Craniometry and Functional Craniology

Part I:
Anthropometry, Craniometry and Cephalometry

Michael S. Yuan, DDS, MA, PhD
Assistant Professor of Clinical Dentistry

Division of Orthodontics
School of Dental and Oral Surgery
Columbia University

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Lecture outline

1. Introduction: the scope and history
2. Definition and objectives
3. Identification of anatomical landmarks
4. Measurements: metric vs non-metric; direct vs indirect
5. Measuring devices
6. Sex/gender estimation
7. Age estimation
8. Racial/ethnic estimation
9. Other methodology, comparisons, and interpretations
10. Clinical applications

Anthropometry

- **Definition**: measurement of human head and body
- **Scope**: somatometry, osteometry, craniometry, cephalometry, odontometry
- **Origin**: The methodology probably began because of the interest in the racial classifications (in search of the origin of the human races: monogenism vs polygenism) (Anders Retzius: Swedish; cephalic index)
- **Objectives**: 1) to examine the differences between species;
  2) to investigate the variations within species, which include temporal changes, sexual dimorphism, geographical and ethnic differences;
  3) to explore the trends and evolution as well as to interpret fossil records;
  4) to apply in clinical diagnosis, treatment planning, forensics, and other commercial applications.

Anthropometric Measuring Devices

Direct method

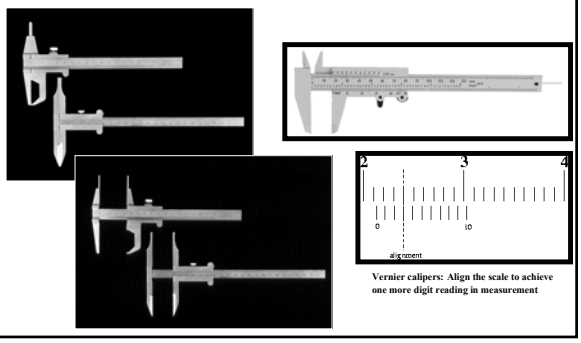
- Sliding caliper
- Hinge (spreading) caliper
- Stadiometer/Osteometric board
- Coordinate caliper
- Head spanner/Todd's craniostat
- Soft metric tape
- Others

Indirect method

- Digitizer
- Surface scanner
- Radiography
- Other computer assisted imaging and measuring devices (CT scan, MRI, Sonography, etc.)

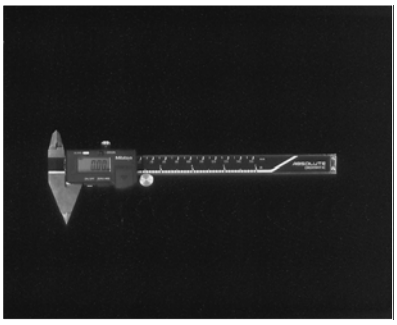
Sliding Caliper

(Non-Vernier vs. Vernier)

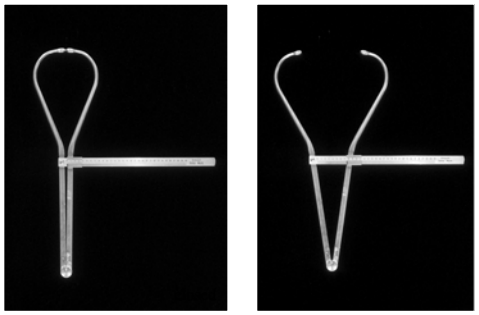


Vernier calipers: Align the scale to achieve one more digit reading in measurement

The Mitutoyo Digital Sliding Caliper



Spreading Caliper

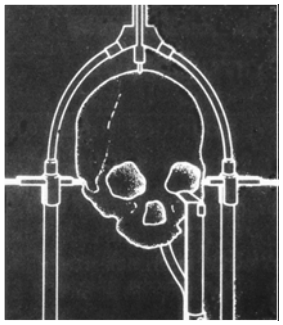


Stadiometer

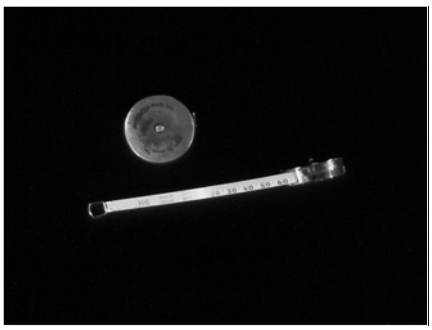
"*Stretch of the Measuring*"
Johann Wolfgang von Goethe, 1779

