Cephalometric Radiography

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Biological Foundations of Orthodontics and Dentofacial Orthopaedics

Seminar 9

2004

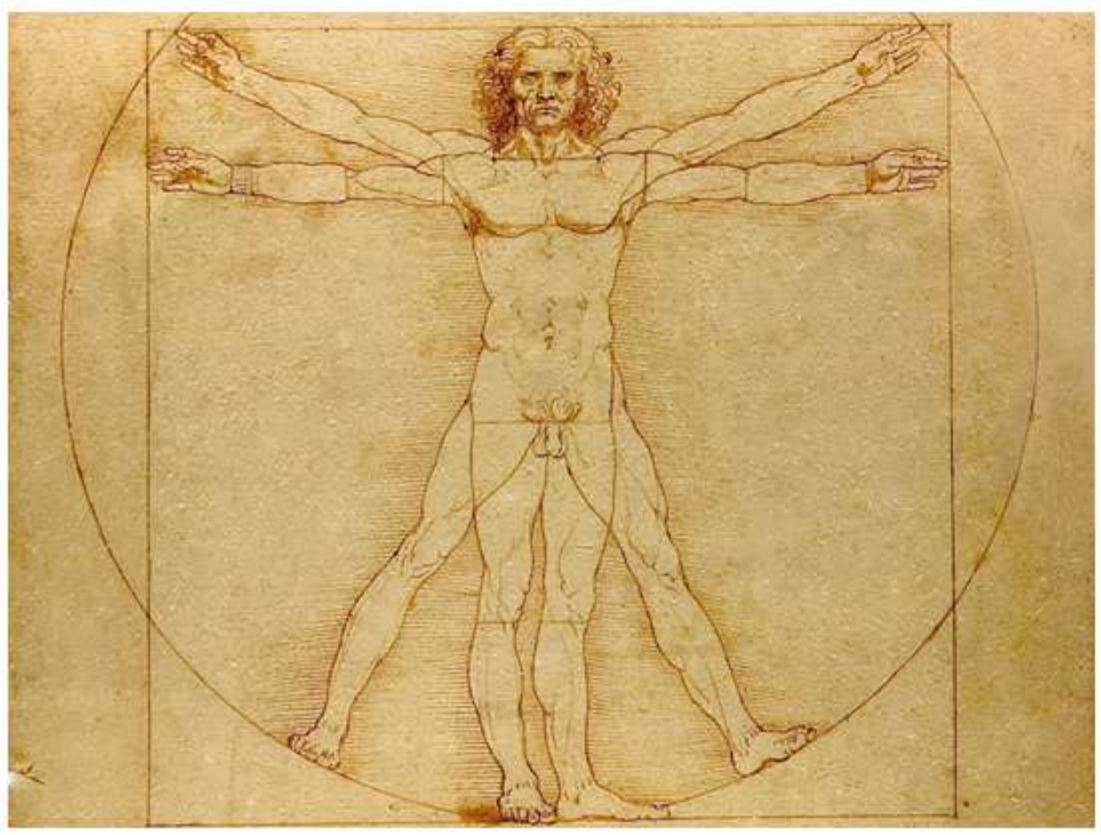
UNIVERSITY of OTAGO
SAPERE AUDE
Te Whare Wānanga o Otāgo

- Cephalometric radiography or cephalometry is the technique of using orientated radiographs of the head for the purpose of measuring the dimensions of the face and skull. Cephalometry is measurement of the living head and evolved from craniometry, a term traditionally reserved for anatomical and anthropological studies of dried skulls.
- Standardized cephalometric radiography was developed independently by Broadbent in the USA and by Hofrath in Germany (Broadbent, 1931; Hofrath, 1931). The technique represented an advance over craniometry in that accurate longitudinal studies of craniofacial growth could be undertaken on living subjects for the first time.
- A vast clinical and research literature has accumulated since 1931, and several textbooks have been published devoted entirely to the subject, of which those edited by Athanasiou (1995) and Jacobson (1995) are among the most recent. The aim of this seminar is to provide a basic foundation in the subject.

Origins of cephalometry

- The measurement of the dimensions, shape and proportions of the human body, are generally recognized to have originated during the Renaissance with the work of Leonardo da Vinci and Albrecht Dürer. These were undertaken to provide general and objective rules for portraying the human form in painting, drawing and sculpture. Such studies were part of a search for a utopian ideal of physical beauty based on geometric relationships, and on the harmony of the parts of the human body.
- During the latter half of the 18th century the motivation for measuring skulls was anatomical and marked the origin of physical anthropology, the study of the external characteristics of man. Natural historians became interested by questions related to evolution and man's place in nature. For example, what are the morphological characteristics that distinguish humans from the rest of the animal world, in particular from non-human primates?

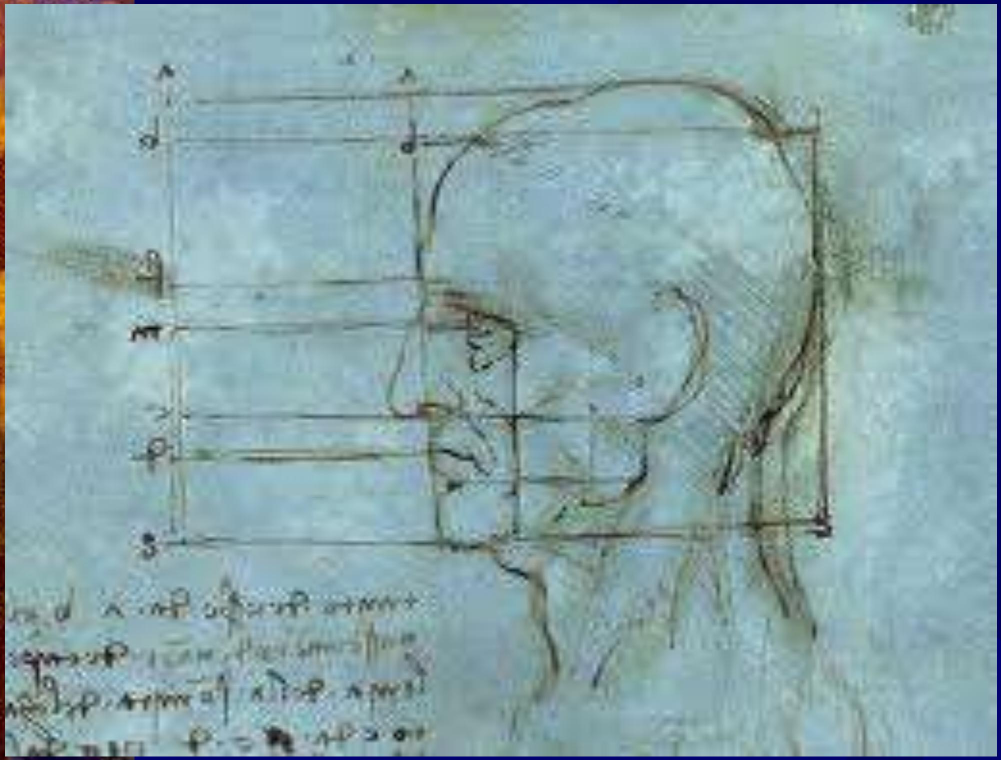
Leonardo da Vinci



Original in the Gallerie dell Accademia, Venice.

- *The Proportions of the Human Figure* (*circa* 1490) by Leonardo da Vinci (1452–1519). Probably the best known of all his drawings, Leonardo re-interpreted the ancient teachings of Vitruvius on the proportions of the human body.
- According to Vitruvius if the figure of a man with legs and arms outstretched was shown within a square (*homo ad quadratum*) and a circle (*homo ad circulum*), then the centre of the human body would coincide with the navel.

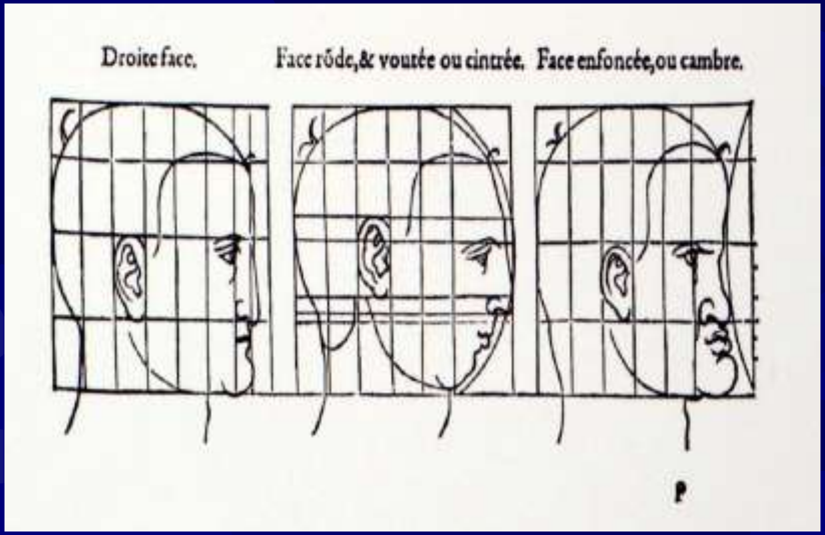
Man’s head in profile

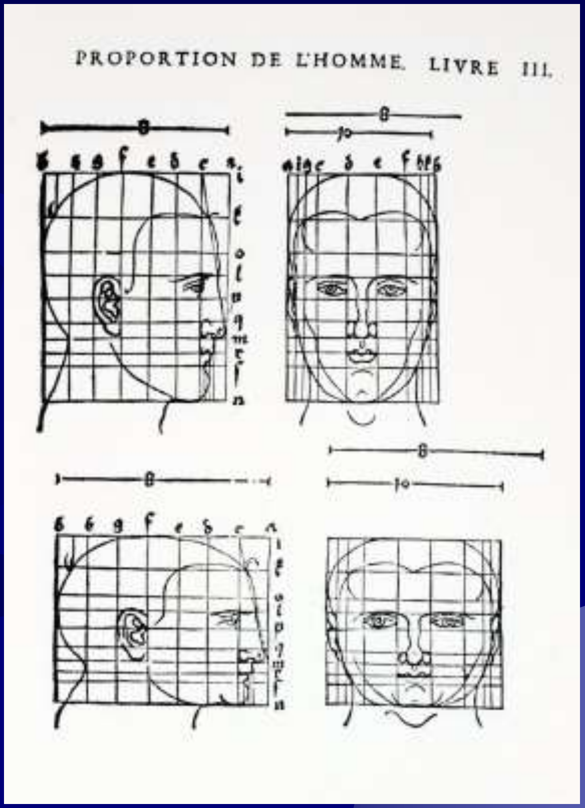


- *Study for Man’s Head in Profile* by Leonardo da Vinci (*c.*1490). A proportional analysis of the face has been made using a grid system of horizontal and vertical lines.
- According to the marginal notes the head has been divided into seven parts by eight horizontal lines; the eye is situated midway between the crown of the head and the chin. Leonardo’s drawings represent the first scientific studies of the human body.
- Original in the Royal Library, Windsor Castle, Windsor.

Albrecht Dürer

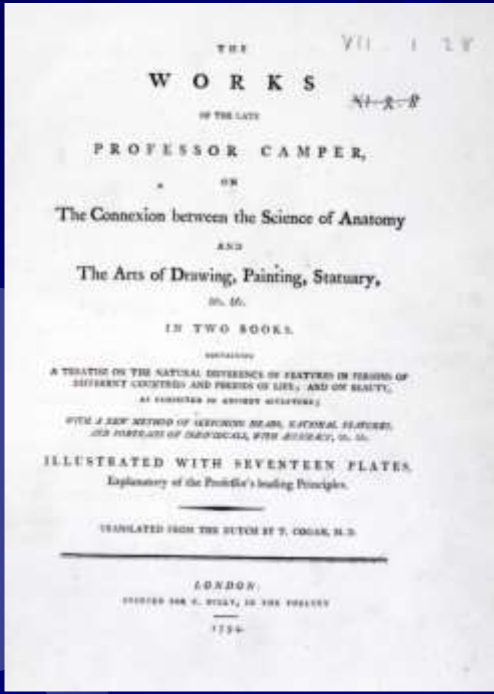

LES
QVATRE LIVRES
D'ALBERT DVRER,
Peintre & Geometrien Tres
excellent, De la Proportion
des parties & pourtraicts
des corps humains.
TRADVICTS PAR LOYS MEIGRET
A PARIS,

