C4. Forensic identification. Anthropology and odontostomatology

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Main objectives

- identifying the victim and/or creating a biological profile of the victim: height, sex, age, race, bone pathologies
- establishing the postmortem interval (based on the characteristics of the bone remains and the environment in which they were found)
- obtaining information regarding the context in which death occurred (circumstances, causes, manner of death)

Identification degrees

- **unlikely** – the available data do not support a positive association between the found fragments and a specific person, in relation to whom the identification was attempted
- **possible** – the profile obtained supports a positive association between the found fragments and a specific person, but the data is not extremely specific, so there is a reasonable possibility that the profile also fits other people.
- **probable** – there is circumstantial evidence to support a positive association between the found fragments and a specific person (e.g. an identity card is found next to some bone fragments), but the anthropological/anthropometric data are not highly specific for a definite identification.
- **certain** – there is objective evidence to prove that the profile obtained belongs to a specific person (dental profile, DNA).

Why it is necessary

- victim/criminal identification
- remarriage - in many religions a person can only remarry after confirmation of the death of the consort
- financial - funeral assistance, life insurance payment, entry into force of testamentary provisions
- preserving the dignity of the deceased - it is essential that they be correctly identified

Identification algorithm

1. Evaluation of postmortem data that can be used - teeth, bones, genetic material, restorative materials, toxicological examinations, prostheses/ortheses, etc.
2. Establishing a probable identity, based on preliminary/investigative data
3. Obtaining antemortem data from likely identified individuals, which can be compared with postmortem data
4. Structuring ante and post-mortem data so they can be compared
5. Comparing ante and postmortem data
6. Establishing a degree of identification

Types of forensic examinations used for identification

- forensic anthropology
  - corpses/skeletonized parts
  - establishing identity
- clinical forensic anthropological examination
  - people (living)
  - age determination

Forensic anthropology

- subdiscipline of anthropology
- is a subtype of biological anthropology (along with evolutionary medicine, nutritional anthropology, and primate conservation)

Anthropology = the evaluation of the particular aspects that characterize the uniqueness of the human being from a biological, behavioral, linguistic and cultural point of view

Forensic anthropology has as its main purpose the application of knowledge characteristic of biological/physical anthropology to recent skeletal remains, to assist judicial bodies in establishing identity and, if possible, identifying the circumstances or even causes of death.

The scope of forensic anthropology

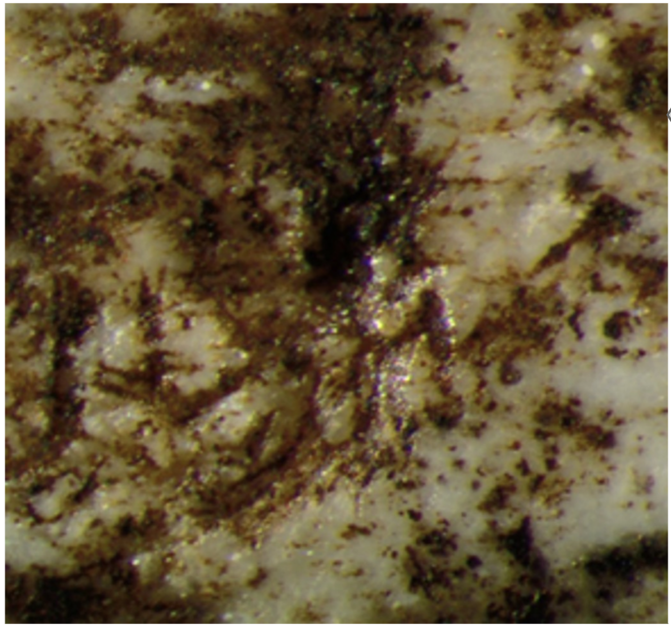
Forensic anthropology	<	Estimated age 50 years old	>	Forensic archaeology

Subdisciplines of forensic anthropology

- forensic taphonomy
- forensic osteology
- forensic odontology (odontostomatology)
- forensic entomology

Forensic taphonomy

the study of postmortem changes in the corpse determined by the environment (decomposition of the corpse, movements - made by wind, water, animals, conservative changes - mummification, tannification, adipocere, freezing and destructive changes determined by fauna).



Fragment of a fibula, showing multiple, irregular, overlapping striations, produced by the action of beetle mandibles

Superficial, linear striations with notched edges associated with circular pits of 0.1-0.3mm, produced by the larvae of some beetle species

https://commons.wikimedia.org/wiki/File:Taphonomy%E2%80%94surface_modifications.jpg

Odontostomatological taphonomy

- teeth resist postmortem changes very well (increased content in mineral substances)
- teeth resist much better than bones in the event of mechanical, thermal or chemical damage to the corpse
- DNA can be harvested from dental pulp in some situations where it is no longer possible

Postmortem changes occur, which:

- must be differentiated from pathological aspects
- useful in establishing the cause/mechanisms of death
- useful in identifying the causes of death

Mechanical destruction of teeth

- extremely rare, the force required being extremely high
- may appear:
  - severely decayed teeth
  - extensive prosthetic work
  - locally developed forces are extremely high (aircraft accidents, explosions)

Example - American Eagle Flight 4184 plane crash of 1994

In 1994, a plane crash occurred in northern Indiana, USA; there were 68 passengers and crew on board. The impact resulted in extreme bone fragmentation, with most bones fractured in multiple lines; after days of searching, 198 teeth (either complete or restored from fragments found at the scene) were identified, of which 163 could be classified by type; based on the 163 teeth, 34 individuals (almost half of the total number of cases) were ultimately identified.

Thermal changes in teeth

- High temperature leads to:
  - color changes
  - changes in the organic and crystalline structure
  - decreased weight
  - decrease in volume
  - break
- the changes depend on:
  - combustion temperature
  - burning time

Example - eruption of Mount Vesuvius, 79AD

- The eruption of the Vesuvius volcano killed an extremely large number of individuals through direct (lava action) or indirect thermal effect (extremely hot air).
- The average initial temperature to which the citizens of Herculaneum were exposed was 600°C; however, most of the bones showed characteristics of much lower combustion temperatures (around 300°C) - the thermal energy being absorbed by overlying structures (soft tissues, clothes)
- Theoretically, the teeth should have been exposed to higher temperatures because the perioral soft tissues are relatively thin.

However, temperature-induced dental changes were relatively minor, including:
- blackening of the roots
- covering of teeth with charred soft tissues
- oorange spots on the enamel
- blackish dental alveoli;
- a small number of individuals experienced thermal dental fractures.
- in all cases excavated from Herculaneum, thermal changes in the dentin occurred before those in the enamel;
- in teeth lacking enamel, the roots were dark brown.
- dental thermal fractures occurred more frequently on the labial surface of the teeth, more often in the vertical direction.
- in some cases, the crowns were separated at the cementum junction, possibly due to the temperature differential between the crowns (exposed to a higher temperature) and the roots (protected by soft tissues and maxillary/mandibular bone)

The orange stains on the surface of the teeth (also identified at the bone level in the skeletons from Herculaneum) contain sulfur, sodium, silicon, aluminum and iron, elements found in high concentrations in volcanic ash.

Vertical (anterior teeth), horizontal (molars) fractures and blackening of the roots

Orange staining of dental structures (sulfur-based compounds)

Forensic odontology and osteology

Are the bones human?

1. Are the objects made of bone materials?
    a. YES - go to point 2
    b. other objects (e.g. educational materials, stones ceramics etc.) - anthropological examination is stopped
2. Are the bones actually human? Diff. dg with:
    a. large mammals living in the same geographical area (bear, dog, deer, pig, horse, pony)
    b. small animals (dogs, birds, cats, large rodents) -> children/fetuses

Useful elements for #dg

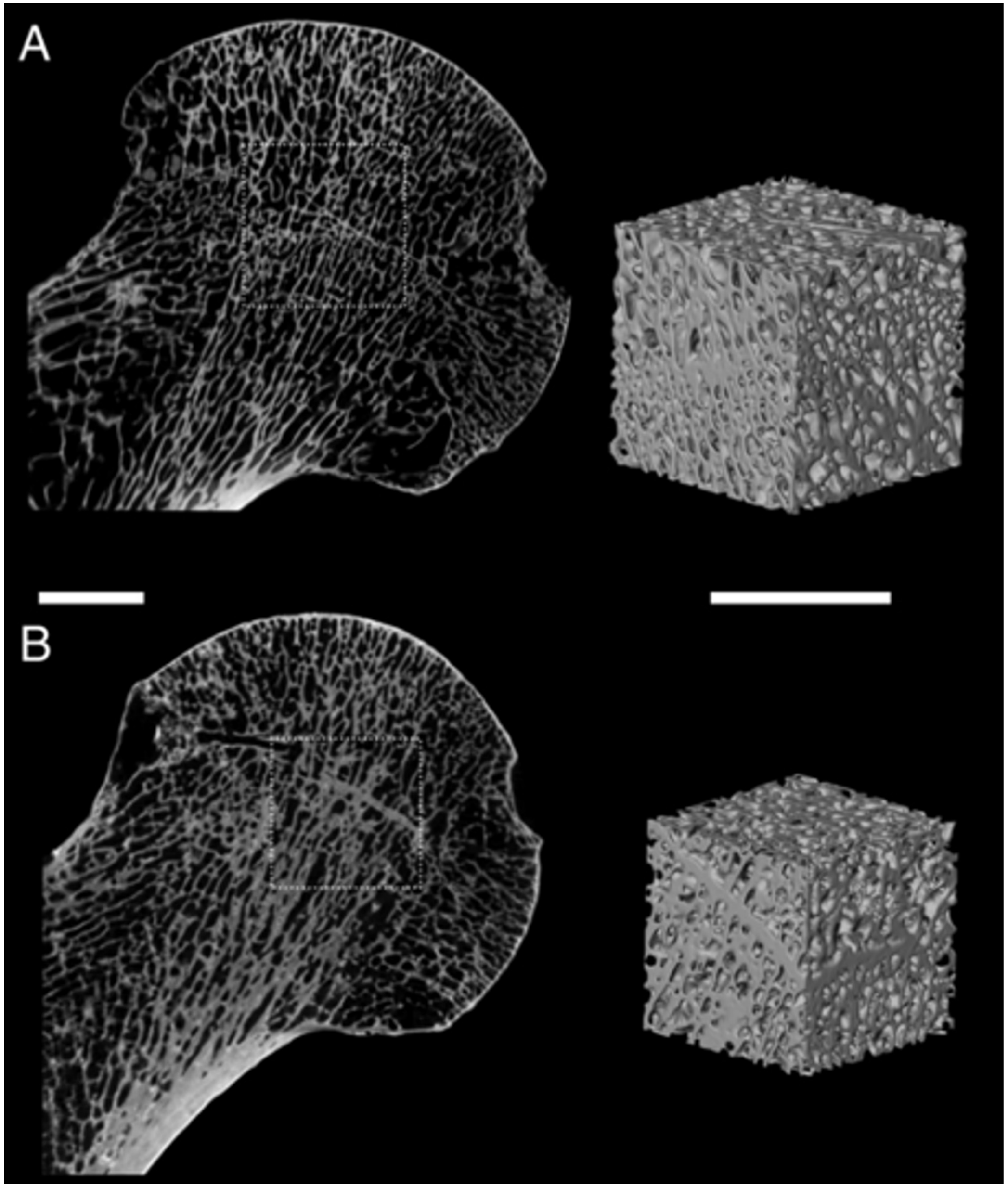
- bone maturity - useful when comparing small bones, for example, to differentiate between the bones of children and small animals
- curvatures of long bones - high interspecies variability; in humans, particular curvatures due to bipedal gait
- cortical-medullary ratio: humans: 1:4; large mammals: 1:3; birds: 1:8
- osteons - randomized arrangement in humans, relatively ordered, in rows in most mammals
- immunological/genetic tests

Radius și cubitus de om versus cal. Diferențe de curbură, mărime, calul prezintă fuzionarea parțială a radiusului la ulnă la adult

Femur de om versus porc. La om diafiza este mult mai lungă și ceva mai subțire, se observă linia aspera, curbura este diferită, capul și colul femural mult alungite pentru a permite mersul biped