Osteometric Board

Todd's Craniostat (Head Spanner)

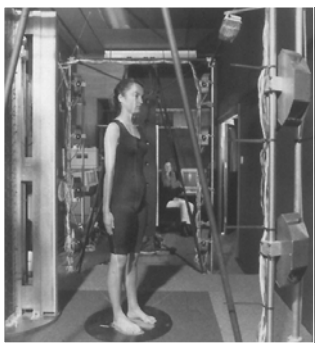


Soft Metric Tape



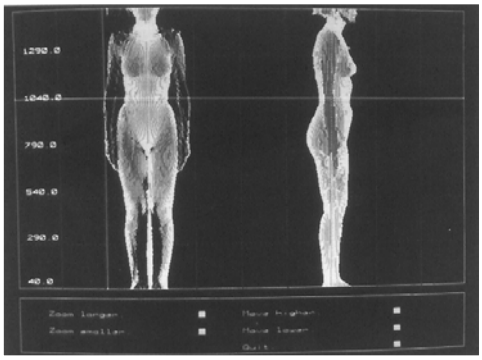
Body Imaging: 3D Surface Anthropometry

The Loughborough Anthropometric Shadow Scanner



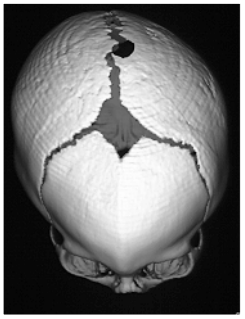
The computerized whole-body image after scanning

(Surface area and volume estimations; Shape capturing and reconstruction)



3-D Imaging

(morphometrics in size and shape)



Source: Pre-operative (L) and post-operative (R) 3-D images of a trigonocephaly case
http://www.health.adelaide.edu.au/paed-neuro/craniofacial.html (2002)

Craniometry

- **Definition**: measurement of human dry skull
- **Landmarks**: 1) true vs relative landmarks
  2) mid-sagittal vs bilateral landmarks
- **Measurements**: 1) qualitative (non-metric) vs quantitative (metric)
  2) metric: angular, arc, linear, volumetric proportional
- **Cranial and facial indices**
- **Cranial and facial forms**

The Traditional Landmarks of the Skull

Mid-Sagittal

Acanthion	**Inion**	**PNS** (Anterior nasal spine)
Alveolare	**Lambda**	**Prosthion**
Alveolon	**Menton**	**Rhinion**
Apex	**Nasion**	**Staphylion**
ANS (Anterior nasal spine)	**Nasospinale**	**Subnasale**
Basion	**Obelion**	**Subspinale (A)**
Bregma	**Ophryon**	**Supradentale**
Glabella	**Opisthion**	**Supramentale (B)**
Gnathion	**Opisthocranion**	**Symphysion**
Incision	**Orale**	**Vertex**
Infradentale	**Pogonion**	

The Traditional Landmarks of the Skull

Bilateral

Alare	**Euryon**	**Porion**
Asterion	**Frontotemporale**	**Pterion**
Coronale	**Gonion**	**Sphenion**
Crotaphion	**Jugale**	**Stephanion**
Dacryon	**Lacrimale**	**Zygion**
Ectoconchion	**Mastoidale**	**Zygorbitale**
Ectomolare	**Maxillofrontale**	
Endomolare	**Orbitale**	

Basion: the midpoint of the anterior margin of the foramen magnum.

Bregma: the intersection of the coronal and sagittal sutures in the midline.

Glabella: the most forward projecting point in the midline of the forehead at the level of the supra-orbital ridges and above the nasofrontal suture.

Euryon: the two points on the opposite sides of the skull that form termini of the lines of greatest breadth. The two points are determined instrumentally.

Gnathion: the most anterior and lowest median point on the border of the mandible.

Gonion: the midpoint of the angel of the mandible between body and ramus.

Lambda: the intersection of the sagittal and lambdoidal sutures in the midline.

Mastoidale: the lowest point of the mastoid process

Menton: the lowest median point of the chin.

Nasion: the intersection of the nasofrontal suture with the midsagittal plane. Nasion is the uppermost landmark for the measure of facial height.

Opisthocranion: the most posterior point on the skull not on the external occipital protuberance. It is the posterior end point of maximum cranial length measured from glabella. It is determined instrumentally.

