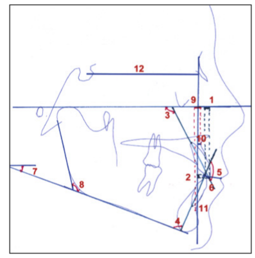
DOI: 10.1051/odfen/2010406

J Dentofacial Anom Orthod 2010;13:385-400



A new method for the utilization of cephalometric measurements in orthodontics

or

how standard deviations can sometimes be the practitioner's false friends (Part 1)

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C.R.A.N.I.O.M., January 2010

ABSTRACT

Today there is near universal agreement that the cephalometric analyses presented by the Americans R*ICKETTS*, S*TEINER*, *and* T*WEED* *need to be re-evaluated and brought up to date. To this end, our C.R.A.N.I.O.M group has prepared a new method for using cephalometric numerical and angular readings in the preparation of a reasonable and well-reasoned aid to diagnosis.*

We analyzed the data from a sample of 83 young adults with Class I occlusions, none of whom had ever received orthodontic treatment.

In our work the most striking ***new consideration*** *that we employed was to use* ***the extreme values for each variable*** *of this sample. These figures constitute* ***extreme parameter limits*** *very distant from each other: for example there is a gap of* 30^{0} *between the most buccally inclined incisor and the most lingually, or palatally, inclined.*

Therefore, we found incisor inclination to be acceptable within a range of 78 to 114^{0} *to Downs's mandibular plane on the lower arch and from 97.5 to* 130.1^{0} *to the Frankfort plane for the upper arch. So in our reasoning there is far less need to reposition these teeth in conformity to an arbitrary cephalometric norm.*

And, for the same reason, we find far fewer cases requiring extraction in order to allow orthodontists to achieve results that satisfy abusive standards established by Ricketts, Steiner, and Tweed. The osseous measurements that

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Article available at http://www.jdao-journal.org or http://dx.doi.org/10.1051/odfen/2010406

we report simply describe the forms we observed, none of which constitute anomalies but, instead, ***describe a particular type.***

The C.R.A.N.I.O.M group believes that cephalometric analysis occupies a place in orthodontic record taking that comes after those occupied by esthetics, periodontal status, and muscular balance.

Key Words

Cephalometrics

Averages

Standard deviations

Extreme values

Inclination of incisors

Facial and mandibular forms

Cephalometric incisal repositioning.

Article received: 09-2009
Accepted for publication: 06-2010

In a preliminary note we should like to state that we have written this article primarily for practitioners who believe in a reasonable and prudent use of cephalometric measurements.

Before the advent of cephalometrics practitioners quite understandably carried out their clinical observations with the aid of one simple measuring tool, their own eyes.

They might find, for example, ''the upper lip is in an advanced or a retruded position'' and that relatively vague formulation sufficed for their needs.

Then cephalometrics was introduced and measurements calculated to a single millimeter or a single degree took over as a new diagnostic standard.

As time passed, and as orthodontists contemplated the enormous change that had taken place in orthodontic measurements, some began to ask themselves if this new precision was really necessary.

We include ourselves in the group that doesn't think so.

As adjuncts to the classical diagnostic measuring instruments we are presented with a set of standards that admit no nuance. This sternness forces us to ask ourselves how we should use those arbitrary forms. We accept the idea that an overly strict and overly rigid utilization of cephalometric standard measurements could lead to a **total rejection of cephalometrics as a diagnostic tool.**

Therefore we think that there is much to be gained by introducing to a wide audience of interested practitioners the vision of cephalometrics that our C.R.A.N.I.O.M group has formulated.

We are going to show the benefits that can be derived from a **special use of cephalometric figures** based on the study that C.R.A.N.I.O.M carried

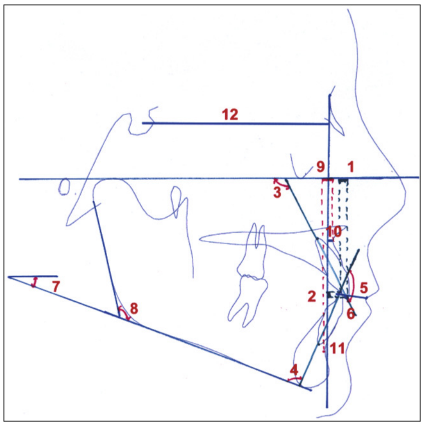


Figure 1

out on a sample of 83 cephalograms of **young adults who had had not had orthodontic treatment and whose classification was dental Class I.**

We shall present our analysis in its entirety and go into detail about what seem to us to be its most interesting aspects.

We selected 14 points that allowed us to define 12 variables that constitute a method (fig. 1):

1 – overjet: a segment obtained by projecting the incisal edges of the upper and lower incisors onto the Frankfort plane;

2 – incisal overbite: a segment obtained by projecting the incisal edges of the upper and lower incisors onto a vertical plane;

3 – the inclination of the upper incisors on the Frankfort plane;

4 – the inclination of the lower incisors on Downs's mandibular plane;

5 – the inter-incisal angle;

6 – the vertical position of the incisal edge of the upper incisors with respect to Stomion;

7 – angle of the face's shape: formed by line SN intersecting Downs's mandibular plane;

8 – angle of the mandible's shape: formed by intersection of articulare-upper goniac and the mandibular plane;

9 – the antero-postero discrepancy measured by the segment A'B' defined by the projection of points A and B on the Frankfort plane; we explain the reasons that induced us to make this choice;

10 – distance of point A from the MacNamara line, a line perpendicular to the Frankfort plane passing through Nasion;

11 – distance from point B to the MacNamara line.