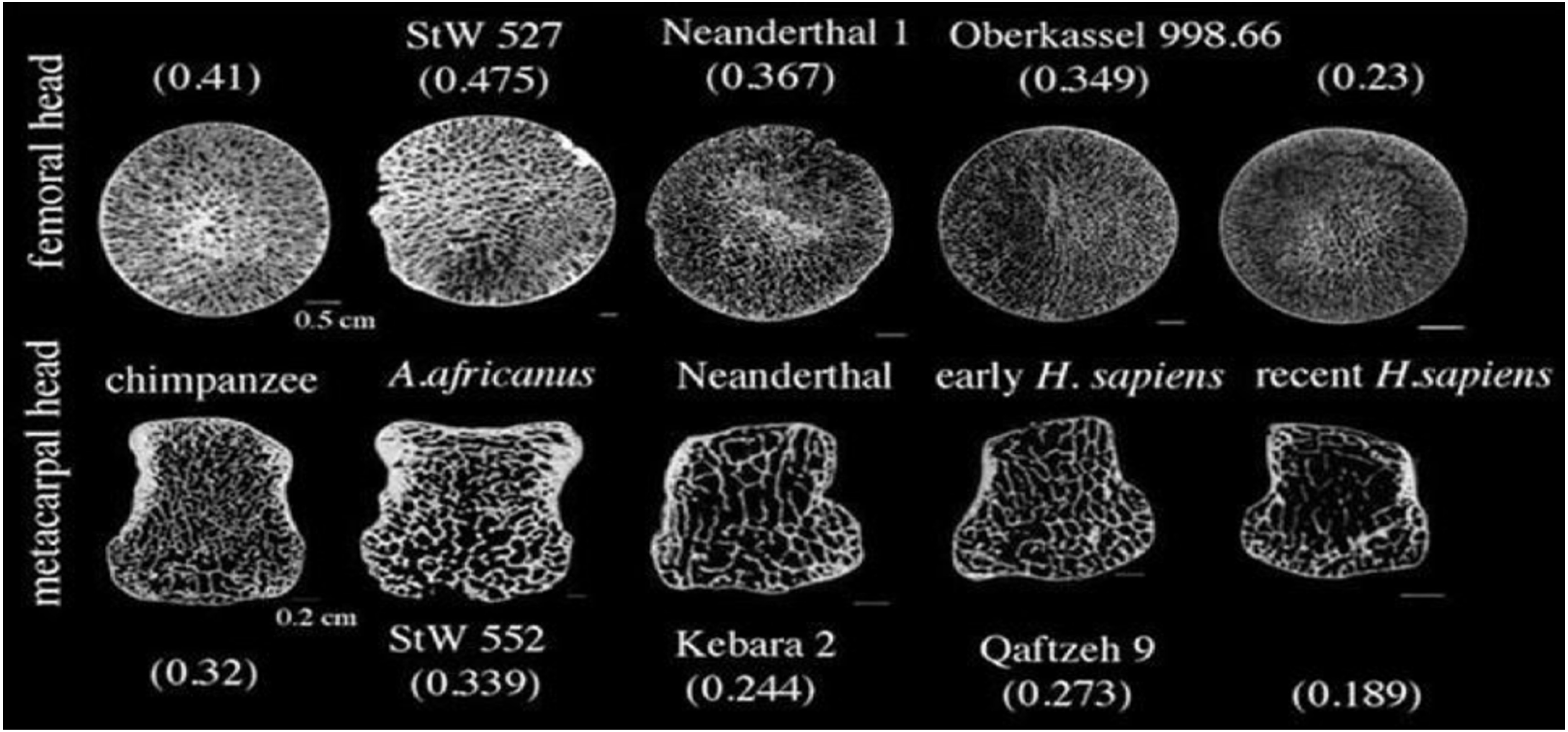
Ulnă dreaptă de om versus câine. Olecranul uman este mult mai mare, diafiza mult mai lungă, curbura este în sens invers

Adams B, Crabtree P (2008) Comparative skeletal anatomy: A photographic atlas for medical examiners, coroners, forensic anthropologist, and archaeologist. Humana Press, New York



Trabecular bone structure in the proximal femur of prehistoric populations of farmers (A) and hunters (B). Coronal microCT analysis with 3D reconstruction, revealing a much denser structure in hunters

Ryan TM, Shaw CN (2014) Gracility of the modern Homo sapiens skeleton is the result of decreased biomechanical loading. Proc Natl Acad Sci



Density of cancellous bone in different hominid species (Femoral head and metacarpal head). With the change in lifestyle (from hunter-gatherer to agricultural, sedentary) a decrease in the density of cancellous tissue and a more irregular distribution of it is observed.

Differentiating human and non-human teeth

- #dg - easy, most species that have teeth similar to human ones due to their size have different diets and implicitly different dental conformations.
- pig molars - relatively easily confused with human ones, as pigs have a diet extremely similar to ours.
  - differentiation - size (pig molars are larger) and the cusps (which in pigs are more obvious and somewhat sharper

Age determination

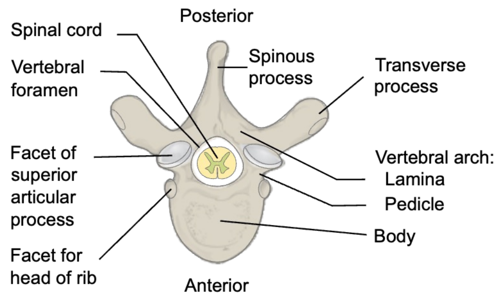
- Based on:
    - growth processes (infants, children, adolescents, young adults)
    - degenerative processes (adults)
- precision - variation inversely correlated to chronological age
- age determined on skeletal/dental pieces = bone age -> represents the estimated age at the time of death

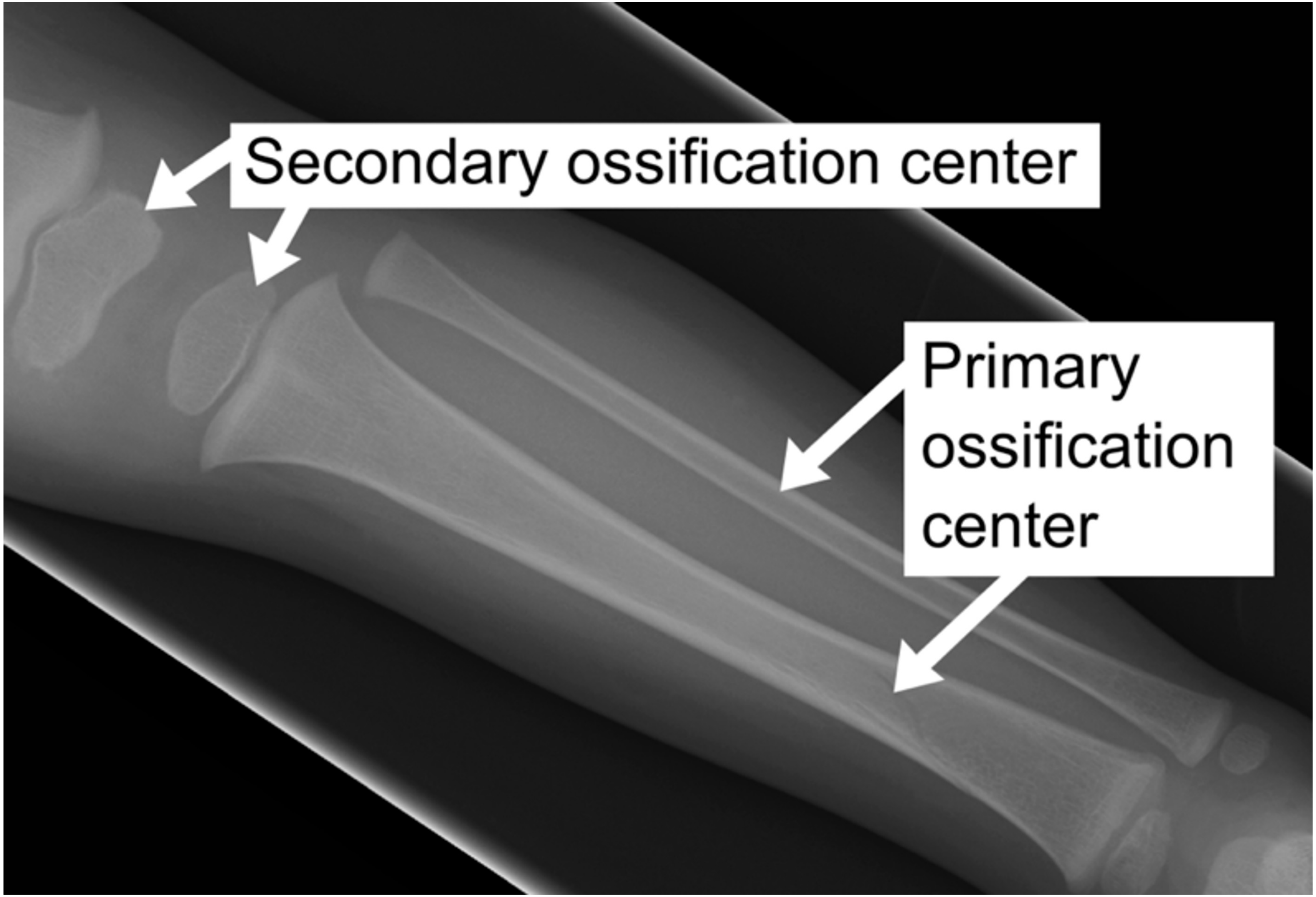
Before birtth

- ossification centers
- length of long bones
- the degree of mineralization of the enamel
- histological methods

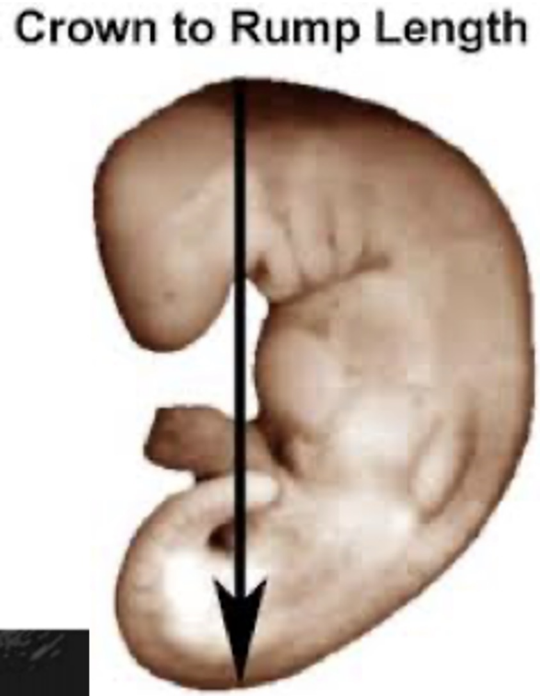
Ossification centers

- Mammalian bones develop from a variable number of ossification centers, which in humans begin to be individualized starting at W6iu (at the frontal, maxillary and mandibular levels)
- In W11iu, 806 ossification centers
- At birth - 450 => 206 bones in adult
- Types
  - PRIMARY
    - the first ossification centers that appear in a bone
    - usually occur antepartum
    - in bones formed by intramembranous dermal ossification there may be multiple
  - secondary
    - usually appear after birth
    - in long bones - usually epiphyseal
    - may be:
      - pressure - the end of long bones, forming articular surfaces
      - completion - small cortical centers that spread like putty on a surface (acetabulum, sternum)
      - traction - insertion of ligaments or muscles => small bone protrusions (transverse processes of the vertebrae)
      - atavic - atavic bone structures




Secondary ossification center
Primary ossification center

Estimation of fetal age based on long bone length



Stages:

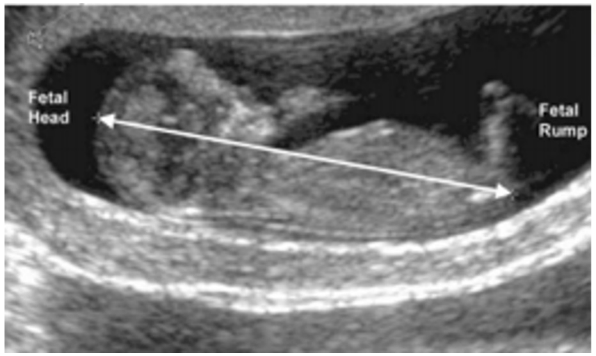
1. determining the probable length of the fetus
2. based on probable length - establishing VG

