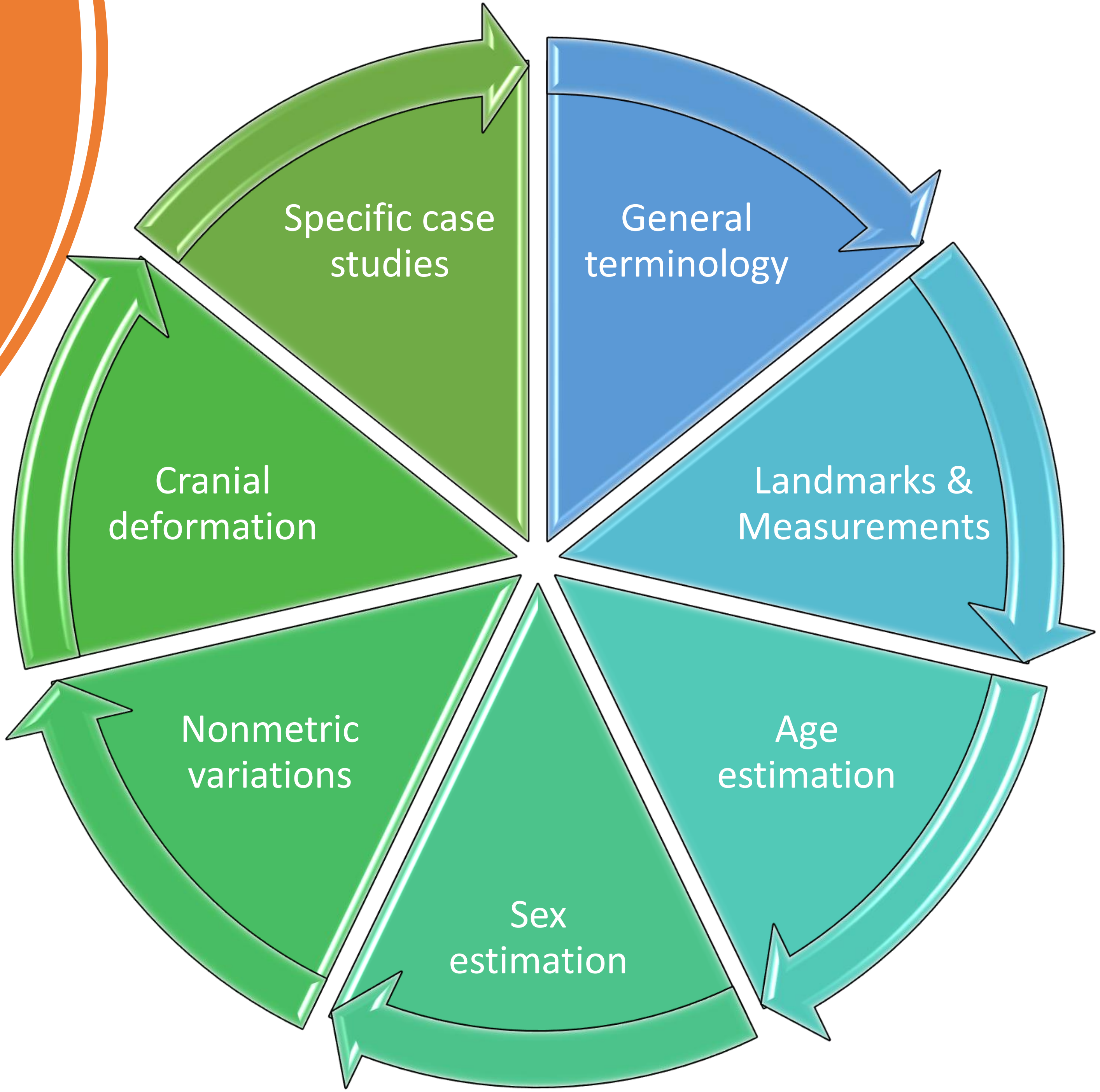
Cranial Variations

Dr Arwa KHAROBI

Main ideas


General terminology
Landmarks & Measurements
Age estimation
Sex estimation
Nonmetric variations
Cranial deformation
Specific case studies

I. General Terminology

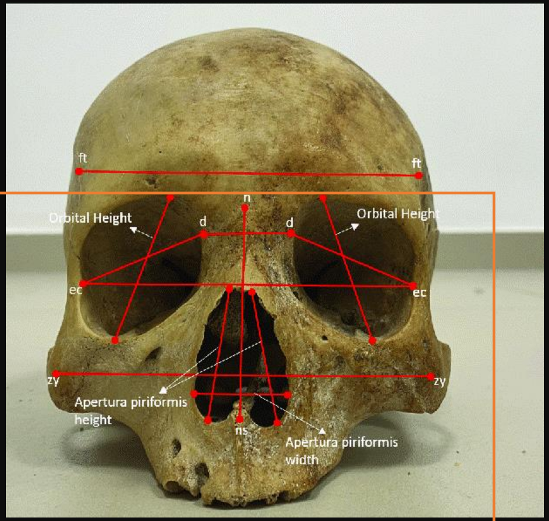
I. Skull: Skeleton of the head, face, and lower jaw.

II. Cranium: A skull lacking its lower jaw.

III. Calvarium: A skull lacking the lower jaw and face.

IV. Calotte: A braincase or skull cap.

Landmarks & Measurements



i. Standardized landmarks & measurements essential for scientific validity.

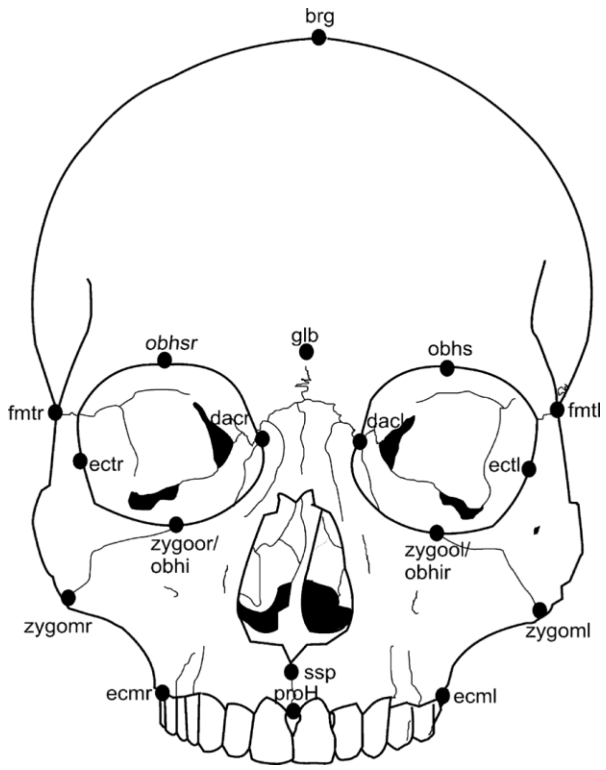
ii. Used for estimation of age, sex, biological affinity, stature, modernity & facial features in unknown remains.

iii. Agreed-upon landmarks on the skull necessary for accurate measurements.

iv. To increase reliability, measurements should be repeated on the same individual(s) multiple times to estimate **intra-observer error**.

v. Same process should be undertaken to determine **inter-observer errors** (error rate between researchers).

i. Landmarks of the Skull

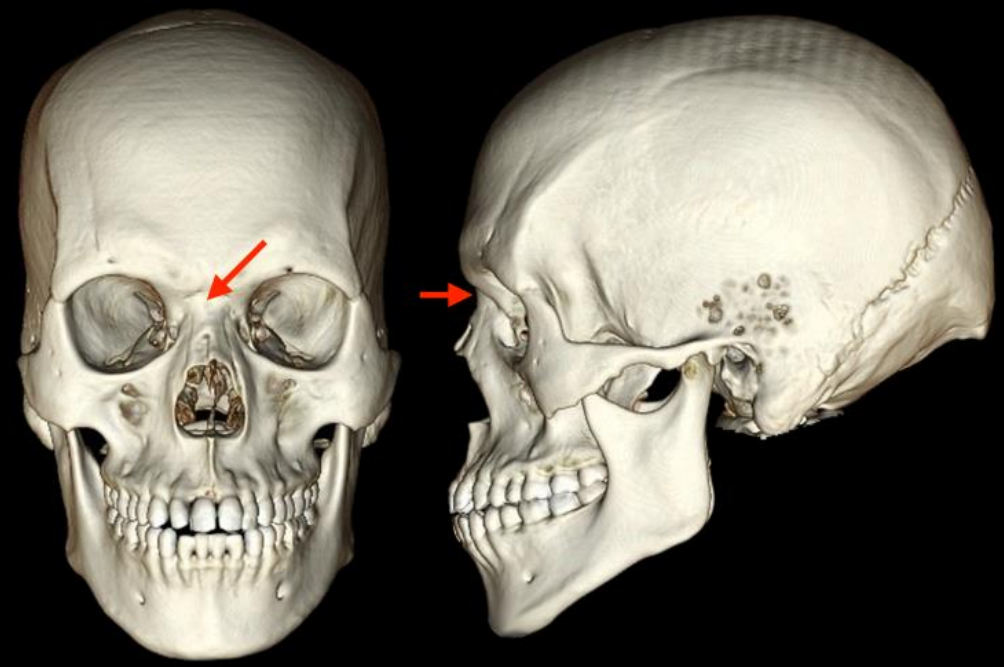


Landmarks	Abbreviations
Asterion left/right	ast l/r
Basion	bas
Bregma	brg
Dacryon left/right	dac l/r
Ectoconchion left/right	ect l/r
Frontomalare temporale left/right	fmt l/r
Glabella	glb
Lambda	lam
Mastoidale left/right	mast l/r
Superior orbital height left/right	obhs
Inferior orbital height left/right	obhi
Opisthion	ops
Prosthion	proH
Subspinale	ssp
Zygoorbitale left/right	zygoo l/r
Zygomaxillare left/right	zygom l/r

i. Landmarks of the Skull

Nasion

The point located most superiorly where the nasal bones meet.



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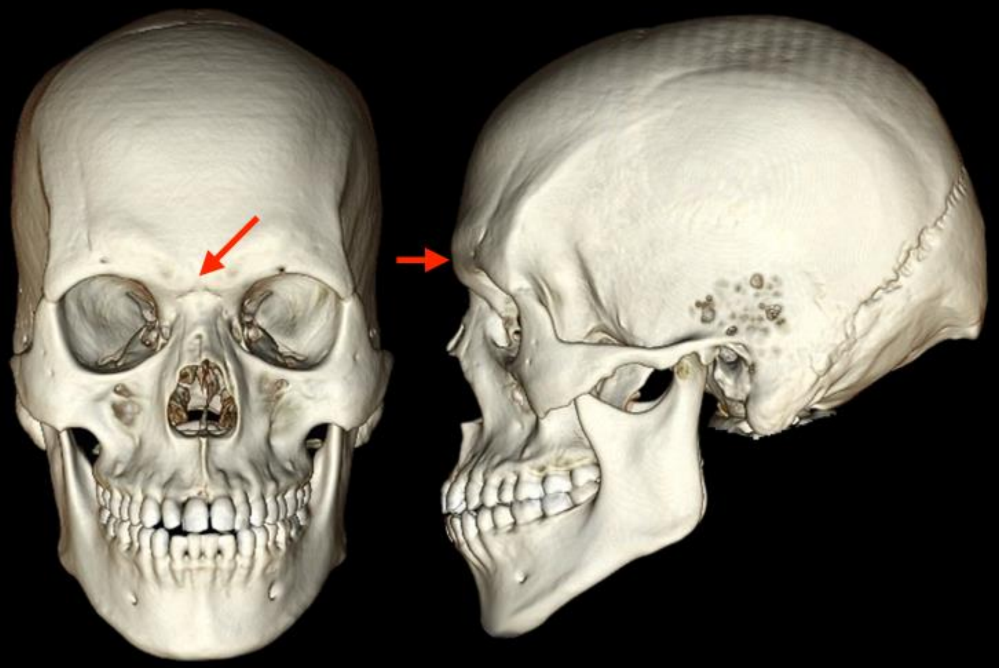
Usually more pronounced in males ♂

Glabella

The point superior to the nasal bones, between the supraorbital ridges.



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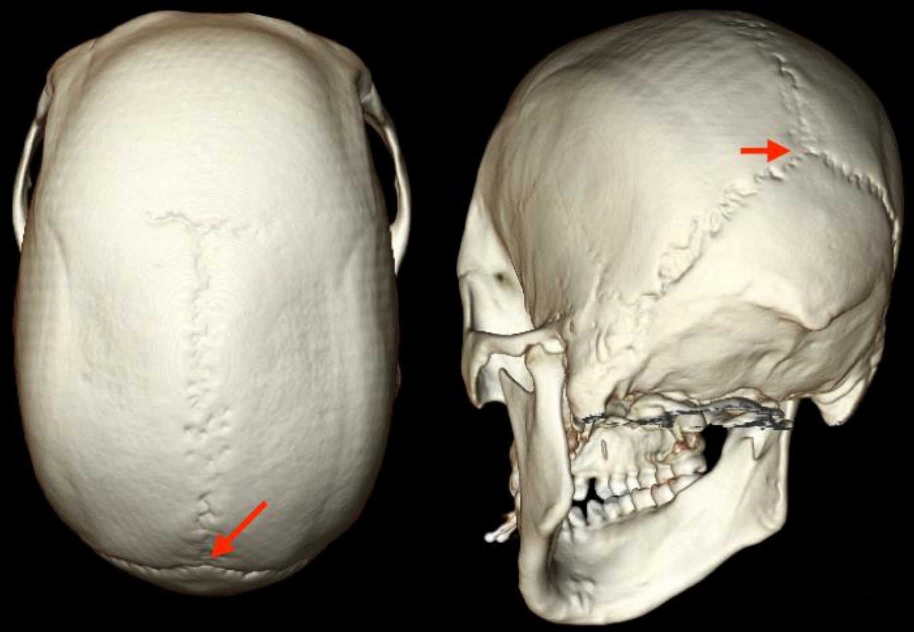
Lambda

The intersection point of the lambdoidal suture and the sagittal suture.



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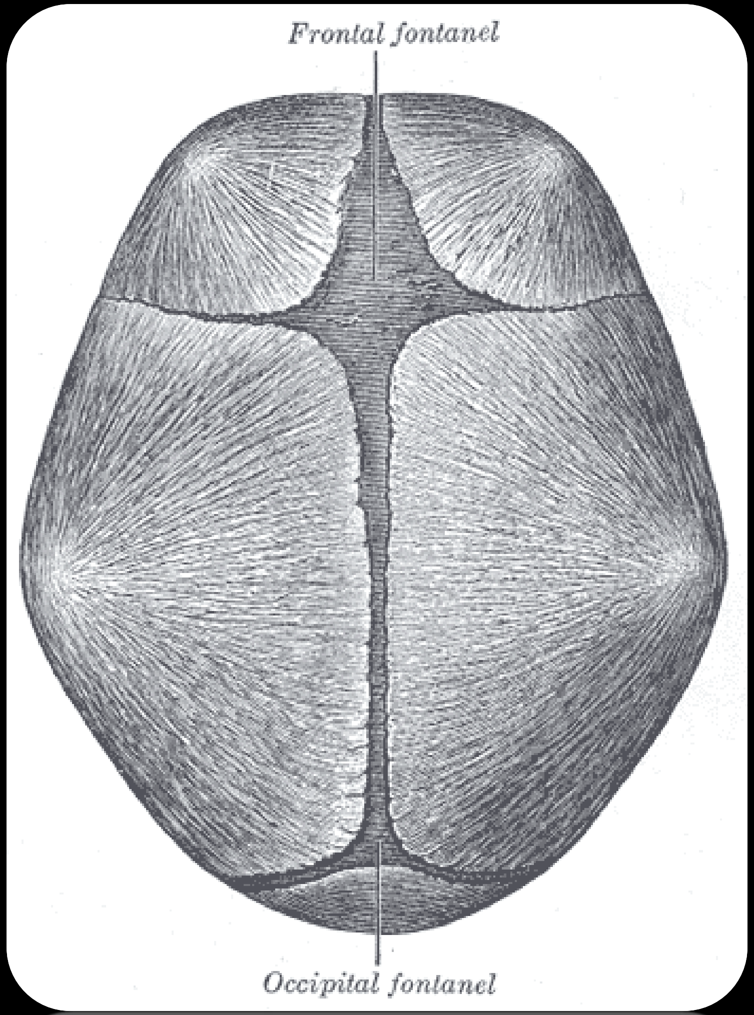
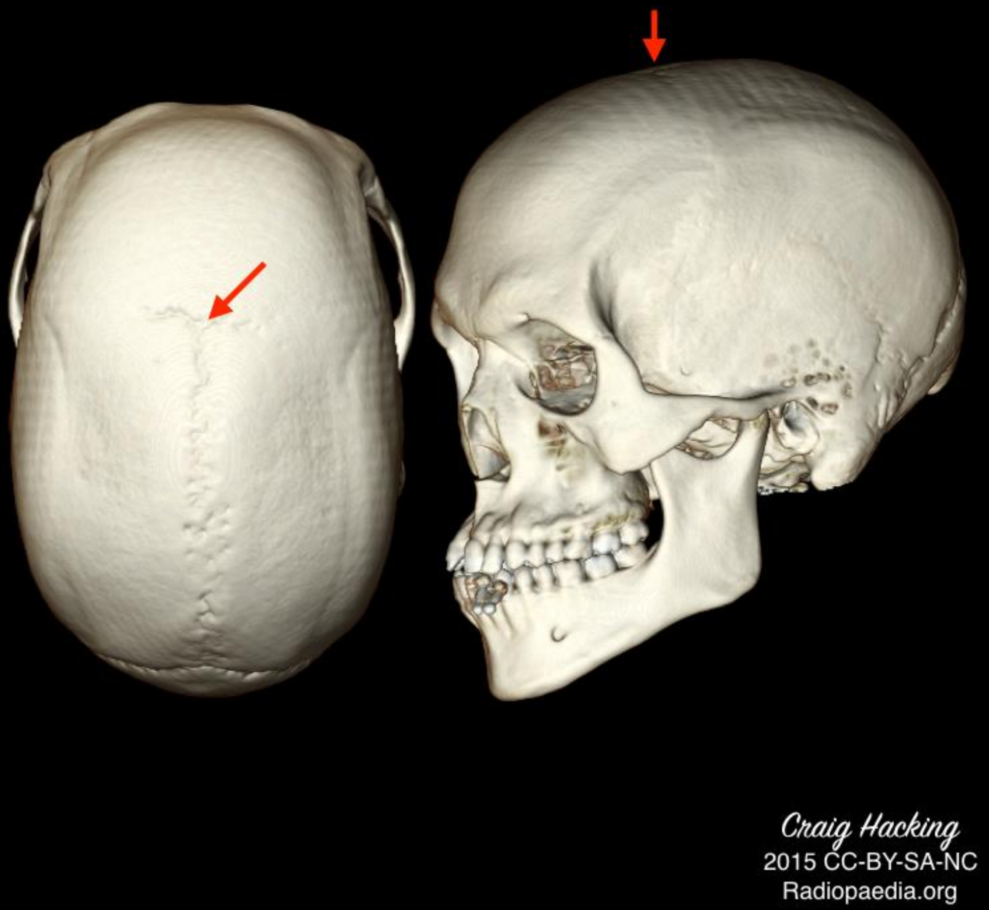


