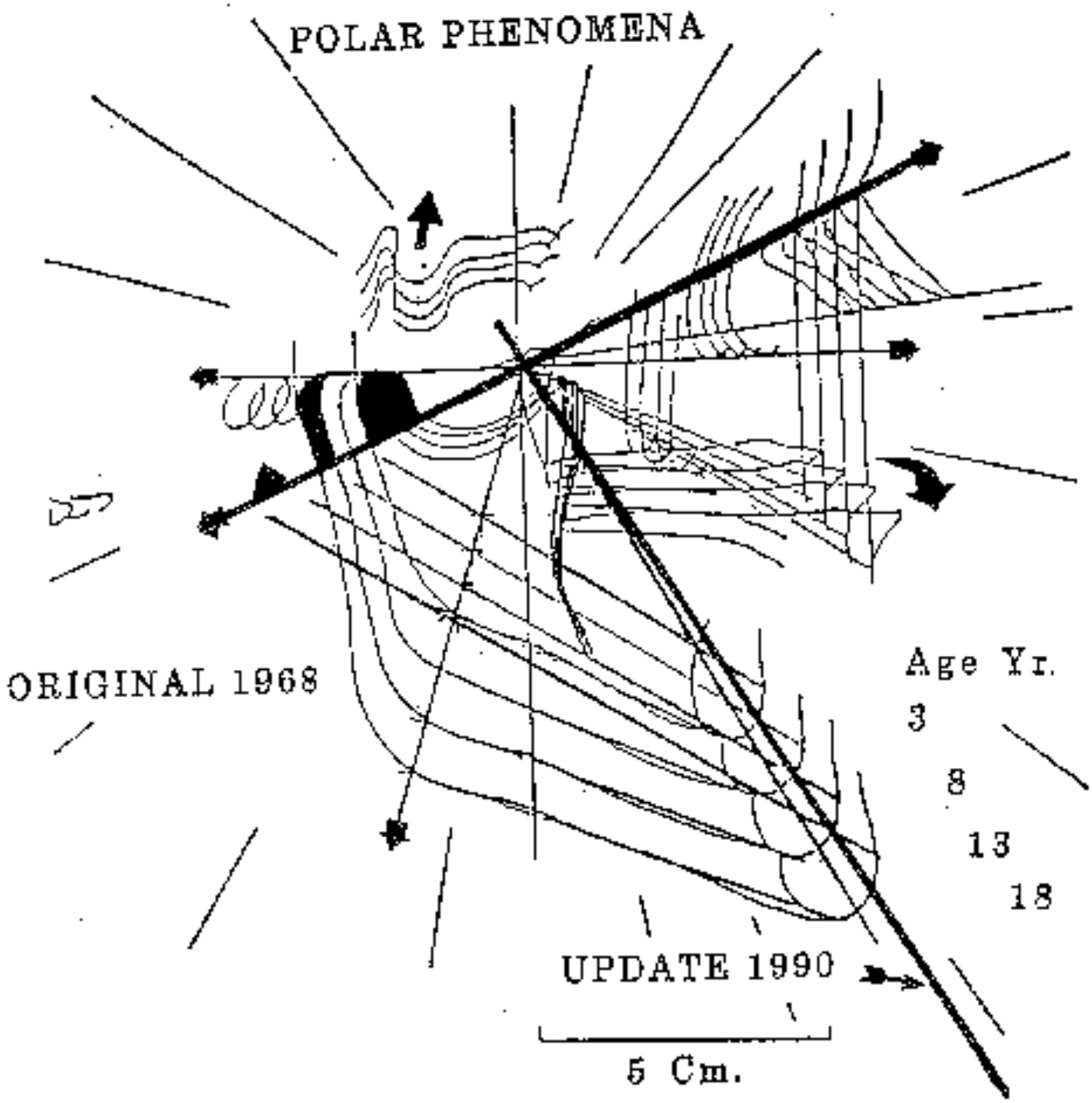
Polar Growth (Lateral)

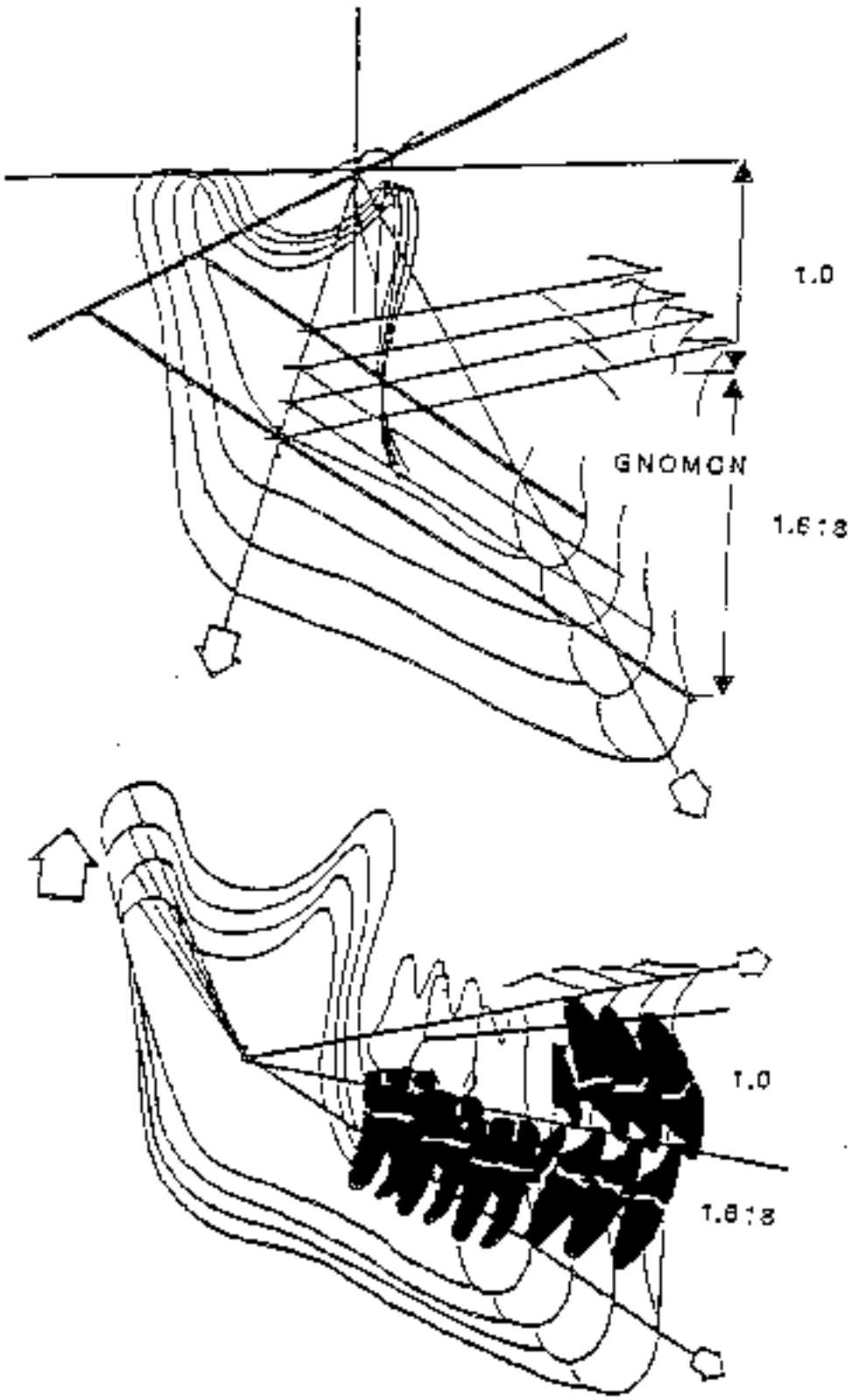
A central reference was found to exist at the basis of the sphenoid bone at foramen rotundum. Brodie frequently remarked that when he superimposed a series of tracings he "peered right down the spheno-palatine fossae".

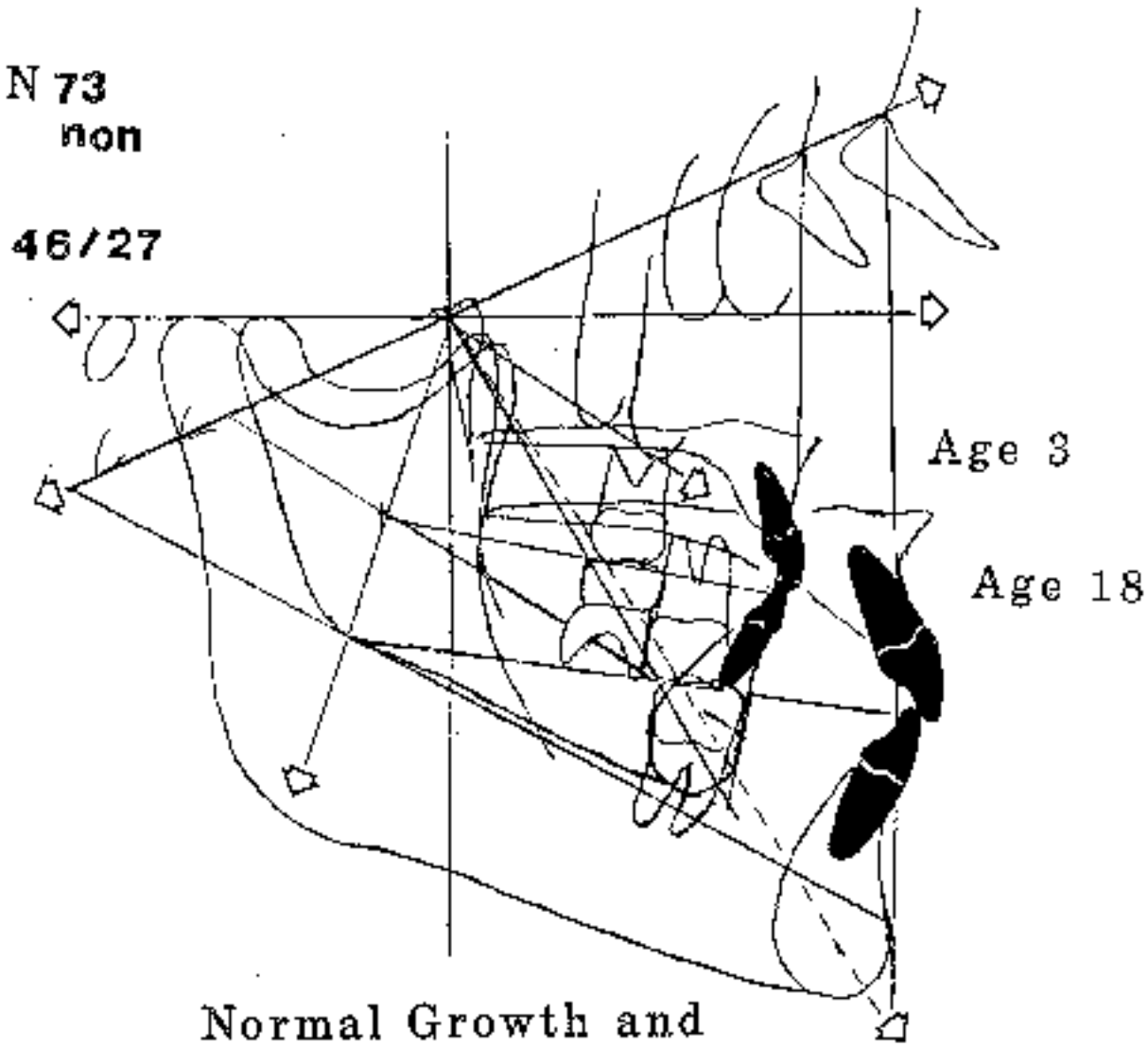
A more complete posterior to anterior cranial base is represented by Basion-Nasion. A cut through this plane separates the face from the cranium. Use of the Basion-Nasion plane registered from foramen rotundum (Pt) at Cranial center (Cc) simplifies growth analysis significantly.

With this orientation a remarkable order was noted in facial behavior and even in the nasopharynx and vertebrae. Thus, when two or more tracings are superimposed in this manner on a polar grid, points tend to follow the polar course.

[See illustrations on following pages.]


POLAR PHENOMENA
ORIGINAL 1968
Age Yr.
3
8
13
18
UPDATE 1990
5 Cm.

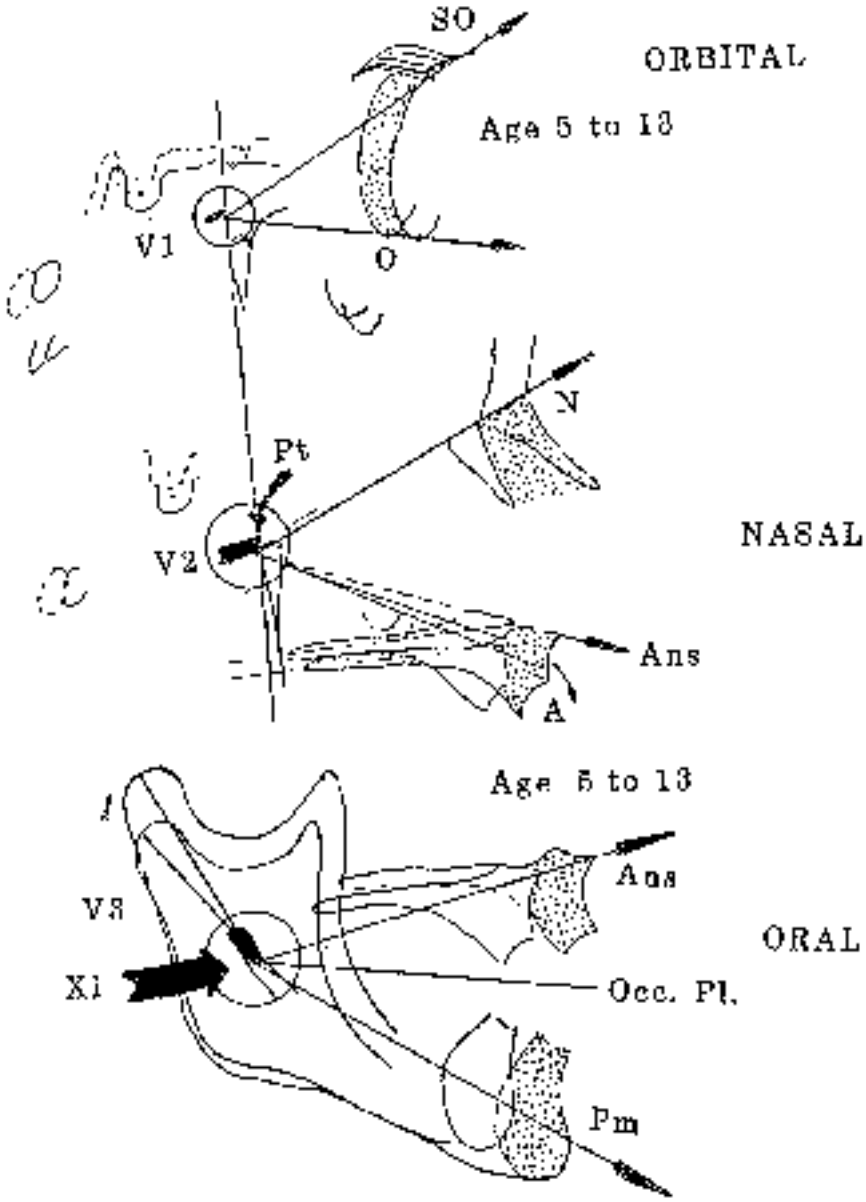

1.0
GNOMON
1.618
1.0
1.618



Normal Growth and
Developement of Occlusion

Gnomon Behavior

Growth occurs in proportion. A gnomon is the added part to a form which does not change it geometrically. As centers or vertexes of angles were located, superposition showed relative continuation in form for the orbital, nasal, and oral cavities. Ironically, the vertexes of angles or bases or references were located at entrances of nerves. This phenomenon also becomes useful for growth analysis. Allometric is another word employed for relative constancy of shape. Mechanisms for growth of the cranium, the mandible, and the maxilla seem to take precedence in that order.



C H A R T F O R

VALUES FOR RICKETTS CRANIAL BASE

	Posterior PTV to Cb			Anterior CC-N		
Age	$\bar{X}$	♂	♀	$\bar{X}$	♂	♀
3	28.5	29.0	28.0	51.5	52.5	50.5
4	29.0	29.5	28.5	52.3	53.3	51.3
5	29.5	30.0	29.0	53.1	54.1	52.1
6	30.0	30.5	29.5	53.9	54.9	52.9
7	30.5	31.0	30.0	54.7	55.7	53.7
8	31.0	31.5	30.5	55.5	56.5	54.5
9	31.5	32.0	31.0	56.3	57.3	55.3
10	32.0	32.5	31.5	57.1	58.1	56.1
11	32.5	33.0	32.0	57.9	58.9	56.9
12	33.0	33.5	32.5	58.7	59.7	57.7
13	33.5	34.0	33.0	59.3	60.3	61.3
14	34.0	34.5	33.5	60.1	61.1	62.1
15	34.5	35.0	34.0	60.9	61.9	62.9
16		35.5			62.7	
17		36.0			63.5	
18		36.5			64.3	
19		37.0			65.1	

Breaking Growth Down (Abstraction)

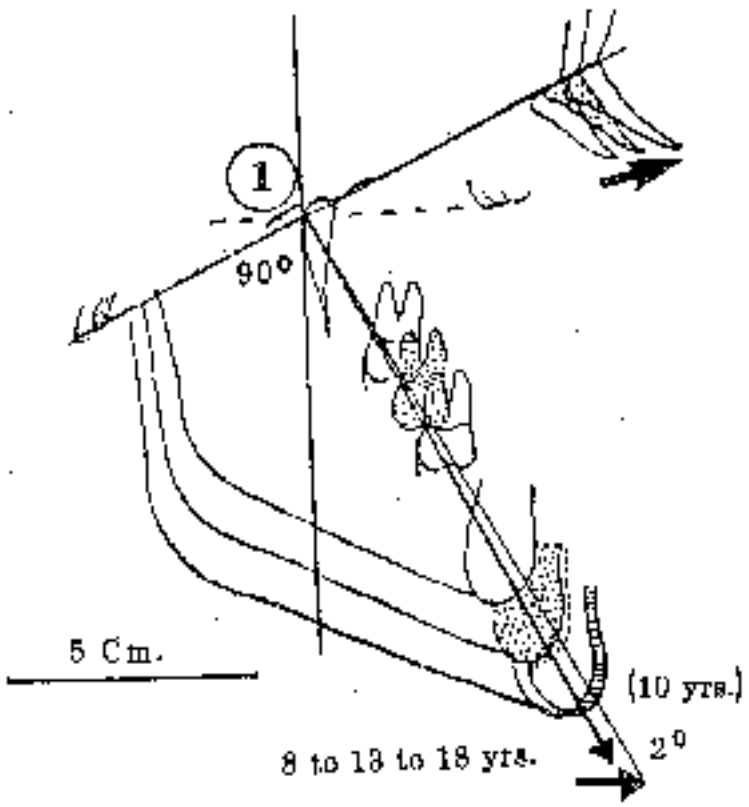
Frequently growth direction is unclear to the clinician. In fact, different directions can be interpreted from different planes of reference. Therefore, a central area from which to assess growth and direction needs confidence levels. Such overall facial growth behavior is witnessed from the Basion-Nasion Plane registered at Cc, as shown in polar growth.

