New Perspectives on Orientation and Their Benefits to Clinical Orthodontics--Part II

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In Part I of this present thesis the effort was made to show from a statistical as well as a practical standpoint why the conventional SN or anterior base should be limited and why Frankfort horizontal and the basion-nasion planes hold greater promise for clinical and perhaps research use. Large computer studies pointed the way. In addition, there is value with the computer in that new and vital patterns and orientation may be revealed. Such observations are to be portrayed and discussed in this part.

BACKGROUND

Based on the classic work of D'Arcy Thompson, Moss rekindled the theory on capsular matrices and gnomonic figures in facial growth[1] and added much emphasis to it. Studying facial growth by the organs and functions involved rather than bones or sections, development was viewed as a product of neurotrophic input. A gnomon is that part added to the size of a form without a change in shape, in other words the "constancy" of the pattern. Ricketts called the average yearly values of increase "K" factors as starts for "prediction" exercises. The vertices of certain angles or bases of some of the capsular or facial cavity forms, derived from the previously described computer studies, were found to be located at the entrances of nerves which seemed to conform to that theory. Control mechanisms were hypothesized to exist so that order and proportion were established from these "energy sources."[2] This seemed true of our studies in the human, and Moss found these characteristics also among the parts in lower animals.[3] The mechanisms are unique and somewhat different (if true) from long-held concepts in anthropology and orthodontics regarding facial growth.

Let us examine some evidence on the basis of the aforementioned computer composites.[4] Ricketts followed one group of twenty nontreated subjects for eight years, 5 to 13, and analyzed these with computer study. Relative facial and capsular constant figures were suggested in many relations as composites were analyzed (Fig. 1). Verification was needed by other and larger samples, and one was done with the courtesy of Dr. James McNamara who supplied a ten-year longitudinal sample of headplates on fifty subjects from the University of Michigan (Fig. 2). Please refer to the captions on Figures 1 and 2 for explanation of these observations.

Brodie's studies from the third month to the eighth year yielded a gnomonic-like behavior of the brain cavity from a central area of sella.[5] Although composites of his sample were not available, he tended to show a central phenomenon somewhere near the center of the skull base or around sella in isolated subjects as the calvaria expanded. While this was true for the growth of the neural cavity or brain, it does not necessarily follow that it becomes the adopted center for the development of the orbital, nasal or oral complexes which grow under different needs; the latter two follow general vegetative influences rather than neural functions.

Sagittally, the *face* is composed of two orbital cavities, the two nasal cavities and the sinuses, plus the oral cavity. A biologic struggle may exist particularly

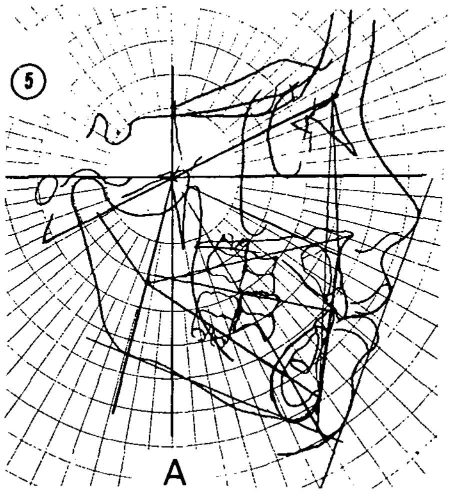

Fig. 1A Analysis of 20 untreated patients, age 8-13. The original composite at age 5 is seen superimposed over a polar grid on basion-nasion at the crossing of the facial axis. The intersection of Frankfort with the basion-nasion plane is also near this point. With the original superimposed in this manner, the points on the face tend to follow these lines as an explosion from the polar center. Compare with Figure 1C.

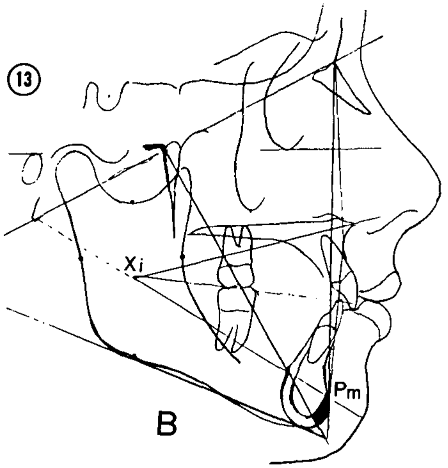

Fig. 1B The mean composite of patients eight years later at age 13. Note Xi and Pm points making up the corpus axis.