Uses:

1. regression equations

2. Probable fetal length - 2 parameters:

1. CRL (crown-rump length) = the distance between the top of the head and the bottom of the buttocks
2. CHL (crown-heel length) = the distance between the top of the head and the heel

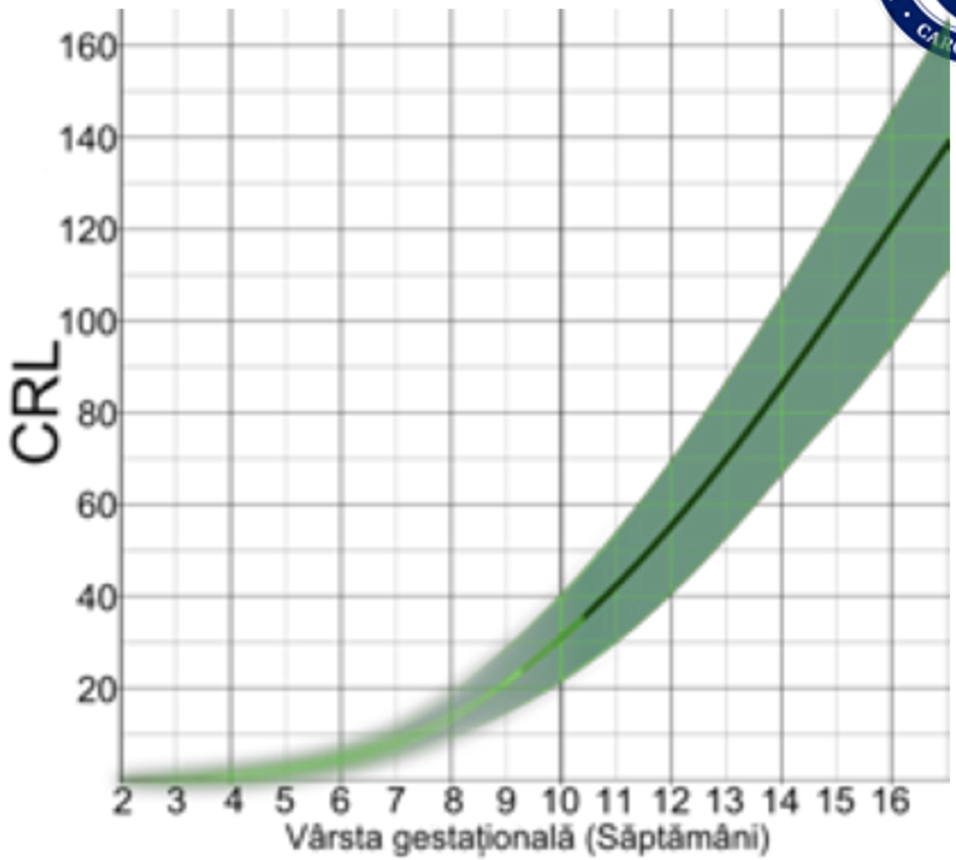


Regression equations

- CHL=5.188*Lfemur+90.935;
- CHL= 6,038*Tibia+82,858;
- CHL=6.896*Lfibula+79.677;
- CHL=6.839*Humerus+45.571;
- CHL=8.196*Lradius+47.886;
- CHL=7,193*Lunna+51,642

CRL - determined by ultrasound

- *VG=8.052*SQR(1.037*CRL)+23.73* ,
- VG=SQR(CHL), if CHL<25cm and
  VG=CHL/5, if CHL>25cm



Methods based on the degree of enamel mineralization

- X-Ray - detection of the degree of mineralization
- tables are used

Tooth	Initial Mineralization	Crown Completion	Root Completion
Maxilla			
Central Incisor	14 w (f)	1.5 y	1.5 y
Lateral Incisor	16 w (f)	2.5 y	2 y
Canine	17 w (f)	9 y	3.25 y
1st Molar	15.5 w (f)	6 y	2.5 y
2nd Molar	19 w (f)	11 y	3 y
Mandible			
Central Incisor	14 w (f)	2.5 y	1.5 y
Lateral Incisor	16 w (f)	3 y	1.5 y
Canine	17 w (f)	9 y	3.25 y
1st Molar	15.5 w (f)	5.5 y	2.5 y
2nd Molar	18 w (f)	10 y	3 y

Histological methods

- enamel formation in utero - secretion of specific proteins by ameloblasts
- subsequently - the proteins are mineralized;
- during the mineralization phase - ameloblasts produce enamel matrix at a rate of 4µm/day, and with a rhythmic variability of the calcification process at 4z -> Retzius lines = parallel, concentric bands
- prolonged stresses - interruption of mineralization
- the most important stress - birth => neonatal line

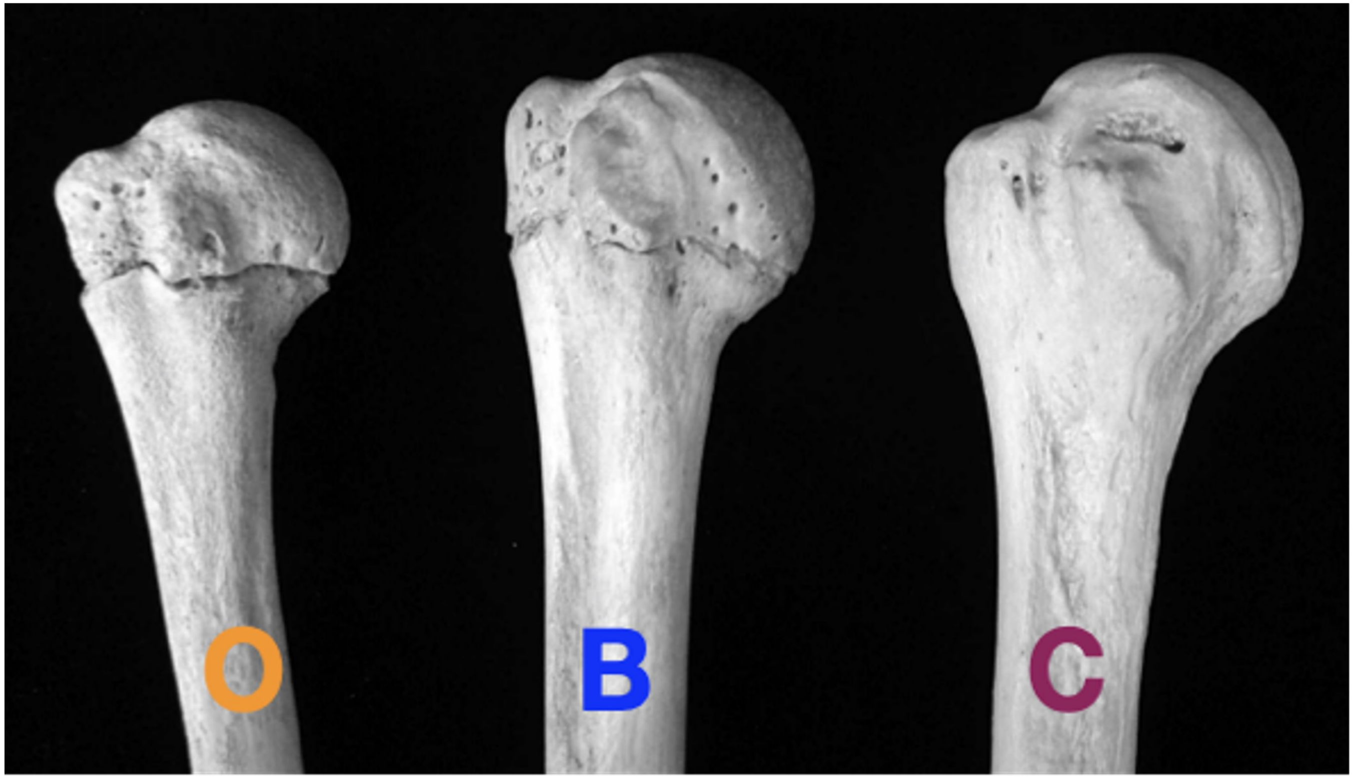
Anatomical Structure	Ossification Centers	If Absent (Max Age)	If Present (Min Age)
Scapula	Coracoid process	12 y	37 w (f)
	Acromion	16 y	10 y
Humerus	Humeral head	6 y	37 w (f)
	Greater tubercle	2.5 y	2 y
	Capitulum	2 y	1 y
	Medial epicondyle	8.5 y	2 y
	Lateral epicondyle	14 y	4 y
Ulna	Proximal	12 y	6 y
	Distal	10 y	2 y
Radius	Proximal	8 y	4 y
	Distal	2.5 y	4 y
Hand	Capitate	7 y	37 w (f)
	Hamate	10 y	38 w (f)
	Pisiform	5.5 y	3 y
	Scaphoid	8 y	2.5 y
	Lunate	7 y	1 y
	Trapezium	9 y	2 y
	Trapezoid	8.5 y	2.5 y
	Metacarpals 2–5 heads + base of 1st	4 y	8 y
	Middle + distal phalanges bases	5 y	8 y
	Proximal phalanges bases	3 y	5 y
Femur	Proximal	10 y	2 y
	Greater trochanter	4.5 y	1 y
	Distal	1 y	34 w (f)
Tibia	Proximal	2 y	34 w (f)
	Distal	10 y	4 y
Fibula	Proximal	5.5 y	1.5 y
	Distal	2.5 y	7 y
Foot	Cuboid	4 y	37 w (f)
	Lateral cuneiform	1.5 y	1 y
	Medial cuneiform	4 y	6 y
	Intermediate cuneiform	4.5 y	10 y
	Navicular	5.5 y	9 y
	Calcaneus	9.5 y	3.5 y
	Proximal + middle phalanges bases	4 y	5 y
	1st metatarsal base	1 y	1 y
	Metatarsals 2–5 heads	6.5 y	2 y

Subadults - dry ossification centers

- earlier onset in females
- extremely wide variability in the literature regarding the values identified, for reasons related to:
  - the particularities of the study groups
  - reporting method (for example, some studies report the date of first appearance of an ossification center, others - the date when 50%, 80% or 100% appear)
- useful in clinical forensic anthropology and on fresh cadavers, when imaging analyses can be performed;
- limited value on excavated, old pieces, many secondary ossification centers being lost in the process of recovering bone fragments

Union of the epiphyseal centers

- begins at 12-14 years old, earlier in girls
- Stages:
    - non-union (0 = no union) - obvious hiatus between the epiphysis and diaphysis, with a sawtooth appearance at the epiphyseal and diaphyseal margins; completely separated in skeletonized cadavers
    - initiation of union (B - beginning): line of separation evident on the outside, with loss of the sawtooth appearance and with the deposition of granular bone, de novo, between the tooth depressions
    - recent union (R - recent): a fine line of demarcation persists between D and E, slightly more reddish:
    - complete union (C - complete) - a fine line of demarcation may persist, the same color as the rest of the bone tissue

