Structural Goals in Craniofacial Surgery

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The major craniofacial abnormalities and procedures to correct them can be considered as a group for purposes of operative planning. The deformities have been described in a number of publications. The abnormalities are predominantly structural leading to functional and physiological problems. The goal of the surgery is normal facial structure. Norms have been described in a variety of sources and are the basis for determining what is abnormal, and in defining the goal of the surgery. Our purpose is to state criteria to be used as guidelines for evaluating structural facial deformities amenable to surgical correction and to assemble this data in a manner useful to the craniofacial surgeon.

ABNORMALITIES. The principal syndromes that can be corrected surgically are the craniofacial dysostoses (Apert's and Crouzon's), median facial clefts and residua of encephaloceles with hypertelorism, mandibulo-facial dysostoses (Treacher-Collins Syndrome), hemifacial microsomia, and post traumatic deformities. These deformities primarily involve the middle and upper thirds of the face and include the forehead, orbits, zygomas, nose and maxillae. Maldevelopment of portions of these interrelated areas usually results in distorted growth in adjacent structures. The result is often a complex of bony and soft tissue deformity. A clear definition of the abnormality and delineation of the surgical goal is accomplished by means of a physical examination, photographs, x-rays, dental models, and growth studies, all with appropriate measurements.

TOOLS FOR PLANNING. The face as a whole must be considered as with any facial reconstructive procedure. Concepts of symmetry and facial norm are widely known: alterations of soft tissue, the nose, and the ears are based on these principles. Gonzales-Ulloa (*7*, *8*), Broadbent (*1*), and others have described useful methods of assessment. Physical examination and photographs are key. 8 × 10 inch black and white photographs, full face, both profiles, ¾ facial views, and a view from the chin to visualize the malar region are particularly helpful in planning. Entire facial height, width, and configuration must be considered. An artist may be of value in

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determining which side is normal, sometimes a very difficult problem in subtle hemifacial abnormalities.

Dental models are essential in determining the amount of midface advancement necessary in cases of hypoplasia or retrusion and are the guideline to calculate the size of bone grafts to be cut and placed in the pterygomaxillary and/or zygomatic region.

X-rays essential to planning are PA and lateral films of the craniofacial structures corrected for magnification distortions. Cephalograms or x-rays taken at a two meter distance minimize the amount of distortion for direct measurements. X-rays calculated for the amount of magnification can also be used (*9*). Frontal and lateral tomograms of the orbits and anterior cranial base help to define the often complex irregularities present. Panorex views of the maxilla are useful if this area is involved or to be used for fixation following midface advancement. A basal or Hirtz' view best defines the zygomatic arch areas and lateral walls of the orbits.

Planning. Precise measurements about the orbits and careful observation of the maxillary-mandibular relationship are necessary for operative planning. The interpupillary distance (IPD) while often inaccuarate because of strabismus is a useful preliminary guide and has a range of norm of 58 to 71 mm. in the adult (*2*). Measurement is between the midpoints of the pupils.

The medial intercanthal distance (MICD), obtained by using calipers to measure the distance between the medial most extent of the palpebral fissures, is another simple guide for preliminary planning. False impressions of hypertelorism may occur with prominent epicanthal folds or in certain syndromes involving telecanthus without true orbital hypertelorism such as in the recently described blepharonasofacial syndrome (*13, 14*) (Figure 1), or in Waardenburg's syndrome.

In spite of the rightful emphasis on bony measurements to determine the presence or absence of orbital hypertelorism, the final determinant of surgical success in this region is the MICD. If excess intercanthal distance is still present following bony correction, the distortion is conspicuous and a secondary corrective procedure is needed. This situation is not rare despite adequate bony correction. The value of the normal MICD is 5–8 mm. more than the bony interocular distance (BIOD) (*20*). A comprehensive study of normal MICD values has been done by Laestadius, et al. (*11*). Selected values from their study are given in Table 1.

The medial and lateral canthi are normally in the same plane or with a slight inferior tilt from medial to lateral (Figure 2). Orientation is determined by photographs and direct patient examination. Correction is important if exaggerated variations occur from the horizontal plane in any direction.

