Editor:
ROBERT B. SHIRA, D.D.S.
School of Dental Medicine, Tufts University
1 Kneeland Street
Boston Massachusetts 02111

An architectural and structural craniofacial analysis: A new lateral cephalometric analysis

J. Delaire, S. A. Schendel, and J.-F. Tulasne, Honolulu, Hawaii, and Nantes, France*

This architectural and structural craniofacial analysis is based upon mutual balance of the cranial and facial bony structures. With this technique, the base and calvaria of the cranium and then the face can be studied successively in relation to the cranium and craniospinal articulation. Statistical averages are avoided, and individual proportions influenced by the unique features of each skeleton are relied upon. The dentition is placed within the cephalic context, and thereby etiologic factors of dentofacial dysmorphoses which would not otherwise be demonstrated by conventional analysis are made obvious. This technique is particularly useful to the maxillofacial surgeon, as it clearly demonstrates all of the maxillofacial deformities and the pathologic balances that need to be corrected. In severe craniofacial malformations, it offers better possibilities than other cephalometric analysis methods of detecting the various cranial and facial anomalies which characterize these conditions.

All of the cephalic structures, hard and soft (viscera, muscles, and skeleton), arise, grow, and organize in a mutual balance. Therefore, the craniofacial skeleton constantly reflects these influences and their related functional conditions. On the basis of this knowledge, it is thus possible to construct a physiologic craniofacial analysis.

This analysis relies on those principles common to all human craniums. These are applied to each case to determine the existing individual proportions and balance based upon the unique craniofacial features of that case. Statistical averages relating the individual to an average group are not used; nor are measures that have no morphologic or physiologic base.

This architectural and structural craniofacial analysis of the lateral cephalometric radiograph clarifies the mutual balance of the various bony structures of the cranium and face, individualizes certain of these structures, and specifies their normal or pathologic relationships. With this analysis, one can then study successively the cranium (calvaria and base) and then the face in relation to the cranium and the craniospinal articulation.

*Stomatology and Maxillofacial Surgery Service, Nantes, France.

ANALYSIS

Analysis of the cranium

Theoretical principles (Fig. 1 to 4). The cranium is supported by the spine, and at the anterior of the cranium is suspended the facial mass, whose weight is compensated for by the tonus of the posterior neck muscles. The force from these muscles is carried throughout the cranial cavity by the falx cerebri and the falx and tentorium cerebelli. These dural fibrous septa join together at the internal occipital protuberance with the various bony components of the cranial base and calvaria. Embryologically, these muscles and dural septa appear before the primary ossification centers and therefore play a fundamental part in the morphogenesis of the cranium and, consequently, of the face.[1-5]

Within the cranial cavity there are two dural aponeurotic systems, one horizontal and one sagittal, which act as a stretcher upon the base from the calvaria (Figs. 1 to 3). These are formed by three strong dural septa—the tentorium cerebelli, the falx

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cerebri, and the falx cerebelli–and are in a state of permanent tension. Their fiber tracts are interdependent and directed to take advantage of mechanical properties, that is, considerable longitudinal tensile strength, less opposition to transverse pressure, and slight bending strength.[2] Spatially, the sagittal sinus represents the axis of the orthogonal system formed by these three dural septa. Each half of the tentorium cerebelli is formed by two different fiber networks which produce a latticed appearance. Some are arranged in a radiating manner and go up to the falx cerebri, while others are arranged circularly and go from the clinoid processes to the medial ridge of the tentorium cerebelli, with most of them ending in the falx cerebelli. The diaphragm of the sella, the tentorium of the optic nerve, and the tentorium of the olfactory bulb are also connected with this system.

The horizontal system (tentorium cerebelli, diaphragm of sella, and tentorium of the optic nerve) stretches the base and puts in a nearly horizontal plane the upper surface of the cribriform plate, the lesser wings of the sphenoid bone (particularly their posterior borders), the roof of the diaphragm of sella, the clinoid processes, and the superior border of the petrous portion of the temporal bone. The lateral surfaces of the sphenoid body are interdependent with this horizontal plane through the walls of the cavernous sinuses.

The medial or sagittal system stretches the calvaria and runs from the foramen magnum to the crista galli. It is interdependent with the former and curves the vault in the medial sagittal plane, whereas the lateral parts of the calvaria are free where the dura is not strongly attached.[2-3]

These two systems are closely interdependent and are kept in permanent tension by the posterior and lateral muscles of the neck. Therefore, we can understand how and why all of the primarily independent skeletal cranial components are arranged, directed, and shaped in such a manner that (1) the cerebral surface of the cranial base, from the crista galli to the posterior clinoid processes, is straight and (2) the calvaria is regularly curved from the foramen magnum to the crista galli. The curve of the calvaria, the position and orientation of the foramen magnum, and the sphenoidal angle very according to the posture of the head in relation to the cervical column as dictated by the muscular-aponeurotic system. There are close relationships between the slope of dorsum sella and clivus, the posterior segment of the sphenoidal angle, and the orientation of the petrous part of the temporal bones.[6] It is thus possible to represent these cranial segments by lines and curves and to analyze their shape and mutual balance by geometric construction.[7]

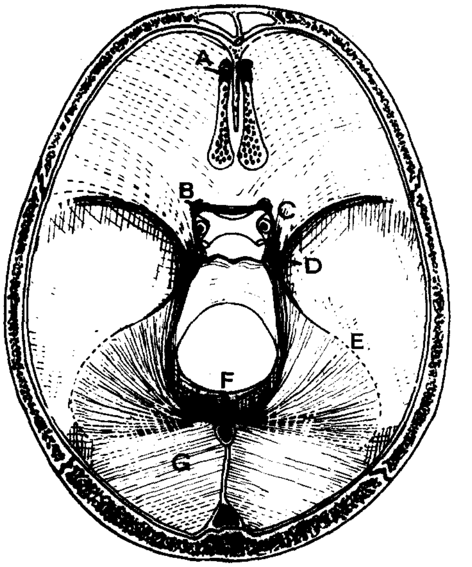

Fig. 1. Superior view of the cranial base. *A,* Anterior attachment of the falx cerebri and tentorium of the olfactory bulb. *B,* Tentorium of the optic nerve. *C,* Region of the anterior clinoid process. *D,* Posterior clinoid process. *E,* Petrous portion of the temporal bone. *F,* Falx cerebelli. *G,* Tentorium cerebelli.

Cranial cephalometric analysis. Four lines are used and designated C1 through C4 to analyze the cranium (Fig. 5):

1. The line C1 (craniofacial base line) represents the craniofacial frontier and runs from the frontomaxillary suture to the most posterior part of the occipital bone. It is formed by connecting the points M the junction of the nasofrontal, maxillofrontal, and maxillonasal sutures which is the anterior part of the frontomaxillary articulation[7-8] and CT (the temporal condylar point, the inferior point of the posteroinferior surface of the articular tubercle of the temporal bone).