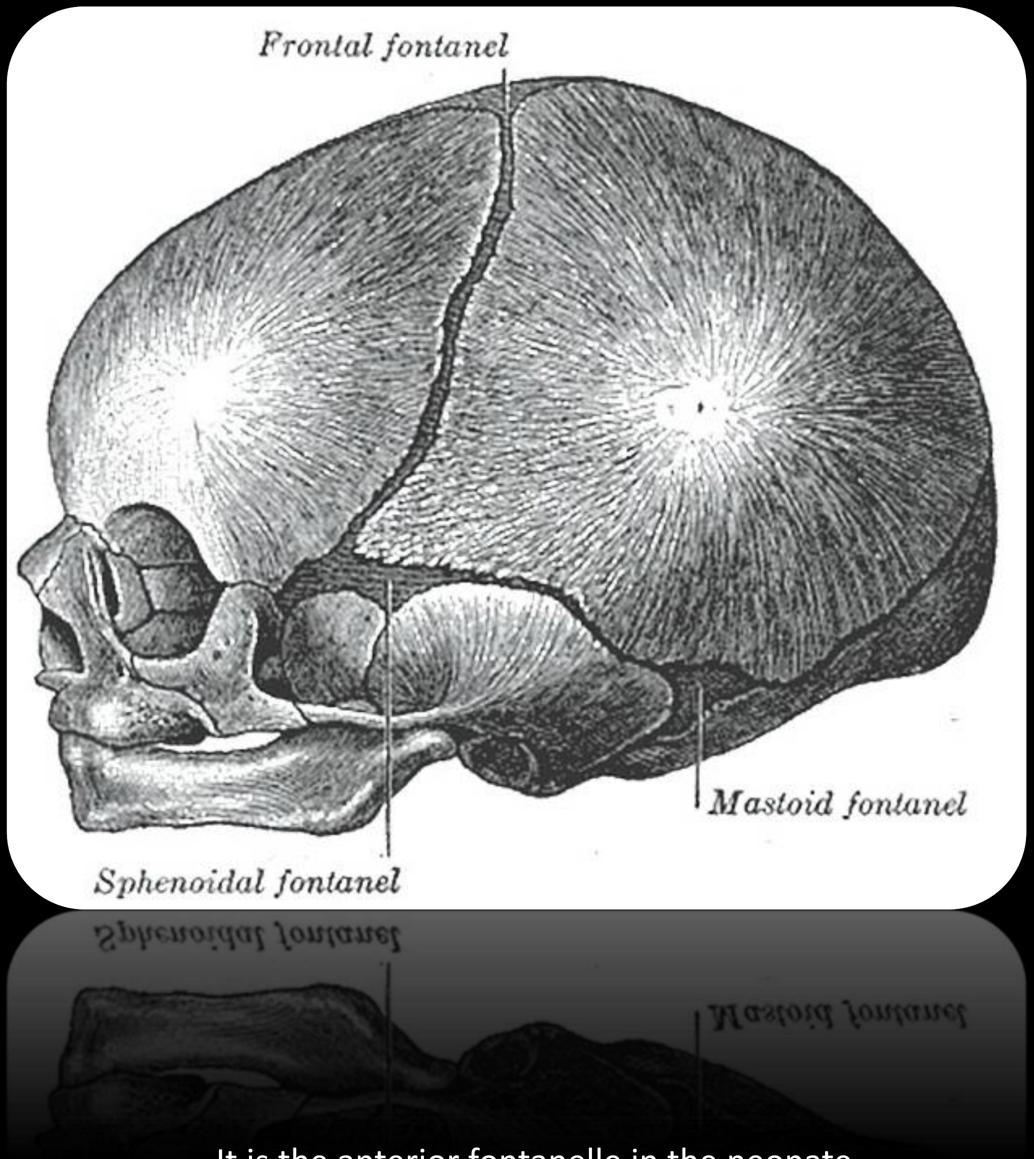
It is the posterior fontanelle in the neonate
Closes by the 2nd month after birth (although normal closure can occur up to 6 months after birth).

i. Landmarks of the Skull

Bregma

The point where the sagittal suture meets the coronal suture anteriorly

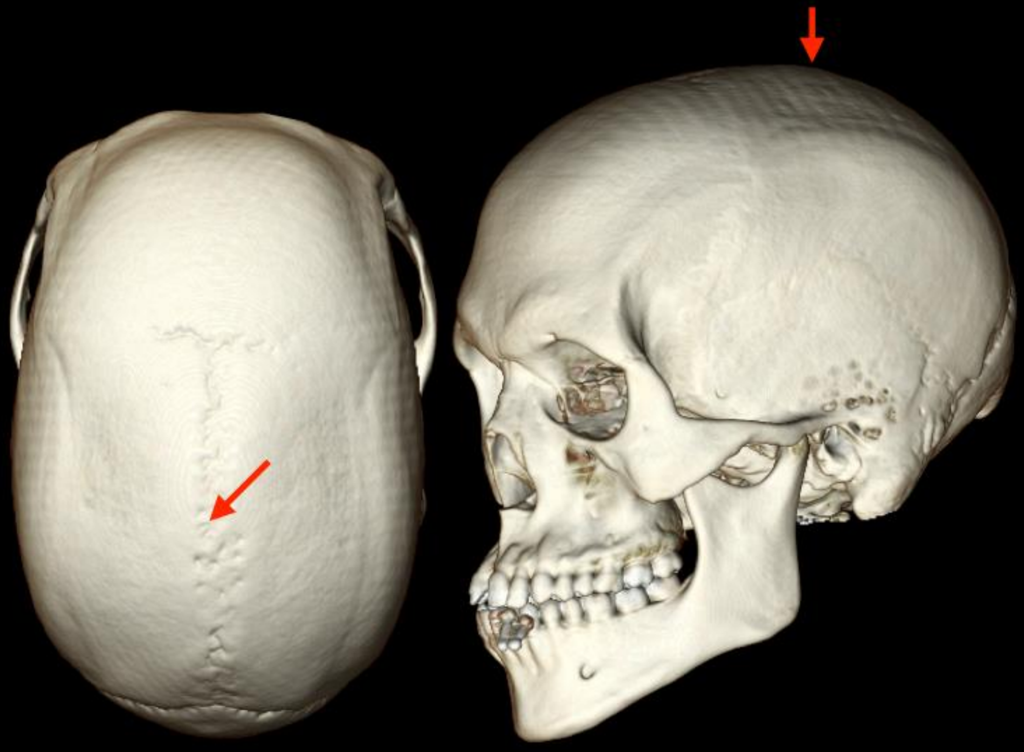




It is the anterior fontanelle in the neonate
Closes in the 2nd year (typically around 18 months after birth)

Vertex

The midline point at the most superior part of the calvaria between the bregma and lambda



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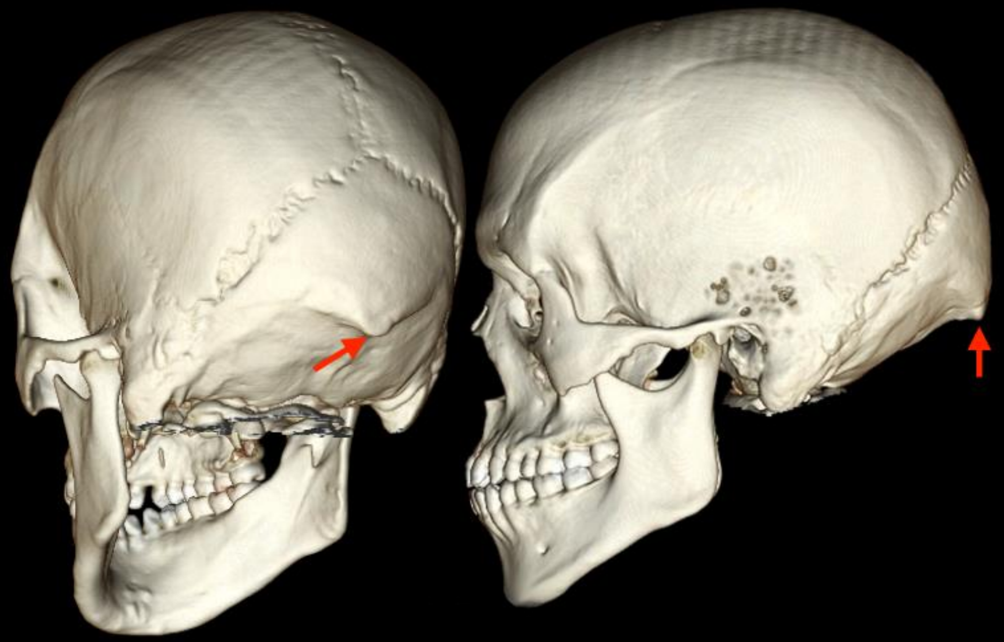
i. Landmarks of the Skull

Inion

The midline point in the occipital bone from which the ligamentum nuchae and trapezius muscle attach



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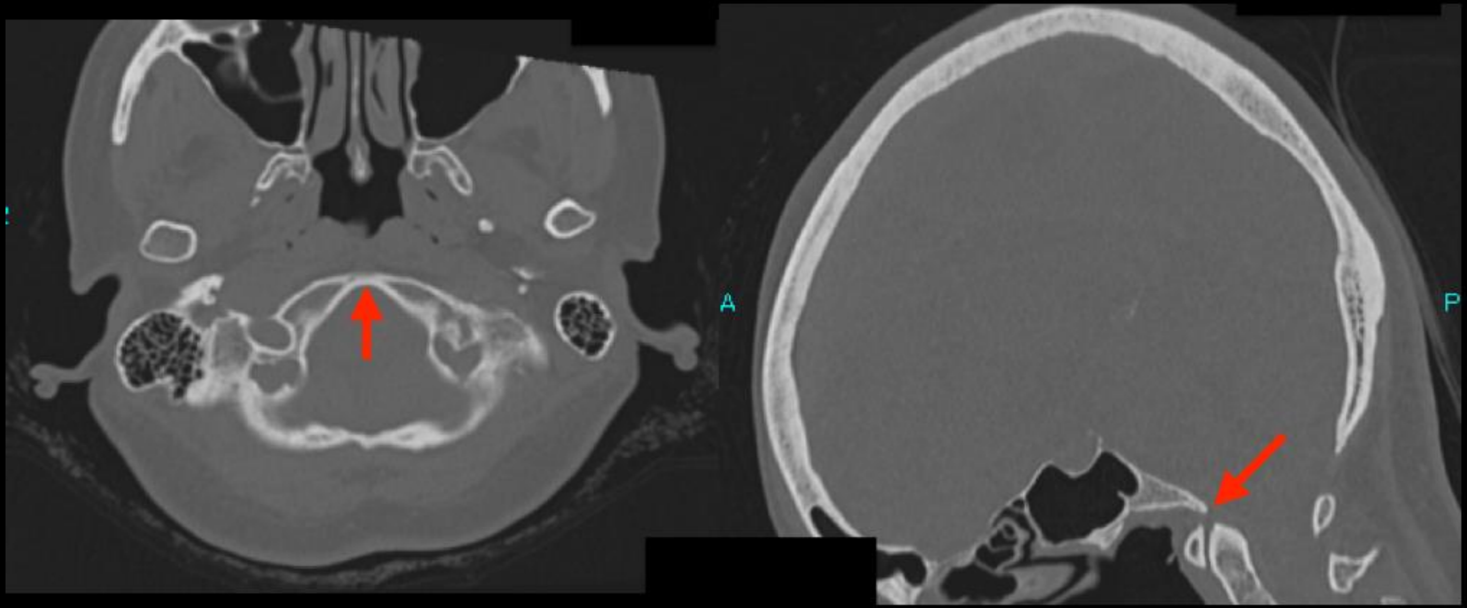
Basion

The point located on the anterior border of the foramen magnum.



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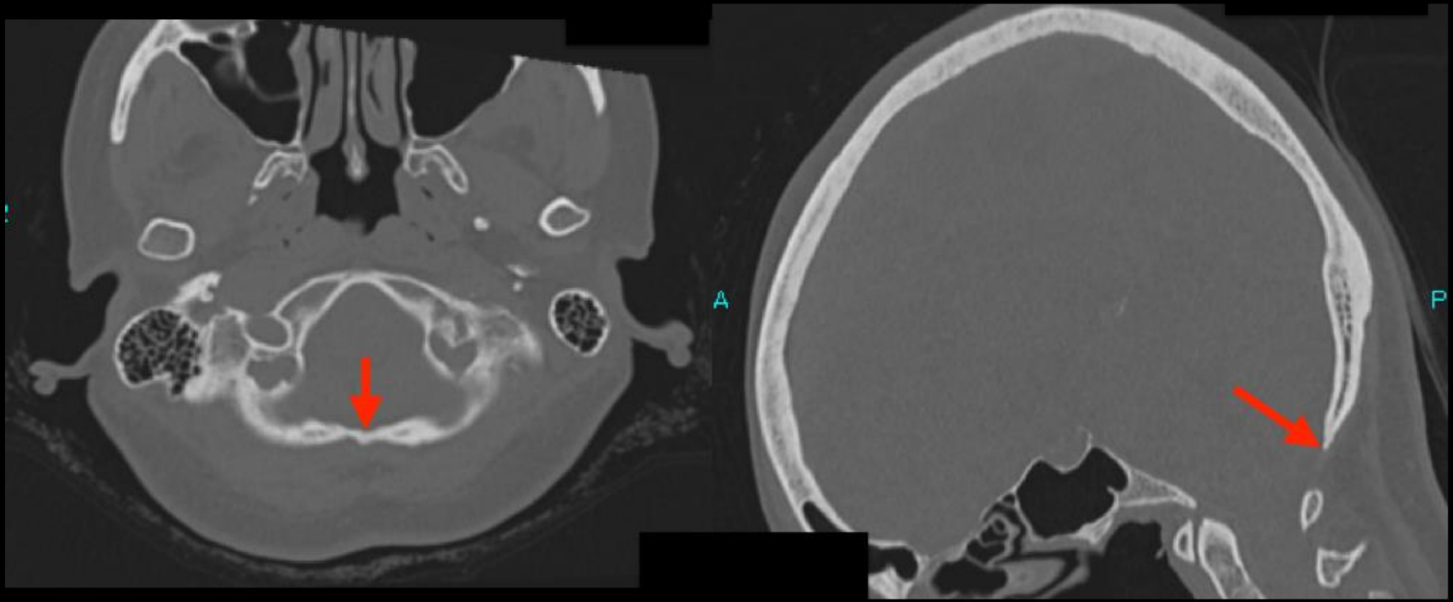
Opisthion

The most medial point on the posterior aspect of the foramen magnum.