Orbitale: the lowest point in the margin of the orbit; one of the points used in defining Frankfort Horizontal.

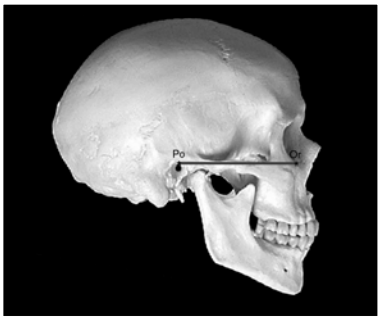
Pogonion: the most anterior point in the midline of the chin.

Porion: the uppermost lateral point in the margin of the external auditory meatus. The right and left porion with the left orbitale define the Frankfort Horizontal

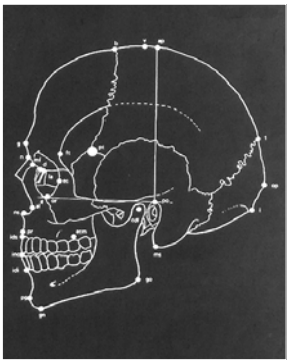
Zygion: the most lateral point of the zygomatic arch. It is determined instrumentally.

Frankfort Horizontal (FH)

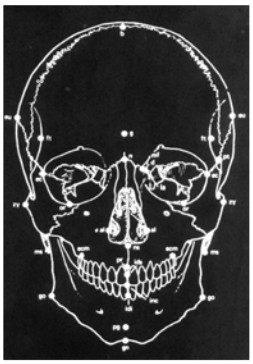
1) A plane passing through three points of the right and left porion and the left orbitale.
2) First proposed at the Craniometric Congress held in Munich, Germany, 1877.
3) An orientation of skull in a consistent and reproducible position.
4) Comparisons: natural head position; horizontal visual axis; and horizontal plane.



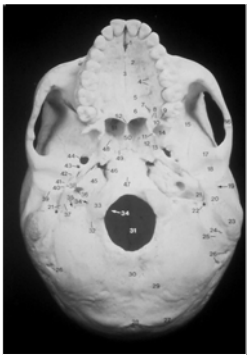
Skull: Lateral View

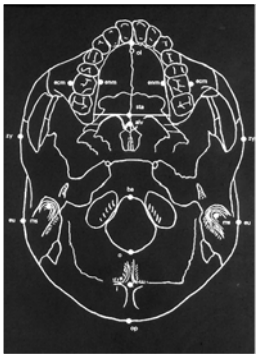


Skull: Frontal View



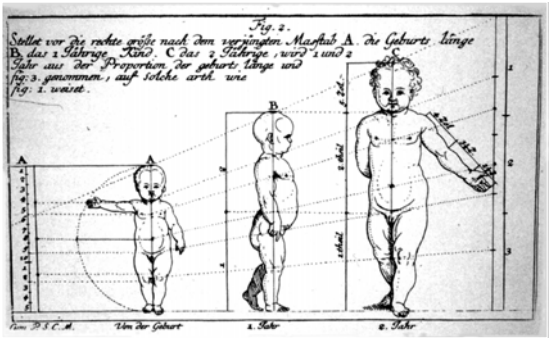
Skull: Basal View





Drawing of a Child at Birth, Age 1, Age 2

Bergmüller (1723), Countway Library, Boston



Craniometric Measurements (I)

Cranial circumference	**Cranial height**
Max. cranial breadth	**Max. cranial length**
Min. frontal breadth	**Bizygomatic breadth**
Bigonial breadth	**Total facial height**
Upper facial height	**Basion-Nasion length**
Basion-Prosthion length	**Basal height**
Nasal breadth (max.)	**Upper nasal breadth**
Lower nasal breadth	**Orbital height**
Orbital breadth	**Interorbital breadth**
Biorbital breadth	**Palate-external breadth & length**
Foramen magnum breadth	**Palate-internal breadth & length**

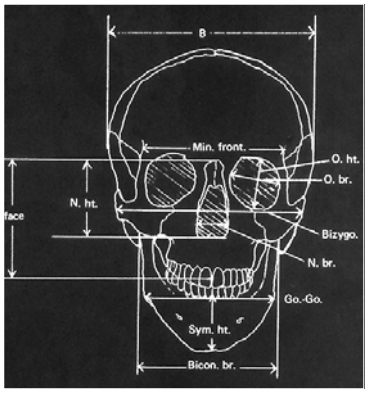
Craniometric Measurements (II)

