Correction Of Frontal Dimensions From Head X-Rays

CARLOS-JORGE VOGEL, D.D.S., M.S.

CHICAGO, ILLINOIS

INTRODUCTION

Roentgenography, particularly that of the head, is being employed increasingly for investigative purposes. This has required the utilization of measures for the correction of the well-known limitations and errors of all x-ray methods, viz., the superimpositioning of images, distortion and enlargements. The first of these has been overcome to a limited degree by projections from a complementary exposure taken at right angles to the first while distortion and enlargement have been minimized by the careful positioning of the subject and by sufficient target-film distance in combination with correctional scales.

The bilateral symmetry of the head affords means for correcting the dimensions derived from the sagittal film through the superimposing of right and left structures. Such correction of frontal dimensions, however, is only possible through the projection of points discernible in both the frontal and the lateral films. A method to accomplish this by drafting techniques was developed by Wylie and Elsasser.[7] They showed that it was possible under ideal conditions, i.e., with perfect positioning of the head.

It was the purpose of the present work to attempt to find additional landmarks for measurements in the frontal plane as well as to determine whether correction was possible in the presence of less than ideal positioning.

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MATERIAL

The material used in this study was of two kinds. The first was a collection of ten skulls, used to check the accuracy of the technique. The second was a series of twenty-six sets of frontal and lateral cephalometric x-rays of a single female taken periodically from three years, one month to nineteen years, six months. These were studied to appraise the usefulness of the method.

All films were taken with the aid of the Broadbent-Bolton cephalometer in the Department of Orthodontics of the University of Illinois. The machine was checked optically for correct orientation of the two anodes with the transporionic axis and the midsagittal plane. Templates were secured on blank films to aid in the precise orientation of the x-ray images to the machine. These will be described later.

The location of the same landmark in both the lateral and frontal films is fraught with great difficulty because of superimposed images in one or the other. To determine which landmarks would be available for study every such possible landmark was made discernible on skulls by lead markers. These landmarks were then sought in films of the living and if they could not be delineated they were discarded. Those which met all requirements were: (1) frontal spine, (2) odontoid process of the axis, (3) the junction of the lambdoidal and sagittal sutures (lambda), (4) optic foramen, (5) foramen rotundum, (6) most lateral point on the zygomaticofrontal suture, (7) zygomaticomaxillary suture and subjacent max-

illary crest (jugal process), (8) eminentia arcuata of the petrous portion of the temporal bone, (9) mastoid process, and (10) maxillary and mandibular first molars.

Method

Distances between the accepted landmarks were established from the frontal headplates by both Wylie's and the author's method of correction. The data thus obtained were compared with the measurements which had been taken previously, directly from the skulls, by anthropometric methods.

Some of the landmarks have been used in previous studies and need no further explanation. Other points, however, were introduced in the present work and will be discussed below.

In order to determine the true cranial midsagittal line an anterior and a posterior landmark had to be established. As the anterior point the frontal spine was chosen. It could be depicted easily on the frontal film. On the lateral film nasion was considered to be the reference point for the determination of its frontal plane. While lambda could be identified as a posterior midsagittal point in the skulls, there was difficulty in locating it in the living material. Therefore, the tip of the odontoid process of the axis was taken as a suitable substitute for the posterior midline landmark.

The shadows of the optic foramina could be located in both frontal and lateral headplates. The lowest points of their outlines were considered as reference points for subsequent measurements.

The distances between the foramina rotundum were measured by using the most inferior points of their outlines representing their openings into the pterygomaxillary fissure.

The most lateral point of the zygomaticofrontal suture was taken from the frontal film and the center of the suture was taken from the lateral.

It was found that the most inferolateral point of the zygomaticomaxillary suture lay in the same frontal plane as the lowest point of the outline determined as the "key ridge" in the lateral film.

The arcuate eminence is an elevation of bone covering the superior semicircular canal and is located on the anterior surface of the petrous portion of the temporal bone. This landmark was first mentioned by Seward[6] and checked for its accuracy of location in the present work.

For the upper and lower molars the centers of their distobuccal cusps projected to the widest mesiodistal diameters of their crowns were considered as representatives of the most lateral points of their crowns.

Since the method employed in this study was based on Wylie's compensating method, it becomes imperative that his technique be reviewed first. The head x-rays are oriented on a transilluminated drafting surface in the usual manner, i.e., along their common transmeatal axes. They are then covered with matte acetate and all details traced (Fig. 1).