The Four-Position Analysis of Growth

In general, the clinician is interested in four phenomena. These are the chin (**Position 1**) the maxilla (**Position 2**), the upper teeth (**Position 3**), and the lower teeth (**Position 4**). This information is provided by the "Summary" positional analysis and is shown at ages 3 to 8, 8 to 13, and 13 to 18 (or three five-year intervals).

Position One -- For the chin (mandible)

With the central position of two tracings at Cc, growth and behavior of the chin is visible by behavior of the Facial Axis. Growth tends to follow the original axis, particularly in short range, and increases at a remarkable uniform rate of 2.5 mm. per year. In long range (5 to 15 years) the Facial Axis tends to close slightly on average.



POSITION ONE

FUNCTION: Indicator of Direction and Amount of Growth (or change in chin)

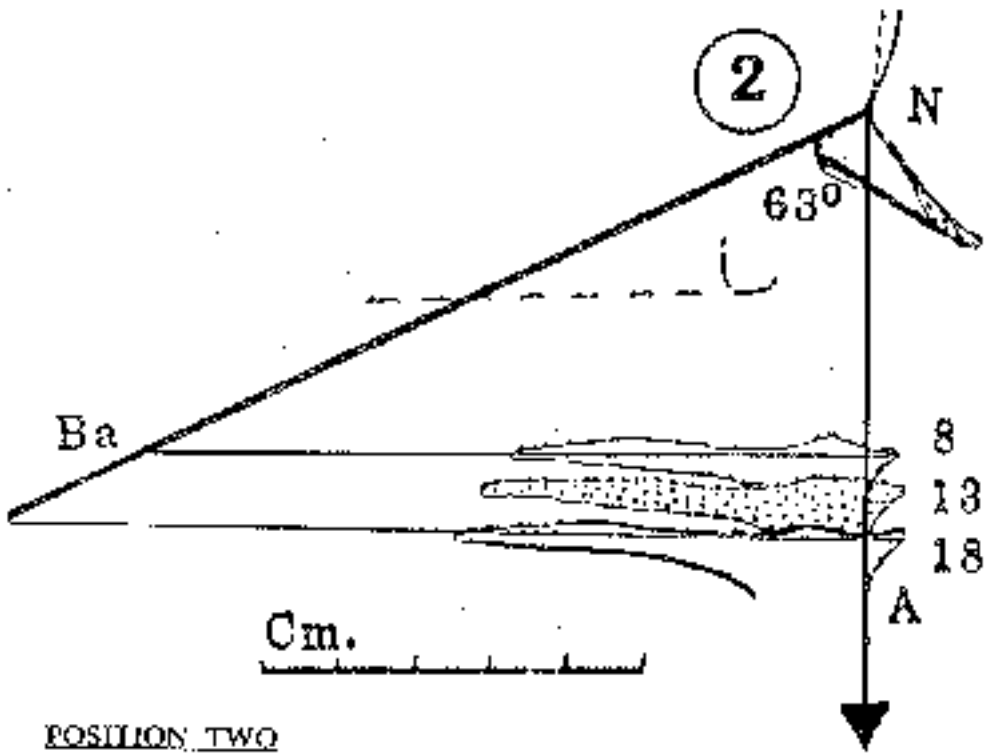
CHANGE VALUES:

Direction: 0° (+2° in 10 years)
Standard Variation:
1.5° at 5 years
2.0° at 10 years

Amount: 2.5 mm. each year,
or 10 mm. each 4 years.
C.D. = ± 0.5 mm. each year

Position Two -- For the maxilla

Shifting forward on the Basion-Nasion plane to register at Nasion serves as a reliable reference to evaluate maxillary or palatal behavior. The angle of BaN to Point A is almost a perfect constant. In long range Point A may move forward one or two degrees, but it is remarkable how constant it is, as Brodie proclaimed. The angle of the palatal plane to BaN changes hardly more than a tracing error without treatment.



POSITION TWO

FACTOR: Basion-Nasion at Nasion

FUNCTION: Indicator for Direction and Amount of Growth (change) in Anterior Maxilla

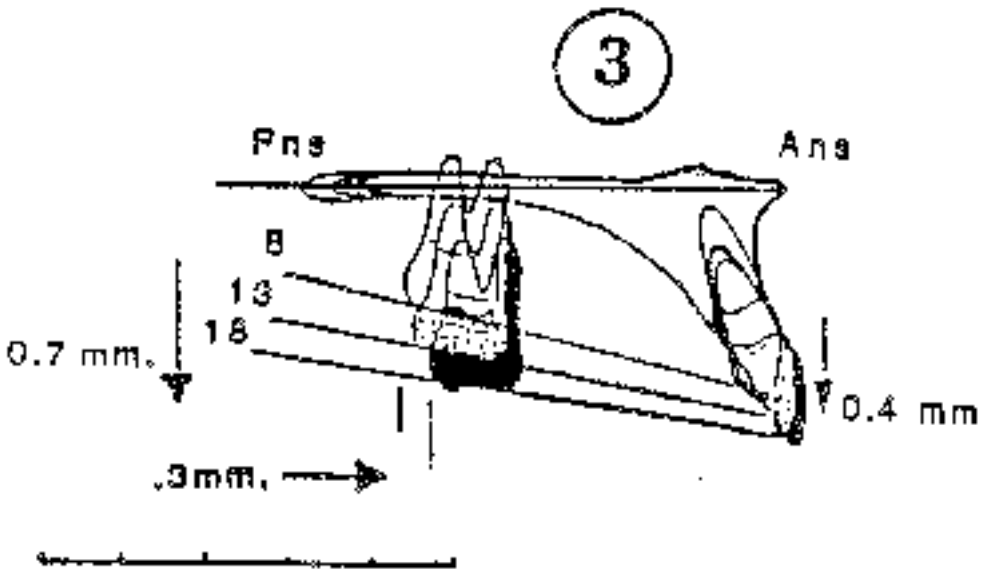
CHANGE VALUES:

Direction: 0° Standard Variation ± 1.0
(Very rare cases: slightly +)

Amount: For ANS Vertical,
1.15 each year.
C.D. = ± 0.25 each year.

Position Three -- For the upper teeth

The maxillary molars and incisors have been target teeth for reference by many practitioners. Their normal behavior is related to the palatal plane registered at ANS. This reference has remained essentially unchanged since 1930.



POSITION THREE

FACTOR: Palatal Plane (ANS-PNS) at ANS
For reading of incisor - Molar
+ Occlusal Plane

FUNCTION: Indicator for Maxillary
Denture Change

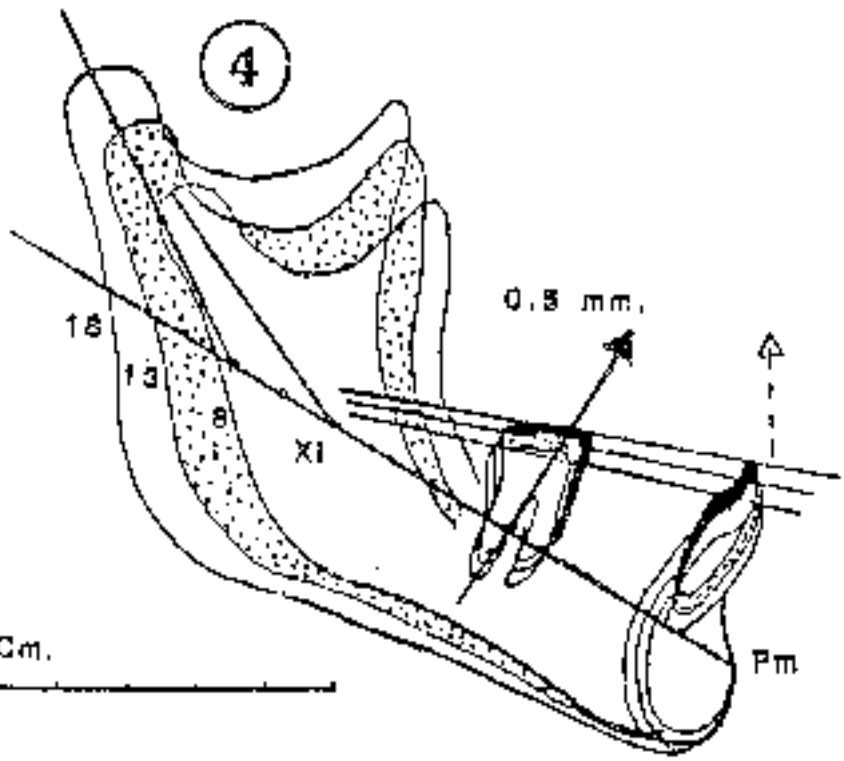
CHANGE VALUES:

Forward:
0.3 mm. each year.
C.D. = ± 0.1 mm.
Occlusal Plane - drops at molar more,
0.6° each year, i.e 3° at 5 years,
6° at 10 years.
$\underline{6}$ = 0.7 mm./year $\underline{1}$ = 0.4 mm./year

Position Four -- For lower teeth

While the maxillary tooth behavior is relatively clear, the behavior of mandibular teeth has been more problematical. The mandibular plane registered at the symphysis have led to controversy. However, with the development of Xi and Pm points, it was discovered that the angle of the buccal occlusal plane to the corpus axis also remained a solid base for reference. This is so reliable, in fact, that it is used for prediction of molar behavior.

It should be understood that the whole lower denture erupts upward and forward as revealed by the growth arc.



POSITION FOUR

FACTOR: True Occlusal Plane to Corpus Axis at PM point

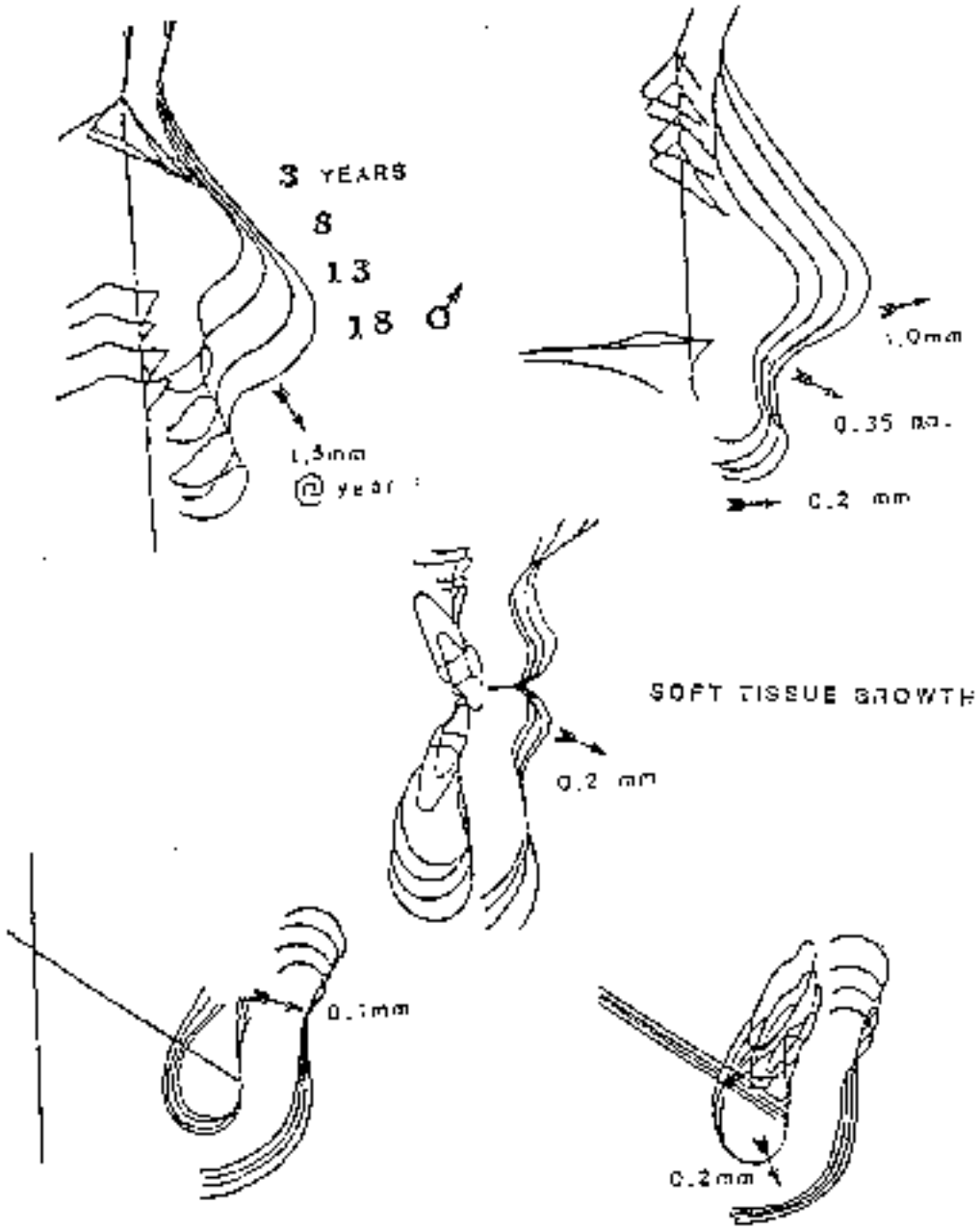
FUNCTION: Indicator for Change in Lower Denture

Change Values: 0° change in Occlusal Plane
Eruption from Corpus Axis 0.5 mm. each year
Lower Incisor 3.0 mm.

Soft Tissue

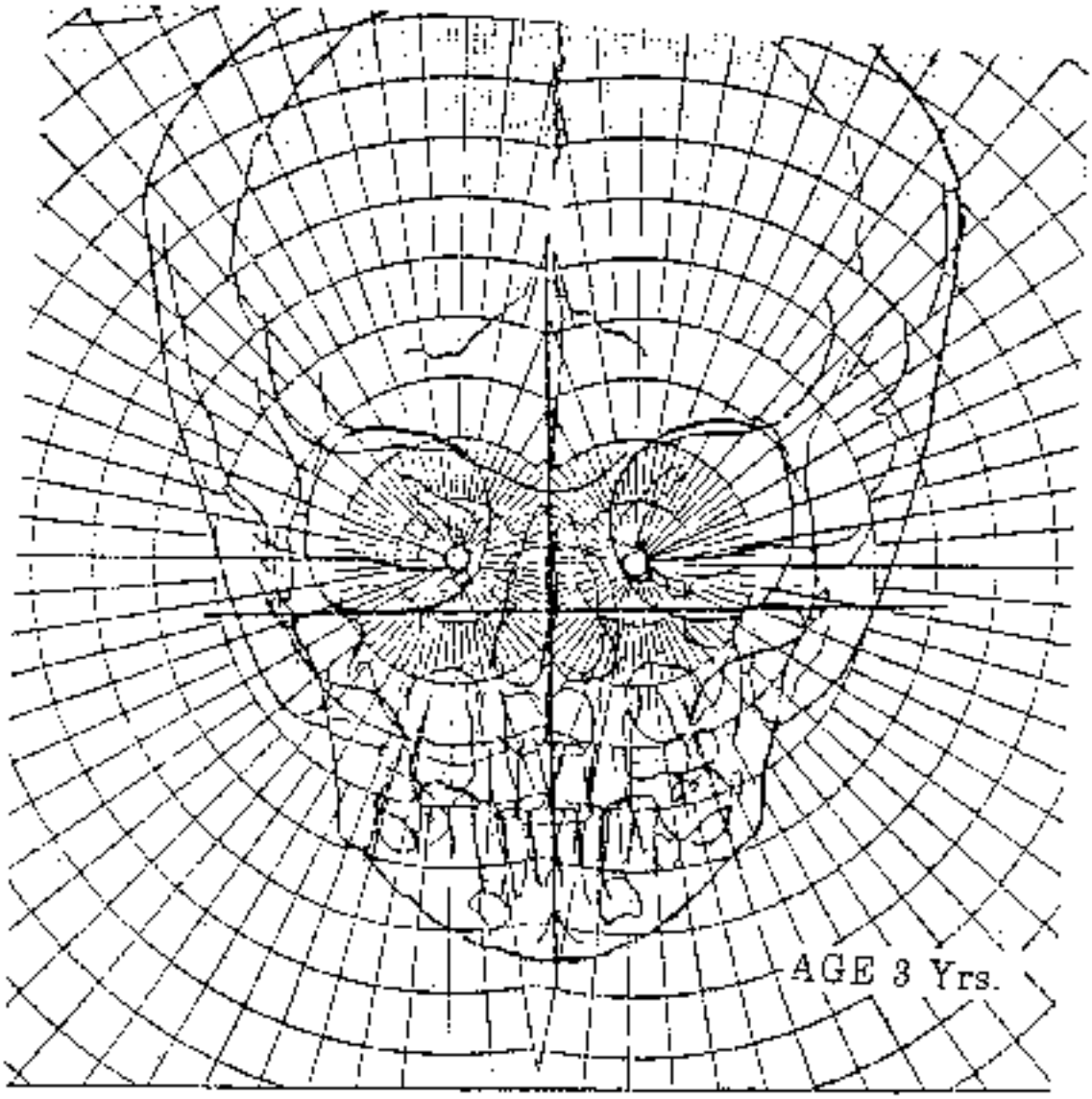
Nose growth is measured from ANS (Position Three). Lip thickness and position are related to the labial surfaces of the incisors. Chin tissue is related to the symphysis (Position Four).

