Use of Foramina Spinosa to Determine Skull Midlines

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Asymmetry of the face is one of the more difficult problems with which orthodontists have to contend and which often presents serious diagnostic difficulties. The recognition of the actual site of asymmetry is essential for correct treatment planning.

Asymmetry is defined as being present when one or more of the facial or cranial bilateral components (bone or soft tissues) are not equidistant from the midline or that the center of each of the unpaired structures does not lie on that line.[12]

Gross asymmetries occur in developmentally acquired as well as in congenital abnormalities, such as unilateral complete cleft lip and palate,[3] first branchial arch deformities, facial hemiatrophy or hemihypertrophy, and in cases of unilateral ankylosis of the temporomandibular joint.[4,9] Such anomalies usually involve both soft and hard tissues. Minor asymmetries of the face are a common finding in normal individuals,[4,10,12] although they are rarely evident and generally pass unnoticed.[7,9] Minor asymmetry results from the normal differences in size or shape of bones forming the craniofacial complex.

Qualitatively, gross asymmetries are first recognized visually and only then quantitatively assessed. Gross asymmetry of soft tissue can be detected directly on the living face using the soft tissue nasion and pogonion as landmarks for construction of the central line.[12] This method is not precise and cannot be easily reproduced.

An alternative and more accurate approach is to use standardized full-face photographs of the subject and later pairing the right and left halves of the photographs with their respective mirror images.[13]

A still more precise method is to use radiographs of the subject after marking the soft tissue with a radiopaque material.

Asymmetry of the craniofacial bones can be quantified by X-ray techniques only. An orthodontic cephalometric unit may be used to produce posteroanterior, verticosubmental and basilar radiographic views of the skull.

The most common view used is the posteroanterior on which workers have used different reference points for construction of the midline of the face, which is essential in the study of asymmetries. Cheney[2] draws the midsagittal plane through nasion and the anterior nasal spine. In symmetrical faces the extension of this line will pass through prosthion and menton. Sutton[12] in his study of the cephalometric posteroanterior view found that subnasale, prosthion and pogonion are rarely found on a straight line, which indicates the uncertainty of these points as an indicator of the midline. Mulick[7] suggested the use of the ethmoid triad point, anterior nasal spine, and menton as registration points in his study of asymmetry using the twin-study method.

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In subjects where part of the anatomical structures of the midline mentioned above are destroyed or displaced, as in cleft lip and palate, Harvold[3] constructs the midline geometrically. In this method a horizontal line is drawn between the lateral parts of the zygomaticofrontal sutures and the midline used in perpendicular to this line drawn through the root of crista galli. Plint,[9] who was unhappy with the midlines used by others, suggested that the landmarks for construction of the midline should be those which are part of the base of the skull, outside the face. He recommends this due to the fact that asymmetry may be linked with and involve differences in size and morphology of facial structures such as the eyes, nose, ears, maxilla and others. Berger[1] proposed the use of the basilar cephalometric view. He drew his midline through the dens of axis, vomer, posterior part of nasal septum and crista galli. Nahoum[8] suggested the verticosubmental view in cephalometrics to improve the image of the mandible and adjacent structures on the radiograph.

All of the above-mentioned midlines were constructed using bony anatomical landmarks on the face or on the base of skull, which were assumed to be either on the midline or equidistant from it. However, these structures can be altered when the asymmetry is being developed in an acquired or developmental abnormality.

Moss and Salentijn[6] concluded that there are several functions which cannot be violated during orofacial growth, one of which is the passage and location of the neurovascular bundle. In their studies it was shown that, for example, the position of foramen ovale was remarkably constant for any given dental age. Assuming the validity of their findings for other basal foramina, we hypothesize that a midline drawn between the basal foramina will be reliable.

The aim of this study was to explore the reliability of the midline drawn between the foramina spinosa on the cephalometric basilar view for the study of asymmetry of face and cranium.

Materials and Methods

A group of 86 adult skulls, originating from India, were chosen randomly for this study. No information about the sex and age of those skulls was available.

Each skull was radiographed after being placed in a Broadbent-Bolton cephalostat. Each skull was fixed by inserting the ear rods into the external auditorial meatuses. Skull orientation was that a plane determined by the external auditory meatuses and the infraorbital foramen was perpendicular to the floor. The base of the skull was directed toward the source of radiation. The mandible of each was fixed by wires to the skulls using occlusion as the guide for stabilization.

