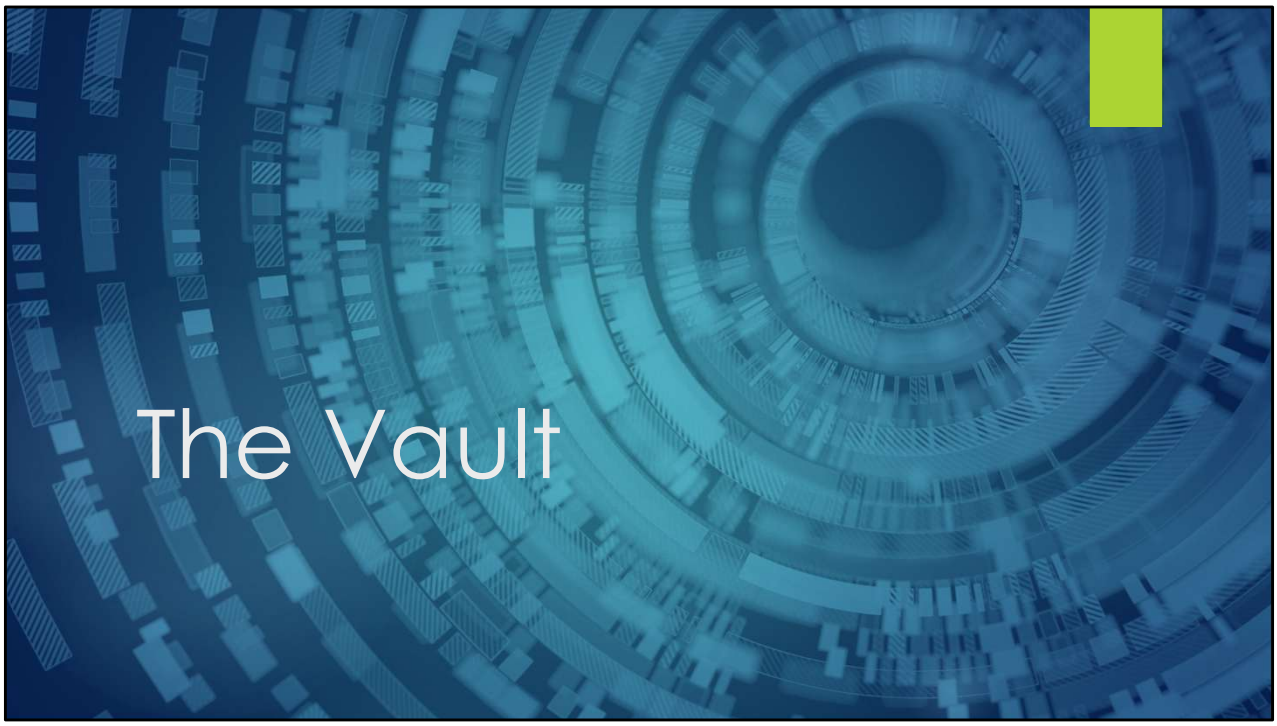
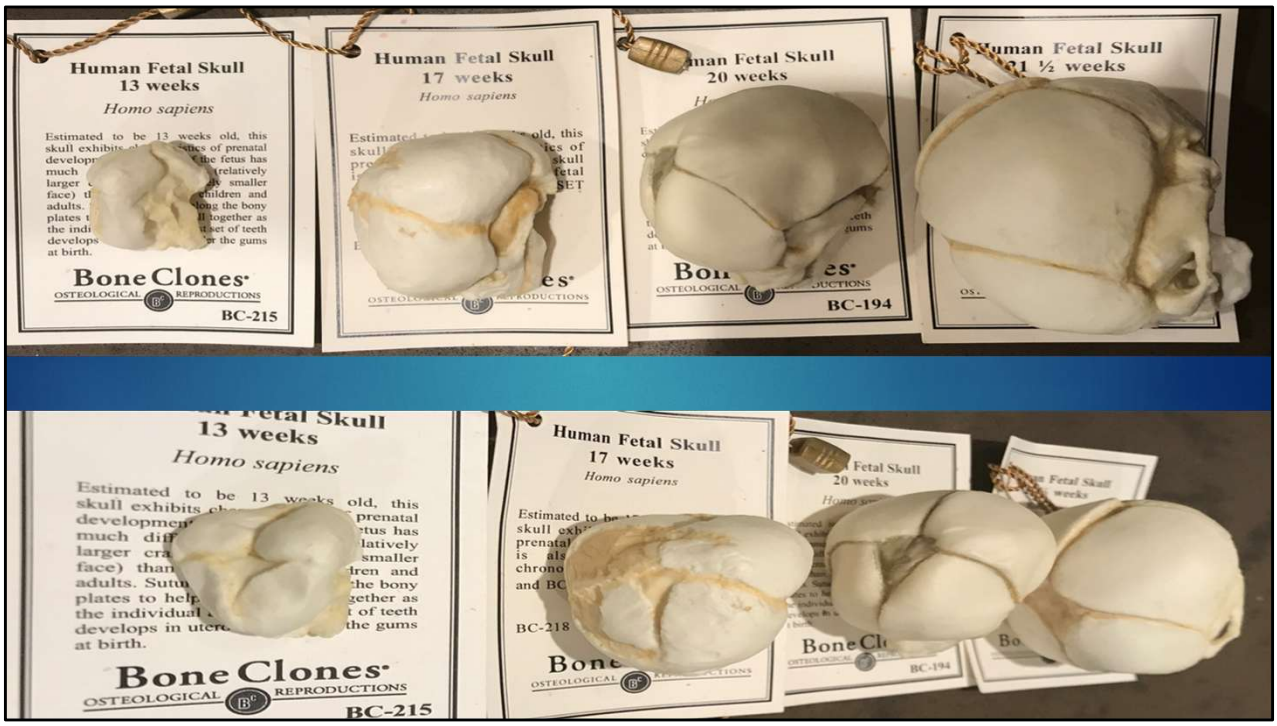
The Cranial Vault

VICTOR NUÑO, D.O.

Welcome to your next lecture on OCMM! We will continue to explore the anatomy and clinical indications for the use of this modality. This lecture is on the vault. There will be one PowerPoint for all three.



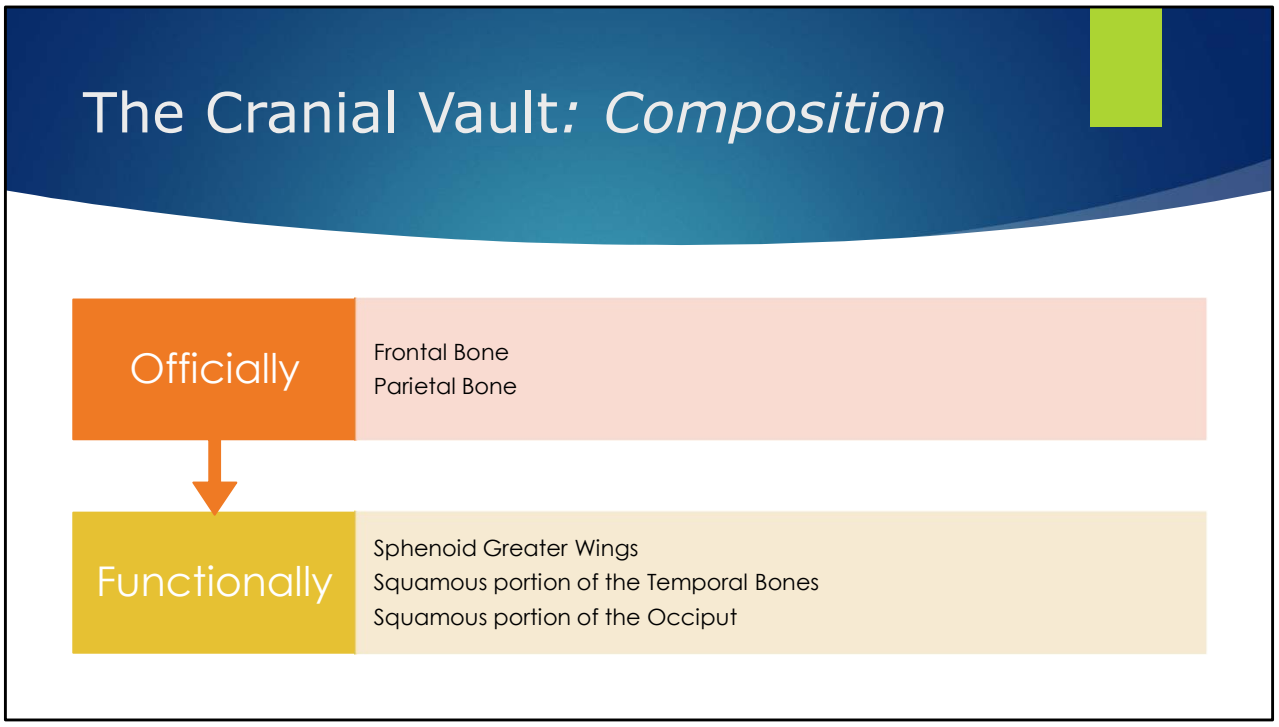
Welcome to Part 3 of your cranial base fees and Vault lecture will be running through a vault anatomy now.



So I just wanted to begin by putting this in here. But I find these fascinating personality. These are from my collection of fetal skulls which you're all welcome to come and look at a little bit more closely. But just a reminder of where this anatomy comes from that we will be talking about and what it looks like as it develops and grows. And this gives you some context for what these bones look like in the adult head, but also where they come from and their development. So they're the same skulls on the upper and lower rows, just a different angle of them. So 13 week, 17 weeks, 20 weeks, and 21.5 weeks gestation. And again, just keep this anatomy in mind. We're going to be talking about the vault a little bit later. You can see the differences in the vault which forms in membrane on these upper bones that are thin and stretch and form from that expansion of the membrane versus compression of the lower portion or base that's forming in cartilage, which we're also going to be talking about in just a second. So again, you can kind of see the differences in how these look in these fetal skulls as they're developing and what these landmarks look like over time.

Objectives

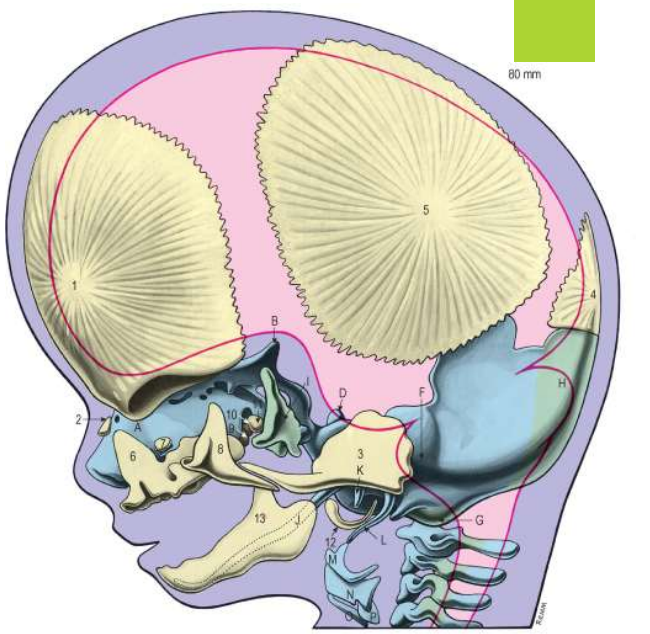
- Identify the components of the cranial vault and base, including anatomic landmarks and articulations
- Recognize the developmental origin of the vault bones and associated structures, along with examples of their osteopathic clinical significance
- Recognize key features of normal primary respiratory mechanism (PRM) motion of the frontal and parietal bones, including axes of motion, and anatomic influences



So the cranial vault consists oofficially the frontal bone and parietal bone. However, functionally it also includes the greater wings of the sphenoid, squamous portion of the temporal bone and the squamous portion of the occiput. We have already talked about some of these other structures so we will be focusing here on frontal and parietal bones in the lecture. But these, these are all functionally considered vault because of how they form in membrane as we have talked about before.

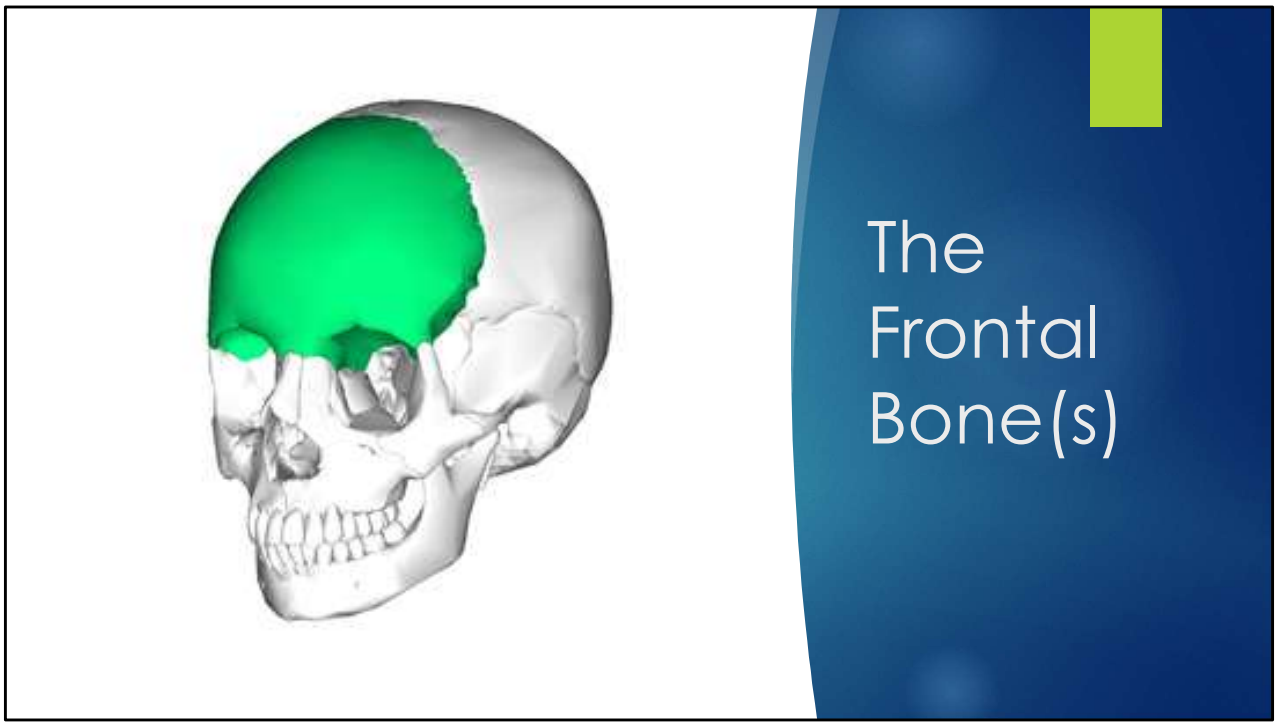
The Cranial Vault

- Bones formed embryologically in membrane
- Held internally by the dura and its folds
- Thin bone
- Key in accommodation:
  - Processes of labor and birth
  - Developing and expanding brain
  - Impact of trauma/injury by absorbing shock and distributing forces
  - Alterations in the cranial base



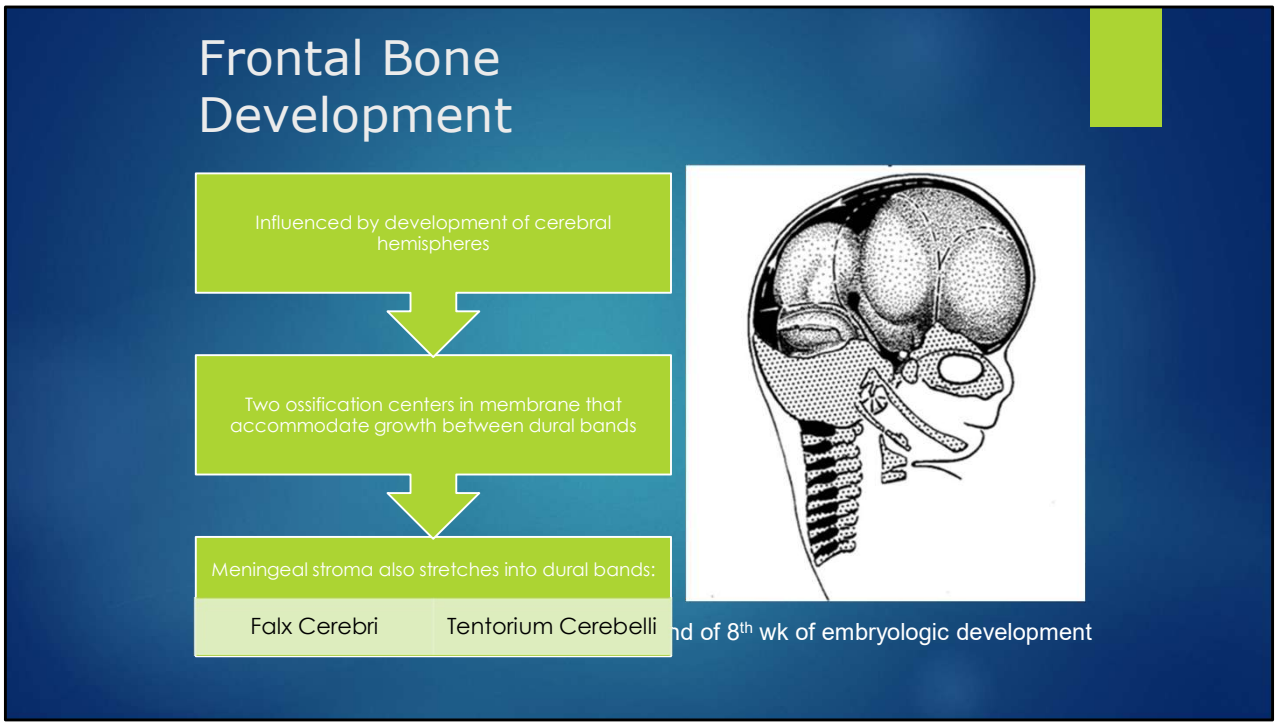
Dura: falx and tent
Formed in membrane by expansion vs formed in cartilage by compression

So again, bones formed embryologically in membrane, so held internally by the dura and it's folds. And it is a very thin bone as you guys have hopefully seen now throughout these images, but also in lab. And make sure to look at some real bone specimens if you haven't had a chance, happy to help you do that. But it's really helpful for understanding.
And these bones form by the developing and expanding brain, expanding this tissue as it's laying down. Unlike again, are our cartilaginous portion as we've talked about before at the base is forming from the compression of the growing CNS.
But a reminder that all of this skull is forming secondary ultimately to the developing central nervous system. So the cranial vault is key for accommodation, especially in labor and birth. And we'll be talking about this more again later in our clinical indications lecture. But the impact of trauma or injury can be huge because these bones are so thin and some of their connections so vulnerable. And then alterations in the cranial base are sometimes seen by through accommodation in the vault as well.