An understanding of orbital bony anatomy is essential. As expected, the orbits change with growth. At birth the orbit is well ossified and roughly quadrangular in shape with height and width about equal forming a square

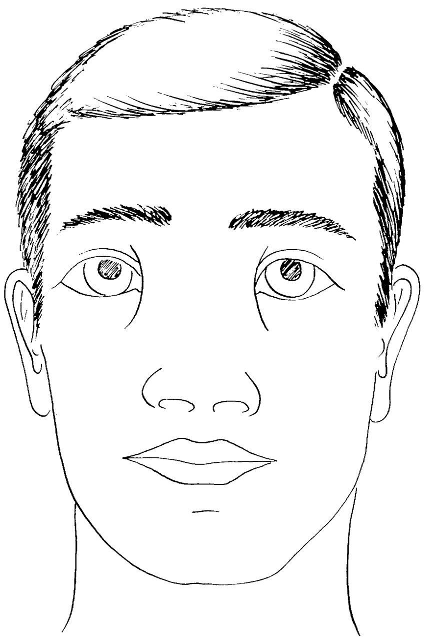

FIGURE 1. Patient with telecanthus but with normal BIOD giving false impression of hypertelorism.

TABLE 1. Medial intercanthal distance (in mm.)

age	*avg*	*2 std. deviations*
Birth	20	4
1 yr.	25	5
3 yrs.	26	4
5 yrs.	27	5
7 yrs.	28	4
12 yrs.	29	5
Adult	30	6

From: Laestadius, Aace, & Smith J. Ped. March, 1969.

with rounded corners at the orbital rim. In infancy the orbital axis is directed slightly more laterally than in the adult. With growth the orbits become more medially directed, the sharp orbital rim margins become rounded, and the orbit assumes a more rectangular shape, width predominating over height especially in males (Figure 3). At birth the size of the orbits is relatively great, but changes in size and shape continue into adulthood. Averages at the orbital rim have been compiled for the orbit through its stages of development (*5*, *10*) (Table 2). While specific rim measurements are not often helpful, shape and orientation are, in determining the final modeling to be done at surgery.

The orbital axes form about a 45° angle with the opposite side. The angle between the lateral and medial walls of each orbit is about 45°, between the lateral walls of the two orbits about 90°. The two medial walls are almost, but not quite parallel. They are slightly further apart posteriorly than anteriorly. These assessments can best be made by x-ray with basal or Hirtz views, aiding also in assessing the severity of hypertelorism. The orbit inside is roughly the shape of a pyramid, the apex located posteriorly. The optic nerves diverge laterally from the optic chiasm averaging 14 mm. between the two nerves at the cranial openings and 28 mm. at the orbital openings in the posterior portions of the orbits (*5*). These relations may be of practical help in avoiding injury to the optic nerves (Figure 4).

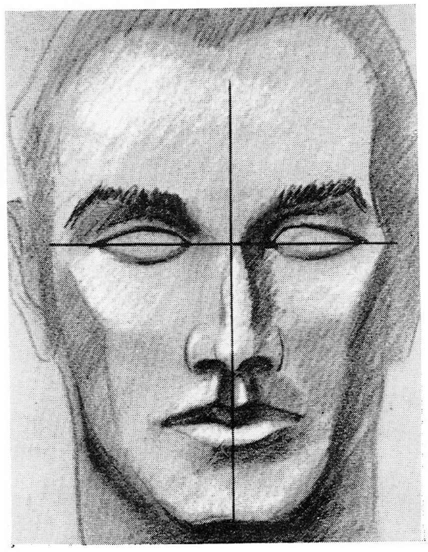

FIGURE 2. Normal canthal axes.