12 – facial depth: distance from point S to the MacNamara line.

We divided these 12 variables into **two categories:**

1 – the first, comprising the inclinations of the incisors, represents the structures upon which orthodontic appliances can exert a real, direct action;

2 – the second, comprising the osseous structures, represents, on the other hand, those structures upon which orthodontic treatment exerts, according to various authorities, little or no action, i.e.:

- the shape of the face,
- the shape of the mandible'
- the skeletal type, the discrepancy between upper and lower basal bone,
- the depth of the face.

The **averages and the standard deviations** of these variables were calculated.

The traditional use of these figures would lead to a definition of **limits**, calculated with the average $\pm$ one or more deviations.

These limited values allowed practitioners to compare the variables measured on any patient to those of a reference sample.

A series of values that up to now has never been used is included in the figures we derived from our sample. These are the extreme values for each variable.

Accordingly, we withdrew the cephalograms containing these extreme values from the sample.

It is this finding, for each variable, of the great space that separates the smallest value from the largest value (about 30^0 for angular variables) that made us aware of this new observation.

As with any study of this type, we have to exploit the statistical numerical values (a quantitative notion) in order to substantiate a literal proposition, that is a diagnostic element (a qualitative notion).

These 83 subjects were a special group, as we have already stated. They were all in dental Class I occlusion and none of them had ever had orthodontic treatment.

All the values come from "normal" subjects; therefore they are all acceptable.

We shall present, for each variable, the cephalograms and the measurements of the extreme values. This will make it quite clear how far apart these extreme values are.

CATEGORY ONE

This comprises the incisal teeth upon which orthodontic appliances exercise a very complete action.

We shall also indicate on each tracing the value of the inclination of the incisors in the jaw occluding with the affected teeth, findings we shall discuss in a later chapter.

Tracings containing the extreme inclination values of the mandibular incisors

– The lower incisor the most lingually inclined at 78^0 occluded with an upper incisor whose inclination was 117.2^0 (fig. 2).

– The lower incisor the most labially inclined at 114^0 occluded with an upper incisor whose inclination was $I15.7^0$ (fig. 3).

The inclinations vary, it can be seen, from 78° (fig. 2) to 114° (fig. 3), a substantial difference of 36°.

Tracings showing extreme inclinations of maxillary incisors

– The most palatally inclined maxillary incisor, at 97.5°, occluded with a lower antagonist at 97° (fig. 4).

– The most labially inclined maxillary incisor, at 130.1° occluded with a lower antagonist, inclined 90° (fig. 5).

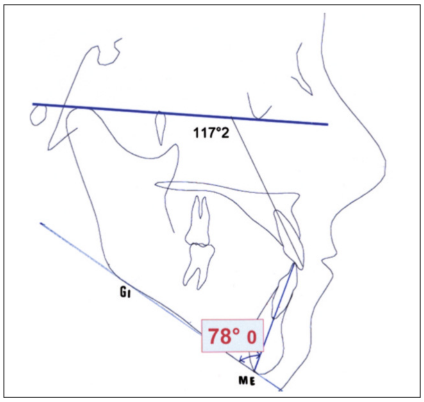
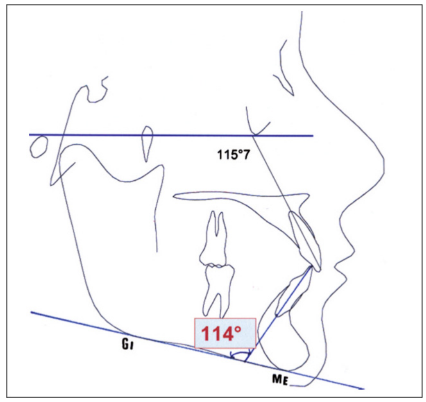


Figure 2



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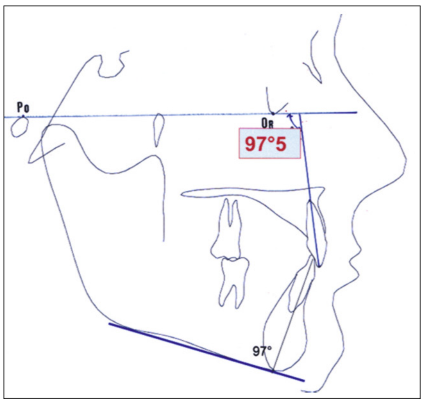


Figure 4

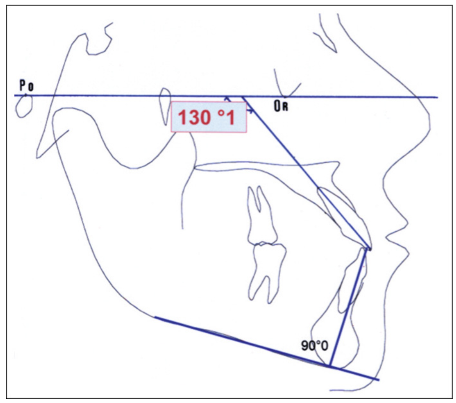


Figure 5

Inclinations of the maxillary incisors varied, then, from 97.5° (fig. 4) to 130.1° (fig. 5), also with quite a substantial spread of 32.6°.

