The Mesh Diagram And Cephalometrics

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Present methods for studying cephalograms date from the last century or earlier and they can be summarized as follows:

(1) The mesh diagram. Introduced at the beginning of the sixteenth century by Albert Dürer, this method constitutes the classic approach for studying facial proportions in art. The mesh is constructed by inscribing the face in a rectangle and drawing horizontal and vertical lines through various anatomical landmarks. The shape of the outside rectangle and the relative position of the lines drawn through corresponding landmarks illustrate differences in facial proportions among individuals.

By changing the relation between horizontal and vertical coordinates of a rectilinear equidistant coordinate system, Dürer also demonstrated that different facial forms can be reduced to a common pattern. Similarly, D'Arcy Thompson[1] utilized transformations of a coordinate system for his studies of growth and form. This method was applied by De Coster[2] and subsequently by Moorrees[3] to analysis of standardized head radiographs.

(2) Angular measurements. Pieter Camper (1722-1789), the Dutch anatomist, determined the profile contour by an angle (Fig. 1). Thus, instead of drawing Dürer's mesh, Camper used only two coordinates and measured the angle between them. Many contemporary cephalometric analyses exemplified by Downs[4] and Schwarz[5] make use of angular measurements.

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(3) Two perpendicular coordinates. A system of two perpendicular coordinates used previously by Lucae[6] in 1864 is found again in Coben's[7] studies of facial growth.

(4) Mathematical figures. The triangle is a convenient mathematical figure that is defined by three parameters. It was advocated for craniometric studies by Koster[8] in 1860 and first applied to orthodontic diagnosis by Margolis[9].

The polygon dates back to a report of Welcker[10] in 1868. Hellman[11], Björk[12], and Korkhaus[13] also selected this figure for analyzing facial form and growth.

Of these methods, the mesh diagram is particularly suited for studying facial morphology because the findings are shown graphically, facilitating interpretation. For research purposes it can be subjected to mathematical and statistical treatments[14].

The purpose of this paper is to demonstrate various applications of this method and different mesh constructions to determine: the facial pattern of a child, its resemblance to that of other members of his family, as well as growth changes and the effects of orthodontic treatment.

The Analysis of Facial Pattern

The first application of the mesh diagram method at Forsyth has been for a study of the variation in the facial pattern among eighteen to twenty year-old females with normal occlusion. The mean location of various landmarks and their variation at the one and two standard deviation limits were determined, as shown by concentric ovals in Figure 2. Once obtained, this diagram

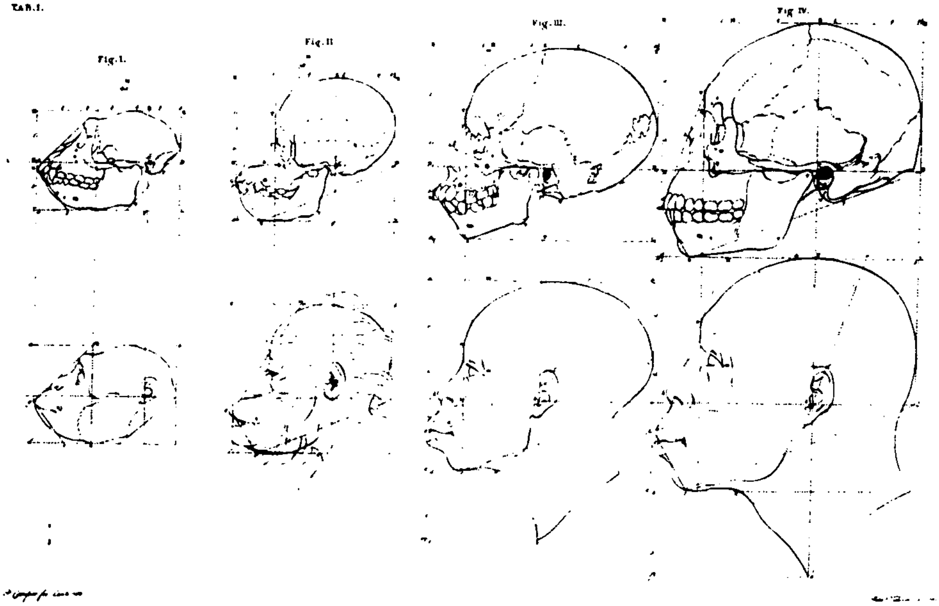

Fig. 1 The Dutch anatomist, Pieter Camper (1722-1789), expressed differences in the physiognomy of monkey, orang-outang, Negro and Kalmuck by the angle formed between the facial line and a horizontal. This drawing was executed by the well-known Dutch engraver, Reinier Vinkeles (1741-1816).

has been used as a norm in clinical evaluations to express the direction and

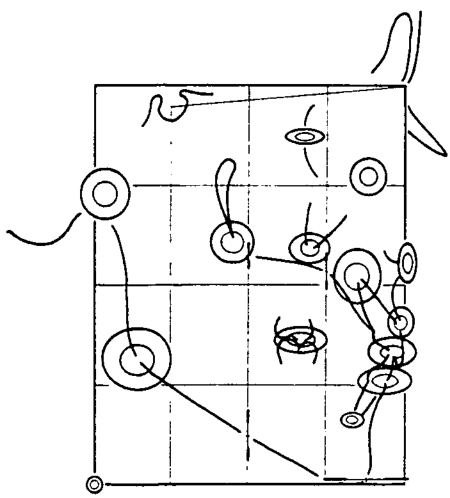

Fig. 2 The average facial pattern of fifty North American females. The concentric ovals show the spread of individual variations for the location of landmarks in their respective mesh rectangles at the one and two standard deviation limits.

amount of variation in the facial configuration of individual patients.

It soon became disturbing that the findings of cephalometric analyses frequently did not corroborate the findings from the clinical examination[15]. Such discrepancies are not related to any particular method but they are explained by the biologic variation of the intracranial lines that are used as reference for angular measurements or for the orientation of a triangle, polygon and coordinate system on the face.

Clinically, patients are studied when sitting upright or standing while looking at a distant point. In this pose the visual axis is horizontal and the head is in its so-called "natural position". This orientation of the head is the generally accepted basis for comparing individuals.

Craniologists also tried to orient their skulls in a manner corresponding to the natural head position of the living.

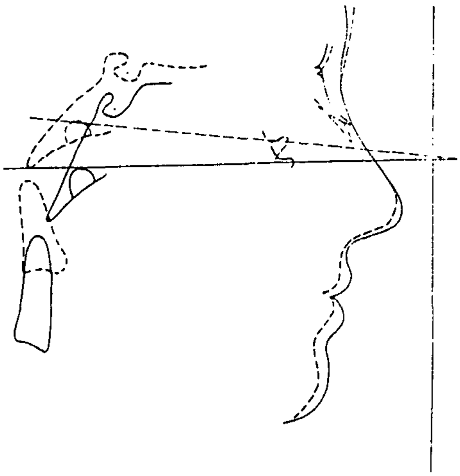

Fig. 3 Marked differences in the inclination of the Frankfort Horizontal and anterior cranial base in two females with close similarity in facial profile.