By Anatomography (en:Anatomography (setting page of this image)) [CC BY-SA 2.1 jp (http://creativecommons.org/licenses/by-sa/2.1/jp/deed.en)], via Wikimedia Commons

So looking at our frontal bones first,

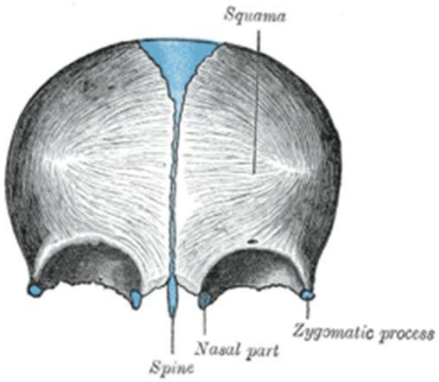


they develop secondary to the development of the cerebral hemispheres and their expansion and growth over time. They have two ossification centers in that membrane that accommodate this growth between dural bands and the meningeal stroma also stretches and becomes the falx cerebri and the tentorium cerebelli. So this is a picture of what's happening at the end of the 8th week. So it's impressive how rapidly this develops and changes over time.

And again, remembering that this bone is developing secondary to that central nervous system as it grows and expands.

Metopic Suture

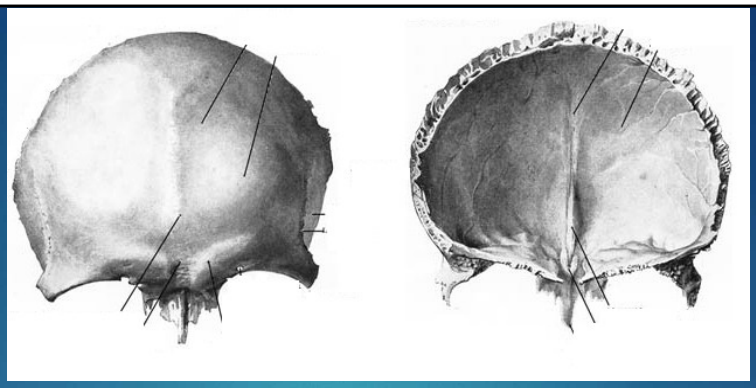
- Usually, fusion starts at age 2, and finishes at age 6-8 years
- Persists into adulthood in some
  - According to one recent study of adult human skulls in India, 55% had complete fusion, and 5% had complete patency, with the remaining 40% with various types of incomplete fusion



Chandrasekaran, Shanta, and Deepti Shastri. "A study on Metopic Suture in Adult South Indian Skull." *IJBMS*, volume 7, issue 1, April 2016.

Looking at a metopic suture, we have these two bones at birth -two individuals frontal bones. And here's our metopic, suture down the midline, including the frontal spine down here at the tip, which doesn't fuse until a patient's around 12 years old. And then we have our bony ossification centers, one in each bone and these become our frontal eminences.

So fusion of this metopic suture usually begins around age two and finishes at between six to eight years old, but may persist into adulthood. And many, some studies have show about 55 percent. Some studies may be lower or higher. So it's hard to know exactly. But remembering that even at when this suture is because this is living bone and not our fragile bone that we see in an anatomy lab or on dry specimens, but living flexible tissue, these functionally two paired bones, no matter where it will feel like separate paired PRM motion in the living skull.



Frontal Bone Anatomy

Vertical portion

Squama frontalis (forehead)

Horizontal portion

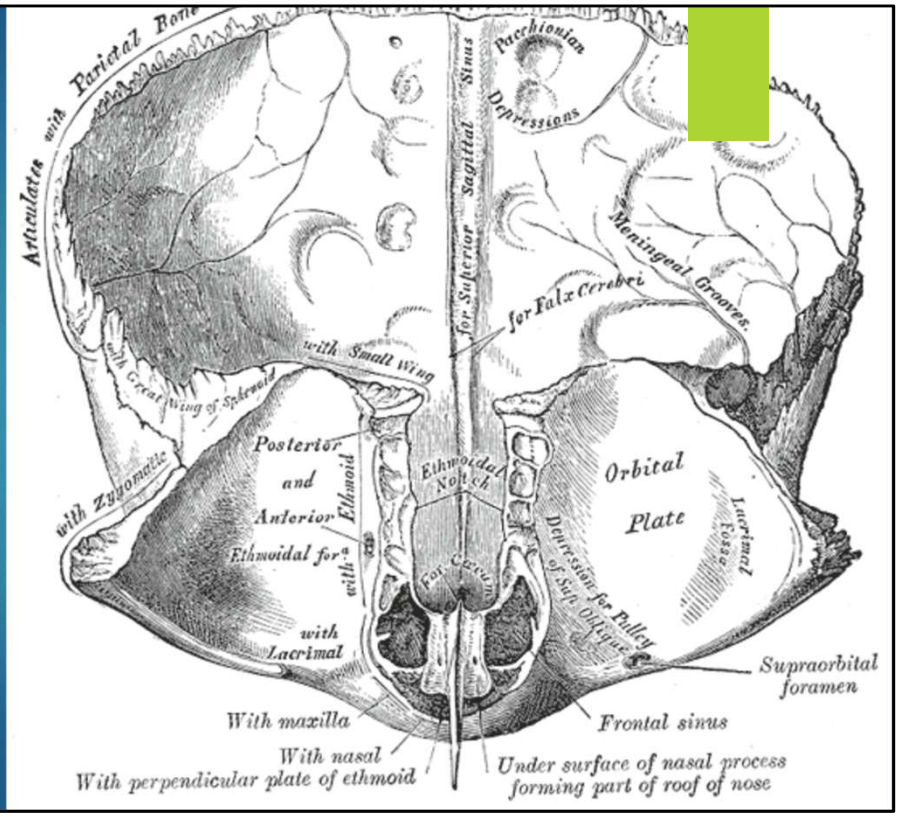
Pars orbitalis (roof of the orbits)

Pars nasalis (roof of the nasal cavities)

So frontal bone anatomy, Here's an anterior view is vertical portion is again this squama frontalis. So this is what forms really in the membrane versus again this inferior portion forms in cartilage and more from compression. This is looking at the flip side of this bone so the interior surface of this frontal bone and you can see we have the pars orbitalis and pars nasalis which form the roofs of the orbits and nasal bones respectively.

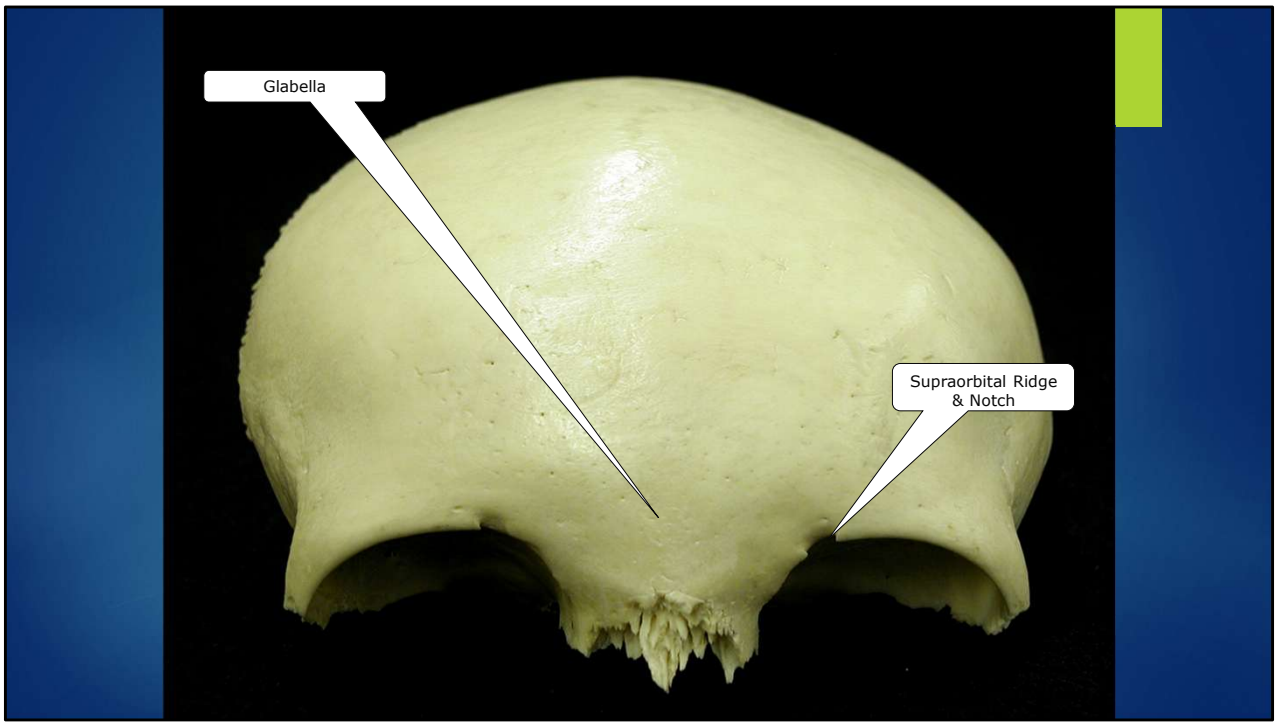
Frontal Bone Landmarks

- External Aspect
  - Glabella
  - Metopic Suture
  - Supraorbital Ridge & Notch
  - Frontal Eminences
  - Bregma
  - Pterion
- Internal Aspect
  - Frontal crest
  - Ethmoid Notch
  - Orbital Plates
  - Frontal Spine



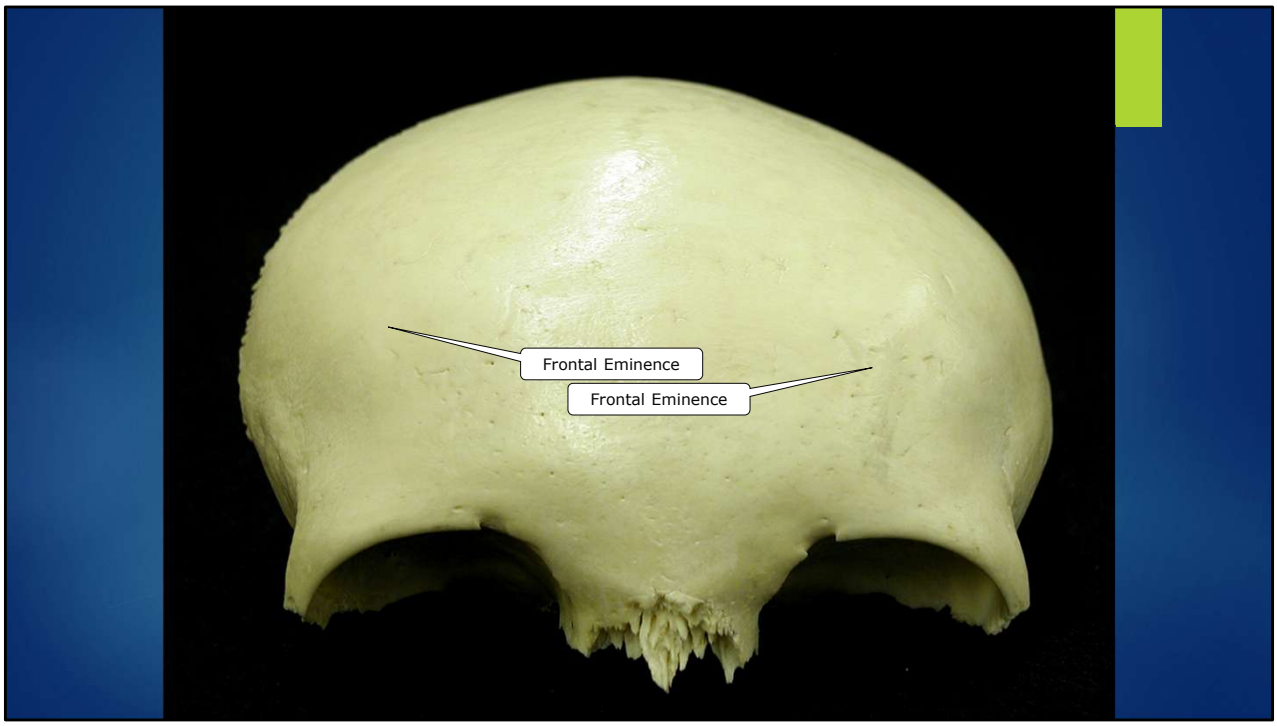
- Glabella - just above nasion (midpoint of frontonasal suture)
- Supraorbital notch/foramen – contains supraorbital nerve which is terminal branch of V1's frontal nerve branch that provides sensory to forehead, frontal sinus, and conjunctiva of eyeball
- Frontal eminences – former ossification centers
- Bregma – junction of coronal an sagittal sutures, anterior fontanelle
- Frontal crest – falx cerebri attachment
- Ethmoid notch – separates orbital plate, filled with cribiform plate in skull, margins contain half-cells of ethmoid air cells
- Orbital plates form vaults of the orbits
- Frontal spine aka superior nasal spine – projects inferiorly to articulate with nasal bones

- So some frontal bone landmarks again, please take some time to find each of these and familiarize yourself with them. And we'll be going over a lot of these on real bone pictures over the next few slides as well.