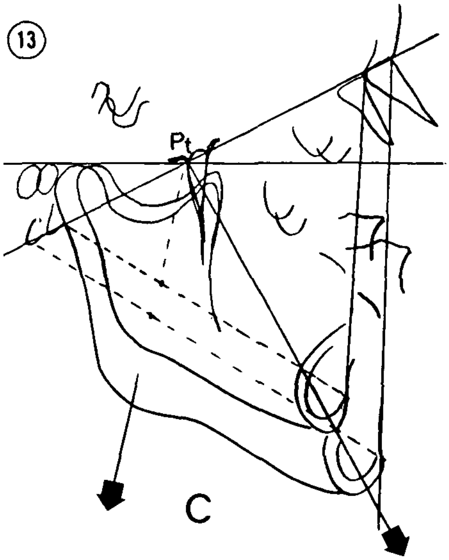

Fig. 1C Superpositioning of the 5 and 13-year composites on the basion-nasion plane at cranial center (CC) (or from Pt at the bottom of foramen rotundum). Notice the growth directly downward on the facial axis. Note the Xi axis downward and backward. Notice the gnomonic character of the development of the facial plane and the corpus axis as related in this manner.

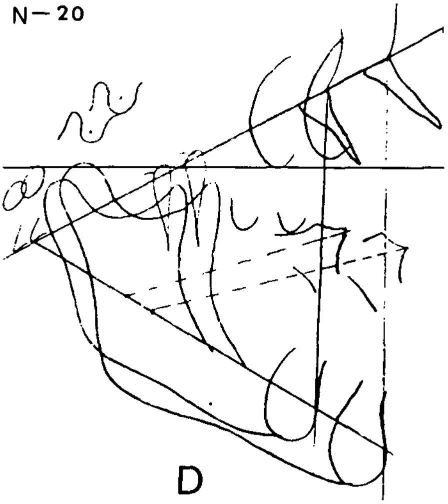

Fig. 1D The same composites superimposed over the point of intersection of the corpus axis with the basion-nasion plane showing the gnomonic-like behavior of the form of the face when related in this manner which helps with predictions of total facial height.

in the midface complex where the functions of olfaction and sight are established early but in which also respiration makes demands on maxillary morphology. The palate is a division between the nasal and oral cavities, and the battle between the organs supporting these vegetative systems probably accounts for its complicated and diverse development seen clinically. Even more, the face, particularly the mandible, is also involved in the demands for deglutition and the valving or the naso-orolaryngeal space for the pharynx as secondary biologic inputs to posture the head. It would at first seem impossible that any order could be established out of this highly complicated arrangement.

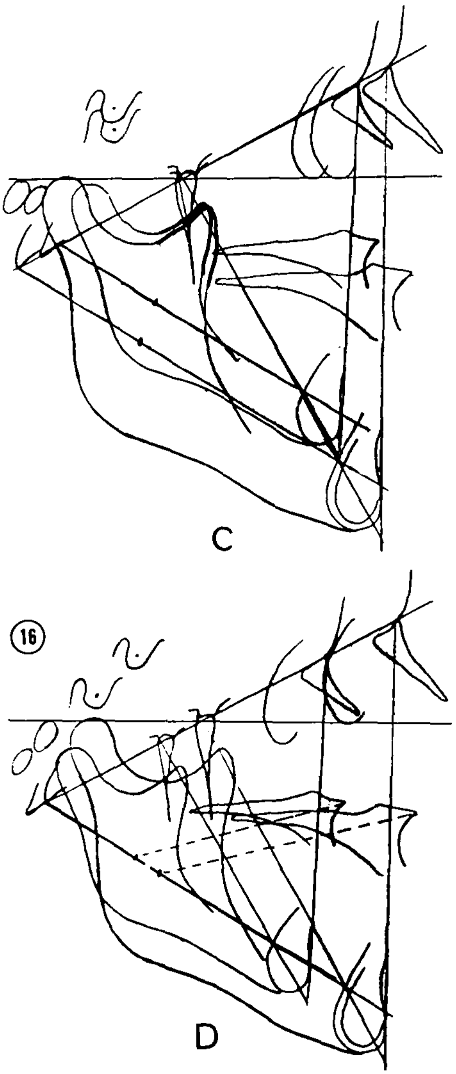

Fig. 2 A second sample of 50 untreated patients, followed ten years from 6 to 16 from the University of Michigan, analyzed by the computer. Notice that the conditions and observations found in the first computer study were confirmed in the second almost absolutely. Attention is directed also to the behavior of the coronoid process which seems to be the closest orientation in the original and ten-year sample.