Subnasali is considered in a downward and forward oblique direction from the base of the anterior nasal spine. Supramentali (soft tissue, B) is calculated from the roof of the lower incisor near the root-crown junction.



Frontal Growth -- The Bi-Polar Phenomenon

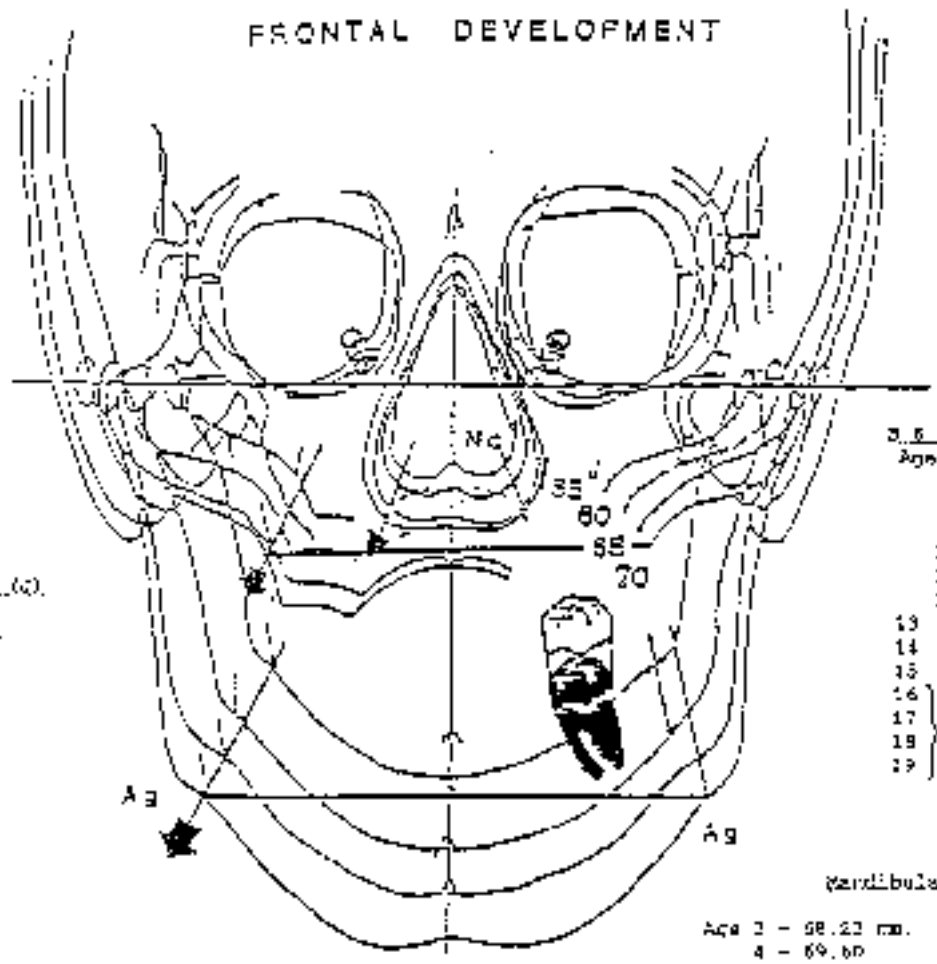
When the polar grid was studied relative to Time I and Time II, for the frontal composites one center could not be found. However, when each foramen rotundum was employed it was discovered that growth occurred from two centers or poles in the frontal perspective. The idea of the influence of two neurotrophic centers was further supported by this finding. However, two centers were almost unworkable for the typical clinician. Therefore, the data was collected for a single coordinate, the crossing of the Frankfort with the mid-sagittal plane.



BI-POLAR

With this coordinate orientation, the relative growth of the nasal cavity, jugal process, and antegonial points was observed. There seemed to be a "one-two-three" order, which was later found to be consistent with the divine proportion.

From the original 1966 computer work growth data was collected. Findings are shown in tabular form.



Mandibular Width (Co)

Age 3 - 55 mm.
6 - 60
13 - 63
18 - 70

3-6 Yrs Long'l Ag
Age 6 - 4.0 mm.
7 - 5.2
8 - 6.0
9 - 6.8
10 - 7.6
11 - 8.4
12 - 9.2

13		10.0 mm
14		10.8
15		11.6
16	Males	12.4
17		13.2
18		14.0
19		14.8

Mandibular Width (Ag)

Age 3 - 58.20 mm.
4 - 69.60
5 - 70.95
6 - 72.30
7 - 73.65
8 - 75.0
9 - 76.35

Age 10 - 77.70 mm.
11 - 79.05
12 - 80.40
13 - 81.75
14 - 83.10
15 - 84.45
16 - 85.80

Males
Age 17 - 87.15 mm.
18 - 88.50
19 - 89.85
20 - 91.20

Nasal Cavity Width (Na)

Age 3 - 22.0 mm.
4 - 22.5
5 - 23.0
6 - 23.5
7 - 24.0
8 - 24.5
9 - 25.0

Age 10 - 25.5 mm.
11 - 26.0
12 - 26.5
13 - 27.0
14 - 27.5
15 - 28.0
16 - 28.5

Age 17 - 29.0 mm.
18 - 29.5
19 - 30.0
20 - 31.5
21 - 32.0
22 - 32.5
23 - 33.0

The Divine Proportion analysis was found useful in transverse considerations. This is described in a separate paper.

Function #7. Supplies a Monitoring Process for Treatment

Separation of Growth from Treatment Changes

Often clinicians may be reluctant to obtain progress headplates because of their inability or uncertainty of comprehending sequential analysis. As stated previously, a trustworthy method and data are required for confidence to be gained.

*Monitoring means to apply a process for ongoing observation.

*Monitoring provides a device for checking and regulating the performance of treatment mechanics.

*Monitoring means to warn, caution or advise.

*Monitoring provides a reference for the following of a given series of events in operations.

Monitoring, with the forecast to maturity, permits the detection of any catastrophic accident, disease, or treatment misfortune that would overthrow the turgor of the natural growth process.

When is a change of your doing?

The idea of Clinical Deviation was an adjustment of Standard Deviation for better application to the clinical experience. As stated before, for the sake of memory, all values needed rounding out. Also for the sake of notification of importance, values needed to match the clinical experience. These adjustments for clinication deviations were for descriptions of morphologic variables for the analysis.

A different condition exists, however, in small increments of change for the monitoring of treatment. Growth in analysis and forecasting is reduced to a "**modular concept**". A module value is a mean growth from an adequate sample of one year's duration. Thus, a two-module experience for usual treatment would be typical two-year growth. However, a patient may be slower or faster in growth expression. Therefore, the clinician's concern is not time exactly, but amount to be employed or built into the plan. If two modules occur in 1.5 years, fine. If it takes 2.5 years, it may just take longer to complete the treatment.

The Ten Percent Rule

The concept for clinical interpretation is further complicated in monitoring for

periods of weeks or months. As a working hypothesis, therefore, a protective variation of ten percent (10%) is employed. In other words, the yearly module is divided by ten for a base reference.

The Four-Position Analysis for Monitoring

The normal values with growth need to be memorized on a modular basis from each position, together with a one-year value of clinical deviation. Any departure from those expected values is thought to be an influence from mechanical or treatment procedures.

Position One -- For Mandibular Orthopedics

The chin moves on the facial axis 2.5 mm. per year. Ten percent would be .25 mm. This would mean the clinician can candidly take credit for anything more than 2.75 mm. or less than 2.25 mm. in one year's time. If the monitoring is 6 months, then a 1.25 mm. base is used ± 10% would be .125 mm. or 1.3735 mm. (1.4) or less than 1.125 mm. (1.1).

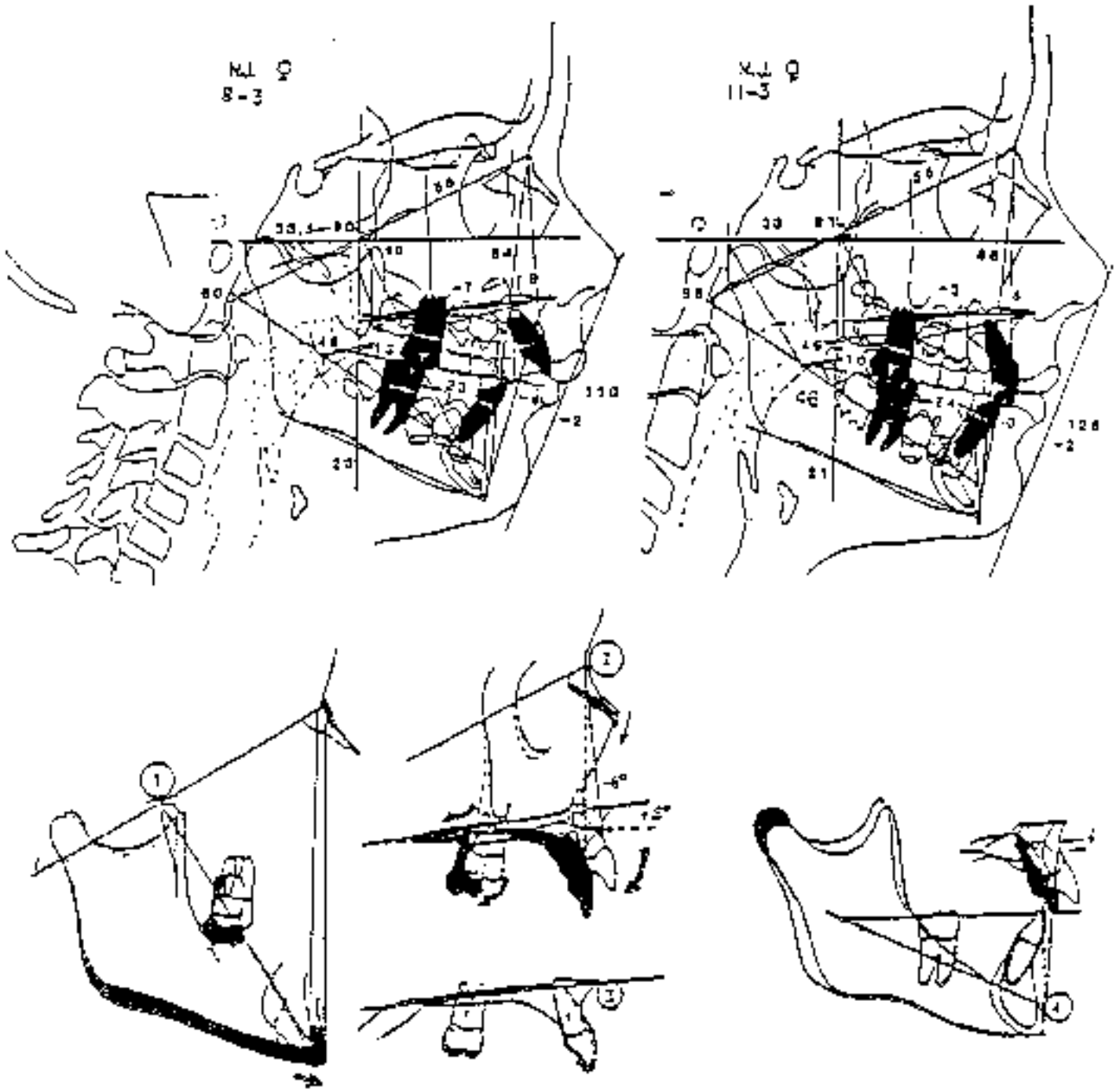
Given a tracing error of 0.5°, if a change of one degree on the facial axis occurs in six months, the clinician may conclude the change is produced by treatment.

Position Two -- Maxillary Orthopedics

Experience has shown that almost any change in a Basion-Nasion Point A angle is treatment-induced. Ten-year growth periods may show a mean increase of about one degree. About two degrees is the maximum ever observed. Thus in short time periods of one to three years point A change is within tracing error.

The same regularity is expected in the angle of the palatal plane to BaN. It is so small over long periods that any change can be assumed to be treatment-induced.

In summary, since the change in the angle of the facial axis is so small on a yearly basis, and because the BaNA angle is so very orderly, any change at all in six months to a year is taken to suggest treatment influence on the mandibular and maxillary bases.



Position Three -- Maxillary orthodontics

The occlusal plane behavior is largely controlled by events in the behavior of the mandible! With normal development the occlusal plane drops posteriorly from the palate about 3 mm. each 4 years. The denture moves forward about one mm. each three years. Any alteration from this pattern in short range can be taken to suggest alteration of maxillary teeth positions.

For detailed consideration, the upper molar moves forward toward ANS only 0.3 mm. per year. In six months it would be only 0.15 mm. (not even a tracing error). And in two years its forward movement is only 0.6 mm. Therefore, practically any horizontal movement under two years signals a treatment change in either direction.

Vertically, the upper molar erupts from the palatal plane at a rate of 0.7 mm. per year. This would be only 0.35 mm. in six months. Again, this is similar to a tracing error essentially. Therefore, if in one year the upper molar is extruded 3mm., 2.3 mm. can be claimed to be caused by treatment. If, on the other hand, it is intruded 2.0 mm., then actually it has been affected 2.7 mm. from its predicted position. But by using the Ten Percent Rule the amount for clinician credit is 2.63 mm.

Position Four -- Mandibular orthodontics

From a carefully selected **Corpus Axis** registered at Pm the molar incisor positions are compared to the normal. This will reveal induced changes.

Molars

Critical points for monitoring of treatment are the molars because of anchorage interests. The lower molar erupts at a right angle to the corpus axis registered at Pm. On average, 0.5 per year or 1.0 mm. in 2 years is the (usual?) behavior. According to the Ten Percent Rule, the protective variable would be 0.5 X .10 = .05 mm. Thus in one year 0.45 mm. to 0.55 mm. would be the sensible reference. If in one year the change is 4.0 mm. then essentially 3.45 mm. would be due to treatment. If six months' duration, 3.7 or nearly all would be due to treatment. In the forward direction, any change is thought to be treatment-induced.

The lower incisor (from the corpus axis orientation) tends to move bodily upward and backward also, about 0.5 mm per year. It moves backward 4 mm. in 15 years, which is about 0.25 mm. each year. Therefore, if the lower incisor moves straight upward it has been moved forward from that which would be expected without treatment. The exception may be those patients developing generous dental

protrusions from the influence of large tongues and loose lips.

Soft Tissues

Lip changes are influenced by tooth movements. Behavior of the chin can be altered by changes in the mentalis provoked by the original malocclusion and corrected with treatment.

Function #8. Delineates Treatment Possibilities (See page 74)

In 1938 the first cephalometric study of treated patients was reported by Brodie, Downs, Goldstein, and Myer. Conclusions were drawn on only fourteen Class II patients and six Class III patients. Treatment with the edgewise mechanism was alleged to have no effect on the skeletal pattern except for mandibular rotation which "tended to recover". Six Class I patients were treated with expansion and would not be expected to have basal skeletal change other than mandibular rotation. All arch changes were achieved by the use of intermaxillary elastics in that sample.

Remember that this study was "preliminary". Yet most conclusions drawn were considered by most to be final. Also, treatment was performed in mostly full dentition ages or beyond ages where skeletal effects would be manifested as understood presently.

No extraoral traction was employed (particularly as currently prescribed with cervical traction). No anterior tooth intrusion with transformo anchorage was used as presently applied. No positioning devices or palatal appliances were employed. No transverse data was reported from the frontal film. The findings suggested orthodontics or tooth movements were limits of possibilities.

Tweed, Nance, and Strang joined forces with Steiner and many others in accepting the "doctrine of limitations". The concept was that teeth could be moved over significant distances but that "pattern expression" accounted for the basal change and that the basal structures were immutable.

Throughout the next two decades the cephalometric tool became the primary source of treatment information. In 1960 the immutable theory was severely challenged. While mean composites were manually made in the 1930s, to study and display growth behavior, composite data of treated cases did not become available until the application of the computer in the 1970s.

New findings in 1957 and 1960 indicated that skeletal maxillary change was possible with extraoral traction. Thus treatment possibilities were assessed to lie in three areas: skeletal, dental, and environmental.

Short Range Results (one to three years)

Another question regarded permanency -- the skeletal changes, and stability of dental and soft tissue change. From the beginning it was determined that a two-year plan made sense for treatment planning. Therefore, a two-year or treatment experience analysis, would be considered a short term when compared to the whole growth period. As specific appliances were used, significant changes were seen in the short range. The following statements represent the current conclusions reached from analysis of several hundred patients and composites of about 30 samples of treated patients.

Cranial

Posterior cranial base growth may be affected slightly, while the behavior of the temporal complex anterior cranial development seems to be totally genetic. This conclusion awaits larger samples and careful study procedures.

Mandibular

Mandibular bending and condyle behavior may be influenced by mandibular posturing devices and vigorous elastic traction. Excessive mandibular rotation may cause compression of the chondrogenic zone in the condyle and inhibit growth.

Direct anterior superior or superior compression of the condyle may inhibit growth and sometimes it may not rebound.

Condyle growth vertically may temporarily be enhanced by producing posterior support if not excessive.