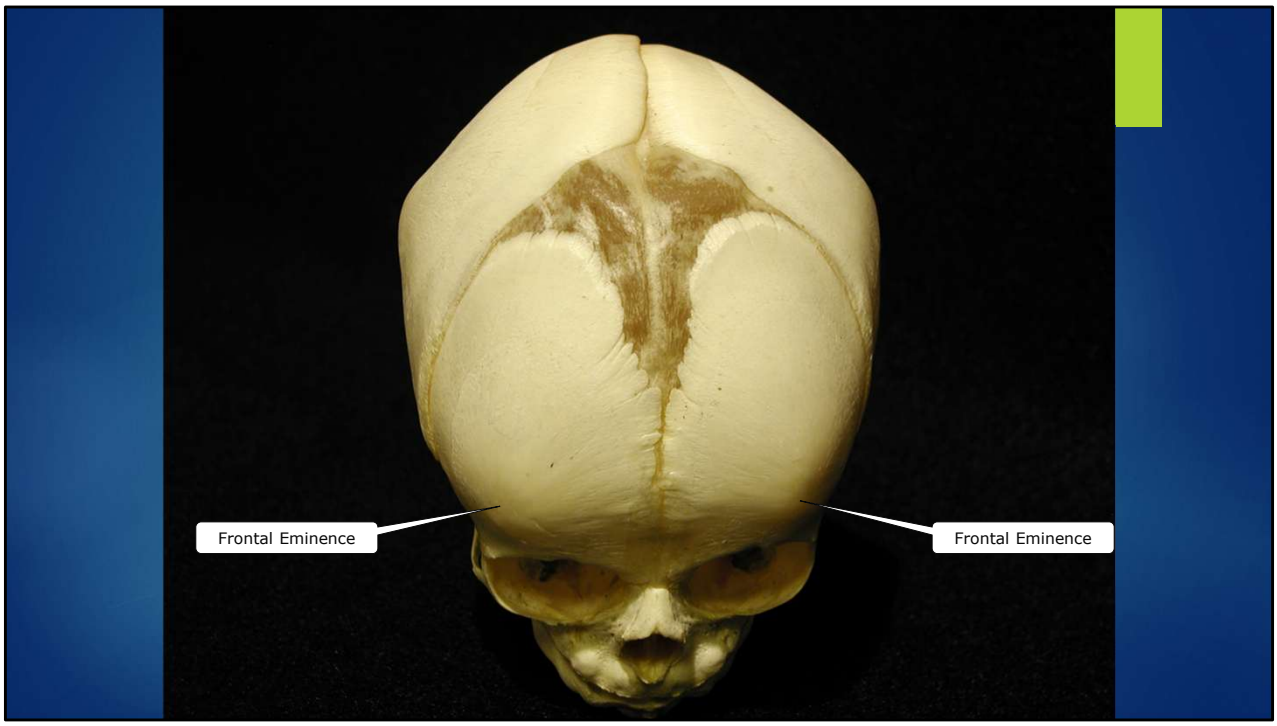


Frontal Bone Anterior View

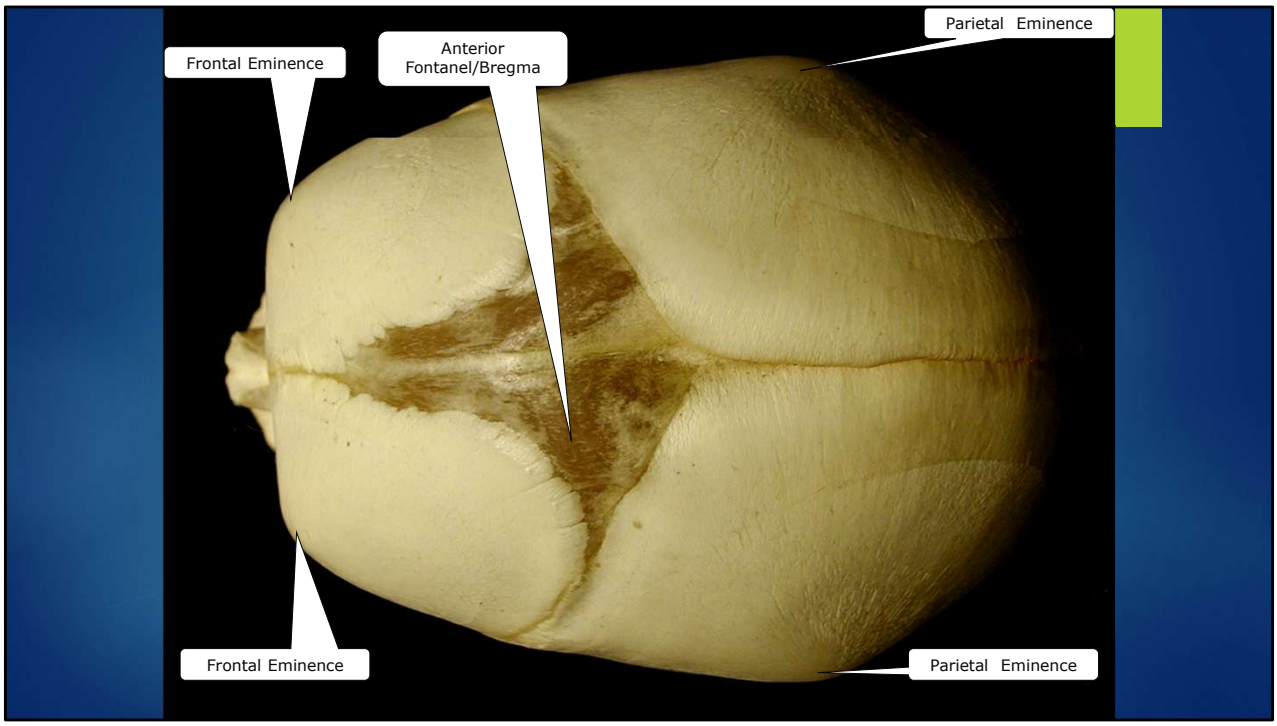
So here's again, an anterior view to this metopic suture is fused here. Here's glabella in the midline between the superior orbital ridges. Here is the supraorbital ridge and the super orbital notch.



Here are our frontal eminences – prominences where former ossification centers were located



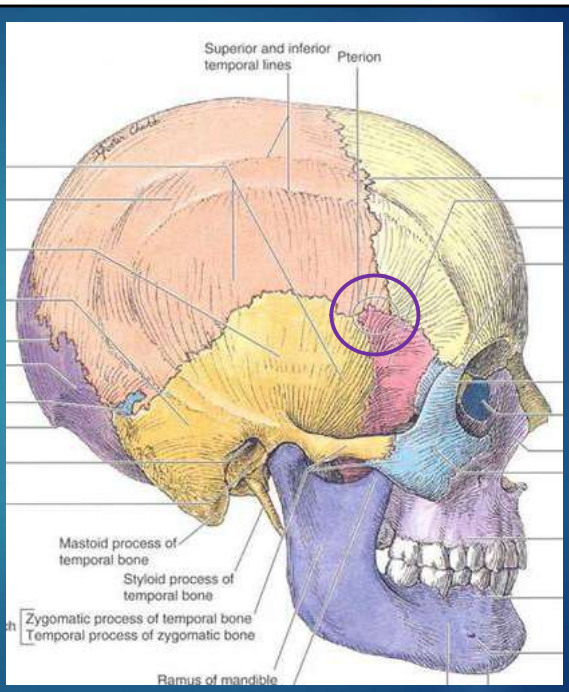
Looking at a fetal skull, here's where those frontal eminences lies. You can see these prominences And if you look closely, you can see this line up here where that bone, then new ossifying bone is extending outwards from those frontal eminences as it's laid down, just to orient you again, this is a coronal sutures, sagittal suture and this is our bregma However, again, in infants, they're soft spot, which we call the anterior fontanelle.



90% close between 7 and 19 months of age.
http://pediatrics.aappublications.org/content/6/2/223.abstract

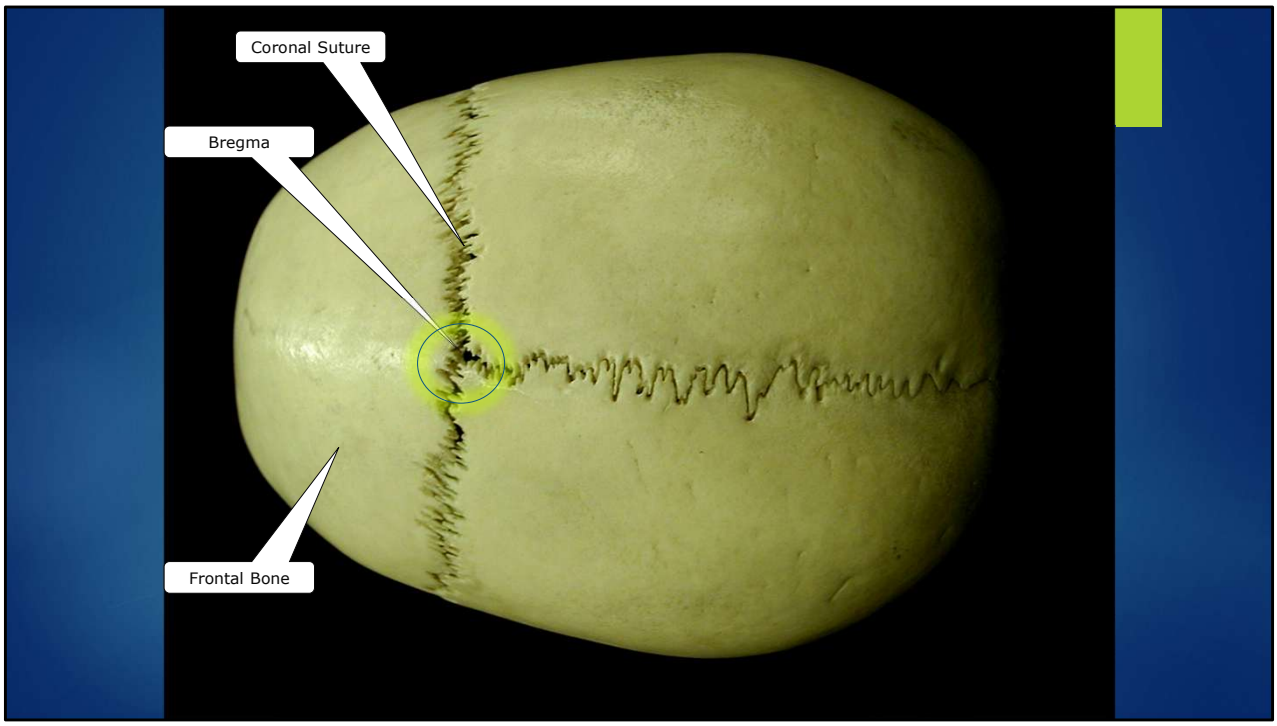
Here's another view of that. The frontal eminences. You can see these prominences, again, anterior fontanelle or bregma, and then parietal eminences. We're going to talk about parietal bones in just a little bit, but also the ossification center for each of these. And again, you can see that ossifying bone extending out from those eminences.

Pterion

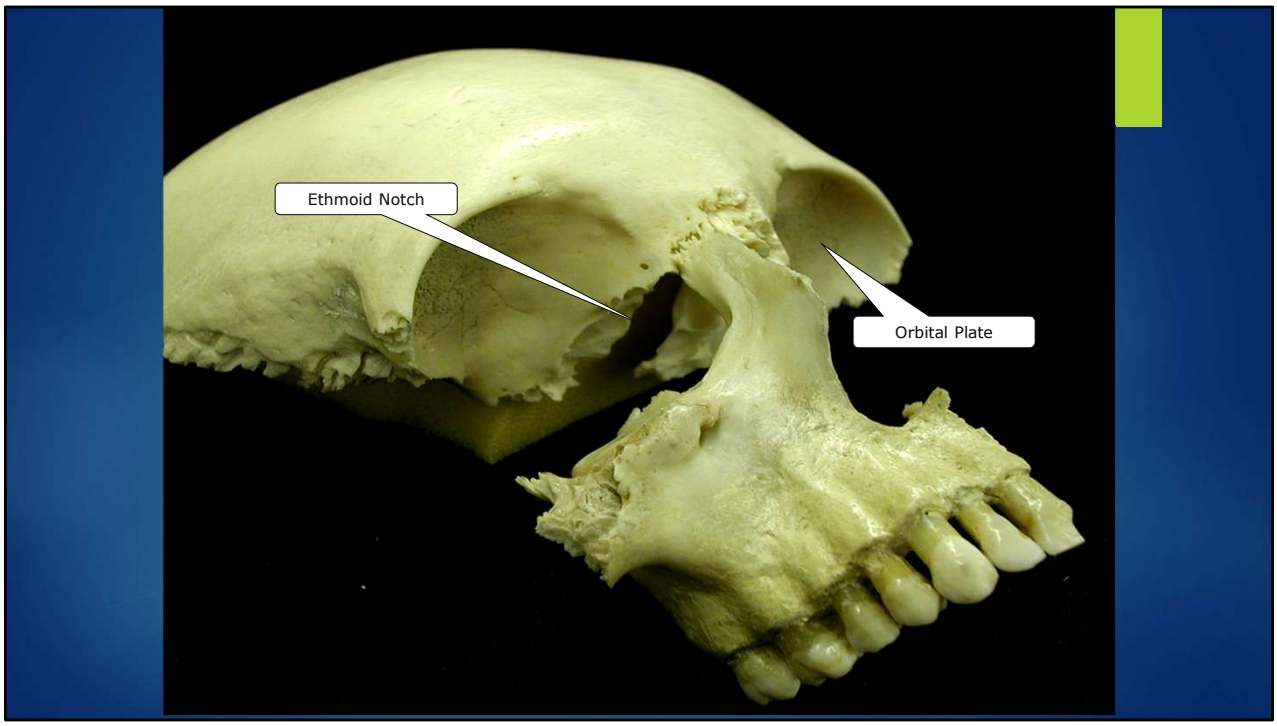


Picture from *Clinically Oriented Anatomy*, 4th Edition. Similar to Figure 7.4 in 6th Edition of same text.

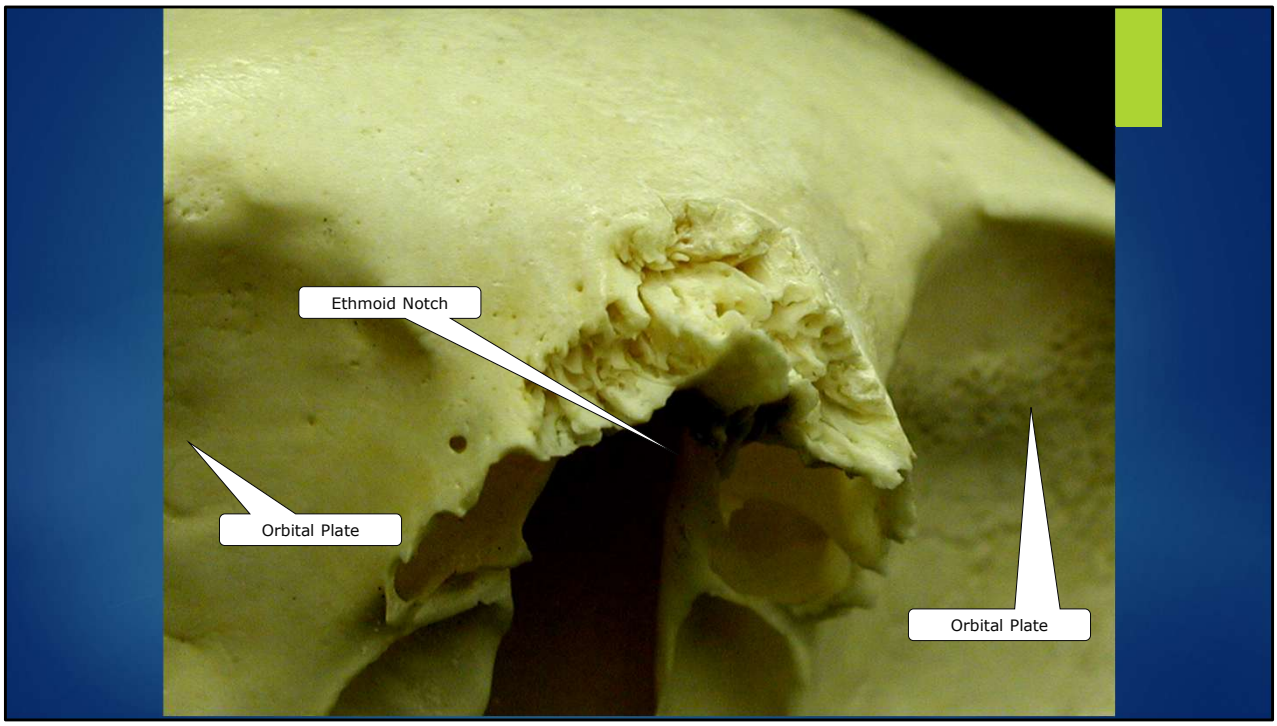
Pterion is an important landmark. Again, it is where our frontal parietal, temporal and sphenoid come together.