Commentary

These two extreme inclinations prompt us to make this observation:

We know that a desire to improve facial appearance is the primary motivation that impels patients to consult an orthodontist and the status of the upper incisors is a leading factor in this impulse because, of course, these are the most visible teeth in the mouth.

When they are too protrusive or are separated by spaces, they almost always have an excessive labial inclination and patients – or their parents – ask the consulting orthodontists to **straighten** them or to close the spaces.

But when maxillary incisors are inclined too far palatally patients ask orthodontists to **straighten** them much less often because teeth in that malposition are not readily visible to others.

The subjects in our sample whose teeth were inclined in these extreme fashions accepted them as they were: the malpositions of these teeth did not seem to their possessors to be unattractive and the subjects had never sought to have them **straightened.**

It is evident that our assessment of the value of the inclination of a patient's upper anteriors by simple visual inspection cannot be very precise; but this visual impression seems, for most people, to provide sufficient evidence for deciding whether or not to seek orthodontic assistance.

CATEGORY TWO

This group includes the osseous structures upon which orthodontic appliances exert an action that is more or less limited.

Once again, we note extreme values.

Types of vertical osseous structures

- **The face:**

A measurement of the angle made by the intersection of line SN with Downs's mandibular plane:

– the most vertical: 45.2° (fig. 6);
– the most horizontal: 15.2° (fig. 7).

This reading varies, then, from 15.2° to 45.2°, a rather substantial gap of 30°.

- **The mandible**

This measures the angle made by the posterior border of the ascending ramus as it intersects Downs's mandibular plane:

– the most vertical mandibular angle was 143.4° (fig. 8);
– the most horizontal mandibular angle was 107.3° (fig. 9)

Accordingly, there was a gap of 36.1°.

For these two variables, the gap varies from 30°, for the face, to 36.1° for the mandible, both of which figures are fairly substantial.

Osseous horizontal forms

The gap between upper and lower basal bone is indicated by the segment A'B'.

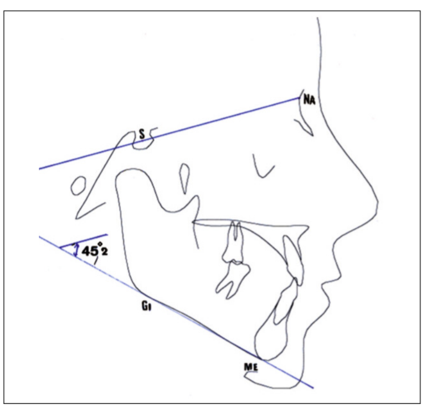
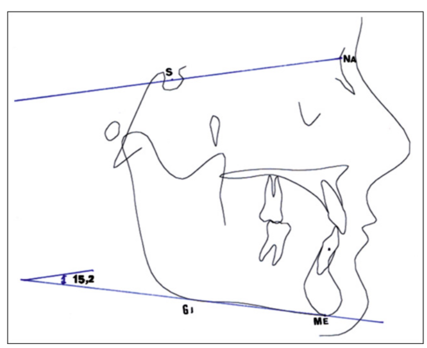


Figure 6



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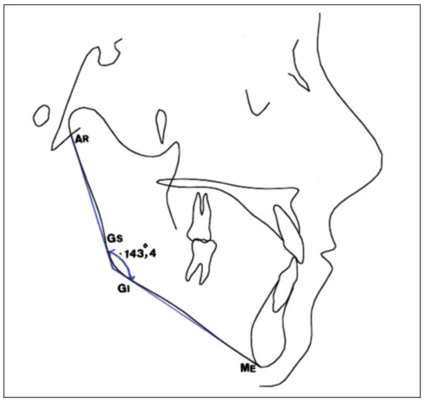
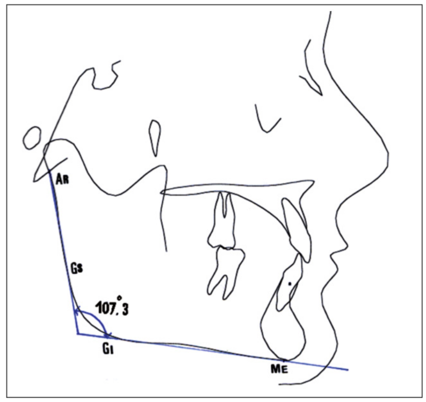


Figure 8



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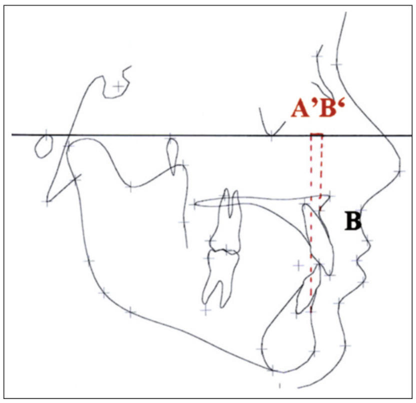