Maxillary

Major skeletal and palatal change can be made in three dimensions. Changes induced may be small, to am much as a centimeter or more. Techniques employed are critical to the changes induced.

Dental

All teeth can be intruded or extruded. Molars can be moved distally, mesially or buccolingually. Expansion can be done safely. Teeth can be moved several millimeters within the basalar apparatus, as witnessed in canine impaction.

Soft Tissue

Muscle adaptation often occurs automatically. When "habits" persist, greater attention may be needed therapeutically. Too much mandibular rotation may be dangerous.

Long Range (more than three years)

Cranial Base

Minor temporal bone cranial alteration may be permanent.

Mandibular

Any induced change in the form or size of the mandible is temporary. When predictions of composites are made in long term they compare precisely withthe treated actual composites. Opening rotation of the mandible may not always return and can damage the condyle theoretically.

Maxillary

After treatment a maxillary rebound may occur if not retained, but when managed properly it does not commonly occur. A forward growth of the mandible may be a factor in maxillary retention.

Maxillary reduction for high convexity tends to be permanent.

Dental

Final tooth positioning is at the mercy of the muscles, and nerve directs muscle. Overtreatment is essentially needed for all treatment with the possible exception of male growth in treated Class I or Class II.

Function #9. Allows Prognosis and Simulation of Objectives

Prognosis is a form of prediction. Prognosis is made at each adjustment that the teeth will move as desired and directed with appliances. Faith is needed.

Definition:

*Prognosis is the prediction of the probable course of a condition or the foretelling of the outcome.

*Prognosis is a two-edged sword for orthodontics: one is the probable growth and developmental consequences without treatment; the other is the projected results with therapy by one of various modalities or their combinations.

We have listed fifty-seven functions of a forecast to maturity in a young child. But a forecast further becomes a matrix on which planning is made. Therefore, two forecasts or prognoses may be constructed. One is without treatment, and the second is the changes made with the treatment objectives.

In short range treatment objectives are visualized (VTO). In long range the thought is for a goal of final results (VTG)(visualized treatment goal).

The process of construction of a "forecast" may be linear, or arcial with modification of vectors and directional components. Contributory allowances are made according to size, form, pattern, age, sex and relationships. Therefore, a mean data base value is only a starting basis.

Forecasting

Anything that can be explained and correlated can be predicted. The concept of simulation is more appropriate because prediction carries a degree of absoluteness. Forecasts are rendered in percentages. The question regarding accuracy has been raised since the beginning. How accurate must a forecast be to be of value, and by how much will it need to miss to be misleading in a plan? Many researchers objecting to forecasting practices have not addressed these fundamental questions.

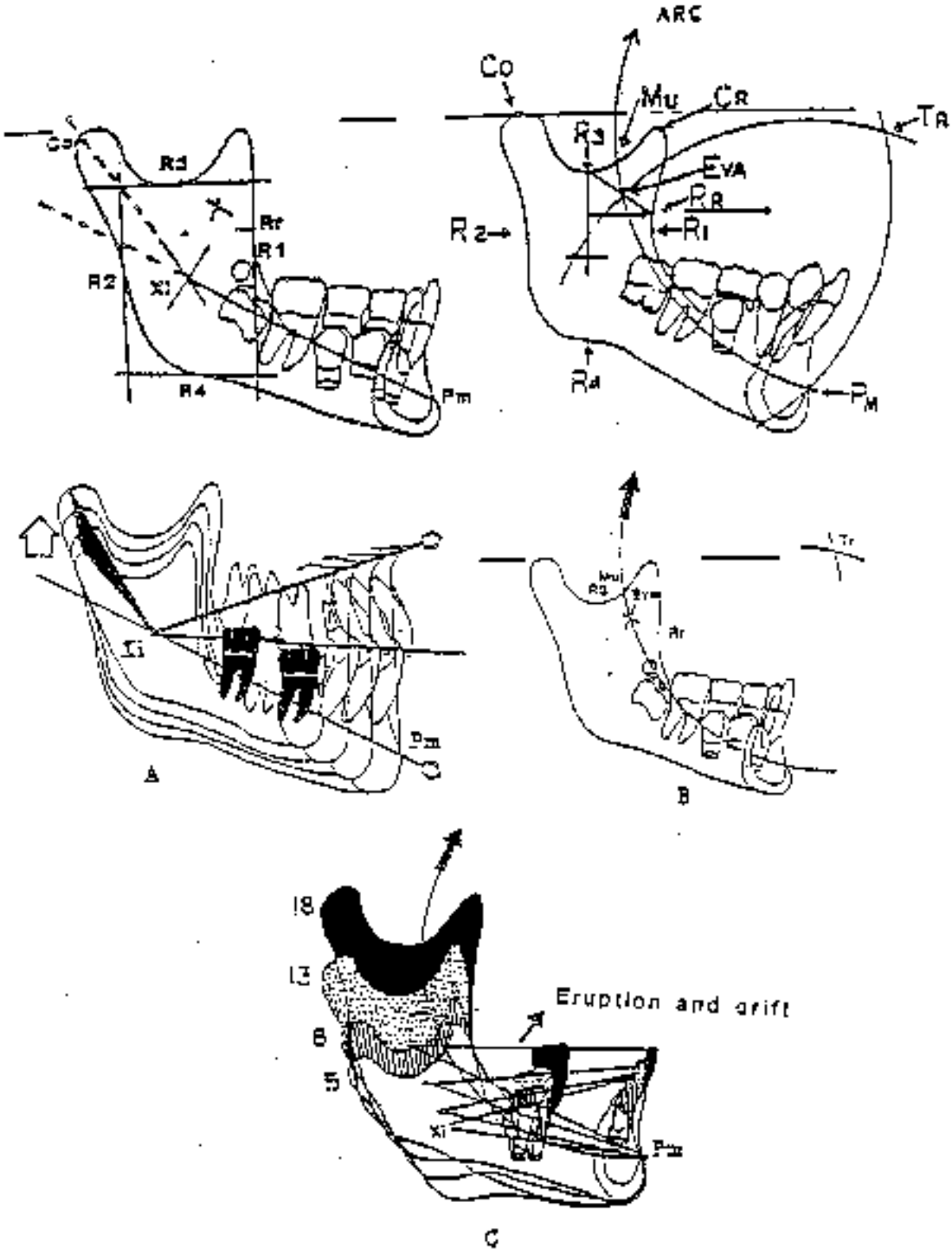
Extension and Modification Technique

The forecasting techniques started with cranial base extension and a plane down the long axis of the condyle to connect with the mandibular plane. Modifications were made for biologic factors, and treatment effects on the mandible were calculated into the design. In fact, the effects of treatment far overshadowed the growth magnitudes.

The original technique was modified to the basicranial axis and the condyle corpus axis matrix. The maxilla was forecast to fill in the space between cranial base and mandible.

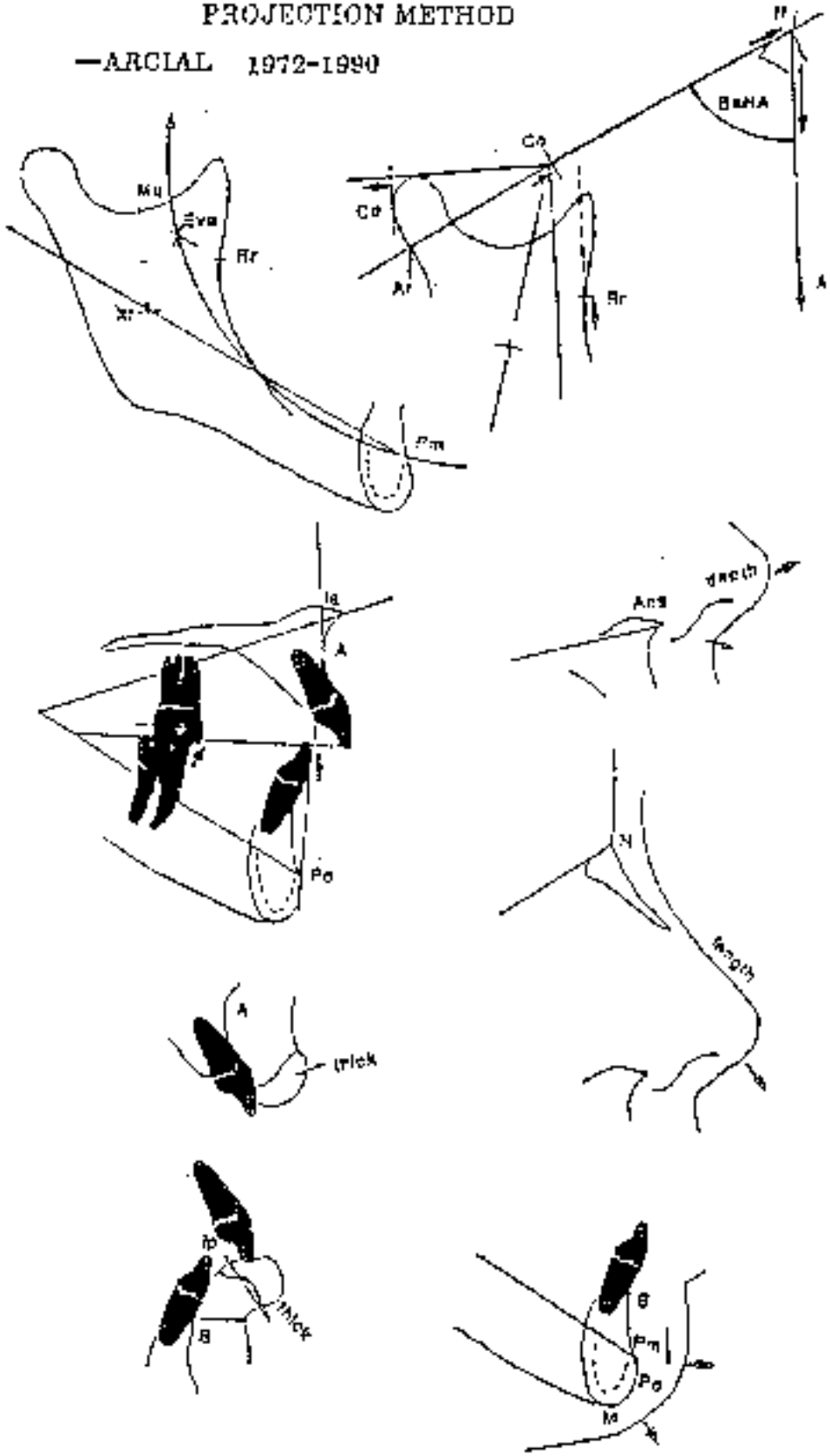
Mandibular Arc

A true breakthrough for long range occurred with the discovery of a growth arc for the mandible (not to be confused with Sassouni's profile arc). The subsequent discovery of modifications for sex and type led to further refinement and accuracy, often approaching perfection of fit of the forecast to the actual. The mandible can be forecast independently of the cranial base.

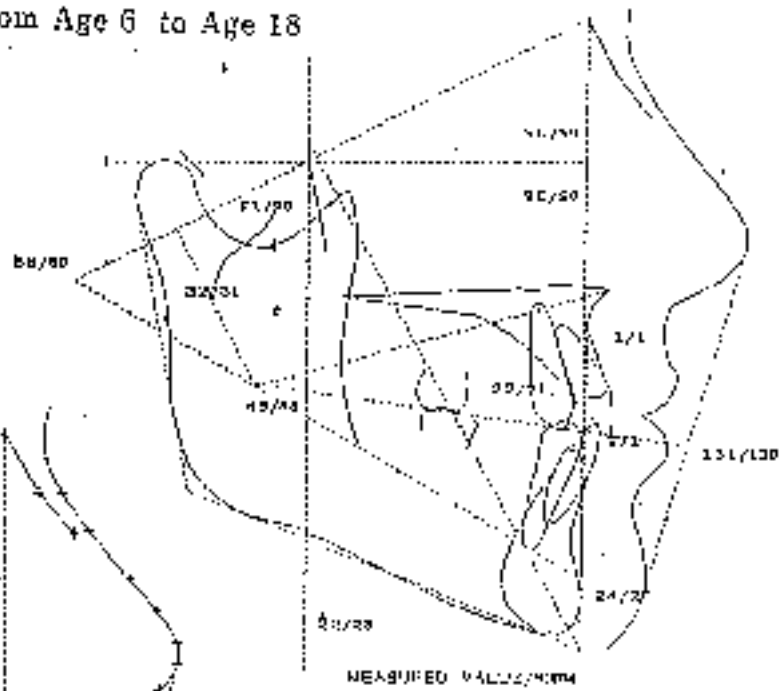

ARC
Co
Mu
CR
TR
R3
EVA
RR
R1
R2
R4
PM
A
B
C
18
13
8
5
Eruption and drift

PROJECTION METHOD

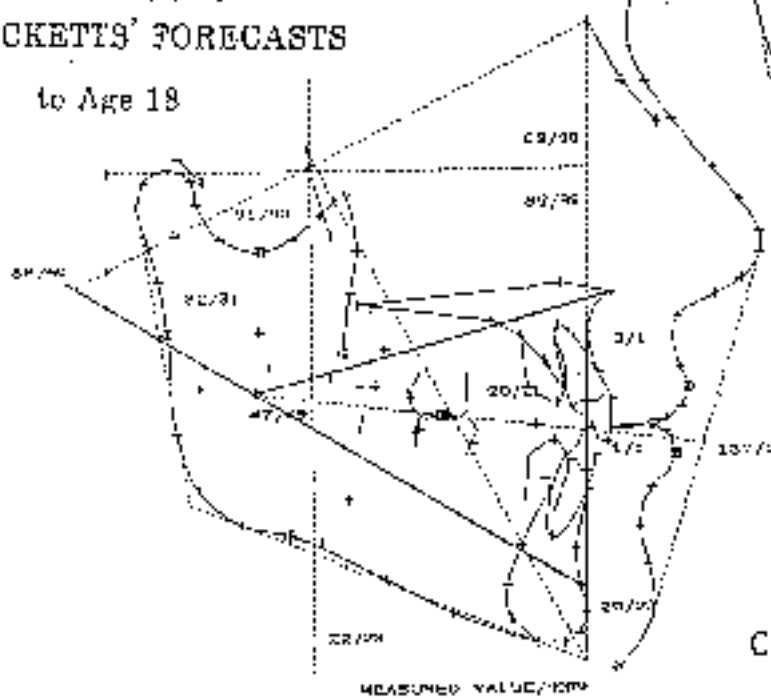
—ARCLAL 1972-1990



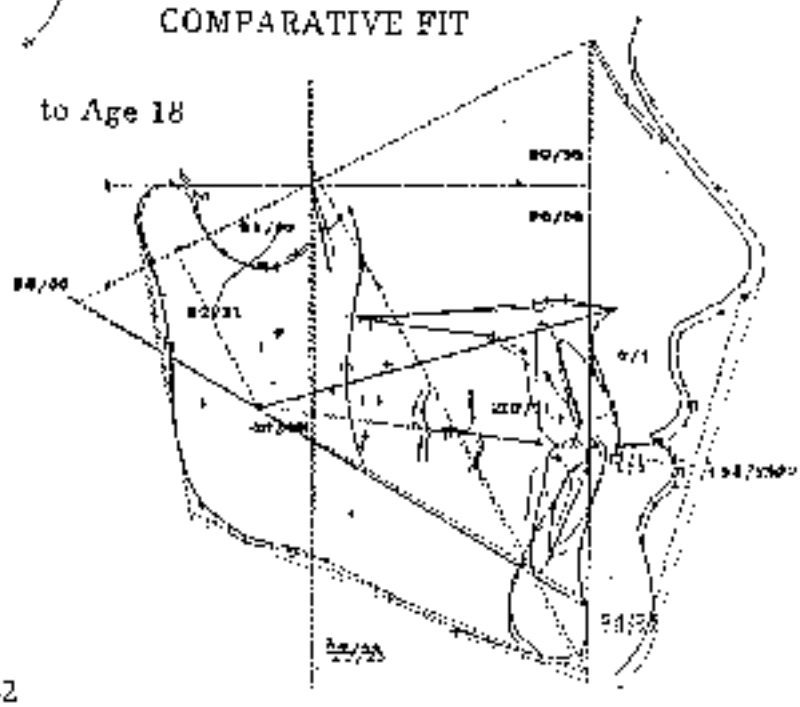
NORMAL ACTUAL
From Age 6 to Age 18



NORMAL N28
RICKETTS' FORECASTS
to Age 18



COMPARATIVE FIT
to Age 18



The Cranial Base

The mandible expresses itself from a cranial support. The condyle, however, resides in the temporal bone. Muscles are attached to cranial bones. Therefore, two procedures can be employed, but both require a basic cranial prediction. Our posterior base is the dimension from posterior condylion (Cp) to PTV. The anterior is taken to be Cc to Nasion. The basi-cranial forecast can be independent of all else in the skull and face.

Maxilla

Probably the phenomenon that led Brodie to the "constancy" idea was the gnomic behavior of the palate to cranial landmarks (SN). Grossly, the mid-face is independent in behavior of mandibular effects. Much greater variation is seen in the lower face than in the upper face. After the maxilla has been loosened at its sutures with treatment the mandibular growth may sway its behavior to some degree.

Teeth

Mandibular teeth are predicted from the corpus axis at Pm. Maxillary teeth are forecast from the Palatal Plane at ANS. Both areas are connected at the occlusal plane and reciprocal factors play a role.

Soft Tissue

After the skeletal matrix and teeth are predicted, only then can a profile prediction be constructed. Nasion, anterior nasal spine, incisors and sites in the bony chin serve as references for growth additions. Changes with (in?) function with correction of malocclusions make it more complicated to predict with exactitude.

* * * * *

Function #10. Grants a Medium for Planning All Treatments.

The Actual Purpose and Function of Visualized Objectives and Goals

Constructing a visualized rendering is not just a meaningless artistic exercise. It has an extremely valuable use to help with staging the mechanical treatment. This is a point often overlooked by clinicians. With the VTO or VTG, maxillo-mandibular relationship has been corrected, and a new APo exists.