Wylie's compensating device (Fig. 2-top) included two components: the drafting surface or bedplate and a modified T-square. The bedplate is made of lucite, one-fourth inch in thickness. The sides and bottom of the plate form three sides of a rectangle while the fourth side is an arc. Two lines are engraved in the material. One is parallel to the base of the bedplate and represents the transporionic axis. The other is erected at right angles to the middle of the transporionic axis and represents the midsagittal plane. The top or fourth side of the bedplate is cut to form the arc of a circle which is concentric to one with a radius of five feet from

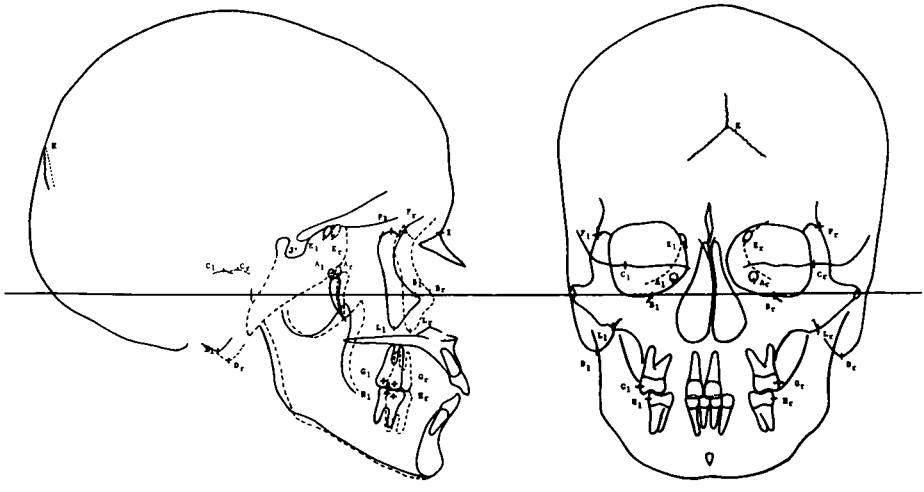

Fig. 1, Tracings of lateral and frontal head X-rays oriented on Frankfort Horizontal. Note that both left and right sides are traced.

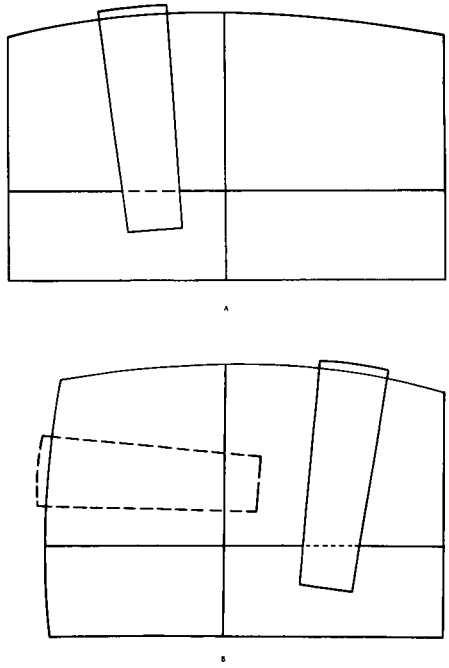

Fig. 2

the intersection of the two engraved lines. The T-square is so modified that its bearing edge adapts perfectly to the arc of the bedplate and its sides form radii representative of divergent frontal roentgen rays.

Arbitrary lines designated as the midsagittal plane and the transporionic axis are drawn on a piece of graph paper. This paper is then placed upon the bedplate so that the lines are superimposed on those permanently engraved in the bedplate.

The distance from the transporionic axis to the frontal film surface varies with the depth of the face and is always read at the time of the exposure. This distance is stepped off on the vertical or midsagittal line and a horizontal line is drawn through it. This represents the frontal film surface on the graph paper.

Correction of Measurements in the Frontal Plane According to Wylie's Technique

Following the complete tracing of the frontal plate, a straight line is drawn through midline structures (crista galli, nasal septum, etc.) perpendicular to the transporionic line. Points representing all bilateral structures that can be identified on both the frontal and lateral films are then located at their correct distances from the midsagittal plane of the tracing and transferred to the film surface line on the graph paper.