The M-CT line is then extended to the point OI (inferior occipital), which is the intersect of the line C1 and a line perpendicular to C1 and tangential to the external surface of the occipital bone. The intersection of the plane C1 and the posterior contour of the mandibular condyle is point CP. Normally, CP is located midway between M-OI (that is, M-CP = CP-OI). This forms two equal segments which are termed the "craniofacial area" and the "craniospinal area," respectively. CP seems to be the equilibrium point between the face and the cranium in the normal Caucasian skull. The line M-CP intersects the top of the pterygomaxillary

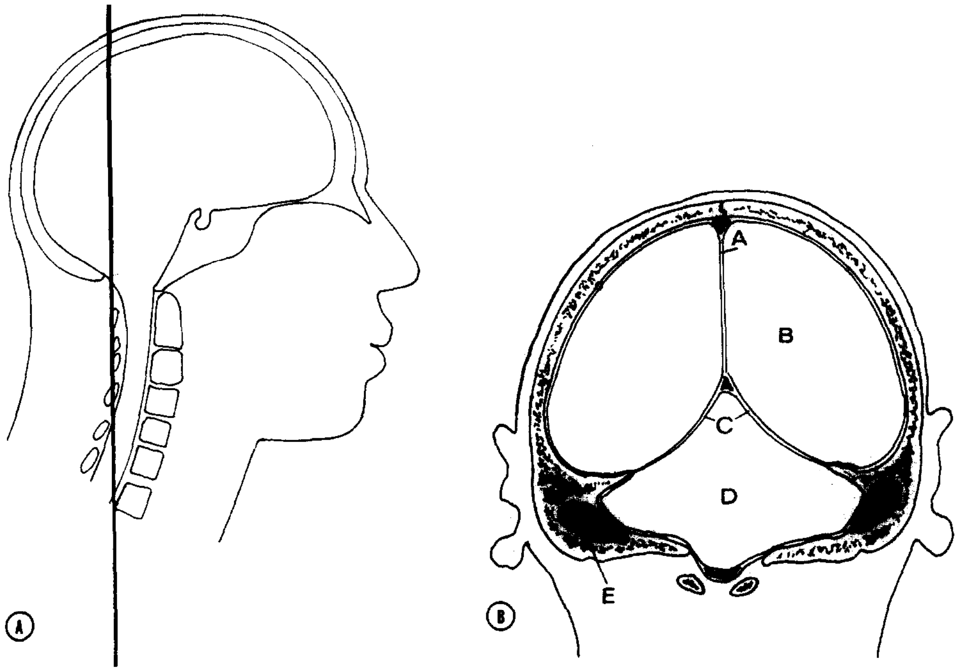

Fig. 2. A, Coronal section of the head behind the foramen magnum as shown by the vertical line. **B,** Coronal section. *A,* Falx cerebri. *B,* Cerebral area. *C,* Tentorium cerebelli with the straight sinus just above. *D,* Cerebellar area. *E,* Lateral sinus.

fissure Pts (superior pterygoid point) which is just above and posterior to Rickett's CC point and is formed by the intersection of lines Cl and CF2 (CF2 will be explained later). In patients with good cephalometric balance, M-Pts = 30 percent of M-CP and Pts-CP = 20 percent of M-CP.

2. The line C2 (cranial height) is perpendicular to Cl at its center and intersects the calvaria at the point SC. Normally, SC is the farthest cranial point from CI, the calvaria height decreases regularly on both sides of this point (that is, SC is the summit of the cranium), and the length of C2 is approximately 80 percent of Cl (75 to 85 percent).

3. The line C3 (superior line of the cranial base) is drawn from M to Clp (apex of the posterior clinoid process) and extends posteriorly until it intersects the external surface of the occipital bone at OP, posterior occipital point. Normally, the segment M-Clp is approximately parallel to the cribriform plate of the ethmoid bone and passes close to the anterior clinoid process and the pituitary tubercle; the point OP is very close to the tangential occipital point of the perpendicular to CL registered at point OI; and the angle between lines Cl and Clp is normally close to 22 degrees.

4. The line C4 (basilar slope) is formed by connecting point Clp to the posteroinferior part or the apex of the odontoid process. Normally, C4 is tangential to the dorsum of the sella turcica, the cerebral surface of the basi-occipital bone and basion, and it is very close to the posterosuperior surface of the mandibular condyle and is often tangential to it.

Analysis of the face in relation to the cranium and the craniospinal articulation

Theoretical principles. The face is suspended below the anterior cranial base and is constructed according to the size, shape, and orientation of its skeletal components (Fig. 4). On the lateral cephalometric radiograph, the building area of the face, or "craniofacial area," is delineated by the segment M-Cp of the craniofacial base line Cl. As previously noted, it is divided into two segments: M-Pts (30 percent) and Pts-Cp (20 percent). M-Pts is termed the "maxillary area" because all of the maxillary structures are located in front of the pterygoid plates. The anterior part of the plates are normally aligned with the anterior border of the ramus, and the anterior and posterior borders of the ramus are normally parallel.[9]

The maxilla is suspended below the frontal and ethmoid bones with the malar bones laterally. It receives the masticatory shocks and transmits them to its base or support. These shocks are caused as the mandible contacts the maxilla. Consequently, there appears and remains between the "anvil" (maxilla, ethmoid, and frontal bones) and the "hammer"

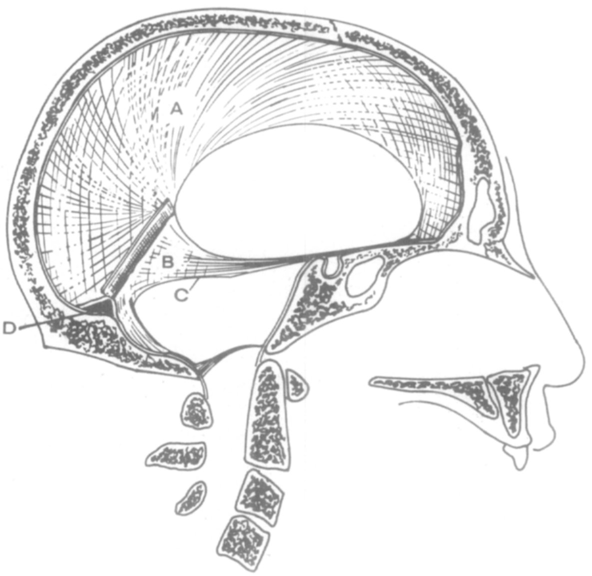

Fig. 3. Paramedian sagittal section of the head. *A,* Falx cerebri. *B,* Tentorium cerebelli, left half, right shown cut. *C,* Inferior side of the left lateral sinus where the lateral aspect of the tentorium cerebelli inserts. *D,* Lateral sinus.

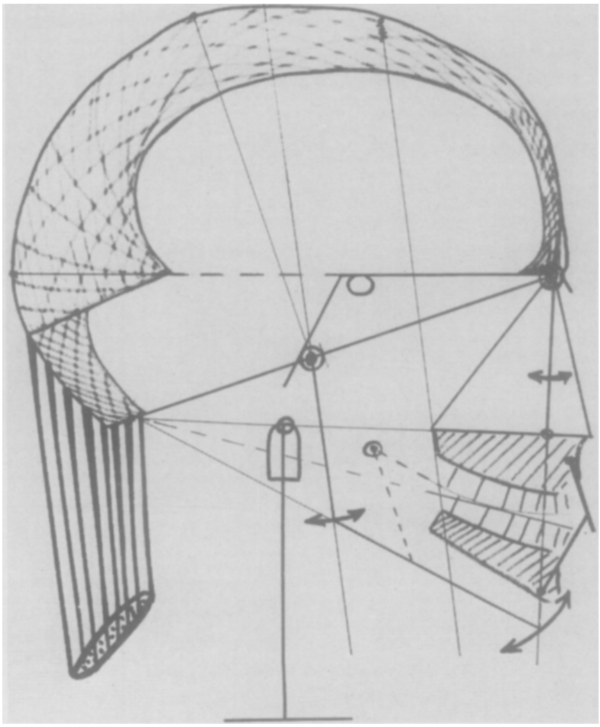

Fig. 4. Diagram of craniofacial and cervical balance. Schematic drawing of the craniofacial and cervical equilibrium. The weight of the face suspended from the anterior cranial base is compensated for by the tonus of the postcervical neck muscles. The action of these muscles is carried through the cranium by the falx cerebri and cerebelli and the tentorium cerebelli. The articulation of the vertebral column to the cranium, the temporomandibular articulation, the maxilla, and the mandible are connected by their mutual equilibrium.