Sequence

Planning starts with needed changes in the **lower incisor.** If the objective is accepted, then how does the incisor need to be changed? Is it forward, downward, backward, or upward? How does its movement affect arch length and arch depth? If expansion is contemplated, how will transverse premolar changes affect arch length and depth?

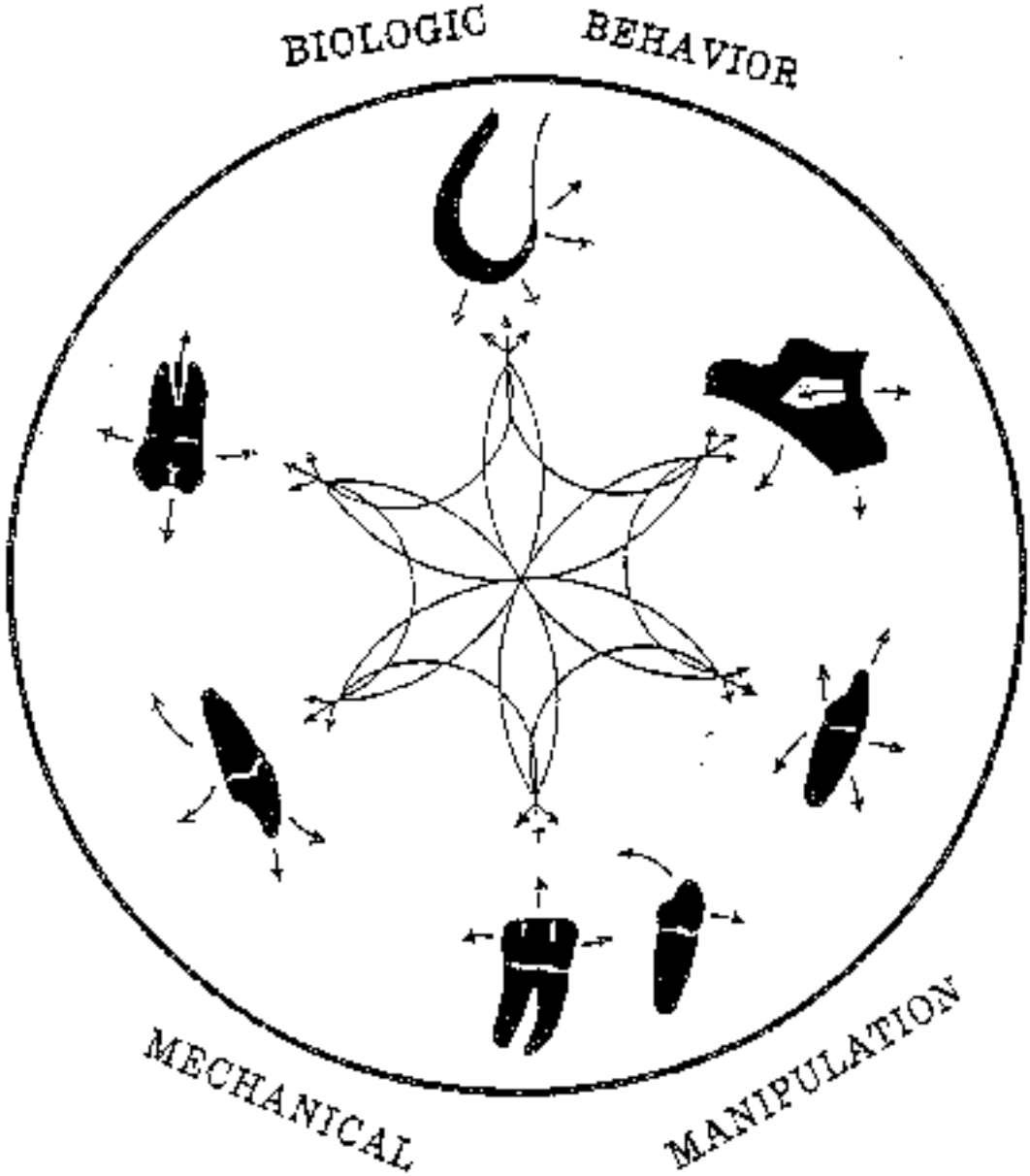
After calculation of effects on arch length, the **lower molar** is positioned. Is extraction necessary and cogent?

The **upper incisor** is then calculated for movement needed. How much movement is required, and how much anchorage is needed? Must the lower be modified to compromise the objective?

Lastly, the **upper molar** is visualized from its base when put into a normal locked Class I position. How much anchorage is needed? Now, as a feedback, must other compromises be made?

The Cybernetic Circle

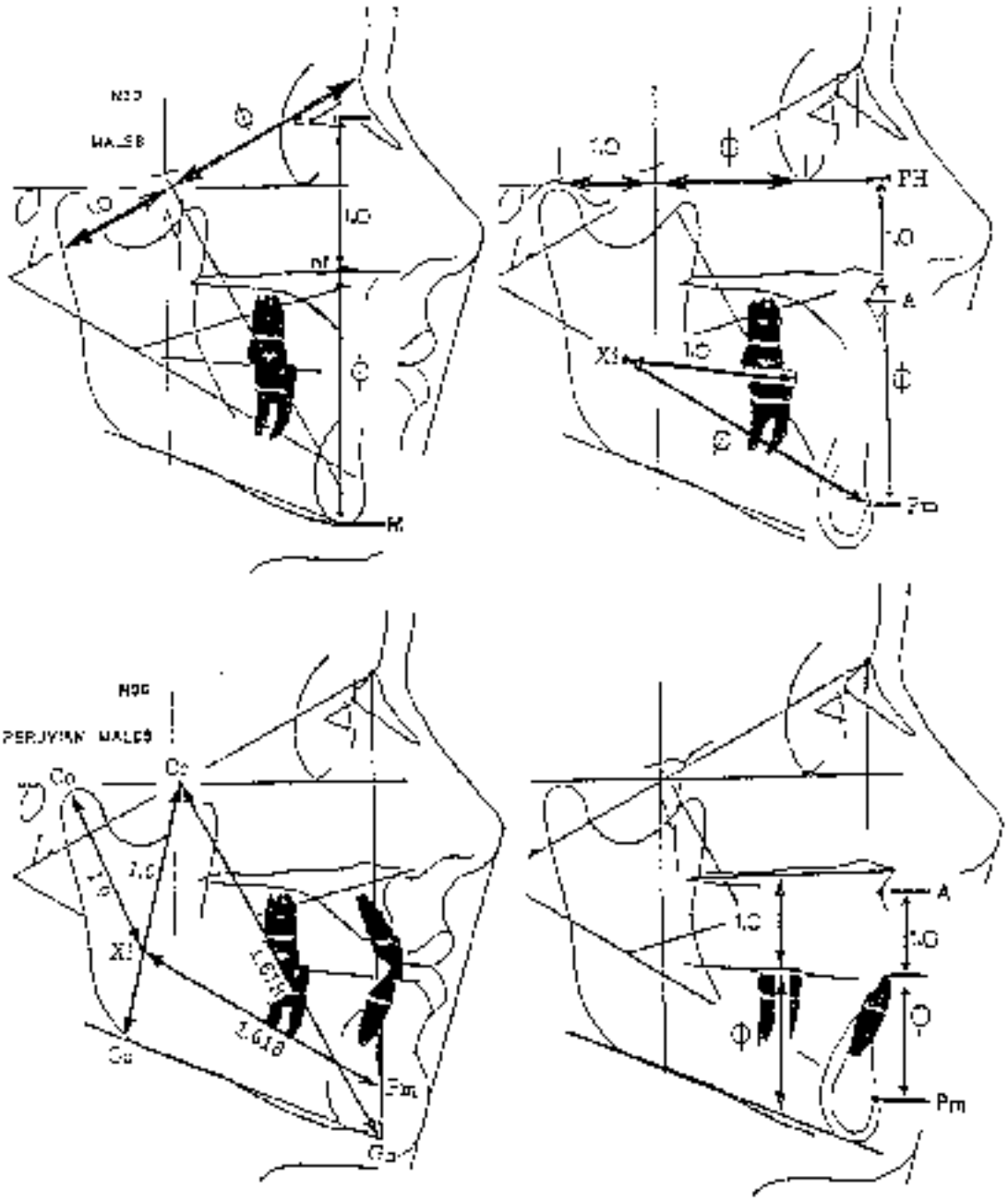
In order to visualize this sequence with a picture, Ricketts developed the cybernetic circle as an abstraction and reduction of the treatment planning sequence. The order was the skeletal matrix, lower arch and upper arch, to be followed by soft tissue considerations.



The Surgical Objective (STO) and the Divine Proportion

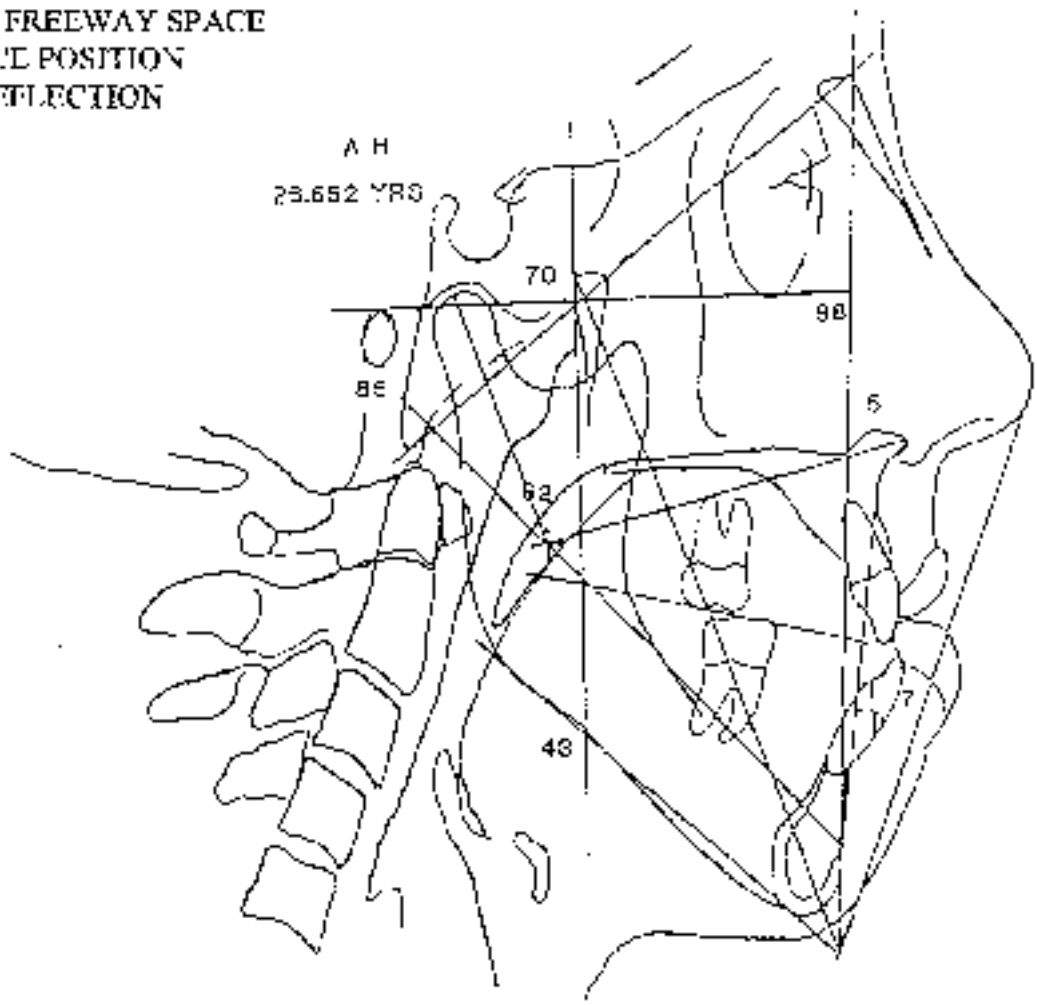
Extensive skeletal alteration can be made with surgery. The sequence for planning is the same as with orthopedics, but now is usually in adults where growth and orthopedics are changed to skeletal cuts.

The Divine Proportion (or golden cut) Analysis is a separate subject. However, the golden relation between Frankfort Plane, Point A, and Pm is highly valuable. The height of the lower incisor to A and Pm is of paramount value for denture emplacement.

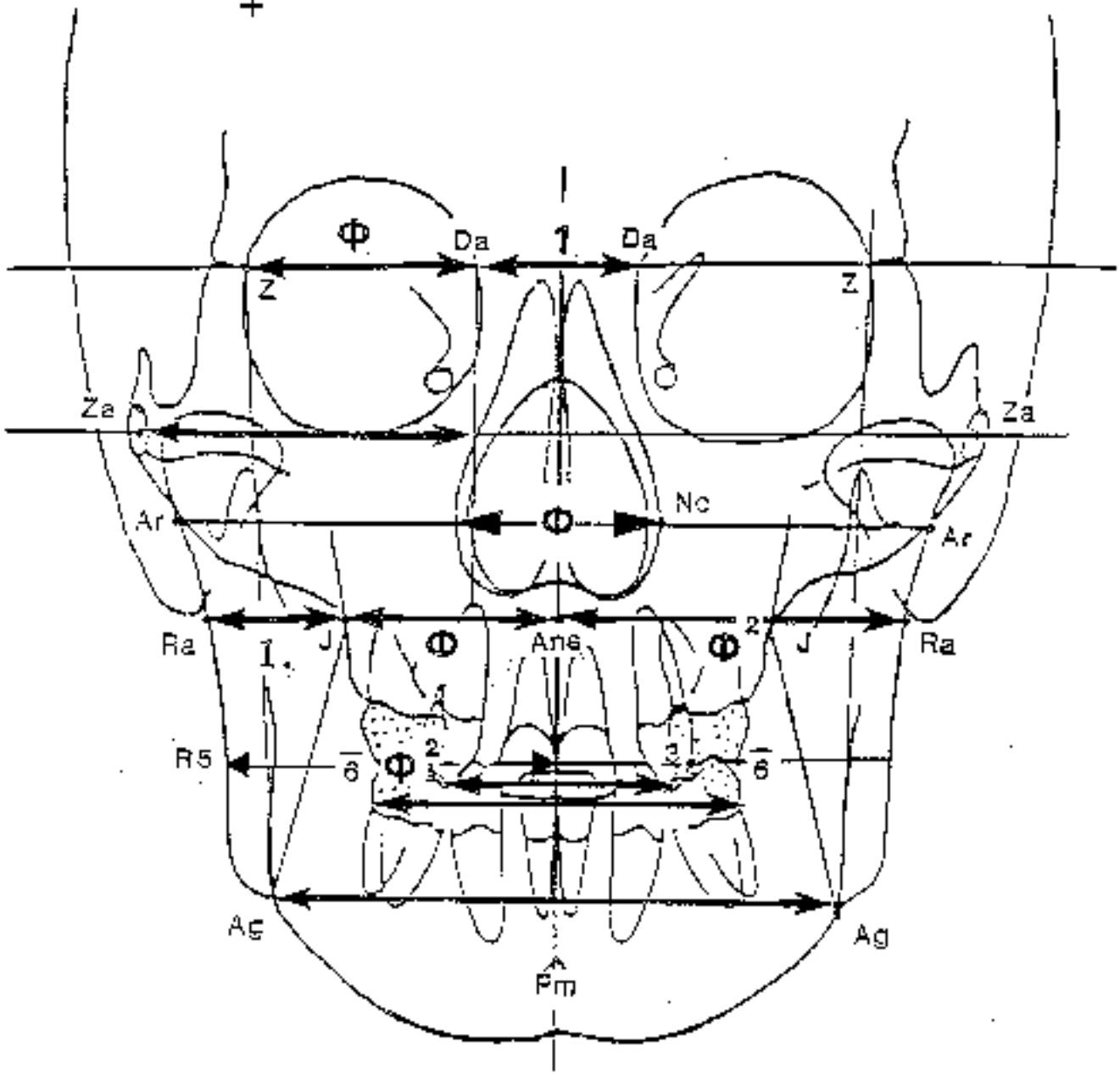


SEVENTEEN CLASS III CHARACTERISTICS
(NOT ALWAYS IN EVERY PATIENT)

1. SYMPHYSIS FORM (LONG)
2. OBTUSE MANDIBLE
3. WEAK GONIAL ANGLE
4. CORPUS LENGTH
5. CONDYLE LENGTH
6. CONDYLE FORM (NARROW SAGITTALLY)
7. XI POSITION FORWARD
8. JOINT UPWARD AND FORWARD FROM BASION
9. SPACE IN JOINT DIMINISHED SUPERIORLY
10. EMINENCE FLAT
11. ANTERIOR CRANIAL BASE SHORT (CC-N)
12. POSTERIOR CRANIAL BASE SHORT (PTV-P)
13. SHORT MAXILLA (BaNA)
14. NEGATIVE PALATAL PLANE
15. VERY WIDE FREEWAY SPACE
16. LOW TONGUE POSITION
17. CRANIAL DEFLECTION



♀♂ ADULT COMPOSITE N82



Function #11. Equips the User for Practice Management

When an artistic visualized image of the present conditions is available in the form of an analysis, and when the image of the objectives is shown, it goes a long way in creating confidence in the eyes of the patient or parent. In addition, when the necessary movements are explained and materialized on paper, the patient derives a better impression of the nature of the needed correction and its acceptance.

Further, during treatment as the patient is monitored and the patient is shown the results to be essentially as planned, a higher and higher level of confidence is reached by both doctor and patient.

Cephalometrics in this practical way contributes to a "flow". It is a tool for making the sale. It is also a vehicle for teaching the patient the results of treatment.

Employed correctly, progressive cephalometrics can be a tremendous tool for internal practice marketing and providing something tangible for selling.

Function #12. Manifests a Principal Tool for Education

Communication

Education is tantamount to communication. An analysis communicates the exact nature of the condition to the clinician (diagnosis). Cephalometrics provides an access to the literature and to other colleagues for second opinions.