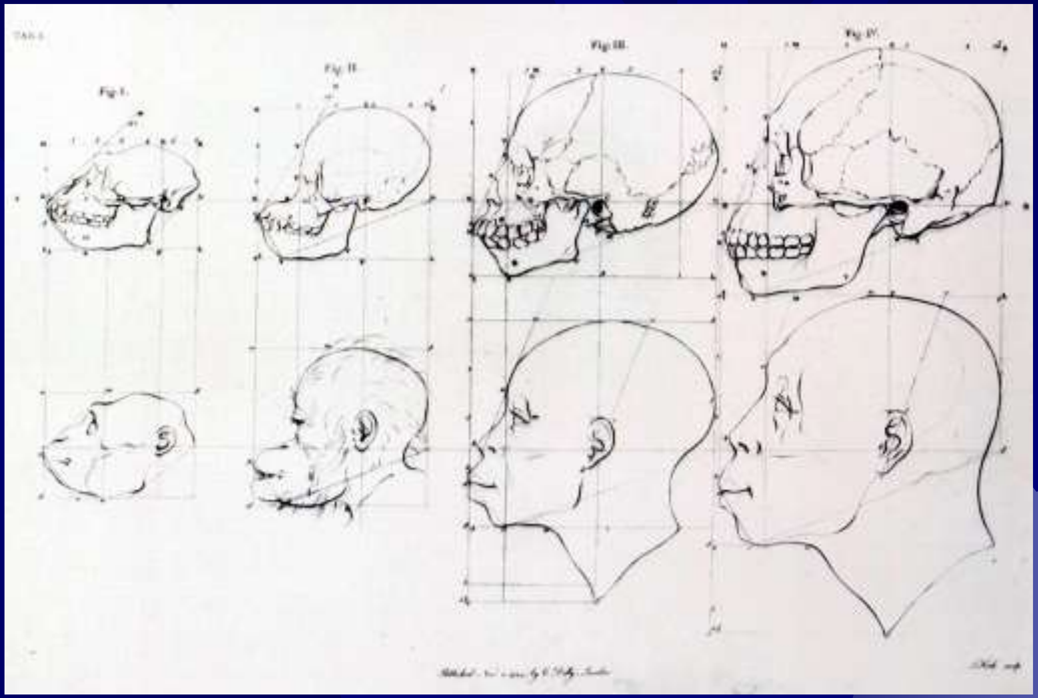




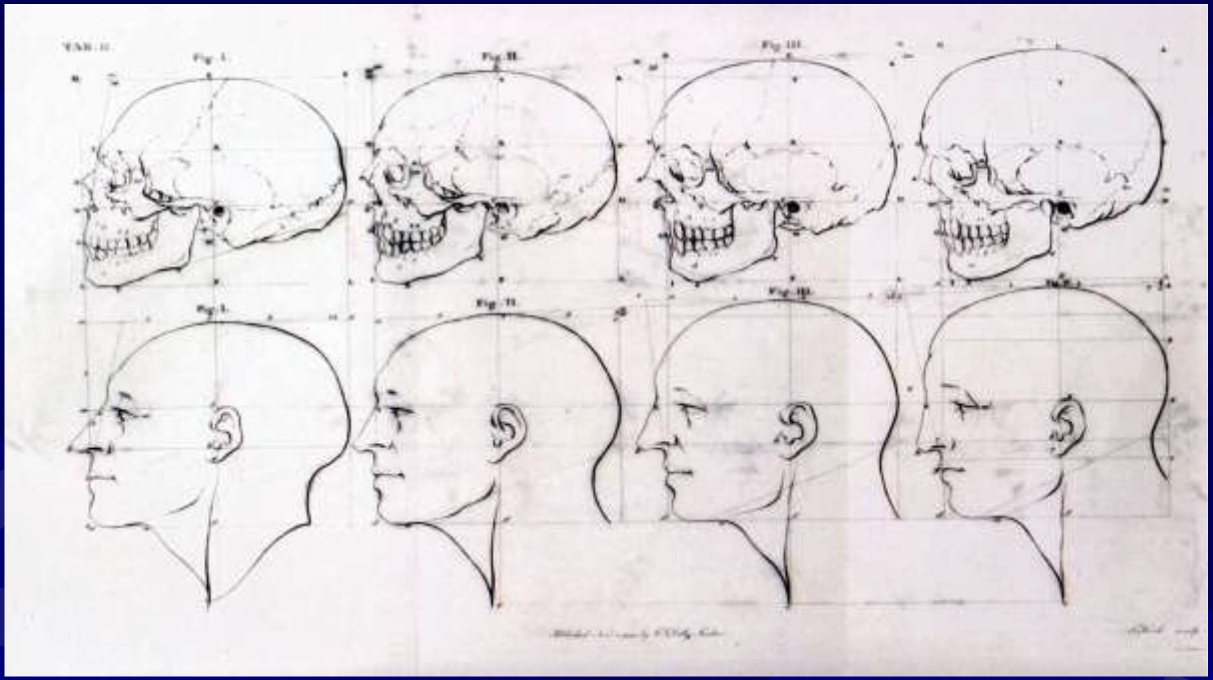
- Albrecht Dürer (1471–1528) also used a rectolinear coordinate system to demonstrate the characteristics of different facial types.
- The middle figure shows a proportional analysis of straight, convex and concave facial profiles (Class I, II and III) and on the right a dolichocephalic (narrow) and brachycephalic (broad) head to show variation in facial form.
- Woodcut sfrom *Les Quatre Livres d'Albert Dürer* (1557), actual size 120x150 mm. Courtesy of the Syndics of Cambridge University Library.

Petrus Camper and the facial angle





- Petrus Camper (1722–1789) is remembered today for defining the facial angle, which measures the relative protrusion of the jaws to the cranial vault, and is the traditional beginning of craniometry.
- Plate I from *The Works of the Late Professor Camper* (1794), showing the increase in facial angle of a monkey (Fig. I) an orangutan (Fig. II) an African (Fig. III) and a Kalmuck (a Mongolian people of Russia and Central Asia).
- Actual size 210x300 mm. Courtesy of the Syndics of Cambridge University Library.



- Camper orientated the skulls on a horizontal reference line connecting acanthion to porion (the line N–C). The facial line was constructed from the incisor teeth to the most prominent point on the forehead (the line S–T).The facial angle is the intersection of the two lines; a low angle indicates prognathism of the jaws.

- This illustration is Plate V from *The Works of the Late Professor Camper* (1794), showing a series of skulls and facial profiles with a progressive increase in the facial angle. In IV (a Grecian head) the facial angle exceeds 90º and the cranial vault projects in front of the jaws. Actual size 210 x 300 mm.

Johann von Spix

CEPHALOGENESIS

SIVE

CAPITIS OSSEI STRUCTURA, FORMATIO

ET

SIGNIFICATIO

PER OMNES ANIMALIUM CLASSES, FAMILIAS, GENERA AC AETATES DIGESTA,

ATQUE TABULIS ILLUSTRATA;

LEGESQUE SIMUL PSYCHOLOGIAE, CRANIOSCOPIAE

AC

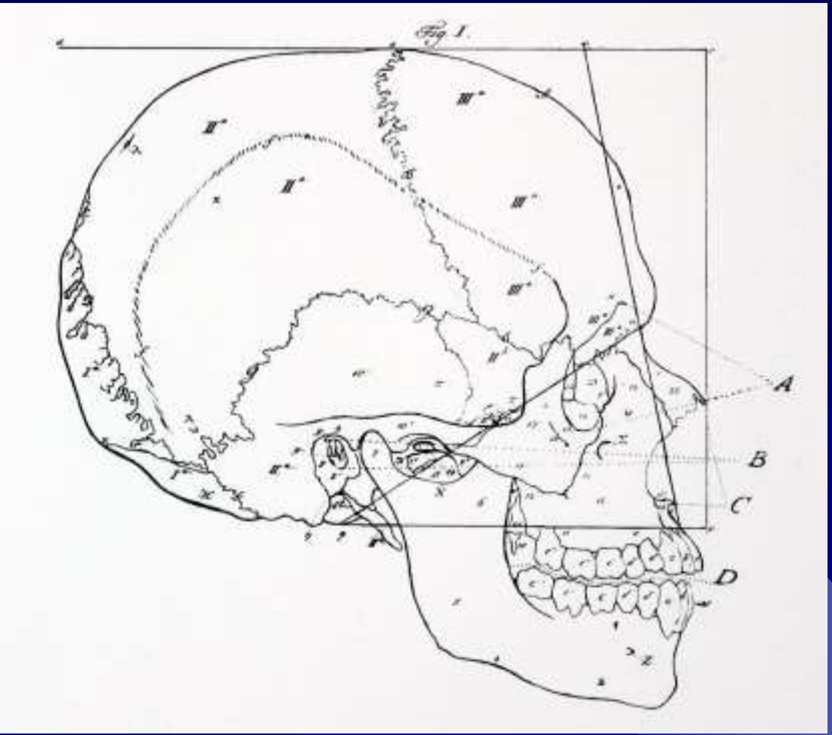
PHYSIOGNOMIAE

INDE DERIVATAE.

AUTORE

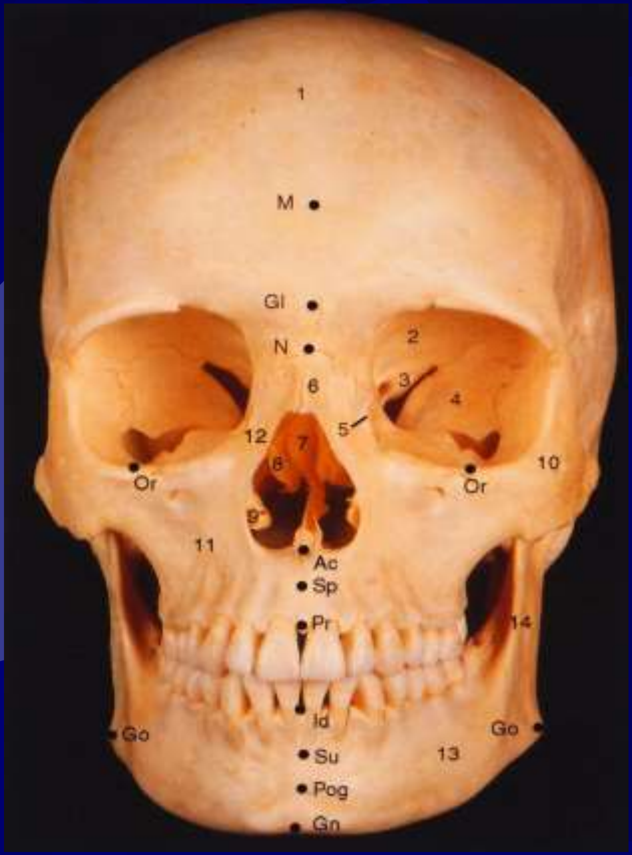
IOANNE BAPTISTA SPIX.

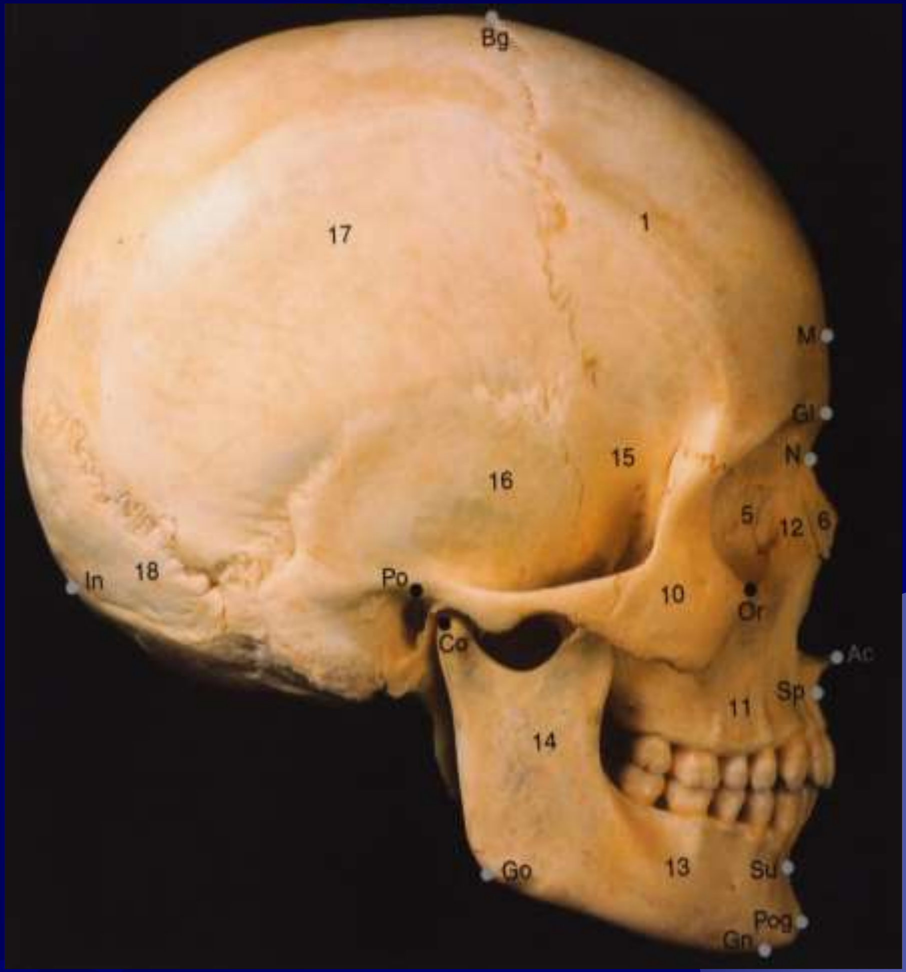
MONACHII.



- Johann-Baptiste von Spix (1781–1826) proposed an analysis incorporating several planes and angles; it has a rather modern look about it.
- Von Spix used a line from the lowest point of the occipital condyle, to the anterior point of the alveolar process between the central incisor teeth (prosthion) to orientate the skull. The facial line joins prosthion to the frontonasal suture (nasion) and the angle between the horizontal reference line and the facial line represents the facial angle.
- Actual size 200x195 mm. Courtesy of the Syndics of Cambridge University Library.

Craniometry





- Craniometric landmarks: Bg, bregma; M, metopion; Gl, Glabella; N, nasion; Ac, acanthion; Sp, subspinale; Pr, prosthion; Id, infradentale; Su, supramentale; Pog, pogonion; Gn, gnathion, Go, gonion; Co, condylion; Po, porion; Or, orbitale; In, inion.
- Images Courtesy of B Berkovitz.

From craniometry to cephalometry

- Prior to the development of cephalometric radiography, physical anthropologists had to rely on measurements carried out on dried skulls of uncertain age. These could be carried out very accurately using a craniostat or skull holder.

- Longitudinal studies required measurements to be carried out on living children, but were hampered by difficulties in measuring hard tissue landmarks through skin and soft tissues. What was needed was a standardized technique for measuring the living head as accurately as the dead skull. This requirement led Broadbent to design a roentgenographic craniostat, the forerunner of the Broadbent–Bolton Cephalometer (Broadbent, 1931).

- Although Broadbent and Hofrath both published on the cephalostat in 1931, the priority of invention belongs to Broadbent. In 1930 he had presented the Bolton technique at both the *Conference on Adolescence* held in Cleveland, and the *White House Conference on Child Health and Protection* in Washington, D C (Broadbent, 1930a, 1930b).