To add to the confusion, probably one of the most illusive areas to be considered is the area of the temporal bone. The temporal bone's petrous portion houses the most primitive of all organs, the semicircular canals, and is well-established or matured by the time the infant is born. The petrous bone is extremely dense and probably undergoes only little remodeling with growth although evidence is scant as to its actual growth behavior. In addition, the temporal bone, housing the tympanic cavity, is in immediate juxtaposition to the glenoid fossa which is a seat for the mandibular condyle or a reference for the lower jaw (Fig. 3). The total behavior and displacement of the temporal bone has been a mystery, yet the zygomatic process of the temporal bone is the root of the zygomatic arch which *is* Frankfort.

Let us therefore look at the temporal bone in a new light. For years a key to the organization of the glenoid fossa relative to the cranial base has been sought. Usually the anterior cranial base was used to determine growth behavior of the joint in the sagittal view. So, finally a new tack was decided.

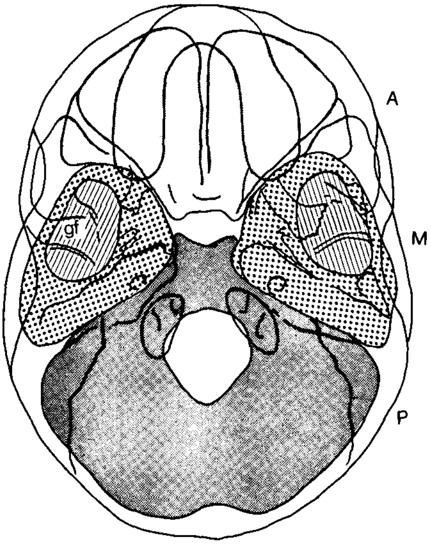

Fig. 3 Tracing of an adult skull in the basal view showing the three cranial fossae: A, anterior; M, middle and P, posterior. Notice the location of the glenoid fossa (gf) which is a reference for the mandible via the joint. The condyle is related to the middle cranial fossa and yet the most popular method of lateral cephalometric analysis relates the mandible only to the anterior cranial base.

Studies of the vertex view (inferior-superior) were designed to give some leads. From the orientation the temporal bone and sphenoidal great wing seem to be related in some functional arrangement, both to each other and to the Frankfort plane.

THREE-DIMENSIONAL ORIENTATION

Lacking serial x-rays in this view in the living, study was conducted on dried skulls. Some 65 skulls were available for examination in our laboratory. Skulls at birth, the deciduous and mixed dentition levels, the adolescent stage, and many different adult types were x-rayed in lateral, frontal and vertical views and all were oriented to the Frankfort plane. Three skulls, at birth, age three and an adult, were selected for comparison, and the characteristics were studied as seen in Figures 4, 5 and 6.

When the tracings were superimposed as if in a series (although they were different subjects) and with polar orientation, a phenomenon of gnomonic-like behavior was noted which could be likened to the entire growth span. In the vertical the angle formed by the two petrous temporals tended to meet at two common vertices, one for each side. The temporal bones seemed to be moving outward and backward from a general focal point at the base of the body of the sphenoid. This point was located quite near the same polar center discovered in the lateral and frontal computer printouts.[6] It thus appeared, in theory at least, that an XYZ or cartesian coordinate could be present in the head with the bisection of these bilateral foci.

With this type of consideration it became unreasonable to expect a functional growth connection of the joint to the *anterior cranial base* alone. Orientation to a polar center for facial growth, therefore, was from the *floor* of the entire cranial base, not its roof. Developmental behavior laterally, or from the vertical view, seemed to depend on the original divergence or inclination of the temporal bone from the sphenoid center or to depend on its early organizational pattern from neural and postural phenomenon (Fig. 7).

ORIENTATION TO STUDY THE GROWTH OF FACIAL CAVITIES

In a conceptual analysis of facial growth the Frankfort plane orientation with a vertical from the pterygoid root seemed to simplify and uncomplicate morphologic analysis. Several computer composites were available which led to methods of orientation. To portray these concepts three skulls were superimposed and analyzed and are used to illustrate the concluding principles (Figs. 8, 9, 10).