After much debate they finally selected the Frankfort Horizontal as the best approximation of the true horizontal as it intersects the head of the living in its "natural" position. It was fully recognized, however, that a true horizontal line cannot pass through the same two anatomical landmarks in all individuals.

The Frankfort Horizontal intended solely for the study of innate crania is still used in the study of the living both for orientation of the head in the cephalostat and for analysis of the cephalogram. Instead, our patients can be oriented in the cephalostat directly in natural head position rather than in the Frankfort Horizontal that constitutes an indirect and frequently inaccurate means to obtain this position (Fig. 3).

The technique for recording natural head position with a mirror has been described[16]. It must only be emphasized that unnatural tilting of the head owing to nervousness of young patients should be corrected. When the subjects focus on the midpoint of a small (10 cm) mirror suspended exactly at pupillary level in front, the visual axis should be horizontal.

This corrected natural head position is remarkably constant as determined from two series of observations of sixty-one North American females ($r = +0.85$)[16].

From our study the individual variations in the inclinations of the two most commonly used intracranial reference lines (*NS* and *FH*) with the vertical were also obtained (Table 1). The findings show that these variations are considerable, with standard deviations ranging from 3.67 to 4.02 degrees. Since the mean angle between the line nasion-sella turcica and the vertical closely approximates eighty-five degrees (Table 1), the norm mesh may still be used for comparative purpose because it is also oriented at eighty-five degrees to the cranial base (*NS*). However, the degree of variation in the position of various landmarks in the norm has been affected by the differences in the inclination of the skull base among the individuals studied. The magnitude of

TABLE I

The angles, in degrees, between two intracranial reference lines (*N S* and *F H*) and the vertical in 61 North American females, observed twice in natural head position.

	Nasion-Sella Turcica and the Vertical		Frankfort Horizontal and the Vertical	
	Mean	Standard Deviation	Mean	Standard Deviation
First Examination	85.28	3.92	92.21	4.02
Second Examination	84.74	3.67	91.68	3.68

their influence cannot be defined in the absence of degree and sign of correlation between the variations in skull base and landmarks.

Delattre and Fenart[17] have also discussed the necessity for identical orientation of the skull as the basis of all craniometric and cephalometric studies. For the purpose of orientation according to physiologic principles, they adopted from Girard the semicircular canals which influence head balance through reflexes acting on the head muscles as vision does[18]. However, a tomographic technique is needed for the identification of the semicircular canals in radiographs.

Method. The mesh is oriented on the vertical extracranial reference line and constructed for each analysis according to detailed instructions previously reported[16]. The line nasion-sella turcica may be used for orientation only after determining that this intracranial line makes an angle of 85 degrees with the vertical.

Differences between the face on the tracing and the norm are shown graphically by distorting the rectilinear mesh diagram on the tracing. These transformations indicate, on a proportionate basis, the deviation of landmarks within each small mesh rectangle in comparison with corresponding landmarks of the norm. The distortions can be drawn accurately by utilizing the table giving percentage locations for each landmark studied with respect to its horizontal and vertical coordinates (Table 2).

TABLE II

The position of certain anatomic landmarks and points in the rectangles of a mesh diagram in 50 North American females.

	Horizontal		Vertical	
	Mean	Standard Deviation	Mean	Standard Deviation
Chin point	48.32	25.43		
Mandible intersection			48.98	11.90
Gonion	42.72	20.77	24.27	14.27
Apex mandibular I_1	66.78	6.01	66.23	2.55
Infradental point	24.36	16.77	2.82	5.25
Incisal edge, mandibular I_1	17.30	14.39	32.45	6.41
Incisal edge, maxillary I_1	6.65	9.16	20.77	6.21
Tip mesiobuccal cusp, maxillary M_1	33.73	16.18	43.39	5.40
Posterior palatal intersection			27.75	6.22
Anterior palatal intersection			11.31	8.24
Apex maxillary I_1	62.45	13.20	7.14	12,12
Prosthion	4.51	7.07	61.20	6.67
Anterior nasal spine	0.92	3.79	20.59	8.68
Pterygomaxillary fissure	20.04	12.83	40.89	9.28
Zygomatic process	22.00	11.32	35.29	7.43
Ear point	88.51	15.70	91.43	11.93
Infraorbital point	47.23	10.64	7.65	8.01
Orbital margin	28.00	8.72	51.53	2.16

The figures indicate the position of the landmarks or points in terms of a proportionate distance from the mesh line which is used as the basis of reference. The line selected is in all cases to the left of the point, or below it.

As a short cut, the transparent tracing can be superposed directly on the norm, particularly when the size of the mesh rectangles of tracing and norm correspond closely. If all landmarks on the tracing and norm are in the same position to their respective horizontal and vertical coordinates, there is no need to change the coordinates. When a landmark differs in its location, superposition for this landmark shows how much the horizontal and vertical coordinate lines of the small rectangle containing the landmark must be changed.

When the dimensions of the mesh rectangles of tracing and norm are not the same, either in length or breadth or in both directions, compensation should be made for this difference.

Since the position of the vertical coordinates or mesh lines is determined by the length of the distance between nasion and the mid-point of sella turcica, the distortions of these lines show differences in facial depth relative to the distance nasion-sella turcica.

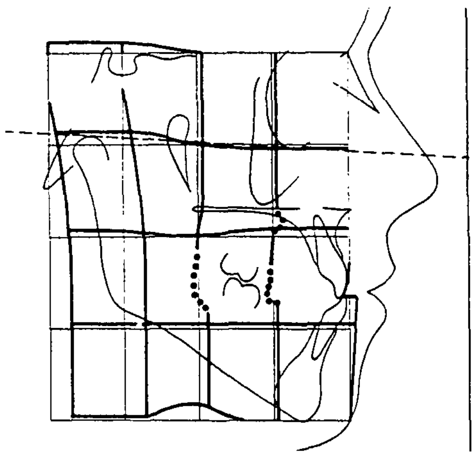

Fig. 4 Cephalometric analysis with the mesh diagram oriented on the vertical. Intracranial lines cannot be used for reference purposes because of the high or cephalad inclination of both the anterior skull base and Frankfort Horizontal.

Differences in height are expressed in terms of face height because the horizontal mesh lines are related to the total face height. Thus, when ramus length is short in an individual instance compared with the norm, this finding actually indicates shortness of ramus length in relation to total face height. If the facial height is disproportionately long, as in the case of open bite, ramus height in absolute terms may be well within normal limits.

Three examples are presented demonstrating the need to obtain radiographs in natural head position. Accordingly, the mesh diagrams are oriented on the vertical and the inclination of the intracranial reference lines, if other methods are used, can be corrected, as already suggested by Downs[19].

In the case of the high anterior skull base (Fig. 4), with similar deviation of *FH*, the face would be prognathic according to any method using intracranial reference lines, while actually it is orthognathic.