TABLE 2. Orbital Size at Rim (in mm.)

age	*height*	*width*
Birth	18	21
3 yrs.	28	32
4 yrs.	28	29
12 yrs.	33	34
Adult male	33	39
Adult female	34	36

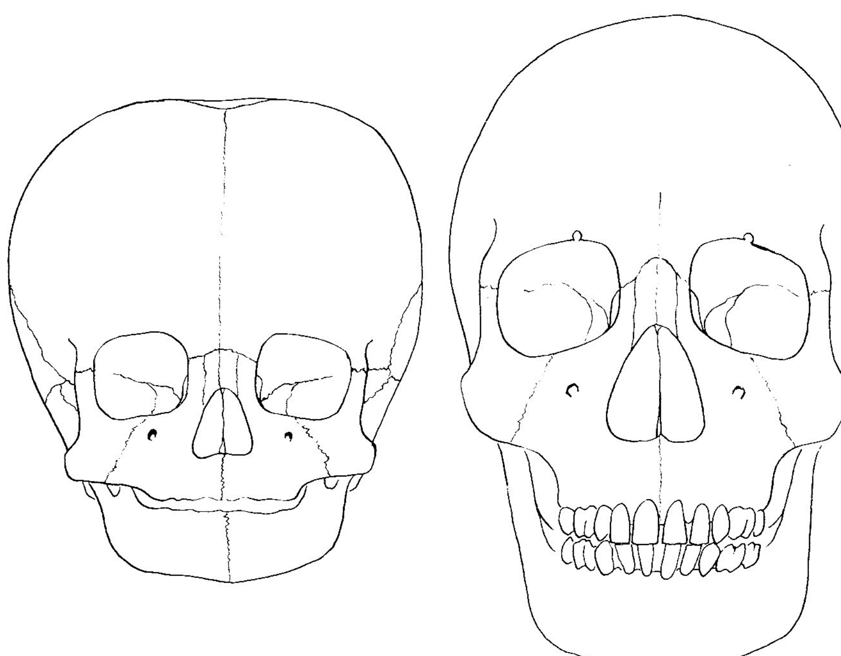

FIGURE 3. Orbital shapes in infancy and adult.

Distance between the lateral orbital margins is 100 to 120 mm. Figures are given for selected ages in Table 3 with figures for two standard deviations being given as the outer limits of normal (*11*). These measurements can be made directly with calipers on the patient and are useful in the

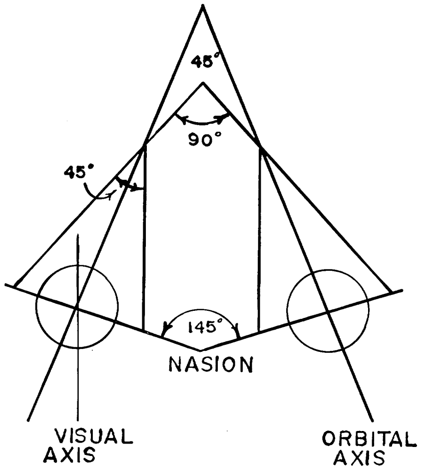

FIGURE 4. Orbital axes showing parallel medial walls of orbit. Apical angle (45°) increases in hypertelorism.

TABLE 3. Lateral orbital margin distances (in mm.)

age	*avg*	*2 std. deviations*
Birth	70	8
1 yr.	78	10
3 yrs.	90	10
5 yrs.	97	4
7 yrs.	101	4
12 yrs.	103	9
Adult	108–113	10

From: Laestadius.

overall assessment of facial width along with consideration of bitemporal and bizygomatic distances and symmetry (Figure 5).

Volumes of the orbits cannot be determined accurately in live patients. Measurements from skull studies from Duke-Elder (*5*) are given in Table 4. The exorbitism present in many of the facial anomalies, particularly Apert's and Crouzon's syndromes, reflects the inadequate volume of the orbit. A helpful guide to the exorbitism present and the amount of lateral orbital rim advancement necessary can be obtained with the Ludee exophthalmometer. The measurement is a direct slight measurement taken from the lateral orbital margin to the apex of the cornea (Figure 6). This distance averages from 10 to 14 mm. in the normal. The difference between the measured and expected value is the distance the orbit must be advanced to produce a normal depth and volume.