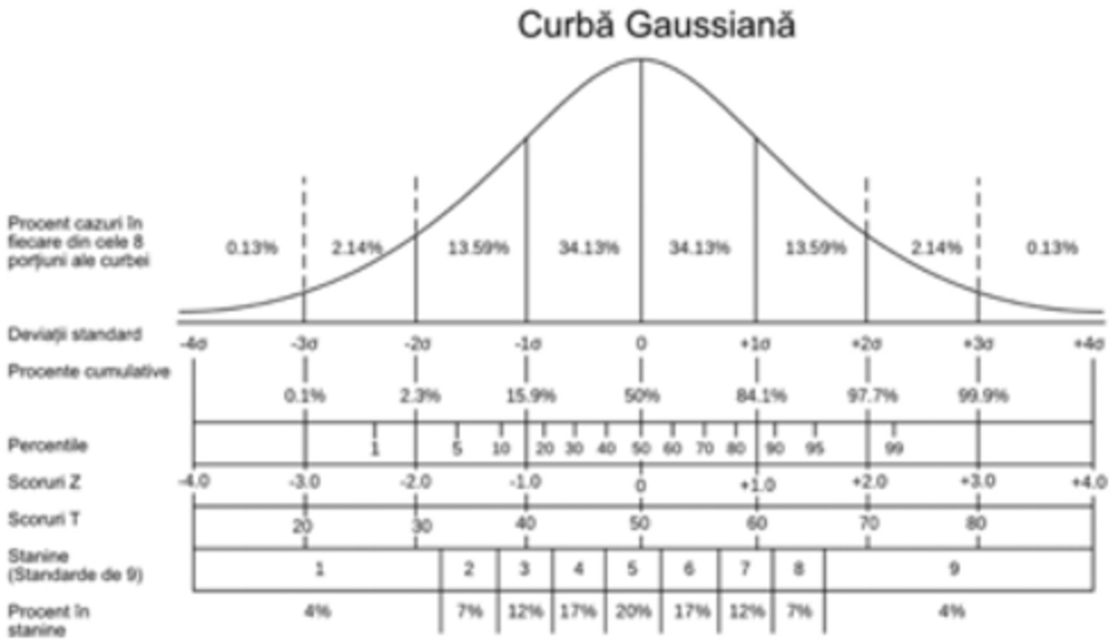

O
B
C


Reper osos
14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Scapulă coracoglenoid
Scapulă acromion
Scapula unghi inferior
Scapulă marginea medială
Humerus proximal
Humerus medial
Humerus distal
Radius proximal
Radius distal
Ulna Proximal
Ulna distal
Mână metacarpiene și falange
Pelvis complexul triradiat
Pelvis tuberozitate ischiadică
Pelvis creastă iliacă
Femur cap
NonUniune
Uniune parțială
Uniune completă

Photo and X-ray of femur. Proximal epiphysis = head and trochanter have begun to unite; Distal epiphysis - united, with a minimal union scar. Age -23 A (male)

Subadults - dental methods of age estimation

- dental development - extremely stable over time =>useful for age estimation.
- the occurrence of a tooth, or a dental characteristic, is not constant in the population => probabilistic estimation methods

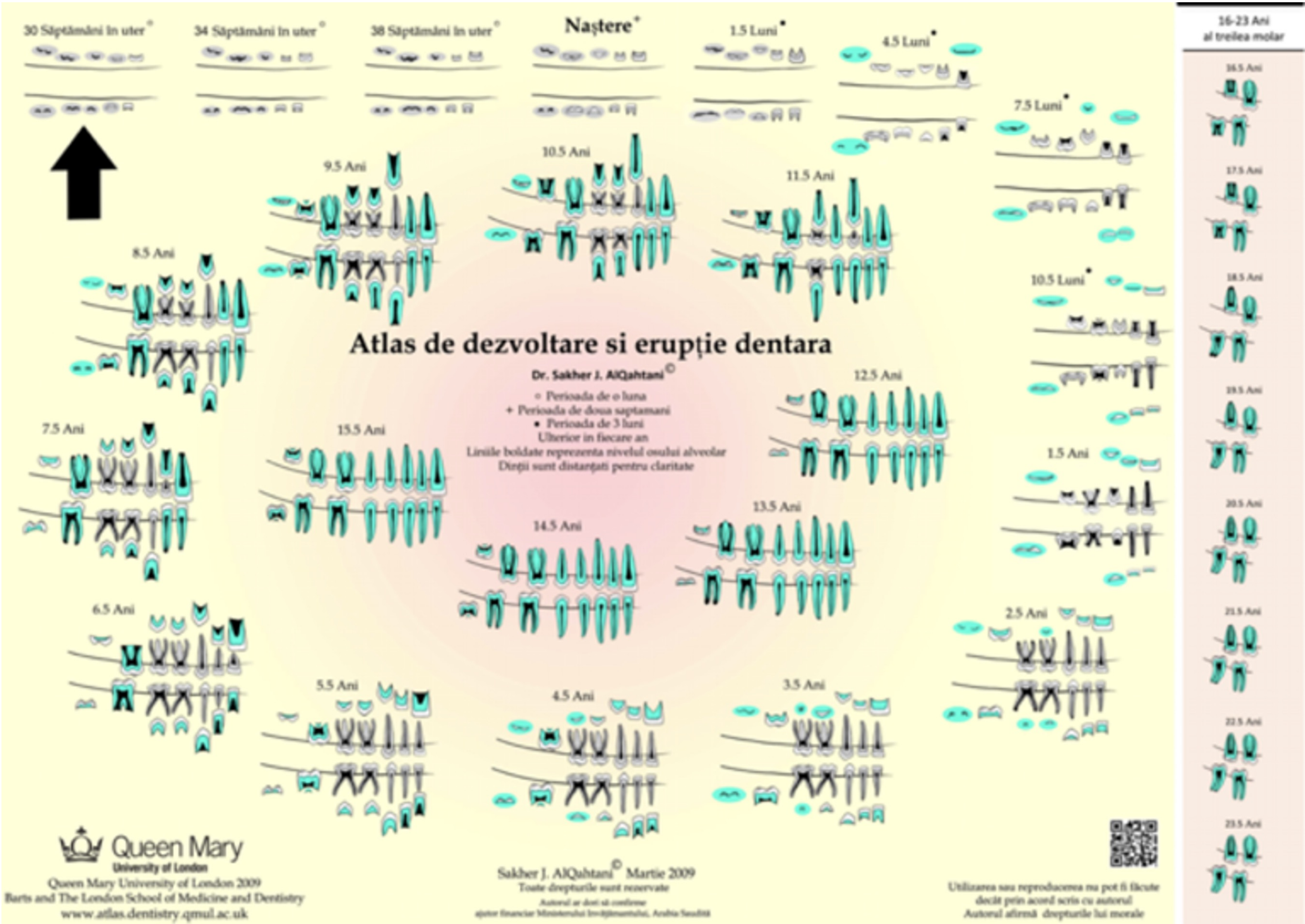


Factors that modulate dental growth and development

- genetics => 80% of total dental variability is inherited
- gender. The appearance of a certain dental characteristic occurs earlier in females, with an average difference of 0.3 years, but with a tendency to increase over time, reaching 1.7 years.
- nutrition, hygiene, education, income. The closer these parameters are to optimal, the closer dental growth and development is to ideal values.
- geographical differences - caused by genetic, racial, or environmental factors - difference of over 1 year
- temporal variations:
    - mineralization of the dental crown - no statistically significant differences are found between studies on historical populations and recent studies (stricter genetic control than in the case of bones)
    - tooth eruption has accelerated in recent decades, with differences of over 1 year being observed between different historical and current samples

Methods

- atlases (Ubelaker, AlQahtani)
- incremental assessment of dental development (Moorrees, Demirjian, Cameriere)



Atlas de dezvoltare si erupție dentara
Dr. Sakher J. AlQahtani©
○ Perioada de o luna
+ Perioada de doua saptamani
• Perioada de 3 luni
Ulterior in fiecare an
Liniile boldate repezenta nivelul osului alveolar
Dinții sunt distanțati pentru claritate
30 Săptămâni în uter
34 Săptămâni în uter
38 Săptămâni în uter
Naștere
1.5 Luni
4.5 Luni
7.5 Luni
10.5 Luni
1.5 Ani
2.5 Ani
3.5 Ani
4.5 Ani
5.5 Ani
6.5 Ani
7.5 Ani
8.5 Ani
9.5 Ani
10.5 Ani
11.5 Ani
12.5 Ani
13.5 Ani
14.5 Ani
15.5 Ani
16-23 Ani
al treilea molar
16.5 Ani
17.5 Ani
18.5 Ani
19.5 Ani
20.5 Ani
21.5 Ani
22.5 Ani
23.5 Ani
Queen Mary
University of London
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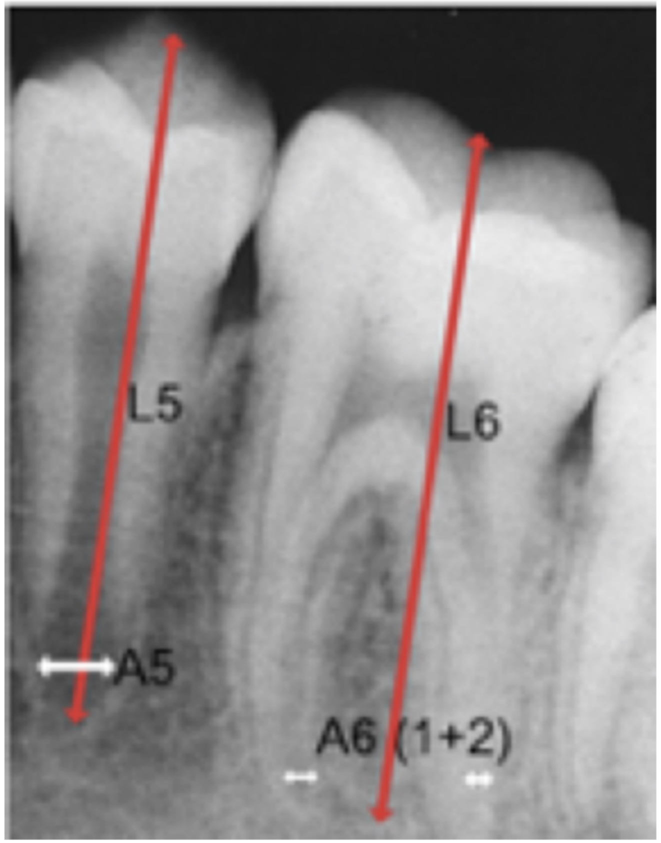
The Cameriere Method



Mandibular teeth - left hemiarch

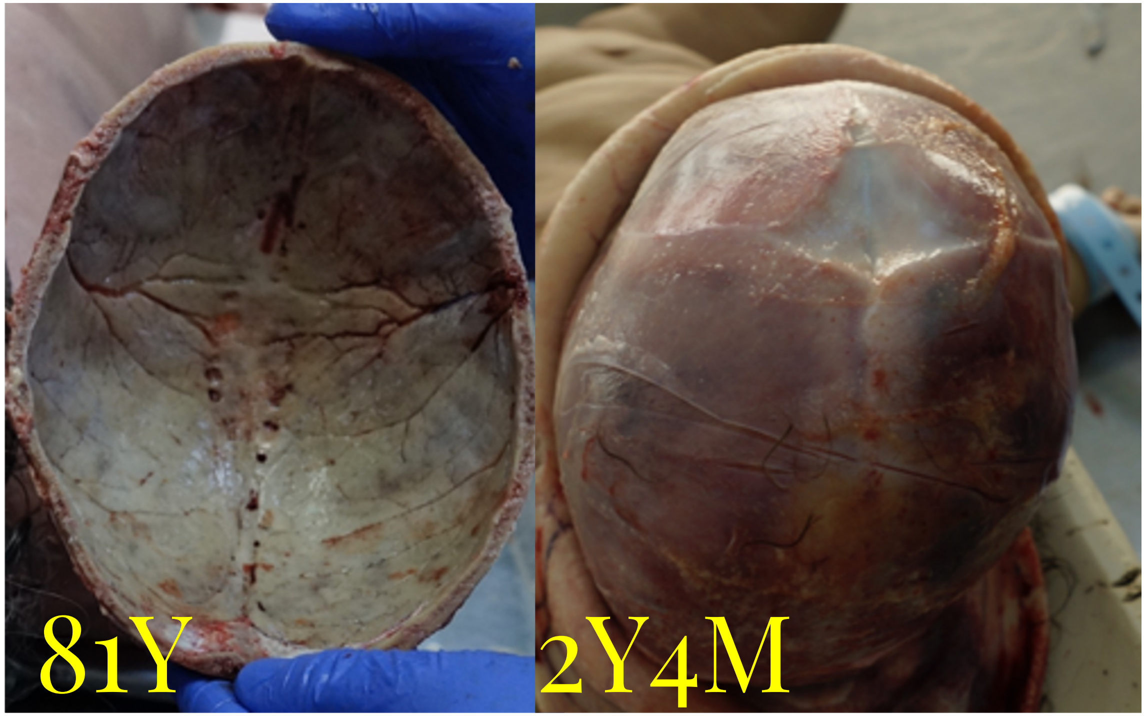
- The number of teeth with complete root development (closed root apex) is calculated: N0
- The distance between the internal portion of the root tips of monoradicular teeth (Ai, with i=1,2,3,4,5) is measured.
- For multi-rooted teeth, the sum of the distances between the internal portions of the root tips (Ai, with i=6.7) is calculated.
- Divide the obtained values by the length of the corresponding teeth (Li, with i=1,2,...,7), obtaining some normalized values (xi, with i=1,2,...,7)
- The normalized values of teeth with incomplete development (s) and the number of teeth (N0) with complete root development are added.
- The obtained values are entered into the equation $V=8.971+0.375g+1.631*x5+0.674*N0-1.034s-0.176*s*N0$,
- V= age (between 5 and 15 years old)
- s=sum obtained for teeth with incomplete root development (s1=sum(Xi))
- g=gender, with values 1 for boys and 0 for girls,
- x5=value corresponding to premolar 2