In the other two instances, a markedly retrusive chin and masking of prognathism result from cephalometric analysis unless the low or caudad inclination of the skull base is taken into consideration. The deviation of the Frankfort Horizontal is slight in one child (Fig. 5) and in the other one it corresponds to that of the skull base (Fig. 6).

Validity of the Norm. The validity of using a norm based on adult American females for studying the young may be questioned. It would be more logical to obtain data for a standard of comparison from children of both sexes in the age range when they generally apply for orthodontic treatment (10-14 years). To acquire such information one should take ethnic origin into consideration and physiologic age should be determined in addition to chronologic age. Statistical evaluation of dif-

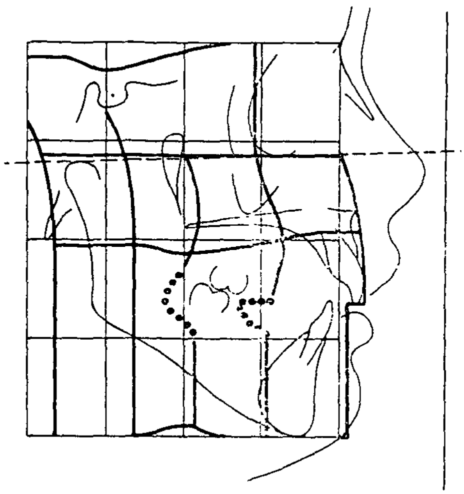

Fig. 5 Cephalometric analysis with the mesh diagram oriented on the vertical. If the line NS had been used for orientation, unrealistic interpretation would result (complete masking of prognathism and marked retrusion of the mandible) owing to the low or caudad inclination of the anterior skull base. The deviation of the Frankfort Horizontal is not as severe as that of the skull base.

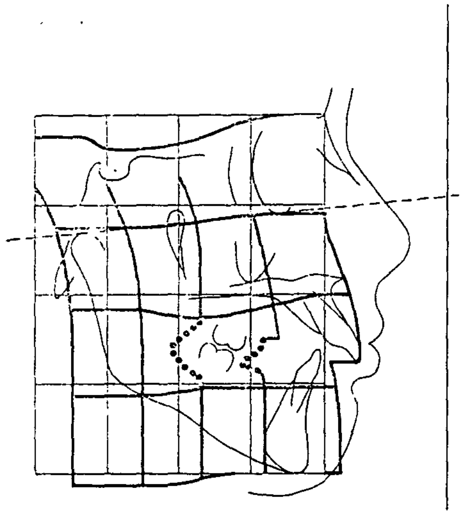

Fig. 6 Cephalometric analysis with the mesh diagram oriented on the vertical, necessitated by the downward inclination of the anterior skull base. Regardless of method, the use of intracranial lines NS and FH would lead to an erroneous description of the facial configuration, namely, markedly retrusive chin and complete absence of prognathism.

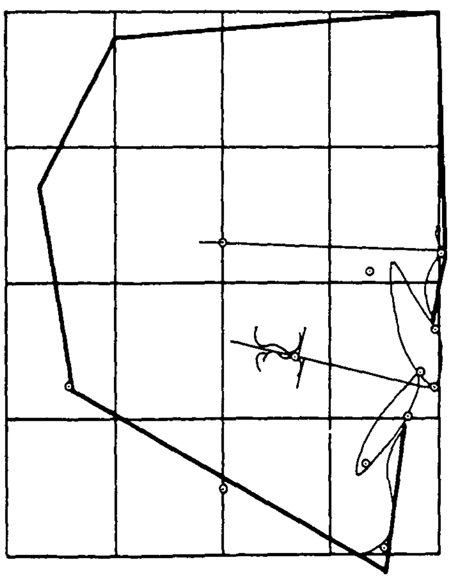

Fig. 7 Mesh diagram constructed on the facial polygon obtained by Björk[12] from mean values of skeletal measurements of twelve year old Swedish boys. The dots within small circles define the average location of landmarks according to the Forsyth norm.

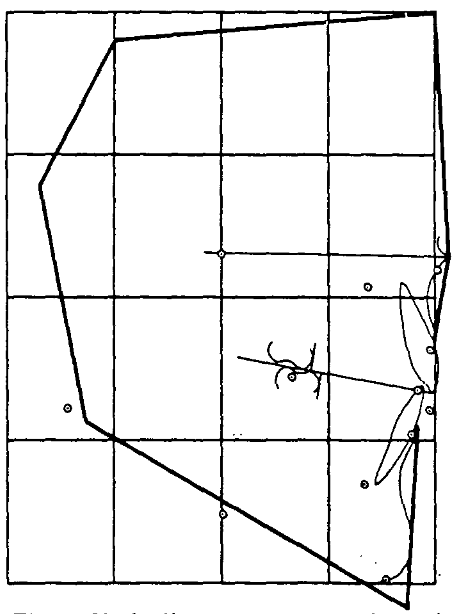

Fig. 8 Mesh diagram constructed on the facial polygon obtained by Björk[12] from mean values of skeletal measurements of twenty-two year old Swedish males. The dots within small circles define the average location of landmarks according to the Forsyth norm.

ferences between samples assembled by the aforementioned criteria would indicate their significance.

Since the acquisition of normative data according to this concept is an enormous task, another approach was used in the past to test the suitability of the "Forsyth" norm mesh diagram. For this purpose a mesh was constructed on Björk's[12] mean polygon for twelve and twenty-two year-old Swedish males (Figs. 7 and 8) and from Coben's[7] data of eight and sixteen year-old American children.

The position of gonion is slightly forward and downward in the Swedes in comparison with the Forsyth mesh and the mandible is somewhat more prognathous in the twenty-two year-old Swedish sample owing to the more rounded chin (pogonion), a landmark that was not studied in the Forsyth mesh diagram. Also it can be noted that position and inclination of the maxillary incisors differ between the two Swedish groups and the Forsyth norm.

Coben did not report the position of all landmarks on both the horizontal and vertical coordinates and, therefore, his data could not be utilized fully. A mesh constructed on the basis of his combined findings for eight year-old males and females shows a slightly higher position for gonion compared with the Forsyth mesh. For the sixteen year-old males and females, gonion is in a low or caudad position just under the horizontal line of the mesh rectangle containing gonion in the Forsyth mesh. For Coben's eight year-old children pogonion is comparable, but at sixteen years this landmark shows greater prognathism of the mandible in both sexes than the norm mesh. The position of articulare corresponds in Coben's eight and Björk's twelve year-old groups as well as in Coben's sixteen and Björk's twenty-two year-old groups. In the Forsyth material articulare was not studied.

Because normative data show slight variations, the interpretation of a cephalogram may differ in some aspects according to the norm selected as a basis for comparison. Actually the differences do not invalidate these norms for clinical use as long as they are considered as useful abstractions. One cannot expect facial patterns of orthodontic patients to conform to an average face when individuals with normal occlusion differ from the average.