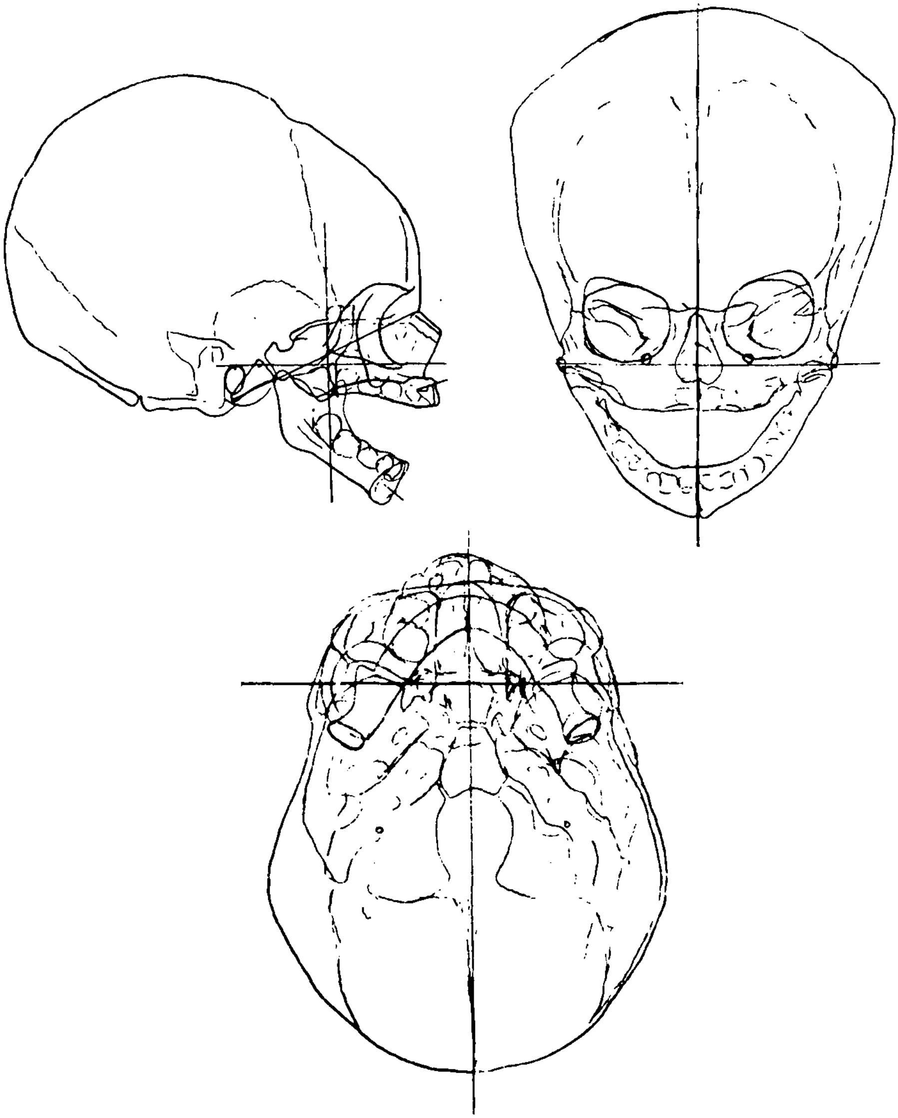

Fig. 4 Tracings of the newborn skull in the lateral, frontal and basal view all on Frankfort orientation. Note the basion-nasion axis in the lateral view.

