# Growth Concepts*

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The method of superimposing tracings of serial lateral cephalometric x-rays to demonstrate growth changes and orthodontic treatment results depends upon one's concept of human head growth.

While we must accept the thesis that no absolute fixed reference point exists from which the pattern unfolds, we may describe growth changes in terms of the movement of parts relative to each other. The dangers involved are that the selection of reference landmarks may lead to errors in interpretation.

The time-honored concepts of human facial growth as advanced by the cephalometric studies of Broadbent[1] and Brodie[2] have long laid the foundation of our understanding of facial pattern development. At the same time, the accepted methods of superimposing serial tracings tend to mask the manner by which the growth of craniofacial structures influence the horizontal and vertical unfolding of the face and, more important, how this growth affects the profile.

The method to be presented for consideration, shown in Figure 1, differs from the Broadbent and Brodie techniques in that serial tracings are registered at basion orienting the anterior cranial bases parallel. The advantage of registering at basion is that serial tracings superimposed in this manner graphically illustrate the contribution of growth systems to depth and height development.

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In order to develop the rationale upon which this method is based, a review of some familiar concepts is necessary. Let us first consider the concept that essentially the head is composed of two bones, the craniomaxillary bone and the mandible; further, that the spatial positioning of the maxillary denture is dependent not only upon the growth of the maxilla and associated bones housing the teeth, but also upon the growth of the cranial base to which it is attached. Todd aptly stated this thought long ago when he wrote, "The face halfted as it is to the cranium, is carried forward by the expanding brain case." Growth of the cranial base carries the maxillary teeth upward and forward away from the vertebral column while the mandibular teeth are carried downward and forward by mandibular growth. Figure 2 is a simple diagram illustrating this concept.

One important finding disclosed previously[3] was that from eight years of age the distance between basion and articulare does not change. This means that using basion as a starting point, the mandible is positioned a set distance forward to basion and from there it is a running race, the maxillary denture being carried upward and forward by the cranial base, away from the vertebral column, the mandibular teeth carried downward and forward by growth of the mandible. If then there is to be normal occlusion there must be complete synchronization of growth, at least close enough to permit inclined planes of teeth to settle the occlusion into proper relationship. Any disharmony in the amount of growth and direction of growth will result in some

degree of dysplasia.

In order to understand the vector of development affecting the spatial position of the maxillary dentition it is necessary that we consider the growth behavior of the anterior and posterior cranial base segments separately. The anterior cranial base to which the upper face is attached is usually delineated in cephalometric studies by sella and nasion. This is a misnomer, as most of us realize. The sphenoethmoidal suture ceases its development approximately at the age of seven years. After this time measurement between sella and the internal plate of the frontal bone shows little to no change. Further increment in the sella-nasion dimension appears to be appositional development of the frontal bone. In forty-seven cases studied[4], measurement between sella and internal plate of the frontal