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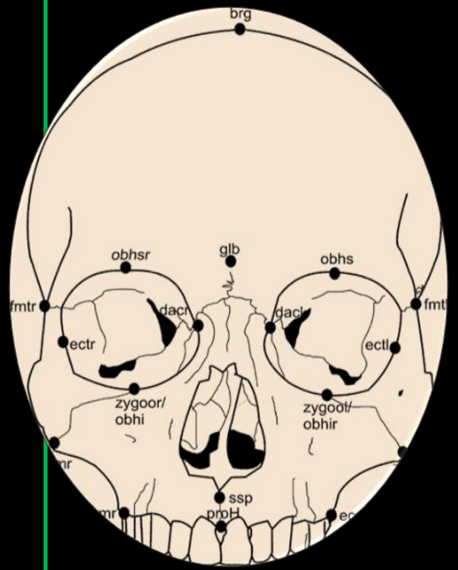
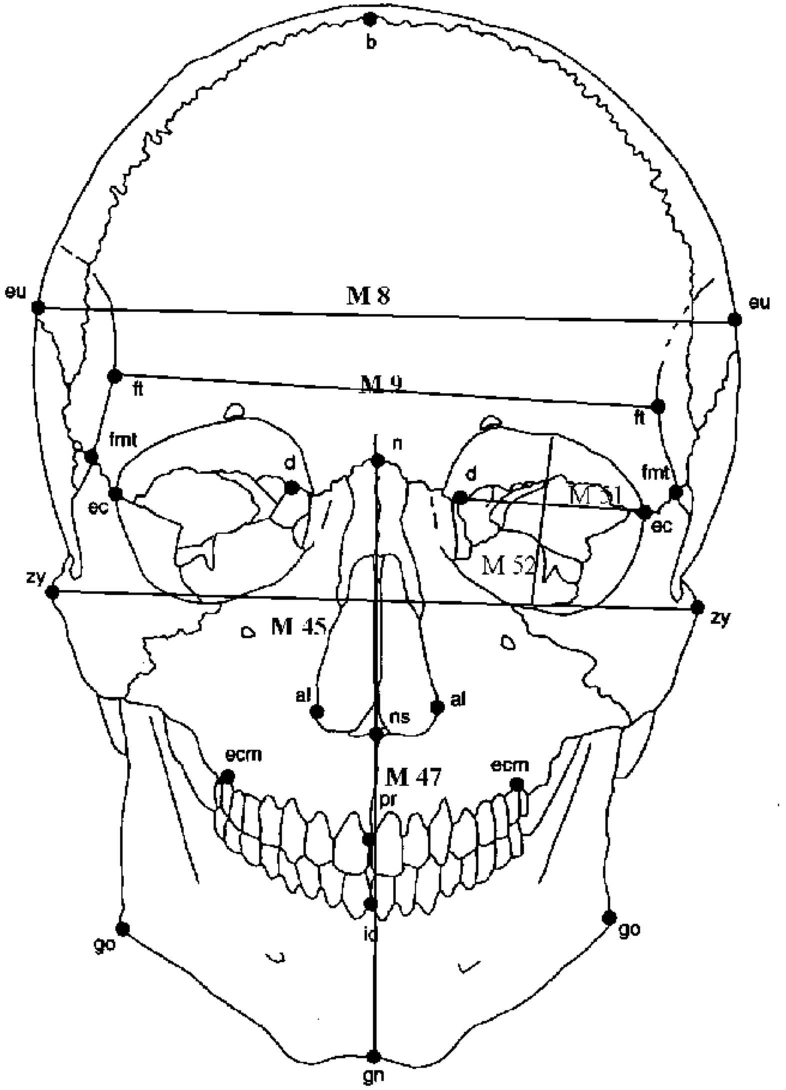
i. Landmarks of the Skull



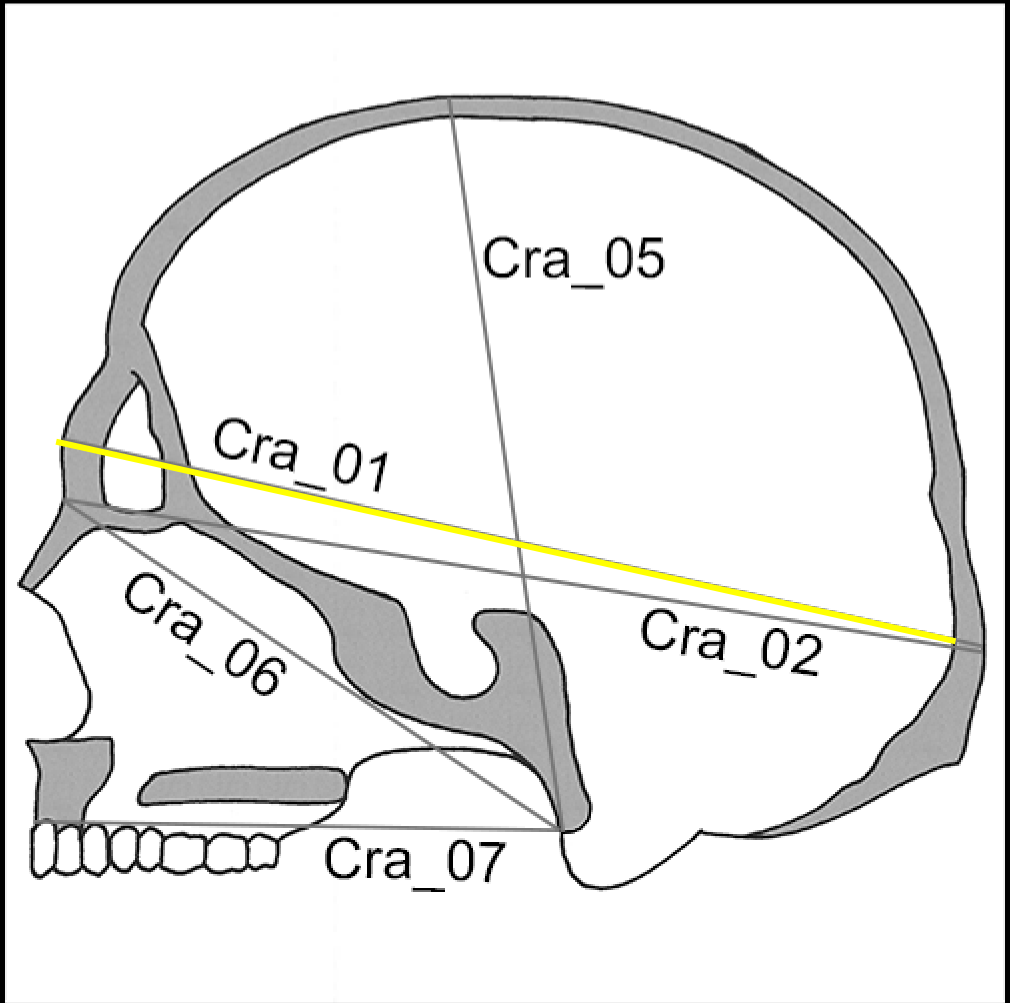
Alveolare	Alare	Dacryon
Ectoconchion	Euryon	Frontotemporale
Gnathion	Infradentale	Nasiospinale
Opisthocranion	Orbitale	Prosthion

ii. Measurements of the Skull



Maximum Cranial Length g-op, GOL

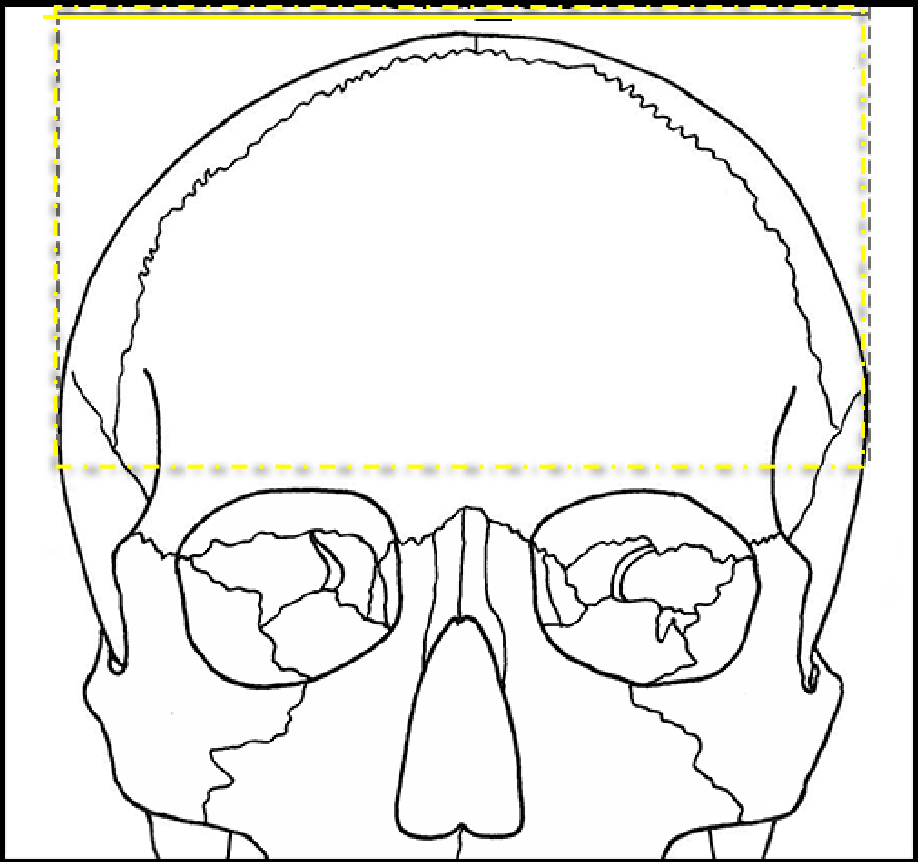
The straight-line distance from glabella (g) to opisthocranion (op) in the midsagittal plane.



Images derived from Langley et al. (2016) by Elizabeth Lockett and Nandar Yukyi.

Maximum Cranial Breadth XCB

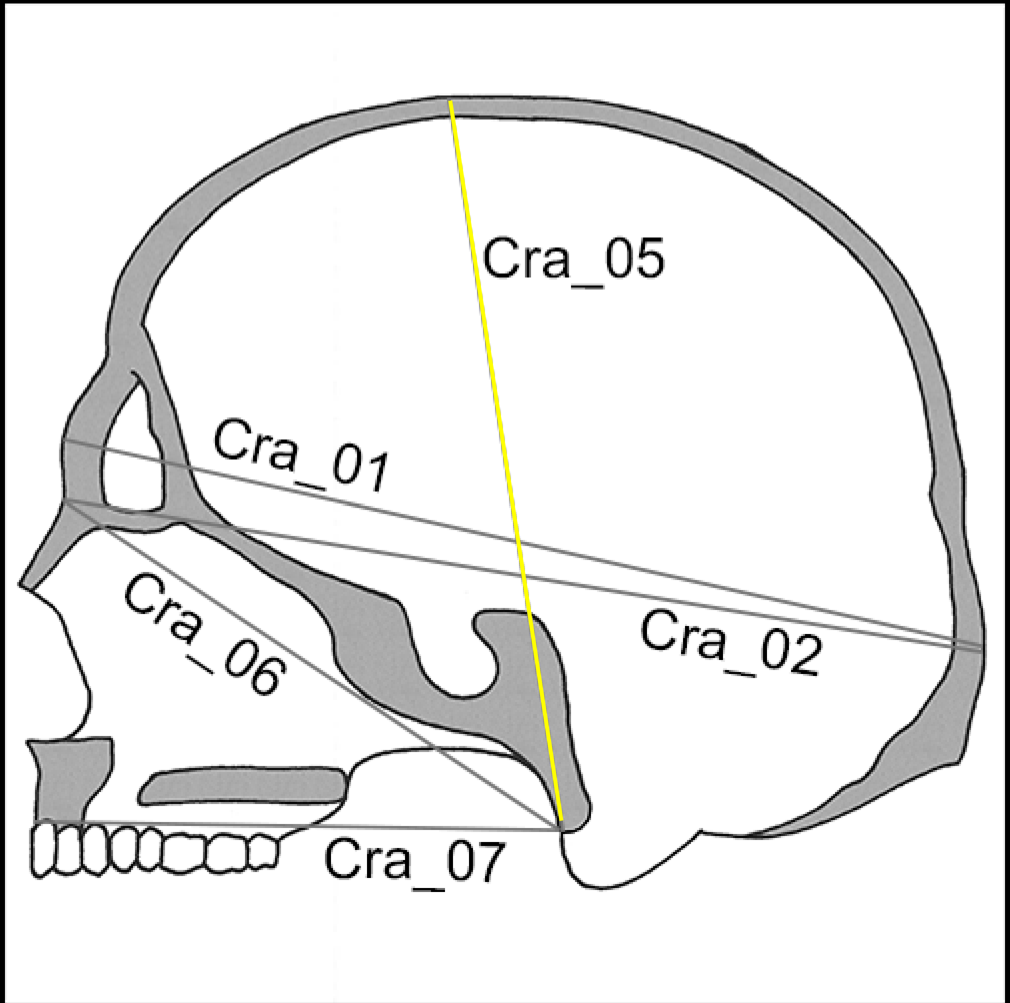
The maximum width of the skull perpendicular to the mid-sagittal plane



Images derived from Langley et al. (2016) by Elizabeth Lockett and Nandar Yukyi.

Basion-Bregma Height (ba-b, BBH)

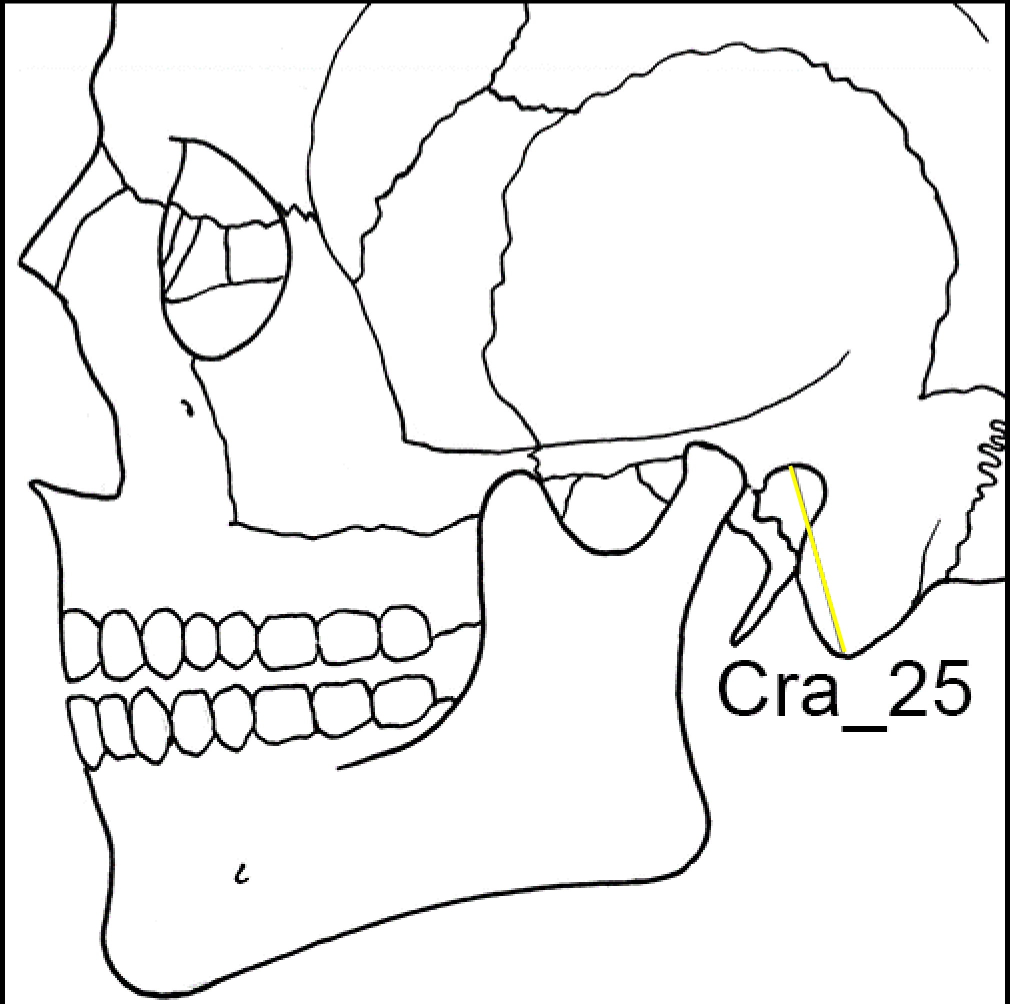
The distance from basion (ba) to bregma (b).



Images derived from Langley et al. (2016) by Elizabeth Lockett and Nandar Yukyi.