Bony interocular distance is a critical measurement when one is planning an orbital reconstructive procedure. BIOD, the only reliable guide to true orbital hypertelorism, is measured at the dacryon, the point of junction of the posterior and anterior lacrimal crests or the minimal interorbital distance (*19*). The measurement can be done by palpation with some loss of accuracy because of superimposed soft tissue or on a two meter PA radiograph or cephalogram taken either in the true PA position or with the head tilted upward 10° (*17*). A helpful method of determining the minimum interorbital distance has been described by Morin using x-rays and tracings to form a parallelogram of the orbits (*9*). The most accurate measurement, however, is done at surgery with calipers placed directly at the minimum bony interorbital distance, after reflection of all soft tissue. Averages obtained from radiographic studies by Currarino and Silverman (4), and Morin (*12*), et. al. are given in Table 5. Tessier aims at a final BIOD or

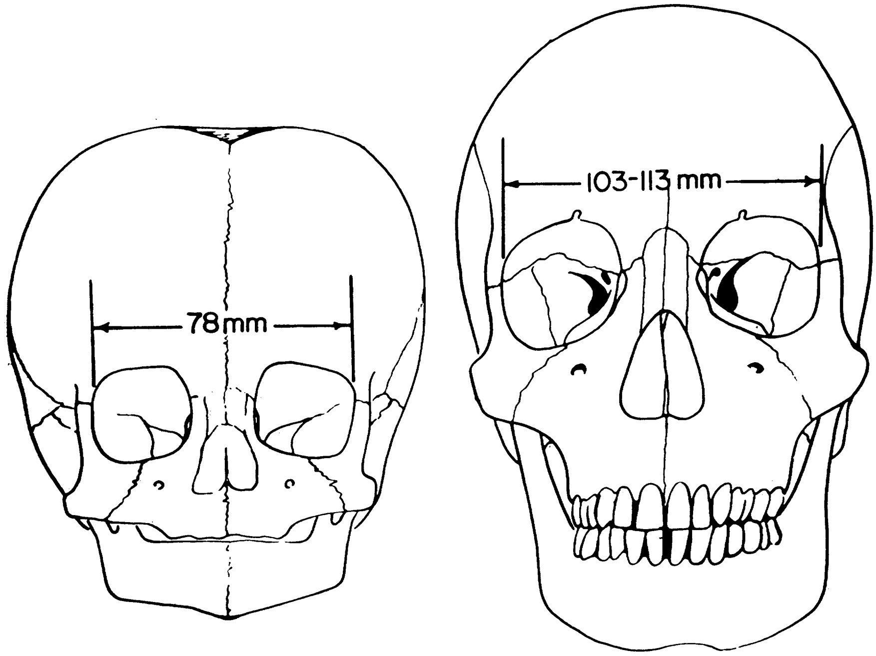

FIGURE 5. Normal bitemporal-bizygomatic distances in child and adult.

TABLE 4. Orbital volumes (in cc.)

age	*volume*
Birth	10
6–8 yrs.	39
Adult male	59
Adult female	52

TABLE 5. Bony interocular distance (in mm.)

age	*distance*	*std deviation*
1 yr.	18	4
2 yrs.	20	2
3 yrs.	21	2
5 yrs.	22	2
7 yrs.	22	2
12 yrs.	23	2
Adult	25	5

20 to 25 mm. following correction, depending upon the age of the patient (*11*) and has felt that any measurement deviating by more than 5 mm. from the norm is significant and deserves consideration for correction (*17*).

Sinuses bound the orbits on three sides and must be traversed by osteotomies in orbital displacements. Inferiorly the maxillary sinuses are important only in recognizing their essentially trouble free nature. Drainage is good and bone grafts are rapidly incorporated though only covered on three of four sides by soft tissue (*5*). Superiorly the paired frontal sinuses are traversed in procedures utilizing an intracranial approach. Their drainage is poor and complications are consequently frequent, unless obliteration is complete. Frontal sinus development begins at one year of age from