Adults, skeletal methods

- closure of cranial sutures. Although several methods have been developed, the association between suture closure and age appears to be quite weak
- morphology of the sternal end of the ribs
- morphology of the auricular surface of the ileum
- morphology of the pubic symphysis
- bone microstructure analysis
- the “complex” method, which includes analysis of trabecular bone loss at the femoral and humeral heads, either radiologically or by bone sectioning and direct morphological analysis. Often used in Europe

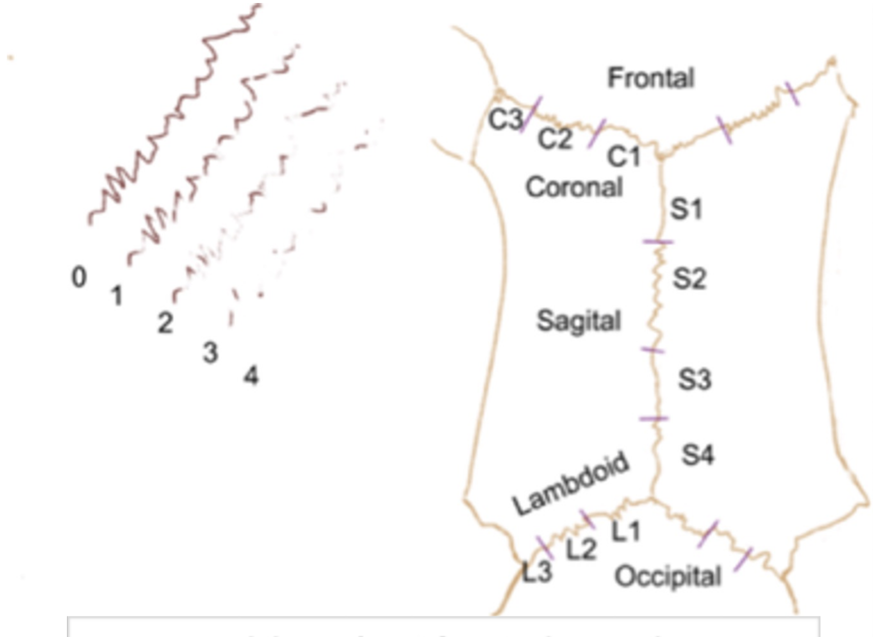
Cranial sutures

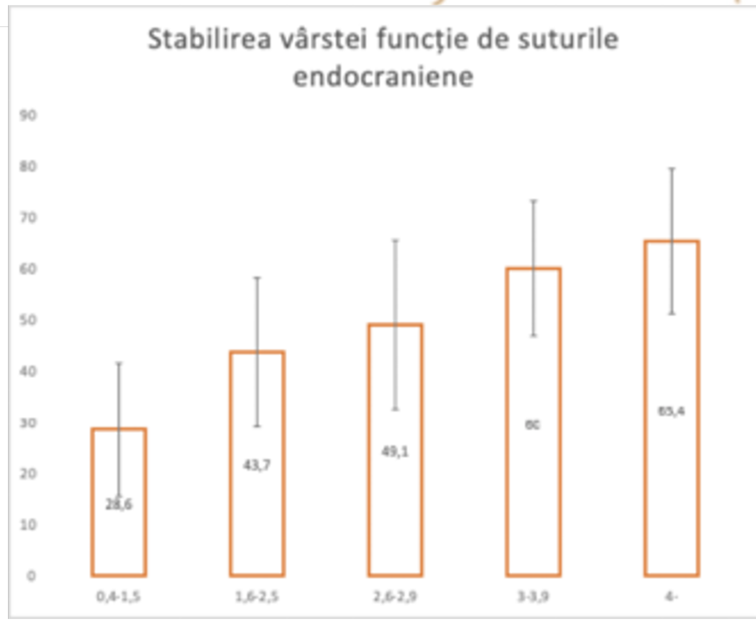
- relatively large errors
- age can be estimated based on endocranial, ectocranial, or palatal sutures



Acsadi and Nemeskeri method (endocranial sutures)

- Identification of the sagittal (divided into 4 zones), coronal (divided into 3 zones on each hemicranium), and lambdoid (in 3 zones on each hemicranium) sutures
- Quantification of the degree of closure of the sutures, quantified in 5 degrees, respectively:
    - 0 – completely open suture;
    - 1 – closed suture, but clearly visible in the form of an irregular line;
    - 2 – the suture line is thinner, with islands where it is completely closed;
    - 3 – the suture is completely closed, but traces of the suture line can still be identified in the form of small indentations;
    - 4 – the suture is completely obliterated
- The arithmetic average of the degree of closure of the sutures is taken, on all the sutures analyzed, after which the age is estimated based on the data in the graph.





Dental methods of age estimation in adults

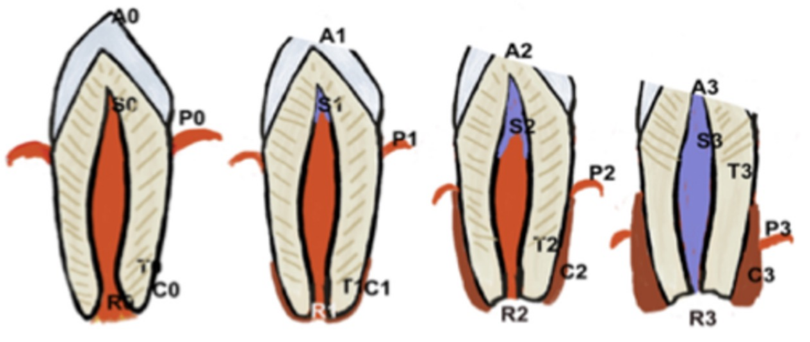
- Gustafson method
- The Lamendin Method
- Prince & Ubelaker method

Gustafson method

- historical interest
- relatively large errors
- is the basis of most current methods
- Steps:
  - a microscopic preparation is made (a cross-section through a tooth
  - the scores are calculated according to the table above
  - the total score is calculated $ST=An+Pn+Sn+Cn+Rn+Tn$, where $n\{0,1,2,3\}$
- Age estimation is based on the regression equation: $V(years)=11.43+4.56*ST$, with a standard error of 3.63

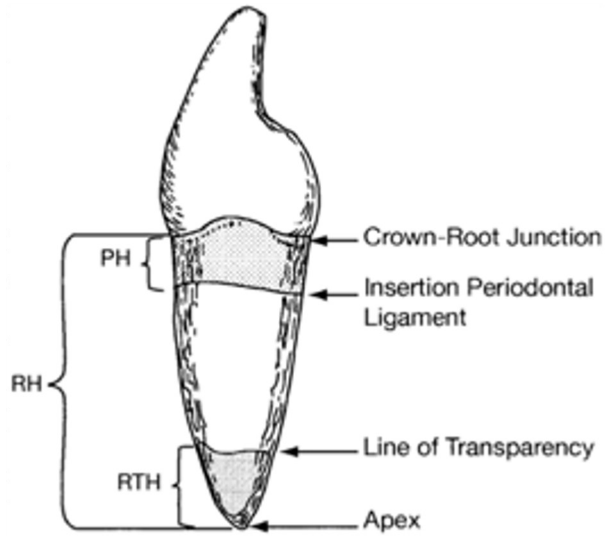
Gustafson

Parameter	Scale
Attrition	A0 – no attrition A1 – attrition involving enamel A2 – attrition involving enamel and dentin A3 – attrition involving enamel, dentin, and pulp chamber
Periodontosis	P0 – no periodontosis P1 – initial periodontosis P2 – periodontosis along the first third of the root P3 – periodontosis beyond two thirds of the root
Secondary Dentin	S0 – no secondary dentin S1 – secondary dentin forms at upper pulp cavity S2 – pulp cavity reduced by half S3 – attrition reaches pulp cavity
Cement Apposition	C0 – no cement apposition C1 – slightly above normal C2 – moderate cement apposition C3 – significant cement apposition
Root Resorption	R0 – no root resorption R1 – resorption as small irregular points R2 – greater substance loss R3 – large areas of cement and dentin affected
Root Transparency	T0 – undetectable T1 – detectable transparency T2 – transparency up to apical third T3 – transparency up to apical two thirds



The Lamendin Method

- uses only two parameters out of the six previously presented, namely root transparency and periodontitis, at the level of a single tooth (incisor, canine, premolar).
  - Periodontitis: P=height of periodontitis*100/root height,
  - Root transparency: T=degree of root transparency*100/root height.
- the two variables are then entered into the calculation formula V(years)=0.18*P+0.42T+25.53.
- error of +/10 years, being greater at young ages (under 40) and older ages (over 80).



Prince & Ubelaker method

- derived according to the Lamendin method,
- introduced an additional parameter - root height (RH)
- they created distinct equations depending on gender and race (Caucasian/African), the formulas obtained being:

Caucasian, female: $V=1.1*RH+0.31*P+0.39*T+11.82$

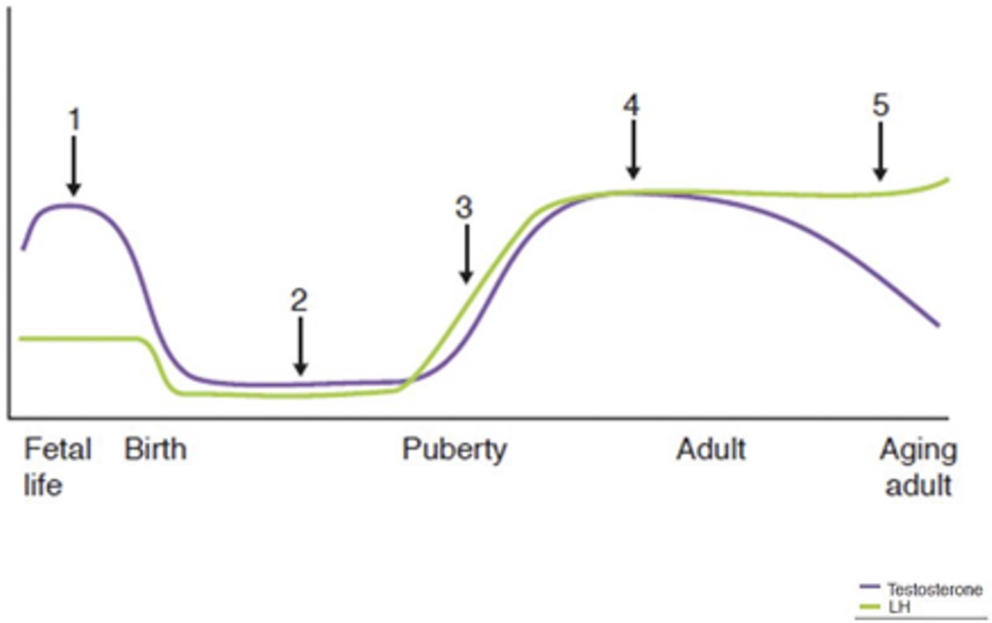
Caucasian, male: $V=0.15*RH+0.29*P+0.39*T+23.17$