Figure 10

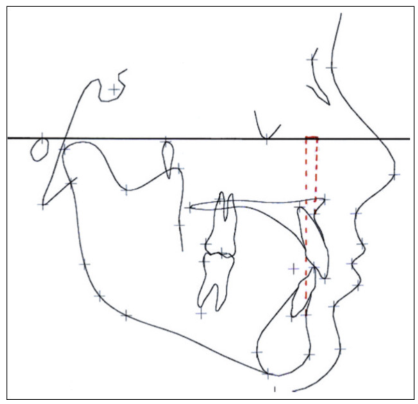

Figure 11

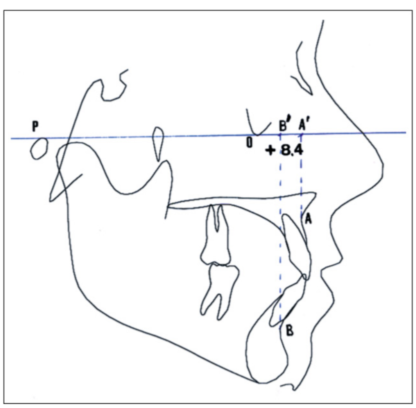

Figure 12

The two points **A′ and B′** of the C.R.A.N.I.O.M analysis are the orthogonal projections of points A and B on the Frankfort plane (fig. 10).

The minimal value of A′B′ = 6.4 mm (fig. 11).

The maximal value of A′B′ = + 8.4 mm (fig. 12)

We shall explain, with two highly illustrative examples, the reasons why we used segment A′B′ for measuring antero-posterior osseous discrepancy.

We decided against using Nasion because it would compromise

Figure 13

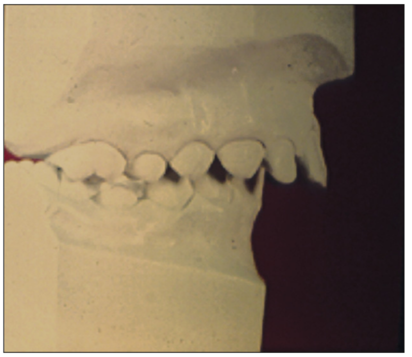

Figure 14

measurement values by its frequent forward and backward and up and down changes of position.

- **Example Number One**

These photos of the facial profile (fig. 13) and of the models (fig. 14) clearly depict the Class II division 1 nature of this boy's anomaly.

One would logically anticipate an accompanying cephalometric inter-arch Type II discrepancy. But the **ANB** angle reading (fig. 15) **is only 11.5^{0},** which indicates a **skeletal type I.**

The **extreme forward** position of Nasion had strongly **lowered the value** of ANB, even though the extent of the osseous gap, or the protrusion, had not been affected in any way.

Ricketts's convexity measurement (fig. 16) also gave a **negative, type III skeletal value** because Nasion was located so far forward.

But if points A and B are projected onto the Frankfort plane as A' and B' (fig. 17) with Nasion ignored, the discrepancy measurement between them is + 5.7 mm, which indicates an osseous gap of **skeletal type II, which is coherent and compatible with the findings of the clinical examination.**

- **Example Number Two**

The next two documents, photographs of models and of the facial profile (fig. 18 and 19) suggest that the patient's anomaly is one of advanced