Constitutes a Language

Language is a tool of communication. Classification aids in the breaking down of complexity. When the user knows the language, appreciates the nature of possibilities and effects of treatment, knowledge is immediately available.

The Essential Tool of Clinical Research

Observation of patients in the chair and comparison of before-and-after models or photographs only yield suggestions. If direct information is desired the only tool for scientific study is the tool of cephalometrics. Thus, the most sophisticated method should be used for the best knowledge to be applied.

IV SUMMARY AND CONCLUSION

The proper application of cephalometrics is three-dimensional and progresses through stages for clinical use. Seven major processes and twelve branches of applications are described.

These processes are divided into four main areas and grossly pertain to diagnosis, prognosis, treatment planning, and practice management.

With such a "Progressive" program of cephalometrics the orthodontist has a tool to personally find out what he or she is actually doing clinically with employed modalities. Further, objectives can be established and targets can be set.

The step-by-step application permits efficiency and competency, and provides a competitive edge.

Progressive Cephalometrics is the tool for sophistication for orthodontists in the new millenium.

Most personal computers or commercially based laboratories adopt the Progressive program because of its biologic base, its completeness, the information gained from its use, and its solid track record.

The Progressive program must, however, be learned and understood in order that the clinician can apply its full benefits. Competency in the method requires a routine application and practice. The clinical benefits far outweigh the effort entailed in learning.

In connection with the clinical field, we can paraphrase Dr. Ronald Roth, who states the case for cephalometrics succinctly.

> The Straight Wire appliance (or any other appliance) will not diagnose the case, will not develop a treatment plan (VTO), nor design the mechanics necessary to correct the malocclusion. **This is the responsibility of the orthodontist.** Roth States, "Assuming formulation of a **thorough and accurate diagnosis and treatment plan,** acquiring good patient cooperation and performing appropriate mechanics, consistently reliable results should be produced."

We could not agree more!

PARADIGM 2000 CEPHALOMETRICS

LATERAL

Conventional		Harmonic
Cranial Base:		
Posterior	Cp-PTV	AR-Cc-N Φ
Anterior	Cc-N	
Mandibular:		
Total Face Height (NVcPm)		Co-Xi-Pm Φ
Facial Axis (BaN at PtGn)		Ic-Nfl-M Φ
Facial Plane (FH at NPo)		FH-Xi-Mpl Φ
Maxillary:		
Palatal Plane (FH to Pal.Pl.)		Cp-PTV Φ PTV-A
Convexity (A to Fac.Pl.)		
Lower Face Ht. (Ans-Xi-Pm)		FH-A-Pm Φ
Teeth:		
T.B.Occlusal Pl. cant (to Xi)		Pal.pl.-Occl.pl.-Mpl. Φ
Lower incisor $\frac{\_\_}{6\text{-}1}$	(⌜1 to APo)	
Arch depth	$\frac{6}{}$	A- ⌞1-Pm Φ
A Molar Position (PTV to		
Interincisal angle	$\frac{1}{1}$	
Soft Tissue:		
Lower lip to E Line		sn-Xi-st Φ st-Xi-ppo
		ai-st-gn Φ
		n-prn-gn Φ
		u-ppo-li Φ prn-ppo-li
		N-prn-a Φ a-N-gn

PARADIGM 2000 CEPHALOMETRICS

FRONTAL

Conventional		Harmonic
Cranial:		
Transverse Parallelism		
Z - Z		**Z - DA - Z**
Za - ZA		
Mandibular:		
Width	**Ag-Ag**	
Midline	**Pm to CSpl**	
Maxillary:		
Nasal width	**Nc-Nc**	**Nc-Nc Φ 0.5 Ag-Ag**
Width	**J to ZAg**	**J-J Φ Ra-Ra**
Width	**J-J**	**J-J = 80% Ag-Ag**
Teeth:		
Occlusal Plane Parallelism		
3 - ⌜3		**3 - 3 Φ 6 - 6**
4 - ⌜4		
6 - ⌜6		**6 - 6 Φ R5 - R5**
B6 to JAg		
6		
6		
1 1 midline		
Soft Tissue:	**PHOTOGRAPH**	
		lc-st = al-m
		tri-al = lc-m
		ch-ln = Φ Δ
		ls-st-li Φ

GLOSSARY

POINTS OF REFERENCE

The anatomy is traced, and points are employed first for the selection of planes for reference and evaluation and, second, for identification of locations from which direct measurements can be made for determination of relationships.

A glossary of the pertinent references is appropriate:

Ba	(Basion) - an occipital center at the skull base
N	(Nasion) - at the suture separating facial bones
P	(Porion) - a center of the temporal bone near the joint.
O	(Orbitale) - lower border of the organ of sight
Pt	a neural landmark for the maxillary nerve
Pr	(Pterygoid Reference) - deepest anterior point at Pterygoids
Co	(Condylion) - point where condylar axis cuts condyle
Cp	(Condylion Posterior) - posteriormost point on condyle
Cs	(Condylion Superior) - superiormost point on condyle
Xi	a neurotrophic site for the mandibular bundle
R1-R4	(Ramus width and height) - points to find Xi
Rr	(Ramus reference) -
Gn	(Gnathion) - the central point of the symphysis
M	(Menton) - lower border of the chin
Po	(Pogonion) - anteriormost border of the chin
Prn	(Protuberance menti) - point at start of reversal line
Sg	(Subgonion) - reference at lower border of ramus
ANS	(Anterior Nasal Spine) - a maxillary rest for the septum
PNS	(Posterior Nasal Spine) - origin for the soft palate
Point A	(Maxillary Basal Reference) - at base of nasal spine
Ve	(Vertigon) - constructed point at Basi-Cranial and Corpus Axes.
Tr	(True radius) - constructed point equidistant from Prn and Eva.
Cc	(Cranial center) - constructed point at Facial Axis crossing BaN

PLANES OF REFERENCE

<u>Cranial</u>

Basion-Nasion -- Basi-Cranial Axis

Porion-Orbitale -- Frankfort Plane

Pterygoid Vertical -- Coordinate to Frankfort from Pr

Facial

Pterygoid Point-Gnathion -- Facial Axis
Nasion-Pogonion -- Facial Plane
Nasion-Point A -- Nasal Plane
Point A-Pogonion -- Denture Plane (Reciprocal Plane)
ANS-PNS -- Palatal Plane
Subgonion-Menton -- Mandibular Plane
Protuberance Menti-Xi -- Corpus Axis
Condylion-Xi -- Condyle Axis
ANS-Xi -- Org line (Oral Cavonon)

Dental

Bocc	Buccal Occlusal Plane
Docc	Divine Occlusal Plane

Soft Tissue Planes

prn-ppo -- Esthetic Line (e-a)

Soft Tissue Points

n	nasion
prn	pronasali (e) end of nose
sn	subnasali
ls	superior lip
st	stomion (lip embrasure)
li	inferior lip
sm(b)	supramentali
ppo	propogonion (d) -- chin dimple
gn	gnathion
m	menton
lc	lateral canthus
al	alar rim

ANGLES AND LINEAR MEASUREMENTS

Total Facial Height -- **N-Ve-Am**
Posterior Cranial Base -- **PTV-Cp**
Facial Axis -- **From Ba on BaN**
Anterior Cranial Base -- **Cc to N**
Facial Angle -- **Facial Plane from FH**
Palatal Plane -- **Pal.Pl. from FH**
Convexity (Concavity) -- **A to Facial Plan**

APPENDIX

On Diagnosis and the Reasons for the Cephalometric Parameters Chosen

Diagnosis

In the whole medical-dental field, diagnosis in orthodontics is unique. Diagnosis in dentistry consists of the distinguishing of signs and symptoms or tests for a disease. Treatment is often a prosthetic replacement or surgical procedure.

Diagnosis in medicine is also directed at identification of a disease or infirmity, but the etiology often concerns systemic factors. Orthopedic medicine is involved with body deformations, injuries, burns, posture and the efficient function of joints and limbs.

In orthodontics the diagnosis and treatment entail decisions regarding morphologic relationships. The diagnosis starts with the relationship of the teeth and goes in two directions: outward to the lips and cheeks, but inward into the jaws, the cranium, the whole head and neck and perhaps even body posture. Because esthetics and psychologic factors are involved with speech and numerous sociobiologic functions, diagnosis becomes further complicated.

Diagnosis requires knowledge [*dia* = through, *gnosis* = knowledge].

The first aim in orthodontic diagnosis is to describe the conditions present so as to **distinguish** the nature of the skeletal, dental and soft tissue in a factual manner. For completeness and detail cephalometrics is employed.

The second purpose in diagnosis is **interpretation** of the conditions described. This entails the determination of the components of a malocclusion as compared to a standard or a known frame of reference -- hence the "norm" concept.

The third aspect of orthodontic diagnosis is the decision reached regarding the **future outcome** which is actually **prognosis**. Prediction of both short-term and long-term to maturity are to be considered, whether it be intuitive or deliberately performed on paper. The "pattern" becomes a basis for the indications of things most likely to come.

From 362 measurements studied about 60 were chosen as a comprehensive

computer program to satisfy the broad interest in the profession. The underlying goal of the resulting parameter was to enable the clinician to determine the components of the individual problem in the diagnosis and prognosis.

In order to reduce the parameters to a practical routine, 27 measurements were taken: 15 in the lateral and 12 in the frontal, with three taken bilaterally. The selected values were tested over a period of 30 years. They were candidly selected as free of bias as possible, and each has a purpose or a reason for its being.

Rather than entering into debate, the function and purpose of each of the 27 parameters are now elucidated.

THE LATERAL SUMMARY ANALYSIS

For the skeletal pattern Downs had five (5) parameters. All were changed in some manner. Subsequently, nine (9) are now deemed to be imperative for determining the skeletal components to a malocclusion.

SKELETAL

Purpose	*Parameter*

1. Total facial height . . . . . Corpus Axis PmXi to BaN

   Reason: The long or short face is of primary interest because faces tend in growth to vary around the original pattern. However, excessive face height is not necessarily connected with open bite nor short faces with deep bite. More critical is lower face height because that is the immediate dental environment. One simple angle describes total facial height. The mean angle is 60°±3.0°. This one angle provides a quick and easy way to depict brachyfacial patterns (50° range) or dolichofacial patterns (70° range).

2. Lower facial height . . . . . Corpus Axis to Org line

   Reason: One simple angle describes vertical maxillo-mandibular relations. The mean is 46°±3.0°. The proportion between the two is around 76% (or three-fourths). Theoretically longer facial heights have higher lower face values to be in harmony. But if, for instance, the total face is 60° and the denture height is 52° the ratio is 86% which means excessive lower face only. The relation serves as an index: lower face X 100 ÷ total face = height index. This diagnosis is important to the gummy

smile patient.

3. **Central facial direction** . . . . . **Facial Axis to BaN**

Reason: The Facial Axis is the best central axis of the face in terms of protrusion or retrusion of the chin. The mean in the Caucasian population is 90°±3.0°. Measured from Basion a reading of 93° indicates one clinical deviation forward. The most common axis in Class II is 89°. Values above 90° favor Class I development. Class III more typically is 95° and above. The Facial Axis assists in description of facial type.

In addition, the Facial Axis tends remarkably to be the growth axis. It tends on average to move forward one degree each seven years. The standard variation in direction was found to be only 2° in 10 years.

4. **Facial depth** . . . . . **Facial Plane to Frankfort**

Reason: This was from Downs and is the best describer for prognathism of the chin. But true Porion is used instead of the ear rod. The angle changes with growth 1° each three years and ultimately reaches 90°±3.0° in the normal mature male. In adult females it stops at about 88° on average. In three-year-olds the angle is normally 84°±3.0°.

5. **Convexity** . . . . . **Point A to Facial Plane**

Reason: Point A is used as a maxillary basal reference. Its position relative to a straight line (NPo -- the facial plane) is a superb simple expression of horizontal maxillo-mandibular relationship. Point B is alveolar bone and not skeletal or basal bone. Because the Facial angle changes with age (chin forward) and Point A tends to move directly with Nasion, the facial convexity normally reduces with growth. In females, by adulthood 2 mm. of convexity is ideal, whereas males, particularly white males, tend to grow to a straight profile or 0.0 mm. Normal children at age 3 years may have convexity of 5.0 mm.

Convexity is a debated issue in orthodontics. Theoretically the straighter the face the more upright the APo plane and the more upright the lower incisor. The choice is to treat the teeth to the convexity or correct the convexity and treat to the new maxillo-mandibular condition.

As a check for interpretation of convexity, the N-Point A line is used as a "nasal plane" and related to the Frankfort Plane. Ideally it is 90°±2°. Point A is forward in typical Class II and the nasal plane is commonly backward in Class III. This means that the maxilla is an

essential component in the classic malocclusions.

6. **Ramus height** . . . . . **Mandibular Plane to Frankfort**

Reason: The mandibular plane is often taken as a measure to describe chin position, but its real function is to indicate **vertical height or position of the ramus.** It helps to define facial patterns. The angle is easily measured off a right angle to the Pterygoid Vertical Plane. A mean 27° angle is present at age 3 and reduces about 0.6° each year with the areial expression of growth of the mandible to about 22° by adulthood.

The main value of the high mandibular plane is that it may herald a sick condyle. The variation of the angle at ±5° is higher than would be desired for a definitive parameter.

Long faces can be long, tapered with high angles, or oblong with square mandibular types or low angles.

7. **Palatal Plane Position** . . . . . **Palatal Plane to Frankfort**

Reason: The palatal plane loomed in importance when it was discovered that the **floor of the nose can be changed in growing children.** By changing the anterior nasal spine the nose is changed because the spine is a platform for the cartilagenous septem. The line from Ans to Pns is measured likewise from a perpendicular to the Pterygoid vertical.

The normal palatal angle is about 2°±2° to the Frankfort plane. This angle is used to help determine nasal dysplasia. It is also combined with the oral gnomon in describing maxillary characteristics because the whole palatal plane can be level but still be located superiorly or inferiorly. When the whole palate is superior the gummy smile tends to develop.

8. **Posterior Cranial length** . . . . . **Posterior Condylion to PTV**

Reason: This measurement denotes the condyle and joint **relation** or position to the coordinate complex. It is a mean of 31 mm. at age 3 and grows 0.5 mm. on average per year.

In Class II it is often longer and in Class III it is shorter. It also was suggested to be associated by deep bite during development, growing more distally. Posterior cranial depth is a significant component of malocclusions being short in Class III and long Class II mean composites.

9. **Anterior Cranial length** . . . . . **Cranial center to Nasion**

Reason: The maxilla is suspended off the anterior cranial floor. Cc point is

constructed from Pt point located at foramen rotundum on the base of the great wing of the sphenoid. The length to N is taken to represent the horizontal dimension of the anterior base, but it is oblique on average 27° to the Frankfort horizontal.

When this measurement is long it becomes a component of Class II and when short it contributes to Class III (when the maxilla is normally related to the anterior cranial base). Thus, shortness on both ends is common in Class III and longness is typical of a Class II cranial component.

This measurement is a sensible test for the position of Nasion as a basis for the Facial Plane origin. In some patients the cranial base alone can account for one-half the morphologic skeletal dysplasia.

DENTAL

Downs chose five parameters for the teeth. Four of them were changed for descriptive purposes for the present summary analysis. One measurement was added for soft tissue.

10. **Lower incisor position (horizontally)** . . . . . **Incisor tip to APo**

Reason: The lower incisor is the first key to dental emplacement. The relating of the lower incisor to anteriormost skeletal landmarks in the jaws therefore relates to a reciprocal line. The more forward the A point the more forward is the average lower incisor in normal occlusion. Conversely, the more concave the face the more the lower incisor is retropositioned to be in harmony. Different races on average definitely have different amounts of dental protrusion.

The study of a sample of 15 children, mixed dentition, age 9, with normal occlusion, revealed a mean of +1.0 mm. for the lower incisor edge to the APo plane. The angle was 22°. On comparing this value to adults with the most acceptable relations it was found to be consistent. The standard deviation in Caucasian occlusions was found to be ±2.5 mm. This value has been considered by the author, since 1948, to be the most ideal as an objective in planning treatment.

Currently many clinicians prefer a relationship of +2±2. In black and oriental men, the mean was found to be 5 mm., as shown by Nezu. The lower incisor is a basic starting point for planning the VTO and calculating anchorage for mechanics. This is one reason for anticipating (or forecasting) the chin position and maxillary alteration in

the cybernetics of the VTO construction.

11. **Lower incisor position (vertically) . . . Incisor tip to Buccal Occlusal Plane**
Reason: The true buccal occlusal plane ignores the incisors which are influenced by perverted lip function. The **buccal plane is a functional plane** and for description the lower incisor edge is essentially on that line.

In construction of a VTO the buccal plane can be used but for greater sophistication in planning, the divine proportion from A to Pm is marvelous. Point A to lower incisor edge to Pm is a divine proportion. The incisor to Pm is 1.618 the height to Point A. In growing children with short lips, adaptation of the lip to the divine height of the lower incisor has been noted to occur with development.

12. **Upper molar position . . . . . Distal of upper molar to PTV**
Reason: The direct distance from the distal of the upper first molar to PTV **describes molar position.** Observation in the 1950s suggested that the upper first molar ideally erupts at the patient's chronologic age in mm. plus 3 mm. (i.e., age 8 + 3 mm. = 11 mm.). It maintains that relationship until growth stops because the denture moves forward 1.0 mm. per year. A normal position does not mean it cannot or should not be moved distally but it does suggest an ultimate limited space for third molars.

This horizontal measurement of the upper molar was the second most frequently correlated in the 362 measurements of the computer study. In other words, it correlated with form and size of the "pattern".

13. **Depth of lower arch . . . . . Mesial of molar to incisor tip**
Reason: Depth of the arch from incisor tip to the molars is diagnostic and needs to be correlated with the dental model. This measurement **converts the information from the dental cast to the head X-ray.** However, this parameter for arch depth is extremely useful in planning denture emplacements in the VTO.