The analysis of standardized head radiographs serves primarily to demonstrate the patient's own unique facial pattern and it may clarify how existing disharmonies can be minimized by orthodontic treatment. However, the requirements for a meaningful diagnosis are not limited to cephalometric considerations. The scope of diagnosis has to be broader because treatment planning is aimed at the establishment of a satisfactory function of the patient[20].

The Analysis of Growth Changes

In the study of facial growth with the mesh diagram, comparisons are made between successive records, the earlier cephalogram serving as a standard of reference to the one obtained subsequently. The overall changes in facial form are determined from the increments in the length and breadth of the basic mesh rectangles, while the changes in facial pattern are shown by the differences in the relative position of anatomic landmarks within each small mesh rectangle.

To demonstrate the method, one longitudinal record is presented that was generously made available by Dr. Alfred H. Washburn, Director of the Child Research Council in Denver, Colorado.

Growth of the neurocranium. Orientation of the mesh for analysis of growth changes in the neurocranium was achieved by superposing tracings along the concentric outline of the cranium, following McDowell[21]. It was not possible to rely on bregma, lambda, nasion or sella turcica, because these landmarks change their relations to each other throughout this individual's growth period between 3 and 19 years.

On the first tracing a mesh was drawn and oriented in approximation of natural head position. The horizontal coordinates were obtained by drawing parallel lines at the most cephalad and caudad points of the skull and at quarter distance between these two lines. (Fig. 9).

A perpendicular at the most dorsal

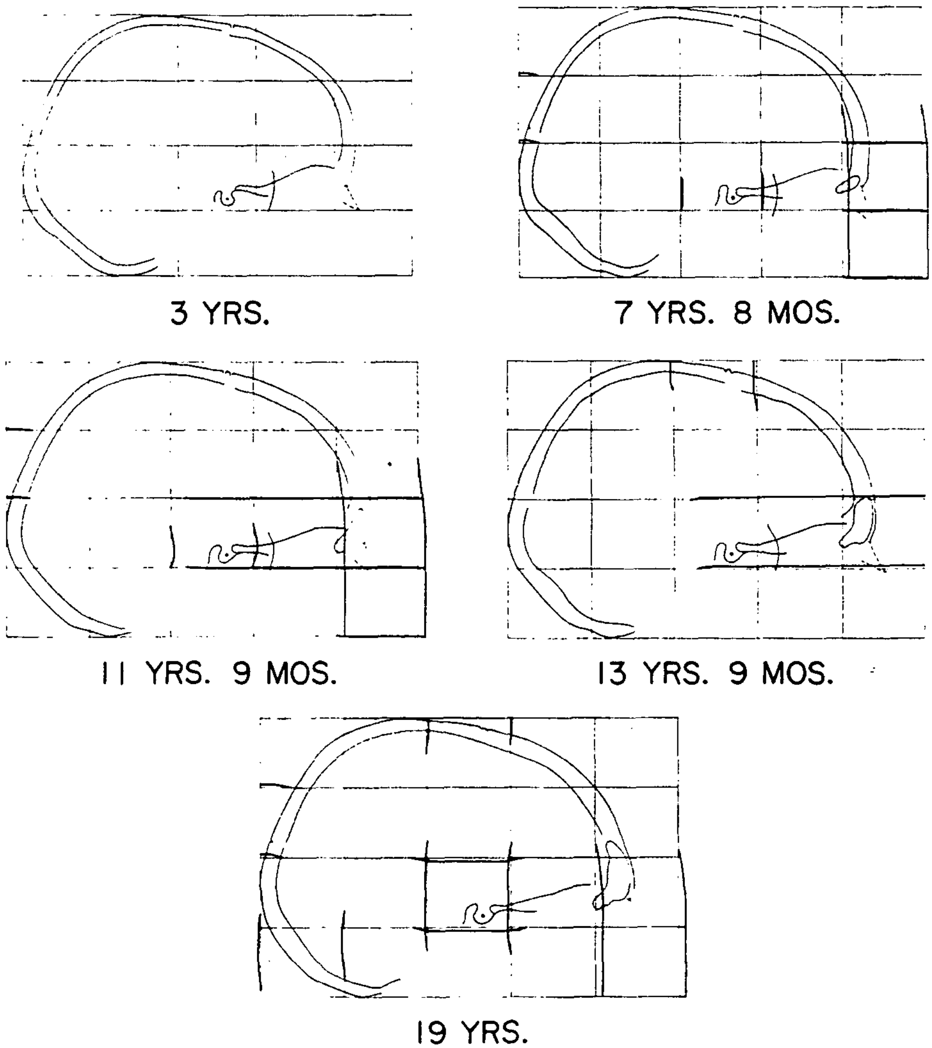

Fig. 9 Analysis of growth changes in the neurocranium by means of a mesh diagram utilizing serial standardized lateral head radiographs. The transformations of coordinates indicate changes in the proportionate relation of landmarks within the mesh rectangles, the comparisons always referring to two successive age levels (between three and seven years, seven and eleven years, etc.).

point of the occiput and one at the intersection of the second horizontal coordinate and the frontal bone were drawn. Their distance was divided in four parts to obtain three vertical coordinates in the cranium. The basic rectangle was completed by a line, parallel to and at equal distance from the other vertical coordinates, to enclose the cranium in its frontal aspect (Fig. 9).

The other tracings were superposed along the concentric outer table of the neurocranium for identical orientation of the meshes utilizing the same procedure for their construction.

Since the skull outline is approximately concentric during the observation period of this child, the ratio of the length and breadth of the basic rectangles remains constant (1.5). The transformations of coordinates illustrate slight differences in the positions of sella turcica as well as bregma and lambda that imply varying rates of bone deposition at the two margins of these sutures during the entire observation period. The changes of nasion are greater than for the other three landmarks.

The inclination of the anterior skull base is not altered in this child up to thirteen years of age, although nasion moves ventrally from three years onward and a very small cephalad movement of both nasion and sella turcica occurs between eleven and thirteen years. However, between thirteen and nineteen years the inclination of the skull base changes owing to a slight caudad move of sella turcica. This finding must be taken into consideration when interpreting growth of the face because the line nasion-sella turcica is used for orienting the mesh.

Growth of the face. As arbitrary approximation of natural head position, the line nasion-sella turcica is used for constructing mesh diagrams on the tracings of the facial skeleton.

The changes in facial form as a result of the marked increments in face height, especially between three and seven years of age, are reflected by the differences in the length-breadth ratios of the basic rectangles (Fig. 10).

The changes in facial pattern for this individual conform to established concepts of facial growth and they are also most pronounced in early childhood. The location of the temporomandibular joint is seen to shift in dorsal and cephalad direction, and ramus length increases markedly between three and seven years. In all other respects the differences in facial pattern at subsequent age levels are small. The caudad inclination of the anterior skull base, between thirteen and nineteen years owing to the change in the position of the sella turcica, results in a rotation of the mesh, the face becoming slightly retrognathic. Actually, this is not the case and it would have been more appropriate to indicate the change in the position of sella turcica by a distortion of its coordinates.