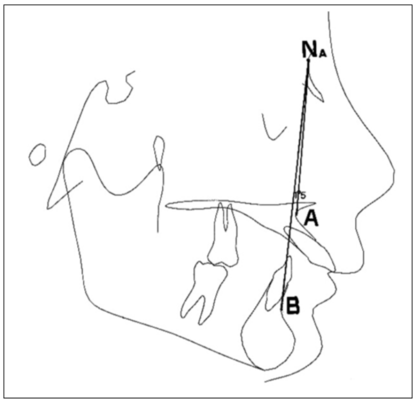

Figure 15

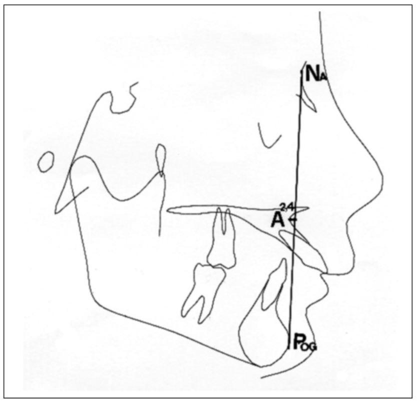

Figure 16

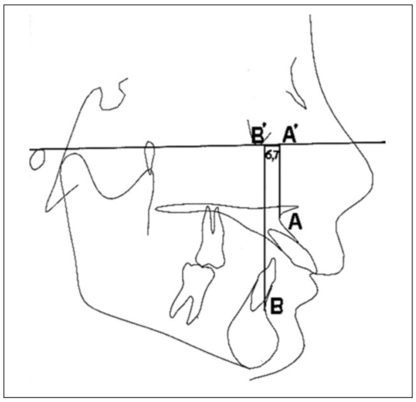

Figure 17

Figure 18

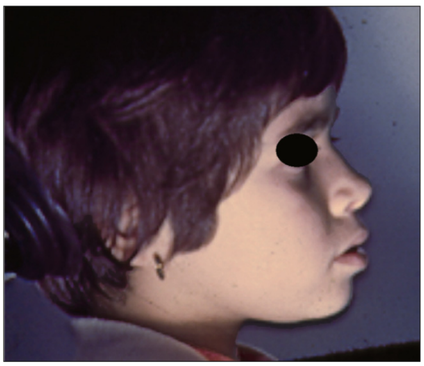

Figure 19

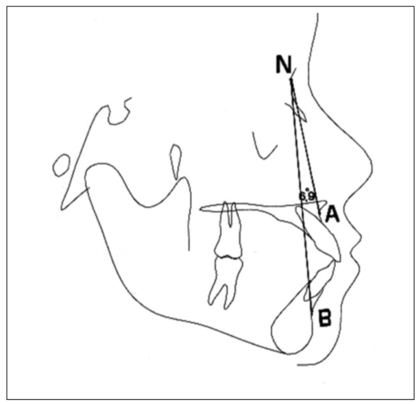

Figure 20

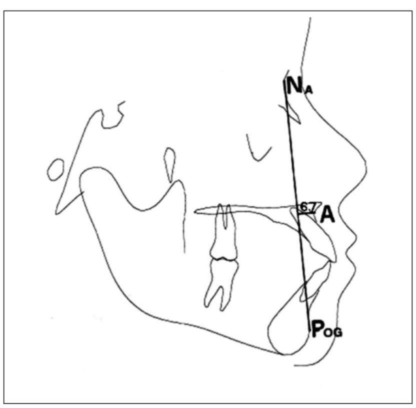

Figure 21

positioning of both dental and osseous structures, Class III in nature, with a possible forward tilting of the maxillary incisors.

The measurements of angle ANB (fig. 20) (+ 6.9) and of the convexity (fig. 21) (= 6.7 mm) indicate, on the contrary, a skeletal protrusion of the Class II type, which is incoherent.

The very much **in arrears** position of the Nasion point has considerably **increased** the value of these two

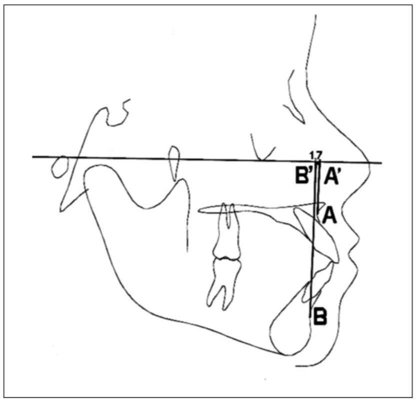

Figure 22

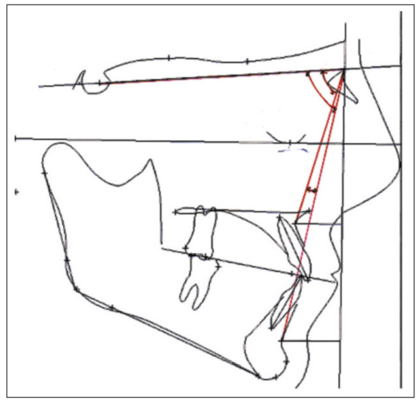

Figure 23

measurements even though the osseous structures containing points A and B have in **no way changed their relative positions.**

If we project points A and B on the Frankfort plane (fig. 22), the value of the segment A'B' (1.7 mm) indicates a normal, **type I, or even a type III, discrepancy, but certainly not one of a Class II type.**

Commentary

The possibilities of ANB measurements being misleading are not often so apparent as they are in the records of these two cases, but they are always present, in relation to the sub-naso-menton profile.

The **sub-naso-menton profile can appear in three different clinical forms**:

– a profile in which the osseous and dental ensemble is behind Nasion, that is to say the forehead. This profile configuration is called **cis-frontal.** In this situation points A and B are both located **behind** Nasion (fig. 23) and the value of the ANB angle is decreased;
– a profile in which the ensemble of the dental and osseous structures are **in advance** of Nasion (fig. 24) and of the forehead. It is referred to as **trans-frontal.** In this situation points A and B are both located **in advance** of Nasion and the ANB angle increases;
– an intermediate profile, neither too far ahead or behind the forehead (fig. 25). This is referred to as **normo (or ortho)-frontal.**

In this situation, points A and B are placed on both sides of Nasion.

The extent of the change in the value of ANB varies in function with the type of profile, as it ranges from cis to trans-frontal.

It is only when the profile is ortho-frontal, neither ahead of or behind Nasion, that the angle ANB or the facial convexity provide relatively undistorted measurements that give an accurate picture of the true discrepancy between the upper and lower jaws.