(mandible, sphenoid, and temporal bones), a sutural shearing line formed by (a) the coronal system (calvaria and base), which includes the following sutures on each side: frontoparietal, frontosphenoidal (between frontal and greater, then lesser, wings), and frontoethmoidal and spheno-ethmoidal (surrounding the cribiform plate), and (b) the pterygomaxillary fissure, palatomaxillary suture, and pterygopalatine sutures. Normally, the frontier between these sutures (which give and receive the masticatory shocks) is well represented by a plane drawn from bregma to the top of the pterygomaxillary fissures.

In all of the animal types, the orientation of the maxilla in relation to the cranial base (degree of maxillary prognathism) depends upon posture, which is traditionally under the influence of gravity and the type of mastication.[10] Without doubt, we must also emphasize the role of the falx cerebri and its changes of direction according to the cervicocephalic posture. It inserts firmly on the crista galli and the continuing medial crest. Therefore, it regulates the orientation of the cribriform plate and the ethmoid bone.

In man, the posture is vertical and the cribriform plate is horizontal. The maxilla, like the anterior end of the falx cerebri, is oriented vertically, as is the line CF1 which is perpendicular to the cribriform plate and the line C3. The line CF1 is registered at the frontomaxillary joint and normally goes through the superior aperture of the nasopalatine canal.[10]

Movements of the head act on the morphogenesis of both the calvaria and base of the cranium and the face. The superior plane of the hard palate is normally aligned with the craniospinal articulation, particularly the apex of the dens which embryologically represents the body of the atlas and is firmly connected to basion. This relationship exists because of the close interrelationship of muscles and tendons in this region. Moreover, the bispinal plane, ANS-PNS, is normally horizontal in man because of his vertical posture and is thus parallel to the line C3. This position of the palatal plane is influenced by the relationships between the muscles of the soft palate, pharynx, and tongue and the temporal bone, sphenoid bone, cervical column, mandible, and hyoid bone. In the embryo, the palate is oriented obliquely and is high and posterior in relation to the sphenoid. After birth, and with the attainment of erect posture, this gradually assumes the adult position.[6]

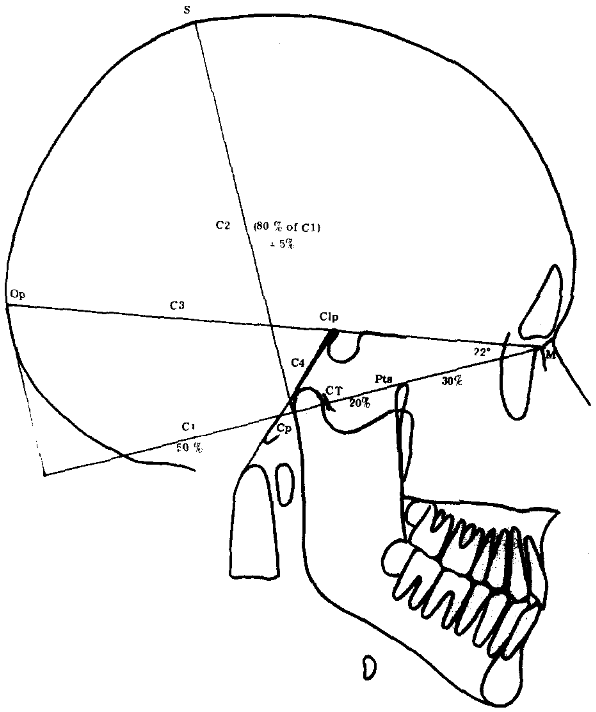

Fig. 5. Analysis of the cranium. *S,* Summit of the skull. *M,* Junction of the nasal, frontal, and maxillary bones. *Op,* Posterior occipital point. *Clp,* Posterior clinoid process. *CT,* Temporal condylar point. Pts, Superior pterygoid point.

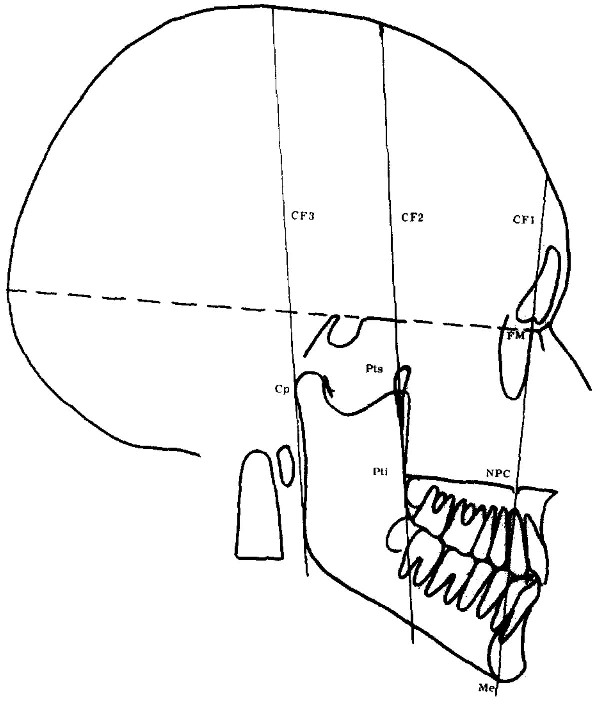

Fig. 6. Lines analyzing the anteroposterior balance of the facial structures in relation to the anterior cranium. *FM,* Frontomaxillary articulation. *Cp,* Posterior tangent of the condyle. *Pti,* Inferior pterygoid point. *NPC,* Nasopalatine canal. *Me,* Menton.

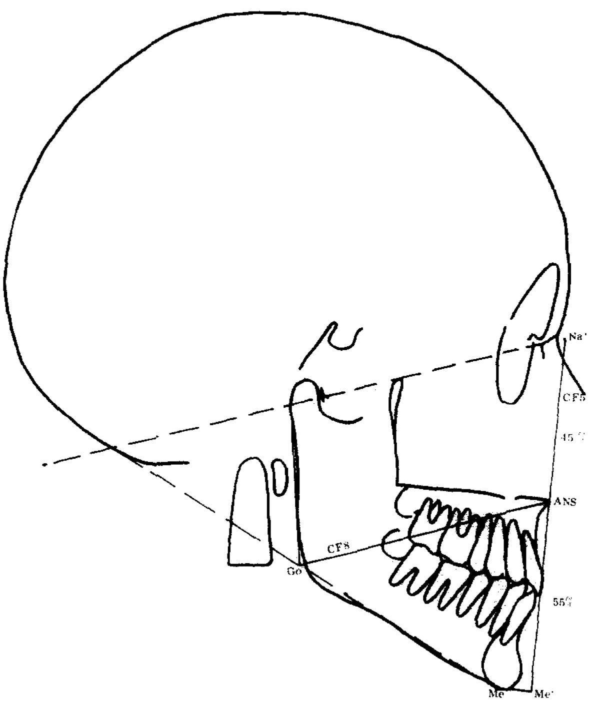

Fig. 7. Lines analyzing the relationships of vertical facial balance. *Na,'* Nasion projected. *ANS,* Anterior nasal spine. *Go,* Gonion.