Throughout the growth period of this child small changes in prognathism relative to point nasion occur, involving the mandible only between eleven and thirteen years. These changes infer differing growth rates for anterior skull base and jaws. Although the position of nasion is generally changing during growth, it is especially important to rule out upward and downward movements of nasion insofar as these would affect the inclination of the base line used in this and other methods of growth analysis. Ventral movement along a true horizontal does not invalidate nasion for reference purpose.

Lower face height increased slightly more than upper face height in the interval between thirteen and nineteen years as shown by the change in the relative position of the nasal floor.

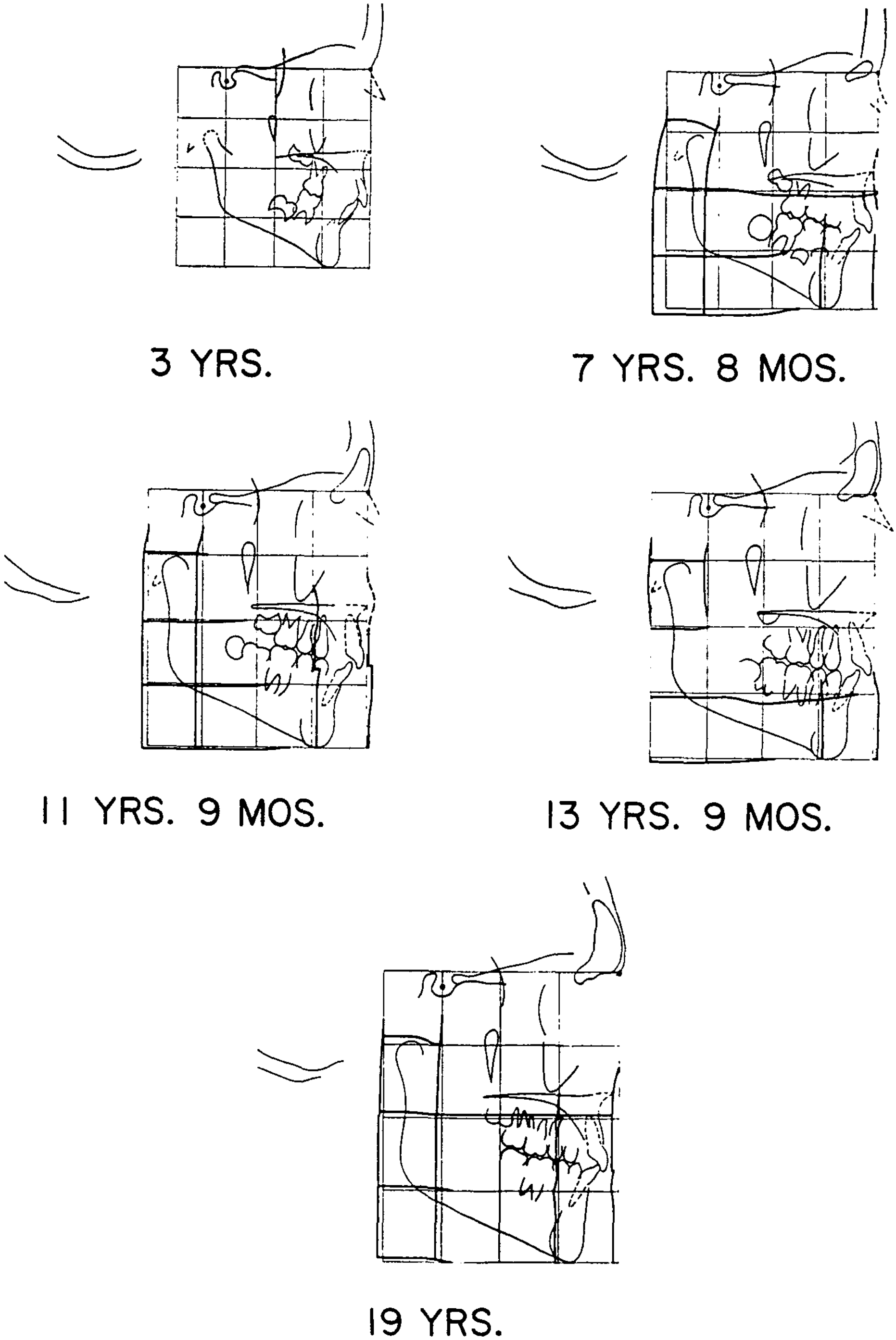

Fig. 10 Analysis of growth changes in the face by means of a mesh diagram utilizing serial standardized lateral head radiographs. The transformations of coordinates indicate changes in the proportionate relation of landmarks within the mesh rectangles, the comparisons always referring to two successive age levels (between three and seven years, seven and eleven years, etc.).

