A Study of the Anterior Cranial Base

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The anterior cranial base was studied to investigate the variability in morphology and to correlate the anatomy of the different structures with the images obtained by lateral roentgenocephalograms. Attention was primarily directed to the posterior half of the endocranial surface of the anterior cranial base following the concept of De Coster,[1] who stated that what he described as the "base line" did not change after seven years of age. De Coster's approach has not been widely used, partly because the anterior part of the base line, representing the endocranial surface of the ethmoid bone, usually does not show up sufficiently well in lateral roentgenocephalograms.[8] Moore[6] proposed studying facial growth in relation to an individual bone and its immediate structures, rather than taking points on several distantly located bones separated by growing areas. He selected the sphenoid bone for that purpose because of its interrelationship with all the bones of the face and cranium. This led to the introduction of the ethmoid triad registration,[7] later used by Wieslander[10] in the evaluation of the effects of orthodontic treatment.

The significance of the anterior cranial base in the analysis of craniofacial morphology and in the evaluation of growth and treatment changes motivated the study presented here. Furthermore, it was felt that the implications recently placed on the sphenoidal wing point, in its relation to the sphenoethmoidal junction, as a guide to the boundary between the anterior and posterior parts of the anterior cranial floor,[4] could be analyzed in detail on dry skeletal material.

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Material and Methods

Eighty human skulls were investigated, the majority of which originated in India. The total sample was divided into five age groups, estimated on the basis of the developing dentition (Table I).

The endocranial surface of the anterior cranial base was studied in detail and drawings were made. A short piece of .005 brass wire was glued in the transverse direction to the sphenoid bone to mark its most anterior median point. The distance between the metal mark and the anterior lateral margins of the sphenoid bone was recorded. Subsequently, standardized lateral roentgenocephalograms were taken. The radiographs were analyzed regarding:

1. The contour of the images of the anterior surfaces of the great wings of the sphenoid bone and their relation to the anterior floor.
2. The distance between the images of the projections of the great wings at the anterior cranial base level.
3. The distance between the metal marker and the midpoint between the wings at the anterior cranial base

TABLE I

The dry skull material was subdivided into 5 age groups, estimated on basis of development of the dentition.

From 2 to 6 years	23
From 7 to 12 years	20
From 13 to 16 years	17
Young Adults	5
Adults	15

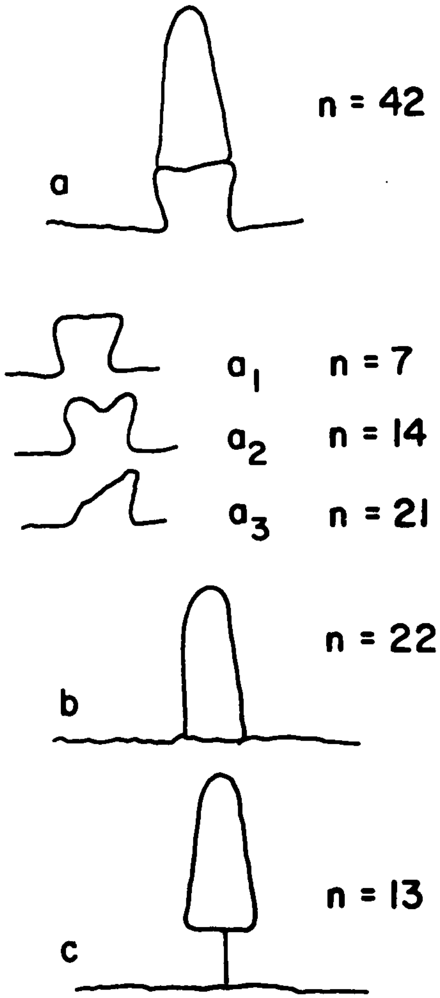

Fig. 1 Variations in the morphology of the endocranial surface of the anterior cranial base.

a) The median part of the sphenoid bone extends anteriorly in relation to the anterior lateral margins in
   a_1—symmetrical form with a straight anterior medial border
   a_2—symmetrical form with a concave anterior outline
   a_3—asymmetrical form.
b) The median part is in the same transverse plane as, or slightly dorsal of, the anterior lateral margins of the sphenoid bone.
c) The sphenoid and ethmoid bones are not in contact with each other. The orbital plates of the frontal bone meet in a sagittal suture between them.