In our group, we no longer use measurements of the AoBo segment (fig. 26) because its value is also biased, by the more or less oblique

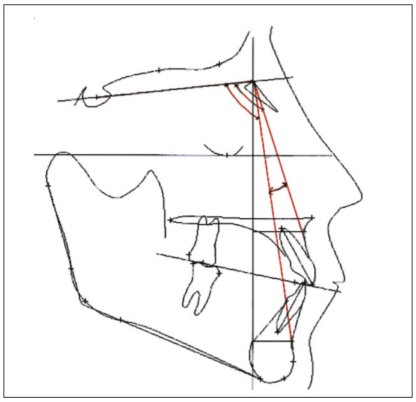

Figure 24

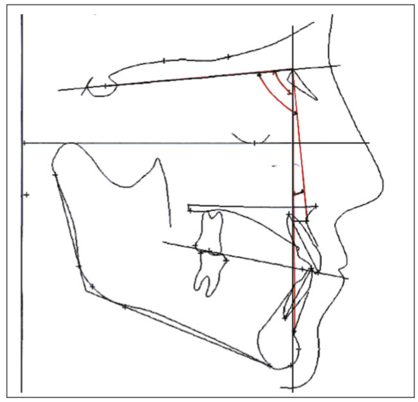

Figure 25

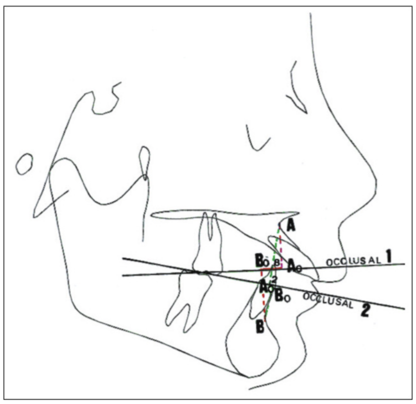

Figure 26

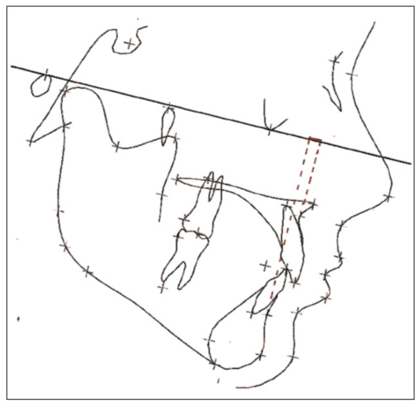

Figure 27

orientation of the occlusal plane onto which points A and B are projected.

But we can state that the value of the A'B' segment does not vary no matter what the inclination of the Frankfort plane is (fig. 27 and 28).

When we eliminated Nasion as a reference point for measuring the extent of the gap, or protrusion of basal bone of one arch with regard to the basal bone of the other arch we had to choose another plane onto which we could project points A and B, an important decision because this plane would play a major role in portraying the value the A'B' segment.

When we first formed our C.R.A.-N.I.O.M. group we selected the Frankfort plane for this purpose, making it **horizontal** by an arbitrary construction adjustment that made its efficacy, at best, debatable. (fig. 29).

The inclination of this plane in space depends solely on the way the patient 's head is oriented in the cephalostat when the film is taken.

The choice of the bone-based Frankfort plane was subjected to understandable criticism because the size of the segment depends not just on the gap to be measured, the discrepancy between the jaws,

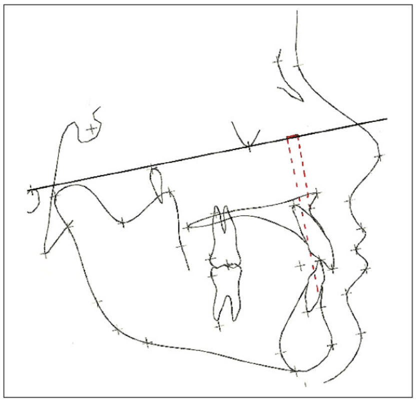

Figure 28

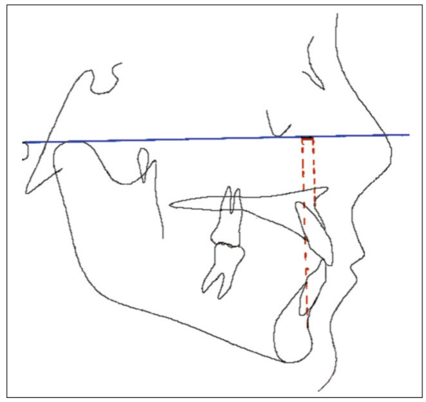

Figure 29

but also on the line chosen to depict it.

Accordingly, we looked for ways to obviate this weakness in our construct.

Eventually we decided to project points A and B to a region **outside the face**. The plane we thought would be most satisfactory for this purpose was one we called **the plane of horizontal looking ahead** (fig. 30).

On this profile photo (fig. 30) we show in a white line this horizontal inspection plane that is parallel to the upper and lower edges of the photograph, depicted in thick red lines representing what we call ''the every-day horizontal.''

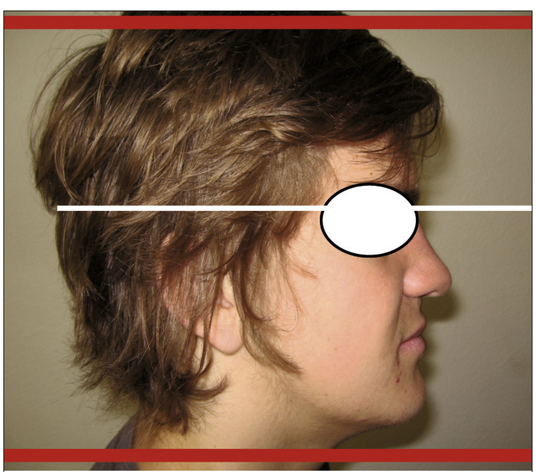

Figure 30

Remember that Downs had already used this very reference line in 1956. At that time he noted, in the course successive examinations of the same subject, that there were variations on the order of 3° in the horizontal looking ahead plane, which he had obtained by asking patients to look straight ahead at their own eyes in a mirror.