Condylo-symphyseal length
Bicondylar width
Min. ramus breadth
Mandibular body height
Symphyseal height
Mastoid length
Ascending ramus height
Mandibular body breadth
Mandibular body length

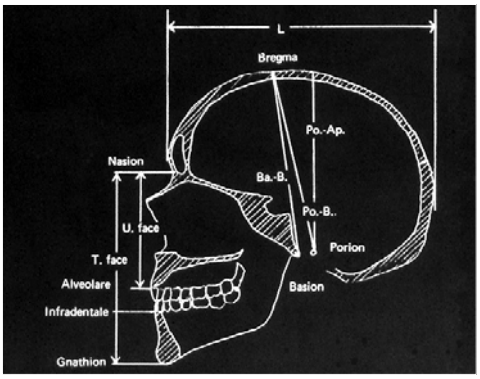
Total facial angle
Mid-facial angle
Alveolar angle

Nasion-Opisthion arc
Transverse arc
Sagittal cord
Coronal cord

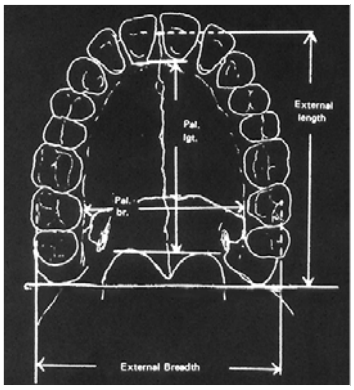
Skull: Frontal Measurements



Skull: Lateral Measurements



Skull: Palatal Measurements

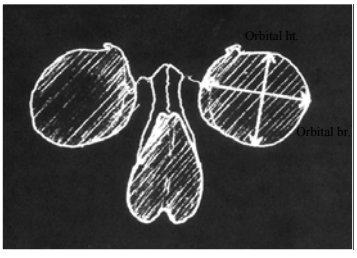


Cranial and Facial Indices

Cranial index
Cranial length- height index
Cranial breadth- height index
Total facial index
Upper facial index
Nasal index
Orbital index
External palatal index

Orbital Index

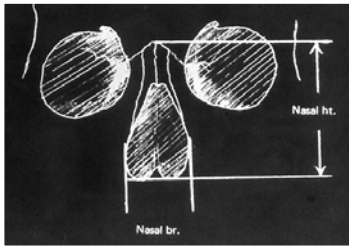
$$\text{Orbital Index} = \frac{\text{Orbital height} \times 100}{\text{Orbital breadth}}$$



Chamaeconchy (X-82.99): wide orbits
Mesoconchy (83.00-89.99): average or medium
Hypsioconchy (89.00-X): narrow or square orbits

Nasal Index

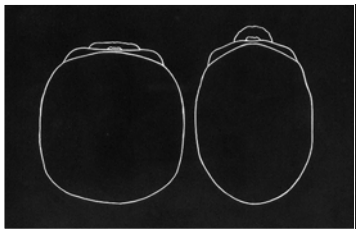
$$\text{Nasal Index} = \frac{\text{Nasal breadth x 100}}{\text{Nasal height}}$$



Leptorrhiny (X-47.99): narrow nasal aperture
Mesorrhiny (48.00-52.99): average or medium
Platyrrhiny (53.00-X): broad or wide nasal aperture

Cranial Index (Dry Skull)

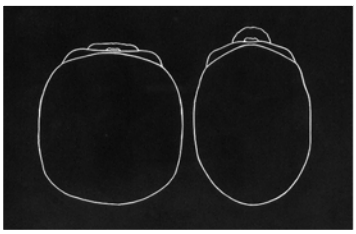
$$\text{Cranial Index} = \frac{\text{Max. cranial breadth x 100}}{\text{Max. cranial length}}$$



Dolichocrany (X-74.99): narrow or long calvarium
Mesocrany (75.00-79.99): average or medium calvarium
Brachycrany (80.00-84.99): broad or round calvarium
Hyperbrachycrany (85.00-X): very broad headed calvarium

Cephalic Index

$$\text{Cephalic Index} = \frac{\text{Max. cephalic breadth x 100}}{\text{Max. cephalic length}}$$