Cephalometric landmarks

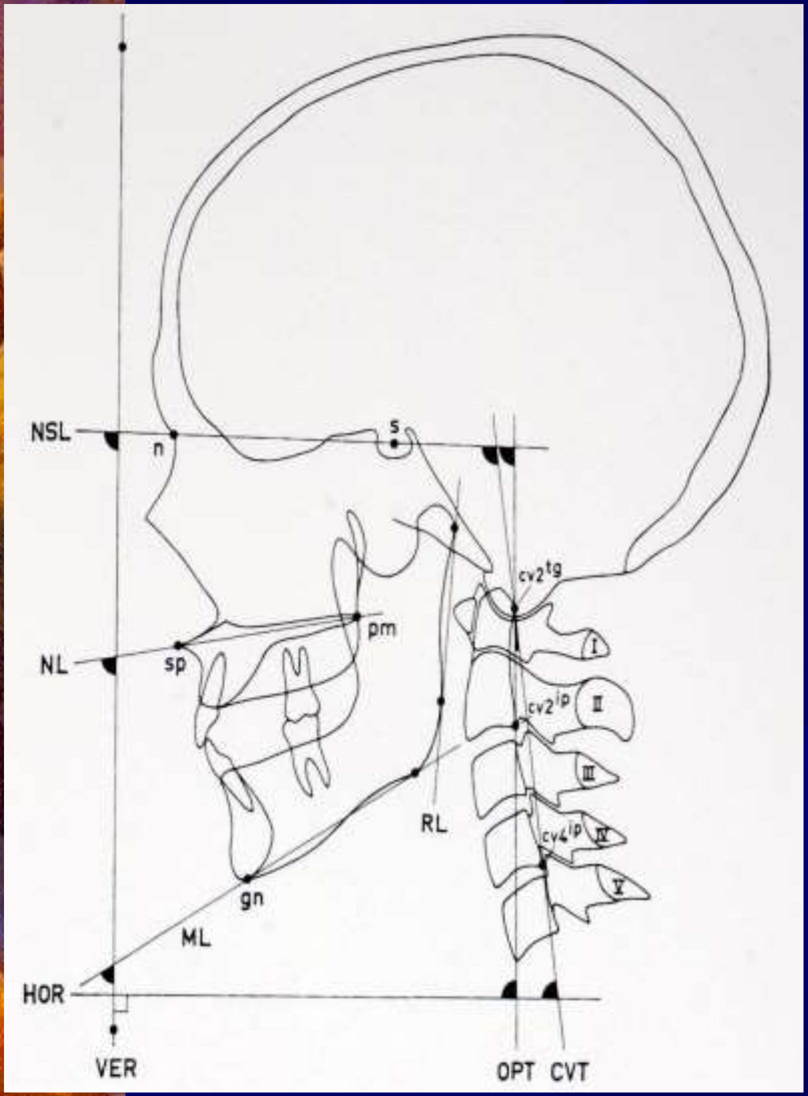
- Accurate cephalometry is dependent on a knowledge of osteology and the precise location of points or landmarks. These are almost exclusively sited on bone and most have been borrowed from craniometry.

- N, nasion; ANS, anterior nasal spine (acanthion); A, A point (subspinale); Pr, prosthion; Is, incision superioris; Ii, incision inferioris; Id, infradentale; B, B point (supramentale); Pog, pogonion; Gn, gnathion; Me, menton (in craniometry defined the same as gnathion); Go, gonion.
- Ar, articulare; Co, condylion; Ba, basion; Po, porion; PNS, posterior nasal spine; PTM, pterygomaxillary fissure; Or, orbitale; Et, ethmoidale; S, sella.

Orientation of the head

- With the development of craniometry a standardized method for orientating skulls was required, and at the Craniometrical Conference in Frankfurt am Main (1884), what became known as the Frankfort horizontal (FH) plane was adopted. This passes through porion and orbitale and the advantage of FH was that (1) both landmarks could be readily identified on skulls, and (2) it coincided reasonably well with natural head position.
- With the introduction of cephalometric radiography, FH continued to be used to orientate the head. However, porion and orbitale were difficult to locate accurately on headfilms bringing into question its reproducibility. (One way of minimizing this problem in the analysis of serial headfilms is to orientate subsequent tracings on the original FH plane.) An additional problem was the normal variation that occurs in the position of anatomical landmarks between individual patients.

Natural head position

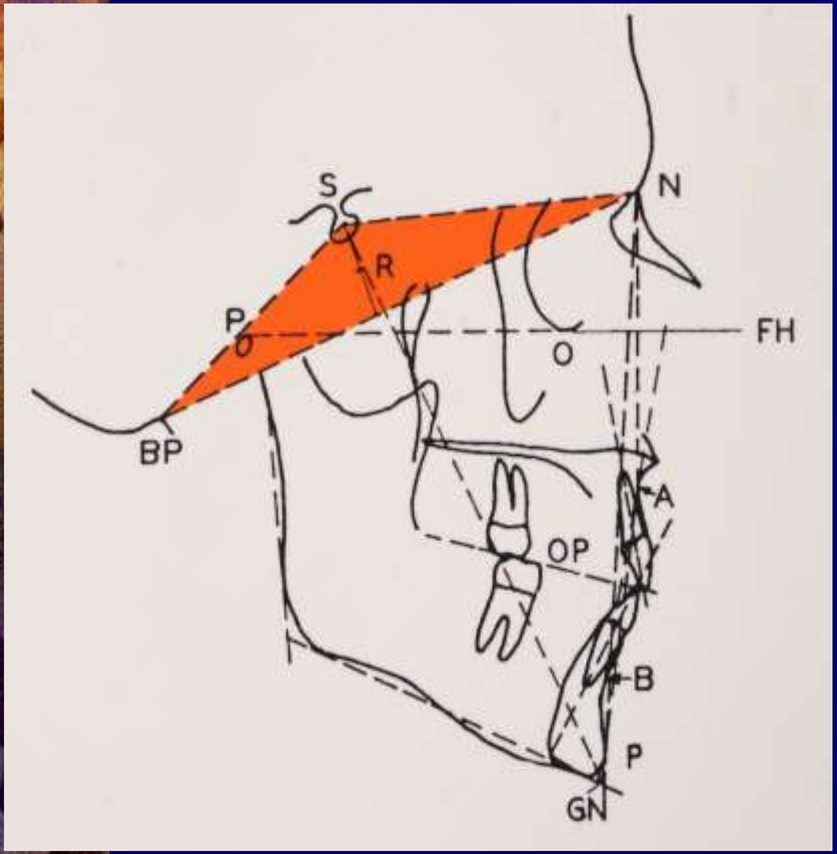


- An alternative to FH is natural head position, defined by Broca (1862) 'when a man is standing and when his visual axis is horizontal, he [his head] is in the natural position'.
- Methods used to determine natural head position vary but most report good reproducibility. Others have been more critical (Bister *et al.,* 2002), and suggest natural head position is no more accurate than FH.
- One should be aware of the problem, but it seems to me to have been somewhat exaggerated. Most competent clinicians can tell by looking at a patient whether the head is tipped up or down.
- From Solow and Tallgren (1971). *Acta Odontologica Scandinavica* **29**, 591–607.

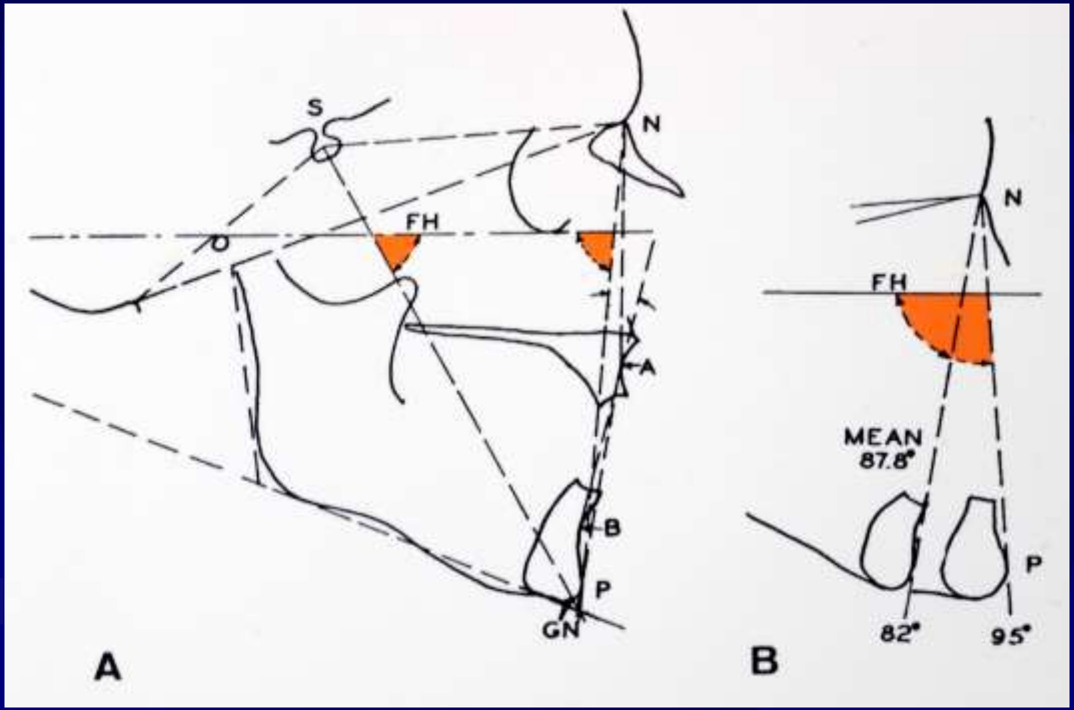
Cephalometric analyses

- A cephalometric analysis is an important diagnostic aid to establish variation in dentofacial form, and to identify areas of significant deviation (particularly for the novice clinician). Besides permitting accurate evaluation of growth of the individual, it is indispensable for distinguishing between normal growth and the dentofacial changes brought about by orthodontic treatment.
- The answer to the question whether one cephalometric analysis is superior to another is almost certainly no. In 1957 Krogman and Sassouni carried out an appraisal of the 45 craniometric and cephalometric analyses published up to that time. All were found to have strengths and weaknesses and many more have been published since then. Most university orthodontic departments will teach an analysis based on historical precedent, and cannibalized from the numerous eponymous analyses published in the literature. See Athanasiou (1995) and Jacobson (1995) for details.

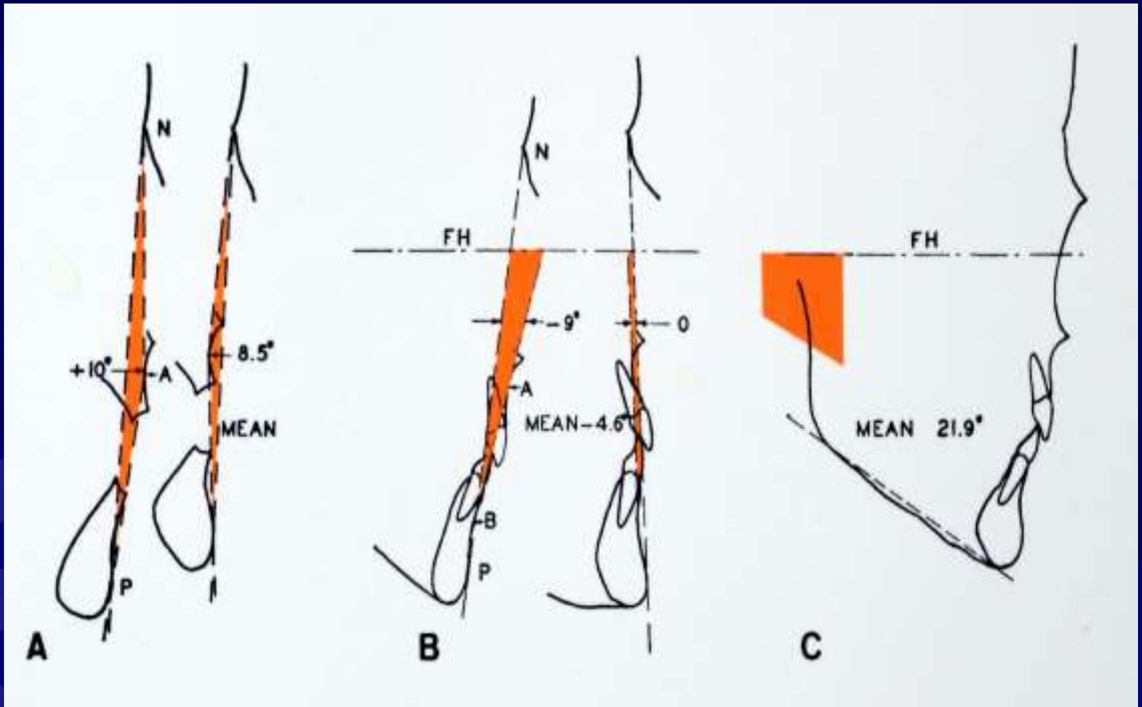
The Downs' analysis



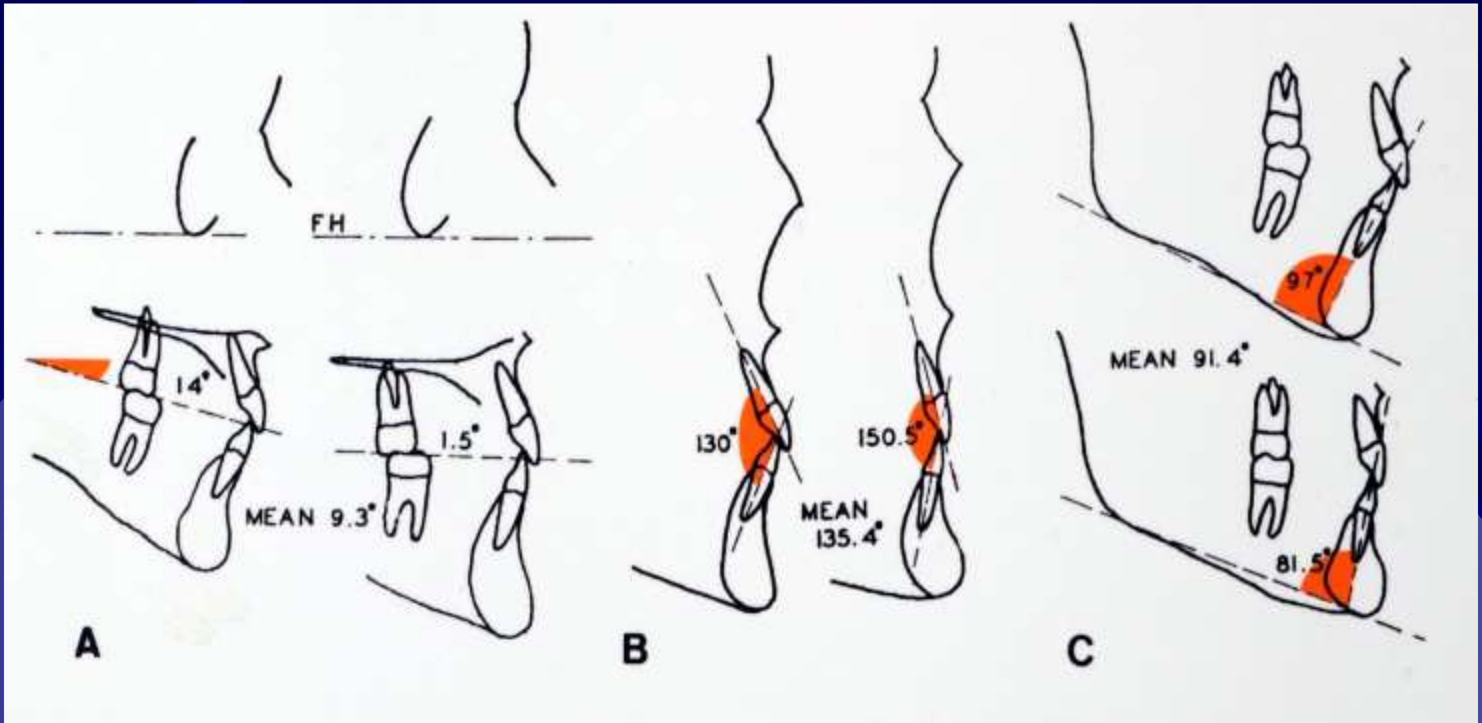
- The first clinically tested and widely used analysis was developed at the University of Illinois by William Downs to determine variation in dentofacial pattern. He found that individuals with clinically excellent occlusions showed considerable differences in skeletal and dental relationships. Single readings were not important; what counted is the manner in which they fit together.
- FH was used for orientation, and the Bolton triangle (N–S–BP) and its registration point R for superimposing serial tracings. BP, Bolton point; GN, gnathion; N, nasion; O, orbitale; OP, occlusal plane; P, pogonion; S, sella.
- From Downs (1948) *American Journal of Orthodontics* **34**, 812–840.