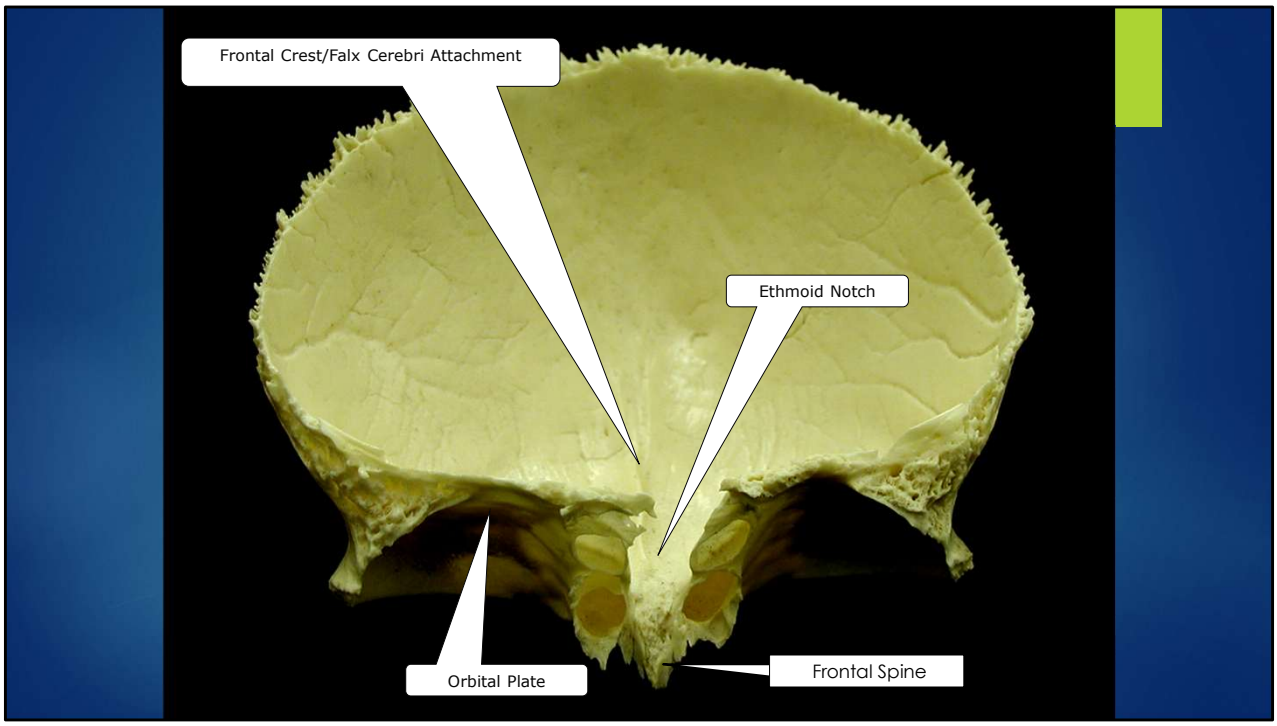
Looking at a superior view. So here's our coronal suture, Here's our sagittal suture. And we saw earlier where that significant fontanelle was but here is Bregma in the adult skull. Here's our frontal bone here. And you can see some remnants of the metopic suture here.



here's our frontal bone here, Here's maxilla in place. This is the frontal process of the maxilla articulating with that frontal bone. Here's our orbital plate, which is forming the roof of the orbits on that frontal bone. And here's our ethmoid notch, where ethmoid will fit in.

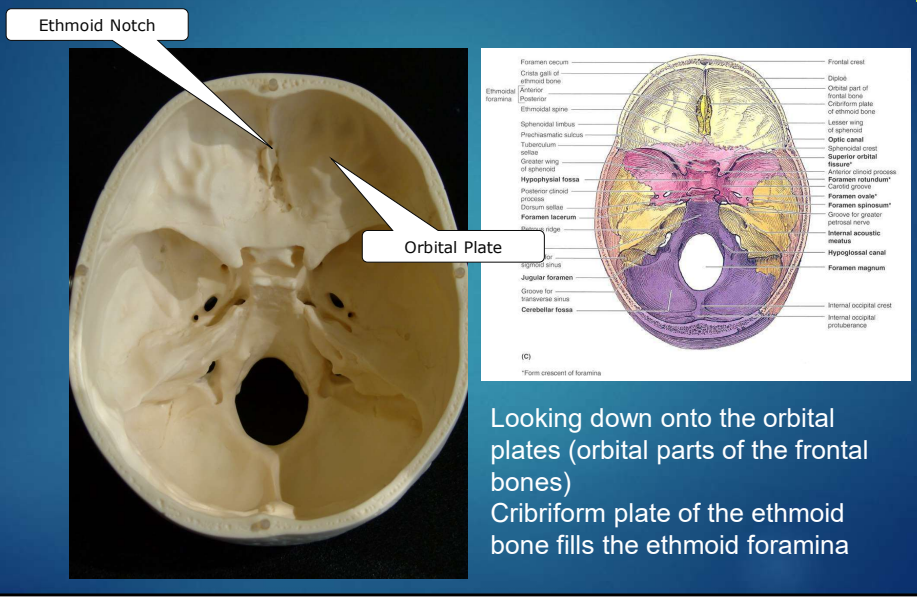


Looking a little bit closer at that articulation. Here's the ethmoid notch. Here's the orbital plates. You can see these ethmoid air cells, which are actually forming the roof of the ethmoid air cells on the frontal bone.



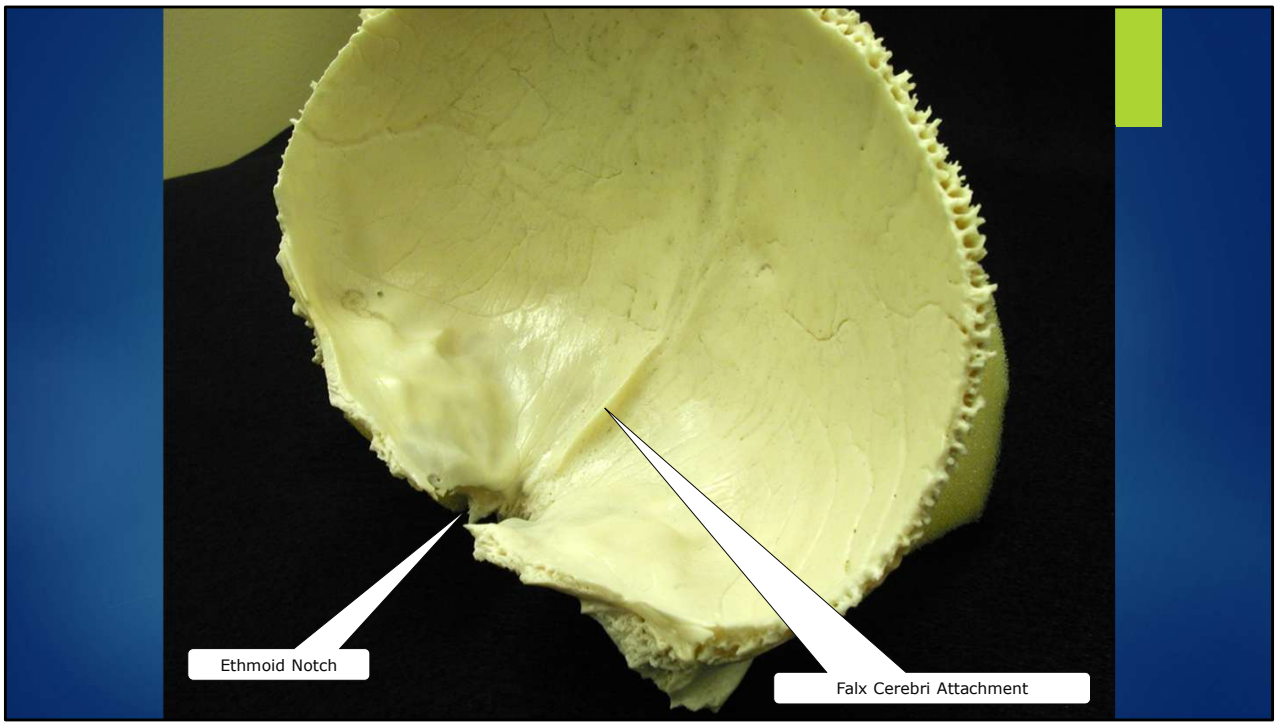
Here's again a posterior to anterior view, looking at the internal surface, you can see the frontal crest, which is where the falx cerebri attaches. We have our ethmoid notch which is where ethmoid will fit in. And those orbital plates which form the roofs of the orbits.

Cranial Base

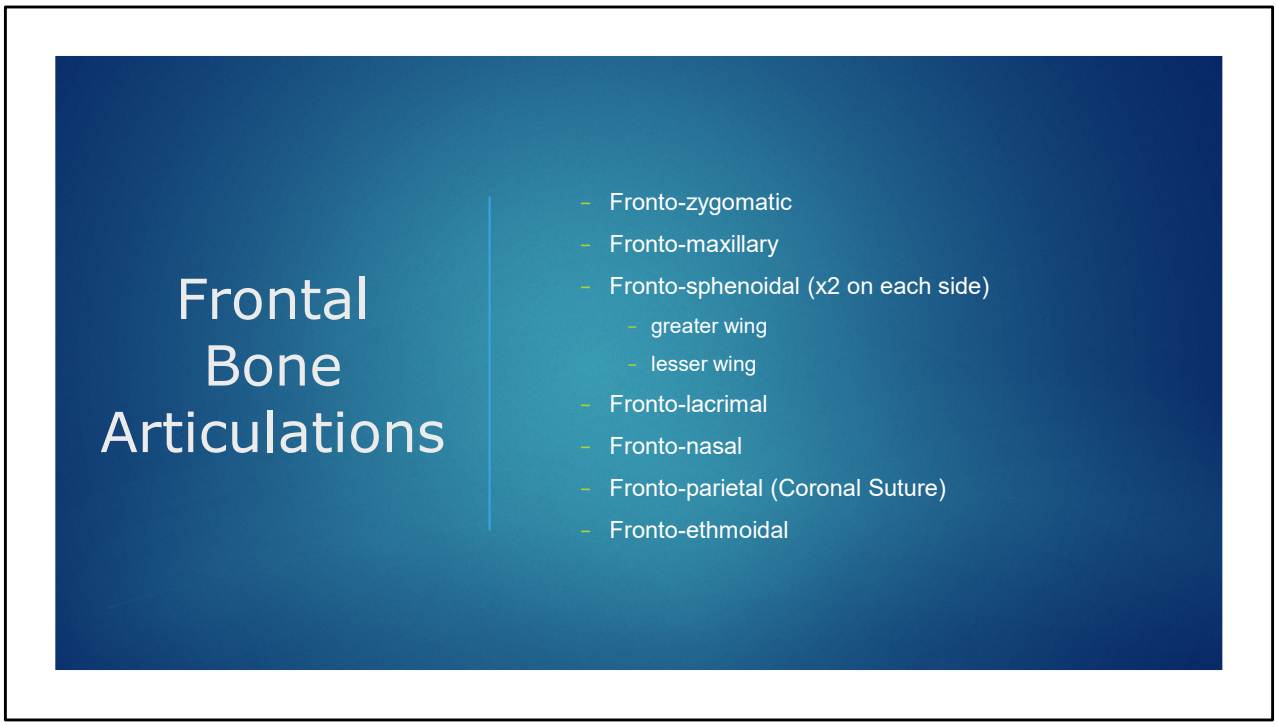


Looking down onto the orbital plates (orbital parts of the frontal bones)
Cribriform plate of the ethmoid bone fills the ethmoid foramina

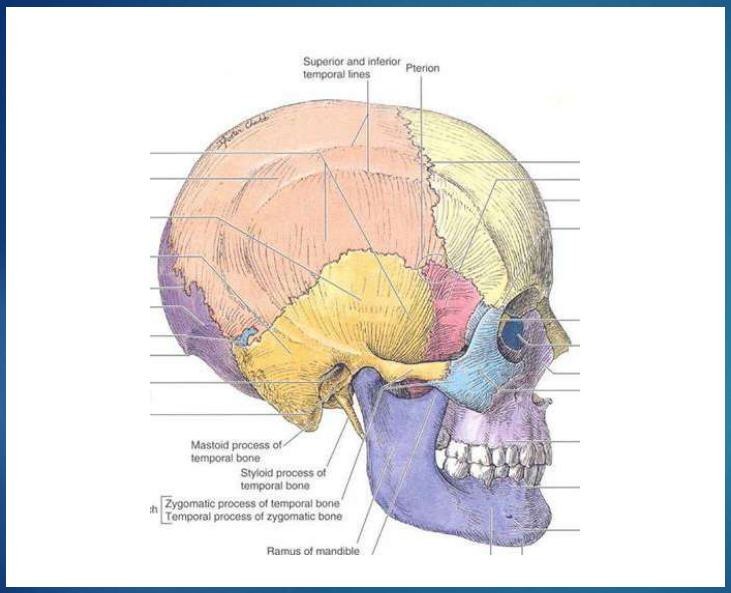
Looking at the cranial base, again, here's our orbital plate, here’s the ethmoid notch with the ethmoid filled in



Here's another view looking at this frontal bone from an oblique angle, you can see the falx cerebri attachment on that frontal crest and here’s ethmoid notch.

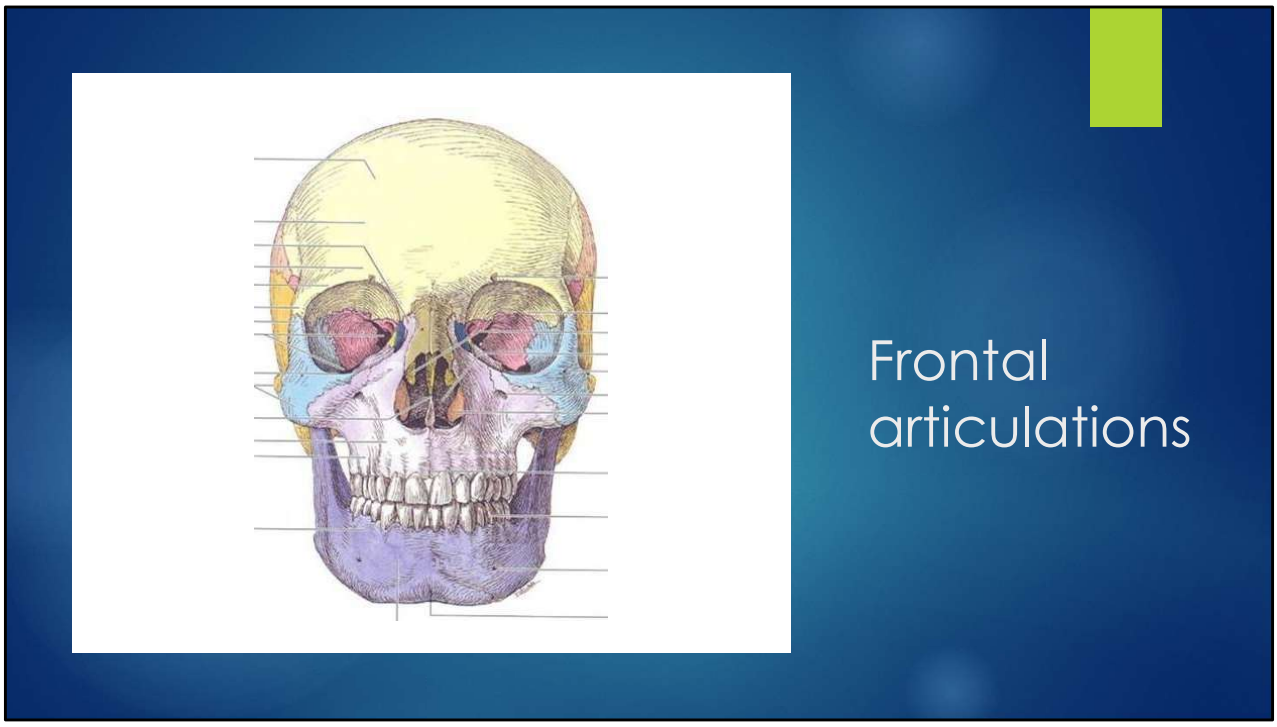


Here's our articulations for the frontal bone, and we've looked at most of these already over the course of the last couple lectures.



Frontal articulations

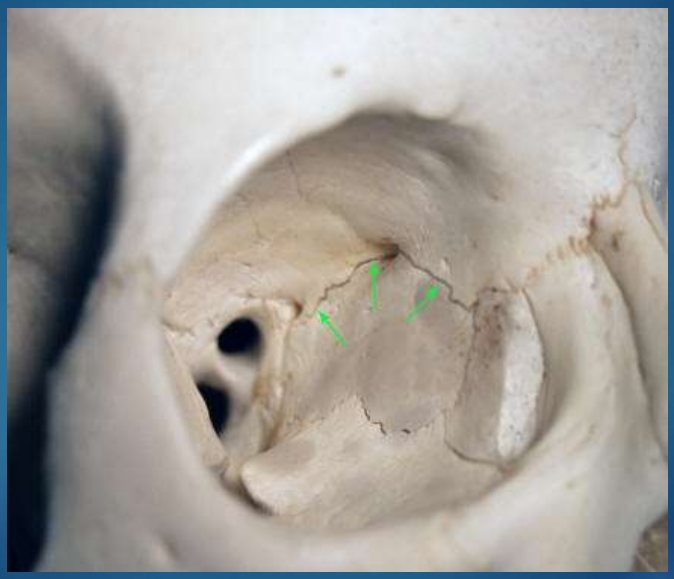
Picture from *Clinically Oriented Anatomy*, 4th Edition. Similar to Figure 7.4 in 6th Edition of same text.