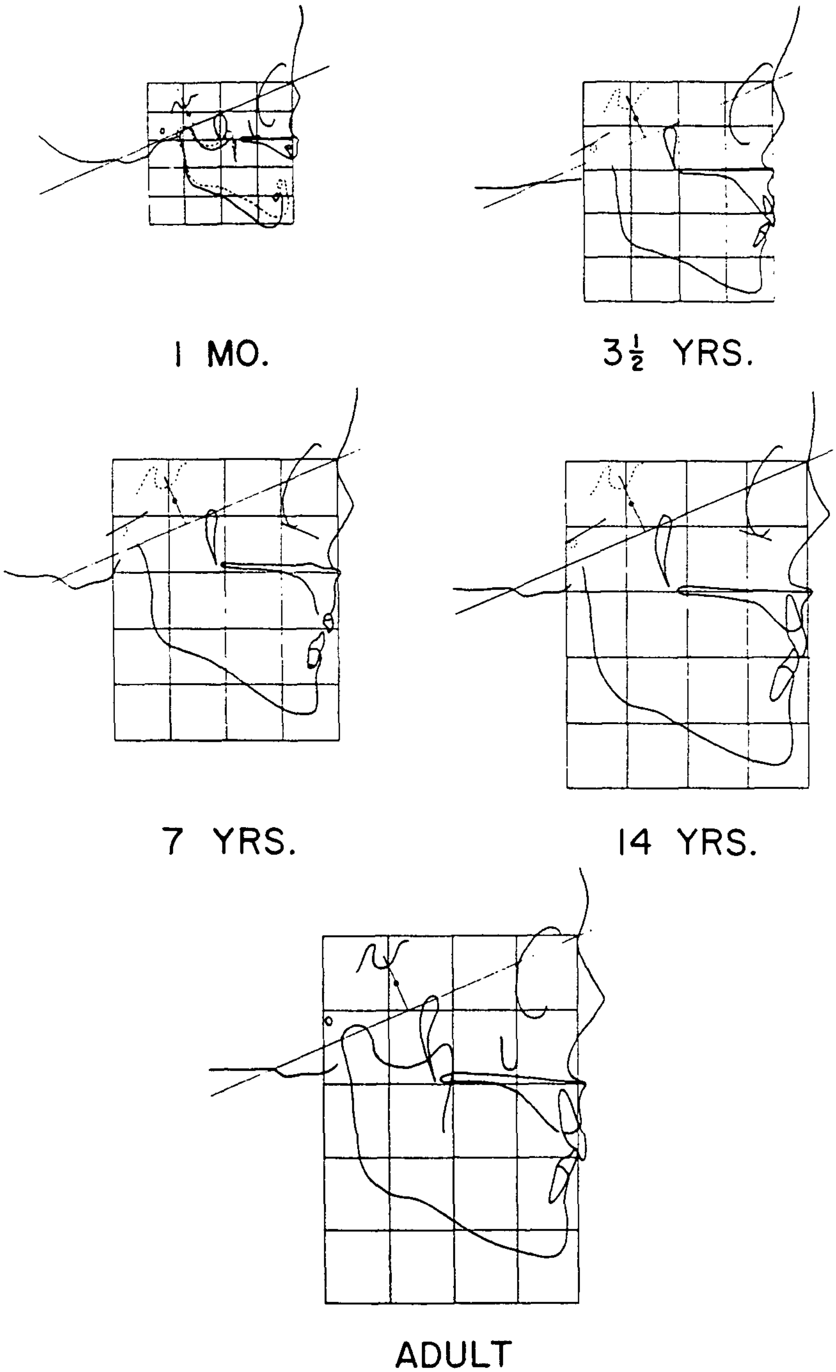

Fig. 11 Analysis of growth changes in the face by means of a mesh diagram utilizing Broadbent's[22] illustration of representative examples of "normal" developmental stages from one month to adulthood.

Otherwise the relation of upper to lower face height has been constant for this individual (Fig. 10).

Broadbent's[22] by now classic illustration of the downward and forward growth of the face, based on representative radiographs of five age groups, has been used to illustrate different parameters for construction of the mesh and to demonstrate that changes in facial patterns can be evaluated also without first distorting the coordinates, thereby simplifying the procedure for its application in clinical practice (Fig. 11).

In this construction, upper face height determines the location of horizontal coordinates, each drawn parallel at one-half of the distance from nasion to anterior nasal spine. The distance from point *R*, proposed by Broadbent, and nasion, divided by three, was used for the spacing of vertical coordinates. The mesh was oriented on the Frankfort Horizontal inasmuch as it was drawn in the original illustration of Broadbent.

Since the mouth was evidently wide open in the radiograph obtained at one month, a correction was made arbitrarily and shown by the dotted outline of the mandible. The location of porion at three, seven and fourteen years, missing in the original, was also estimated at points on the line connecting this landmark in the first and last cephalogram.

Interpretation of findings is immaterial in the context of this report because the data are obtained from different individuals. The two examples are presented to acquaint the clinician with the mesh diagram methods. When children are studied longitudinally to establish individual growth trends, this graphic method is recommended. For the research worker, the mesh has, as yet, untapped potentials for studying facial development.

Analysis of Changes Following Orthodontic Treatment

Before and after treatment cephalograms also constitute a longitudinal record of one patient during which time growth changes, orthodontic treatment and an interaction between these two factors have occurred. All treatment analyses are complicated by the difficulty to differentiate between the contribution of natural growth and treatment.

The fact that the face increases in height or depth or in both dimensions during treatment per se does not affect the location of the landmarks in the "before and after treatment mesh diagram", unless growth changes have been disproportionate in parts of the facial skeleton and these are readily recognized. The method, therefore, eliminates or reduces the analytic complications arising from increases in the absolute size of the facial skeleton during growth[23].

In general, the anterior skull base is used for the construction of the mesh because of its relative stability during the average two year treatment time. Yet upward or downward movement of nasion must be ruled out by superposing the tracings on the *planum sphenoidale* and the inner anterior table of the cranium.

An example is chosen from the Forsyth records relating the results of orthodontic treatment of a boy twelve and one-half years old (Fig. 12). As a first objective, the crossbite of the permanent maxillary right canine was corrected with a removable appliance in two months.

For the treatment of the Class II, Division 1 malocclusion two activators[24] were used. The first one was prescribed three months after correction of the linguoversion of the maxillary canine. The second one was made nine months later and used for a four-month period.

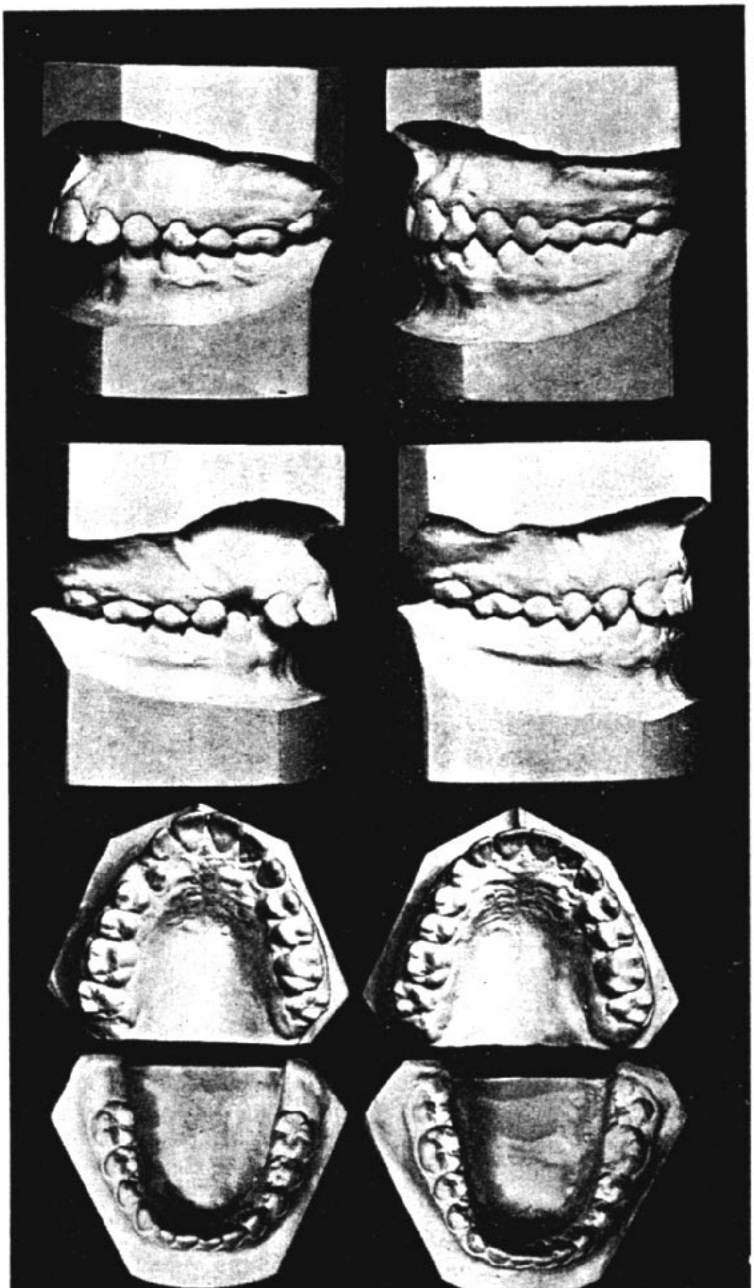

Fig. 12 Dental casts of a boy before and after orthodontic treatment at ages twelve and one-half and fourteen years, respectively. The crossbite of the permanent maxillary right canine was corrected in two months and the Class II, Division 1 malocclusion was corrected in twelve months with two activators, constructed successively.