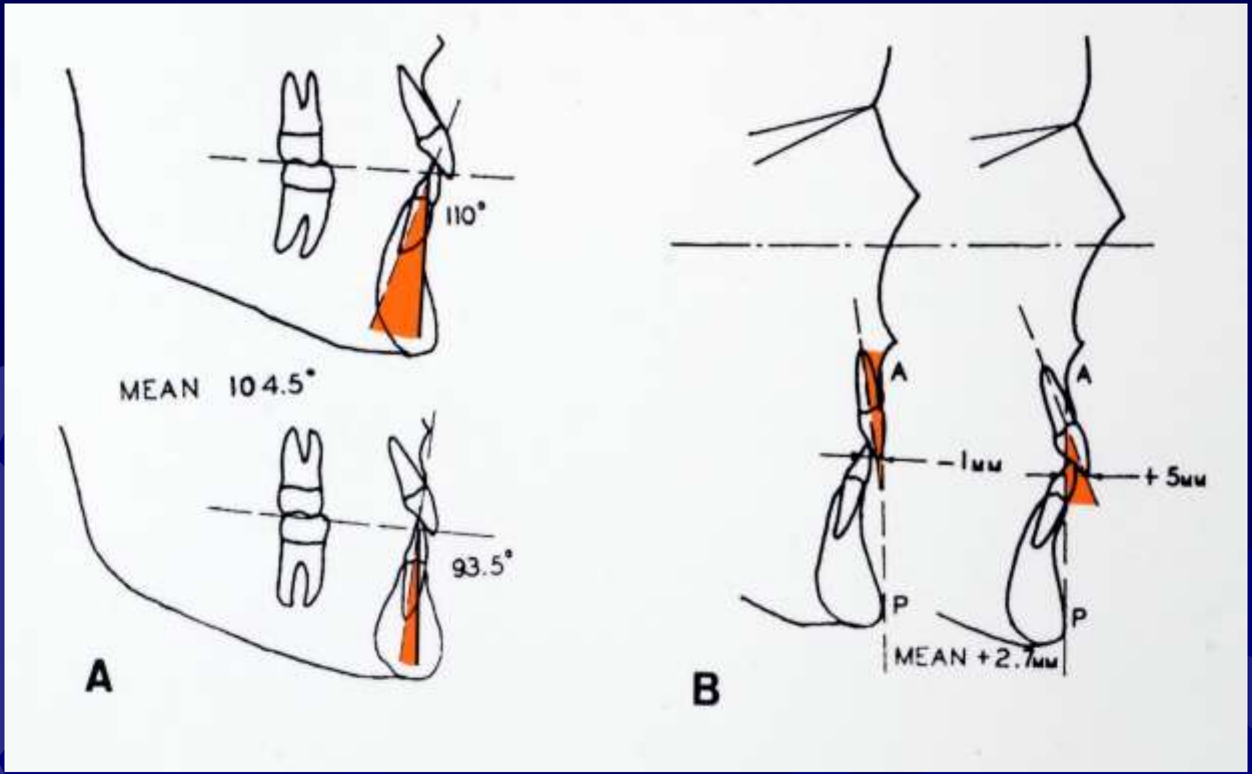
- A. Assessment of the skeletal pattern in the Downs' analysis. The Y axis is the line from sella (S) to gnathion (GN); the angular relationship between the Y axis and FH was used to measure anteroposterior/vertical position of the chin and is complementary to the facial angle.
- B. The facial angle is an expression of the degree of retrusion or protrusion of the chin and is the internal angle formed by the intersection of the facial plane (N–P) with Frankfort horizontal (FH). P, pogonion.
- From Downs (1948). *American Journal of Orthodontics* **34**, 812–840.



- A. The angle of convexity measures the protrusion or retrusion of the maxilla to the facial profile, and formed by the intersection of the planes N–P and A–P.
- B. The A–B plane to the facial plane. A measure of the anterior limit of the denture (apical) bases to the facial plane and was found to range from 0º or parallelism to a posterior position of B of –9º.
- C. The mandibular plane angle is the angle formed by the mandibular plane (Go–Gn) and Frankfort horizontal (FH). From Downs (1948).

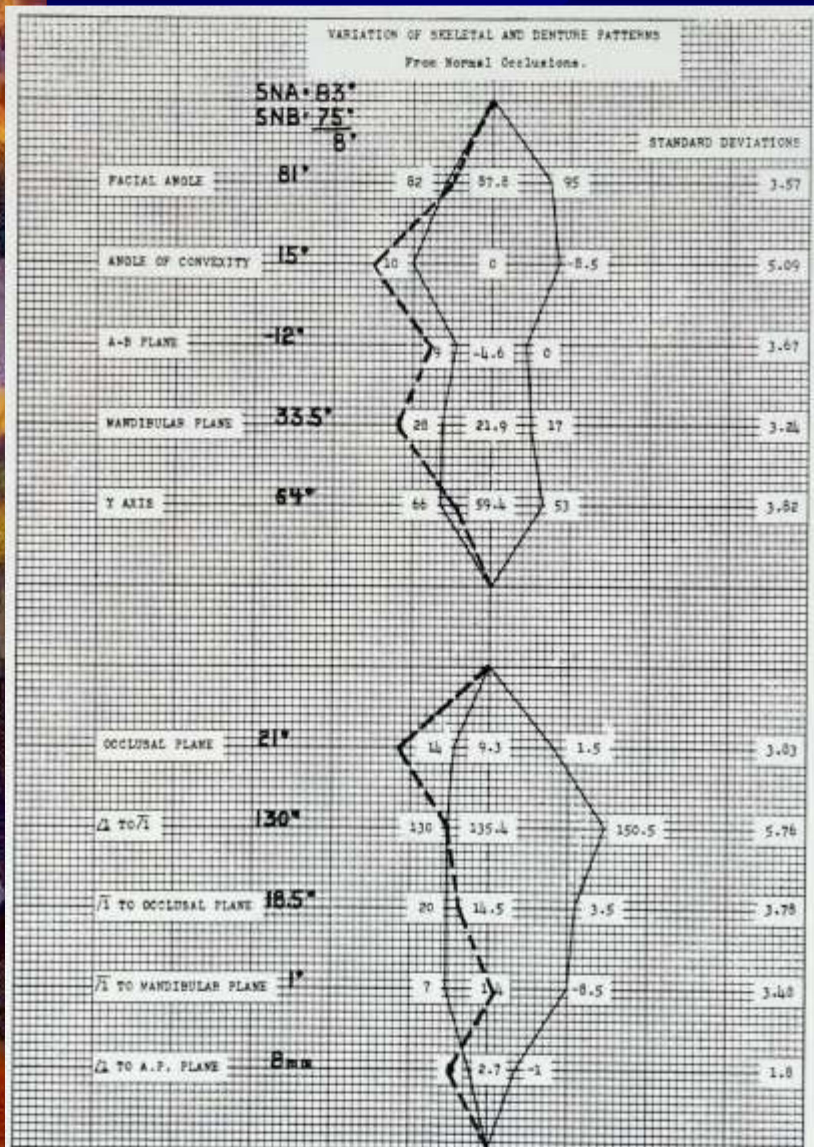


- A. Cant of the occlusal plane. Angular relationship between FH and the occlusal plane. Class II div 1 facial types tended to have a steep occlusal plane; in Class III types the plane became more horizontal.
- B. The inter-incisal angle will be reduced in bimaxillary protrusion and increased in patients with a Class II division 2 incisor relationship.
- C. Lower incisor to the mandibular plane measures the axial inclination of the mandibular incisor teeth. From Downs (1948).



- A. Lower incisor to the occlusal plane. The inferior inside angle was read and the plus or minus deviation from a right angle recorded. The range was from + 3.5º to +20º with a mean of +14.5º. Downs felt this measurement was of value in checking and interpreting the IMPA (incisor–mandibular plane angle).
- B. Maxillary incisors to the line A–P is read in mm and is a measure of maxillary dental protrusion. From Downs (1948), *American Journal of Orthodontics*.

The Downs' polygon



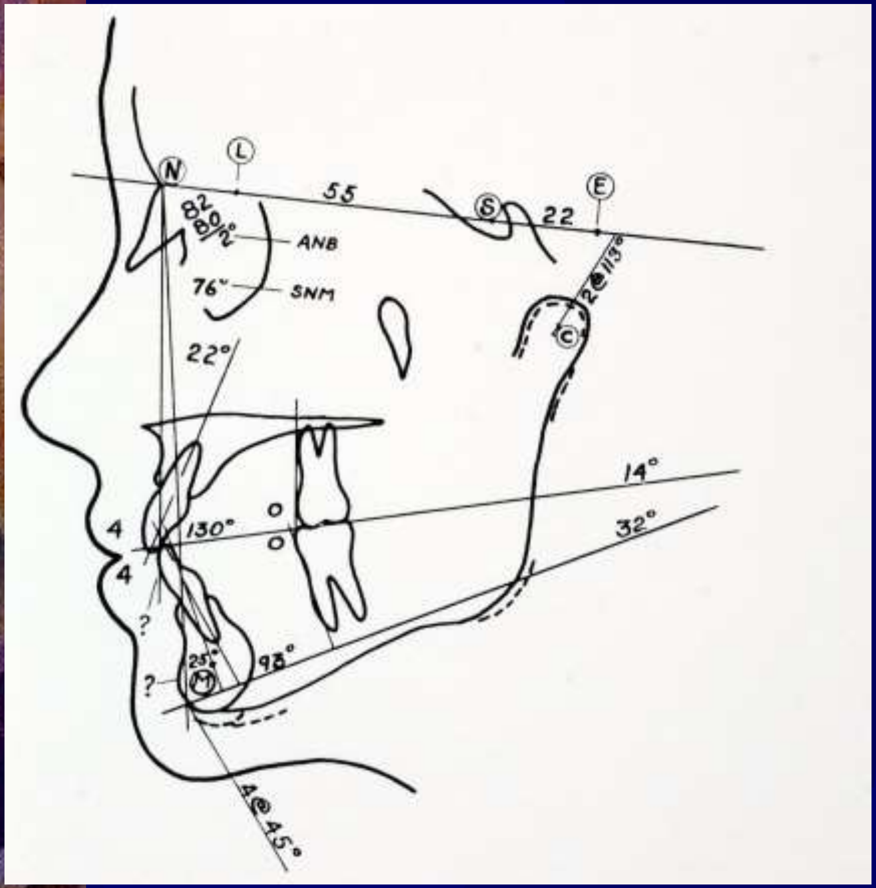
- In 1951 Vorhies and Adams from the University of Indiana, applied to the Downs' analysis the method used by Hellman (1937) to express a large number of anthropometric readings graphically. This took the form of a polygon or 'wiggle'.
- The vertical centre line represents the mean values; those to the left are below average, those to the right are above average. By plotting the values for a given individual graphically, any deviation from the mean is available immediately at a glance.
- From Strang and Thompson (1958). *A Text-Book of Orthodontia.*

The Riedel analysis

	Children (7–11 years)		Adults (18–36 years)	
	Mean	SD	Mean	SD
SNA	80.79	± 3.85	82.01	± 3.89
SNB	78.02	± 3.06	79.97	± 3.69
ANB	2.77	± 2.33	2.04	± 1.81

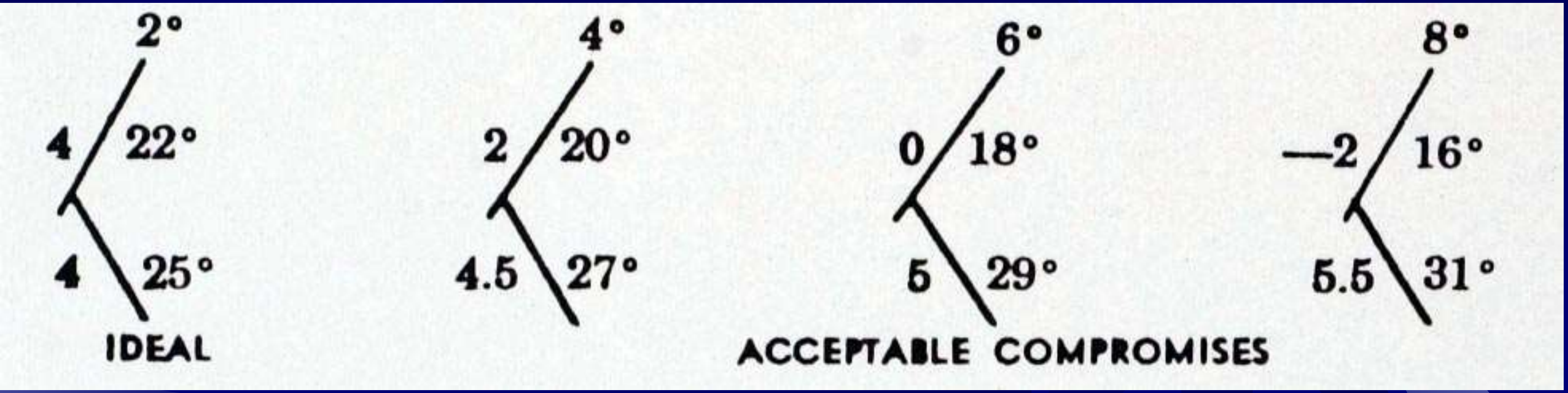
- Riedel was the first to use the angles SNA and SNB to relate the maxilla and mandible to the cranium based on his MS thesis at Northwestern University. The relation of the mandible to the cranial base (SNB) was found to be significantly different in patients with excellent occlusion and those with malocclusion.
- The beauty of SNA, SNB and ANB was their simplicity; they rapidly became incorporated into most cephalometric analyses and despite some shortcomings still remain the standard method for measuring the skeletal pattern.
- Data from Riedel (1952). *The Angle Orthodontist* **22**, 142–145.