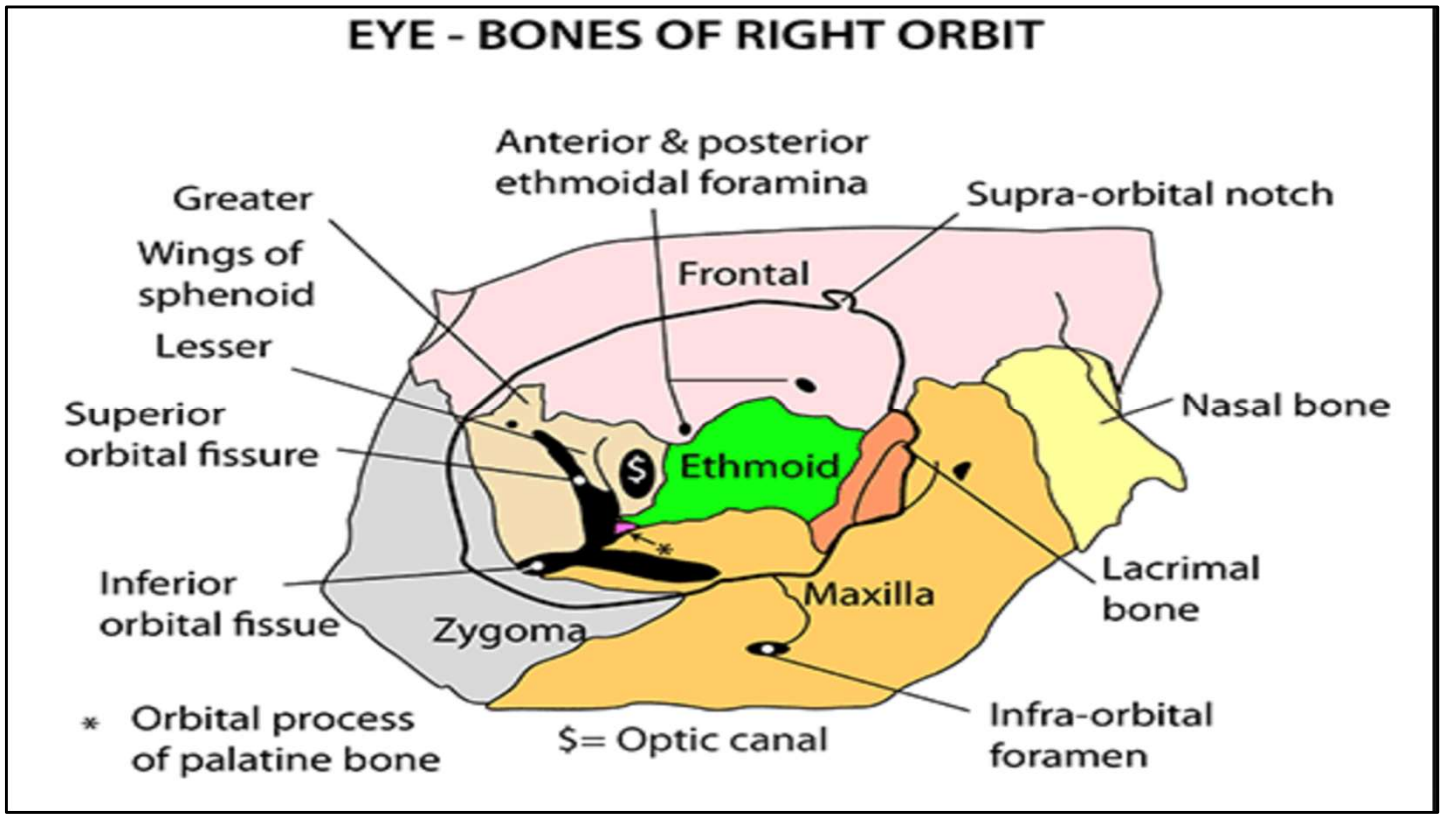


Picture from *Clinically Oriented Anatomy*, 4th Edition. Similar to Figure 7.3 in 6th Edition of same text.

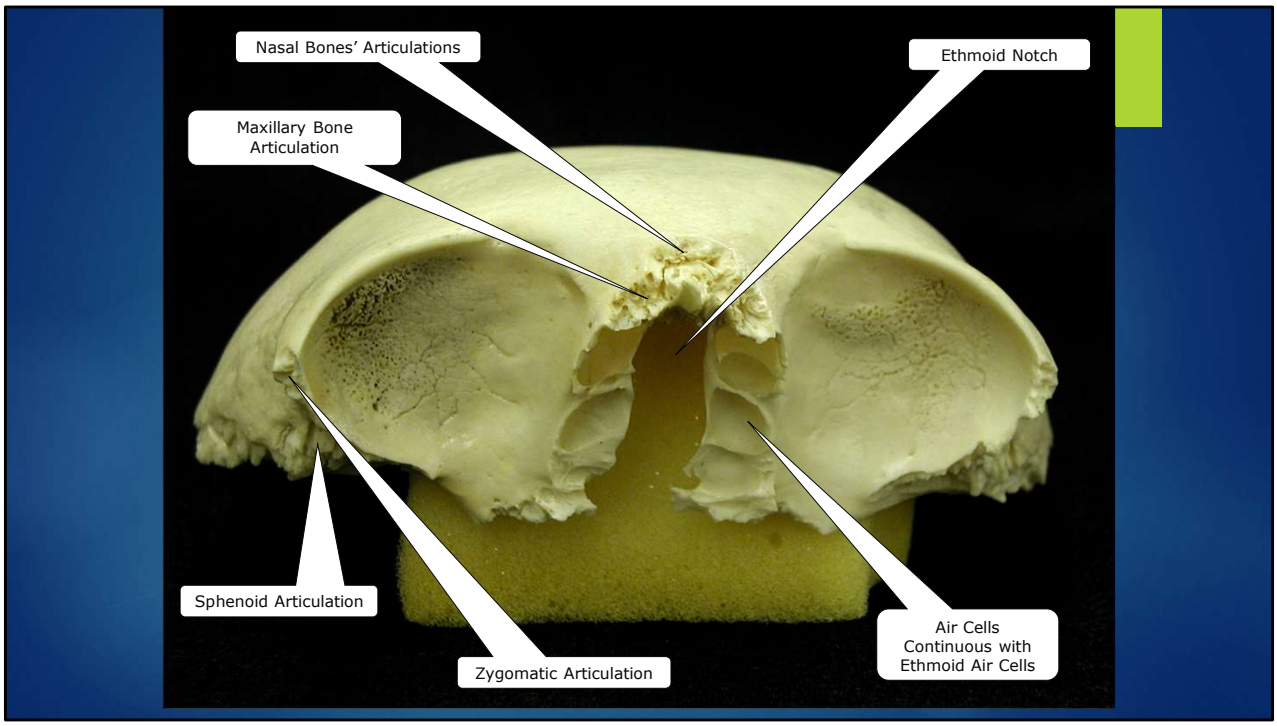
So these are frontal articulations with the sphenoid in the orbit with both greater and lesser wings.

Frontal Articulations In/Near the Orbit



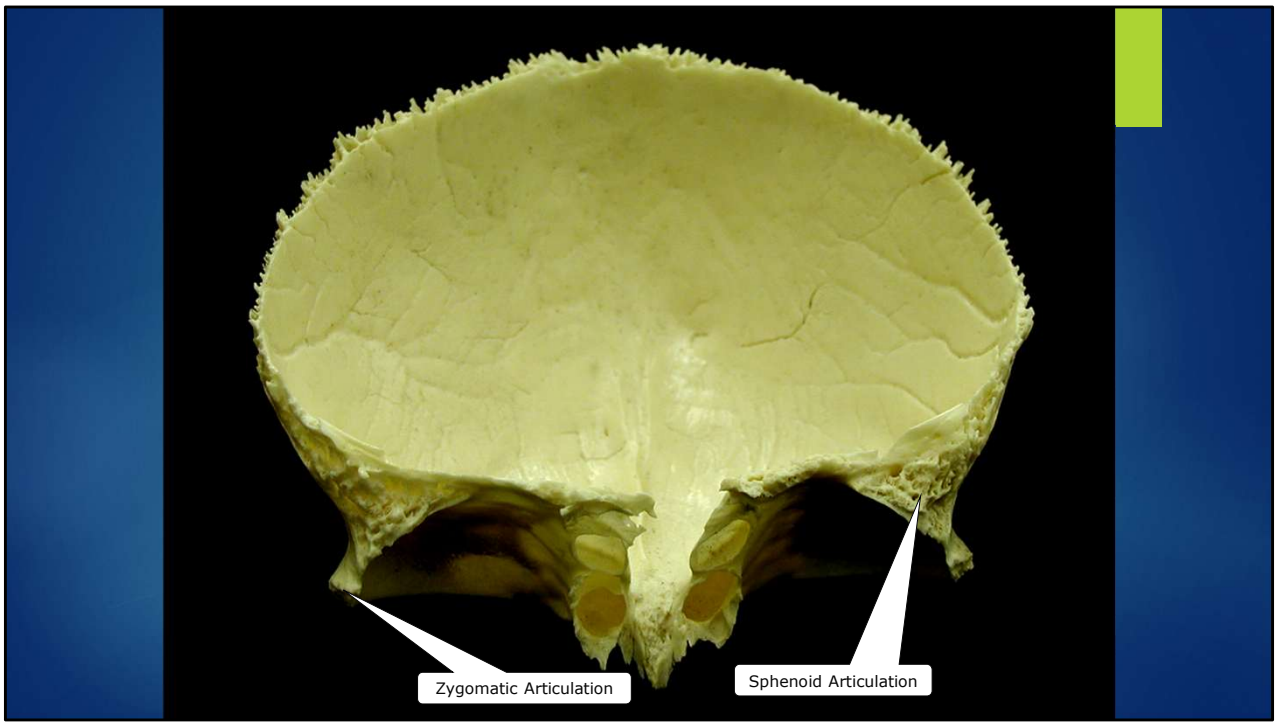


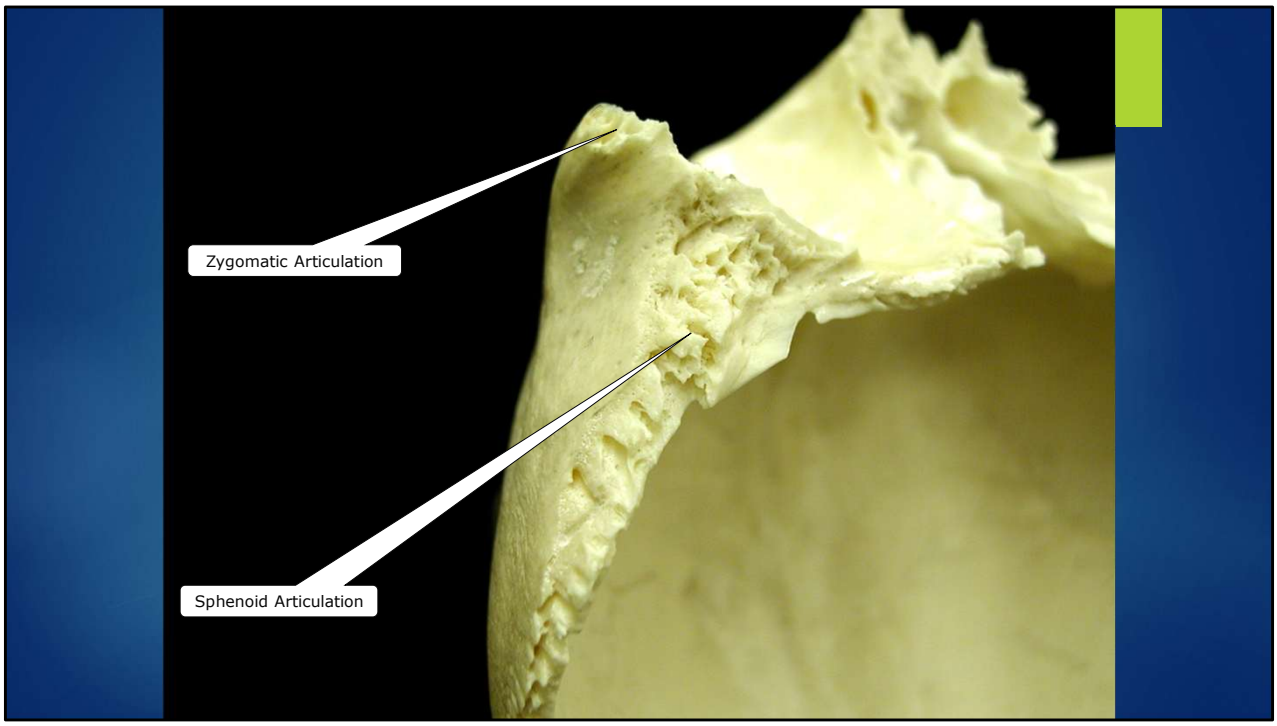
Picture from: https://www.instantanatomy.net/headneck/areas/bonesoforbit.html
Right eye
Zygoma laterally, ethmoid and lacrimal medially
Superior orbital fissure – b/t lesser and greater wings, CN 3, 4, V1, and VI, sympathetic fibers from cavernous plexus, ophthalmic vein



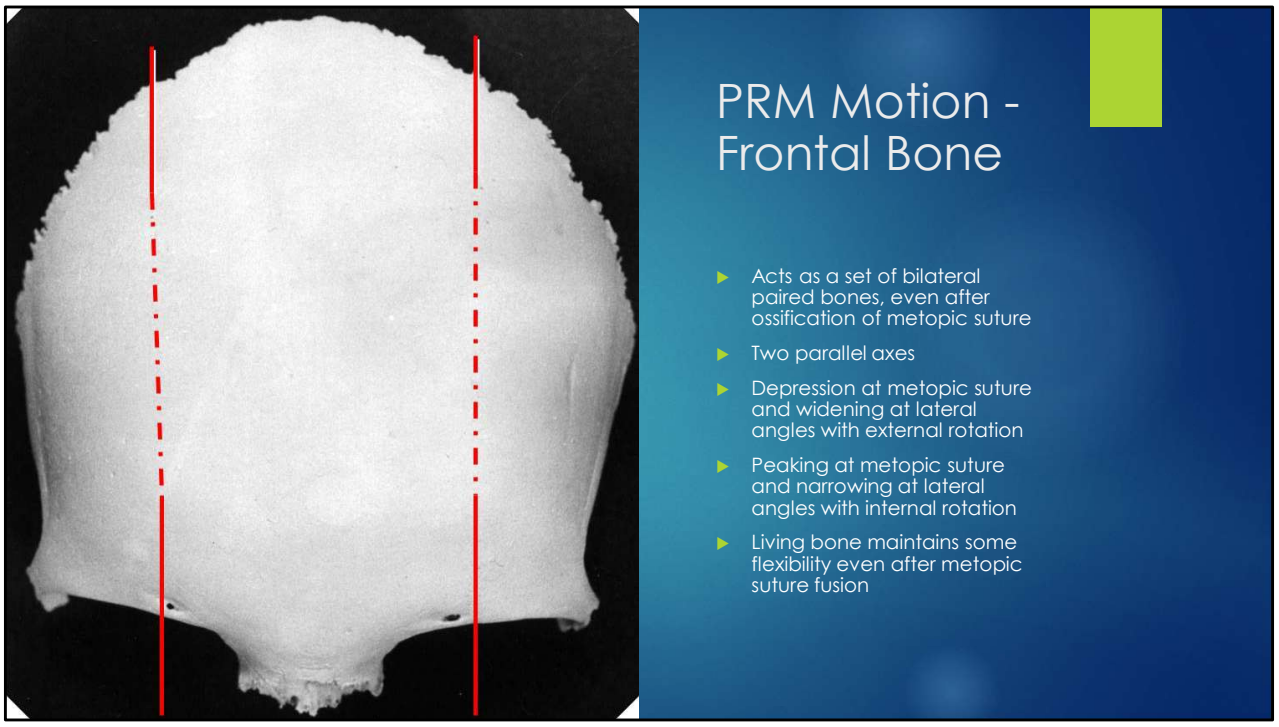
Frontal Bone Inferior View

Here's that same view of the skull with a few other landmarks identified. So here's where zygoma articulates, we've already looked at the sphenoidal articulations. Remember it's a large triangular articulation. Here is where frontal process of maxillary bone articulates here are nasal bones articulates more medially. Our ethmoid, notch for ethmoid. And then again, the air cells on this frontal bone form the roof of the ethmoid air cells.


Zygomatic Articulation
Sphenoid Articulation



Inferior to superior view
Sphenoid much larger articulation



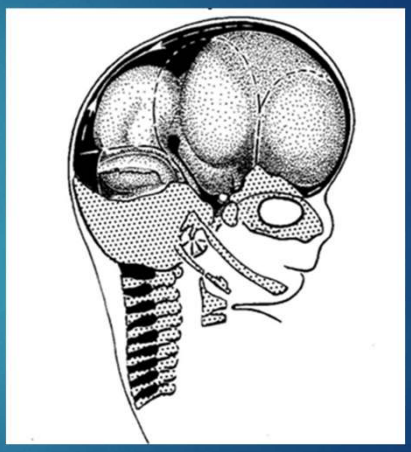
So they, again reminder will always act as paired bones even though in many adults it is fused into one bone. And you can think about this motion if you put your two hands up next to each other and your thumbs are just touching in the midline. That is where our metopic suture is. And your pinky fingers would represent the lateral angles of the frontal bone. And what happens? You have this parallel axis down the middle of this bone that goes from that supraorbital ridge towards the coronal suture. And what happens with external rotation, you get a depression at the metopic suture, so your thumbs move posteriorly and your lateral angles or fifth digits will move anteriorly. And then you get the opposite motion with internal rotation. And then you get a peaking at the metopic suture and a narrowing at the lateral angles. And we will be covering this motion in more detail with you along with treatments for the frontal bone in your vault lab.