Mastoid Height (MDH)

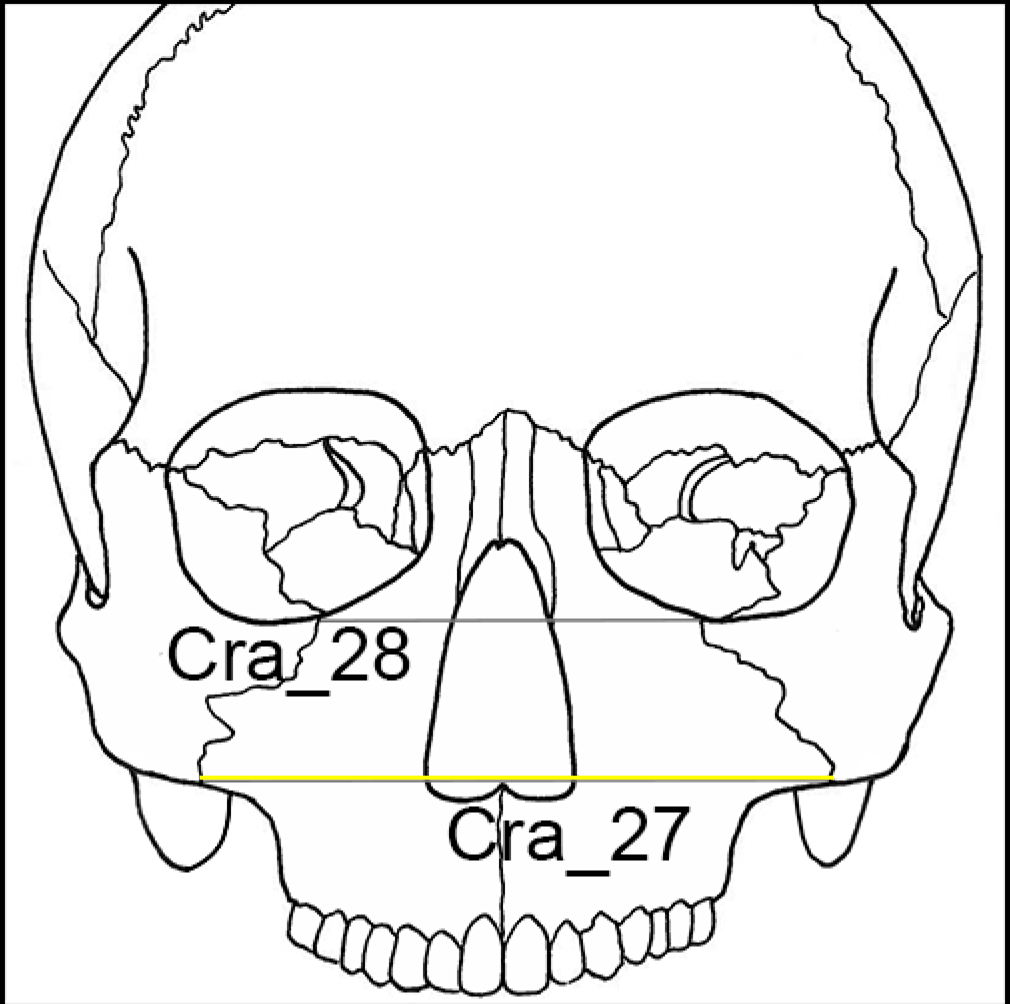
The direct distance between porion (po) and mastoidale (ms).



Images derived from Langley et al. (2016) by Elizabeth Lockett and Nandar Yukyi.

Zygoorbitale Breadth (zo-zo, ZOB)

The distance between right and left zygoorbitale (zo).



Images derived from Langley et al. (2016) by Elizabeth Lockett and Nandar Yukyi.

ii. Measurements of the Skull

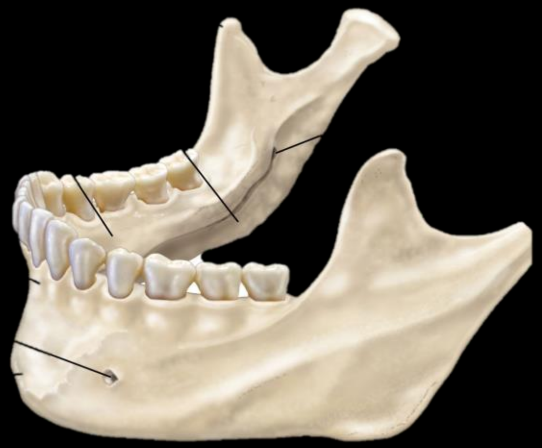
1. Chin Height (id-gn): The distance from infradentale (id) to gnathion (gn).

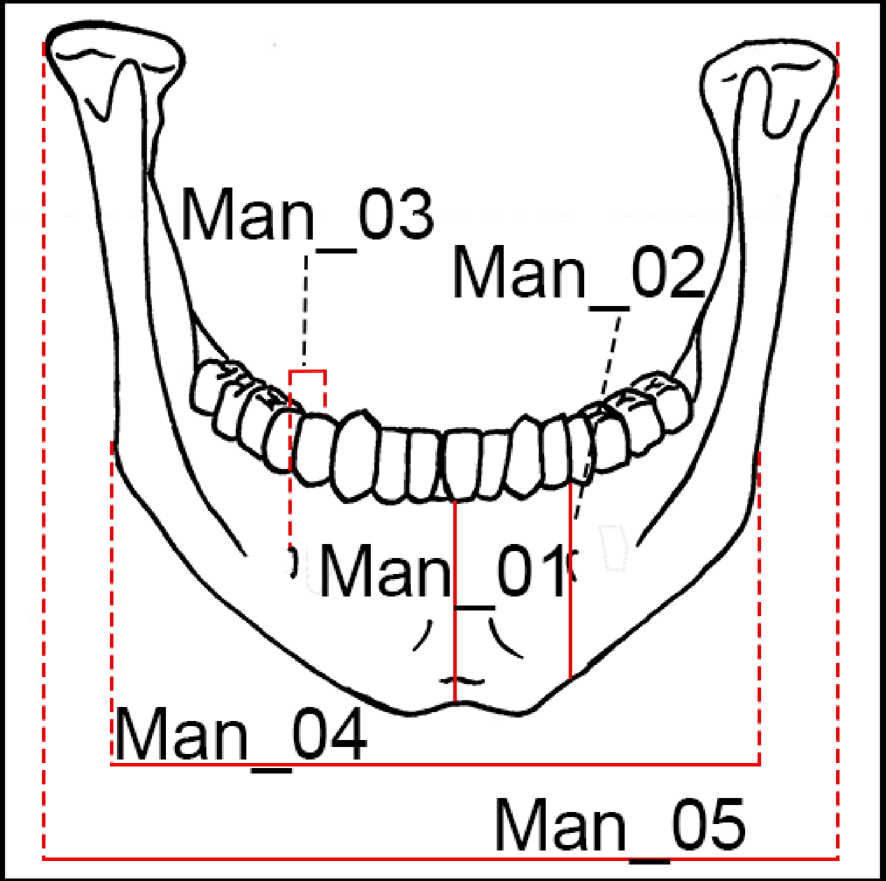
2. Height of the Mandibular Body: The distance from the alveolar process to the inferior border of the mandible at the level of the mental foramen

3. Breadth of the Mandibular Body: The maximum breadth measured at the level of the mental foramen perpendicular to the long axis of the mandibular body

4. Bigonial Breadth (go-go): The distance between the right and left gonion (go).

5. Bicondylar Breadth (cdl-cdl): The distance between the most lateral points on the mandibular condyles (cdl).





Images derived from Langley et al. (2016) by Elizabeth Lockett and Nandar Yukyi.

ii. Measurements of the Skull

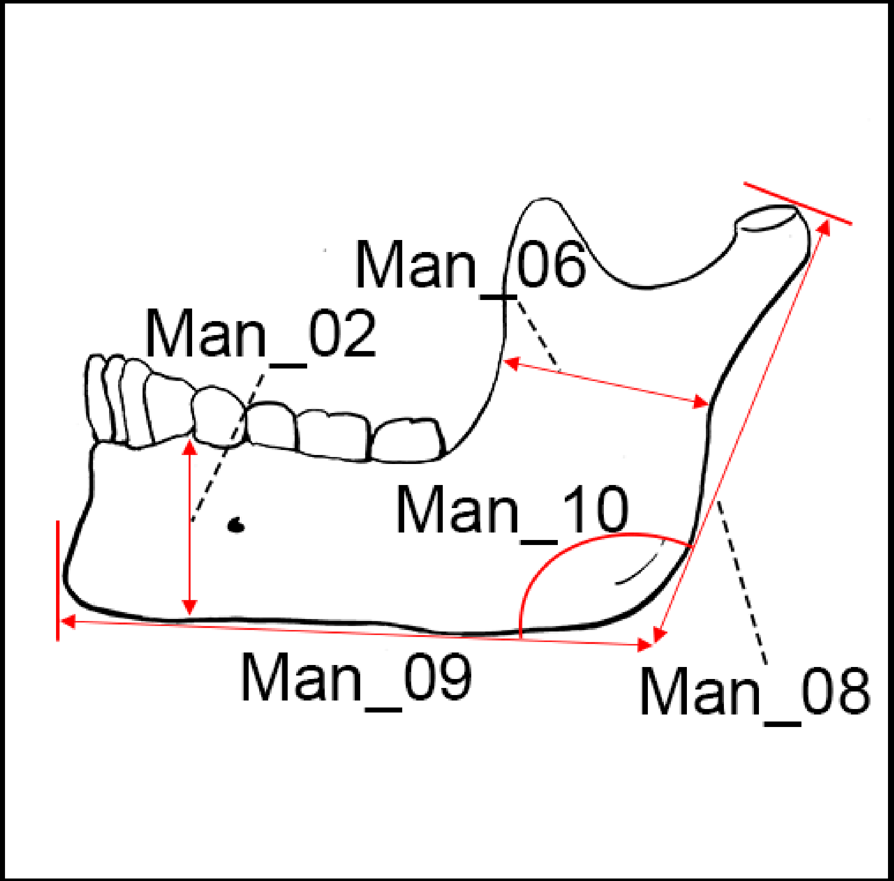
6. Minimum Ramus Breadth: The minimum breadth of the mandibular ramus measured perpendicular to the height of the ramus, of the left (L) and right (R) sides, respectively.

7. Maximum Ramus Breadth: Distance between the most anterior point on the mandibular ramus and a line connecting the most posterior point on the condyle and the angle of the jaw

8. Maximum Ramus Height: The distance from gonion (go) to the highest point on the mandibular condyle.

9. Mandibular Length: The distance from the anterior margin of the chin to the midpoint of a straight line extending from the posterior border of the right and left mandibular angles

10. Mandibular Angle: The angle formed by inferior border of the corpus and the posterior border of the ramus.



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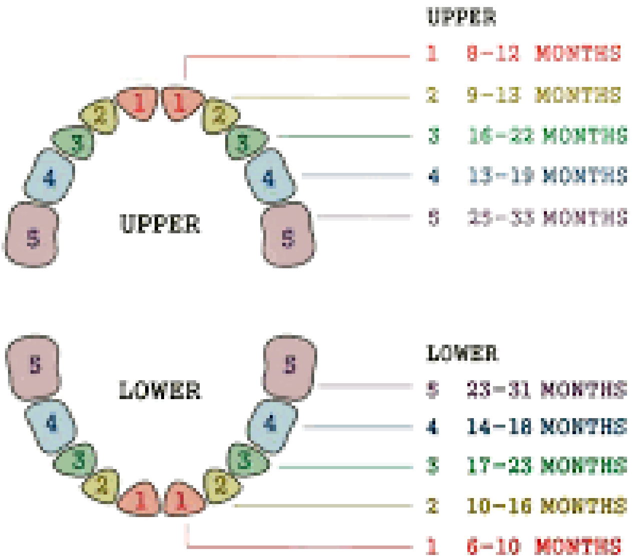
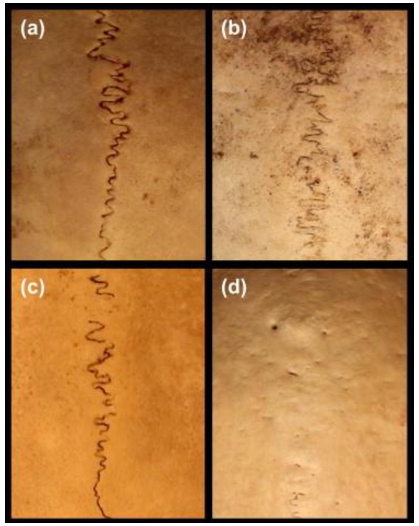
Age estimation

Determining age at death based upon:

1. dental eruption,
2. dental calcification,
3. dental wear,
4. suture fusion,
5. degenerative changes (i.e. arthritis).

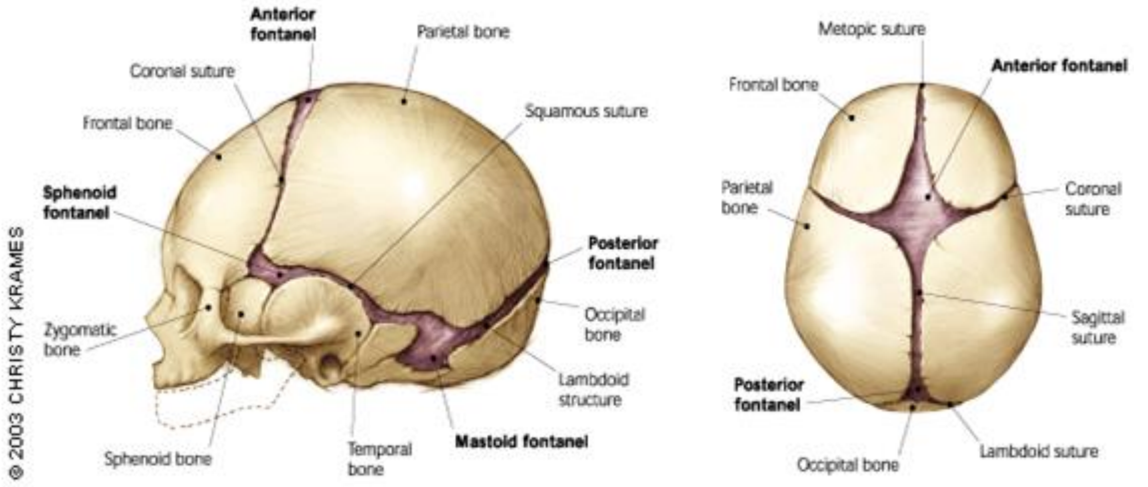
the older the individual at the time of death, the less accurate is the age estimate.