The Steiner analysis



- Steiner was the first to admit many of the measurements included in his analysis were derived from the work of others. To these he made additions, the most original being the method used to orientate the upper and lower incisors to their basal bone. (Legend has it that the standards in his analysis were derived from one Hollywood starlet!)
- The figure shows the average measurements used by Steiner to represent a normal average American child of average age. The tracing shows the linear measurement of the upper incisor to the line N–A (4 mm) and the lower incisor to the line N–B (4mm).
- From Steiner (1959). *The Angle Orthodontist* **23**, 8–29.

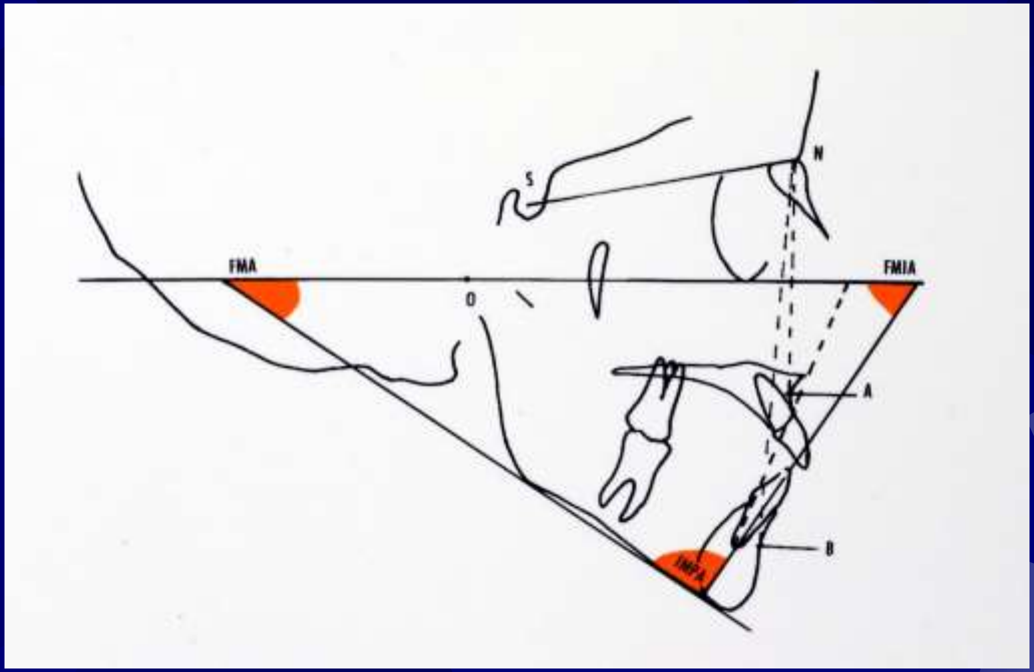
Steiner chevrons



- The location and axial inclination of the upper incisors was determined by relating the teeth to the line N–A. Ideally the crown of the maxillary central incisors should be 4 mm in front of N–A, with an axial inclination of 22º. Similarly, the lower central incisor should be 4 mm in front of N–B with an axial inclination of 25º**.**
- On the left is the ideal relationship of the upper and lower incisors when the ANB angle is 2º. If the ANB angle is increased or decreased, then compromises will have to be made in the inclination of the teeth to compensate for the jaw discrepancy.
- From Steiner (1959). *The Angle Orthodontist* **23**, 8–29.

The Tweed diagnostic triangle

From Tweed (1966), *Clinical Orthodontics*.

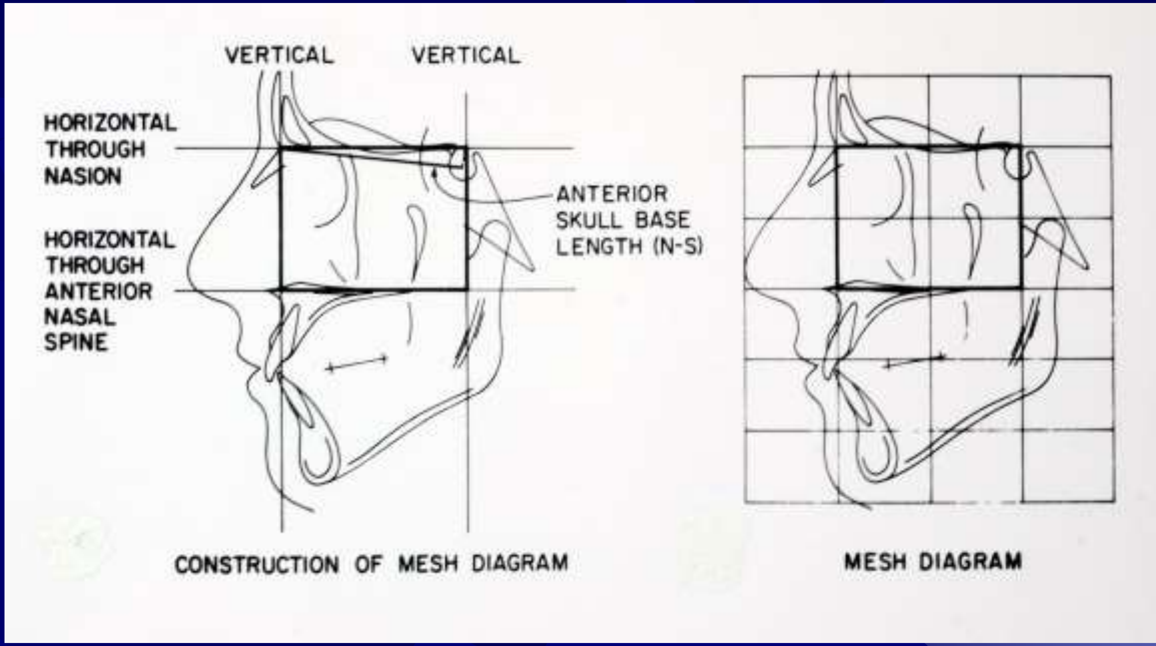


- Developed as a diagnostic and treatment planning for inexperienced clinicians to decide if extractions were indicated (Tweed, 1954). Frankfort–mandibular plane angle (FMPA); the lower incisor–mandibular plane angle (IMPA); and the Frankfort–mandibular incisor angle (FMIA).

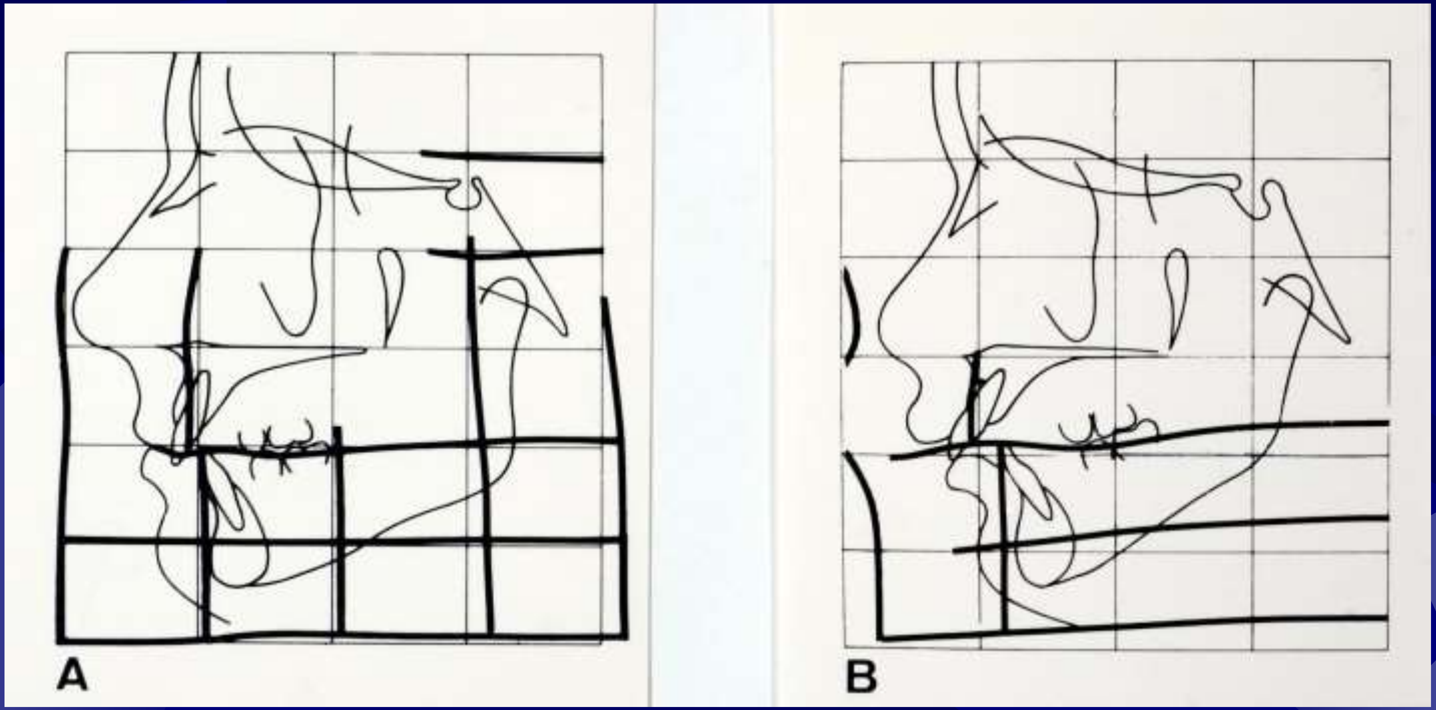
- Tweed attached great importance to the inclination of the lower incisors and aimed for an angulation of 90 ± 5º. The facial triangle formed the conceptual basis of the Tweed technique.

The mesh analysis

From Moorrees *et al*. (1976) *American Journal of Orthodontics* **69**, 57–71.



- An adaptation of the rectilinear grid system of Dürer. Developed at the Forsyth Dental Center, Boston from 1948 to graphically convey the essential aspects of facial development for orthodontic diagnosis.
- The mesh diagram is constructed by drawing a core rectangle to which additional vertical and horizontal lines are added. Compared to numerical analyses the mesh diagram is difficult to produce, and less able to convey information as readily as numerical data.



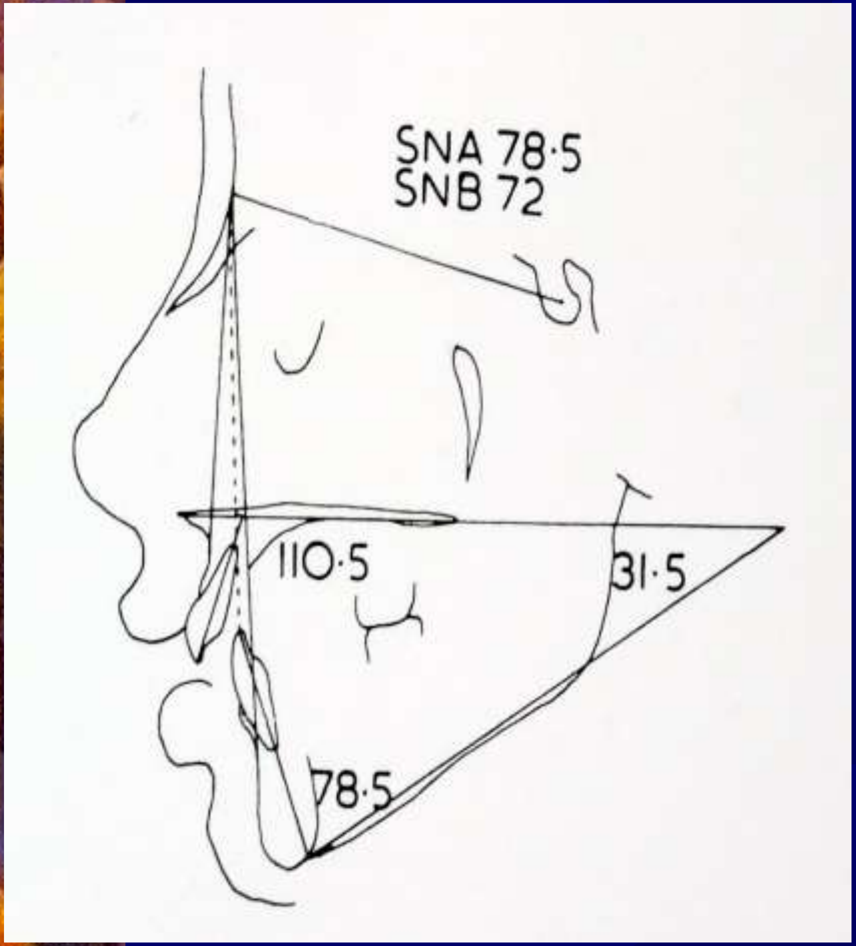
- A. Mesh analysis of a patient with a moderate Class II division 1 malocclusion. There are only minor deviations from the norm with slight maxillary prognathism and upright maxillary incisors; the mandible is orthognathic, *i.e.* average or ideal.
- B. Severe Class II division 1 malocclusion characterized by mandibular retrognathia, short vertical ramus and increased mandibular plane angle.
- From Moorrees *et al*. (1976). *American Journal of Orthodontics* **69,** 57–71.