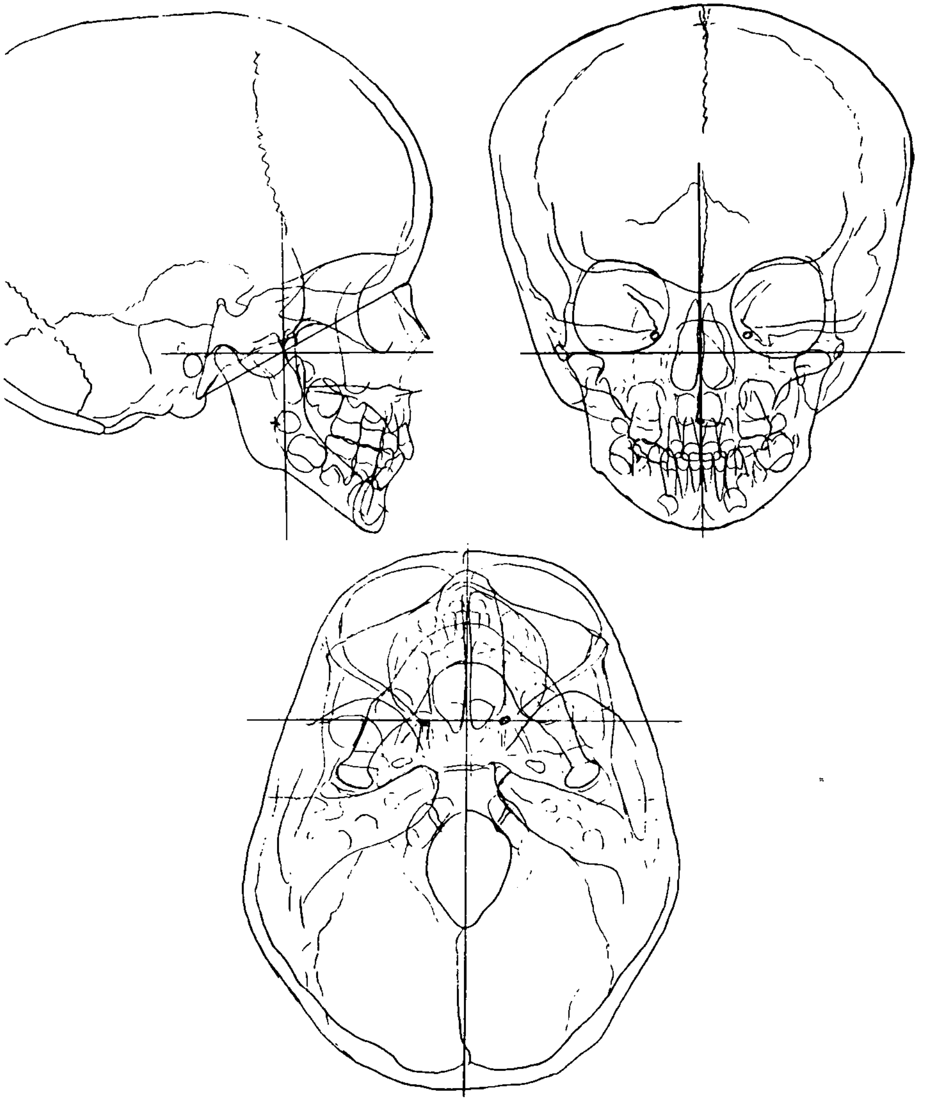

Fig. 5 Tracings of an approximately 3 year-old skull or one with full deciduous dentition development. Again on Frankfort orientation on the three dimensions and BaN included. Notice the dominance of the brain case. In the basilar view the transverse line is at PTV.

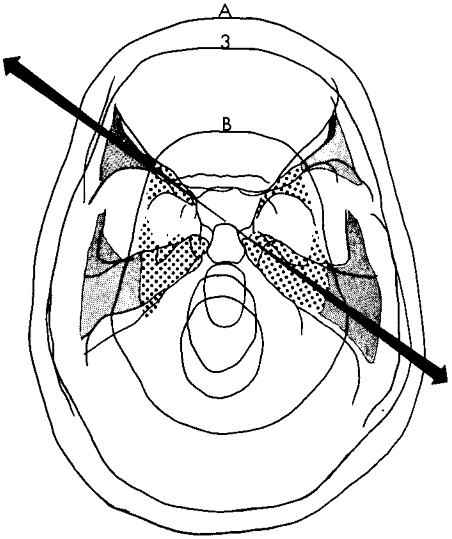

Fig. 7 The basilar view superimposed in the general area of cross-strutting of the orientation of the great wing of the sphenoid with the petrous portion of the temporal bone of the opposite side (B, birth; 3, age 3; A, adult). Such superpositioning gives good gnomonic behavior of the entire outline of the cranial floor. It also shows the outward and backward development of the temporal bone carrying with it the glenoid fossa together with the outward and forward growth of the great wing. This shows the lateral growth of the middle cranial fossa carrying the glenoid fossa outward and backward; compare with Figure 10 showing only the mandibular view.