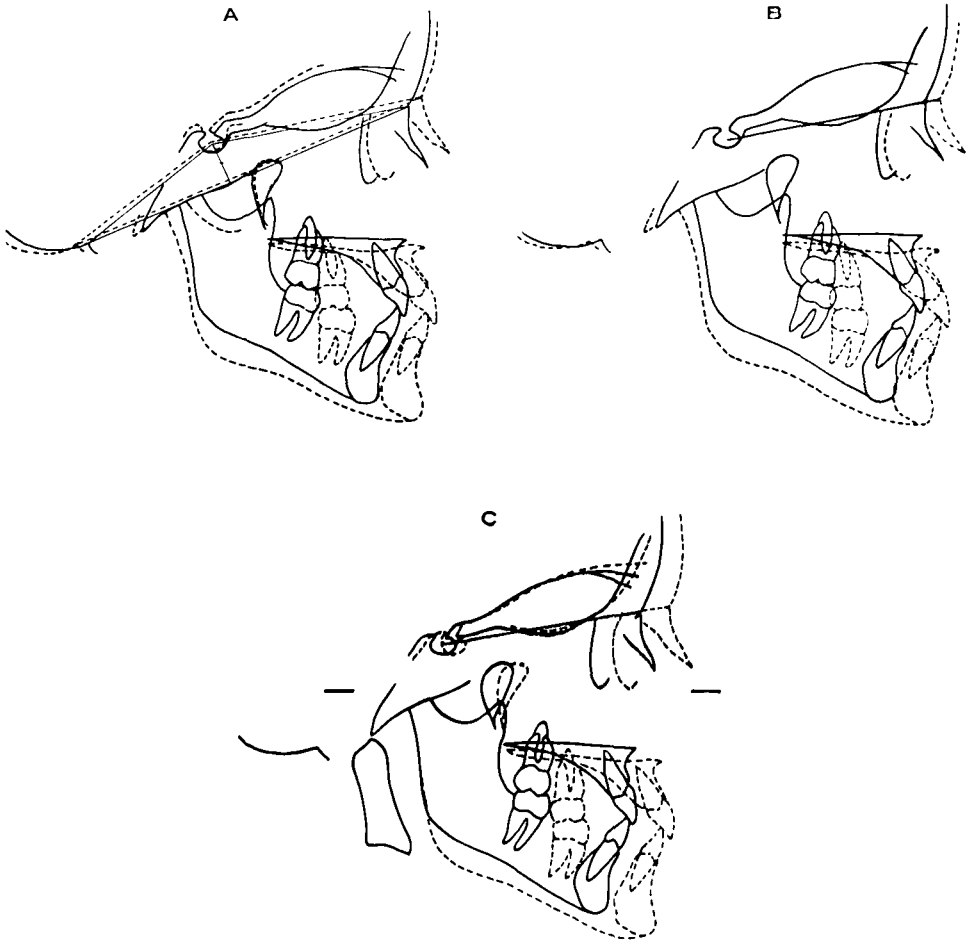


Fig. 1 Techniques of superimposing tracings of serial lateral cephalometric x-rays. "A" (Broadbent) bases of Broadbent-Bolton triangle parallel, registration at R; "B" (Brodie) S-N planes superimposed, registration at S; "C" (Coben) Registration at Basion, S-N planes parallel.

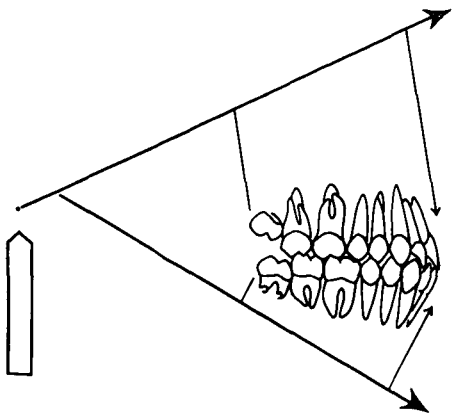

Fig. 2 General vectors of growth. Maxillary teeth carried upward and forward away from vertebral column by cranial base growth. Mandibular teeth carried downward and forward by condylar and ramal growth. Divergence of vectors permits vertical development of the face.

bone from ages 8 years ± 1 year to 16 years ± 1 year ranged from no change to a maximum increment of 2 mm, the mean being +0.5 mm.

Scott[5] states that foetal and early childhood development of the upper facial bones is dependent on growth of the anterior cranial base and nasal capsule, growth being predominantly sutural. He considers the pterygopalatine suture to be part of the same complex as the sphenoethmoidal suture and that when this suture ceases its activity at approximately seven years, so does the pterygopalatine suture. His contention is that additional anteroposterior development of the middle face after this suture closure is due to appositional bone development. Thus, there appear to be two phases of facial growth, the first being sutural until the age of seven years, the second, primarily surface apposition and internal resorption. This theory disagrees with the accepted thought that the maxilla and its teeth are pushed forward by sutural growth to make room for the erupting second and third molars; rather, that after seven years, normal eruption of teeth is downward and forward and the concomitant build up of alveolar process makes room for the eruption of the molar teeth.