He had then analyzed the variations in the relationship of this looking ahead plane to the cutaneous marking of the Frankfort plane (fig. 31).

Then we tested this method by taking photographs of the same subjects on different days, each time attempting to reproduce the same qualities for the **horizontal looking ahead** into a mirror condition. We found variations that were roughly equivalent to those that Downs had obtained, which were about 1.5° on average with a maximum of 3°.

Later, 1n 1977, Ricketts and Langlade, in issue 2, tome XI, pages 161 to 176 of the Revue d'ODF, also argued the case for a cephalometric

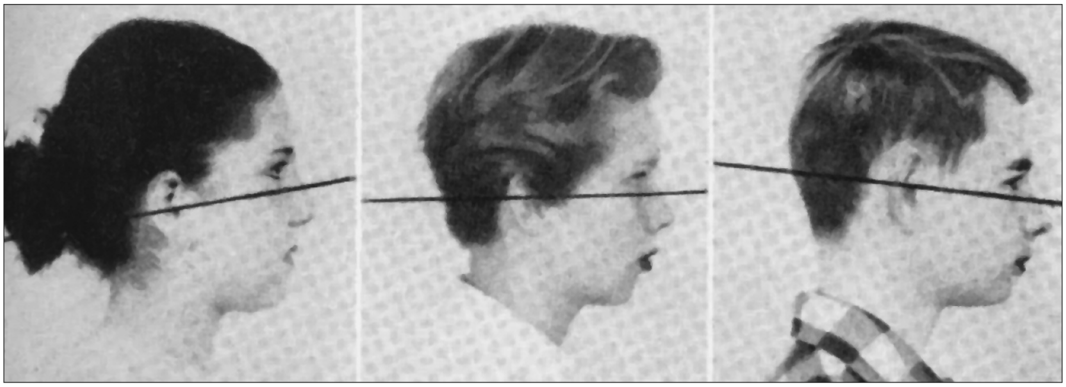

Figure 31

orientation for the analysis of an individual's profile.

It essential that all practitioners have in their mind's eye an intuitive sense of the need for a certain horizontal quality in describing antero-posterior relationships.

In our sample of 83 subjects we measured the value of a **segment called A''B'', as a projection of points A and B on the every-day horizontal plane.**

The every-day horizontal is easy to discern because the lengthwise edges of the film locked in the cassette represent this horizontal line (fig. 32).

If this were not so, the cassette would slip out of its holder.

Let us remember assistants positioned the subjects in our sample in the cephalostat without referring to any particular orientation.

We have already collected a new series of figures standing for the 83 A''B'' measurements.

And we have compared that series of A''B'' measurements with A'B' measurements collected with the scatter method (fig. 33).

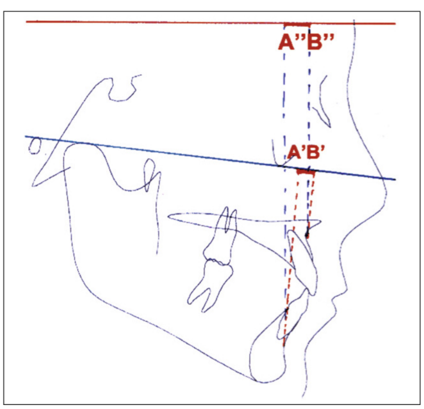

Figure 32

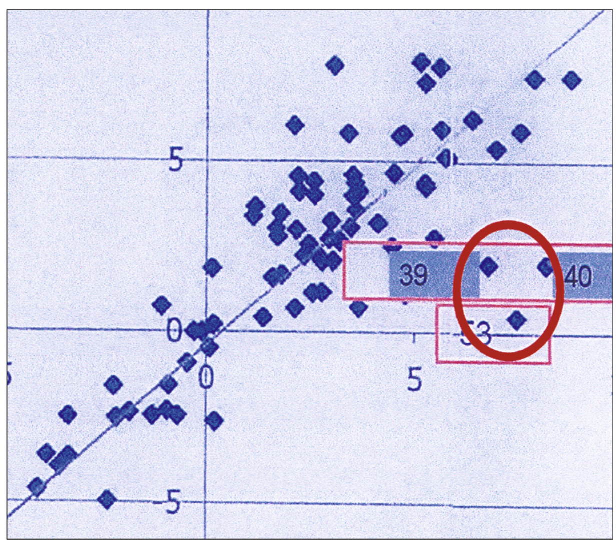

Figure 33

Overall, these two sets of values are very close except for the 3 subjects, Numbers 39, 40, and 53, who were below average in the middle of the ellipse traced in red; for these subjects, **the segmentsA'B' are clearly greater that the segments A''B''.**

These three subjects represent 2.49% of the 83-person sample, which means that using A'B' instead of A''B'' runs the risk of recording an error 3.1 times out of a 100.

This less than 5% risk is statistically acceptable and widely accepted.

It most also be understood that assistants ''oriented'' the heads of the 83 participants in the cephalostat in what amounted to a random fashion. If we had oriented all the subjects in the same look ahead horizontal plane the differences we noted in our findings would probably not have occurred.