TABLE II

Different aspects of the morphology of the endocranial surface of the anterior cranial base.

Type	n	Asym.	n
a_1	7	—	17
a_2	14	±	10
a_3	21	+	27(7)*
b	22	++	23(16)
c	13		

— : no noticeable asymmetry
± : light,
\+ : moderate, and
++ : marked asymmetry.
* : between parentheses the number with accessory bones.

level. The latter has been indicated by Enlow et al.[4] as point SE, and by Knott[5] as point W.

Findings

The anterior cranial base showed a number of variations regarding the boundaries and articulations of the individual bones. Three main types of relationships were distinguished, as illustrated in Figure 1. Further, the sphenoid-ethmoidal and sphenoid-frontal junctions were studied regarding asymmetry and the occurrence of accessory bones at the suture areas. The findings obtained by inspection are given in Figure 1 and Table II. The information obtained from the roentgenocephalograms is presented in Figures 2, 3, and 4.

In the great majority of cases the cranial floor intersects the images of the great wings at their most anterior region (Fig. 2). In cases where this was not true, the discrepancy was never larger than 1.5 mm.

The distribution of the distances between the two projections of the sphenoid bone's great wings at the anterior cranial base level (Fig. 3) reflects, besides anatomical asymmetries in the structures themselves, the differences in enlargement of the left and right sides

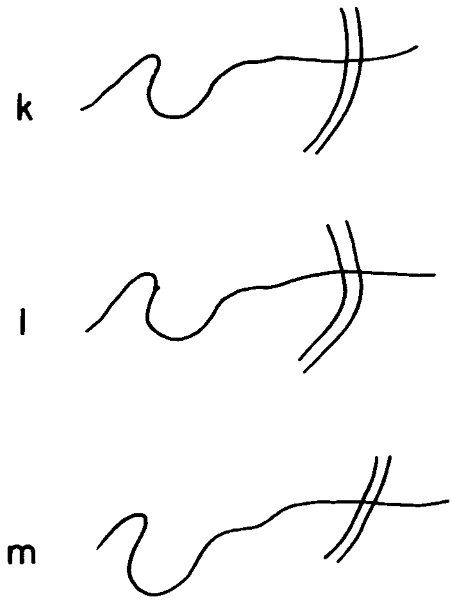

Fig. 2 Variations in the projections of the great wings of the sphenoid bone in their relation to the anterior cranial floor.

k) The cranial floor intersects the images in their most anterior region, N=64.

l) The cranial floor is superior of the images of the most anterior region of the great wings, N=12.

m) The cranial floor is inferior of the images of the most anterior region of the great wings, N=4.

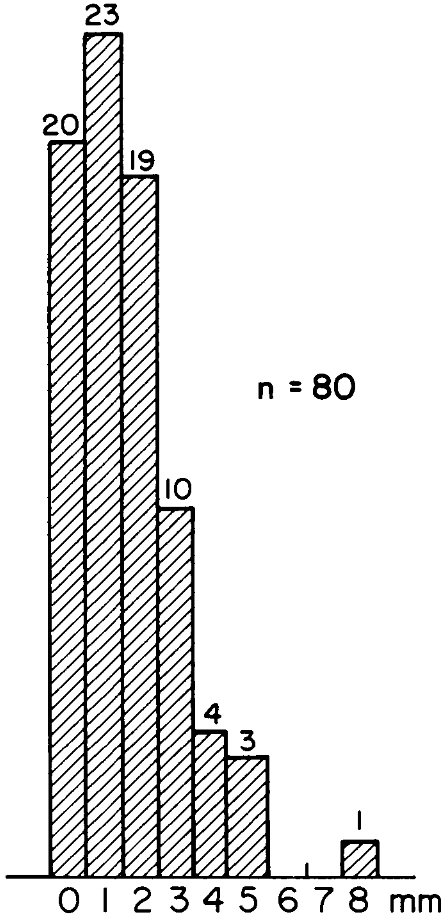

Fig. 3 Histogram of the frequency distribution of the distances in millimeters between both projections of the great wings of the sphenoid bone at the anterior cranial base floor level. (The 8 mm case belongs to a greatly asymmetrical skull).

of the skull on the film. Also reflected are the asymmetry of the head, the location of the ear holes in particular, and the variation in head positioning at the moment the cephalograms were made.