By Anatomography - en:Anatomography (setting page of this image), CC BY-SA 2.1 jp, https://commons.wikimedia.org/w/index.php?curid=23090514

Parietal Bone Growth and Development

Like frontals, influenced by development of cerebral hemispheres

One ossification center in each bone



End of 8th wk of embryologic development

Grow and develop similar to frontals in membrane and extending out secondary to growing and expanding CNS.

Parietal eminence and can see where ossifying bone is being laid down extending out from that eminence.

Parietal Bone Landmarks

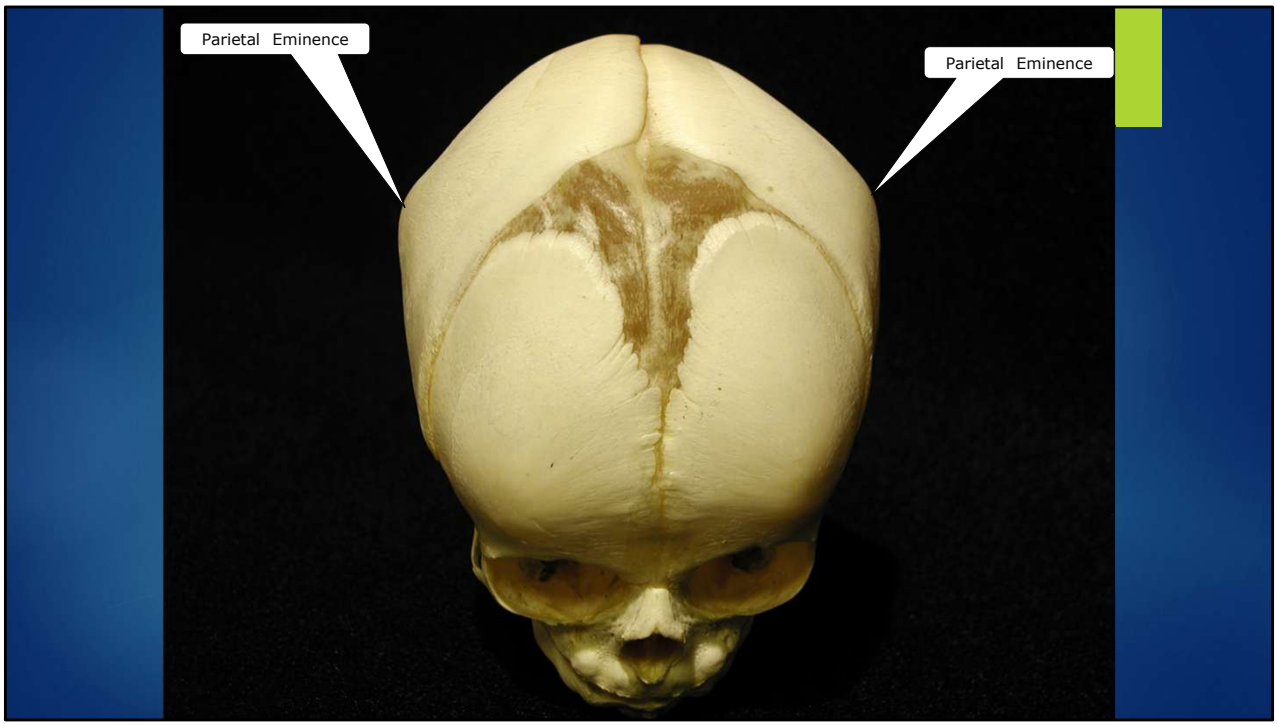
External Aspect

- Parietal Eminences
- Superior/Inferior Temporal Lines
- Mastoid angle (Asterion)
- Occipital angle (Lambda)
- Sphenoid angle (Pterion)
- Frontal angle (Bregma)
- Vertex
- Bevel change along inferior border associated with parietal notch of temporal

Internal Aspect

- Sagittal sinus impressions
- Middle Meningeal Artery impressions
- Attachment of falx lateral to sagittal sinus

We will be reviewing these on next few slides



Superior view

Superior view
Occiput, lambda, lambdoidal suture, sagittal

- Temporal Lines
  - Superior temporal line
    - Attachment of the temporal fascia
  - Inferior temporal line
    - Upper limit of the temporalis muscle

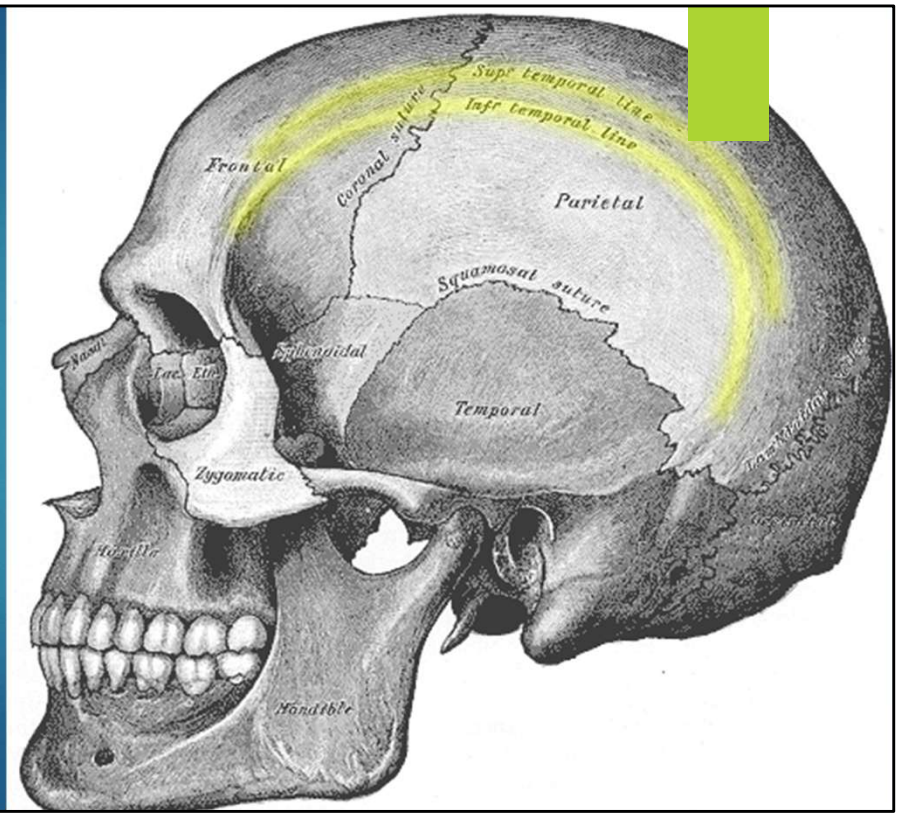
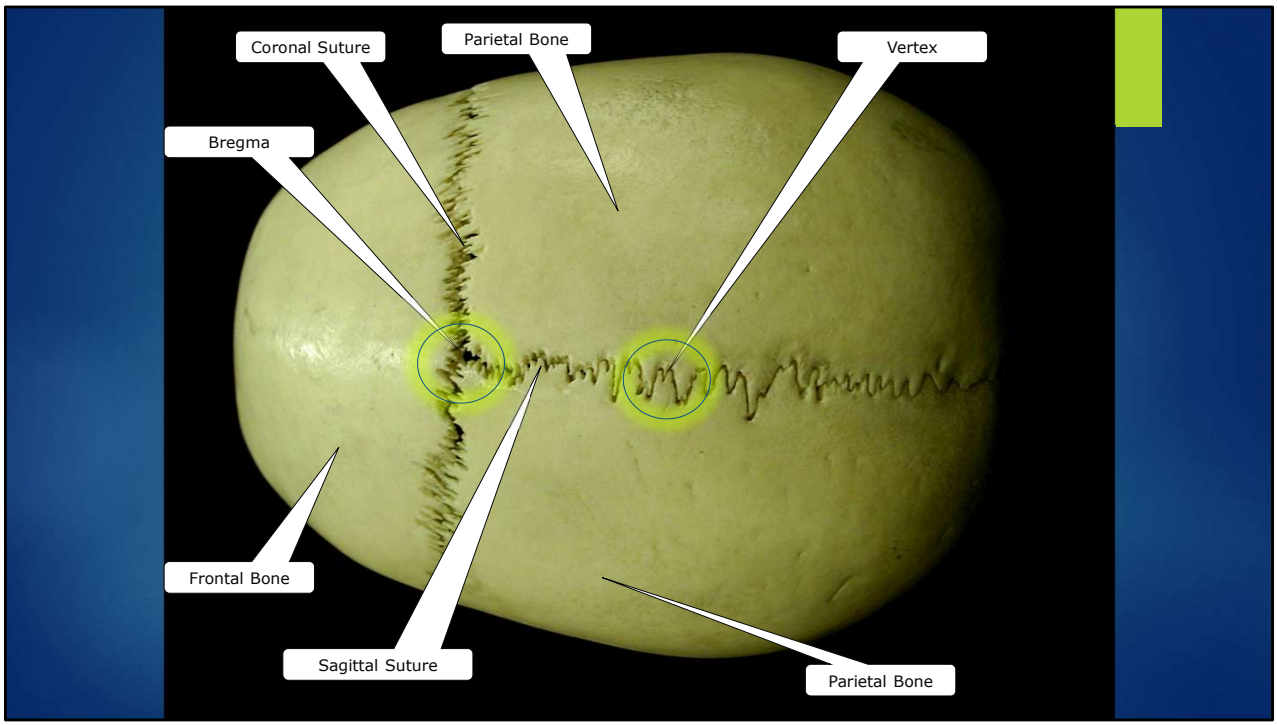
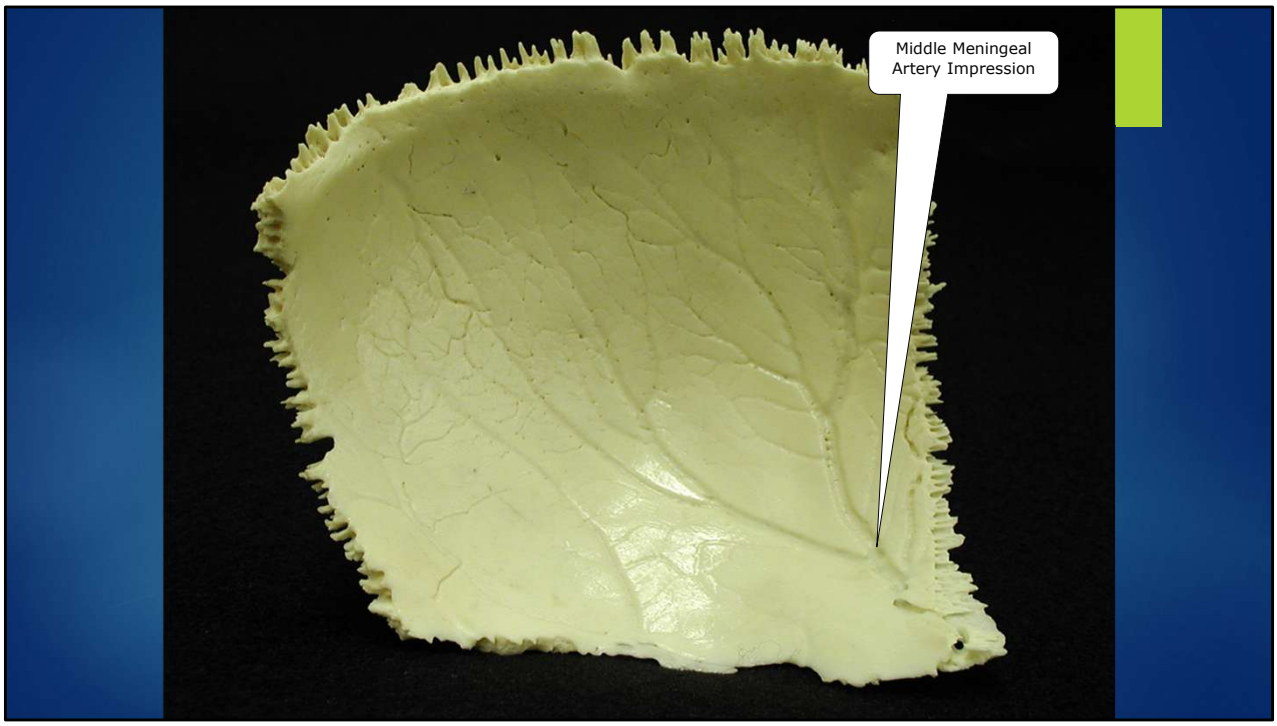


Image: Henry Gray (1918) *Anatomy of the Human Body* (See "Book" section below) Bartleby.com: Gray's Anatomy, Plate 188File:Gray188.png

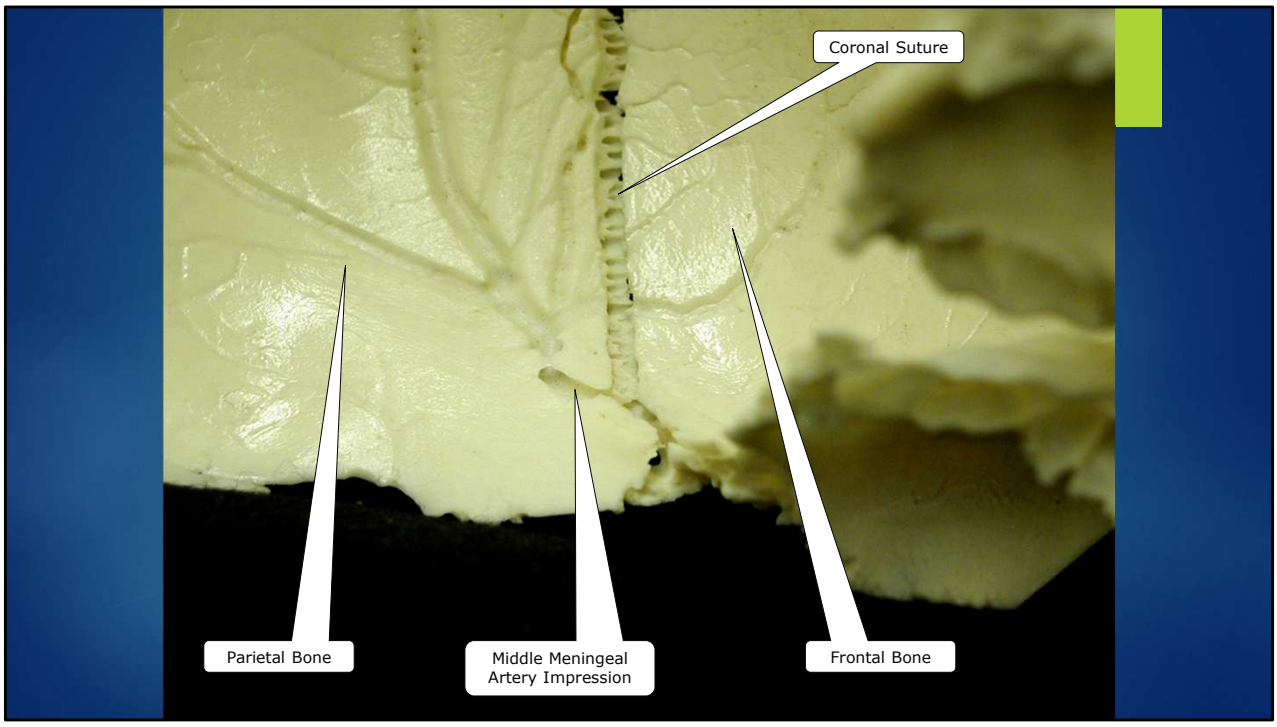
Called temporal lines even though on the parietal bones.
You can palpate this on yourself. If you palpate your own parietal and bite down, you can feel that temporalis muscle flex. And that's again how we will localize in lab to be able to do our parietal lift technique and assess parental motion.