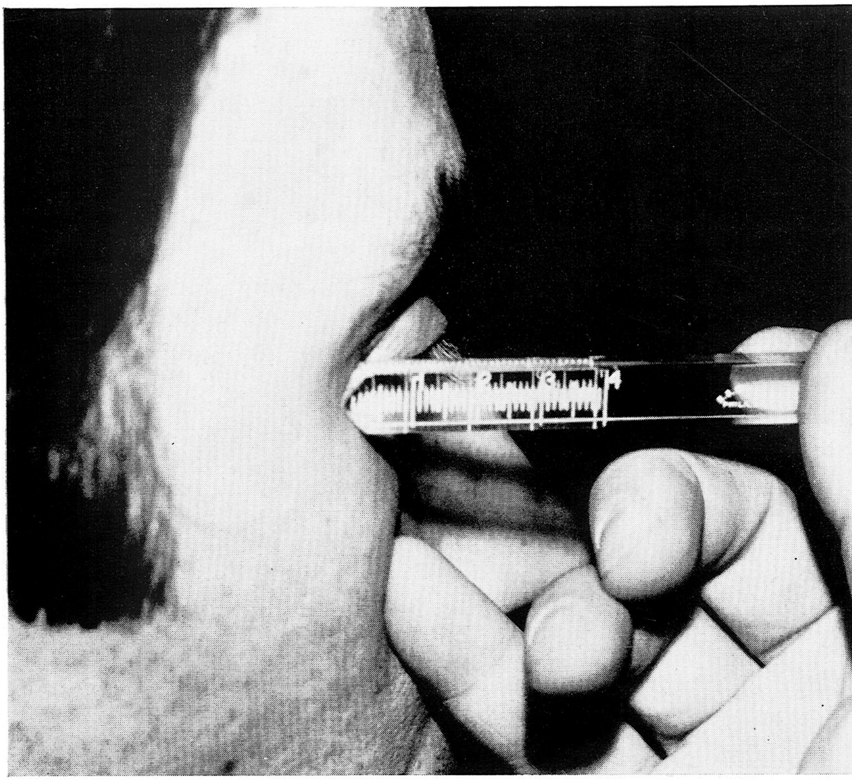

FIGURE 6. Illustrating use of Ludee exophthalmometer.

separate buds in the frontal bone. By seven years of age they average 0.5 cm. in diameter and are rarely more than 2 cms. Accurate assessment of location and size is best made on PA and lateral skull x-rays with use of tomography if necessary for details. The ethmoid sinuses can be critical in planning craniofacial procedures. Located medially and eight to ten in number they are distributed in three groups. They may be displaced in craniofacial deformities. The extent, location, size and shape of these cells are determined by PA and lateral x-rays and tomograms of the orbitofrontal regions. They are most often involved in hypertelorism and may have to be resected or displaced medially (*2, 3, 17*).

Prominence of the malar bones is essential to the normal facial configuration. They are often hypoplastic in the craniofacial dysostoses and may be partially or completely absent in mandibulo-facial dysostosis or hemifacial microsomia (*6*). Zygomatic arches are key in the reconstruction of defects of mandibulo-facial dysostoses. They average 1.5 cm. at their widest anteriorly, and 0.5 cm. posteriorly in the adult. The length from external auditory canal to zygomatico-maxillary suture averages 6 cm. in the adult. Length can be determined in each individual by a direct measurement from