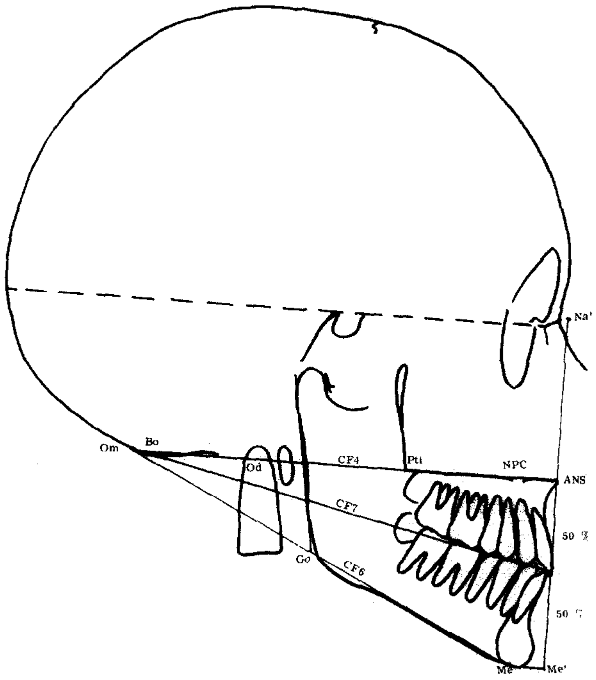

Fig. 8. Lines analyzing the balance of the palatal, mandibular, and occlusal planes in relation to the craniospinal articulation and the inferior part of the skull. *Bo,* Bolton point. *Od,* Odontoid. *Om,* Mandibular-occipital point.

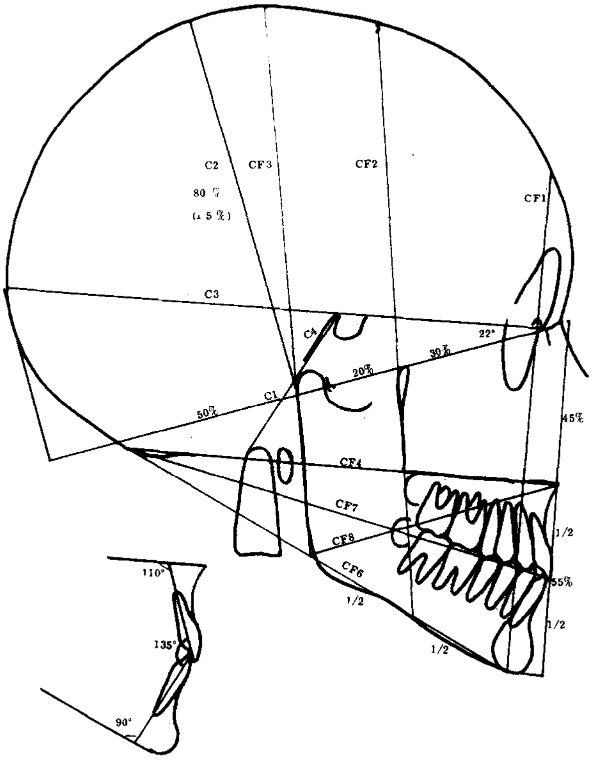

Fig. 9. Complete craniofacial and dental analysis.

Recent research has shown that the mandible and, more generally, the structures of the lower face (especially the tongue) have their spatial position determined to a great degree by the relationships of the maxilla to the cervical spine in the habitual posture. As a result, relationships of balance exist between:[12-16] (a) the orientation and position of the maxilla in relation to the cranium and the craniospinal articulation and (b) the orientation and position of the mandible, particularly its tooth-bearing segment. A normal or pathologic occlusal plane is secondary to these interrelationships.

As noted by Wendell Wylie on the lateral cephalometric radiograph, the anterior facial height from Na to Me consists of two segments[17]: Na-ANS (45 percent of Na-Me) and ASN-Me (55 percent of Na-Me). Other correlations, less studied, exist between the orientation of the mandibular plane, the occlusal plane, and: (a) the occipitovertebral area, particularly the most inferior or squamous portion of the occipital bone, and (b) the position of the temporomandibular joint. These relationships explain the mandibular modifications which occur during phylogenesis with postural changes, such as increasing ramal height and approximation of the craniospinal, temporomandibular, and frontomaxillary joints as the posture becomes vertical.[13]

Facial cephalometric analysis. Eight lines are used to analyze the face and are designated CF1 to CF8.

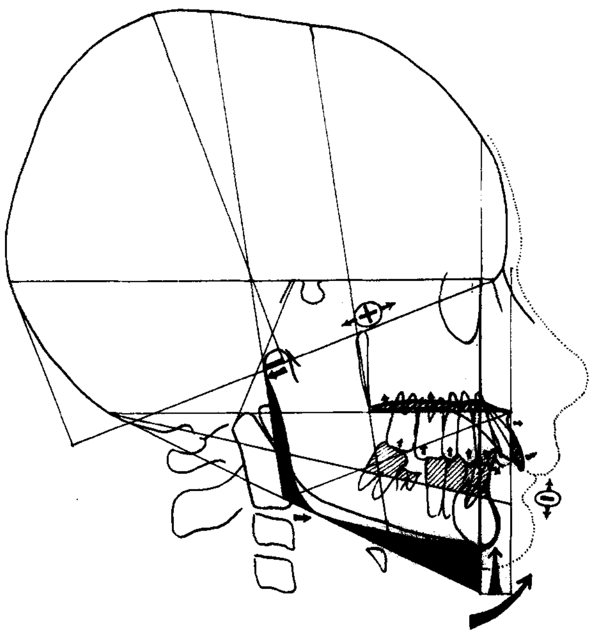

Fig. 10A. A Class II malocclusion secondary to a significant increase in the anterior craniofacial base length according to the analysis, marked by a large +. There also is a posterior position of the glenoid fossa and the mandibular condyle which is partially compensated for by an anterior rotation of the mandibular ramus. Associated with this is a closure of the mandibular angle and an ascension of the occlusal plane caused by a lack of maxillary vertical height. There is also maxillary alveolar protrusion and labial version of the maxillary incisors. This all results in a loss of anterior facial height (the minus sign), and we thus have a short-face syndrome with Class II malocclusion.[21] (In all the example cases illustrated, areas of crainofacial excess as shown by the analysis are cross-lined and deficient areas are shaded black.)

Lines CF1, CF2, and CF3 are used to study the anteroposterior balance of the facial structures in relation to the anterior cranium (Fig. 6), and lines CF5 and CF8 are used to study the relationships of vertical balance, anteriorly and posteriorly, of the face (Fig. 7). Lines CF4, CF6, and CF7 are used to study the balance between the palatal, mandibular, and occlusal planes in relation to the craniospinal articulation and the posteroinferior part of the skull (Fig. 8). Line CF8 is normally parallel to C1 and joins the gonial angle and the ANS.

The line CF1, anterior line of craniofacial balance, is perpendicular to line C3 registered at point FM, which is the intersect point of C3 and the line continuing to the anterior lacrimal crest. Generally, this crest is easily visible in the middle of the frontal process of the maxilla where it goes up into the thickened area of the floor of the frontal sinus.