Let us now consider the posterior cranial base, in particular the spheno-occipital synchondrosis. Here we have the most neglected growth site of all facial growth studies but whose influence, together with condylar and ramal growth of the mandible, probably establishes the entire pattern of the unfolding of facial development.

Growth in the spheno-occipital synchondrosis continues through the pubertal period. It is important to emphasize that not only is there growth in this area, but also consideration must be given to the direction in which this growth is expressed. In one individual such growth may be primarily horizontal, carrying the maxilla and its denture in a forward direction; in another more vertical, contributing primarily to vertical development of the face.

Another interesting finding in the eight to sixteen year growth study to which reference has been made was that, while males exhibited greater overall growth in the posterior cranial base, the contribution of this growth to the depth of the face was the same in both males and females. The explanation lay in the direction of growth. Growth of the posterior cranial base in the male was expressed more vertically, thus contributing more to vertical than horizontal development. One of the basic sex differences in facial growth during puberty is the greater vertical development of the male face. Thus we are not only interested in growth, but also in the direction of growth.

Unfortunately one cannot draw a line from basion to sella along the long axis of the posterior cranial base and expect that this will be the vector of growth of the synchondrosis. The direc-

tion changes, oftentimes more vertical in males, but is unpredictable. It is this change in the directional growth of the synchondrosis that one is measuring when one speaks of a change in the angle of flexure of the cranial base. Attention is now directed to the mandibular vector of growth. If we refer to basion we must first consider the forward positioning of the mandible and from then on it is mandibular growth that is the determinant of the spatial positioning of the mandibular denture.

Just as it was important to emphasize the direction of growth of the spheno-occipital synchondrosis, so it is with condylar and ramal growth of the mandible. In the foetus the direction of condylar growth is more horizontal contributing more to depth of the face to create arch length for the developing dentition. After birth, during eruption and development of the dentition, the direction becomes more vertical that now growth contributes more to the necessary vertical development of the face making room for tooth eruption[6].

It is apparent that there must be a synchronization in the amount of growth and the direction of growth of the cranial base and mandible if there is to be a normal denture relationship. Growth of the spheno-occipital synchondrosis carries the upper face and denture upward and forward away from the vertebral column; growth of the mandibular condyle and ramus carries the mandibular body and denture downward and forward. Between the two vectors space is created for the vertical unfolding of the face. Any excessive deviation in the amount or direction of growth without compensatory changes will result in dysplasia.

Now to make the bridge to a method of superimposing serial tracings to correlate with our concepts of the unfolding of facial growth. This can be done by registering on basion with anterior cranial bases parallel, the anterior cranial base delineated by the orbital roofs and cribiform plate, or the S-N plane, which for practical purposes bears an almost constant relation to the former. The concept of superimposing anterior cranial bases parallel stems first from the fact that the anterior cranial base after approximately age seven is stable, and second, from the thesis that the sight axis of the eye must bear a relatively constant relation to the skull and postural position of the head.

A few cases will demonstrate the value of the method described. Figure 3 illustrates the growth behavior of two males, approximate age span eight years to sixteen years. The vertical development of both profiles as measured from nasion to menton was almost equal; however, each achieved vertical development by different processes. "A" obtained vertical development in the lower face by condylar growth permitting substantial eruption of the dentition. Growth of the posterior cranial base segment having been expressed in a horizontal direction contributed nothing to vertical development. "B" achieved vertical development primarily by vertical growth of the posterior cranial base segment with some small additional vertical change due to condylar growth; most of the vertical change occurred in the upper face with little eruption of the dentition. When horizontal change of the profile is analyzed, "A" shows the combined effect of horizontal growth of the posterior cranial base plus apposition on the frontal maxillary surface. The depth increment in the lower face is primarily due to increase in the length of the mandibular body, condylar growth contributing to vertical rather than horizontal development. Depth development in "B" appears to be primarily due to apposi-