Due to enlargement in the X-ray the arch depth measurement is larger by about 1 mm. more than the actual. In normal arch form the depth cephalometrically is approximately 23.5 to 24 mm. Size of the teeth and arch form are variables. In extraction cases the depth is reduced to a mean of about 18 mm.

14. **Upper to lower incisor . . . . . Inter-incisal angle**
Reason: The interincisal angle is carried over from Downs. It has little value

except in planning and construction of the VTO. Overbite and overjet objectives are so standard at 2.0 mm. they need not be measured. But, interincisal angles at treatment's end are critical. The mean goal at treatment's end is 126°.

Trimorphic arrangements were found from research. For brachyfacial faces and protrusive types 120° to 123° was found. For long faces and Class III angles of 135° to 137° were appropriate.

15. Lower lip protrusion . . . . . Lower lip to E line

Reason: Esthetics is a major concern in orthodontics. The lower lip is influenced by both the lower and upper incisor. A line, from soft tissue chin to the end of the nose, has served as the best single reference. The lower is ideally about 2 mm. closer to the line. Esthetic harmony is tempered by nose length and facial type. However, just as the lower incisor is a basic reference starting point, the lower lip becomes a starting reference for esthetic evaluation.

THE FRONTAL SUMMARY ANALYSIS

Downs offered no frontal analysis. This was possibly due to lack of information and limited interest in transverse phenomena. However, with the advent of palatal separation, the findings of alteration of maxillary base in three dimensions with certain devices, and with surgical intervention in both jaws, interest in the frontal became profound. More than three of every four orthodontic patients are involved with the transverse dimension. Due to the difficulty of procuring identical films, direct transverse measurement are the most trustworthy. Charts for developmental values need to be consulted if the computer programs are not available.

SKELETAL

Purpose	*Parameter*

1. Nasal cavity width . . . . . Nc to Nc

Reason: Breathing space and nasal symmetry are of immediate concern. Air flow through the nasal cavity is of interest to most clinicians. The piriform aperture, at its lower border, is the base for supporting muscles of the upper lip esthetically. This area becomes a concern for many clinicians.

A direct measurement from the inside margin of the two nasal cavities yields an expression of nasal width which naturally increases

only 0.5 mm. per year.

2. **Maxillary width** . . . . . **Jugale to Jugale**
   Reason: Inter Jugale distance is taken to represent the basal bone and hence **transverse dimensions of the maxilla.** This is compared to known standards and to nasal and mandibular individual transverse dimensions. It increases about 1.0 mm. with natural growth starting at 55 mm. at age 3.

3. **Mandibular width** . . . . . **Antegonion to Antegonion**
   Reason: An expression of **width of the mandible** is desirable at the level of the teeth. The Gonial angle flares in males or is flat in females and is posterior to the occlusion; measurements from the gonial region were unproductive. Osteologic studies showed that the trihedral eminence was present at the curve of the external oblique ridge directly below the molars. This was found to be visible on frontal films and was just anterior to the mandibular notch. It is also taken as a layer of cortical bone when the notch is shallow. The point was labeled Ag (for antegonial tubercle).

   Charts were composed and the mandible was found to grow in width 1.35 mm. per year. However, in oblique directions (downward and outward growth) the nasal cavity, maxilla, and mandible behave on the divine proportion X 1.618.

4. **Maxillo-mandibular width (L)** . . . . . **Jugale to Fronto-Facial Plane**
5. **Maxillo-mandibular width (R)** . . . . . **Jugale to Fronto-Facial Plane**
   Reason: Information is needed for **proportion** and **symmetry** of the maxilla to the individual mandible. Just as horizontal maxillo-mandibular relations are measured from Point A to the Facial Plane (NPo) the J points are related to the line from ZF to AG for transverse harmony. This relation can be thought of as maxillary concavity relative to the mandible.

   The normal maxilla during development seems to maintain about 80% of the width of the mandible. Thus, the width of the maxilla inside the mandible decreases with development at a rate of nearly 2 mm. each 5 years (or 1 mm. per side). The maxilla (J) at age 3 is a mean of 9.0 mm. from Z Ag plane, at age 8 is 10 mm., at 13 years is 11 mm., and at age 18 is 12 mm.

6. **Mandibular symmetry** . . . . . **Protuberance Menti to Mid Plane**
   Reason: The center of the chin can be off the "cranial" midline due to both

morphology or functional causes. The trigonum mentali is visible and Pm is selected at its apex.

From the central sagittal plane (or mid-sagittal plane) a position to the right is plus and to the left is minus.

7. **Maxillary symmetry . . . . . Point Ans to Mid Plane**
   Reason: Maxillas may also be asymmetrical. Ans for the frontal is taken to be at the top of the mid-maxillary suture. It is evaluated from the midline. Plus is right, minus is left.

DENTAL

8. **Molar width . . . . . Trans-buccal of lower molars**
   Reason: Arch width is of interest to determine the wisdom of buccal expansion. The first interest lies in the actual arch width at the first molar's widest contour because that is the most visible on the frontal headplate. The mean of normal occlusions at the lower first molar is 55 mm. With the object film distance in the frontal that means a typical 3% increase in the width cephalometrically, which makes mean molar width essentially 56.5 mm. The clinical deviation is ±2.0 mm.

9. **First premolar width . . . . . Trans-buccal of lower first premolar**
   Reason: Arch form is greatly determined by width at the first premolar area. Forty mm. (40 mm.) is the mean in the population. This is tempered by tooth size, arch type and very slightly by sex, being smaller in females. The clinical deviation is ± 1.4 mm.

10. **Intercanine width . . . . . Trans-canine tips**
    Reason: Lower intercanine width is the most crucial area of "overexpansion". The normal tips of canines is 26.0 mm. essentially. Due to the closeness of the canines to the film the enlargement factor is 2%. This is only 0.5 mm. and is essentially a tracing error dimension. We usually consider it without enlargement, therefore. The clinical deviation is ± 1.0 mm.

11. **Molar position (L) . . . . . Molar buccal to Fronto-Dental Plane**
12. **Molar position (R) . . . . . Molar buccal to Fronto-Dental Plane**
    Reason: The dentine is correlated reciprocally with the skeleton. The buccal of the lower molar is related to a reciprocal line between the jaws which is taken to be JAg.

Because the jaws grow this dimension also changes with age. At age 7 it is approximately 5 mm. and by adulthood in males is about 15 mm. At essentially age 13 it is 10 mm., which makes a good reference clinically.

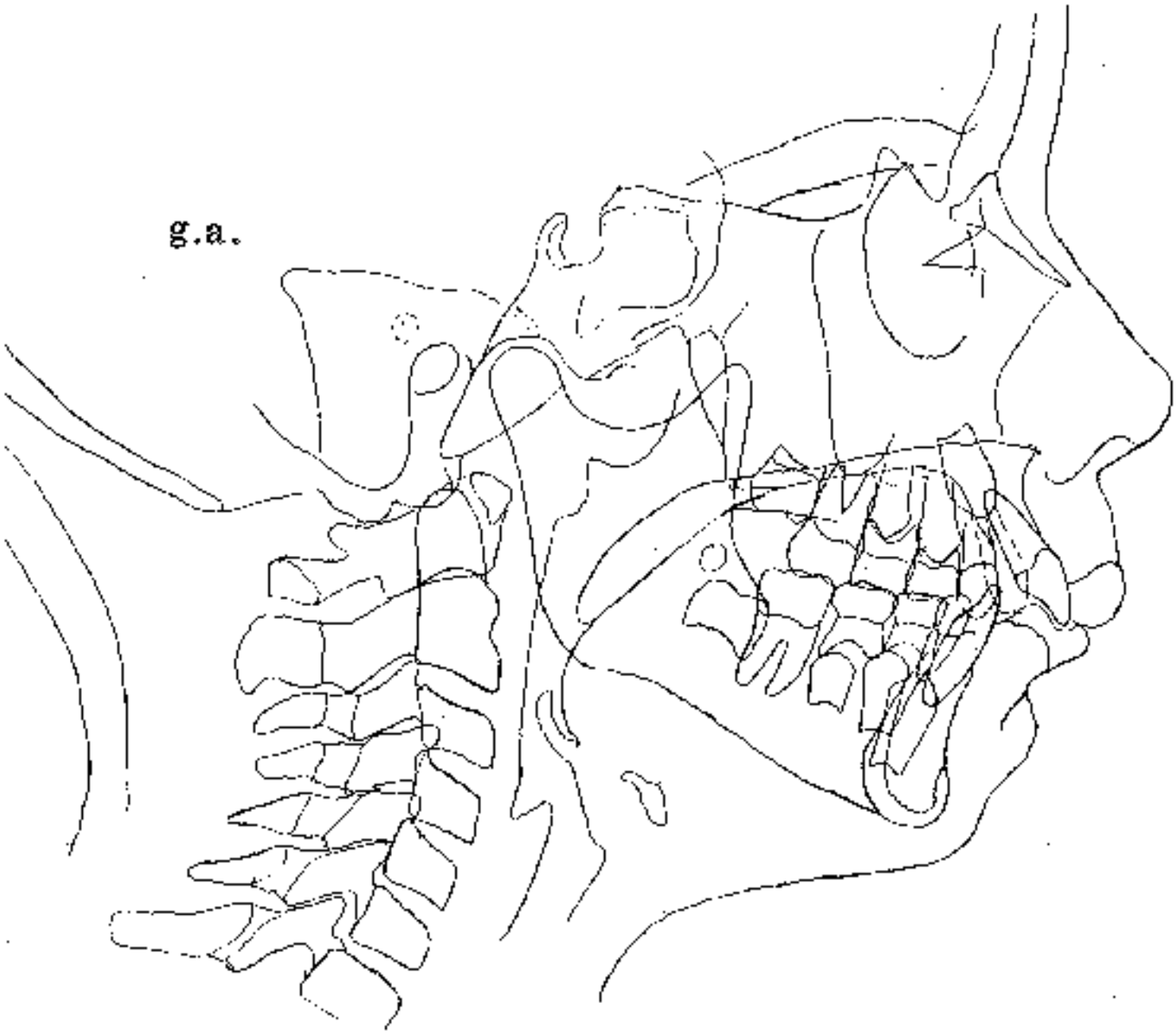
13. **Molar bite (L)** . . . . . **Buccal of A6 to B6**
14. **Molar bite (R)** . . . . . **Buccal of A6 to B6**

Reason: Assessments of maxillo-mandibular dental relations are indicated for description. The widest point on the upper molar is measured perpendicular to the fronto-occlusal plane which bisects the molar occlusion laterally.

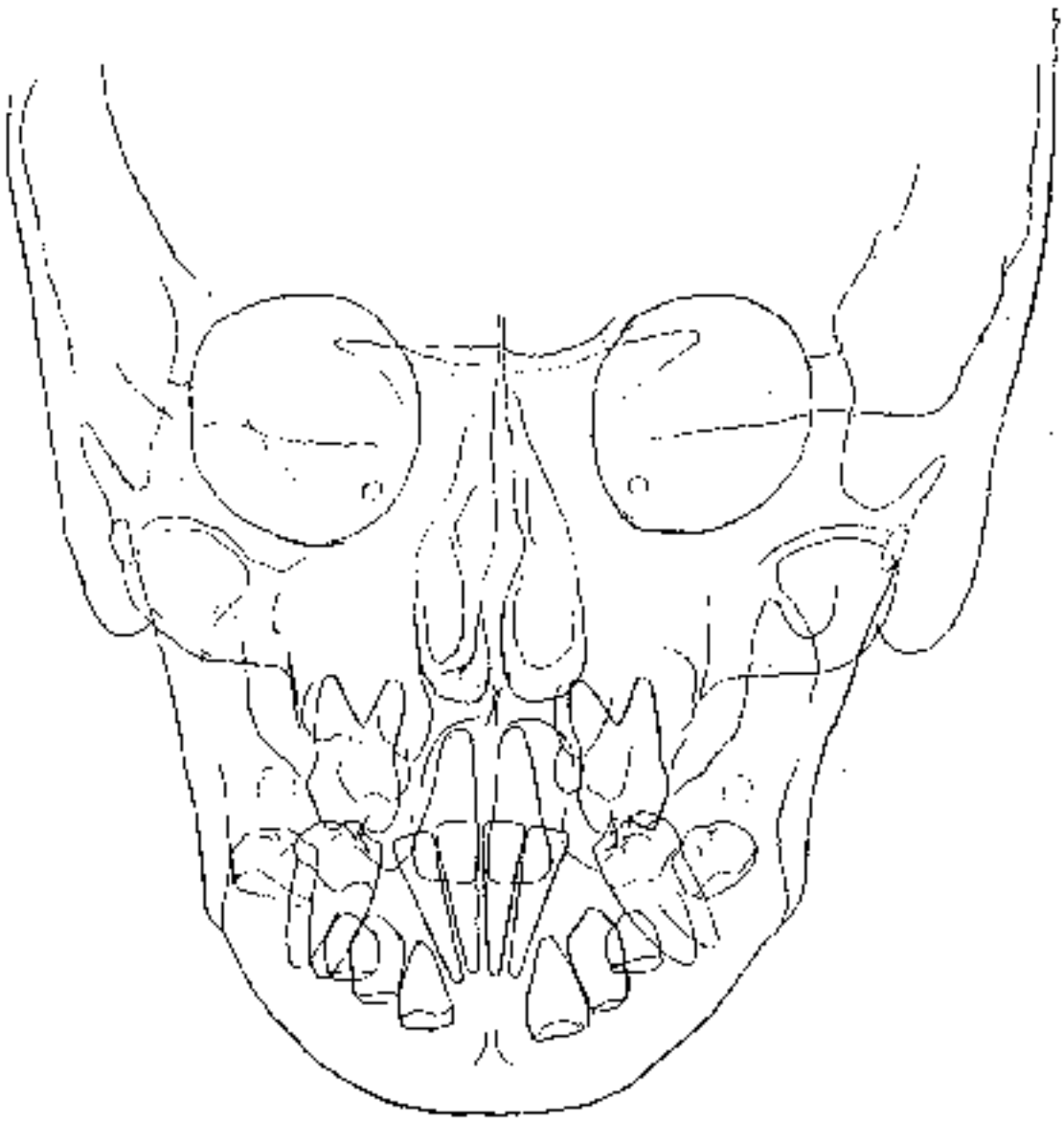
The upper, in ideal occlusions, is 2 mm. wider on each side. Practically all severe Class II cases are actually lingual crossbites in this analysis unless, of course, a buccal crossbite (or Brodie syndrome) is present.

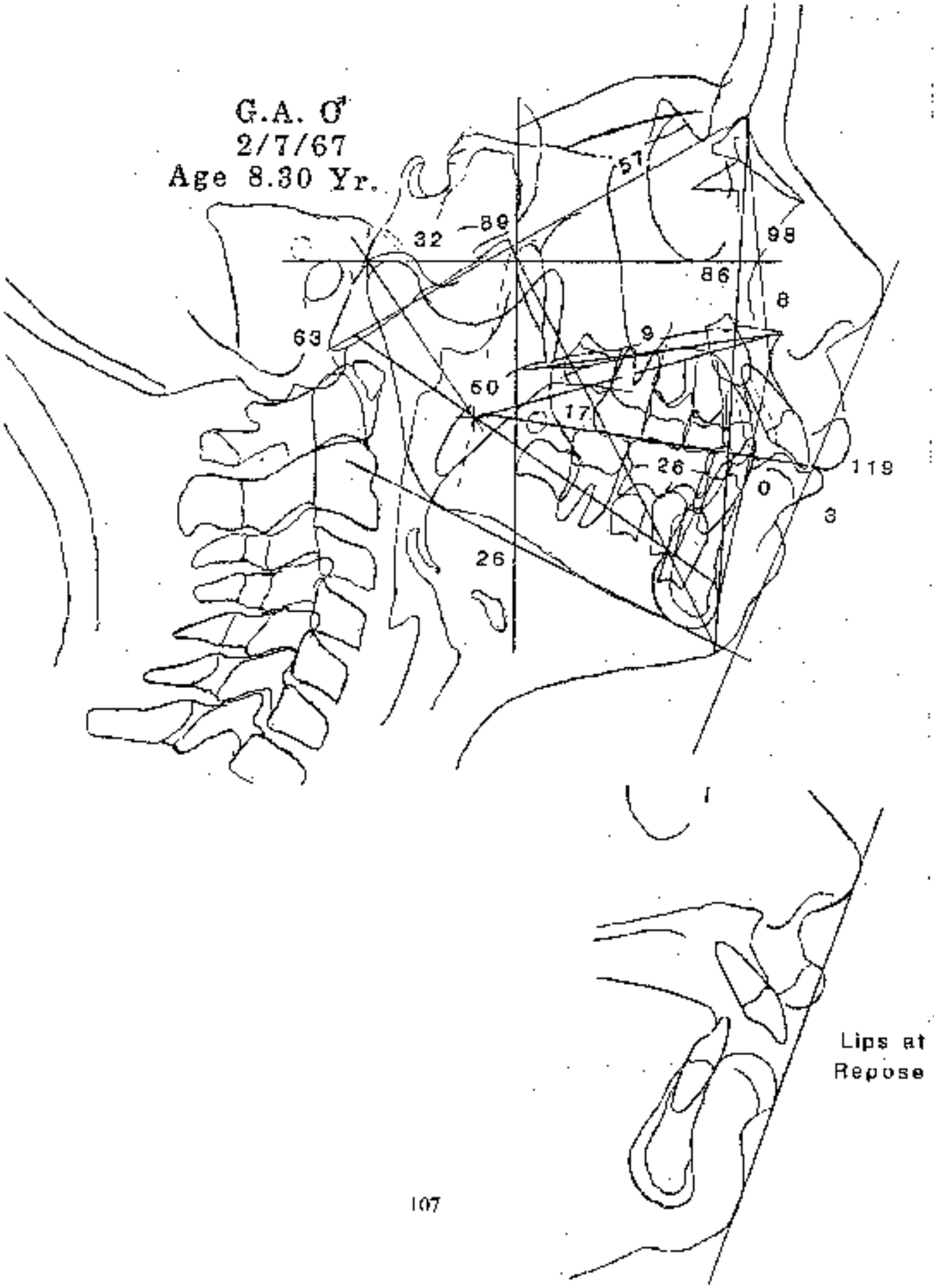
15. Midline of lower . . . . . **Embrasure of lower incisor to Mid Plane**