This realization induced to us to employ the A'B' segment in this article as a representation of the extent of the skeletal antero-posterior gap between the maxilla and the mandible.

If we transform degrees into millimeters after a projection of point A and B on the Frankfort plane (fig. 34), the measurements of segment A'B' vary, on average, about 1.5 mm.

We believe that we can consider these differences to be negligible, taking into account the great variations of the values of the A'B' segment that we observed in our sample of 83 Class I dental subjects, who had not, it must be remembered, received any orthodontic treatment.

Here are the extreme value of segment A'B' of this sample, which range from – 6.4 mm (fig. 35) to + 8.4 mm (fig. 36), showing, accordingly, a 14.8 mm interval.

These figures represent the value of A'B' measured on the Frankfort plane.

Even though we have chosen to use the A'B' segment, we can add, that orienting the cephalogram on the look ahead plane is certainly not made impossible.

There are several ways that this can be done, but we prefer this one:

a) Take a profile photograph oriented as closely as possible on the look ahead plane;

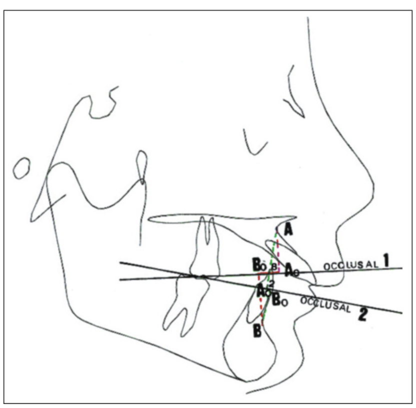

Figure 34

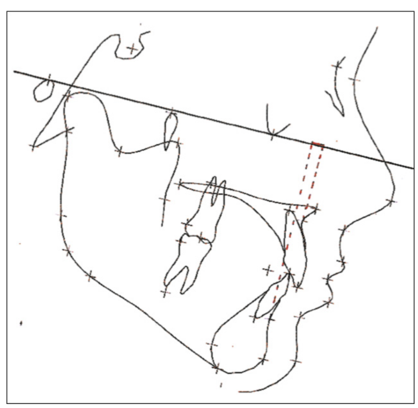

Figure 35

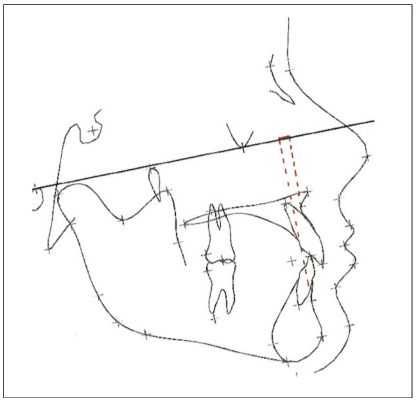

Figure 36

b) Take the profile head film with no special orientation;
c) Superimpose a tracing of the profile head film on the profile photograph and adjust the head film's orientation to that of the photograph so that it assumes a look ahead, horizontal orientation.

The **best and most reliable way** to make this transfer is **digitally, on a computer.**

Using the ODRADE program we find we can make this superimposition with no difficulty (fig. 37).

The program is designed to insure that all linear measurements, especially the A'B' segment, are well oriented. This procedure can be accomplished manually but not with the precision afforded by the computer program.

This superimposition of three documents offers many advantages:

a) with the A'B' segment it offers a good appreciation of the relationship of maxilla with mandible;
b) it ties together, **with precision,** the clinical profile examination with the cephalometric profile examination. It is useful to note that when practitioners declare that the ''high'' or the ''low'' is forward or to the rear, they are, more or less unconsciously, integrating the head of the subject into a primarily horizontal position.
c) It highlights the sometimes considerable differences between clinical and cephalometric assessments. Clinically we express ourselves in terms that are primarily qualitative rather than quantitative; cephalometrics provides us with us with data that is far more precise.

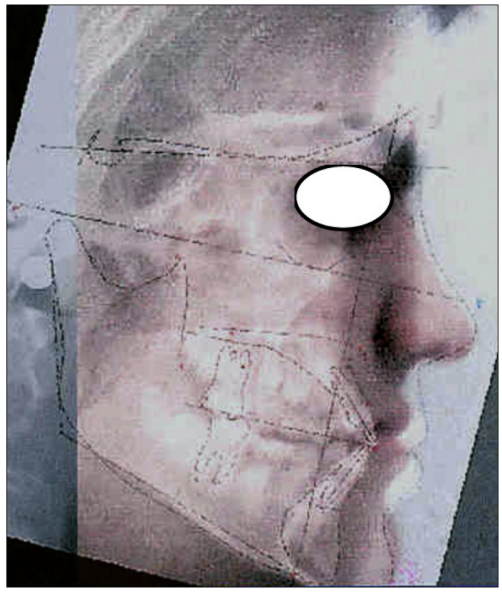

Figure 37

We do not believe that we have any need for precise measurements for their own sake. Clinical assessments may appear insufficient, but often they provide all the information we really need.

End of part one of the article

The continuation of this article, dealing principally with the differentiated use of the sample's extreme values, its average values, and its standard deviation values will be published in the next issue.

Part two will contain commentaries from Professor Julien PHILLIPE. Without renouncing his previously pronounced views, this well known and highly respected author recognizes the advances of our new cephalometric analysis.

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