III. Skulls & age estimation: Suture Closure

Fontanel	Closure time (post birth)
Posterior fontanel	2-3 months
Sphenoidal fontanel	Around 6 months
Mastoid fontanel	6-18 months
Anterior fontanel	1-3 years



Closure time of various fontanels

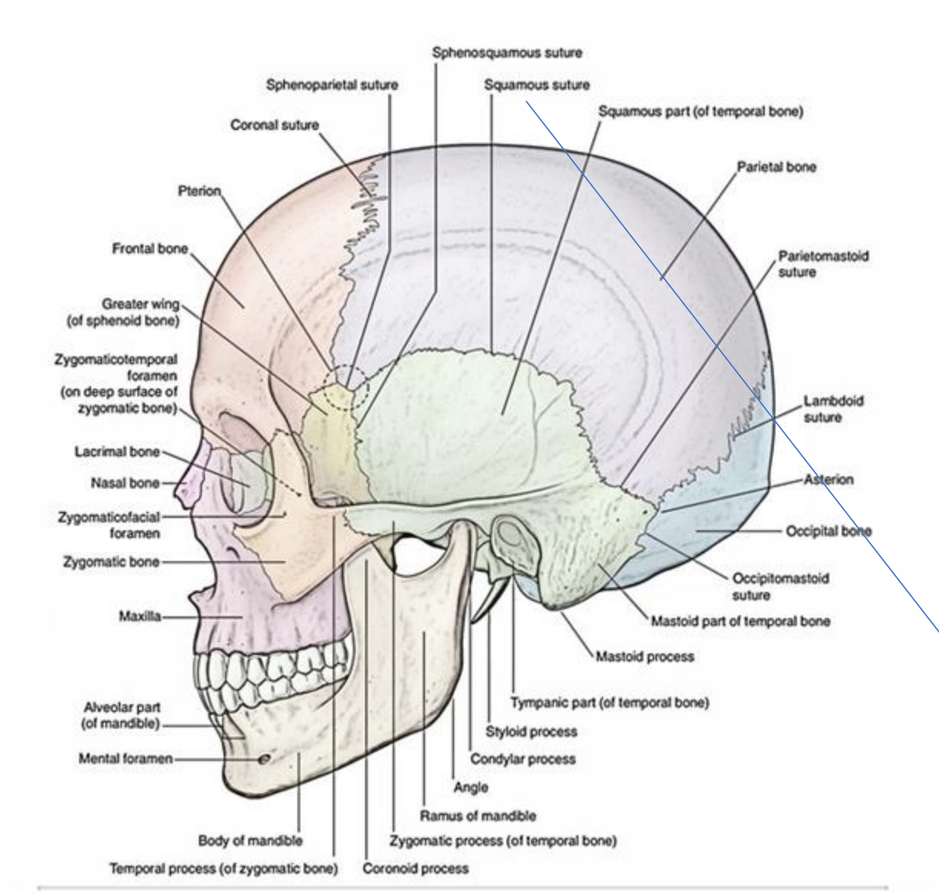
III. Skulls & age estimation: Suture Closure

----- provide broad ranges

Sutures should be recorded as:

1. unobservable,
2. open (no evidence of closure),
3. minimal closure (up to 50% closure observed),
4. significant closure (mostly fused, but not complete),
5. complete obliteration (totally fused)

III. Skulls & age estimation: Suture Closure

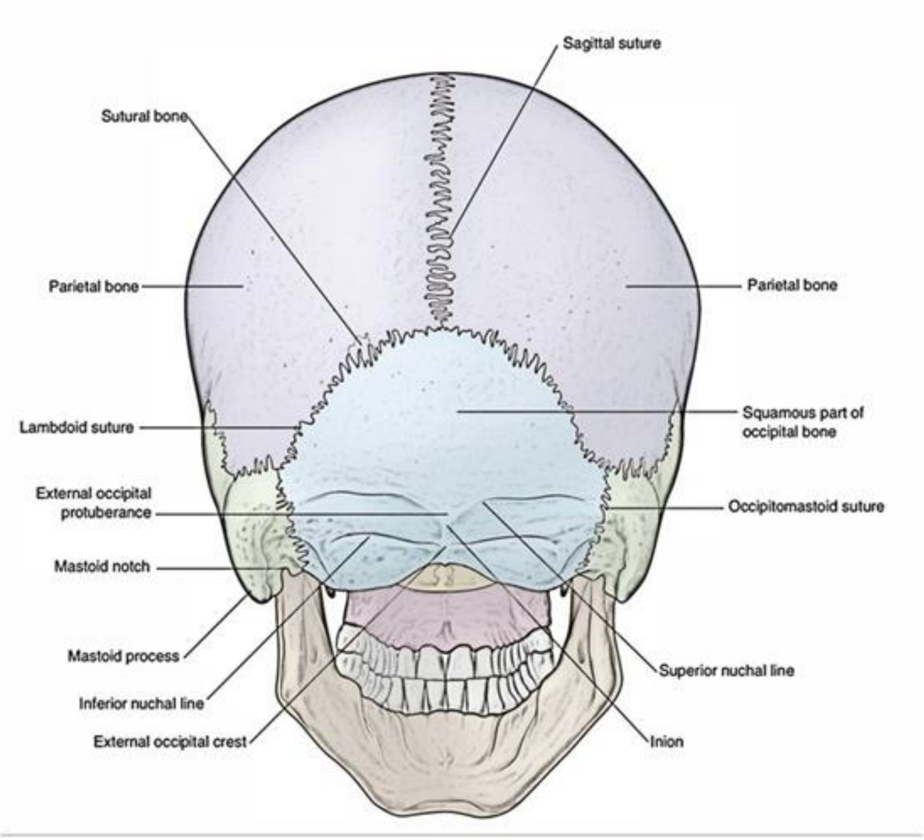


Suture	**Endocranial fusion begins by**	**Endocranial fusion completed by**
Sagittal suture	26 years	Complete fusion by 61-65 years of age
Coronal suture	26 years	Complete fusion by 56-60 years of age
Lambdoid suture	25-30 years	Complete fusion by 60-70 years
Squamosal suture	55-60 years	Complete fusion by 70 years of age

Endocranial closure time of major sutures of skull `

`the closure time of sagittal, coronal and lambdoid sutures in table 3 are ectocranial, while that of other sutures mentioned in the same table are not specified.

III. Skulls & age estimation: Suture Closure



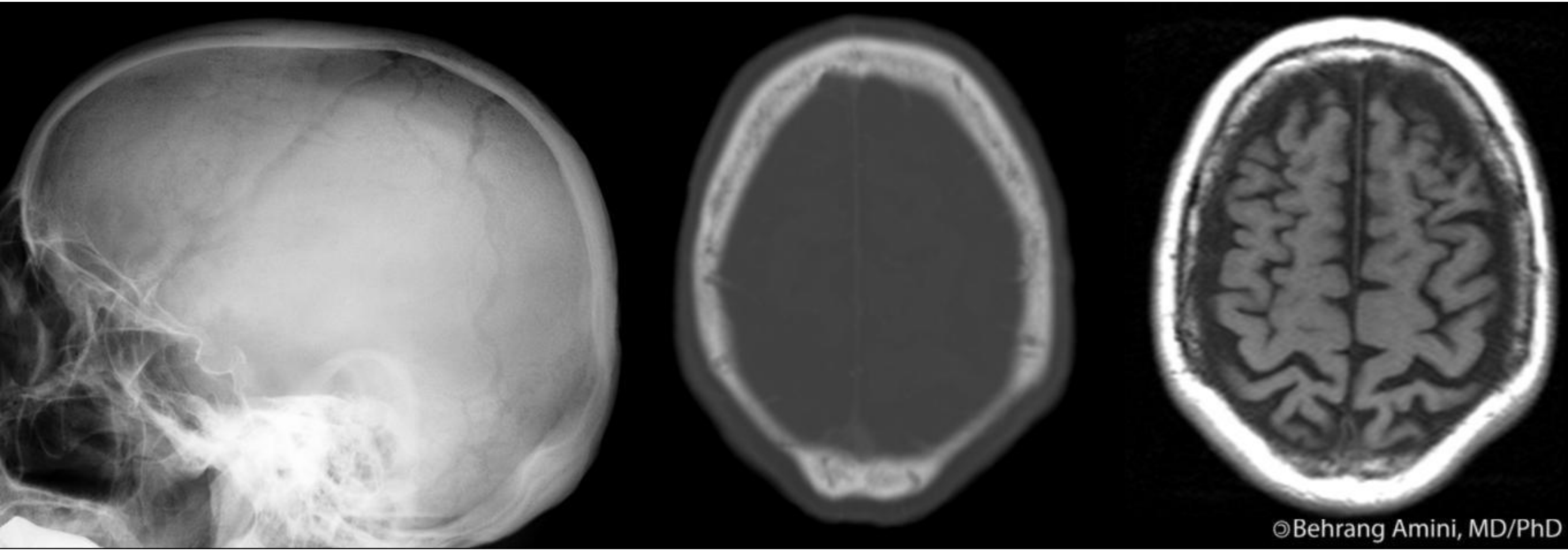
Suture	Fusion begins by	Fusion completed by
Metopic suture	—	2 years
Basilar suture	13 years	22 years
Sagittal suture	30-35 years	50 years, may be extended up to 60 years
Coronal suture	35-40 years	50 years, may be extended up to 69 years
Lambdoid suture	45-50 years	55-60 years, may be extended up to 67 years
Occipito-mastoid suture	60-65 years	80 years
Parieto-mastoid suture	60-65 years	80-82 years
Spheno-temporal suture	50-55 years	70 years
Spheno-parietal suture	60-65 years	70 years, may be up to 80-85 years, last suture to close

Showing closure of various skull sutures``

``the closure time of various sutures and fontanels mentioned in the tables above are based on researches conducted, these values are subject to vary.

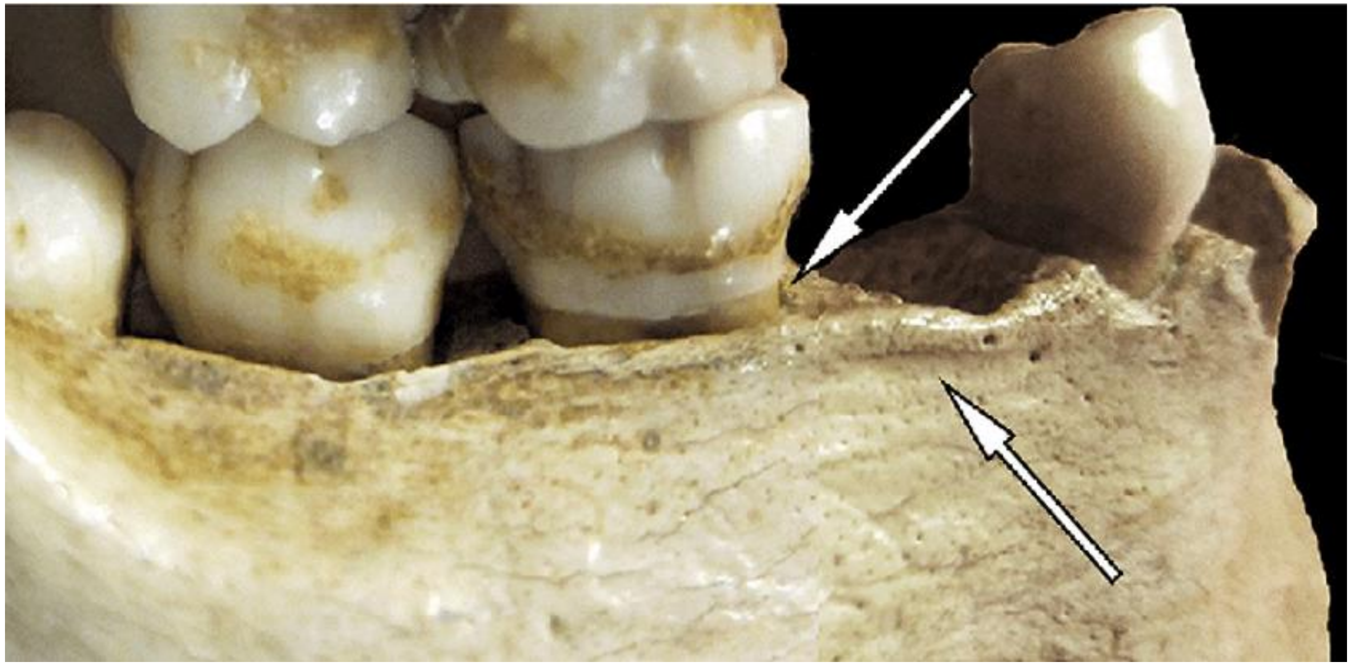
III. Skulls & age estimation: Degenerative Changes

1. **biparietal thinning** it begins on the external table of the lateral and posterior aspects of the parietals.
2. The parietal bosses will appear flattened in nature = 50+ (Mann & Hunt 2005).



III. Skulls & age estimation: Degenerative Changes

2. **alveolar resorption**: It is the product of tooth loss, decrease in bone density associated with age, and also periodontal disease. The alveoli shrink, and as teeth are shed the sockets fill in.



Vilotte et al. 2018

III. Skulls & age estimation: Degenerative Changes

3. Arthritis = 35+

- occipital condyles
- mandibular fossae

Articulation sites ++ movements

→Lipping: small ridges or spicules of bone within or around the margins of the surface

→Erosion: pitting with irregular margins within the surface area


A
B
C

IV. Skulls & sex estimation

- ❑Pelvis is the most reliable for identification

- ❑Skull alone is less accurate

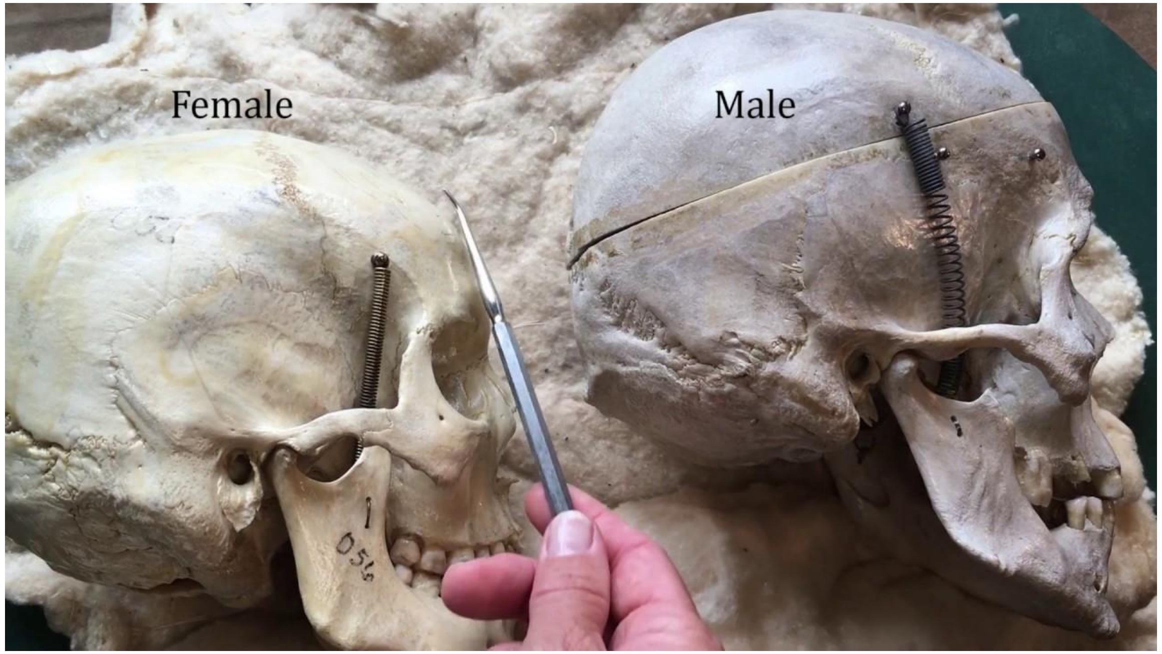
- ❑Diagnosis/Reliability:

- Skull with no lower jaw, nor any other part of the skeleton = 80 % reliable.
- With well-preserved lower jaw = 90 %
- whole skeleton = 96 to 98 %

IV. Skulls & sex estimation

Although there will still remain skeletons which, even though complete, show such ambiguous sexual characteristics that it will be impossible to identify them as either male or female with certainty.

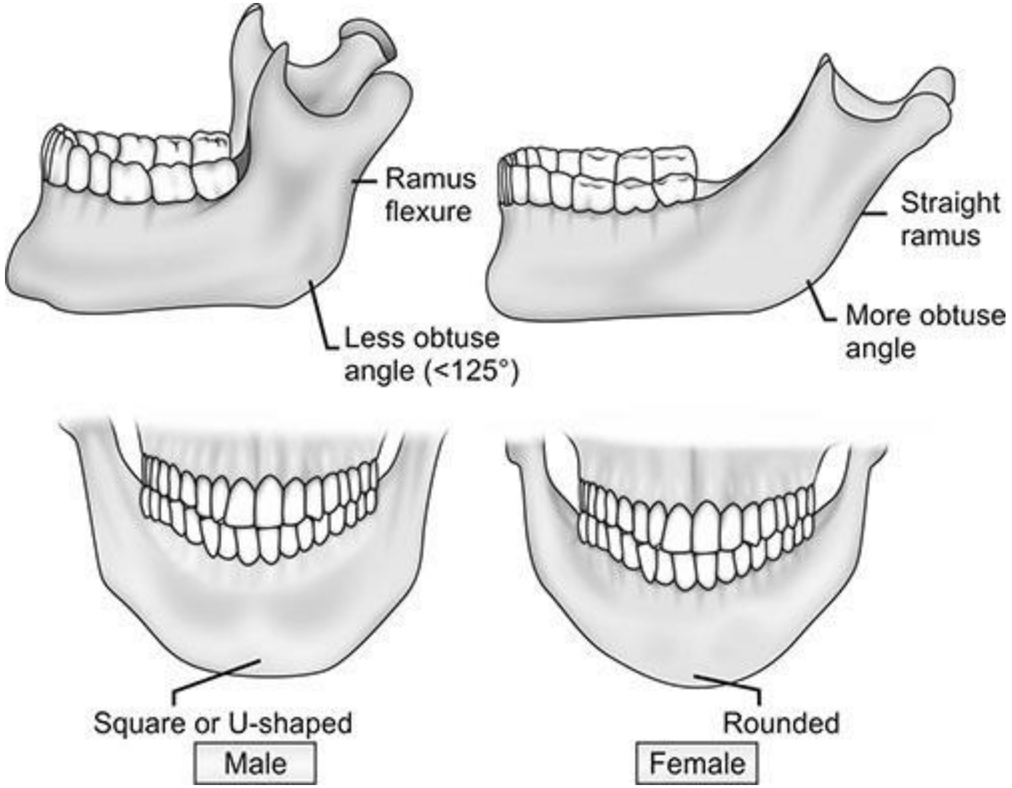
The following are cranial traits used in sex assessment:



Trait	Description
Overall size	Larger in males; smaller in females.
Muscle attachments	Stronger in males exhibited by roughening; females are generally more smooth overall.