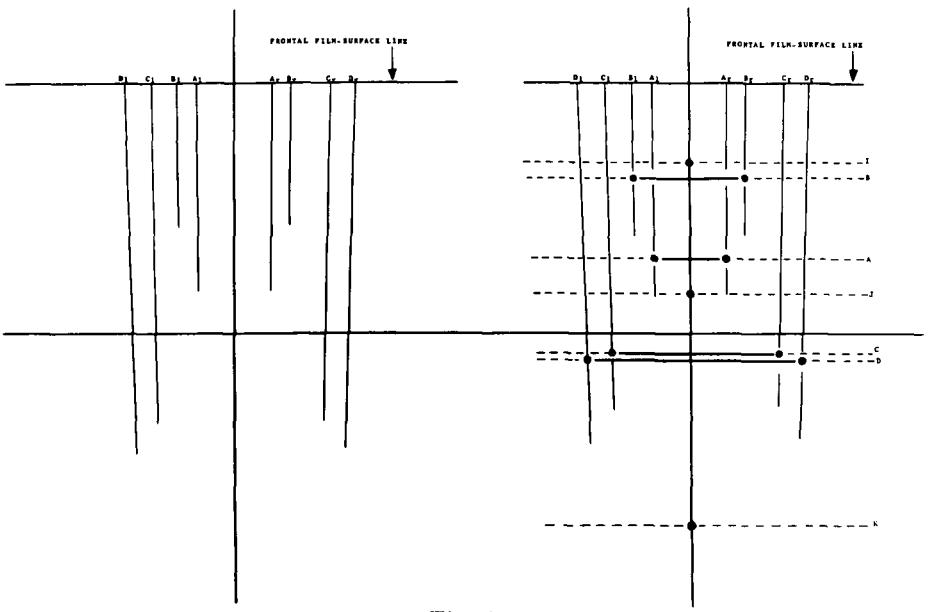

Fig. 3

The paths followed by the frontal roentgen rays in determining the images of the structures are drawn through these points with the aid of the T-square (Fig. 3-left).

Although the positions of the landmarks are now determined mediolaterally by the trajectories of the frontal rays, their exact anteroposterior location on those rays must be established. This can only be accomplished by projections from the lateral headplate.

On the lateral x-ray tracing the right and left images of the bilateral points are projected to the Frankfort horizontal line and then bisected in order to reduce distortion.[1] The distances of the bisection points to porion are corrected by means of correctional scales and transposed to the midsagittal line on the millimeter graph paper. Frontal planes are then drawn through those points parallel to the transmeatal axis; their intersections with the lines representing the corresponding frontal roentgen rays will determine the exact anteroposterior and lateral location of the landmarks (Fig. 3-right). In Wylie's method all midsagittal points will be located on the line representing the midsagittal plane on the millimeter paper. Such coincidence may not occur because of asymmetry or faulty positioning of the head in the cephalometer.

Correction of Measurements in the Frontal Plane According to Author's Technique.

The technique for correction of measurements in the present work diverges slightly from Wylie's method.

It was found necessary to alter the bedplate or drafting surface by modifying the left side in the same manner as had been done with the top edge. Here the edge was cut in an arc concentric to one of a five foot radius so that the T-square could be used for both arcs (Fig. 2-below).

Graph paper was oriented on the bedplate as was done in the previous method but, in addition to a frontal film plane, a lateral film plane was also represented by a line parallel and to the