An X-ray film inserted in an intensifying cassette was placed next to the vertex of the skull perpendicular to the central beam. The source of radiation was a General Electric 90-II X-ray machine with a fixed distance of 150 cm from the center of cephalostat. Radiographs were taken using an exposure of 60 KV, 15mA for 0.8 of a second and the films processed in an automatic processor (Fig. 1).

Each radiograph was traced on acetate paper; the centers of the foramina spinosa were connected, and the midperpendicular line was drawn to serve as the "midline of base of skull" which will be termed from here on as "the centerline" (Fig. 2).

On each tracing a series of perpen-

Fig. 1

dicular lines was drawn from the following, unpaired anatomical landmarks to "the centerline," if they were not on the centerline. These included unpaired landmarks: opisthion, basion, posterior part of vomer, nasal crest of palatine bone and nasal crest of maxilla. The same was done with homologic anatomical structures on the base of the skull and the face. These included: anterior and posterior rims of foramen ovale, center of infraorbital foramen, porion and the medial aspect of the head of the mandibular condyle.

On the same tracing and in equal intervals, another series of perpendicular lines was drawn from "the centerline" to the periphery of the facial and cranial bones which included: frontal bone (lateral anterior border, lateral border adjacent to the sphenoid), maxillary bone (medial

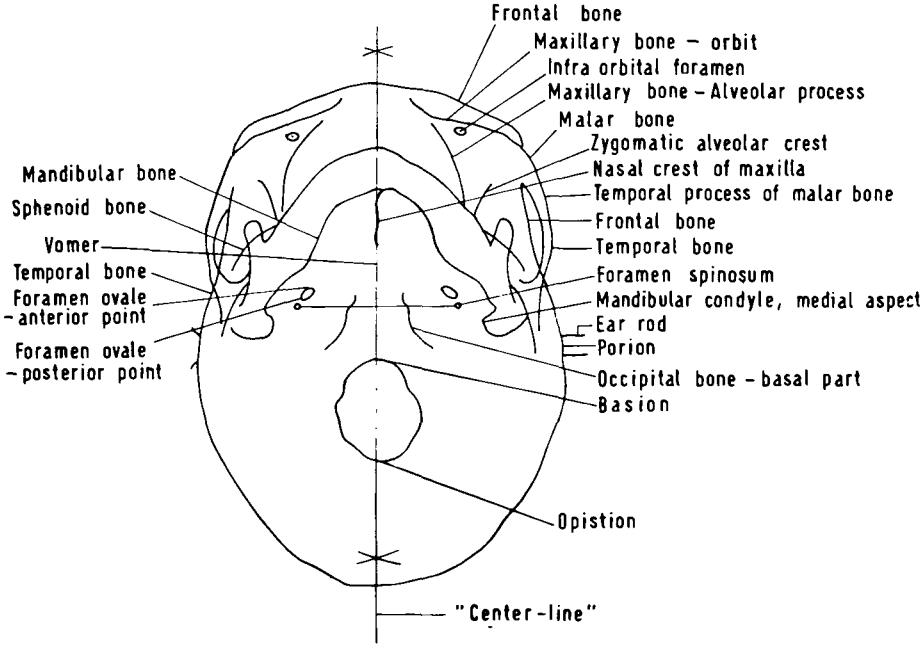

Fig. 2

TABLE I

Deviations of midsagittal (unpaired) anatomical landmarks.

Anatomical landmarks	*Number*	*Mean deviation (in mm)*
Opisthion	86	0.2 ± 1.6
Basion	86	0.1 ± 1.0
Posterior part of Vomer	82	0.6 ± 1.0
Nasal crest (palatine bone)	83	0.6 ± 1.0
Nasal crest (maxilla)	80	0.7 ± 1.2

TABLE II

Deviation of homologic anatomical structures.