Trait	Description
External occipital protuberance	More pronounced in males; rounded and smooth in females.
Forehead	Retreating in males; smooth, round, more vertical and better developed frontal eminences in females.
Glabella	Protrudes in males; smooth in females.
Mastoid process	Large in males; small in females.
Palate	Males are larger and broader; females display less depth.
Supra-mastoid crest	Larger and extend past the external auditory meatus in males.
Supraorbital margins	Rounded and thick in males; sharp and thin in females.
Supraorbital ridges	More pronounced in males; flat and smooth in females.
Zygomatic bones	higher, stouter, and rugged in males.
Zygomatic processes	Heavier in males; more slender in females.

IV. Skulls & sex estimation



Mental eminence	Square and broad in males; v-shaped and narrow in females.
Gonial angle	Less obtuse in males (stouter, rougher, and more everted angles); an angle over 125 degrees suggests female sex.

Actual state of the Zlatý kůň skull with separate fragments—Zygomatic bones and maxilla (recorded in 2018; photo Marek Jantač).

PLOS ONE

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Virtual reconstruction of the Upper Palaeolithic skull from Zlatý Kůň, Czech Republic: Sex assessment and morphological affinity

Rebeka Rmoutilová, Pierre Guyomarc'h, Petr Velemínský, Alena Šefčáková, Mathilde Samsel, Frédéric Santos, Bruno Maureille, Jaroslav Brůžek

Published: August 30, 2018 • https://doi.org/10.1371/journal.pone.0201431

Discovery: Incomplete cranium found at Zlatý kůň site in Bohemian Karst.

Significance: Rare skeletal evidence of Late Glacial period human presence in Central Europe.

Reconstruction: Used mirroring and Thin-plate splines algorithm to virtually reconstruct missing parts of the cranium.

Sex Assignment: Corrected previous unfounded sex assignment through cranial measurements, primarily using a population-specific approach.

Morphological Affinity: Zlatý kůň specimen aligns with Upper Palaeolithic craniometric variation and exhibits pre-LGM population affinity.

Population Processes: Multiple interpretations proposed regarding complex population dynamics after the Last Glacial Maximum (LGM) in Europe.

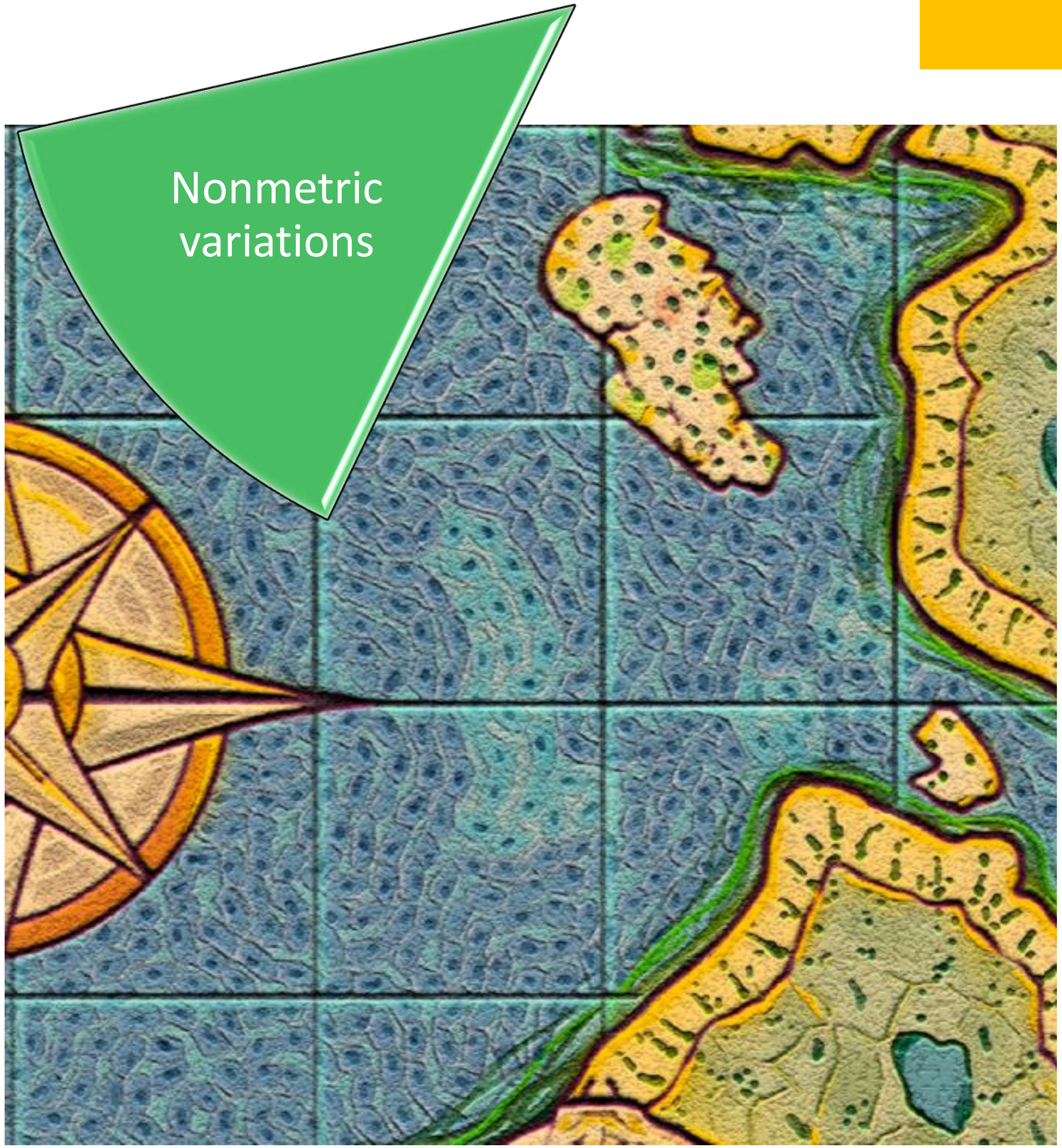
V. Non-metric Traits of the Skull

- ❑ **Biological affinities** estimation

- ❑ Human variability (individual & population)

- ❑ These characteristics are only typical & not diagnostic

→ may be seen at variable frequencies in all human populations



V. Biological Affinity

Affinity	Description
Australian Aborigine	Long cranium, deep set orbits, well developed brow ridges, pronounced postorbital constriction
San Bushman	Very short face, extremely prominent forehead, gracile skull form
American Indian	Round cranium, nasal overgrowth, shovel-shaped incisors, edge to edge bite, central incisors rotated toward midline, prominent zygomatics, smooth orbits, straight face
American Black	Long cranium, short face, smooth brow ridges, wide nasal aperture, nasal gutter, bregmatic depression, overbite, alveolar prognathism.
Euro-American	Variable cranial shape, variable size, narrow and orthognathic face, nasal sill, narrow nasal aperture, highly angled nasals, overbite, highest frequency of Carabelli's cusp.

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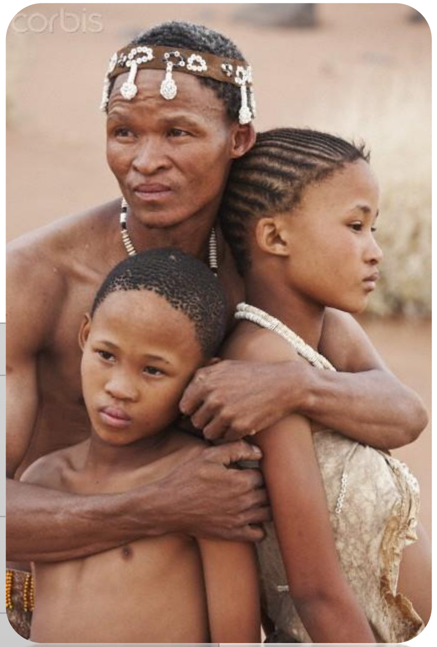

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V. Non-metric Traits: Biological Affinity

Apical bone: Accessory bone located at the intersection of the sagittal and lambdoidal sutures (lambda).

Bipartite occipital condyles: Division of the occipital condyles in the area of fusion between the basilar aspect of the occipital and the squamous portion of the occipital.

Bregma bone: Accessory bone located at the intersection of the coronal and sagittal sutures (bregma).

Maxillary torus: Bulging protuberance located on the lingual margins of the alveoli near the maxillary molars. Generally, maxillary tori are associated with culture groups that use their teeth as tools.

Frontal grooves: Supraorbital, shallow grooves which are tracks for vessels and nerves. May be seen running into the supraorbital notch/foramen. May or may not be present.

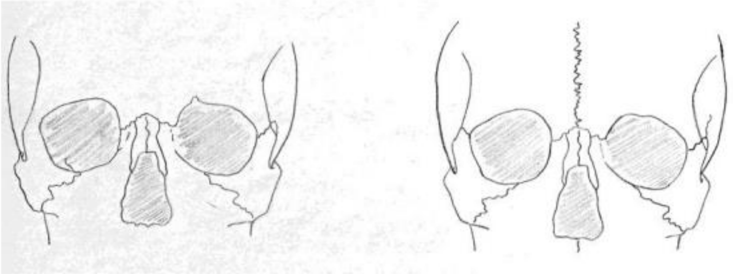
Metopic suture: Divides the frontal bone, located at midline. Generally, closes by eight years of age. If present, it should be scored as complete or partial.

Palatine torus: Bulging protuberance located on the along the lingual aspect of the palatine suture (associated with culture groups using their teeth as tools).

Mandibular torus: Bulging protuberance located on the lingual margins of the alveoli near the mandibular molars (associated with culture groups using their teeth as tools).

Mental Foramen: Foramina located on each side of the labial aspect of the mandible inferior to the second premolar. Usually singular, but may be multiple

V. Non-metric Traits: Biological Affinity



Metopic Suture
1. Absent
2. Present

Adapted from Buikstra and Ubelaker (1994)

International Journal of Legal Medicine (2021) 135:2509–2518
https://doi.org/10.1007/s00414-021-02654-4

ORIGINAL ARTICLE

Exploring the potential of cranial non-metric traits as a tool for personal identification: the never-ending dilemma

Andrea Palamenghi[1,2] · Alessia Borlando[1] · Danilo De Angelis[1] · Chiarella Sforza[2] · Cristina Cattaneo[1] · Daniele Gibelli[2]

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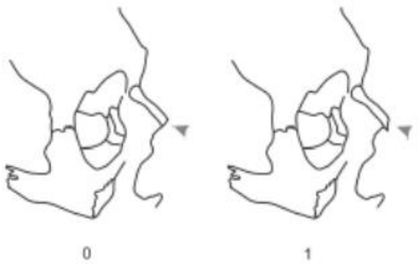
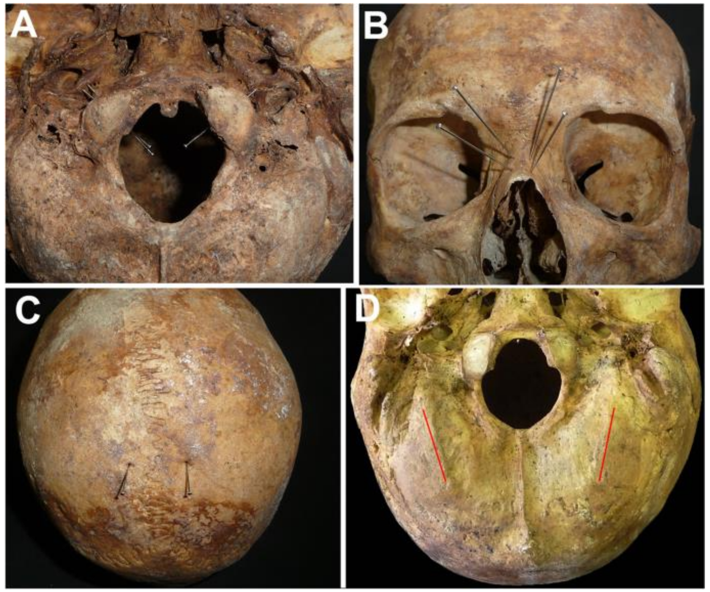
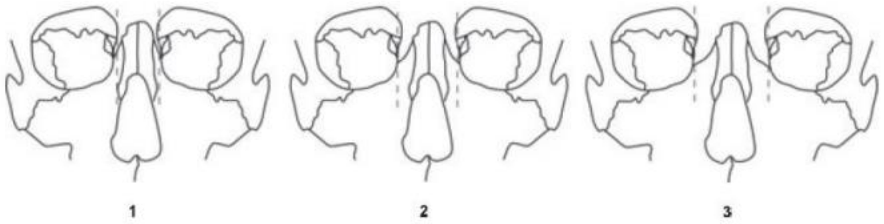


Nasal Overgrowth
1. Absent
2. Present.

Reproduced from Hefner (2009)

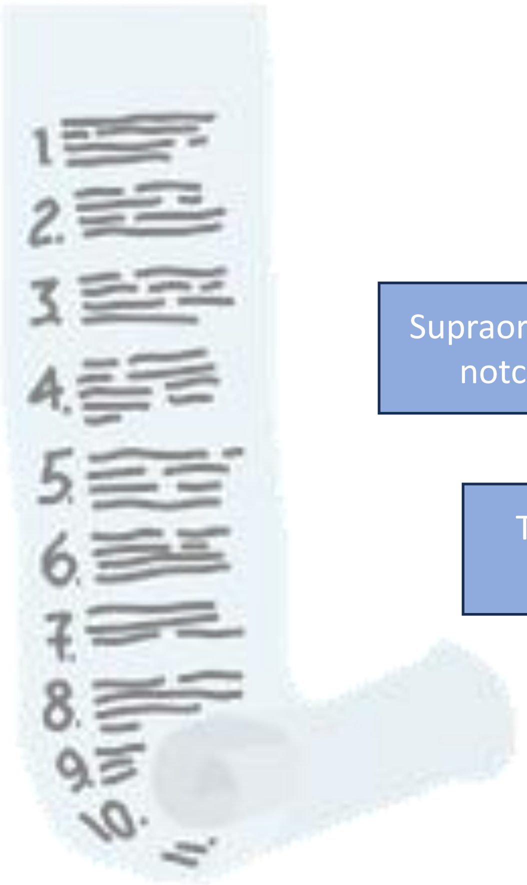




Interorbital Breadth
1. Narrow
2. Intermediate
3. Wide

Reproduced from Hefner (2009)

Non-metric Traits: Biological Affinity



Parietal notch bone

Parietal foramen

Supraorbital notch

Marginal tubercle

Inca bone

Infraorbital foramen

Mastoid foramen

Pterygo-spinous bridge/spur

Zygomatico-facial foramen

Pharyngeal tubercle/fossa

Trochlear spine

Tympanic dehiscence

Inion spike

Infraorbital suture

Pterygo-alar bridge/spur

Supraorbital foramen

Bioarchaeology of the Near East, 15:1–24 (2021)

The people of Avaris: Intra-regional biodistance analysis using dental non-metric traits

Nina Maaranen*[1], Sonia Zakrzewski[2], Arwa Kharobi[1], Chris Stantis[1,3], Silvia Prell[4], Manfred Bietak[4], Holger Schutkowski[1]
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Chowdhry *et al.*
Egyptian Journal of Forensic Sciences (2023) 13:8
https://doi.org/10.1186/s41935-023-00329-2

Egyptian Journal of Forensic Sciences

ORIGINAL ARTICLE **Open Access**

Check for updates

Study of twenty non-metric dental crown traits using ASUDAS system in NCR (India) population

Aman Chowdhry[1*], Deepika Bablani Popli[2], Keya Sircar[2] and Priyanka Kapoor[3]

SYSTEMATIC REVISION

Carabelli's trait: Definition and review of a commonly used dental non-metric variable

Luís Miguel Marado*[1,2], Vanessa Campanacho[2,3]

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[2]CIAS: Centro de Investigação em Antropologia e Saúde, Universidade de Coimbra, Portugal