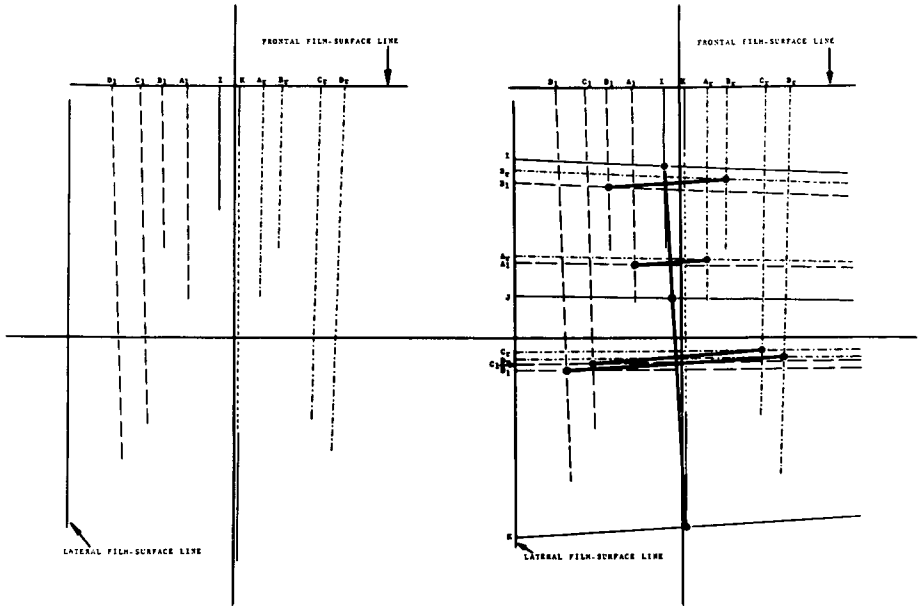

Fig. 4

left of the midsagittal line at the object-film distance taken at the time of the exposure. When the x-ray machine is oriented accurately, the central ray of the posteroanterior x-ray source passes through the bisection of the transmeatal axis and a lead reference point in the nasal rest.

Points representing the images of bilateral structures were located and transposed to the frontal film line but in a manner different from that of Wylie. In asymmetries or in cases where the head has been incorrectly positioned, the anatomical midsagittal plane will not coincide with the central ray axis. To eliminate possible error from this source the midsagittal anatomical points were located exactly where they were shown to lie on the film. Bilateral points were then transferred to the film plane line in their relations to the central ray. Using the T-square against the top edge of the drafting surface, lines representing the courses of the diverging frontal rays were then drawn through these points (Fig. 4-left).

Bilateral structures on the lateral film do not ordinarily superimpose exactly because of the divergence of the rays. Hence in an exact technique it is necessary to trace both images. Points representing these paired images are measured to a line perpendicular to Frankfort. This line represents a frontal plane passing through porion.

Right and left images are considered individually. The right landmark is plotted on the lateral film line and a line is drawn through it with the T-square engaged with the left side of the baseplate. The intersection with the line representing the course of the corresponding frontal ray marks the true location in space of the right landmark (Fig. 4-right). The measurement for the left point is recorded similarly on the film plane line. Extending the left lateral ray from this point, the exact location of the left landmark is determined as it intersects the left frontal ray. The anteroposterior relationship of midsagittal structures is ascertained by the same procedure.

SKULL #7 (Correct Position)

TABLE I

LANDMARKS	Direct Measurements	CORRECTED MEASUREMENTS Wylie's Method	Author's Method 1st	Author's Method 2nd
1. Foramen Opticum	24.75	24.00	24.75	24.75
2. Foramen Rotundum	33.50	33.25	33.00	33.25
3. Zygomaticofrontal Suture	96.00	96.50	96.00	96.25
4. Zygomaticomaxillary Suture (Jugal Process)	87.50	87.25	87.50	87.50
5. Eminentia Arcuata	77.50	77.50	77.50	77.75
6. Mastoid Process	99.25	99.00	99.50	99.00
7. Maxillary 1st Molar	59.00	59.50	59.00	58.75
8. Mandibular 1st Molar	53.50	53.50	53.50	53.50

TABLE II

SKULL #7 (Turned Position)

LANDMARKS	Direct Measurements	CORRECTED MEASUREMENTS Wylie's Method	Author's Method 1st	Author's Method 2nd
1. Foramen Opticum	24.75	24.50	24.75	25.25
2. Foramen Rotundum	33.50	33.50	33.50	33.50
3. Zygomaticofrontal Suture	96.00	95.00	96.00	96.00
4. Zygomaticomaxillary Suture (Jugal Process)	87.50	86.75	87.00	88.25
5. Eminentia Arcuata	77.50	76.75	77.50	77.75
6. Mastoid Process	99.25	98.75	99.25	99.50
7. Maxillary 1st Molar	59.00	59.00	59.00	59.00
8. Mandibular 1st Molar	53.50	53.25	53.50	53.50

Findings

The measurements taken from one skull are given in Table I. In order to check the accuracy of location of the landmarks and their subsequent bilateral measurements their x-rays were traced twice. An interval of six months intervened between the taking of the two measurements.