The problem of ANB

- The most commonly used measurement for determining the anteroposterior relationship of the jaws (skeletal pattern) is the angle ANB which in normal occlusions is generally 2–3º (Riedel, 1952). Although reliable in most instances there are occasions when this is not the case.

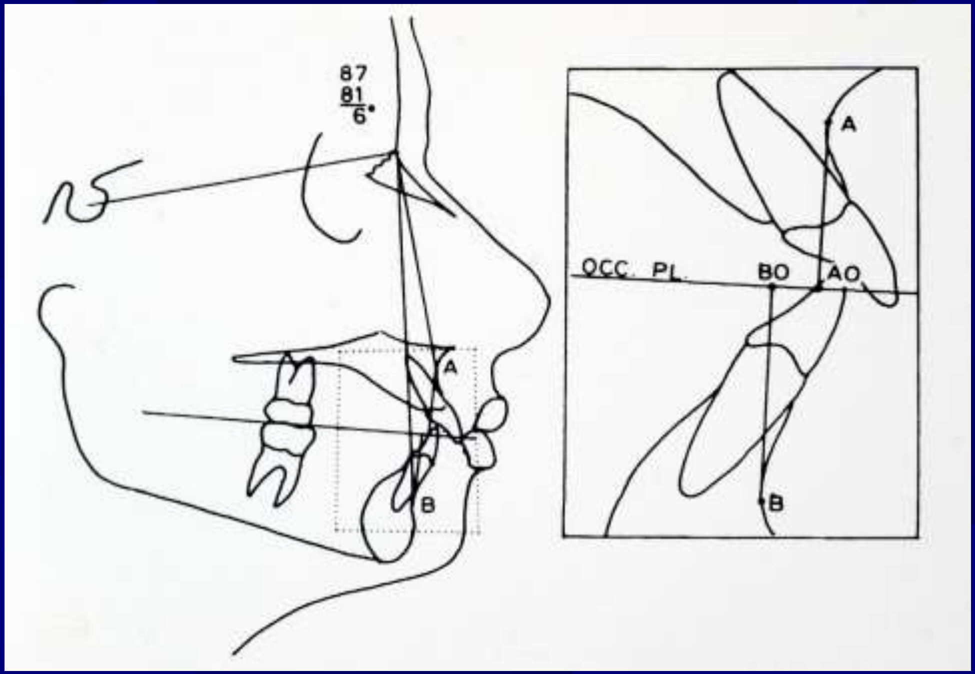
- ANB will be affected by (1) the extent of maxillary prognathia or retrognathia relative to the anterior cranial base (angle SNA), and (2) the slope or inclination of the anterior cranial base (line S–N) itself. Since the significance of the angle ANB varies according to the size of SNA, several methods have been proposed to measure jaw relationships more accurately.

The Eastman conversion

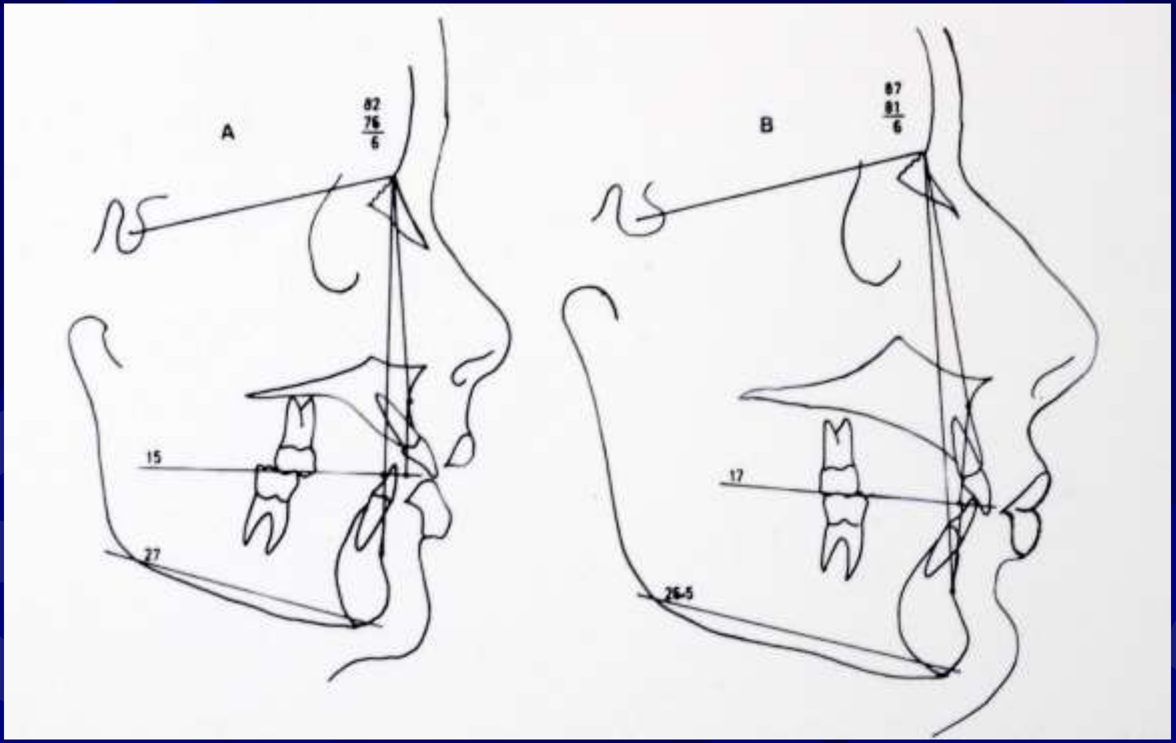


- The method involves adding half a degree to the ANB for every degree the SNA is less than the mean of 81 (and *vice versa*). In this case with an ANB of 6.5º, the SNA is 2.5º below 81º and therefore half this value should be added to the ANB which becomes 7.75º; the Class II discrepancy is therefore more severe than it originally appeared.
- Where SNA exceeds 81º, half a degree is subtracted from ANB for every degree above 81. In practice these simple calculations work reasonably well.
- From Mills (1982), *Principles and Practice of Orthodontics.*

The Wits' appraisal



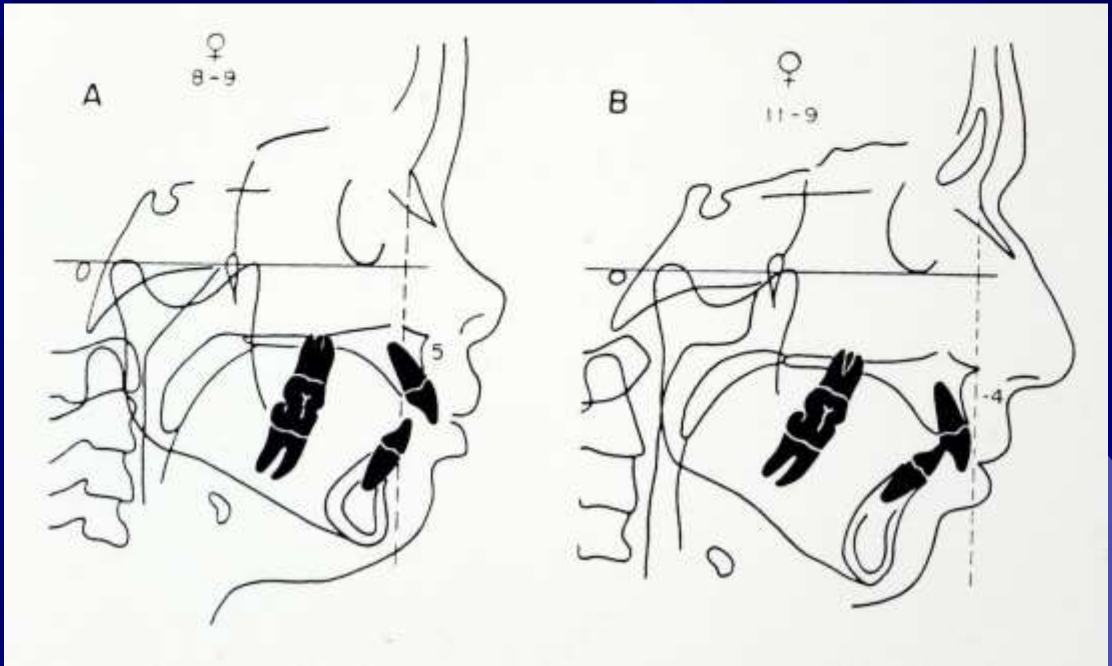
- The Wits' appraisal (Witwatersrand) was introduced to measure jaw disharmony independently of cranial reference planes.
- Perpendicular lines are dropped from points A and B onto the occlusal plane. The Wits reading is measured from AO to BO in mms. In skeletal Class II jaw dysplasias, BO is positioned well posterior to AO (a positive reading), and in Class III cases the reading is negative.
- From Jacobson (1975). *American Journal of Orthodontics* **67**, 125–138.



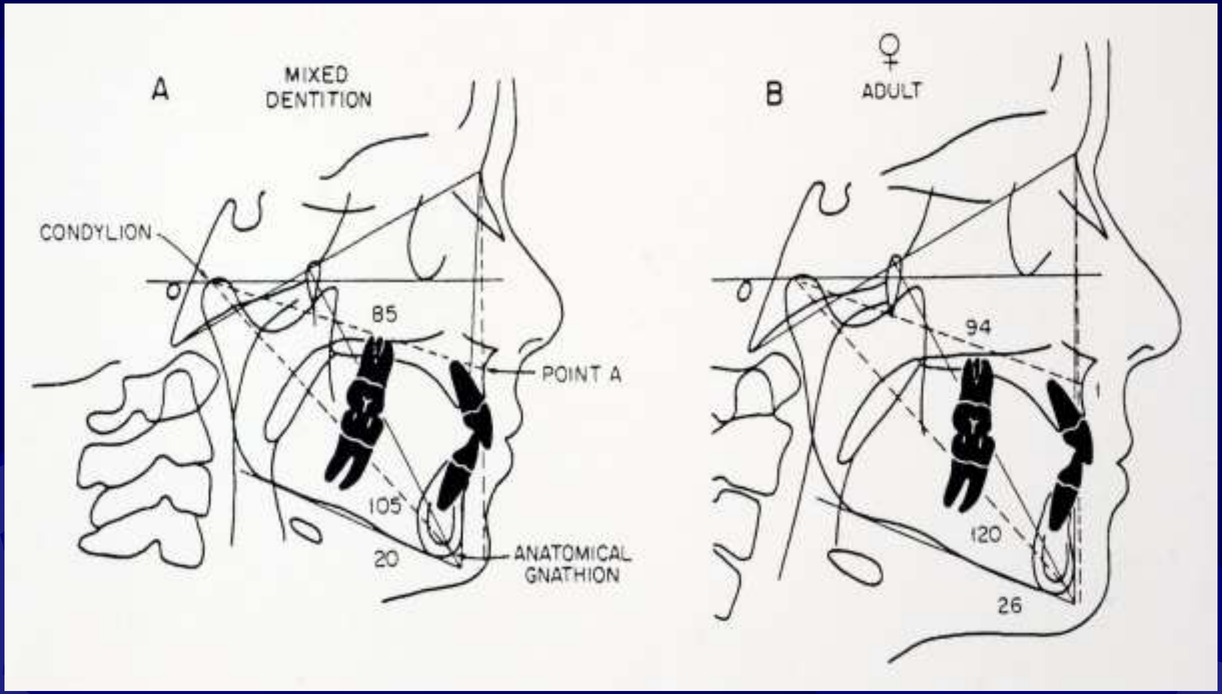
- Tracings of two malocclusions with identical ANB angles of 6º. A. The Wits reading of 6 mm indicates a severe jaw disharmony, whereas in B the Wits of 0 mm indicates a skeletal Class I.
- The Wits appraisal is largely dependent on the correct location or representation of the occlusal plane and should only be used in conjunction with other methods for assessing apical base relationships.
- From Jacobson (1975). *American Journal of Orthodontics* **67**, 125–138.

The McNamara analysis

From McNamara (1984). *American Journal of Orthodontics* **86**, 449–469.



- Derived, in part, from the analyses of Ricketts (1960) and Harvold (1974), with the addition of two new planes, nasion perpendicular and point A vertical.
- A. This patient has maxillary protrusion since point A is 5 mm in front of nasion perpendicular. B. Patient with maxillary retrusion; point A is 4 mm behind nasion perpendicular. She also has severe mandibular retrognathia; Pog is well behind nasion perpendicular.

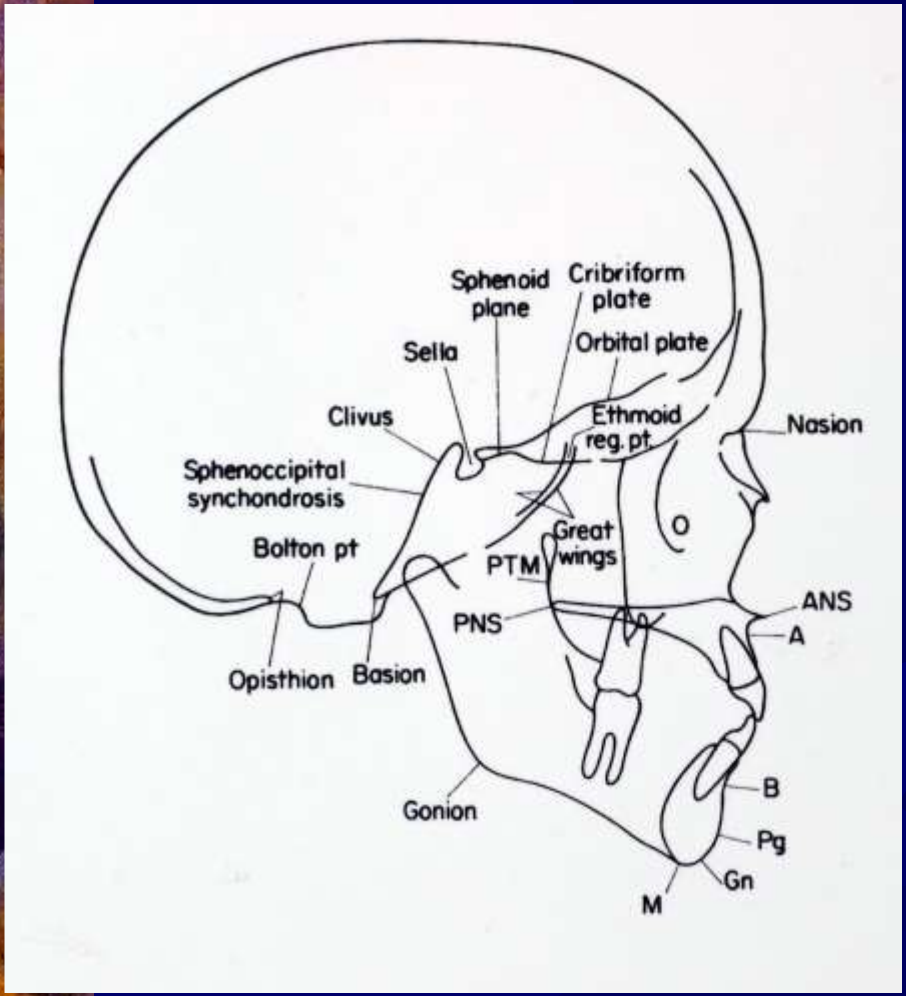


- The lengths of the mandible and the maxilla (or more specifically the midfacial region) are determined by a modification of the method developed by Harvold. The effective midfacial length is measured from condylion to point A; mandibular length is measured from condylion to gnathion.
- A. Midfacial length (85 mm) and mandibular length (105 mm) in a mixed dentition patient with a balanced face. B. In an adult female; midfacial length is 94 mm and mandibular length 120 mm.
- From McNamara (1984). *American Journal of Orthodontics* **86**, 449–469.