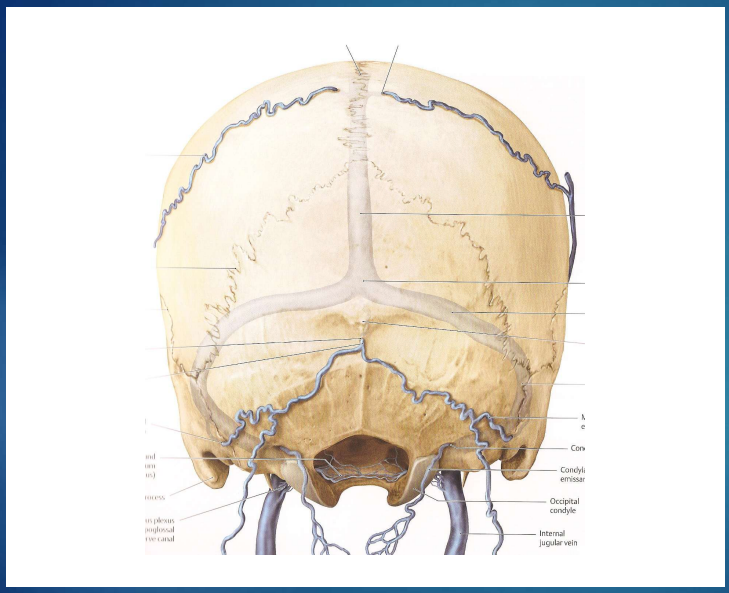
You've seen this image before.
Vertex may have slight peak or depression depending on the patient. We use this to treat straight sinus during VSD.



Internal view
Note the strength of the fluid impressions in developing bone


Coronal Suture
Parietal Bone
Middle Meningeal Artery Impression
Frontal Bone

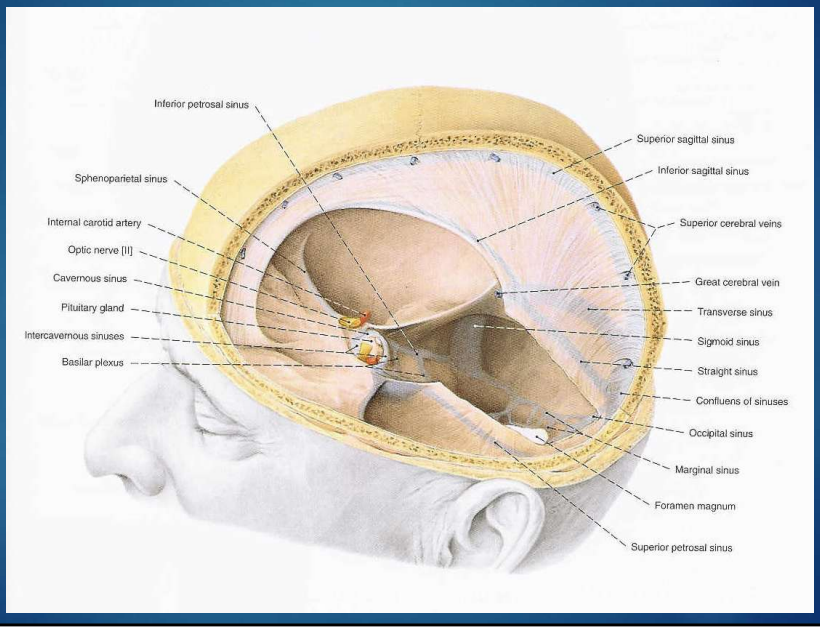
From inferior to superior view
Impression of superior sagittal suture



Posterior Reflection of the Venous Sinuses

You've seen these before but just a reminder to orient

Venous Sinus Associations to the Vault



Seen these before as well

Parietal Bone Articulations

- Coronal (Frontals/Parietals)
- Parieto-squamous (Gr. Wing of Sphenoid/Parietal)
- Parieto-squamous (Squamous Temporal/Parietal)
- Parieto-mastoid (Mastoid temporal/Parietal)
- Lambdoidal (Occiput/Parietal)
- Sagittal (Parietal/Parietal)

Parietal articulations

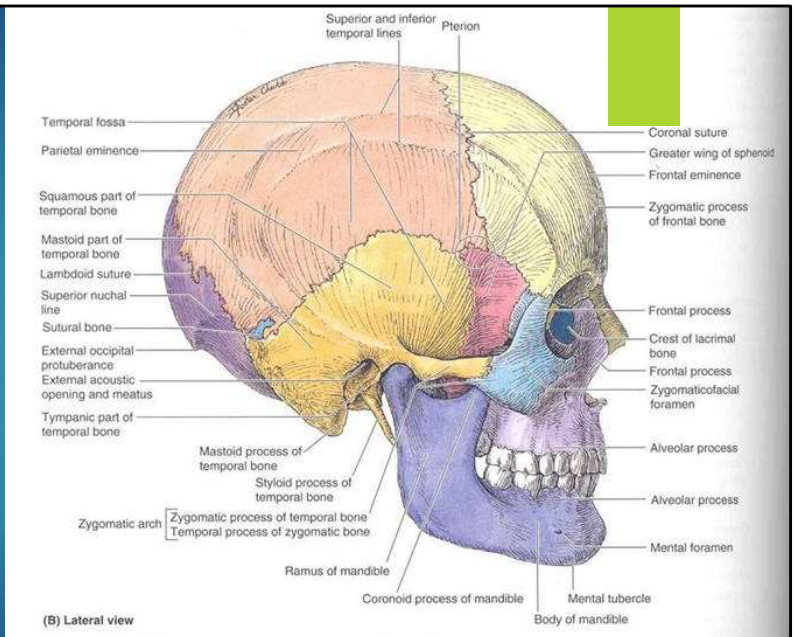
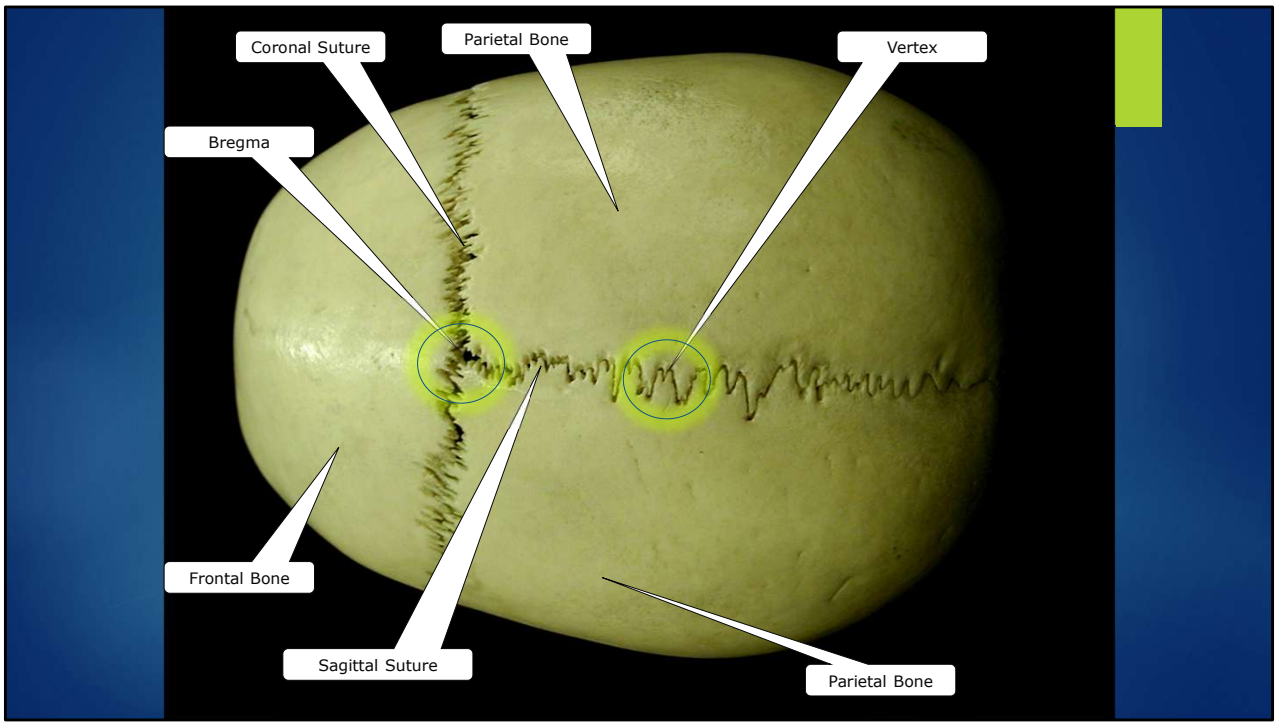
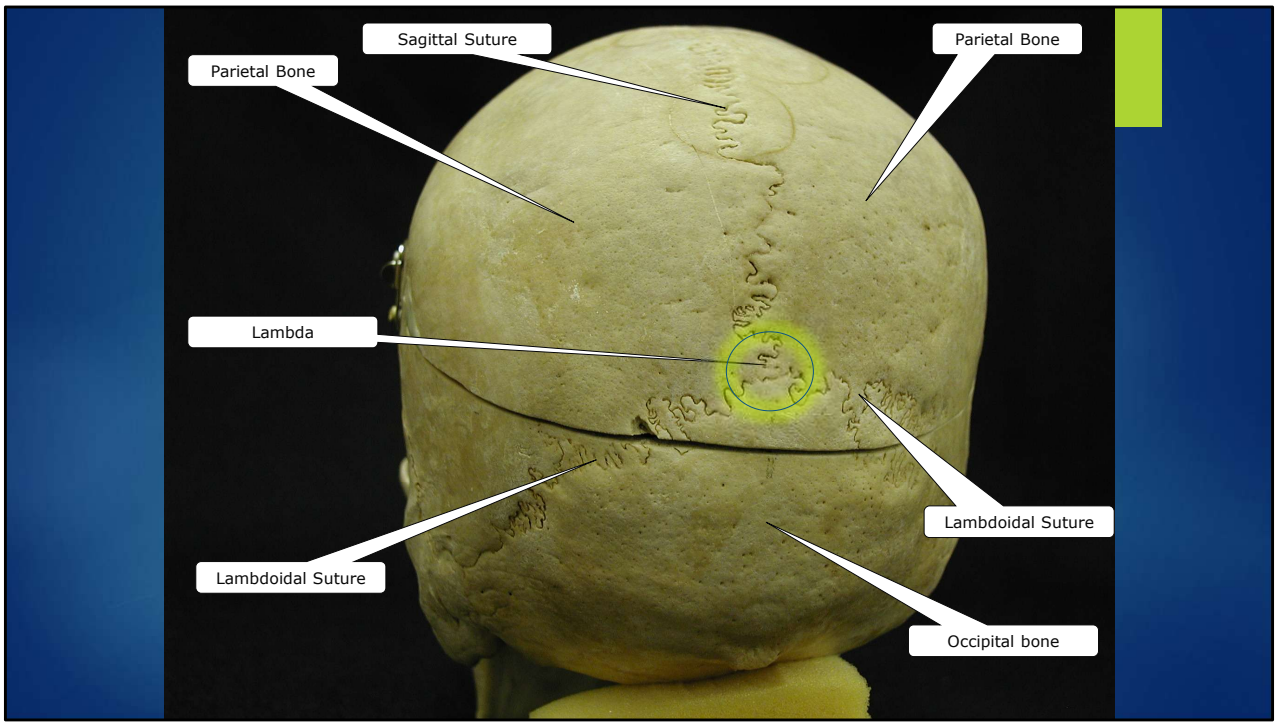
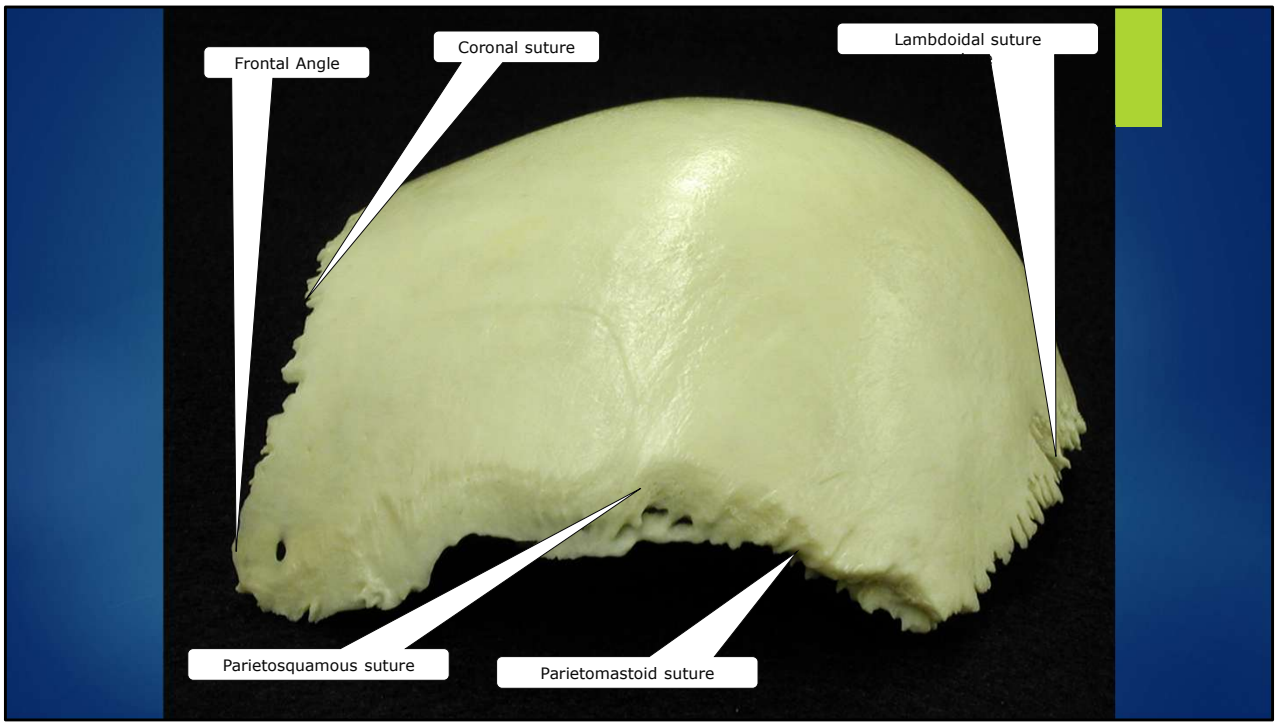


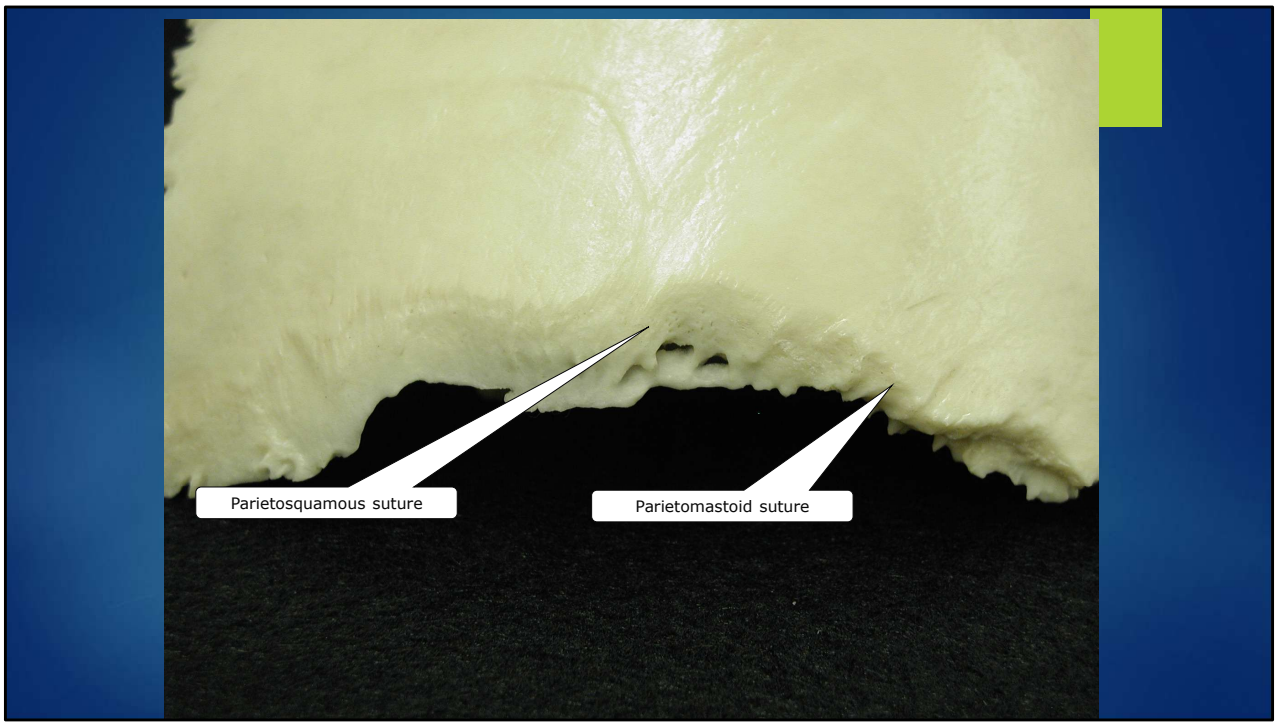
Figure 7.2. *(Continued)* **B.** Lateral view. Within the temporal fossa, observe the **pterion** (G. pteron, wing), a craniometric point at the junction of the greater wing of the sphenoid, the squamous temporal bone, the frontal, and the parietal bones. It intersects the course of the anterior division of the middle meningeal artery (p. 839). Notice that the skull is in the anatomical position when the in-