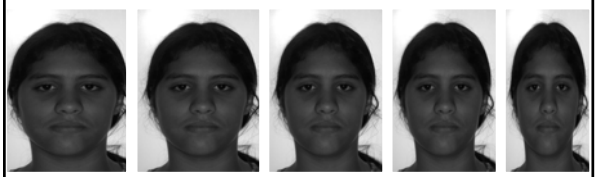


Dolichocephaly (X-74.99): narrow or long headed
Mesocephaly (75.00-79.99): average or medium
Brachycephaly (80.00-84.99): broad or round headed
Hyperbrachycephaly (85.00-X): very broad headed

Dinaric

Facial Index

$$\text{Facial Index} = \frac{\text{Total facial height x 100}}{\text{Bizygomatic breadth}}$$



Hypereuryprosopy (X-79.99): very broad face
Euryprosopy (80.00-84.99): broad face
Mesoprosopy (85.00-89.99): average or medium
Leptoprosopy (90.00-94.99): slender or narrow face
Hyperleptoprosopy (95.00-X): very slender or narrow face

Source: Drs. Bryan Scott & Sonia Abraham

Sex/Gender Estimation

Sex/Gender Differences in the Skull

Trait	Male	Female
General size	Large	Small
Architecture	Rugged	Smooth and gracile
Supraorbital torus	Medium to large	Small to medium
Mastoid processes	Medium to large	Small to medium
Occipital bone	Muscle lines and protuberance marked	Muscle lines not marked
Frontal eminences	Small	Large
Parietal eminences	Small	Large
Orbits	Squared, lower, relatively smaller with rounded superior margins	Rounded, higher, larger with very sharp superior margins
Forehead	Steeper, less rounded	Rounded and full, sometimes infantile
Cheek bones	heavier, more laterally arched	Lighter, more compressed
Mandible	Larger, higher symphysis, gonial angle <125°, gonial angle flares	Smaller, gonial angle >125°, gonial angle does not flare as much outward
Palate	Larger, broader, tends to be U-shaped	Small, tends to be a parabola
Occipital condyles	Large	Small
Posterior part	Has a noticeable crest that may continue posteriorly to meet with the most inferior curve of the temporal lines	Crest usually not as pronounced, does not continue across to temporal lines

Source: Modified from Krogman 1962:115.

Sexing the Skull
(Multiple Regression Analysis)

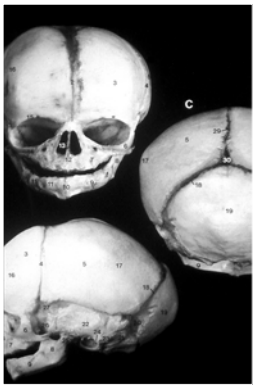
Caucasian samples

1.236 (Glabella.Opisthocranion) – 1.0 (Euryon.Euryon)
+3.291 (Zygion.Zygion) + 1.528 (Porion.Mastoidale)
= [563.93] (mm)

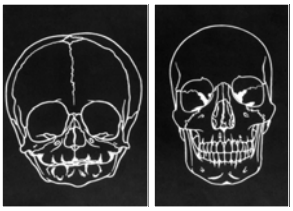
Score > 563.97: Male
Score < 563.97: Female
85.5% confidence of accuracy

Source: modified from Giles (1970)

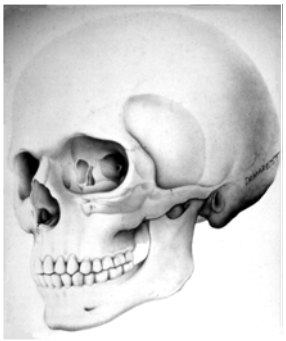
Skull: Infant



Temporal Changes
(Infant vs Adult)