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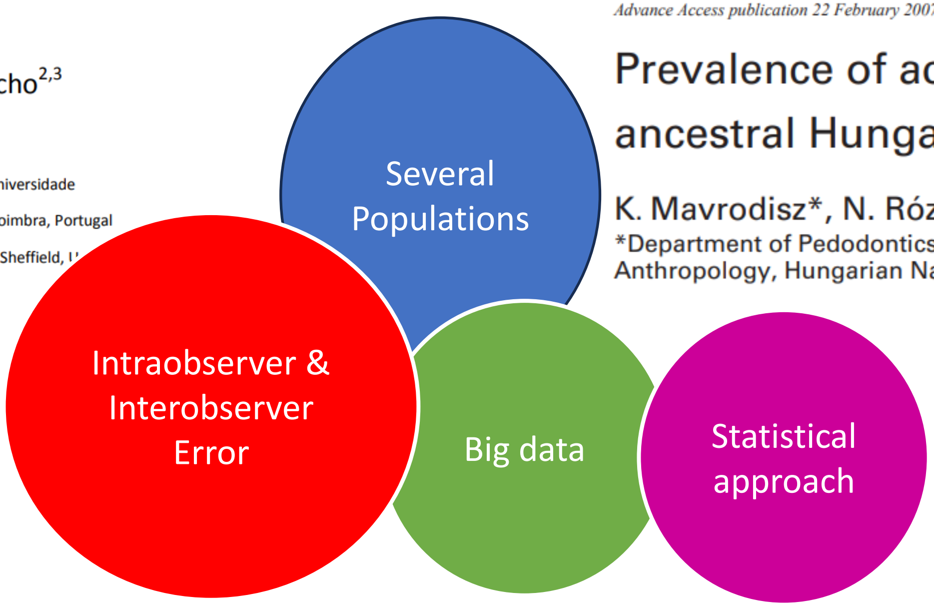
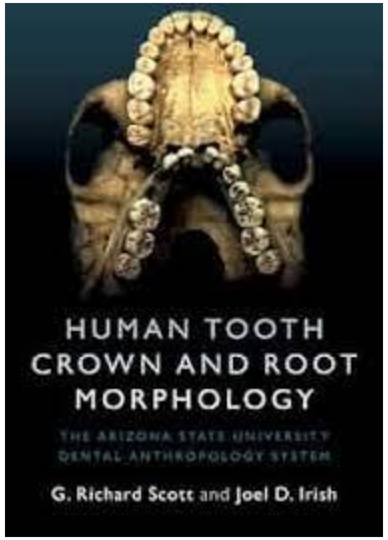
Prevalence of accessory tooth cusps in a contemporary and ancestral Hungarian population

K. Mavrodisz*, N. Rózsa*, M. Budai*, A. Soós*, I. Pap** and I. Tarján*
*Department of Pedodontics and Orthodontics, Dental Faculty, Semmelweis University and **Department of Anthropology, Hungarian Natural History Museum, Budapest, Hungary



The ASUDAS

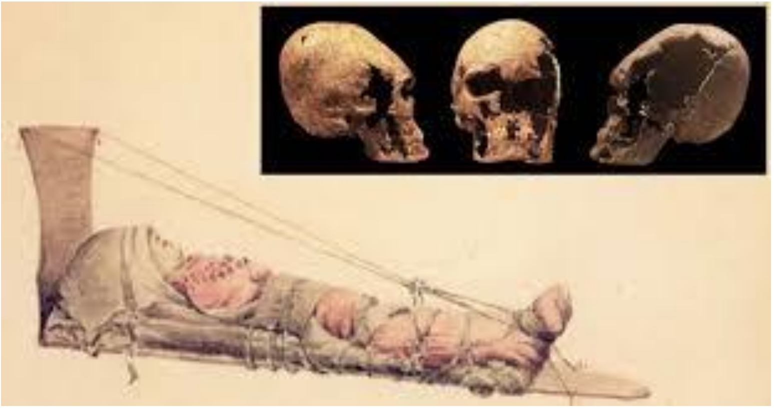
- Arizona State University Dental Anthropology System
- a reference system for collecting data on human tooth morphology & variation
- created by Christy G. Turner II, Christian R. Nichol, and G. Richard Scott.



VI. Cranial Deformations

Cranial deformation

Artificial/Cultural	Accidental
practiced purposely number of cultures globally to show social status, ethnic affiliation, or beauty.	an infant strapped to a cradle board for a long period of time, or to lay flat on their back



VI. Cranial Deformations

On teeth

Where and when?

- Diverse contexts in the Old & New Worlds

How?

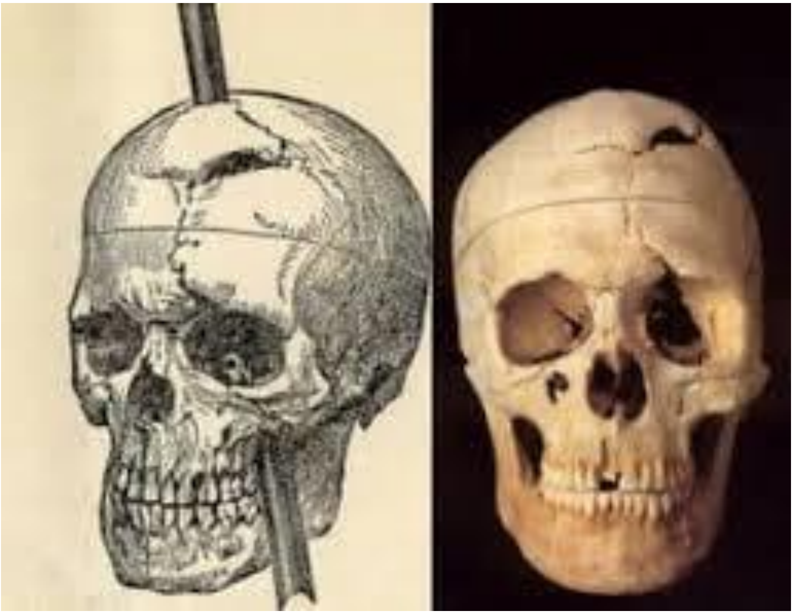
- Intentional, traumatic process
  - Chipping
  - Avulsion
  - Inlay

Why?

- Social identity, e.g., warriors (filed teeth) from the Viking Age, Scandinavia & England

Risks:

infection & death

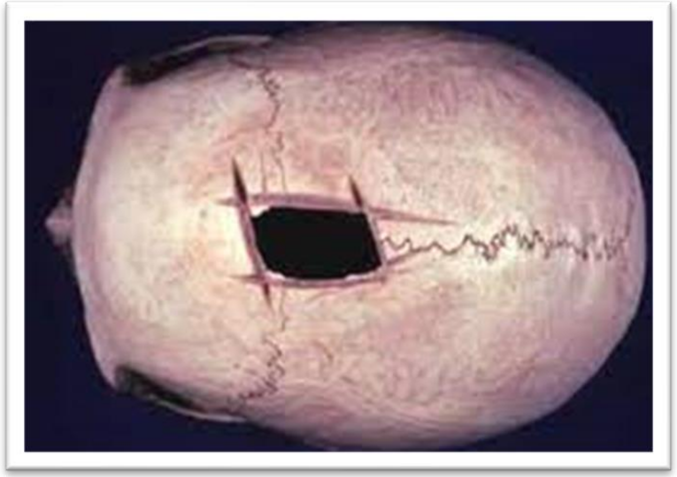


VI. Cranial deformation: Also Trauma

VII. Skulls & Trephination

- Early form of cranial surgery
- Purpose is unknown (decreasing cranial pressure, allowing detrimental spirits to escape)
- Two forms are common

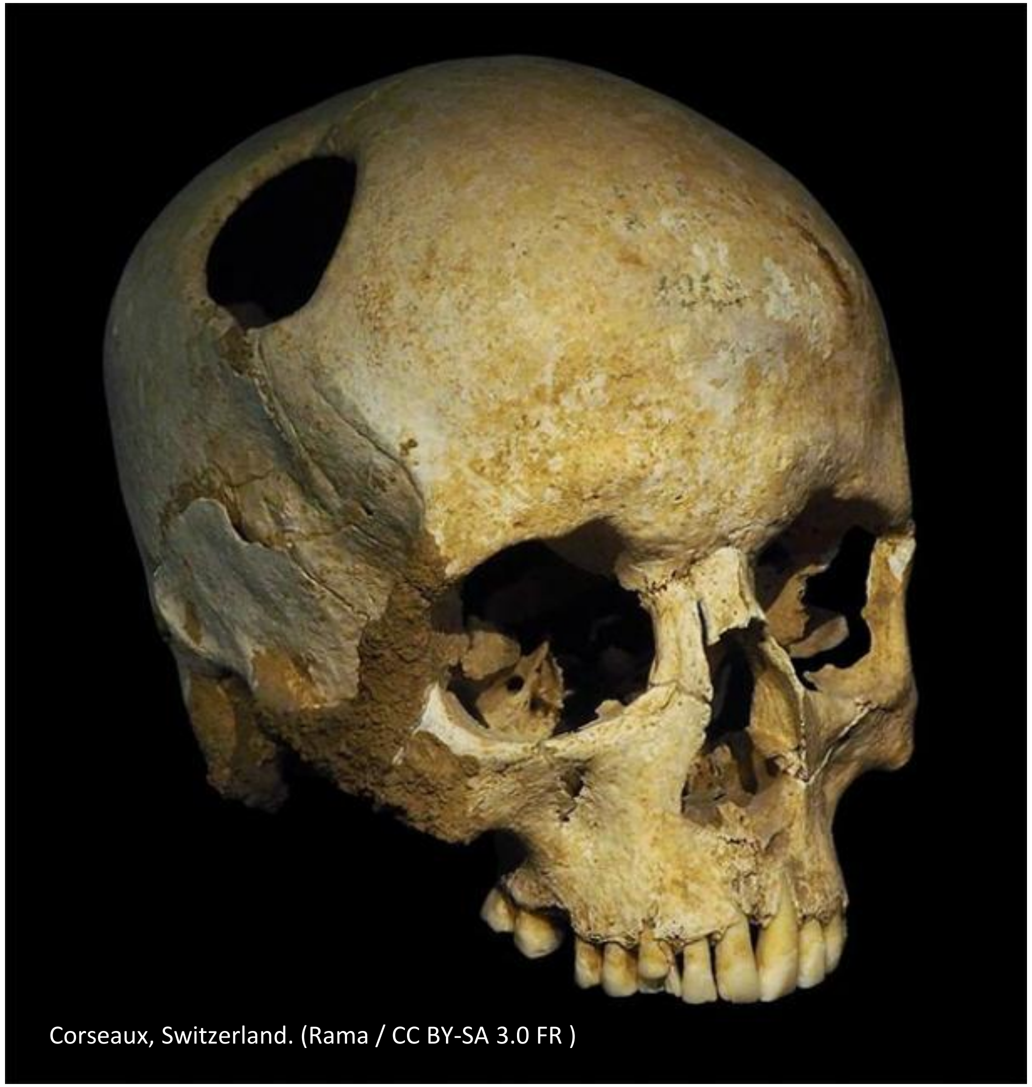
1. **Scraping**: employs a sharp surface & scrape across the cranium until a hole is made.
2. **Cutting**: employs a sharp tool & make linear cuts creating a square fragment of bone that is popped out after perforating the full thickness of the bone.



In either method, it is necessary to not penetrate too deeply to protect the dura which aids in holding infection at bay.


AF:1729
1984

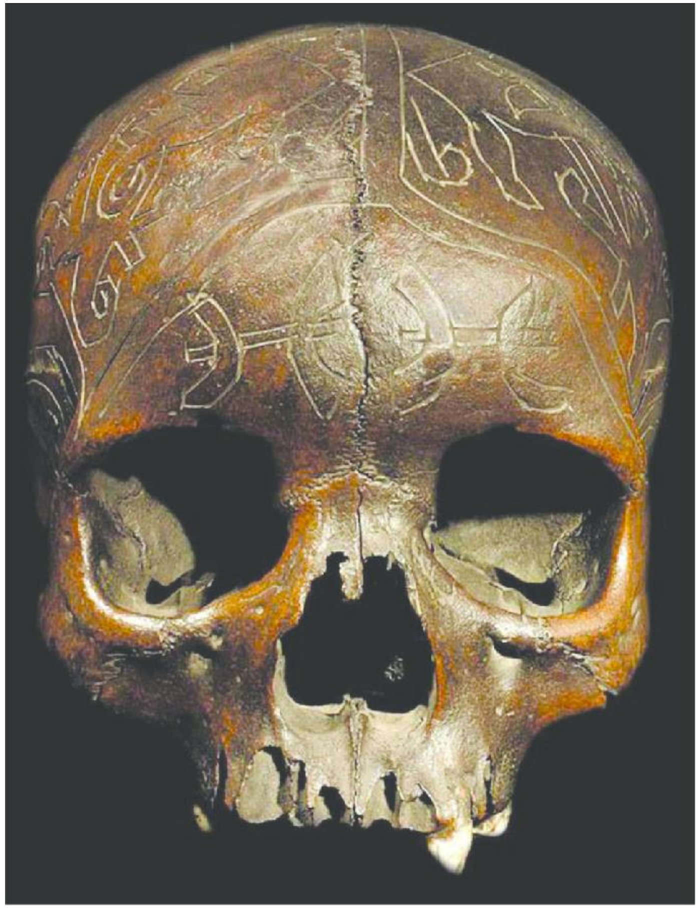
Another Peruvian skull found with evidence of the trephination surgery from 2000 years ago presumably to relieve a front cavity inflammation.



The perimeter of the trephination hole in this Neolithic skull is rounded off by ingrowth of new bony tissue, indicating that the patient survived the operation.

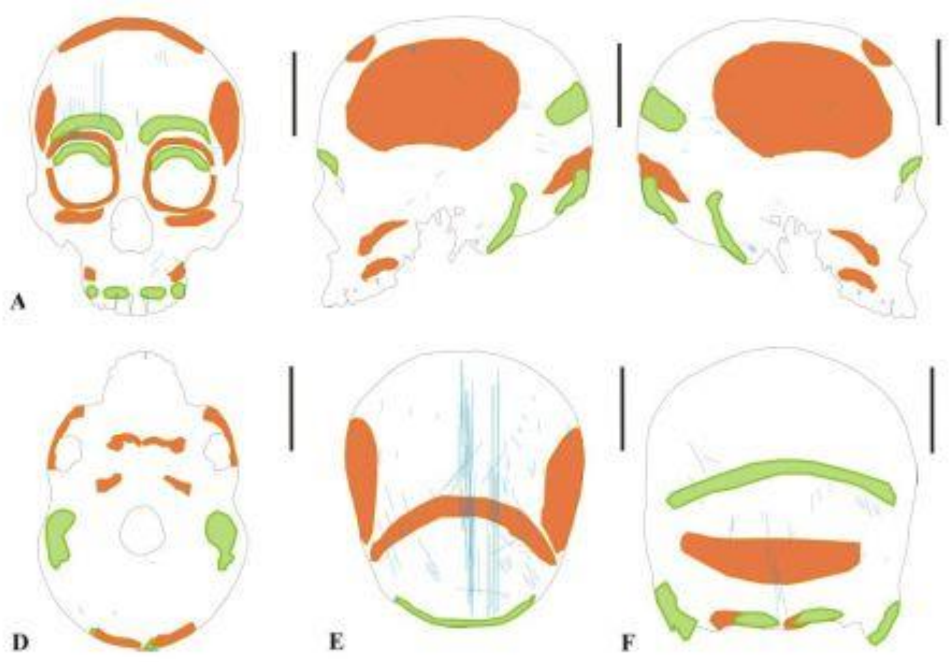
Case studies

- Skull cups
- Shrunken heads
- Plastered skulls



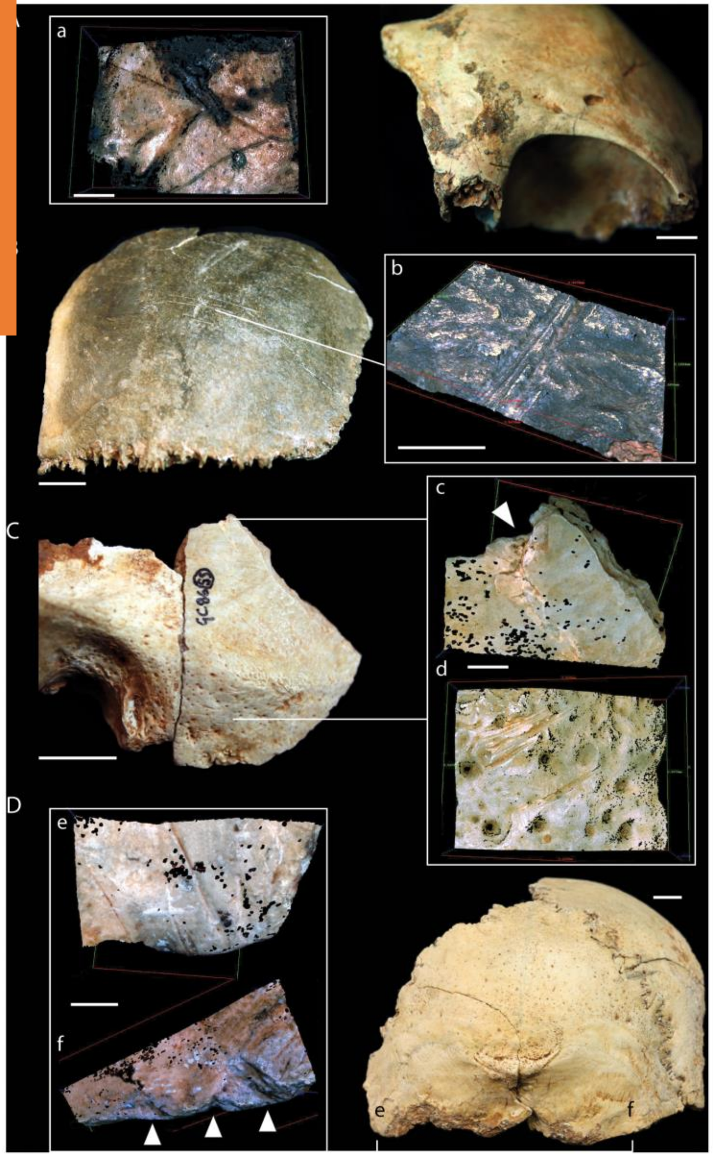
Skull Cups

- ❑Skulls from the UK (Oldest 14,700 cal BP), France, Spain & Germany
- ❑Turning the skulls into bowls, decorations and even war trophies
- ❑Some ancient societies considered that humans skulls possessed powers or life force
- ❑Marks on the skulls related to cutting the scalp, produced by stone tools or metal knives