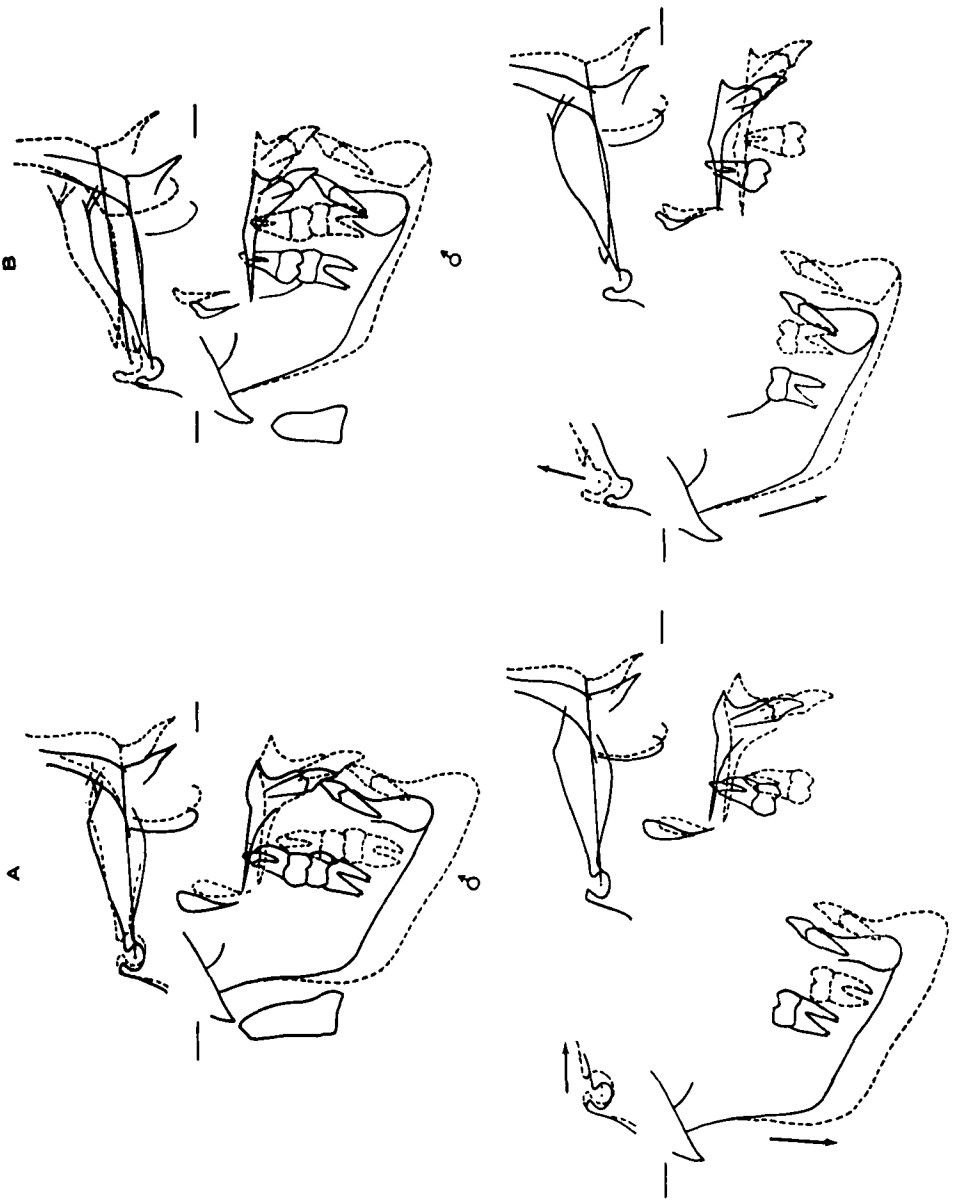


Fig. 3 Growth analysis. Basion registered, S-N parallel. Sectional analysis demonstrates posterior cranial base growth and mandibular growth. S-SN superimposed demonstrates frontal maxillary apposition.