The correction of the Class II malocclusion by means of the activators, worn at night only, required a total of thirteen months.

The results according to the transformations of coordinates show slight tipping of the crowns of the permanent maxillary incisors, correction of the distoclusion and of the vertical overbite (Fig. 13).

A change in the position of the condyle is observed, caudad and dorsal from that noted before treatment. The increase in the length of the mandibular body contrasts to the slight over-all growth in facial depth, as seen by the very small (one mm) difference in the breadth of mesh rectangles. The total increase in facial height, measured on the original tracings, was eight mm in the year and one-half interval between cephalograms, lower face height contributing somewhat more than upper face height to this change.

Apart from the small differences in the position of the maxillary incisors and the condyle, treatment owes its favorable outcome to the increment in the length of the mandibular body that exceeded growth in depth of the skull base and upper face.

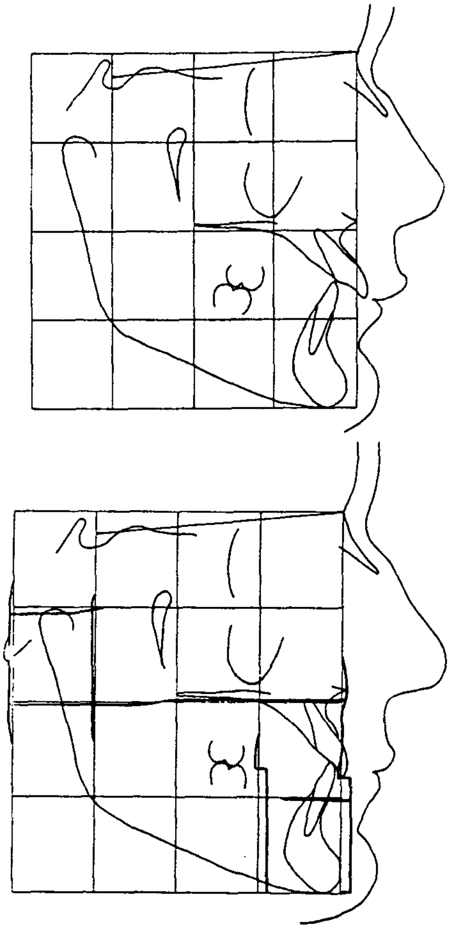

Fig. 13 Analysis of treatment results from tracings of standardized lateral head radiographs obtained before treatment at twelve and one-half years and after treatment at fourteen years of age. Transformations of horizontal and vertical coordinates indicate differences in the proportionate relation of anatomic landmarks in the mesh rectangles of the after-treatment tracing compared with those in the before-treatment tracing.

Analysis of Familial Resemblance

To assess familial resemblance as part of the orthodontic diagnosis, children are compared separately with the father and with the mother as was done in studying before and after treatment results. Since children have not reached their full growth potential, the findings indicate probable trends in resemblance at best. No reference will be made to sex and age.

The method is illustrated by studying a family with six children as shown in Figures 14 and 15. To show a variant in the construction of the mesh diagram, it is oriented on the palatal plane—a line through the anterior nasal spine tangent to the palate.

The horizontal coordinates are all drawn parallel to this line of orientation at a distance equal to one-half of the length of the perpendicular from nasion to the base line.

The vertical lines are all parallel to the perpendicular from nasion. The

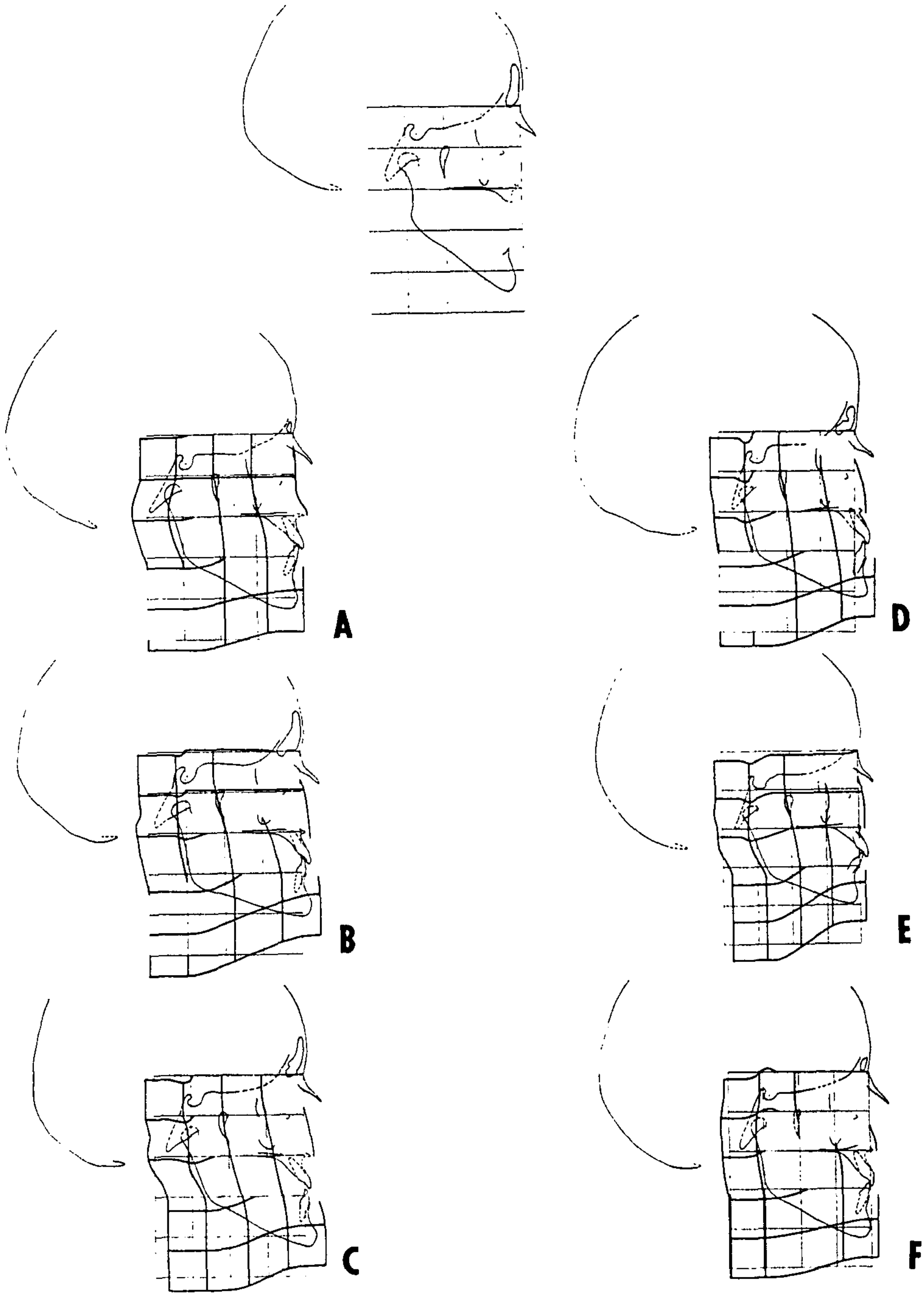

Fig. 14 Comparison of facial form of six children (*A-F*) with their mother by means of a mesh diagram. The distortions of the horizontal and vertical coordinates indicate the difference in the facial form and pattern of each child expressed in terms of the proportionate location of anatomical landmarks in the mother's mesh diagram shown at the top of this figure.