Table I shows the measurements taken from skull #7 with the skull centered in the cephalometer in the position approved for cephalometric x-rays by the Broadbent-Bolton technique. Without removing the skull from the machine after the first set of headplates had been taken, it was rotated to the extreme limits permitted by the ear rods. The measurements taken from the headplate in this "turned position" are shown in Table II. Except for the readings for the zygomaticomaxillary suture, the two readings taken at subsequent dates seem to fall within the limits of acceptability which was considered to be 0.5 mm. When compared with measurements taken according to Wylie's method it can be seen that the values from our study are more in agreement with those taken directly from the skulls.

Measurements taken from a living female series from three through nineteen years of age revealed (Fig. 5):

The foramen rotundum and foramen opticum followed a parallel path in their growth development. They seem to undergo rapid increase until the age of three and one-half years after which the rate of growth decreased slowly

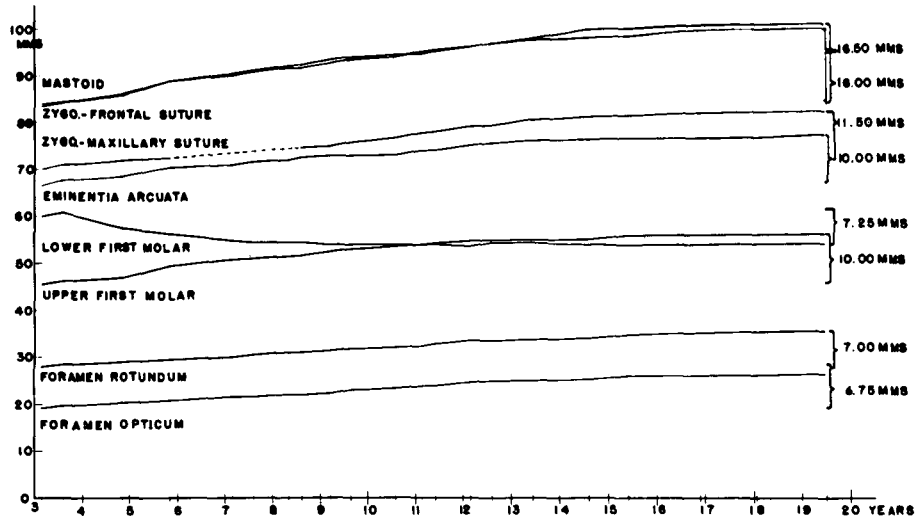

Fig. 5

until nine when a prepubertal increase started. This continued until fifteen and one-half years when it ended.

The eminentis arcuata showed a rapid increase until seven and one-half years of age, slowing down thereafter until the circumpubertal growth. This stopped at the age of thirteen.

The zygomaticomaxillary suture, after its initial growth, slowed down at the age of three years, increased rapidly during the prepubertal period, and came to a stop during the sixteenth year.

The zygomaticofrontal suture revealed a slowing down at the age of six followed by a slight increase at the age of nine and ending at sixteen years.

Mastoid development followed closely that of the zygomaticofrontal suture presenting, however, a less accentuated pubertal growth period. During the sixteenth year it reached its permanent position.

The lower first bimolar width showed a slight initial increase but at the age of three and one-half years it started to decrease rapidly. This decrease continued at a slowly diminishing rate until the age of fifteen when it became stable.

The upper first bimolar width increased rapidly until its eruption after which the increase, although steady, was at a slower rate until the age of fifteen when it ceased. Both the upper and lower bimolar widths presented a plateau of relative stability during the period from twelve to fourteen and one-half years, when an increase in the upper and a decrease in the lower bimolar widths were noticed. Both remained steady after the age of fifteen and a half years.

There was no change in any of the observed dimensions after the age of seventeen and four showed no change after fifteen years.

By using this method it was found possible to determine certain anteroposterior, as well as bilateral, asymmetries, viz., those discernible in both lateral and frontal films.

The left landmarks were located more anteriorly than the right landmarks in this individual. The range of this asymmetric position was between one and three mm except for the eminentia arcuata where that of the left side was located 10.75 mm forward of the right.

In the frontal aspect, the right landmarks were located closer to the midsagittal plane with the exception of the eminentia arcuata and the zygomaticofrontal suture. The range of these asymmetries was 1.9 to 2.9 mm from the midline.

The zygomaticofrontal sutures were found to be equidistant from the midsagittal plane.

The eminentia arcuata showed a marked asymmetry of 11.8 mm, the left side being located closer to the midsagittal plane.

All anteroposterior and bilateral relationships were constant throughout the growth period varying only in their absolute values.

808 S. Wood St.

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