African, female: $V=1.63*RH+0.48*P+0.48*T-8.41$

African, male: $V=1.04*RH+0.31*P+0.47*T+1.7$

Sex estimation on skeletal and dental parameters

Age-related changes in LH and testosterone secretion in the normal male



Intrauterine - Minimal sexual dimorphism

Childhood - attenuation of antepartum sexual dimorphism

Adolescent/Adult - intense sexual dimorphism

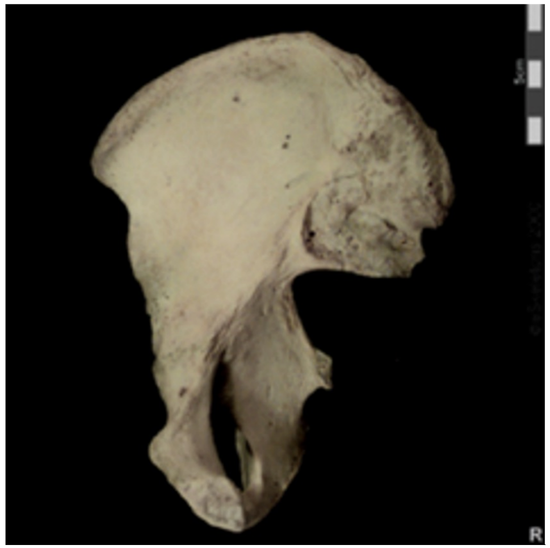
Elderly - attenuation of sexual dimorphism

Methods

- anthropometric (identification based on measurements
- anthroposcopic (visual identification)
- computerized methods

Pelvic morphology

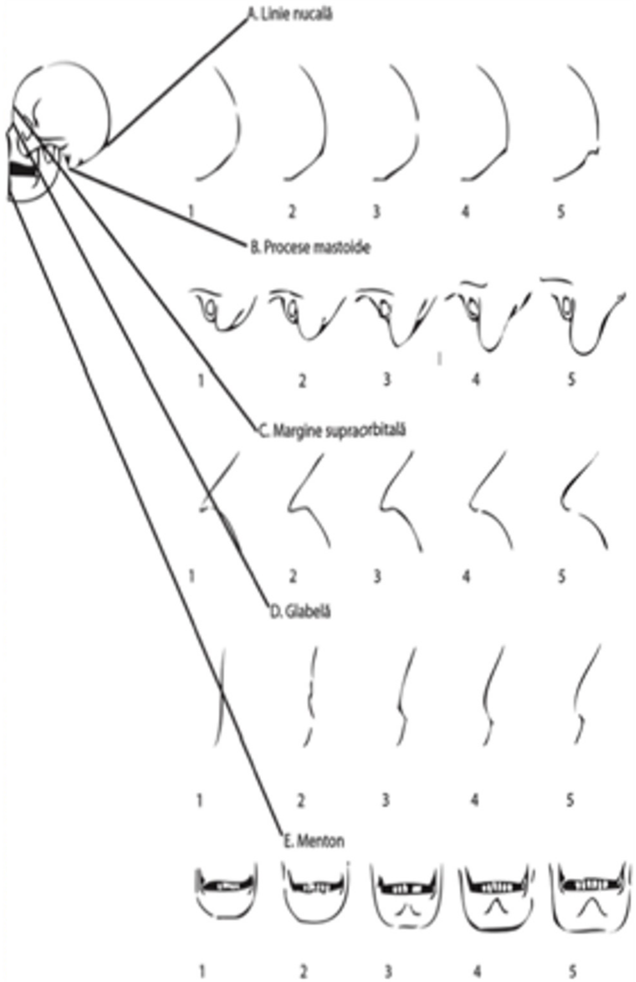
- the most dysmorphic bone
- useful items:
    - pubic length
    - ischial length
    - total height
    - iliac width
    - width of the greater sciatic notch
    - depth of the greater sciatic notch
    - acetabular diameter
- discriminant functions - accuracy >90%
- most persons - intermediate characteristics between the sexes



Characteristic	Male	Female
General appearance	Narrow, tall, prominent bony insertions	Short, wide, gracile, less prominent bony insertions
Shape	Oval, longitudinal, or heart-shaped	Oval, transverse
Pubic symphysis	Located higher	Located lower
Subpubic angle	Under 90° (V-shaped)	Over 90° (U-shaped)
Subpubic shape	Convex	Concave
Ventral arch	Absent or poorly defined	Well defined
Obturator foramen	Large, ovoid	Small, triangular
Acetabulum	Large, laterally oriented	Smaller, anterolaterally oriented
Greater sciatic notch	Narrow, deep	Wide, more superficial
Ischiopubic ramus	Slight eversion	Clear eversion
Sacroiliac articulation	Wide	Small, oblique
Auricular surface	Raised	Flattened
Postauricular surface	Narrow	Wide
Preauricular sulcus	Rare	Frequent, well defined
Postauricular sulcus	Rare	More frequent, sharper at auricular margin
Iliac tuberosity	Wide	Small/absent
Sacrum	Longer, narrower, uniformly curved, often 5+ segments	Shorter, wider, accentuated curves S1–S2, S2–S5; usually 5 vertebrae

Cranial dimorphism

- increases during puberty
- diminishes in old age
- max. utility - 20-55 years
- the most dysmorphic:
    - robustness of the nuchal crest
    - size of the mastoid process
    - sharpness of the supraorbital rim
    - glabella prominence
    - projection of the mental eminence
- discriminant functions - up to 90% accuracy



Characteristic	Male	Female
Size	Large	Small
Cranial volume	Larger (~200 ml more)	Smaller
Architecture	Robust	Smooth
Supraorbital margins	Medium–large	Medium–small
Occipital area	Marked muscle lines and occipital protuberance; occipital squama thicker than frontal	Less evident muscle lines/protuberance; occipital squama thinner than frontal
Mastoid process	Medium–large, supports skull, prevents rolling on flat plane	Medium–small, does not support skull, tends to roll on flat plane
Glabella & supraorbital ridges	Exceed nasal root plane	Do not exceed nasal root plane
Frontal eminences	Small	Large
Parietal eminences	Small	Large
Vertex	Rounded, protruding	Flattened
Orbits	Rectangular, lower, relatively small, rounded edges	Rounded, higher, larger, sharper edges
Forehead	More vertical	Rounded, infantile aspect
Zygomatic arch	Thicker, more laterally arched	Thinner, less arched
Mandible	Larger, higher symphysis, wider ascending ramus, V-shaped	Smaller body and ramus, U-shaped
Chin (menton)	Square	Rounded-oval
Palate	Wide, U-shaped	Narrow, parabolic
Nasal aperture	Higher, narrower, sharper margins, larger nasal bones, pronounced nasal spine	Wider, lower, rounder margins, smaller nasal bones, less pronounced nasal spine
Occipital condyles	Large	Small
Teeth	Larger, molars often 5 cusps	Smaller, molars often 4 cusps
Cranial base foramina	Larger dimensions	Smaller dimensions

Odontostomatological methods

- sexual dimorphism of teeth - extremely variable
- there are statistically significant differences, but they are small -> sex id based on dentition useful in population studies not for identification
- permanent dentition - maximum sexual dysmorphism - canines - #average length =3-9%
- temporary dentition - maximum sexual dysmorphism - incisors, then molars
- parameters with max utility:
  - buccolingual dist, d_{max} (coronal labial surface; coronal lingual surface)
  - mesiodistal dist = the distance between two parallel lines, perpendicular to the axial, mesiodistal plane, of the tooth
- weight of canines m>f by about 2g (16 v 14g)
- anthropometric:
  - aplasia/hypoplasia of the maxillary lateral incisor - more common in females
  - hyperodontia, mesiodontia, gemination of central incisors, three or four premolars or two lateral incisors - more frequently in males

Black Method

- sex determination based on deciduous dentition
- methodology
    - measurement of buccolingual and mesiodistal

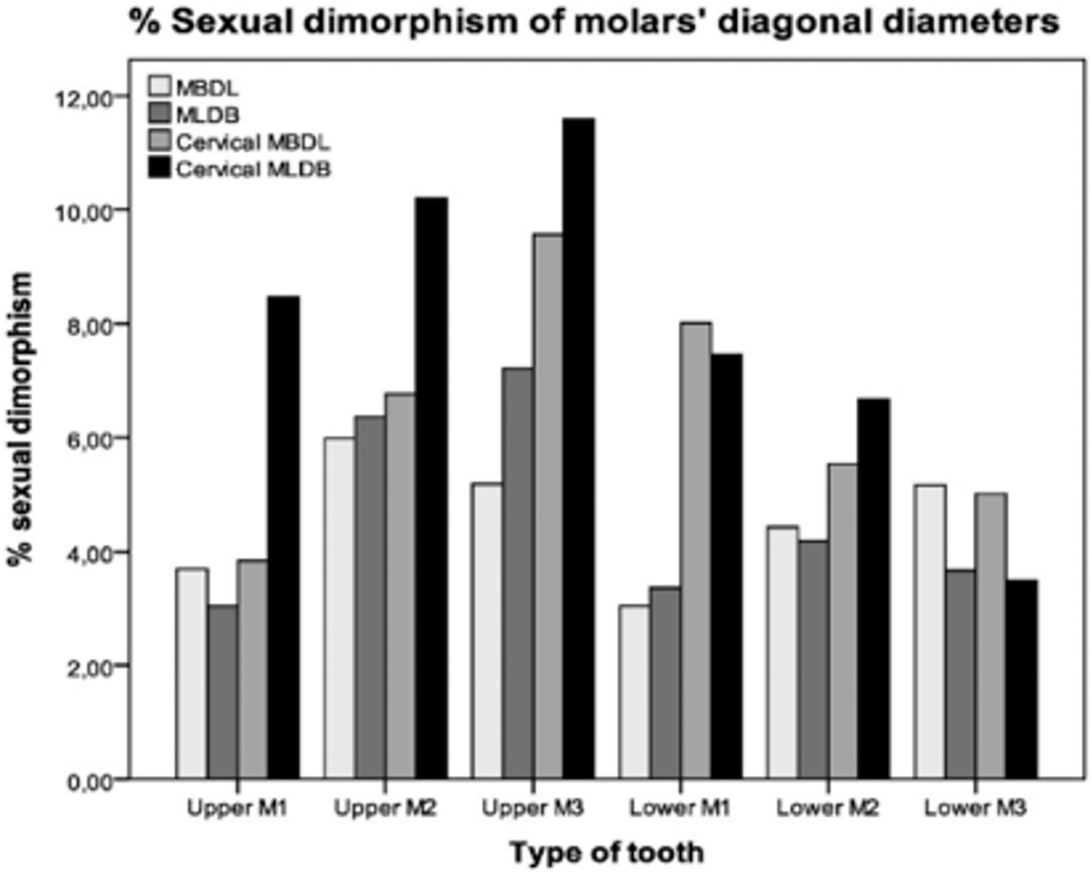
Discriminant functions for sexing the deciduous dentition [1]

Functions	Percent correctly classified		
	Male	Female	Total
1. Function using the maxillary teeth alone: $-2.91 + 1.512(m^1\ b\text{-}1) - 1.585(i^1\ m\text{-}d)$	69.6	57.8	63.9
2. Functions using the mandibular teeth alone: $-8.66 + 1.792(m_2\ b\text{-}1) - 1.528(i_2\ m\text{-}d)$	69.6	62.5	66.2
3. Function using mesiodistal measurements alone: $-7.64 + 1.096(m_2\ m\text{-}d) - 1.976(i^1\ m\text{-}d) + 1.439\ (\text{max. } c\ m\text{-}d)$	68.1	68.8	68.4
4. Function using buccolingual measurements alone: $-11.10 + 2.192(m^1\ b\text{-}1) - 1.924(m_1\ b\text{-}1) + 1.311(m_2\ b\text{-}1) - 1.042(i^1\ b\text{-}1)$	66.7	62.5	64.7
5. Function using mesiodistal and buccolingual measurements of the maxillary and mandibular teeth: $-8.18 + 2.343(m^1\ b\text{-}1) - 2.192(i^1\ m\text{-}d) + 2.046(m_2\ b\text{-}1) - 2.187(m_1\ b\text{-}1)$	72.5	62.5	67.7

The Zorba Method

- uses the upper (UM) and lower (LM) permanent molars, the following parameters being quantified:
  - coronal mesiobuccal-distolingual diameter (MBDL)
  - mesiolingual-distobuccal diameter (MLDB)
  - cervical mesiobuccal-distolingual diameter (cervical MBDL)
  - cervical mesiolingual-distobuccal diameter (cervical MLDB)
- 9 discriminant functions were constructed, the most useful being:
  - F3 = −46.849 + 0.650LM1cervicalMLDB+ 1.002LM2cervicalMLDB + 1.252LM1MBDL+0.837LM1cervicalMLDB + 0.712LM2 MBDL
  - accuracy 88.4%