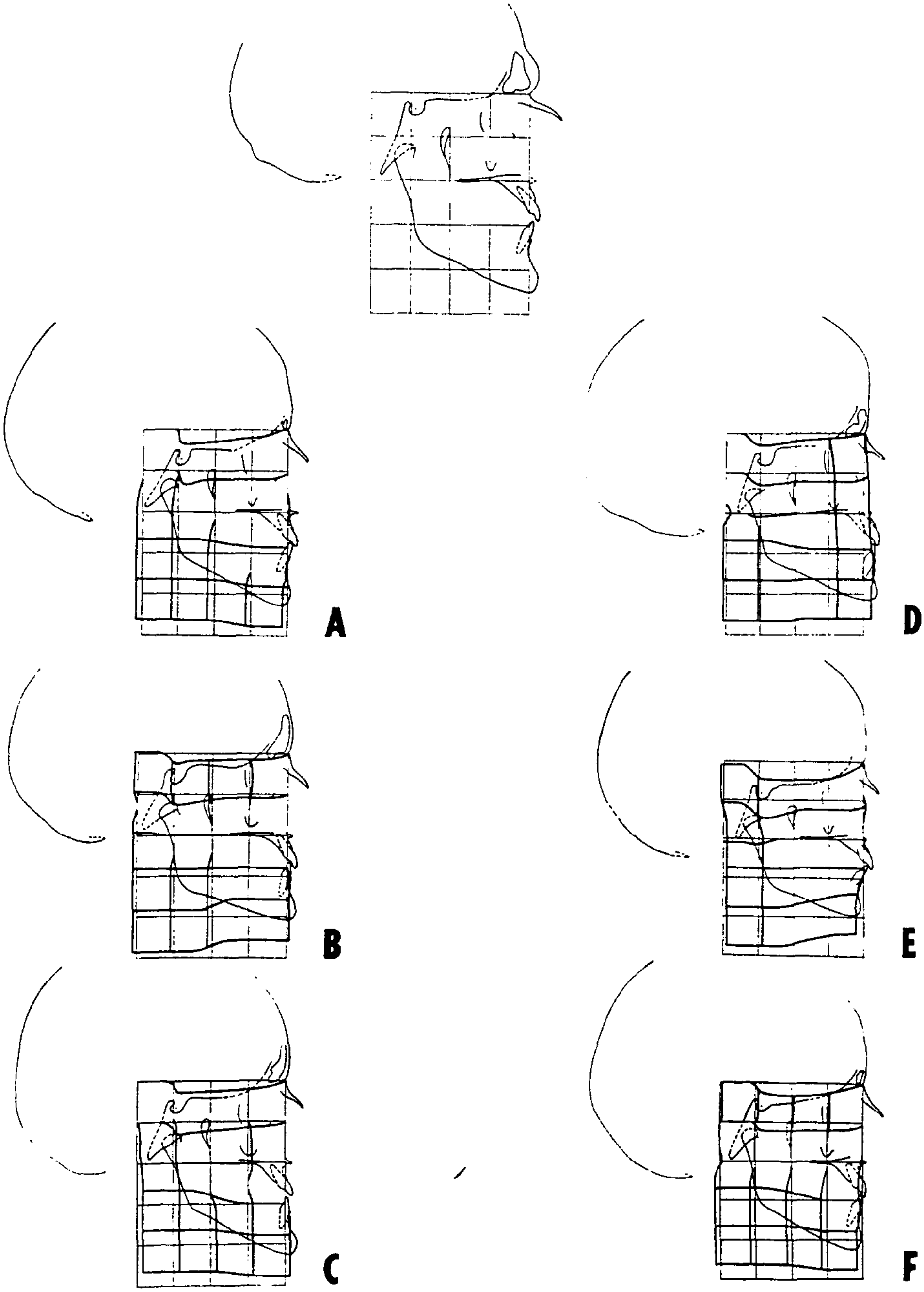

Fig. 15 Comparison of facial form of six children (A-F) with their father by means of a mesh diagram. The distortions of the horizontal and vertical coordinates indicate the difference in the facial form and pattern of each child expressed in terms of the proportionate location of anatomical landmarks in the father's mesh diagram shown at the top of this figure.

distance between the vertical coordinates is determined by one-half of the distance between the perpendicular from nasion and the perpendicular through the caudad tip of the pterygomaxillary fissure to the base line.

This construction of the mesh differs from previous methods because it utilizes the upper face height instead of total face height for drawing the horizontal coordinates, and it also substitutes for the distance nasion-sella turcica another measure of face depth to locate the vertical coordinates.

The mother in comparison with the father, as shown on top of Figures 14 and 15, respectively, has a caudad position of sella turcica relative to nasion resulting in a short length of the projected distance from sella to the condyle. The posterior part of the skull base or *clivus* is also shorter and thicker in the mother while the skull base angle is wider than in the father.

All children resemble the mother in the caudad inclination of their anterior skull base as shown by the slight distortions in this area (Fig. 14) and the marked distortions when they are compared to their father (Fig. 15). However, sella turcica is in a more dorsal position in the children than in their mother and the same finding applies to the position of the condyle. Similarly the proportionate position of basion is also dorsal and caudad in the children. The father and the children are therefore much alike in the position of sella turcica, basion and the condyle.

Ramus height of the children is shorter than that of the father, but longer, proportionally, in comparison with the mother. In studying ramus length the distortions of horizontal mesh lines both in the condylar and gonial regions must be taken into account. The general shape of the mandible in the children shows resemblances to both mother and father in various degrees.

The mesh diagram may well be useful in genetic studies to determine the proportional relation of parts of the face to each other and to evaluate the shape of the face and its components. Distortions of the coordinates are not strictly necessary for clinical application of the method. The relations of landmarks to the coordinates can be quantified mathematically as mentioned already and subjected to statistical and genetic study.

Summary

The mesh diagram is particularly suited for studying facial morphology because the findings are shown graphically, facilitating interpretation.

Different constructions of the mesh diagram have been demonstrated. The method has been applied to studying facial pattern, growth changes, results of orthodontic treatment and familial resemblances.

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