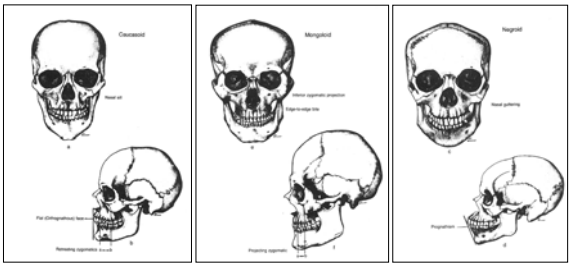


proportion comparison



size comparison

Racial/Ethnic Differences

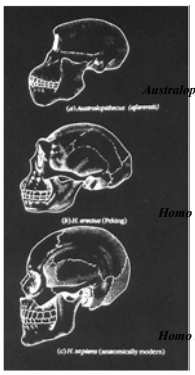


Caucasoid | Mongoloid | Negroid

Differences btw Species: Lateral view

Female chimpanzee

Female gorilla

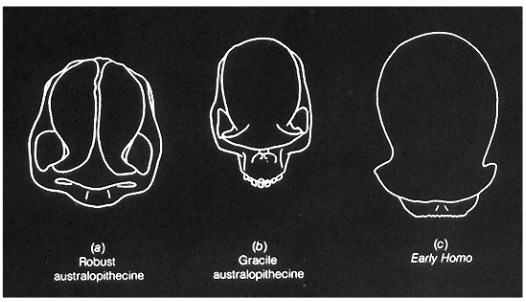


Australopithecus afarensis

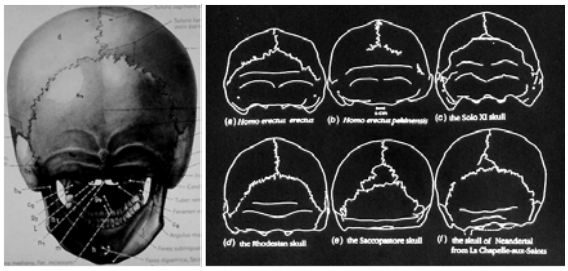
Homo erectus

Homo sapiens sapiens

Differences btw Species: Cranial view



Comparison of Skulls: Occipital View



Modern human *Homo erectus, Archaic Homo sapiens, & Neanderthal*

The Face

Cephalometry

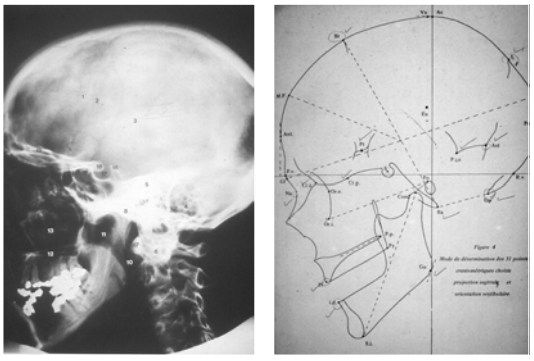
Radiographic Cephalometry
3 Imaging

Growth norms
Growth comparisons
Growth estimation
Growth prediction (?)

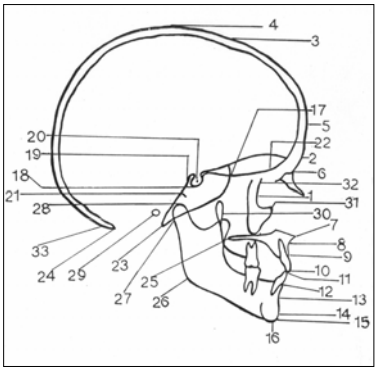
Clinical applications in orthodontics, dentofacial orthopedics, craniofacial surgery

Radiographic Cephalogram (PA view)

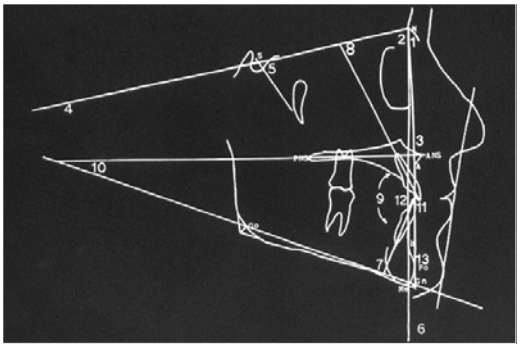
Cephalometric Radiograph and Tracing (lateral view)



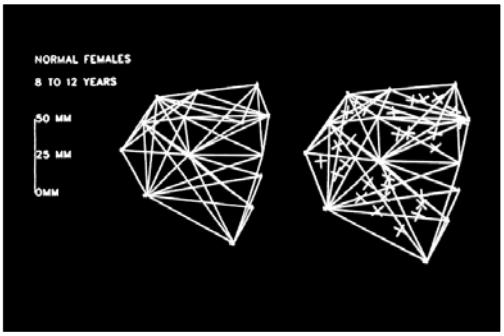
Cephalometric Landmarks



Cephalometric Analysis: Columbia Analysis



Cephalometric Analysis: Finite Element Analysis



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