Steps and variables entered[b]	Wilks' lambda statistic	Exact *F* statistic	d.f. 1	d.f. 2	Sig.
Function 1: all diagonal diameters[c]					
LM1 cervical MBDL	0.722	15.390	1	40.000	0.000
UM2 cervical MLDB	0.586	13.782	2	39.000	0.000
LM2 cervical MLDB	0.468	14.424	3	38.000	0.000
LM1 MBDL	0.414	13.099	4	37.000	0.000
LM1 MLDB	0.368	12.382	5	36.000	0.000
UM1 cervical MLDB	0.311	12.911	6	35.000	0.000
Function 2: maxillary diagonal diameters					
UM1 cervical MLDB	0.784	17.167	1	51.000	0.000
UM2 cervical MLDB	0.665	12.602	2	50.000	0.000
Function 3: mandibular diagonal diameters					
LM1 cervical MBDL	0.722	15.390	1	40.000	0.000
LM2 cervical MLDB	0.604	12.802	2	39.000	0.000
LM1 MBDL	0.483	13.582	3	38.000	0.000
LM1 cervical MLDB	0.417	12.946	4	37.000	0.000
LM2 MBDL	0.359	12.858	5	36.000	0.000
Function 4: all crown diagonal diameters					
LM2 MLDB	0.835	8.869[†]	1	45.000	0.005
LM1 MBDL	0.656	11.526	2	44.000	0.000
UM1 MBDL	0.600	9.565	3	43.000	0.000
LM1 MLDB	0.549	8.631	4	42.000	0.000
Function 5: maxillary crown diagonal diameters					
UM1 MBDL	0.852	9.385[†]	1	54.000	0.003
UM2 MLDB	0.760	8.370	2	53.000	0.001
Function 6: mandibular crown diagonal diameters					
LM2 MLDB	0.835	8.869[†]	1	45.000	0.005
LM1 MBDL	0.656	11.526	2	44.000	0.000
Function 7: all cervical diagonal diameters					
LM1 cervical MBDL	0.722	15.390	1	40.000	0.000
UM2 cervical MLDB	0.586	13.782	2	39.000	0.000
LM2 cervical MLDB	0.468	14.424	3	38.000	0.000
UM1 cervical MLDB	0.418	12.858	4	37.000	0.000
Function 8: maxillary cervical diagonal diameters					
UM1 cervical MLDB	0.748	17.167	1	51.000	0.000
UM2 cervical MLDB	0.665	12.602	2	50.000	0.000
Function 9: mandibular cervical diagonal diameters					
LM1 cervical MBDL	0.722	15.390	1	40.000	0.000
LM2 cervical MLDB	0.604	12.802	2	39.000	0.000
LM1 cervical MLDB	0.490	13.175	3	38.000	0.000



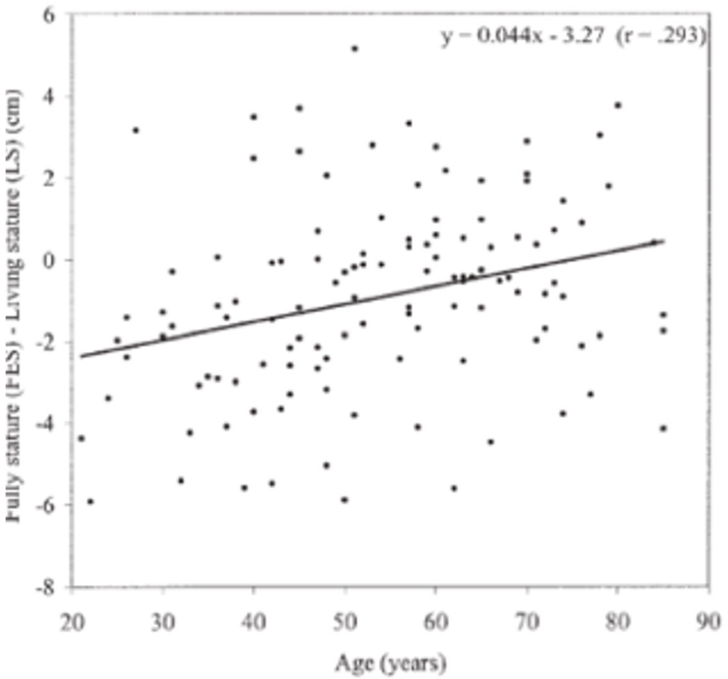
Establishing the height of the individual

Methods:

- measurements of some bones (usually long bones) and the use of the obtained values in regression equations
- measurement of all skeletal elements, in anatomical position; the height obtained will then be multiplied by a coefficient that takes into account the presence of soft tissues and (ideally) the degree of shrinkage of long bones with increasing postmortem interval

The Raxter Method

- calculating the total skeletal height (IST), by adding the basion-bregma length, the spine between C2 and L5, the anterior height of the first sacral segment, the physiological length of the femur and tibia (without the tibial spine but with the medial malleolus) and the talo-calcaneal height.
- entering the obtained value into one of the obtained regression equations, namely:
  - Hreal=11.7+0.996*IST (r=0.952) or
  - Hreal=1.009*IST-0.0426*age+12.1 (r=0.956)



Regression equations based on long bone length

- H = 3.0379*Humerus+736m45+/-40.3mm;
- H = 2.3633*Femur (max)+634.56+/-33 and
- H = 2.5712*Tibia (max)+751.85+/-33.9

(Ross&Konigsberg study, Eastern European Caucasians)

Height estimation based on cranial measurements

- Correlations can be established between height and circumference or other cranial parameters.
- standard errors - larger than in long bones
- useful when isolated skulls are found.
- As a guideline, the circumference of the skull is about one third of the body height in average-sized people.

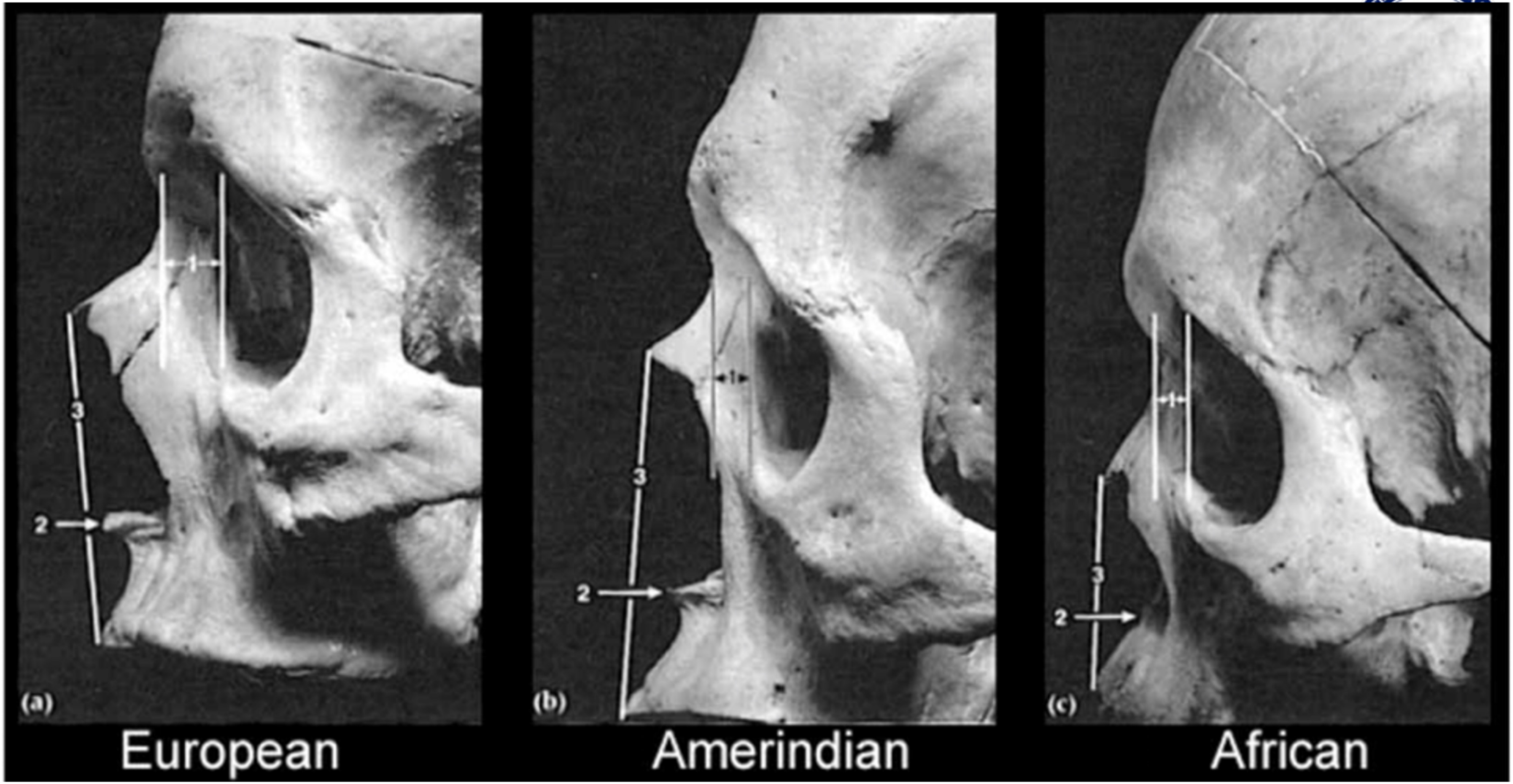
  Chiba and Terazawa equations

  - $H=1.51$ (cranial diameter+cranial circumference)$+59.4+/-6.81$ for males
  - $H=1.41^{*}$cranial circumference$+82.2+/-5.89$ for females and
  - $H=2.02^{*}$(cranial diameter+cranial circumference)$+22+/-7.28$ for both sexes

What is the racial origin?

- the notion of race - extremely debatable today due to the increased interracial mix
- the differences presented are the extreme ones, the averages being much less intense
- the characteristics classically used to establish the race origin are nowadays more important for facial reconstruction than race identification

Characteristic	East-Asian	Amerindian	Caucasian	Polynesian	African
Cranial shape	Broad	Medium-broad	Medium	Extremely variable	Elongated
Sagittal contour	Flat, globular	Medium, low, frontal slope	High, rounded	Medium	Extremely variable, deep post-bregmatic depression
Cranial sutures	Complex	Complex	Simple	Complex	Simple
Nasal bone shape	Medium	Medium/large	Narrow	Medium	Broad
Nasal root shape	Small	Medium/large	Large	Medium	Medium/small
Nasal root form	Flat	Medium, tent-shaped	High, bell-shaped	Medium	Low
Nasal profile	Concave	Concavo-convex	Straight	Concave/concavo-convex	Straight/concave
Interorbital projection	Very low	Low	High, prominent	Low	Low
Nasal spine	Medium	Medium, angular	Sharp	Variable	Reduced
Incisor form	Shovel-shaped	Shovel-shaped	Lamellar	Shovel/lamellar	Lamellar
Facial prognathism	Moderate	Moderate	Reduced	Moderate	Extreme
Alveolar prognathism	Moderate	Moderate	Reduced	Moderate	Extreme
Malar complex form	Projected	Projected	Reduced	Projected	Reduced
Zygomatico-maxillary suture	Angular	Angular	Curved	Curved/angular	Curved/angular
Palatal form	Parabolic/elliptic	Elliptic/parabolic	Parabolic	Parabolic	Hyperbolic/parabolic
Palatine suture	Straight/irregular	Straight	Irregular	Variable	Straight/irregular
Orbit shape	Broad	Broad	Rhomboid	Rhomboid	Rounded
Mastoid process shape	Broad	Broad	Narrow, sharp	Broad	Oblique, posterior tubercle
Mandible	Robust	Robust	Medium, scooped under incisors	Robust, curved	Gracile, oblique gonial angle
Chin projection	Moderate	Moderate	Prominent	Moderate	Reduced