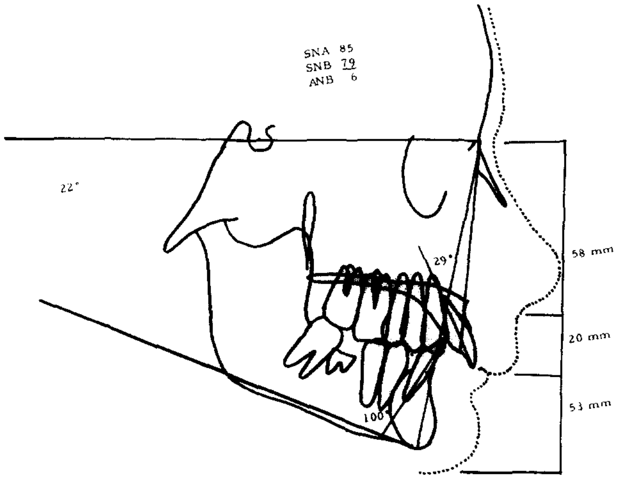

Fig. 10B. The "classic" cephalometric analysis shows a smaller than average mandibular plane angle and increased SNA angle with resultant Class II malocclusion. The decreased lower facial height confirms that this is a low-angle Class II malocclusion. Evaluation of the lip-to-maxillary-incisor relationship demonstrates an incisor that is too high vertically by rapport with the lip, and a vestibuloversion of the maxillary incisors is also seen. This analysis does not show in this case the excessive anterior cranial base length combined with the posterior condylar position which cause the Class II malocclusion. It also does not tell us that the skull is normally shaped. We can easily see in the architectural and structural analysis that the entire midface, including the nose, is short vertically.

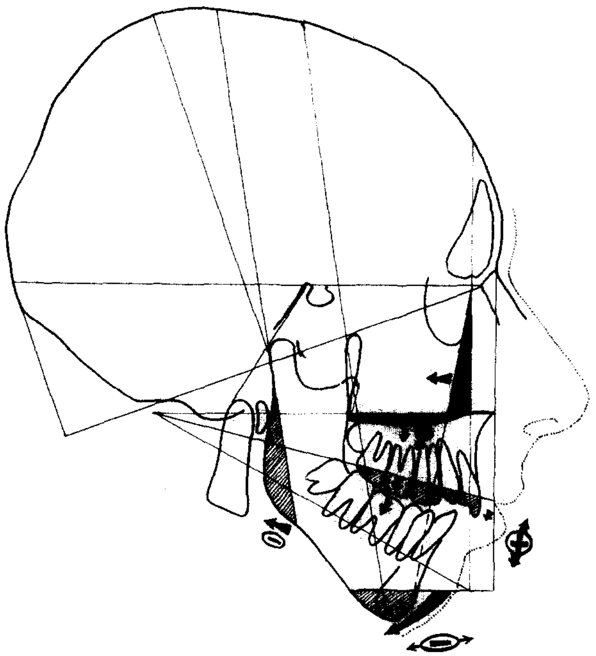

Fig. 11A. The Class II malocclusion demonstrated by Case B has a normal craniofacial base length with opening of the gonial angle and bodily clockwise rotation of the total mandible. These structural changes are secondary to an excessive anterior face height and abasement of the occlusal plane caused by excessive maxillary vertical excess. There is also a slight posterior rotation of the maxilla. Note that the analysis correctly points out a normal palatal plane position with the skull and that the maxillary excess is in the alveolar region. The ideal occlusal plane line also points out the normal position vertically of the upper lip. This is a typical long-face syndrome.[23]

Normally, CF1 merges with the anterior maxillary pillar which, from FM, follows the anterior lacrimal crest just anterior to the infraorbital point and then passes through the anterior edge of the superior foramen of the nasopalatine canal (CPA) and the hypomochlion* of the permanent or deciduous upper canines.[7-11] Below the occlusal plane, CF1 passes normally through the apex of the mandibular central incisor, the union of posterior and middle thirds of the symphysis, and menton (Me). Above C3, it divides the frontal sinus into two parts with an equal base but with unequal height.

However, these ideal conditions of craniofacial balance are not absolutely necessary for good facial balance. In spite of rotation of the anterior maxillary pillar more or less than 90 degrees in relation to C3, the face can be well balanced if all the landmarks from FM to Me are located on the same line. Such a profile should be considered normal, even if not ideal. Particularly in the female and in the child, the anterior pillar is rotated slightly posteriorly, having an average angle of 85 degrees.

The line CF2, middle line of craniofacial balance, is drawn from Br (bregma) to Pts and is extended inferiorly until it intersects the inferior border of the mandible. Normally, this line passes through Pti (inferior pterygoid point, the intersect of the axis of the pterygomaxillary fissure and the superior palatal border), follows the anterior border of the ramus,[9] and intersects the mandibular plane at approximately the midgonion-gnathion distance. The segment Pts-Pti is termed the middle pterygoid pillar.

The line CF3, posterior line of craniofacial balance, is constructed parallel to CF2 and tangential to the posterior border of the condyle. Normally, CF3 is also tangential to the posterior border of the

*The hypomochlion is a point centered in the maxillary cuspid root at the junction of the superior third and the inferior two thirds.

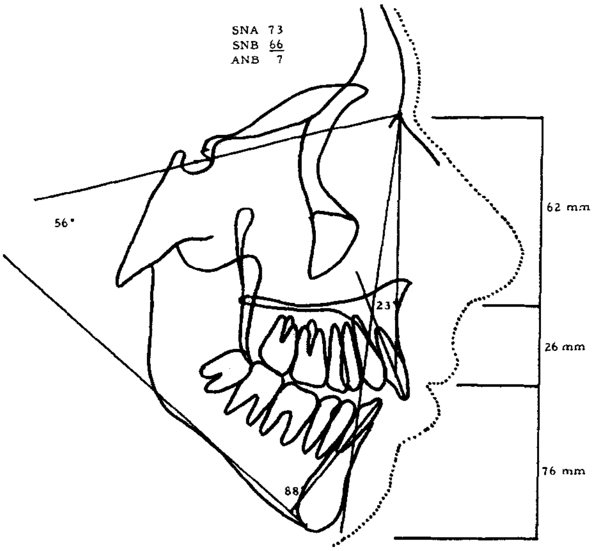

Fig. 11B. The "classic" cephalometric analysis demonstrates small SNA and SNB angles, indicative of a retroposition of the alveolar portion of these bones. However, these small angles may also be secondary to an increased cranial base angle often associated with high mandibular plane angle Class II malocclusions or a high position of the nasion point. The ANB angle is increased into the Class II malocclusion range. While the lips are not completely in a relaxed position in this radiograph, we can see that the maxillary incisor is vertically too long for the upper lip, which measures 26 mm. The anterior face height measures are increased, especially the lower, and the mandibular plane angle is extremely large with a small open-bite.

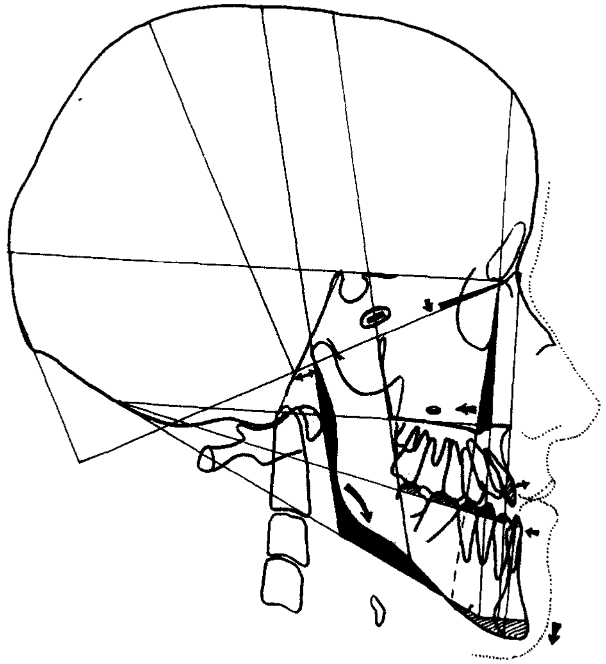

Fig. 12A. In Fig 12 and 13, two Class III dentofacial dysharmonies are illustrated with different craniofacial architecture. The most important deformity in this case is the short craniofacial base, marked by the – sign, which is aggravated by a posterior rotation of the maxilla and an increase in the mandibular body length, opening of the gonial angle, and increased anterior face height. The upper lip and maxilla are short vertically by comparison to the occlusal line. These other factors are, however, functional factors secondary to the short craniofacial base and anterior glenoid fossa position which are the constitutional factors causing maxillary retrusion and the Class III malocclusion.[21]

mandible and therefore merges with the posterior mandibular pillar.