In Figure 4 the different types of morphology of the anterior cranial base are plotted for two measurements as indicated in the insets and the legend. The cases with an anteriorly extending medial part (type *a* of Fig. 1) in general also seemed to have a more anteriorly positioned mark in relation to the great wings.

To eliminate to some extent the variation in the morphology of the medial part of the anterior cranial base, the average of the distances measured on the skull between the most anterior median point and the anterior lateral margins (p in Fig. 4) was subtracted from the difference recorded on the radiographs between the mark M and the point W. The results, representing the relation of point W to the lateral anterior margins of the sphenoid bone, are given in Figure 5. The range is not noticeably reduced in comparison with the data in Figure 4; the variation is still quite large.

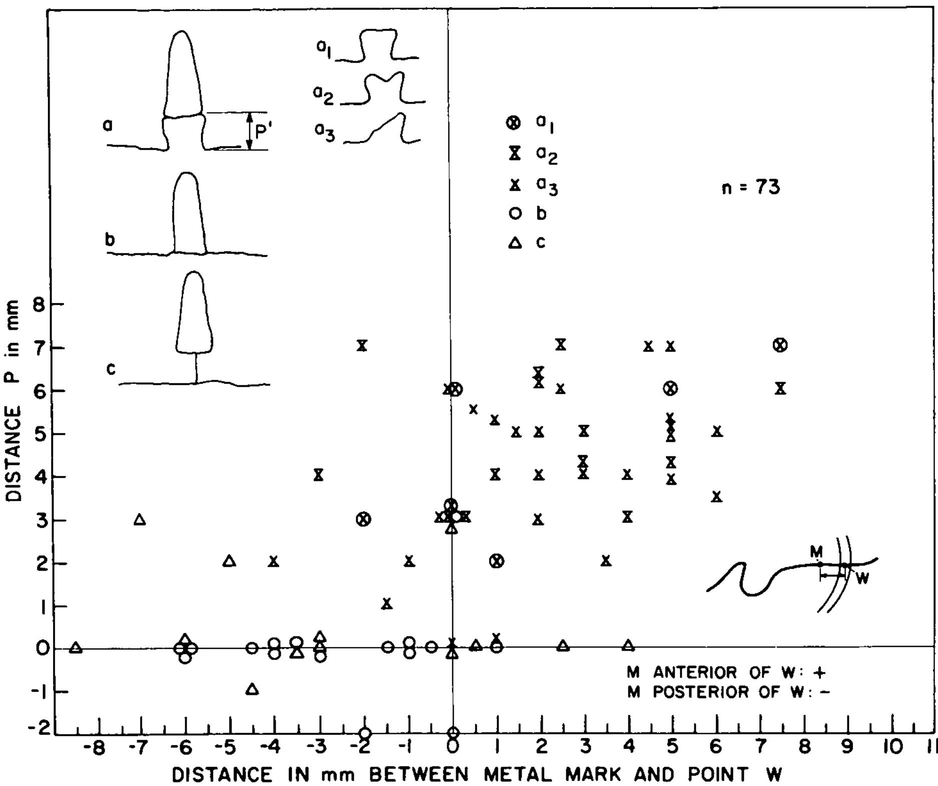

Fig. 4 Distribution of the different types of morphology of the anterior cranial base in relation to the average (mm) of the left and right distances indicated for the latter as p' in the inset (on the vertical axis) and the distances (mm) between the metal marker (M) and the midpoint between the images of the great wings of the sphenoid bone at the anterior cranial base level (W) (on the horizontal axis).

All details presented above were also analyzed for the five different age groups separately. There appeared to be no differences for any aspects studied in the separate stages.

Discussion

The findings presented above indicate that considerable variation exists in the morphology of the endocranial surface of the anterior cranial base. The same holds true for the relationship between the most anterior outlines of the great wings, the median anterior endocranial border and the anterior lateral endocranial margins of the sphenoid bone.