(a)
European
(b)
Amerindian
(c)
African
1
2
3

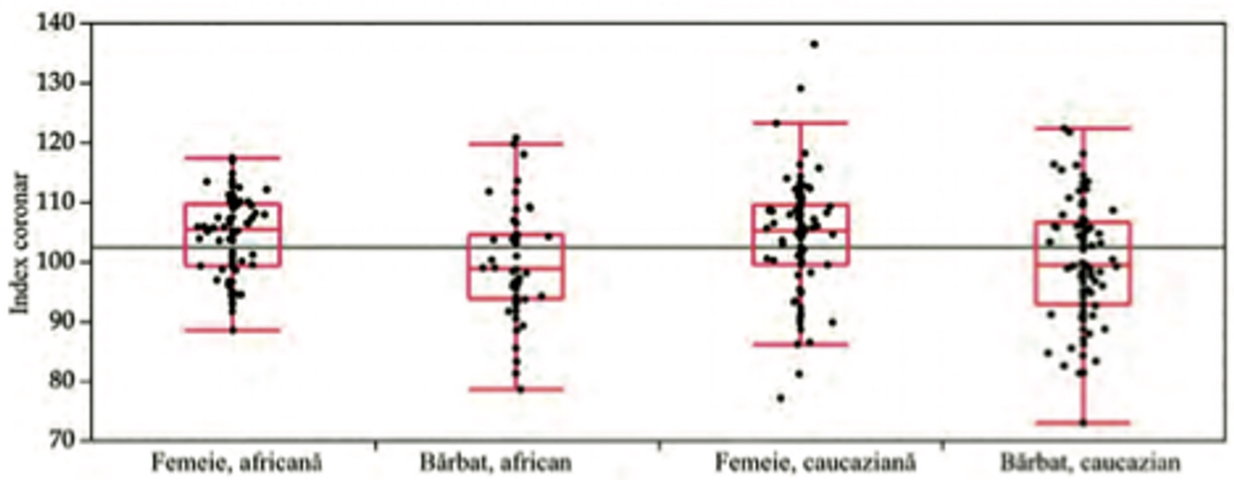
Amerindieni - formă eliptică

Africani - formă hiperbolică

Caucazieni - formă parabolică

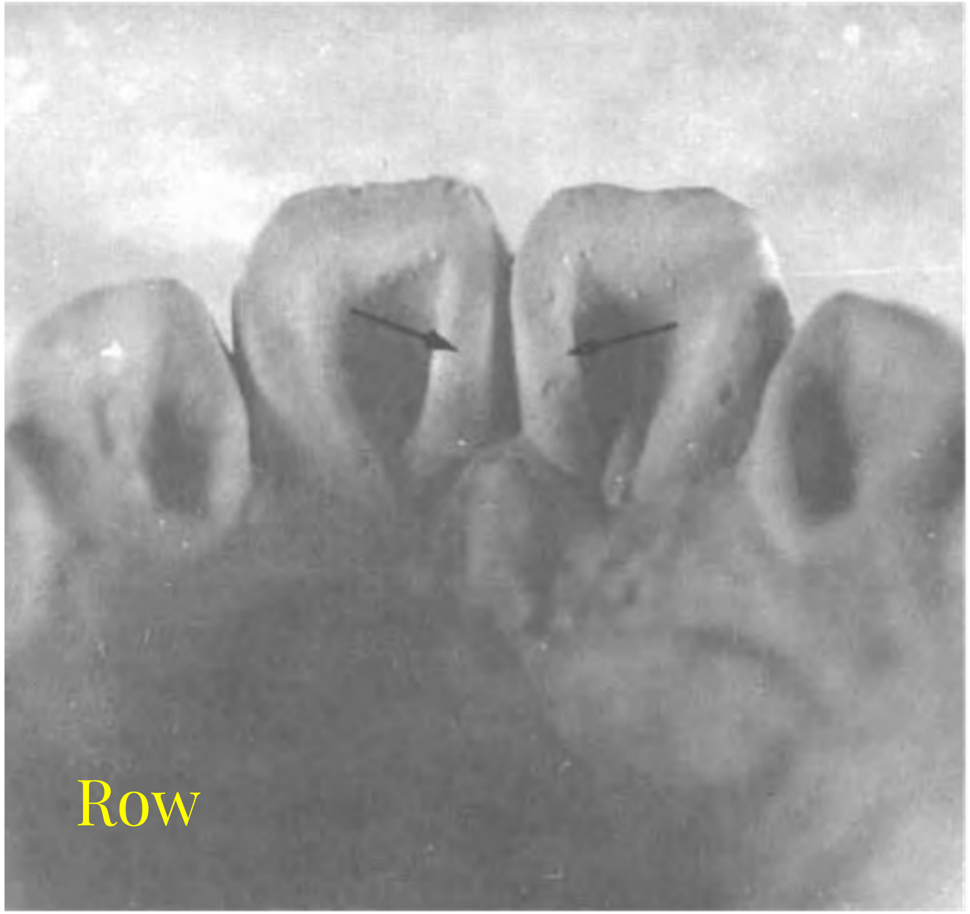
Determining breed based on dental characteristics

- anthropometric - the shape and size of the teeth based on the coronal index.
    - Africans - wider teeth (the bucolingual diameter is much larger than the mesiodistal diameter), especially at the level of the lower 2 molars, followed by the upper canines
    - anterior teeth - buccal-labial diameter larger in sub-Saharan Africans than in Europeans
    - posterior teeth - larger buccal-labial diameter in Europeans



Canine dimorphism (breed, sex)

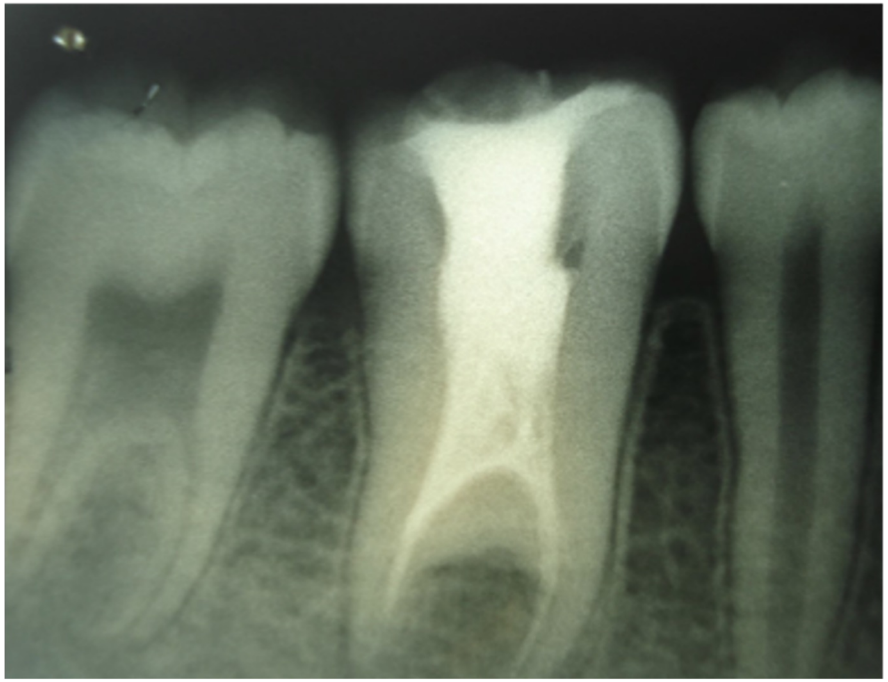
shovel-shaped/double shovel teeth —> Mongoloid, Amerindian, Eskimo

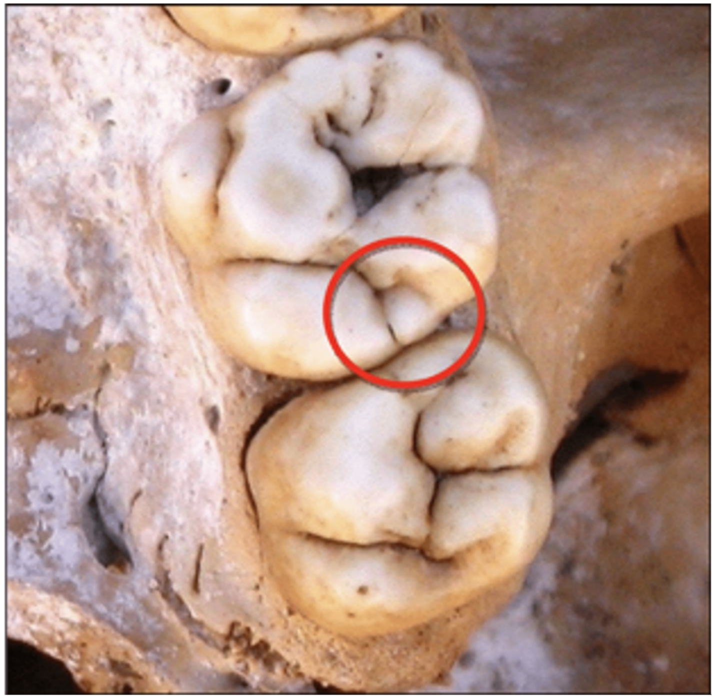


Dens evaginatus, canin inferior stânga, decidual. Mai frecvent - mongoloizi

Cută deflectată, Molar 2 inferior dreapta, decidual Mai frecvent - mongoloizi

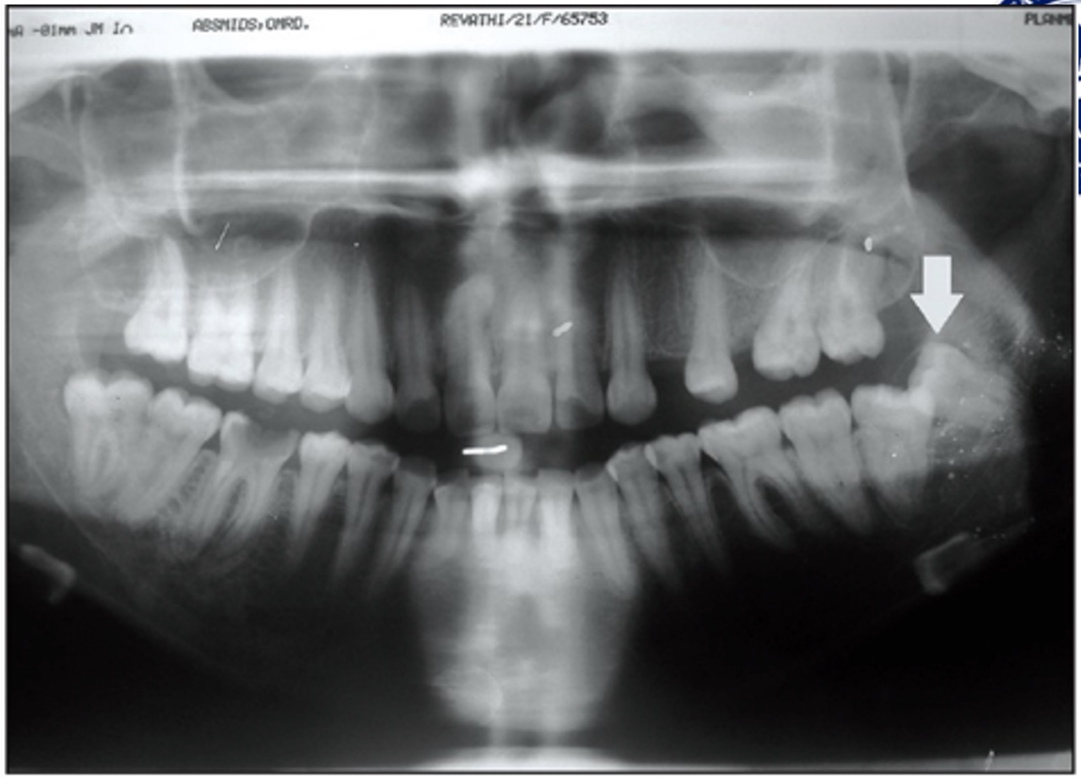
Cuspidă 7, molar 2 inferior dreapta, decidual Mai frecvent - mongoloizi





Taurodontism (left), upper 2nd molar metacone (right) - both more common in Mongoloids

Carabelli's cusp, more common in Europeans



Molar 4. More common in some African populations

Facial reconstruction

It can be:

- manual
- computerized

steps

1. skull analysis:
    - demographic data,
    - unique characteristics (muscle insertions, anthroposcopic or anthropometric characteristics, data that allow the establishment of sex, age, height, race

Adding deep tissue markers

- depend on race, sex

Addition of deep muscle tissue and adipose tissue

Add age and race characteristics (wrinkles, hair)

Add decorative objects characteristic of the period, religious affiliation, etc.