Superimposition of cephalometric radiographs

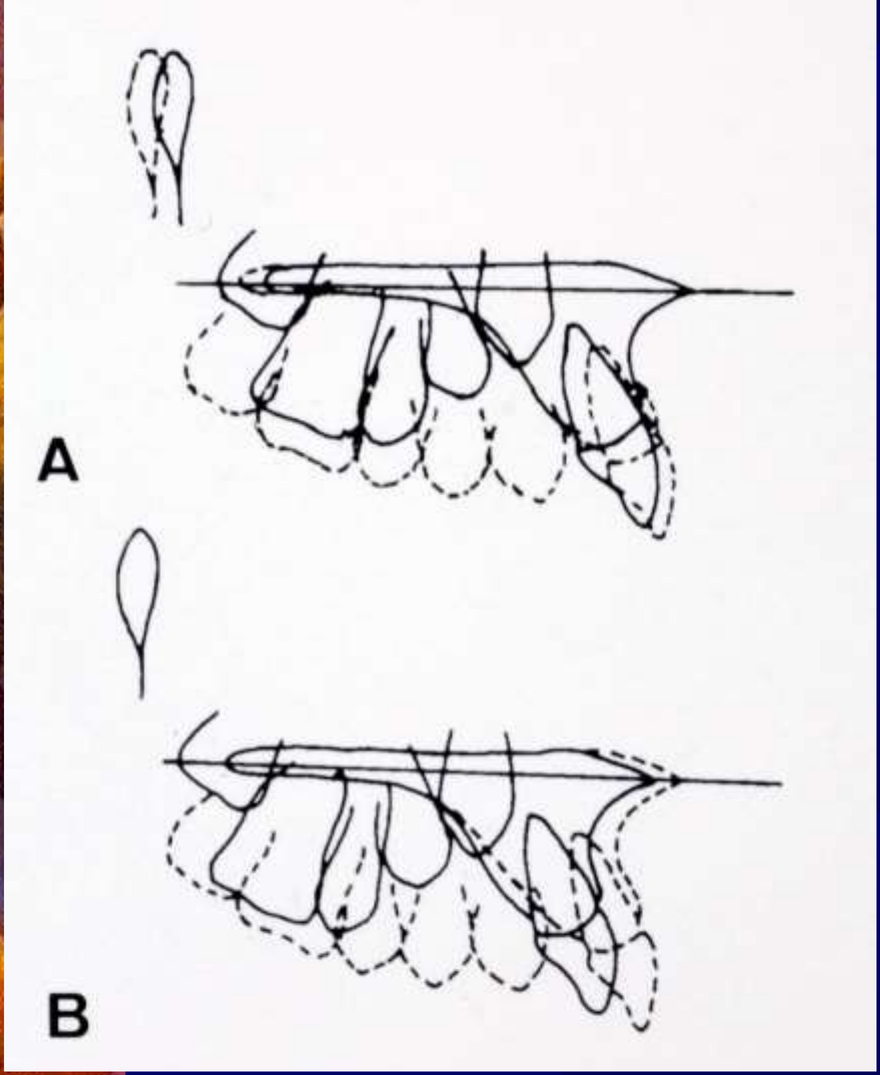
- The superimposition of serial headfilm tracings to analyse changes in craniofacial growth and/or orthodontic treatment has been routine since the introduction of cephalometry. Early reports were limited to an overall superimposition registered on the cranial base. The importance of distinguishing between growth of the jaws and tooth movement, led subsequently to the introduction of separate maxillary and mandibular superimpositions. All three are indispensable for a proper interpretation of growth and treatment changes.
- The longitudinal study of dentofacial change requires serial headfilm tracings to be superimposed on stable anatomical landmarks; such stable or fixed reference points within the skull do not exist. Nevertheless, because of its central location at the interface between the cranial and facial parts of the skull, the cranial base has proved to be the most enduring reference area in cephalometry.

The ethmoid triad



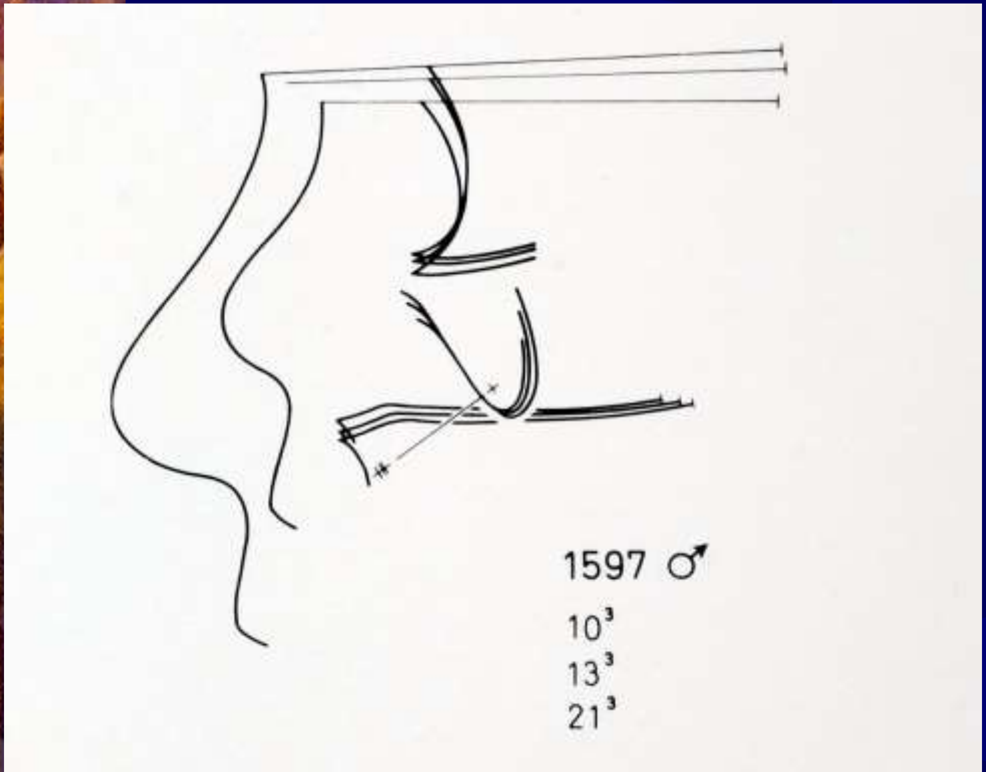
- The anterior cranial base S–N, is the most commonly used registration line, but there are pitfalls in its use. N is not a fixed point and moves upwards and forwards. The pituitary fossa and tuberculum sella also move upwards as the sphenoid sinus enlarges. S–N will therefore give a slightly excessive estimate of vertical growth of the face in comparison with forward growth.
- The two greater wings of the sphenoid together with the outline of the anterior fossa (de Coster's line), form the ethmoid triad, the most stable reference area for superimposing serial headfilms.
- Courtesy of Dr Alton Wallace Moore.

The maxillary superimposition



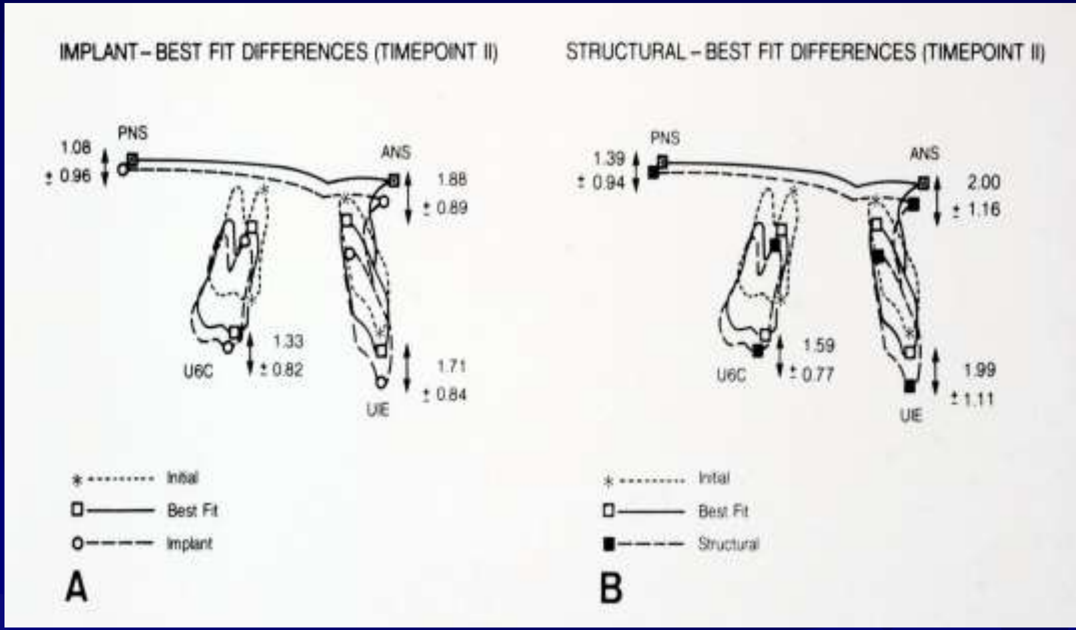
- The aim of a maxillary superimposition is to distinguish changes in tooth position relative to basal bone. Unfortunately, the maxilla may undergo quite extensive surface remodelling. The accuracy of all current methods of superimposition is compromised to some extent.
- A. Superimposition on the palatal plane registered at ANS; with growth PTM moves distally. In practice this is very similar to superimposition on the palatal contour (the method of best fit).
- B. Superimposition on the palatal plane registered on PTM.
- From Moore (1959). *American Journal of Orthodontics* **45**, 399–423.

The structural method



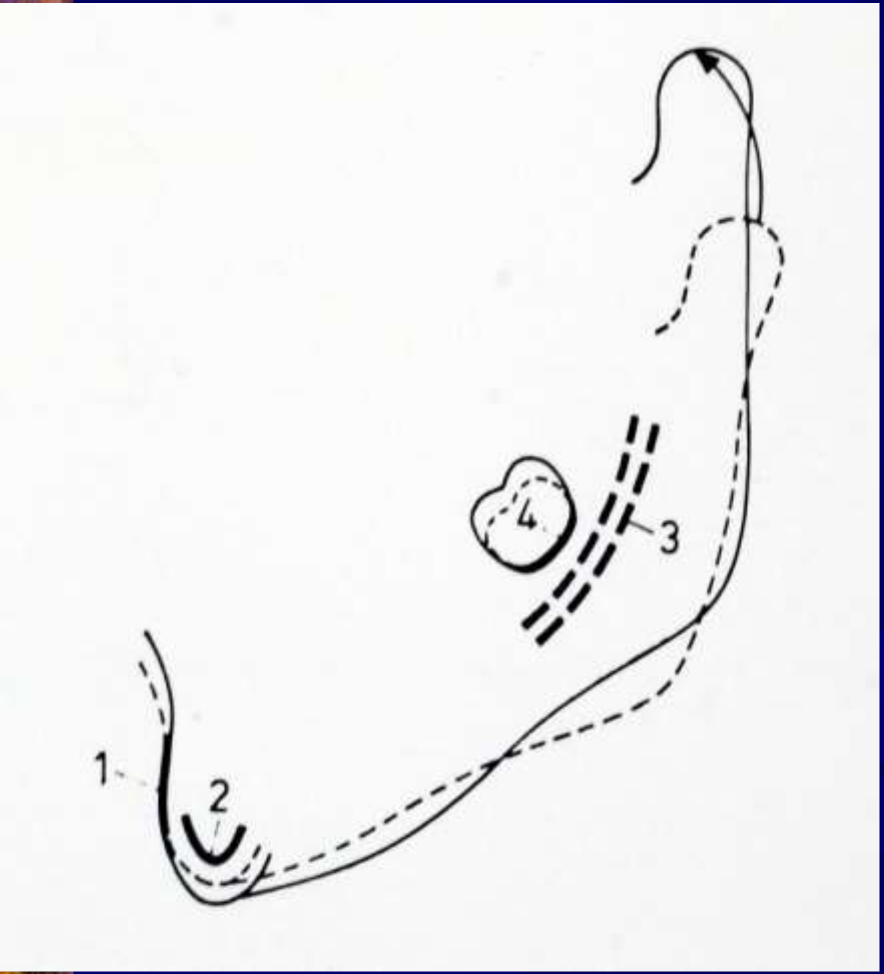
From Björk and Skieller (1977). *British Journal of Orthodontics* **4**, 53–64.

- The problem with the method of best fit is growth remodelling of the hard palate. Implant studies have shown that the palate undergoes significant resorptive remodelling on the nasal surface with concomitant deposition on the oral surface (Björk and Skieller, 1977).
- Björk and Skieller therefore suggested using what is referred to in the literature as the structural method; tracings are superimposed on the anterior contour of the zygomatic process of the maxilla (the key ridge) which is relatively stable after eight years of age.