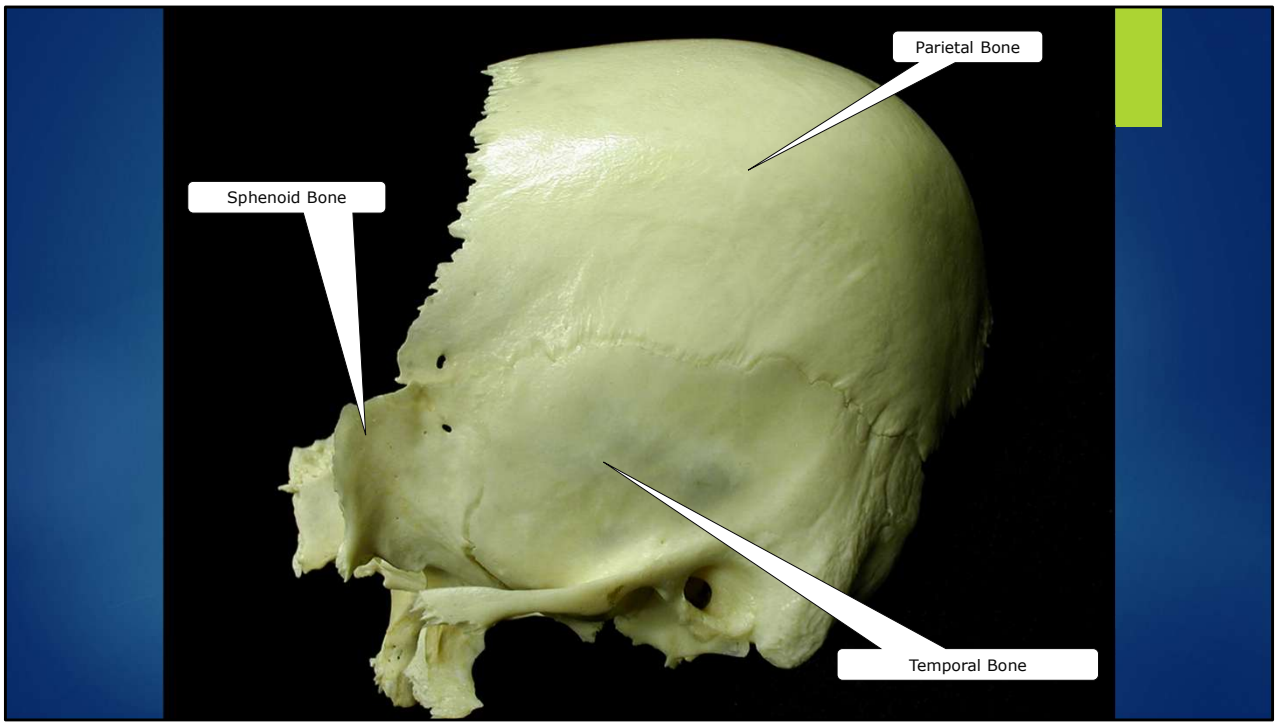

Coronal Suture
Parietal Bone
Vertex
Bregma
Frontal Bone
Sagittal Suture
Parietal Bone

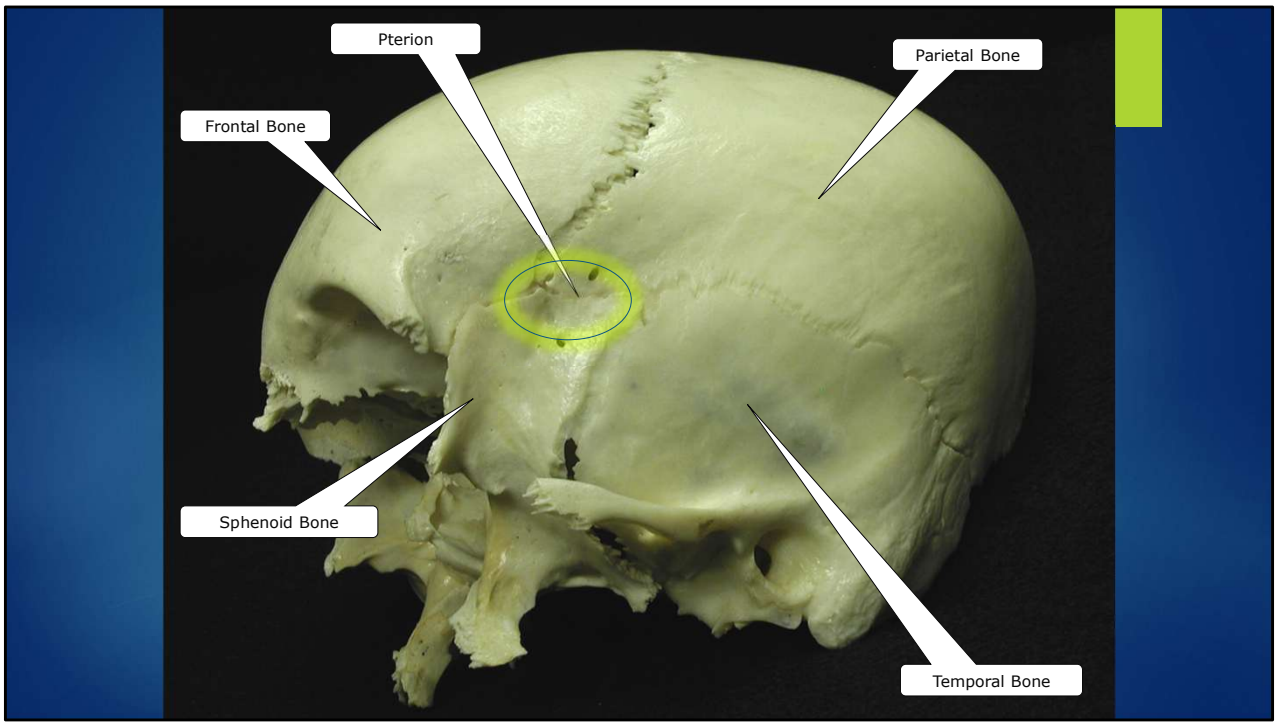

Sagittal Suture
Parietal Bone
Parietal Bone
Lambda
Lambdoidal Suture
Lambdoidal Suture
Occipital bone

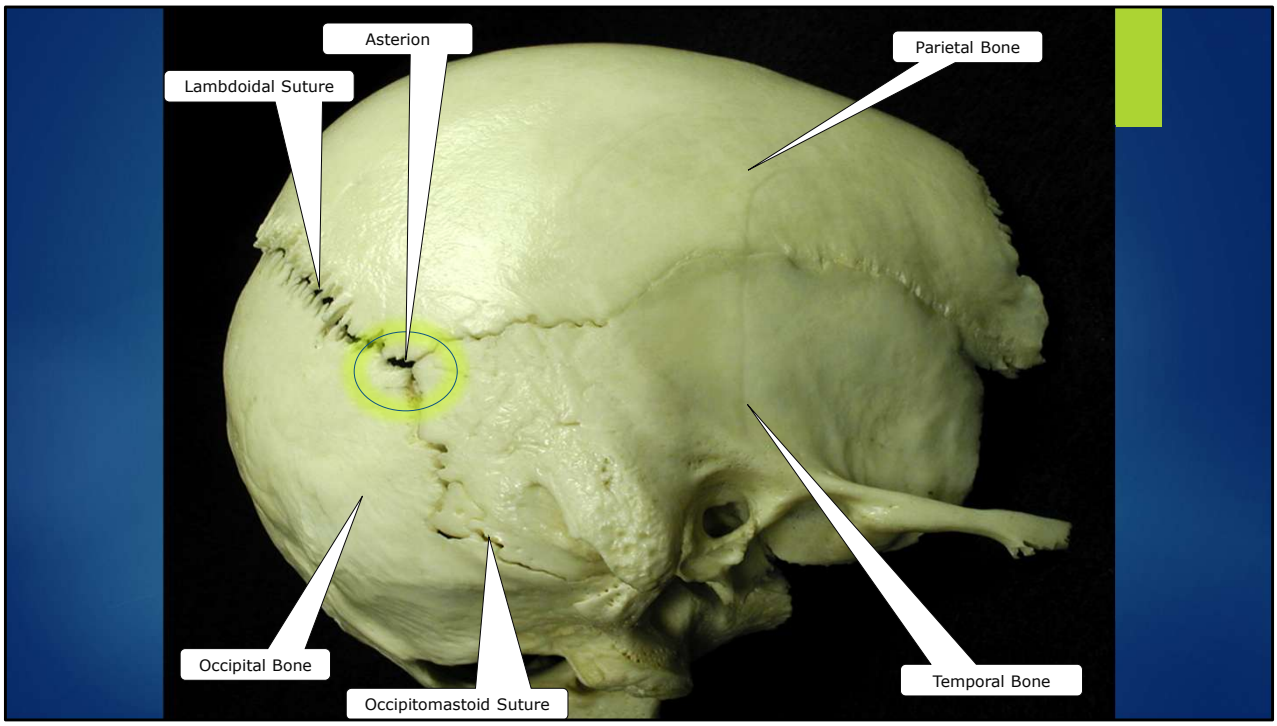


Note bevel changes

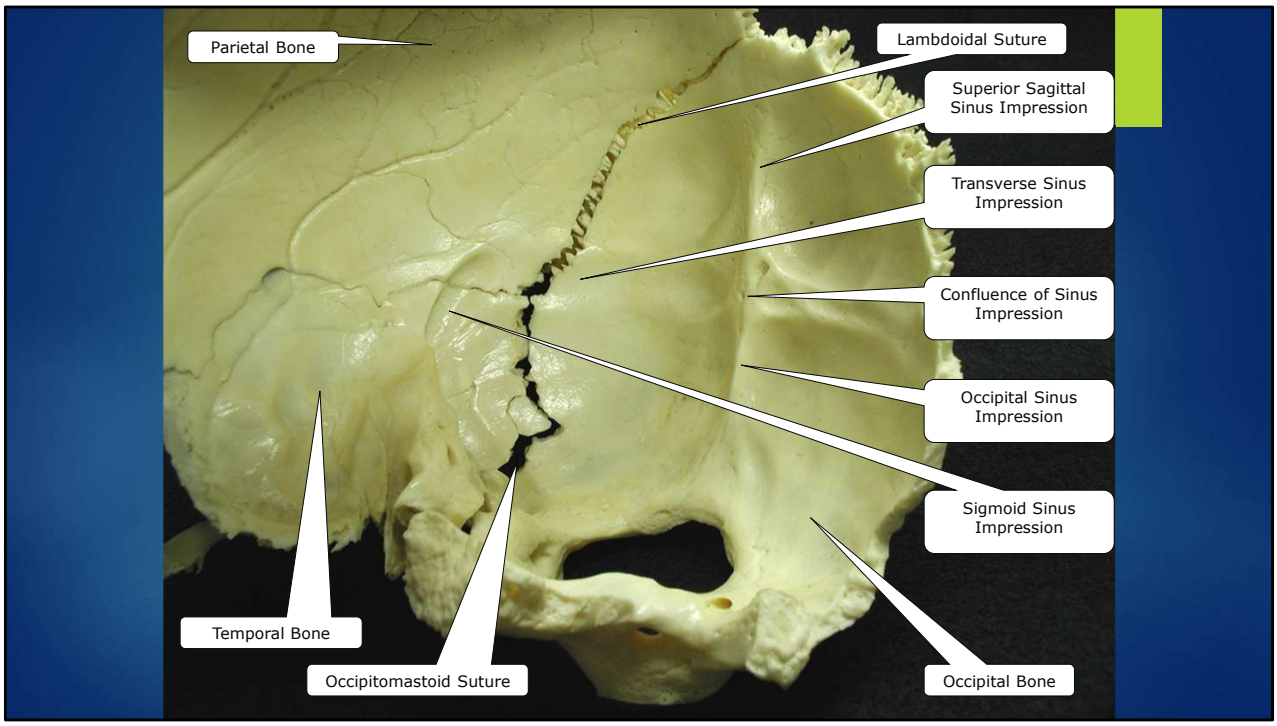

Parietosquamous suture
Parietomastoid suture


Parietal Bone
Sphenoid Bone
Temporal Bone

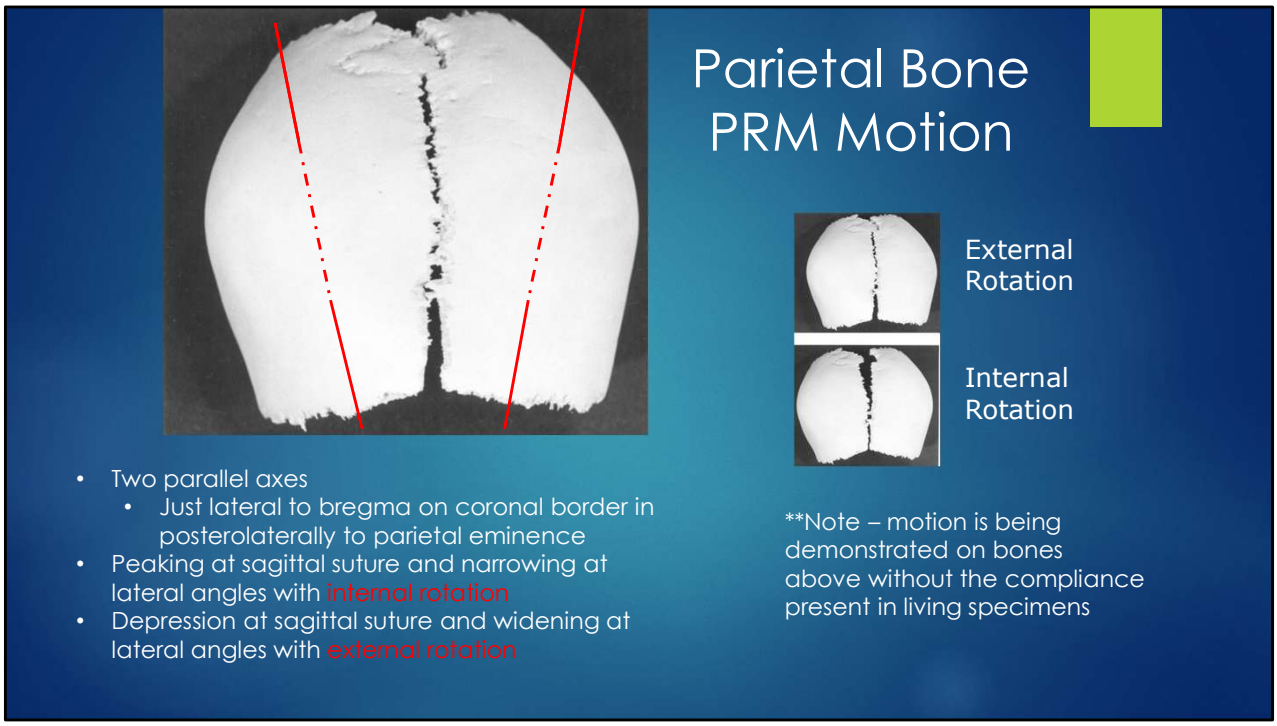

Pterion
Parietal Bone
Frontal Bone
Sphenoid Bone
Temporal Bone



Posterior oblique view



Internal surface of parietal, temporal, and occipital bone
Just review anatomy



we have two axes through the the middle of the parietal bones. They begin just lateral to Bregma on the coronal suture and extend posterior laterally towards the parietal eminence. If you put your hands together in front again, just like we did for frontal bones for internal rotation, we're going to get a peaking at the sagittal suture. So a rise with our thumbs and a narrowing at the lateral angles or fifth digit. And then the opposite with external rotation. So depression at that sagittal suture and a widening at the lateral angles.

References

1. Gilroy, A. Atlas of Anatomy 3rd edition Thieme
2. Chila. Foundations of Osteopathic Medicine 3rd Edition
3. Gray's Anatomy 41st edition
4. Carreiro, J. An osteopathic approach to children- 2nd edition 2009
5. Moore Clinically oriented anatomy 7th edition
6. https://medicine.yale.edu/cranialnerves/nerves/facial/general.aspx
7. Hruby, Raymond J. *Exploring Osteopathy in the Cranial Field*
8. Dr. Hiserote's 2018 Lectures on Face and Temporal Bone
9. Magoun, Harold I. *Osteopathy in the Cranial Field*
   - Third Edition, Sutherland Cranial Teaching Foundation (Pp. 164-180)
   - First Edition, Sutherland Cranial Teaching Foundation (Pp. 133-148)

Here's our references for all of these. And please feel free to reach out if you have any additional questions. Again, these are just a brief introduction to the extensive cranial anatomy. But hopefully it gives you an idea of the importance of treating the cranial base face and vault and remembering their important articulations. Associations of cranial nerves with dura and vascular structures as well. So that when your patients present with different clinical indications, which bones or regions to target for evaluation and treatment with OCMM. Thank you!