The line CF4, craniopalatal line, is parallel to C3 through ANS. Usually, in natural head position,[17] CF4 passes successively through the upper half of the anterior arch of the atlas, the apex of the odontoid process below the upper end of the dens, and the Bolton point (Bo). On the other hand, CF4 also follows the straight upper surface of the primary and secondary bony palate, passes through point Pti, and slightly intersects the most inferior squamous part of the occipital bone. In children, this craniopalatal line is in a higher position than in adults in relation to the odontoid process.

The line CF5, theoretical facial height, is perpendicular to CF4 through ANS from Na′ (projection of Na) to Me′ (ANS-Me′ = 55 percent of Na′-Me′). In practice, the Me′ position is found by doubling the distance Na′-ANS and adding ⅑ to it. Normally, the parallel to CF4 through Me′ intersects CF1 at Me, the ideal osseous mental point. CF5 is also the vertical reference for CF6. Usually, Na′ is located slightly in front of Na, and CF5 is nearly tangential to the upper central incisors or passes just in front of them.

The line CF6, craniomandibular line, is a tangent to the squamous occipital bone through the ideal Me. Normally, CF6 follows the inferior border of the mandible from Me to the antegonial notch and then slightly intersects the mandibular angle and CF4 at Go. In some cases, the lower part of the squamous occipital bone presents such modifications that it cannot be used to draw CF6. Then one must determine the height of the ramus by tracing CF8, which normally intersects CF3 at Go, the theoretical gonion. Normally, Go is therefore located at the intersection of CF3, CF6, and CF8 (Fig. 9). In the cases of an abnormal squamous occipital bone, CF6 is drawn by connecting Me to Go after tracing CF8.

The line CF7, cranio-occlusal line, passes from

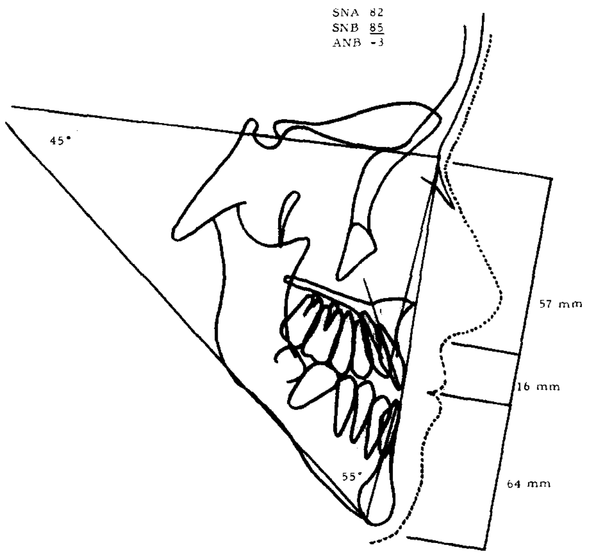

Fig. 12B. The "classic" analysis demonstrates a Class III malocclusion with a normal SNA angle and increased SNB angle. Other abnormalities are an increased lower anterior face height, a large mandibular plane angle, vestibuloversion of the maxillary incisors, and lingual version of the mandibular incisors. The upper lip is short, measuring 16 mm. However, there is a very close to normal maxillary-incisor-to-stomion relationship. This analysis does not show that the skull is well balanced and that the main constitutional problems are the short anterior cranial base and anterior position of the glenoid fossa.

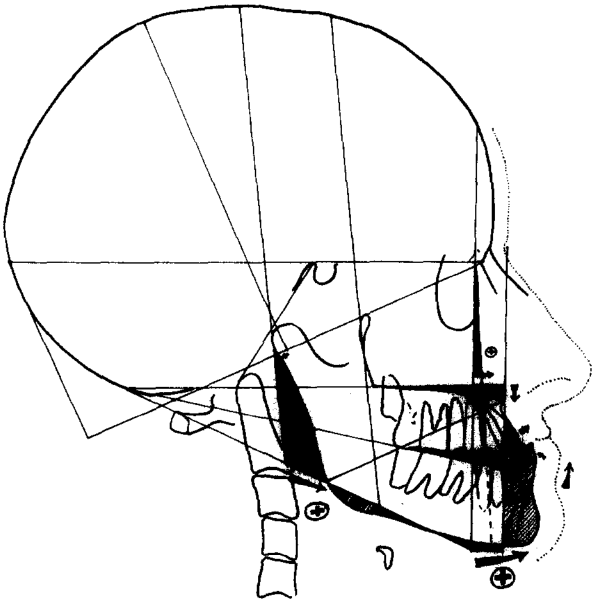

Fig. 13A. In this case, the craniofacial base is long, and yet a Class III malocclusion exists. There is a significant increase in the mandibular length, a closure of the gonial angle, and a decreased facial height as shown by the arrows. Interestingly, there is also an increased anterior rotation of the maxilla compensating and probably secondary to the true mandibular prognathism.[11, 15, 20]

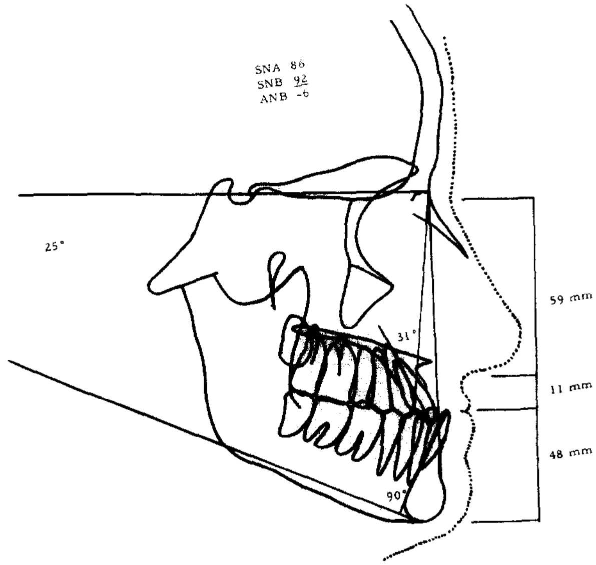

Fig. 13B. The "classic" cephalometric analysis demonstrates a Class III malocclusion with a large SNA angle and an even larger SNB angle. There is a low mandibular plane angle, and the anterior facial height is decreased. The upper lip measures short of normal, but this is most likely due to overclosure of the mandible and the maxillary incisors are in vestibuloversion. The normal skull is not noted; nor is the anterior rotation of the mandibular ramus, a significant cause of the malocclusion.

Om to the middle of ANS-Me'. Om is the mandibular occipital point which is generally tangential and just touching the occipital bone. Normally, CF7 is tangential to the premolar occlusal surfaces and is slightly below the lower incisor edge.

The line CF8 is a parallel to the C1 through ANS and usually passes through Go.

Dental analysis

Dental analysis includes the study of the orientation of the upper and lower incisors in relation to each other and to the mandibular and palatal planes. In this analysis, i = lower incisor, I = upper incisor, i/CF6 = 90 degrees, I/CF4 = 110 degrees (±2), and I/i = 135 degrees (±5).