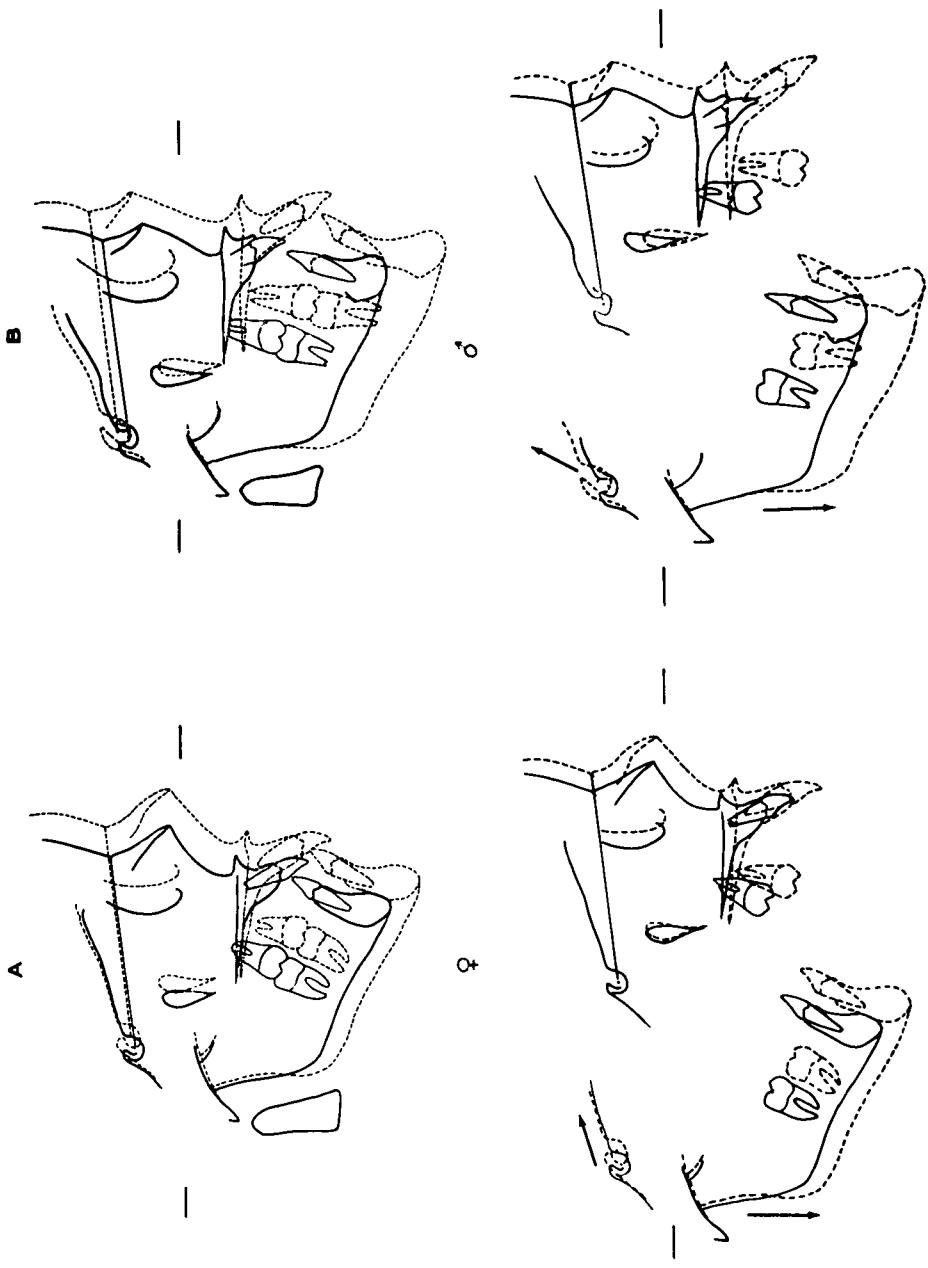


Fig. 4 Growth analysis of facial patterns exhibiting Class II, Division I malocclusion. Basion registered, S-N parallel. Sectional analysis demonstrates posterior cranial base growth and mandibular growth. S-SN superimposed demonstrates frontal maxillary apposition.

tion on the frontal maxillary surface plus a small horizontal component of posterior segment growth. In the lower face mandibular body growth was equal to that found in "A"; however, in "B" the chin point developed farther for-