Anatomical structures	*Number*	*Mean deviation (in mm)*
Anterior rim of foramen ovale	85	0.4 ± 0.7
Posterior rim of foramen ovale	85	0.3 ± 0.6
Center of infra-orbital foramen	40	0.8 ± 2.0
Porion	86	0.3 ± 1.5
Medial aspect of head of mandibular condyle	24	0.3 ± 0.9

and inferior border of orbit, lateral aspect of alveolar process, posterior lateral border of zygomatic alveolar crest), mandible (medial border of body, medial border of ramus, medial aspect of condyle), temporal bone (lateral border, lateral of zygomatic process) malar and occipital bones.

Measurements by a Fimec-Metricu calipers, calibrated to 0.1 mm, were made for all perpendicular lines (left and right sides separately). Half the difference between both scores was defined as the deviation from "the centerline."

Means and standard deviations were calculated for each set of measurements.

To check the reproducibility of this method, a random sample of eight X-rays was chosen and a second tracing made of each. Two hundred forty-four measurements were carried out. It was found that the mean of double measurement error amounted to 0.5 mm.

Results

Tables I and II present the measurements made between the unpaired anatomical structures in the midsagittal plane and the bilateral homologic anatomical structures in their relation to "the centerline."

From Tables I and II it is evident that the average deviations are within the limits of measurement error, thus it can be concluded that "the centerline" is indeed in the midsagittal plane.

Table III presents data obtained from measurements carried from "the centerline" to several homologic points on the periphery of calvarian and facial bones. From Table III it is clear that for a random sample of

TABLE III

Deviation of the periphery of facial and calvarian bones from "the centerline."

Bone	*Number*	*Number of measurements*	*Mean deviation (in mm)*
Frontal	86	325	1.1 ± 1.7
Maxilla	86	338	0.5 ± 1.7
Mandible	26	152	0.2 ± 1.1
Temporal	86	493	0.7 ± 1.2
Malar	86	252	0.8 ± 1.1
Occipital	84	159	0.3 ± 0.7

skulls, like those used in this study, the craniofacial bones were found to be quite symmetrical in relation to the centerline as the deviation of peripheral points from the centerline was within the limits of 1.0 mm.

Discussion

In the determination of the centerline in conventional cephalometric techniques, many different anatomical landmarks have been suggested. This fact may indicate that there is no method which is totally reliable and universally accepted.

For the most part the centerlines have been constructed in relation to points on the facial skeleton, bones which themselves are often being examined for asymmetry. Additionally, these "midlines" have never been checked to see whether they coincide with "midlines" drawn from the center of the base of the skull or from those drawn on other structures of the facial skeleton.

We are proposing a midline which is based on anatomical landmarks which are believed to remain constant throughout growth and development of the skeleton.[6] Moreover, since we are examining asymmetries of the facial skeleton, our use of a centerline constructed from points in the base of the skull would seem to have significant advantage over other methods.

This centerline was constructed on radiographs of 86 skulls. Many measurements were made from paired and unpaired landmarks to the line, and it was found that its reliability was very high, with a mean deviation from it of a millimeter or so. Woo,[14] in a study of the variation in size of the bones on one side of the face and cranium to the other, found differences of a similar magnitude. This degree of deviation may be regarded as the "normal asymmetry" of these bones and passes unnoticed in clinical examination.

There are two other factors which are methodological in origin and must be considered when evaluating this technique. These are as follows:

(a) In the various X-ray tracing techniques there are often difficulties involved in the identification of the anatomical landmarks. In a retracing exercise one may often find discrepancies in the location of these points. In this way a millimeter or so may be included in the error of method in many cases.

(b) The skulls are standardized in their position by reference to the external auditory meatuses, which themselves may not be at exactly the same horizontal level. A small difference in their positions will cause a rotation of the skull influencing the radiographic representation of the asymmetry. In the living patient the use of a modification of the "natural head position" as described by Moorrees and Kean[5] and Solow and Tallgren,[11] but where only one ear rod will be used, may eliminate this problem. Another solution, as suggested by Mulick,[7] is to use direct measurements from the reference points to the areas measured without the actual need of a midline.

In conclusion, we propose a method for the construction of a midline which has a high degree of reliability and can be used with confidence in quantifying the degree of asymmetry that may be present. This line is determined by the use of neural foramina in the base of the skull (foramen spinosum), which are believed to be relatively unaffected by environmental factors. We recommend the use of the cephalometric basilar radiographic view on which these structures are clearly visible.

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