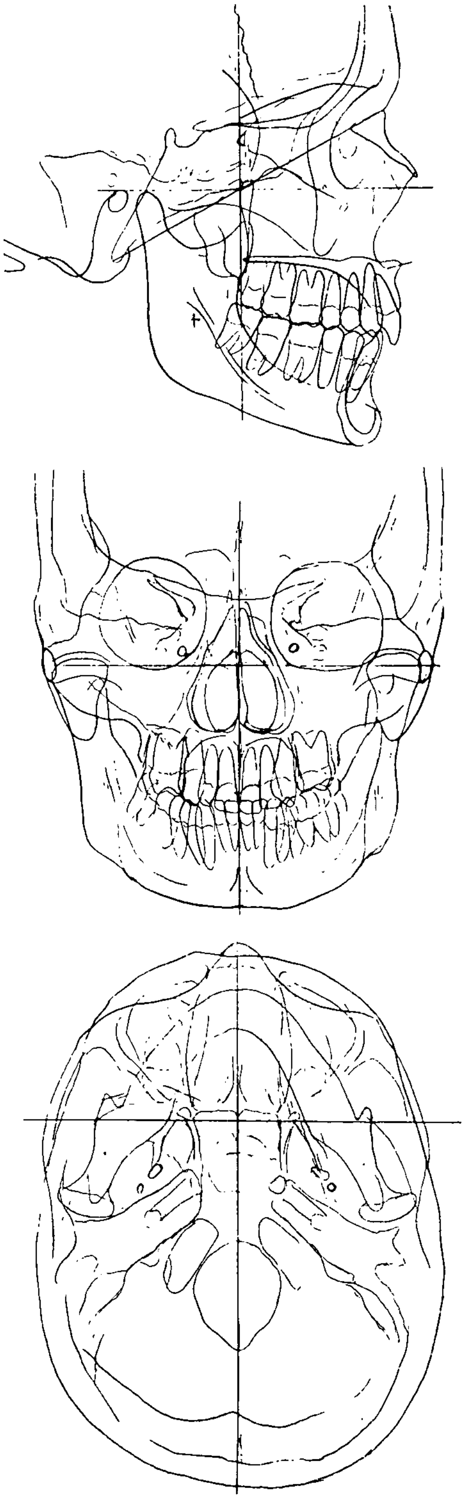

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Fig. 6 An adult skull, again x-rayed on the three different views of Frankfort horizontal orientation and traced accordingly. Refer to the analysis of these specimens in Figures 7-10.

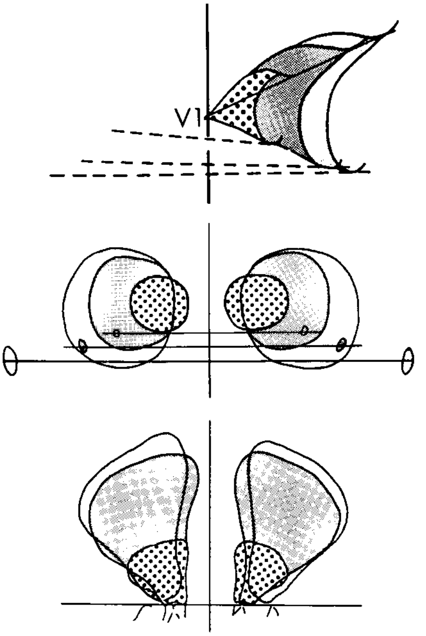

Fig. 8 Comparison of orbital cavities from Figures 4, 5 and 6. The development of the orbit is viewed in three planes of space and superimposed at the approximate area of the ophthalmic division of the fifth nerve (V1). Notice the tendency for gnomonic-like growth in all three views.

Orbital Growth

Looking from the lateral view, a gnomonic figure for the orbit is noted with the vertex located near the bottom of the superior orbital fissure at the exit from the skull base of the ophthalmic division of the fifth nerve, which is the sensory nerve to the superior part of the orbit and nasal cavity. The orbital nerve or orbital foramen located at the root of the small wings does not seem to yield a vertex for a gnomonic figure with growth. Thus, the blood and nerve supply to the functional eyeball, not sight, tends to dominate orbital morphology. Predictions of orbital growth can be made by projecting the trajectory of growth from the sites of entry of the sensory nerve. It should be remembered that two orbits and both halves of the face are involved; hence, two sets of bones are involved in adjustments for the orbit. From this type of gnomonic capsule analysis, the lower orbital rim drops downward somewhat during growth. As the roof of the orbit is supportive of the cranial vault, the floor of the orbit is in the face. Yet it is the same functional eyeball that is contained. With this type of consideration the lower border of the orbit or orbitale should be a reasonably stable reference, even though it is located in the face.