- A. Mean ± SD of differences in displacement of skeletal and dental landmarks between implant and best fit during a 4-year period (N=18). ANS and PNS show upward movement, with ANS showing twice as much vertical displacement as PNS. The best fit method underestimated molar eruption by 30% and incisor eruption by 50%.
- B. Mean ± SD of differences in displacement of skeletal and dental landmarks between structural and best fit superimpositions during a 4-year period. No statistically significant differences were found between the structural and implant methods in the vertical plane.
- From Nielsen (1989). *American Journal of Orthodontics and Dentofacial Orthopedics* **95**, 422–431.

Mandibular superimposition: Björk's structures



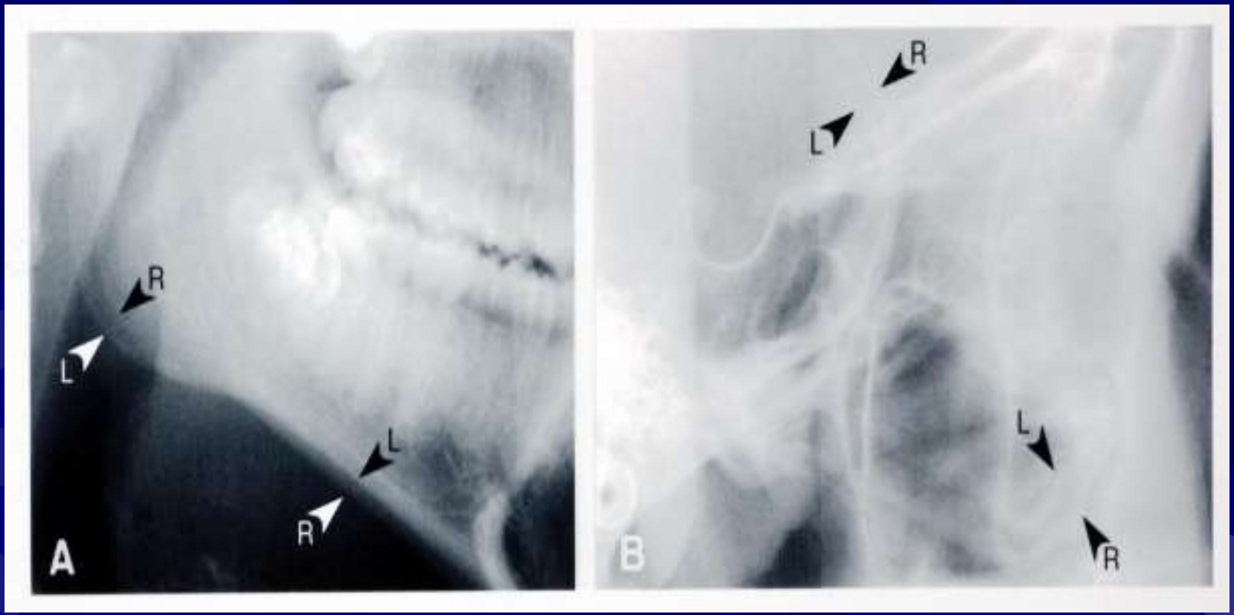
From Solow (1980). *British Journal of Orthodontics* **7**, 145–161.

- Anatomical structures in the mandible recommended by Björk to assess mandibular dentoalveolar changes. (1) Anterior contour of the symphysis, (2) Internal contour of the symphyseal cortical bone, (3) outline of the inferior dental (mandibular) canal, and (4) lower contour of the third molar tooth germ before the start of root formation.
- These have become known as Björk's structures and widely used for clinical and research purposes to demonstrate mandibular growth changes and alterations in tooth position.

Errors in cephalometric radiography

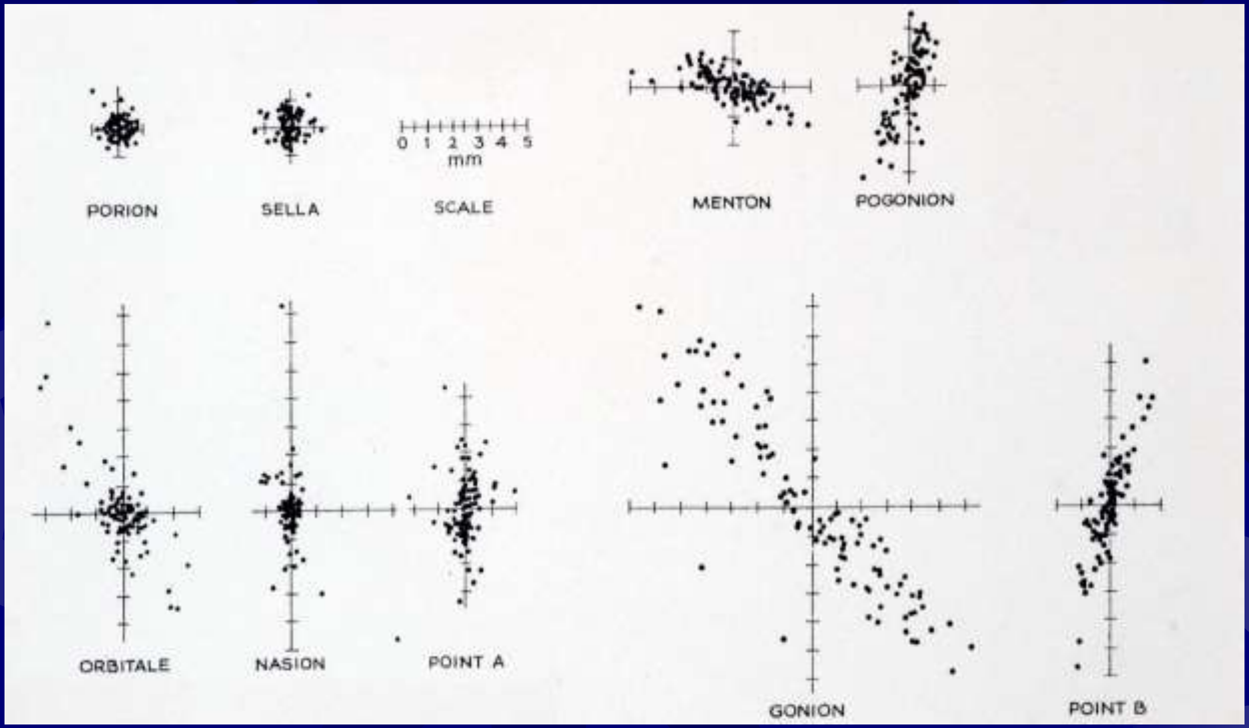
- It is important to realize that in spite of an appearance of mathematical rigour, cephalometric radiography and the quantitative analyses derived from it are subject to many sources of error.
- These may be grouped into three categories; (1) errors of projection; (2) errors of landmark identification, also referred to as tracing errors; and (3) validity, that is to say, does the measurement actually represent what it is supposed to?

Errors of projection



- These arise from the fact that a 3-D image of the head is projected as a 2-D shadow with magnification of structures not on the principal axis (the central ray). The image is also distorted and structures closer to the film (customarily the left) are magnified less.
- A. Bilateral images of the mandible; the inferior dental canal is difficult to identify. B. Bilateral images of the greater wings of the sphenoid and the key ridges. When tracing bilateral structures one can either trace the left of the two images or split the difference.

Errors of landmark identification



- The largest errors arise from landmark identification. These are specific to each landmark which has its own characteristic envelop of error; dental landmarks have a particularly low level of reliability.
- The problem is that definitions often lack precision and landmarks within the skull such as condylion may be obscured by anatomical structures.
- From Baumrind and Frantz (1971). *American Journal of Orthodontics* **60**, 505–517.

Validity of cephalometric measurements

- Validity is the extent to which, in the absence of measurement error, the value obtained represents the object of interest (Houston, 1983). This includes not only the accuracy with which dental or skeletal landmarks can be measured, but also the extent to which certain linear and angular measurements are justified on the grounds of anatomical authenticity.
- A good example of the latter is the way in which changes in mandibular growth have been measured. These have included the linear measurements condylion–gnathion (Go–Gn), articulare–gnathion (Ar–Gn) and gonion-gnathion (Go–Gn), all of which have drawbacks. Ar–Gn and Go–Gn are not valid measurements because they exclude changes at the condyle, and although Co–Gn includes changes at the condyle, it does not take into account condylar growth direction, or its effect on mandibular growth rotation. (These problems are discussed further in Seminar 10.)

Posteroanterior (frontal) radiography

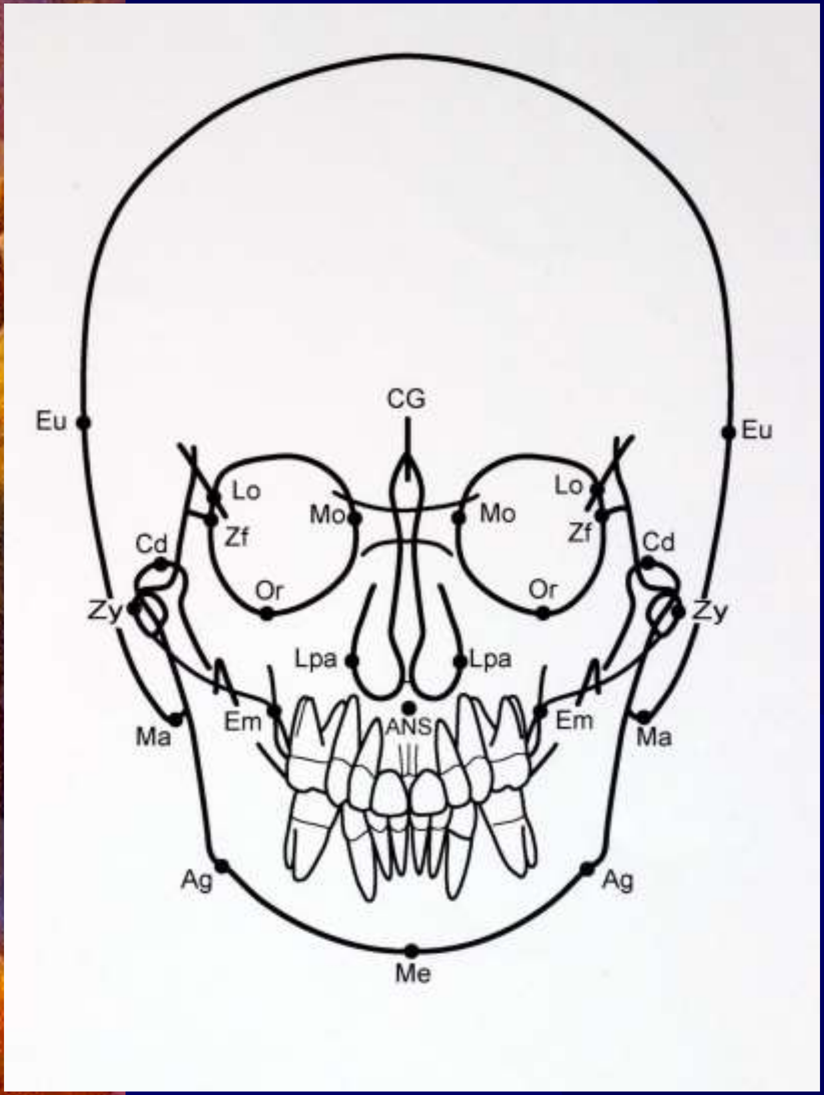
- Posteroanterior (PA) radiographs are not taken routinely in orthodontic practice. Normative data for transverse measurements of the face and jaws derived from PA cephalometric radiographs have been published (Athanasiou *et al.*,1992; Basyouni and Nanda, 2002), but have limited clinical utility.

- PA radiography is, however, indicated in planning the nonsurgical and surgical management of (1) cases with severe dental and/or skeletal asymmetries; (2) patients with maxillary deficiency and associated crossbite and/or airway problems; and (3) patients with cleft lip and palate or other craniofacial anomalies.

PA Cephalometry

- Posteroanterior radiograph of a girl aged 10 years with mild hemifacial microsomia affecting the right side of the face and with marked mandibular asymmetry.
- Menton is approximately 1 cm to the right of the midsagittal plane. There is a considerable element of guesswork and wishful thinking in attempting to identify anatomical landmarks in the middle third of the face. Antegonion is not present on the affected side and the mandibular condyles are difficult to distinguish from the mastoid processes.

PA cephalometric landmarks



- PA headfilms are difficult to interpret. Landmark identification can be unreliable due to overlying hard and soft tissues, and the absence of well-defined stable structures complicates superimposition. The position of the head is also difficult to control and tilting is a significant source of error; transverse measurements are least affected by positional errors.
- Posteroanterior cephalometric landmarks: Ag, antegonion; Em, ectomaxillare; Eu, euryon; Ma, mastoidale; Cd, condylar; Lo, latero-orbitale; Mo, medio-orbitale; Or, orbitale; CG, crista galli; Lpa, lateral piriform aperture; Zy, zygion; Zf, zygomaticofrontal suture; ANS, anterior nasal spine; Me, menton.
- Adapted from Athanasiou (1995), *Orthodontic Cephalometry*.

Summary

- Cephalometry [Gr. *cephale*, head] is measurement of the living head and evolved from craniometry [Gr. *cranium*, skull], a term traditionally reserved for anatomical and anthropological studies of dried skulls.
- Given the importance of cephalometry to current orthodontic practice, it is perhaps surprising to find that in its early years there was a good deal of resistance to its use by orthodontists. It is also clear that some of the high expectations that accompanied the development of cephalometric radiography as a clinical diagnostic technique failed to be realized.
- First, it soon became apparent that cephalometrics had little or no value in predicting craniofacial growth and limited value in providing valid treatment goals.

- Second, comparing the cephalometric values of an individual patient, with the normative values for a given population in deciding treatment objectives has no scientific justification. (It is curious that we persist in comparing the cephalometric values of an individual patient to an artefactual mean, which for all practical purposes is clinically meaningless.) In other words, we treat individuals not averages.
- However, despite its limitations, cephalometric radiography besides permitting accurate evaluation of growth in an individual, is also indispensable for distinguishing between normal growth and the dentofacial changes brought about by orthodontic treatment. Cephalometry demonstrates the effectiveness of treatment as well as its shortcomings, and as such benefits not only our clinical practice, but also our patients.