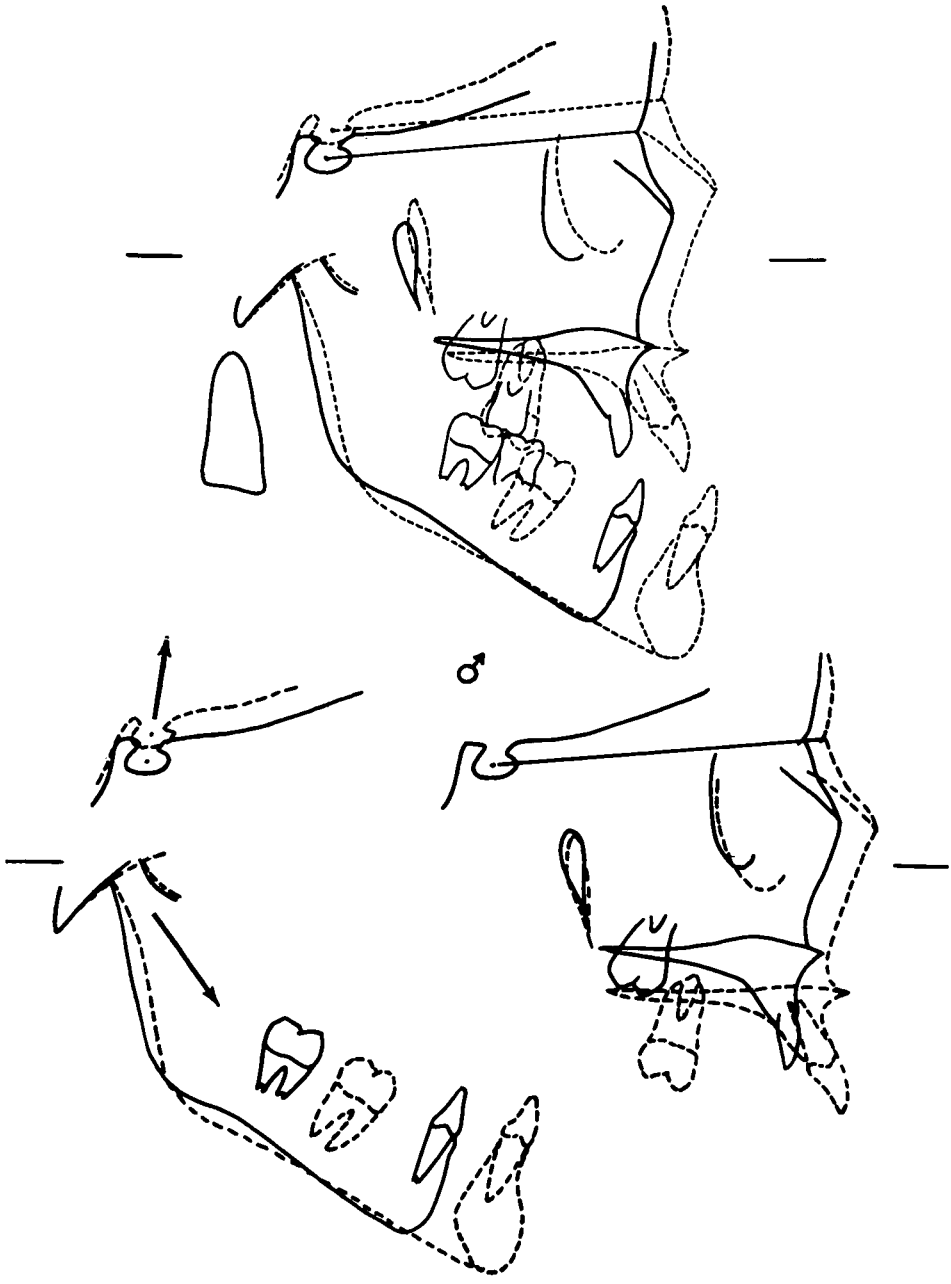

Fig. 5 Growth analysis of facial pattern exhibiting Class III malocclusion. Basion registered, S-N parallel. Sectional analysis demonstrates posterior cranial base growth and mandibular growth. S-SN superimposed demonstrates frontal maxillary apposition.

ward due to the addition of a horizontal component of condylar growth.

Figure 4 illustrates the facial growth behavior of a female "A" and a male "B" both exhibiting Class II, Division 1 malocclusions. Here we see that both faces exhibit similar patterns of development except for the greater overall vertical development of the male face as is generally expected. The vertical difference seen in the male face is due to a greater vertical increment of the posterior cranial base segment and a more vertical direction of condylar growth.

Figure 5 illustrates the growth behavior of a facial pattern exhibiting a Class III malocclusion where lower face prognathism became excessive with age. The case serves to illustrate the result of a disharmony in the direction of growth. The sectional superimposed tracings show a lack of depth development of the upper face. Although the amount of growth of the posterior cranial base was average, its direction was vertical and contributed little to horizontal development. This coupled with a deficiency in appositional development of the frontal maxillary surface resulted in a deficiency of depth increment. On the other hand, increase in the size of the mandibular body was closer to average. In addition there was an atypical horizontal expression of condylar growth to further increase the depth development of the lower face. This disharmony in directional growth of the posterior cranial base and condylar development appears to be the significant factor in the production of this dysplasia.