While the orthodontist is not particularly concerned about orbital growth (except in extreme hyperteleris or craniofacial dysostosis), he does use the lower border as a craniofacial reference for the FH plane. Also, the orbit is located as a part of the upper jaw; the floor of the orbit is the maxilla so it is within his realm of consideration. Thus, the lower border of the orbit, or orbitale, is probably of as much biologic significance as more common references in the anterior cranial base.

Nasal Growth

The nasal cavity is also complicated. Above, it is draped by olfactory nerves streaming downward from the olfactory bulbs lying superior to the cribriform plates. The nasal cavity also is served by the ophthalmic division above for sensory functions. But the majority of the maxillary elements and the maxillary sinuses are served by the maxillary division of the trigeminal. Since little motor function is needed within the nasal cavity, a moving functional site for growth would be difficult to exact. However, the exit of the maxillary nerve is at the foramen rotundum at the pterygopalatine fossa which, in addition, serves as a housing of the internal maxillary artery and nerve ganglia. This tends to be a vertex of an angle but, as mentioned above, the floor of the nose may be influenced somewhat by the oral cavity. A generality seems to fit. The gnomonic figure for the nasal cavity tends to follow the figure from foramen rotundum but, being bilateral, it can also be represented as a quadralateral structure for gnomonic growth although it is actually periform in shape.

It is of interest to note that the Frankfort plane through the lower border of the orbit almost bisects the nasal cavity. It is further significant that the line N-A holds a relative constancy to a line from foramen rotundum and orbitale. But, as stated earlier, the palatal growth vertically is difficult to predict until an analysis is made of the lower facial growth because there seems to be some limited dependence. This area of the face is affected by cleft palate surgery, and also by orthopedic intervention in orthodontics. Still, the line through orbitale and porion, i.e., Frankfort horizontal, serves as a useful reference for longitudinal considerations in the midface as well as for descriptive purposes.

Lower Face or Oral Cavity

Turning to the lower face, a gnomon was also observed from the computer composites. When it was discovered that Xi point was almost always at the mandibular foramen or canal, and when it was also found that the occlusal plane tended to be gnomonic to the corpus axis, a third phenomenon seemed likely and was observed. A line from the anterior nasal spine to point