Remarks

It is clear that the lateral architectural and structural craniofacial analysis (Fig. 9) requires a cephalometric radiograph in which all of the hard and soft structures are visible. These structures include the frontal sinus, nasal bones, orbit, maxillary sinus, shape of nasal spine, alveolus, chin, osseous and soft palate, condyle, coronoid process, mandibular angle, tongue, hyoid bone, and cervical vertebrae. In addition, such an analysis requires a detailed clinical examination, including a patient examina-

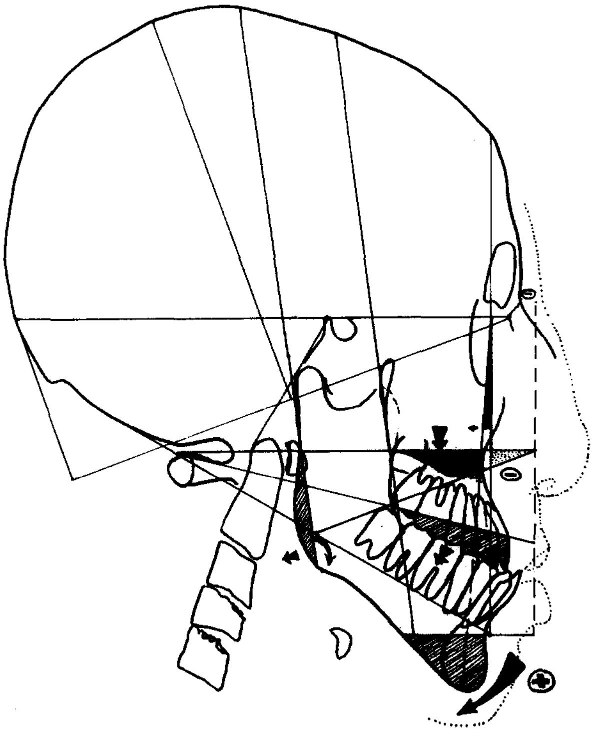

Fig. 14A. A case of maxillonasal dysplasia or Binder's syndrome.[23, 24] This complex craniofacial syndrome has a tendency to excessive cranial height in relation to the cranial base line C_2. There is also an opening of the gonial angle and excessive anterior face height, which is caused by abasement of the occlusal plane and palate in relation to the cranium. Also typical of this syndrome is a significant premaxillary hypoplasia which is often the cause of a Class III malocclusion. Associated deformities also seen are multiple cervical malformations.

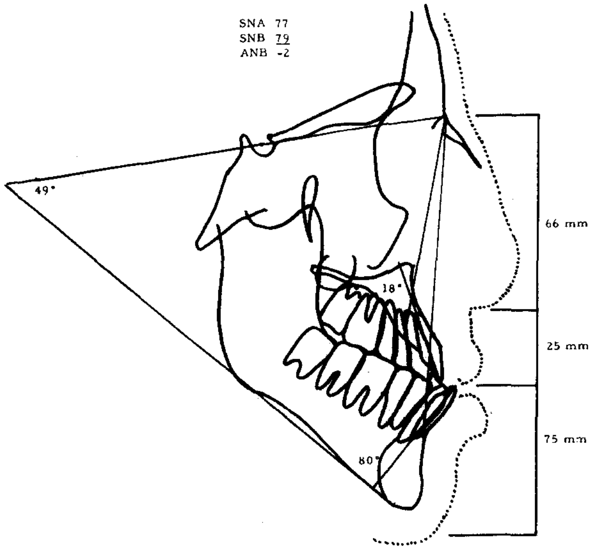

Fig. 14B. The "classic" analysis demonstrates a decreased SNA angle with a fairly normal SNB angle resulting in a Class III malocclusion. The mandibular plane angle is increased, as is the anterior face height. The amount of total maxillary retroposition and premaxillary hypoplasia is not distinguished by this analysis; nor is the cranial shape. Here there is seen a normal maxillary-incisor-to-lip relationship with an excessive facial height. The architectural and structural analysis defines this problem as not only a maxilla that is vertically too long but the soft tissues of the nose and lip (see the occlusal and palatal plane lines). Anatomic studies have shown that the soft tissue is abnormal, lacking the facial muscle attachments to the anterior nasal spine and septal cartilage and a hypoplasia of the septal cartilage, thus resulting in a loss of support for this part of the face.

tion, photographs, and dental models. In the case of facial asymmetry, a tridimensional analysis (lateral, frontal, and vertical) will be necessary.[19]

Case examples

In the following section (Figs. 10 to 16), examples of several common dentofacial anomalies and complex syndromes will be evaluated physiologically by means of the architectural and structural craniofacial analysis.[20, 21] This will then be compared to a type of analysis used by oral and maxillofacial surgeons in planning treatment. The more typical analysis is by no means all-inclusive but is included mainly as a reference for the reader who is more familiar with this type of analysis. Also, these case examples in no way demonstrate the total range of variation in craniofacial anomalies but serve to illustrate the use and value of this analysis. The differing cranial and facial lines are not marked in the cases, and the reader is referred to the preceding tions. The basic structural malformation for each case is described and surgical-orthodontic correction should be based on normalizing these relationships. To use this analysis, one simply constructs the cranial and facial lines according to their relationship and compares the case being examined to this.

DISCUSSION

In this analysis, some of the points and planes of reference are taken from various cephalometric techniques, and some of the constructions and concepts are similar to those of Broadbent, Chateau, Wylie, Bimler, Sassouni, Enlow, Ricketts, Leroi-Gourhan, Delattre and Fenard, and Gudin.[1, 2, 8, 13, 16, 17, 26-28] However, most of these cephalometric techniques are primarily directed toward growth problems of the dentition and supporting osseous structures. Their points of reference have usually been selected because they are easily visible on a radiograph, and their use is based on statistical

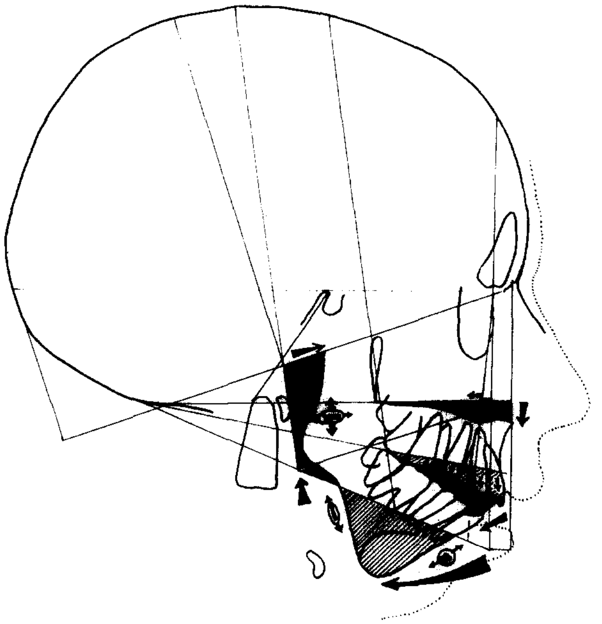

Fig. 15A. A case of the mandibuloacral dysplasia syndrome. The principal anomaly seen here is a considerable hypoplasia of the mandibular ramus with ascension and opening of the gonial angle. The maxilla is increased vertically, and an open-bite is often present. Clockwise global rotation of the maxilla and mandible is significant and is demonstrated by the large arrow.[25]