In order to present the growth concept, quantitation has been eliminated from the discussion; however, what has been illustrated can be quantitated by the coordinate method of analysis. The data of several of the illustrations have appeared previously in the literature[3].

It has been said that just about everything is known about the form and growth of the face in norma lateralis to the point where growth changes can be "predicted". Rather, it would be more appropriate to say that we are just beginning to decipher its complexity.

## Summary

1. The method of superimposing serial cephalometric x-ray tracings by use of basion registration with anterior cranial base parallel, is discussed.
2. The method demonstrates the manner by which growth of the spheno-occipital synchondrosis carries the upper face and denture upward and forward away from the vertebral column, while condylar and ramal growth carries the mandibular body downward and forward. The divergence of the two vectors permits the vertical unfolding of the face.
3. The effects of disharmonies in the amount and direction of growth of craniofacial structures are graphically illustrated by this method.

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## Bibliography

1. Broadbent, B. H.: The Face of the Normal Child, *Angle Ortho.* 7: 183-208, 1937
2. Brodie, A. G.: On the Growth Pattern of the Human Head From the Third Month to the Eighth Year of Life, *Am. J. Anat.* 68: 209-261, 1941
3. Coben, S.E.: The Integration of Facial Skeletal Variants, *Am. J. of Ortho.* 41: 407-434, 1955
4. Coben, S. E.: Unpublished data.
5. Scott, J. H.: The Cranial Base, *Am. J. of Phys. Anthrop.* 16: 319-348, 1958
6. Weinmann, J. P. and Sicher, H.: Bone and Bones. *C.V. Mosby Co.,* St Louis, 1955