The assumption that point *W* can serve as a substitute for the midline sphenoethmoidal junction is not supported by the findings presented here. In most cases the sphenoethmoidal and sphenofrontal junction had an irregular course. The variations between the midline and lateral structures were considerable.

This brings up the point of how much preference should be given to midline structures in the analysis of craniofacial morphology and growth. The picture of a lateral roentgenocephalogram is formed by the projection of all structures of the head on a plane parallel to that of the midsagittal. If midline structures possess adequate significance for the analysis of morphology and growth, they can well be used, but

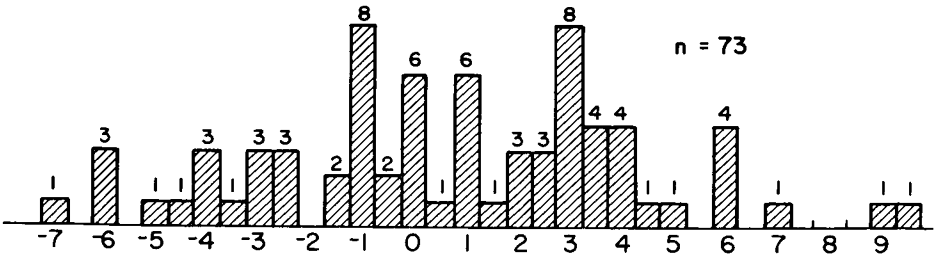

Fig. 5 Histogram of the distances between the anterior-lateral margins of the sphenoid bone and the midpoint between the images of the great wings of the sphenoid bone on the anterior cranial base level (Point *W*).

when lateral points can give an anatomically more correct presentation, they should be given preference. This, for example, is the case for the posterior demarcation of the maxilla, where the dorsal outlines of the maxillary tuberosities form an anatomically more correct delineation of the maxilla than does the posterior nasal spine. The maxilla, as the mandible, is arch shaped, rather than being primarily a midline structure. Furthermore, the posterior nasal spine is of the palatine bone, rather than of the maxillary. According to the same concept, subspinale (point *A*) is of limited value.[9]

In the interpretation of roentgenocephalograms, the midpoints between the paired lateral structures are generally used. They form, together with those located in the midline, one unit of information of the three-dimensional head. The midpoints of lateral images may be more representative for certain structures than those of the midlines and can, as such, contribute to a better interpretation. A good approach is to project the different structures in one plane; however, this should not lead to undue preferences for points located in the midsagittal plane.

With this in mind, the data presented in this paper may be reconsidered. It then becomes clear that point *W* forms an adequate representation of the anterior outline of the middle cranial fossae and, as such, presents a landmark that can be used for a demarcation of the head in anterior-posterior direction, now based on the morphology of actual neural tissues, rather than on the more variable and less reliable course of bone-to-bone junctions.

In this context, it may be of interest to mention that the distance between the pituitary point and point *W*, as seen on lateral cephalograms, does not increase from six to fifteen years of age.[5] This finding further supports the value of the superposition on the ethmoid triad which is, for the most part, formed by the cranial base outline between those two points. However, it must be realized that the cranial base can undergo dimensional and rotational changes not reflected in this measurement. The endocranial surface, indicated by the line of De Coster or the ethmoid triad, will be remodeled during the growth process and, as a rule, will be subjected to resorptive changes.[2]

Summary

The anterior cranial base morphology was studied in eighty human skulls by inspection of its endocranial structures and by lateral roentgenocephalograms, including the use of metal markers. Considerable variation was noticed in the outlines of the endocranial margins of the individual bones. This held true particularly for the midline region. Three different types of endocranial anterior cranial base morphology were distinguished.

The anteroposterior relationship be-

tween the most frontal outlines of the great wings, the median anterior endocranial border and the anterior-lateral endocranial margins of the sphenoid bones also showed considerable variation. There were no indications of a different pattern regarding the aspects studied for the different developmental stages.

The relevance of midline and lateral structures in the analysis of craniofacial morphology and growth is discussed. Point *W* is suggested as an anteroposterior demarcation point in head analyses, not as a substitute for the irregular and variable sphenoethmoidal junction itself, but as a true delineation based on the morphology of neural tissues since it represents the anterior outline of the middle cranial fossa.

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