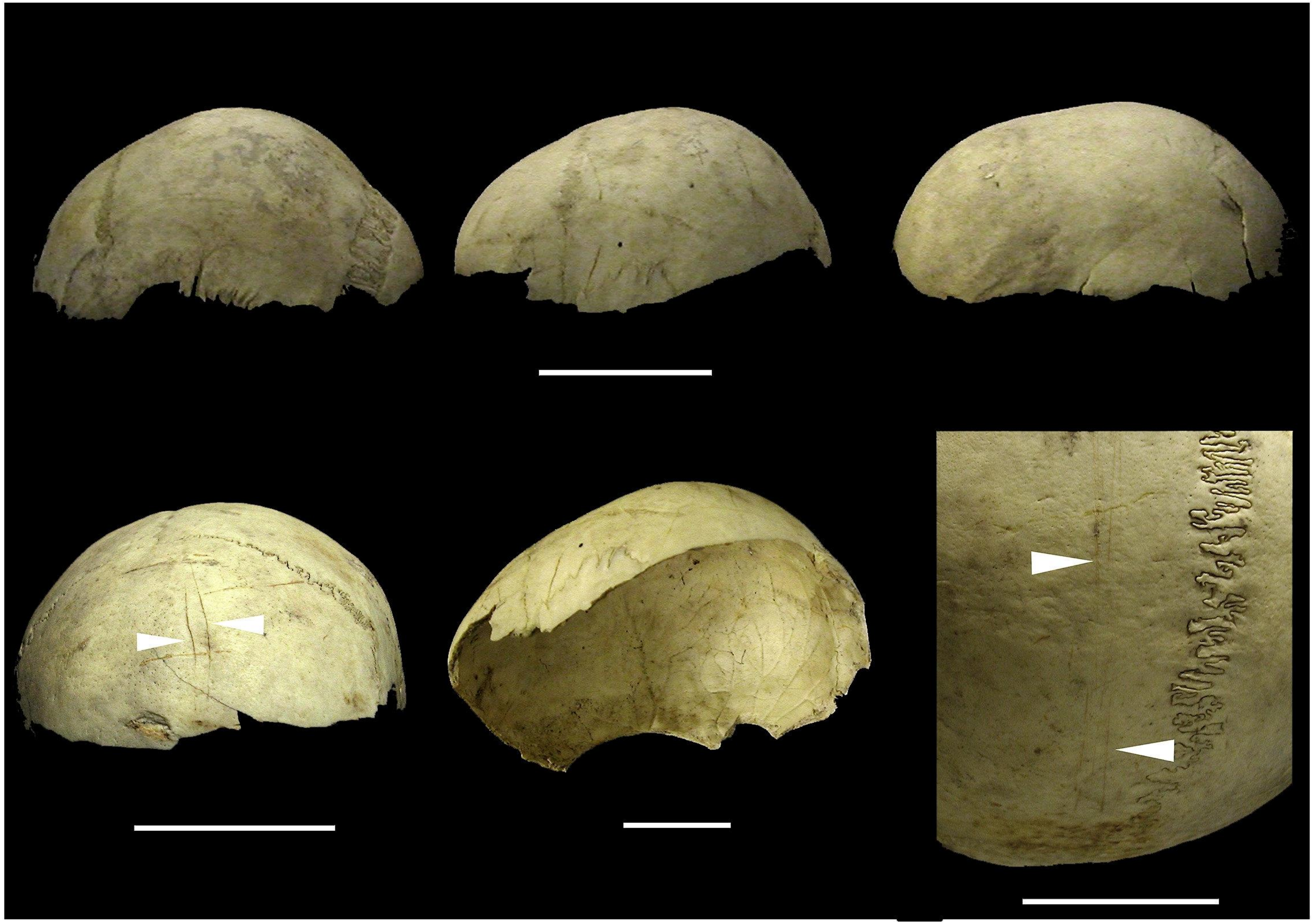


Marginedas et al, 2020

Skull Cups



Bello et al, 2011
Marginedas et al, 2020



Shrunken Heads

Where & when? only been documented in the northwestern region of the Amazon rainforest


Pitt Rivers Museum, Oxford.

Process of head shrinking:

- Removing the skull from the neck.
- Making an incision on the back of the ear.
- Removing all skin and flesh from the cranium.
- Placing red seeds under the nostrils and sewing the lips shut.
- Holding the mouth together with three palm pins.
- Removing fat from the flesh of the head.
- Placing a wooden ball under the flesh to maintain its form.
- Boiling the flesh in water saturated with herbs containing tannins.
- Drying the head with hot rocks and sand while molding it to retain human features.
- Rubbing the skin with charcoal ash.
- Optionally adding decorative beads to the head.

Shrunken Heads

collection of Ye Olde Curiosity Shop, Seattle

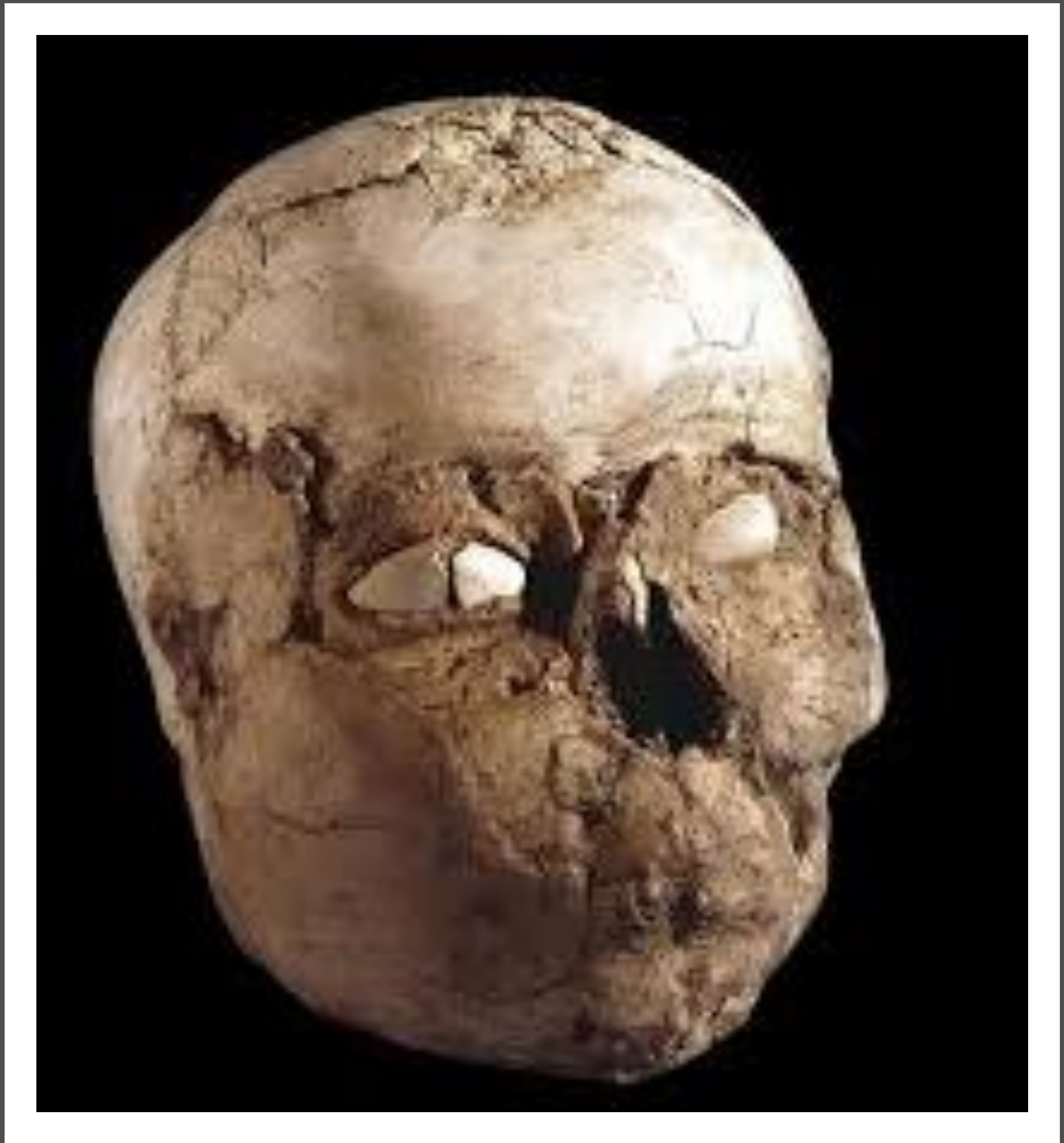
a severed and specially-prepared human head – often decreased to many times smaller than typical size – that is used for:

trophy,

ritual,

trade,

or other purposes



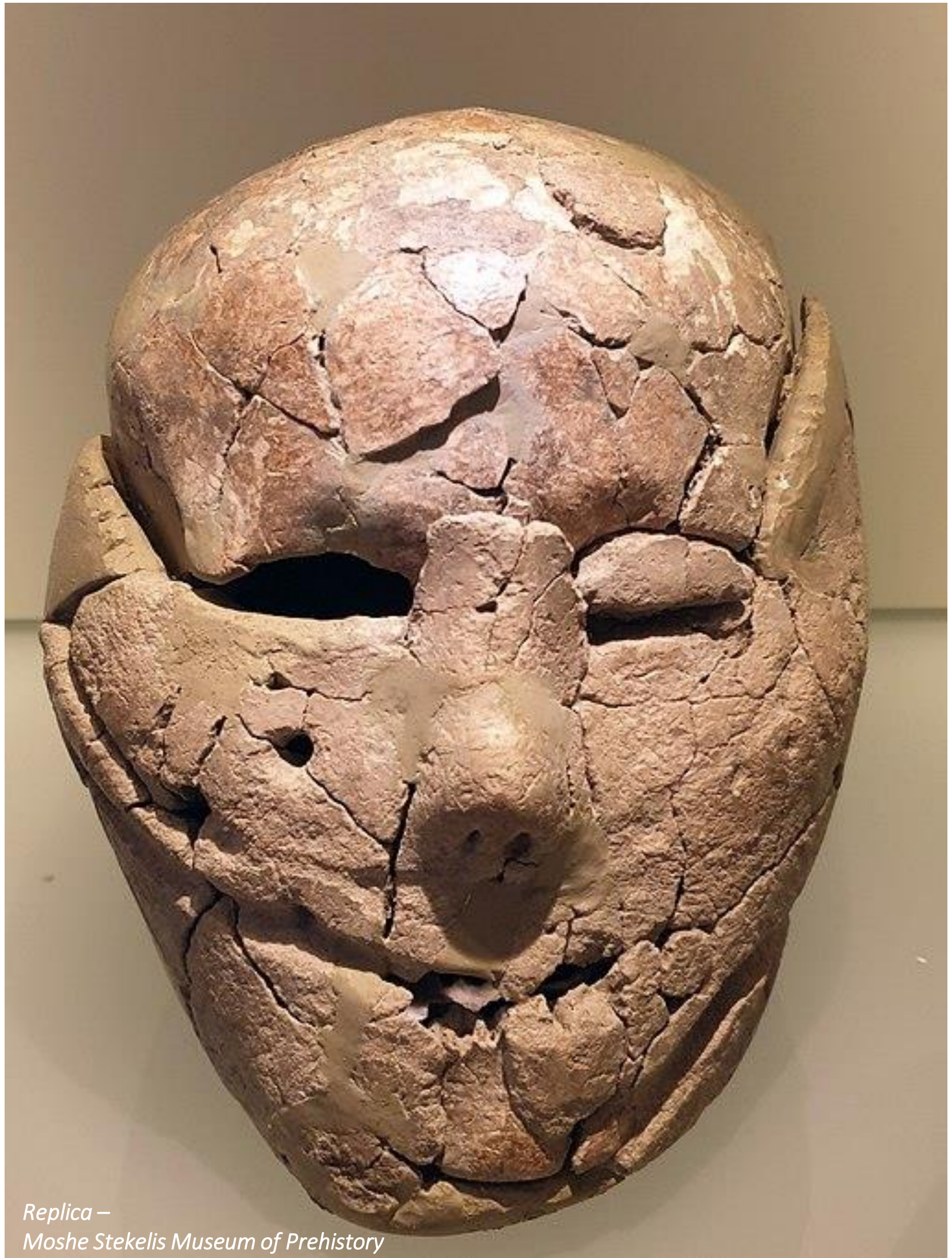

Plastered Skulls

Where & when? Pre-Pottery Neolithic Age, Jericho in the West Bank

Techniques:

1. skull was removed from the body,
2. its cavities filled with plaster and painted.
3. shells were inset for eyes,
4. paint was used to represent facial features, hair, and mustaches.

Significance: Ancestral cult, enemies' trophies?



Replica –
Moshe Stekelis Museum of Prehistory

religious

secular

memorial

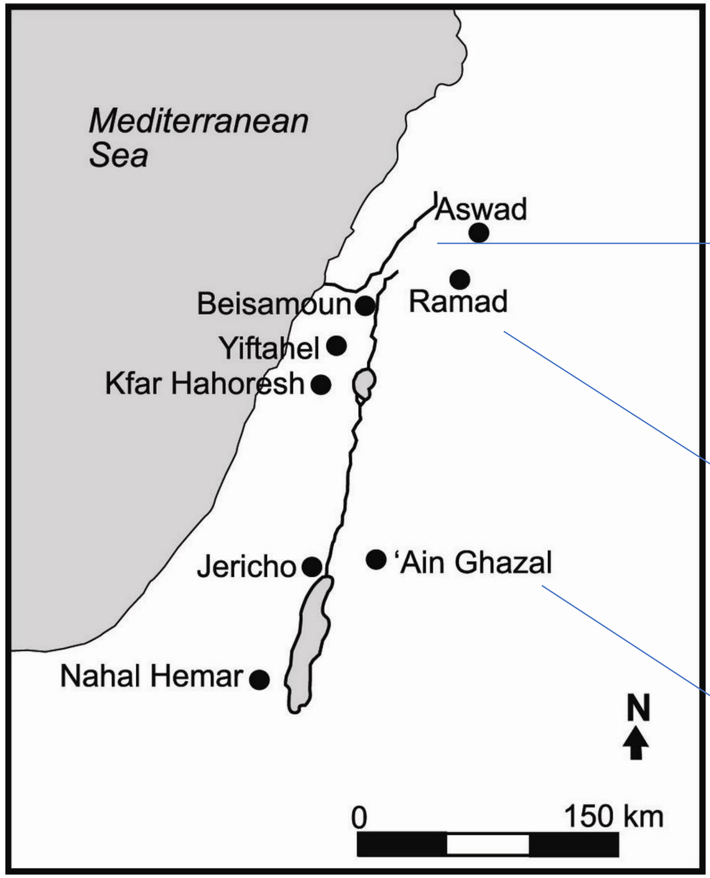
rituals of necromancy

protection against enemy spirits

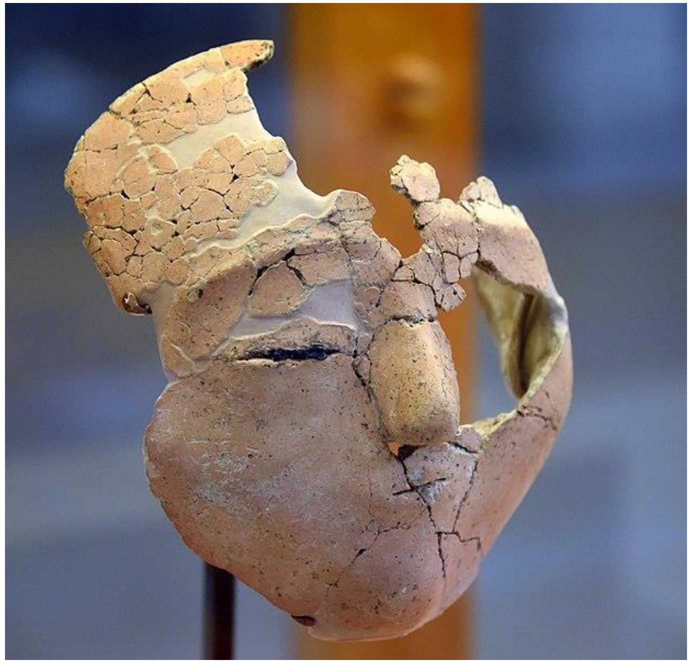
vanquished enemies

ancestral cult

trophies of war



Archaeological sites where artificial remodeled skulls have been found are marked with black dots.

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