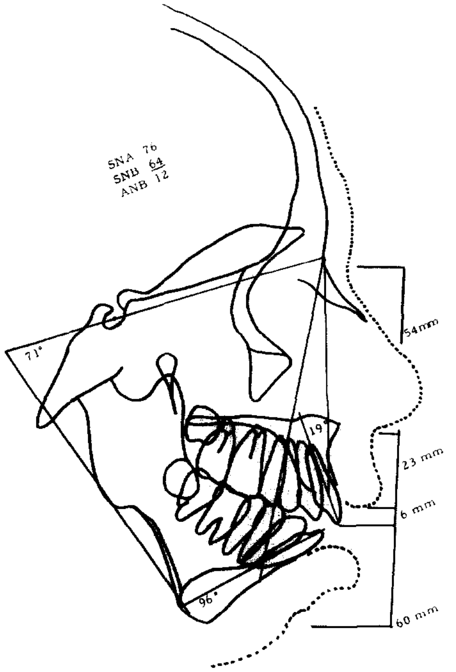

Fig. 15B. The "classic" analysis of this syndrome demonstrates decreased SNA and SNB angles with a very large ANB angle. The mandibular plane angle is also very large, as is the anterior facial height if it is measured along the axis of the face and not perpendicular to the Frankfort plane as demonstrated. The lip-to-tooth relationship shows an excessive vertical component to the maxilla. A posterior facial height measurement would show a decrease, but the actual basis of the deformity would not be as clear as with the architectural and structural analysis.

these techniques are simply mathematical and statistical analyses.

The architectural and structural craniofacial analysis presented here offers the following advantages:

1. It does not refer to statistical averages but only to those balances which are influenced by the unique features of each skeleton within the framework of its own craniofacial architecture.

2. It takes into account all of the cranial and facial skeletal structures by referring to the unaffected structures. It is thus possible to find the shape that the abnormal structures should have had, and this simplifies treatment planning.

It is obvious, however, that this analysis does not solve all of the problems of etiology and treatment of craniofacial deformities. In cases of more complex craniofacial malformation, especially those involving growth and development, one will need to use this analysis in its three-dimensional variation. Errors are inevitable in cephalometry, and thus we should not use only analytical tracings or theoretical reconstructions for diagnosis and treatment. Accurate physical examination remains the basic rule, and a full knowledge of the clinical data is necessary to interpret the cephalometric tracings correctly. This attention to clinical data is particularly important in the child or adult with severe craniofacial malformations. During the first years of life, the proportions between the cranium and the face are not the same as those of the adult, and thus the analysis cannot be used as shown here. After the age of 3 years, as the face grows, the craniofacial analysis becomes reliable with some exceptions: the anterior maxillary pillar is usually rocked posteriorly, although it normally passes through the previously described points of reference, and the apex of the dens may have a low position in relation to the line CF4 which is secondary to the lack of facial height in the young child. In severe malformations involving both the cranium and the face, such as craniofaciostenosis, the problems for cephalometric tracings are maximal since some points of reference, such as bregma, the frontomaxillary

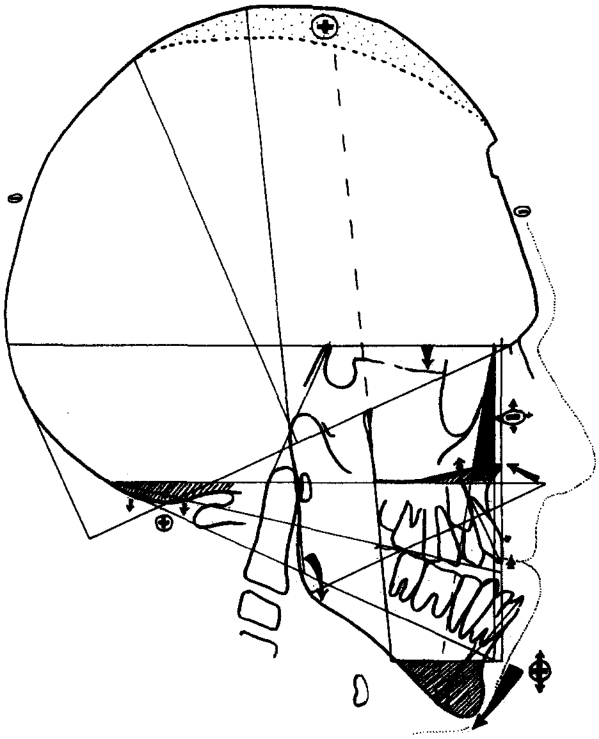

Fig. 16A. This is an example of Crouzon's syndrome with a large deformation of the cranial vault as shown by the plus sign in that region.[25] Unfortunately, the frontal area has been distorted by a cranioplasty done in infancy. The skull is typified by acrocephaly, abasement of the occipital bone, and a concavity of the anterior cranial base, as shown by the analysis. In the facial region, maxillary micrognathia, facial posterior rotation, and excessive anterior vertical face height are demonstrated. Opening of the gonial angle causing excessive anterior facial height and a high position of the anterior maxillary palatal line, specifically the premaxillary segment, which cause the open-bite.

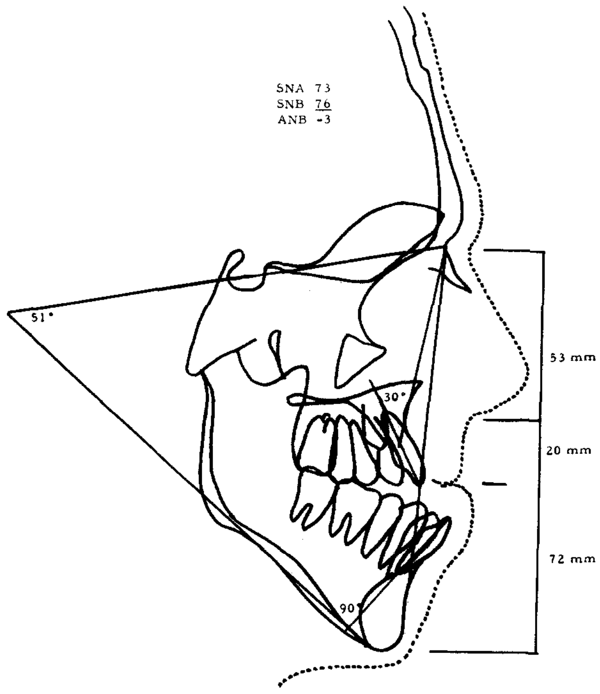

Fig. 16B. The "classic" analysis of this case of Crouzon's syndrome demonstrates a very small SNA angle, slightly reduced SNB angle, and a negative ANB angle, resulting in a Class III malocclusion. The mandibular plane angle is increased and the anterior facial height is large. The cranial base and vault problems are not analyzed here, nor is the true amount of maxillary hypoplasia.

point, and the pterygomaxillary fissure, are often hardly visible. Moreover, as all of the structures are involved in the malformation, there is no unaffected area which can serve as a reference to formulate a balanced face for the patient.

CONCLUSION

The architectural and structural analysis is based upon a study of craniofacial balance. It does not refer to statistical averages, but only to individual proportions. It also takes into account all of the cephalic structure and is therefore particularly useful to all who deal with craniofacial anomalies. For the orthodontist, this analysis places the dentition within the cephalic context and thereby makes obvious certain pathogenic factors of dentofacial dysmorphogenesis as, for example, cranial base or cervico-occipital anomalies. For the maxillofacial surgeon, the analysis clearly demonstrates all craniofacial deformities and thereby aids the surgeon in understanding their etiology and treatment, thus improving the results. It is also possible for the surgeon to construct a balanced face for each patient within the framework of his own skeletal cephalic architecture. This pattern can then serve the surgeon as a surgical reference.

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Reprint requests to:
Professeur J. Delaire
Clinique de Stomatologie et
Chirurgie Maxillo-Faciale
Centre Hospitalier Régional
Place Alexis Ricordeau
44035 Nantes, France