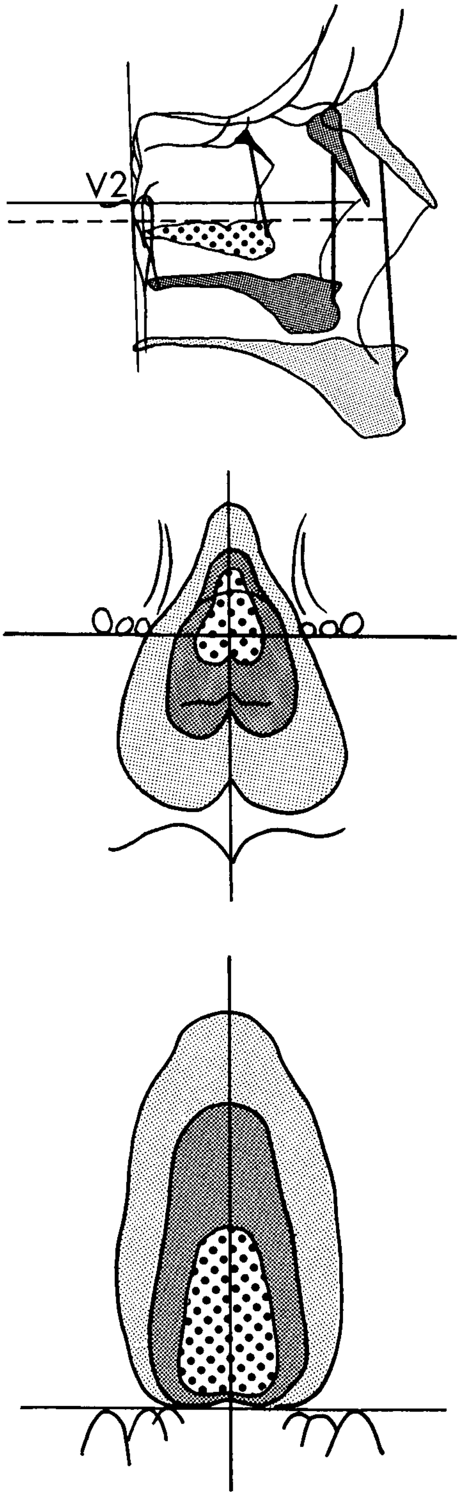

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Fig. 9 The same three skulls showing the general characteristics of the development of the nasal cavity in all three planes of space. Note in Figure 8 the orbit responding to neural (sight) involvement. The predominant growth was prior to age 3 while now in the nasal cavity, concerned with respiratory needs, the great amount of growth is after age 3. All three of these views on the nasal cavity are superimposed in the general vicinity of foramen rotundum or the maxillary division of the fifth nerve (V2).

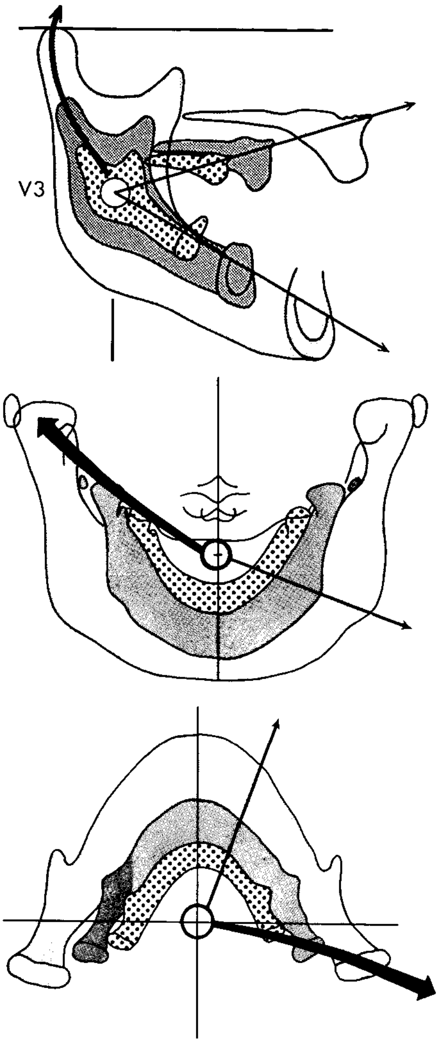

Fig. 10 All three views superimposed on the general vicinity of the Xi point or the common Xi point intersection or at the entrance of the mandibular division of the fifth nerve (V3). Notice the development of lower facial height and the gnomonic nature of growth in the lateral (above). Notice in the frontal view (center) the organization of growth upward and outward for the condyle, and downward and outward on the gonial angle. Notice (below) in the basilar view the organization of growth of the mandible even to the tendency for the orientation of the mental foramina areas. Note all three of these illustrations (Figs. 8, 9 and 10) would tend to support the neurotrophic theory in that the cavities tend to be oriented to the location of nerves.

Xi also produced a figure for the upper denture when compared with the occlusal plane. Thus, the angle ANS-Xi-Pm (suprapogonion) was found relatively constant (although the cases selected for demonstration, being cross-sectional, do not show it exactly); the tracings were adjusted slightly for illustrative purposes.

Furthermore, the location of Xi point in natural development tended to hold its angular relation to the zero point of the Frankfort plane and pterygoid vertical. This became the Xi axis and seemed to be unique for the individual under normal growth characteristics (Fig. 10). This is a key to organizational relationships of the upper to lower jaws and is much more biologically sensible than trying to connect the anterior cranial base to the mandibular border as is commonly attempted in many cephalometric analyses.

As further attempts to study the organized growth of the oral cavity were made, the same midpoint orientation between the mandibular foramina showed interesting relations. In the frontal, the condyles and coronoids emanated outward and upward in this orientation.

In the vertical view, points on the mandible also converged at the common point between the foramina. Growth from these foci remains to be proven, but these superpositionings are of tremendous interest.

SUMMARY

As composites were compared from the frontal and lateral, the organization tended to point to orientation of growth of cavities in the face from the divisions of the fifth nerve.

Three-dimensional constructed capsules of the orbital, nasal and oral cavities may be reduced to the inputs from the entrance of these nerves into their appointed functional matrices.

These orientations were found to be so useful and beneficial that they have been adopted for computer functions. They have also been found fruitful for prediction.

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