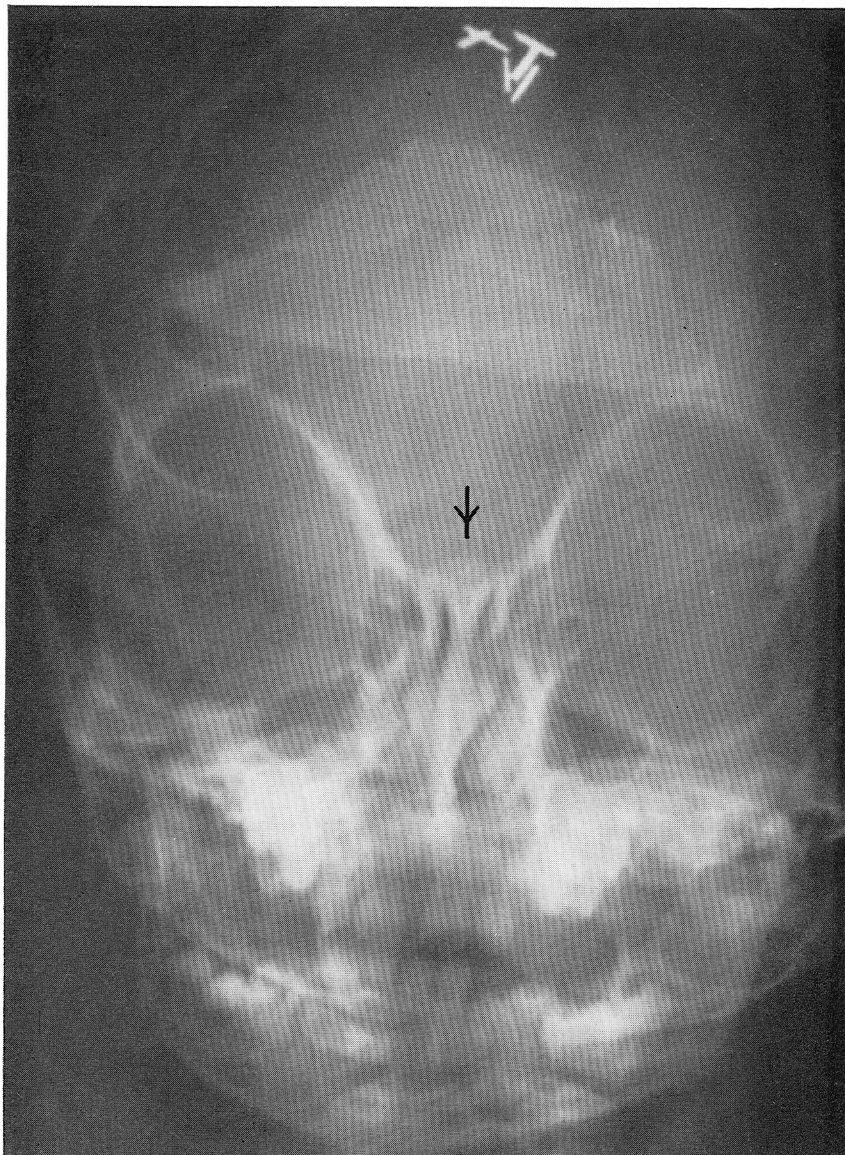

FIGURE 7. Inferiorly placed cribriform plate (arrow) in patient with hypertelorism.

tragus to lateral size of nose. Bone grafts to correct defects will have to approximate these dimensions.

Cribriform plate level is the most important feature in the anterior cranial base (*15*), and is normally about 1 cm. below the level of the anterior cranial base floor and 2 cm. behind the nasion (*3*). This level is the key to determining the approach to be used at operation, whether intra or extracranial (*15*) (Figure 7).

The anterior cranial base averages 45–55 mm. in the adult from inner table of skull to anterior clinoids and is less in craniostenosis. In the child from two to seven years of age it closely parallels development of the face. Deformities of contour of the anterior cranial base are common in stenoses (*16*) and a shortened anterior base may be important in its association with marked anterior projection of the temporal lobe, a hazard at the time of doing orbital displacement (*18*).

The final determinant of surgical success is the closeness with which the reconstructed face approaches the norm, as determined by esthetic and objective statistical criteria. An approach to evaluating the face by a complex series of studies, assessment by judgments, and measurements as outlined in this paper will be helpful in achieving the surgical goal of normal facial structures.

Summary

Major craniofacial abnormalities can be considered as a group for purposes of operative planning. Known normal relations define what is abnormal and indicate goals to be achieved with the craniofacial operative procedures. The principle syndromes with significant facial structural changes amenable to such surgical corrective procedures are craniofacial stenoses, hypertelorism, mandibulofacial dysostoses, median facial clefts, residua of encephaloceles, and trauma. Deformities primarily involve the middle and upper thirds of the face. In planning, abnormal relations and structures must be clearly defined utilizing patient examination, x-rays, dental study models, and photography. Standards of norm indicating goals for the corrective procedure are also based on studies using these tools, data from previous publications, and measurements directly from skulls.

Precise measurements about the orbits and the maxillary-mandibular relation are the keystone for planning. Soft tissue, nose, and ear alterations are based on already widely known concepts of norm and symmetry. Bony interocular distance, medial intercanthal distance, height and width at the orbital rim of the bony orbits, orbital shape, orbital axis, and orbital volume as determined by measurement with an exophthalmometer are useful in determining what is to be done about the orbits. Cribriform plate level, anterior cranial base, length and contour, and size of the zygomatic arches are important dimension considerations. Paranasal sinus size and location is important. These considerations are essential prior to any major facial structural changes.

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