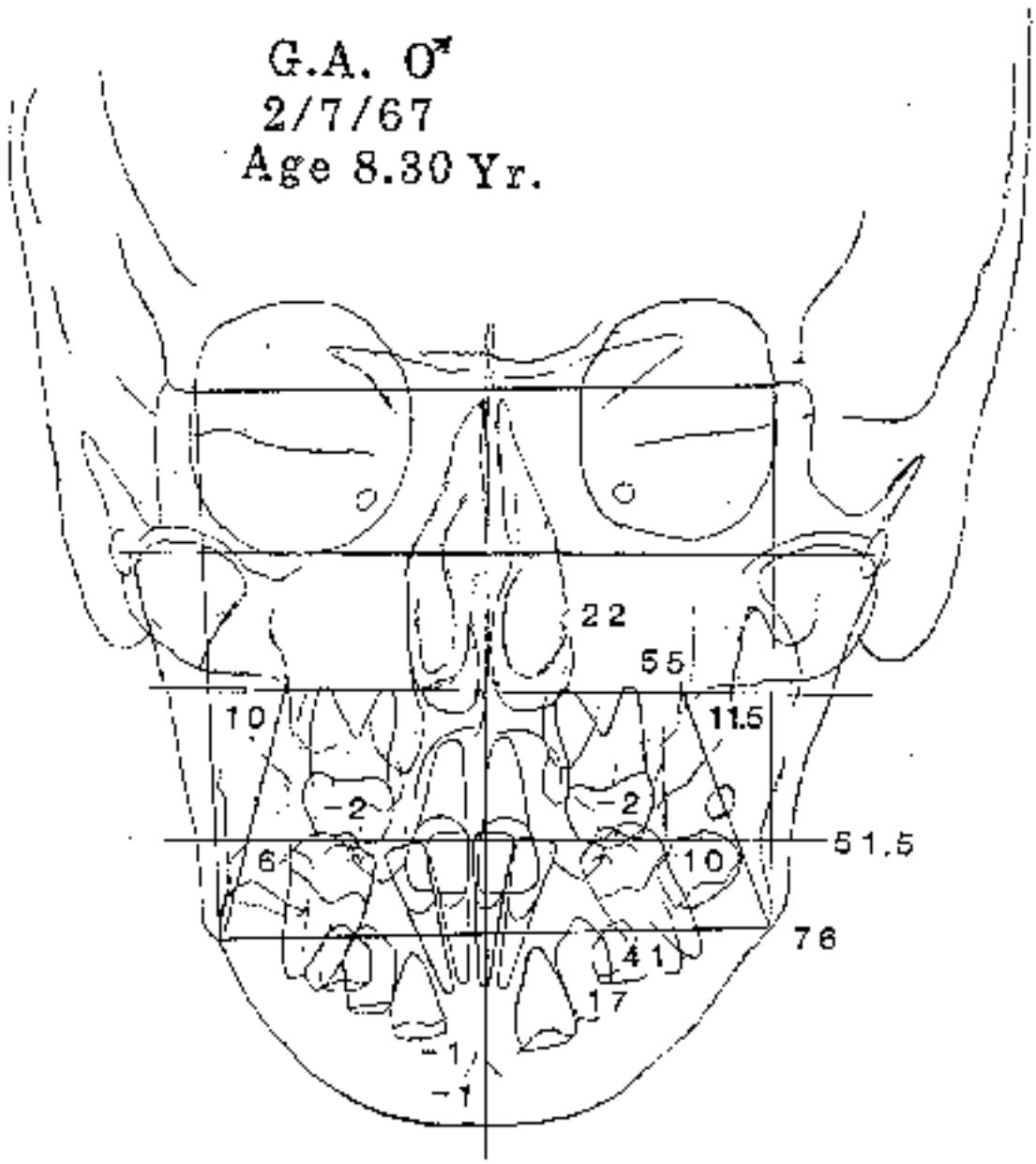
Reason: The denture midline of the lower is a starting point of reference. It can be measured to the central plane or a line from A to Pm. Plus is right, minus is left.

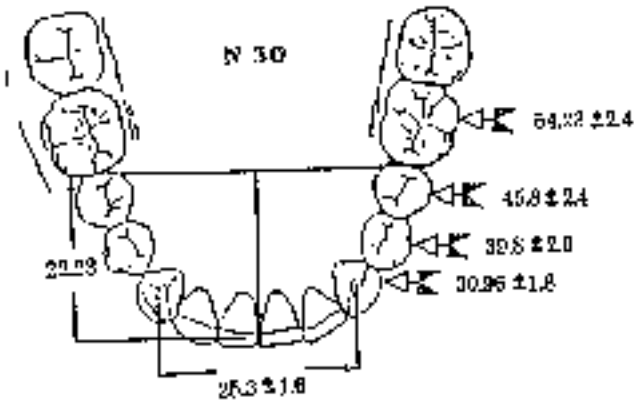

g.a.

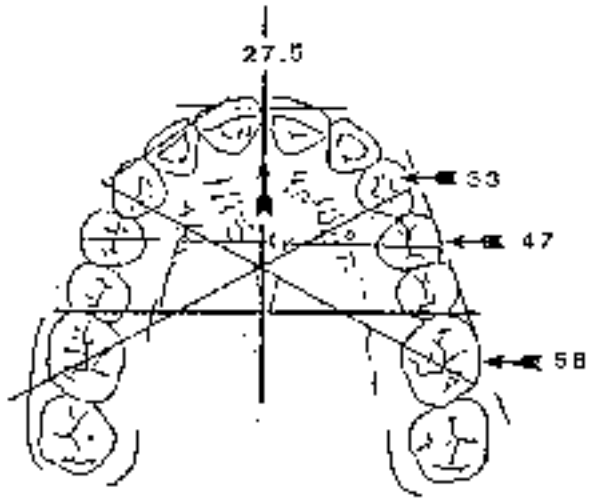
LEFT




G.A. ♂
2/7/67
Age 8.30 Yr.
57
32
89
98
86
8
63
9
50
17
26
119
0
3
26
Lips at
Repose


G.A. ♂
2/7/67
Age 8.30 Yr.
22
55
10
11.5
-2
-2
51.5
6
10
76
41
17
-1
-1
R

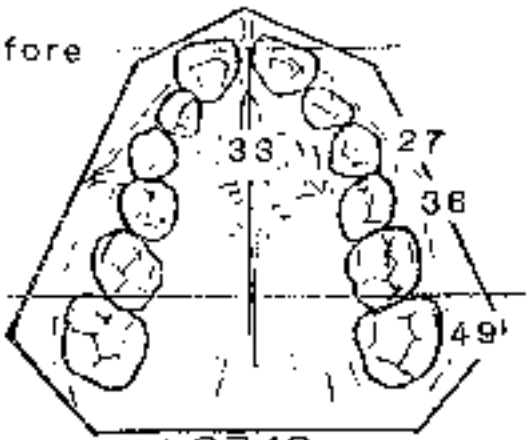




NORMAL DIMENSIONS

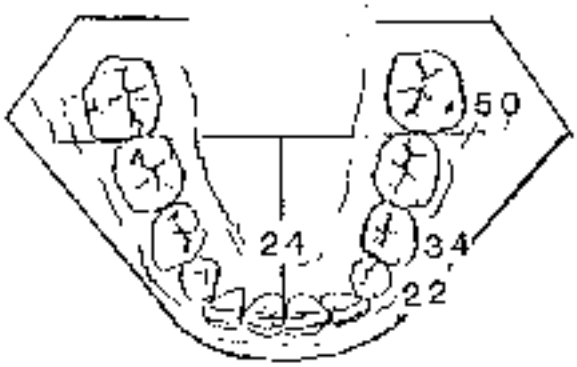
G.A. ♂

Before

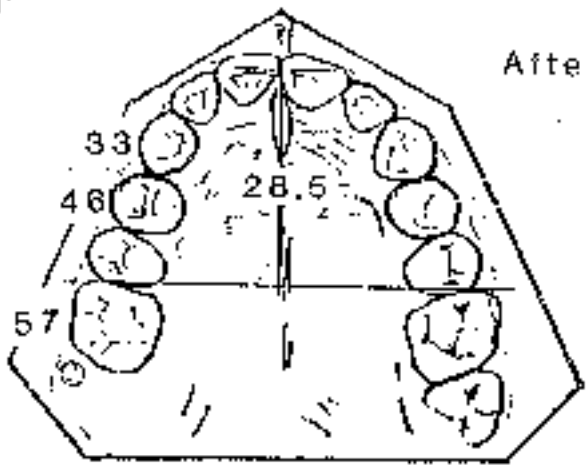


6748

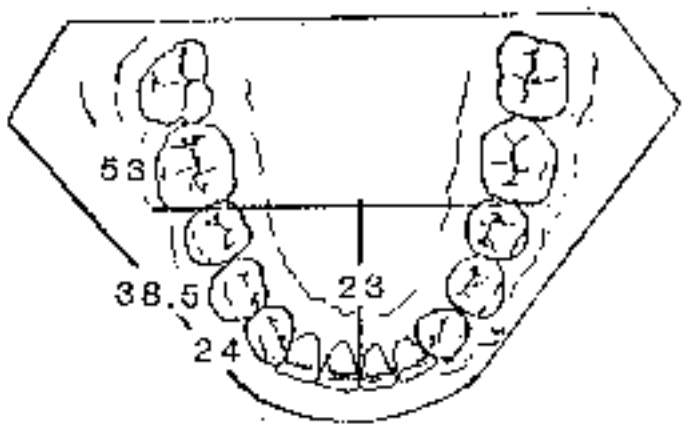
Age 8-4

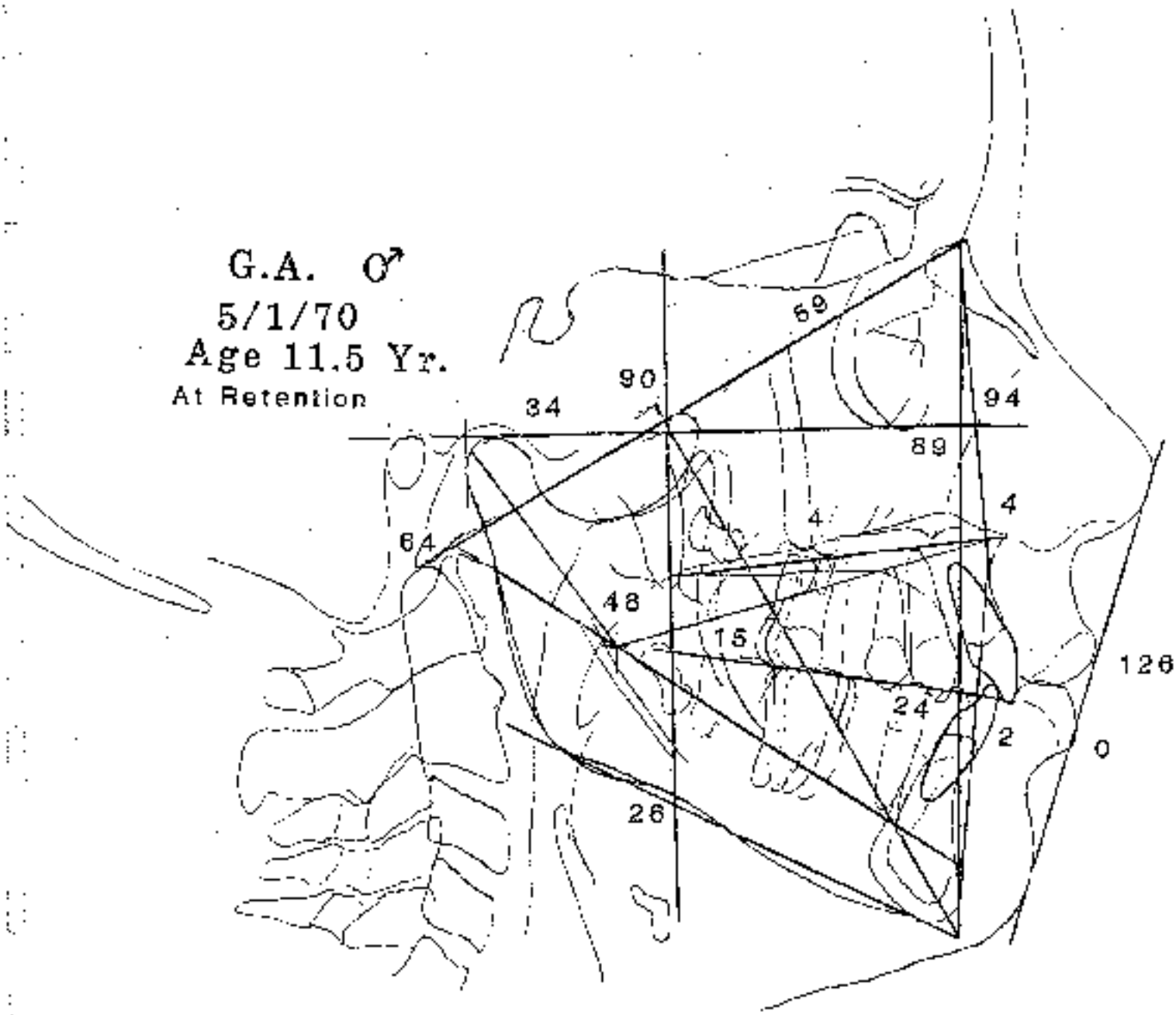


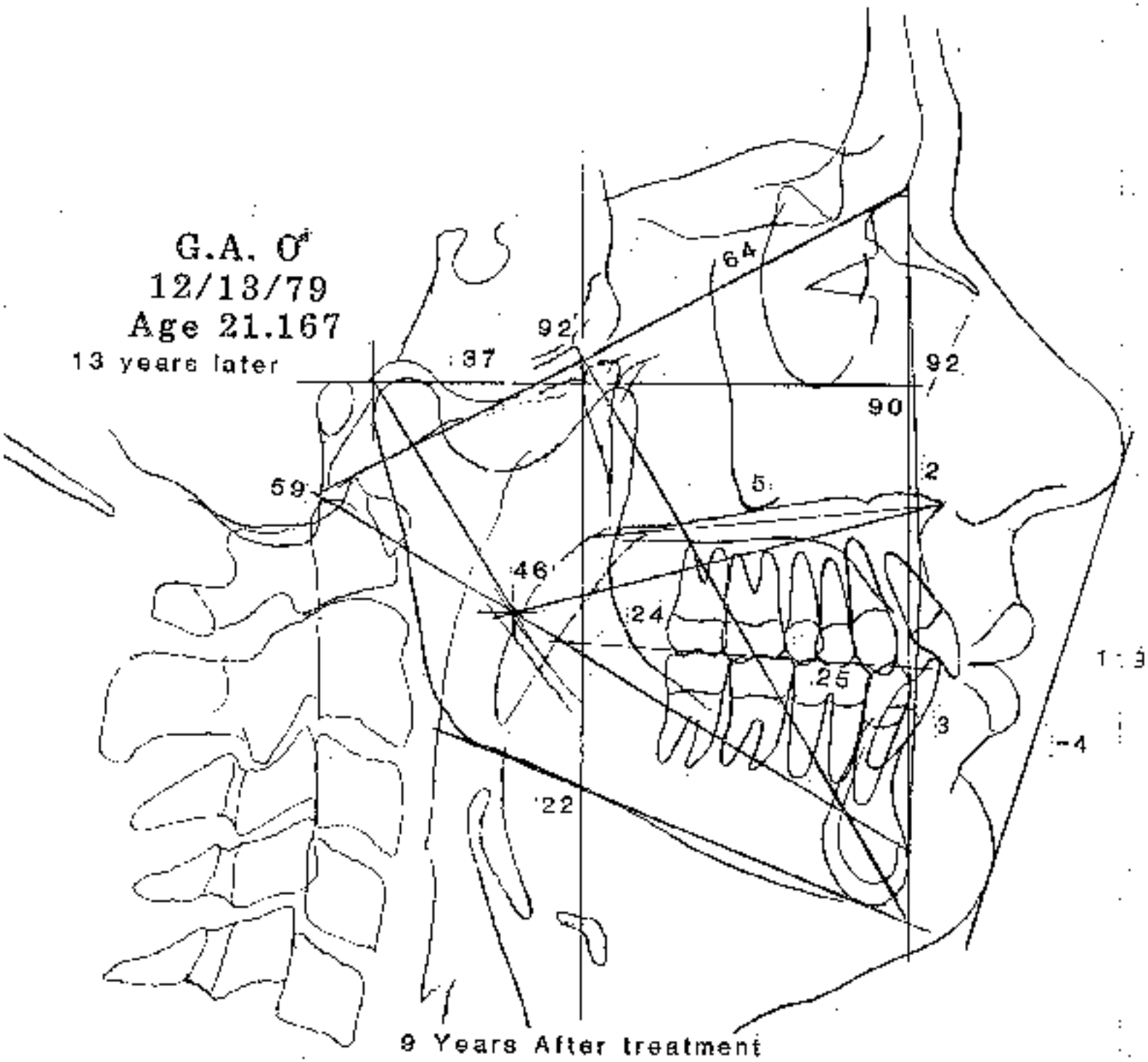
After



Age 11-7




G.A. ♂
5/1/70
Age 11.5 Yr.
At Retention
69
90
34
94
89
4
4
64
48
15
126
24
2
0
26


G.A. ♂
12/13/79
Age 21.167
13 years later
64
92
37
92
90
59
5
2
46
24
25
3
22
9 Years After treatment

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