"Blindness cuts people off from things,

Deafness cuts people off from people".

Helen Keller.

Imaging on Temporal Bone in Emergency States

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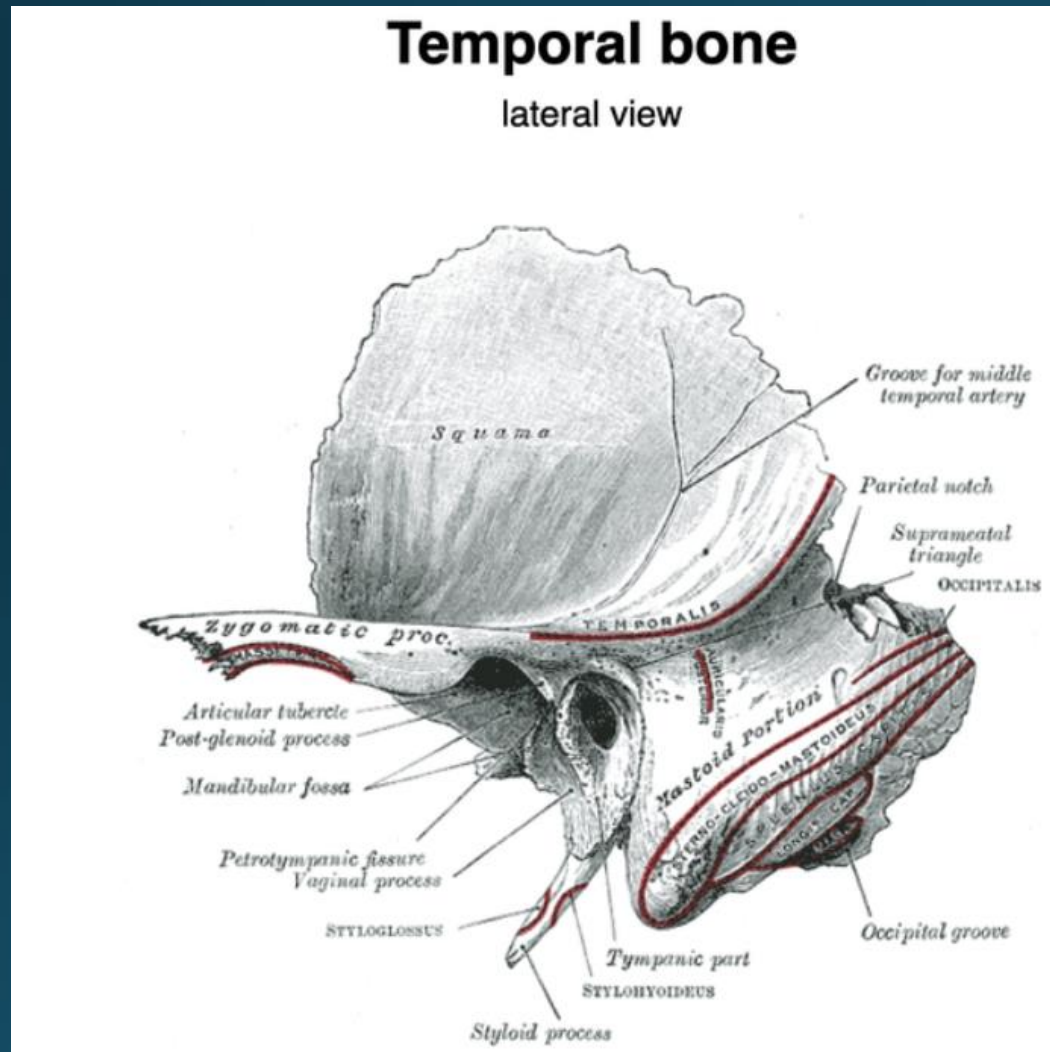
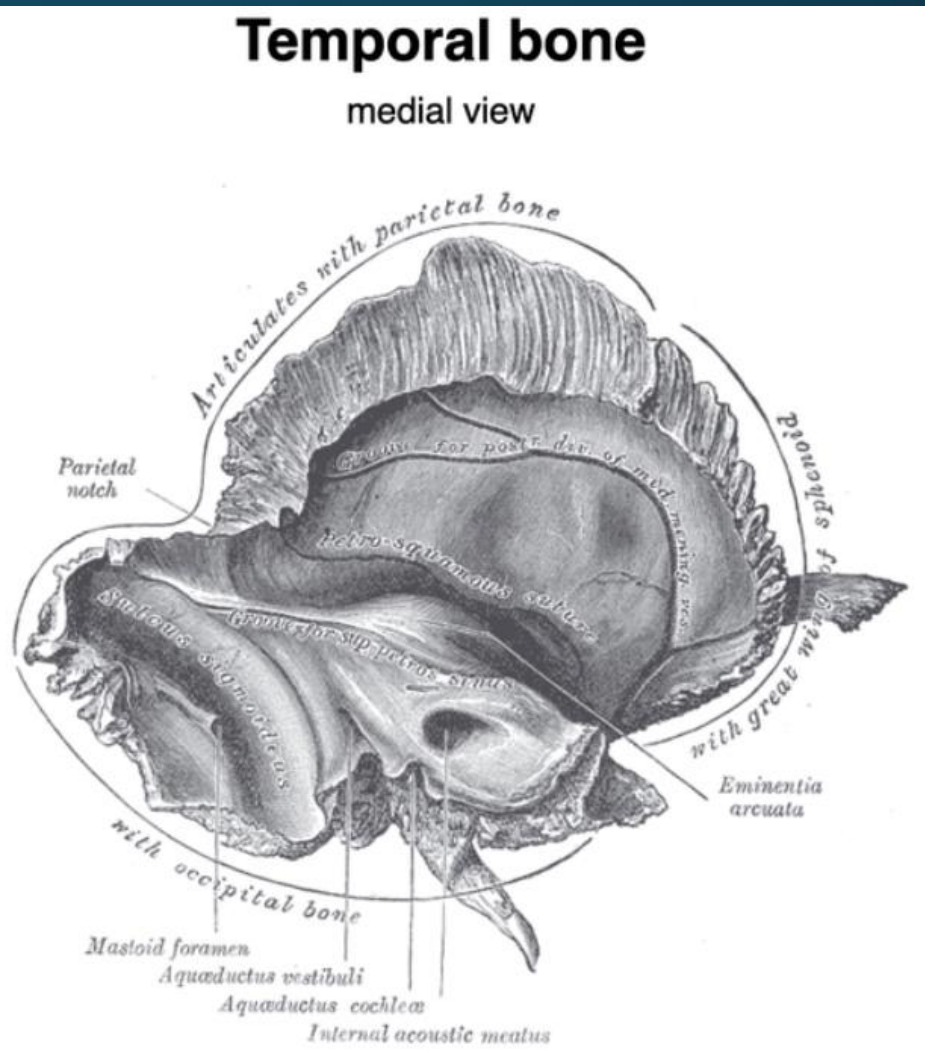
INTRODUCTION

•The temporal bone is a complex structure containing vital auditory, vestibular, facial nerve, and adjacent to intracranial components, making it susceptible to traumatic and infectious emergencies with potentially serious consequences

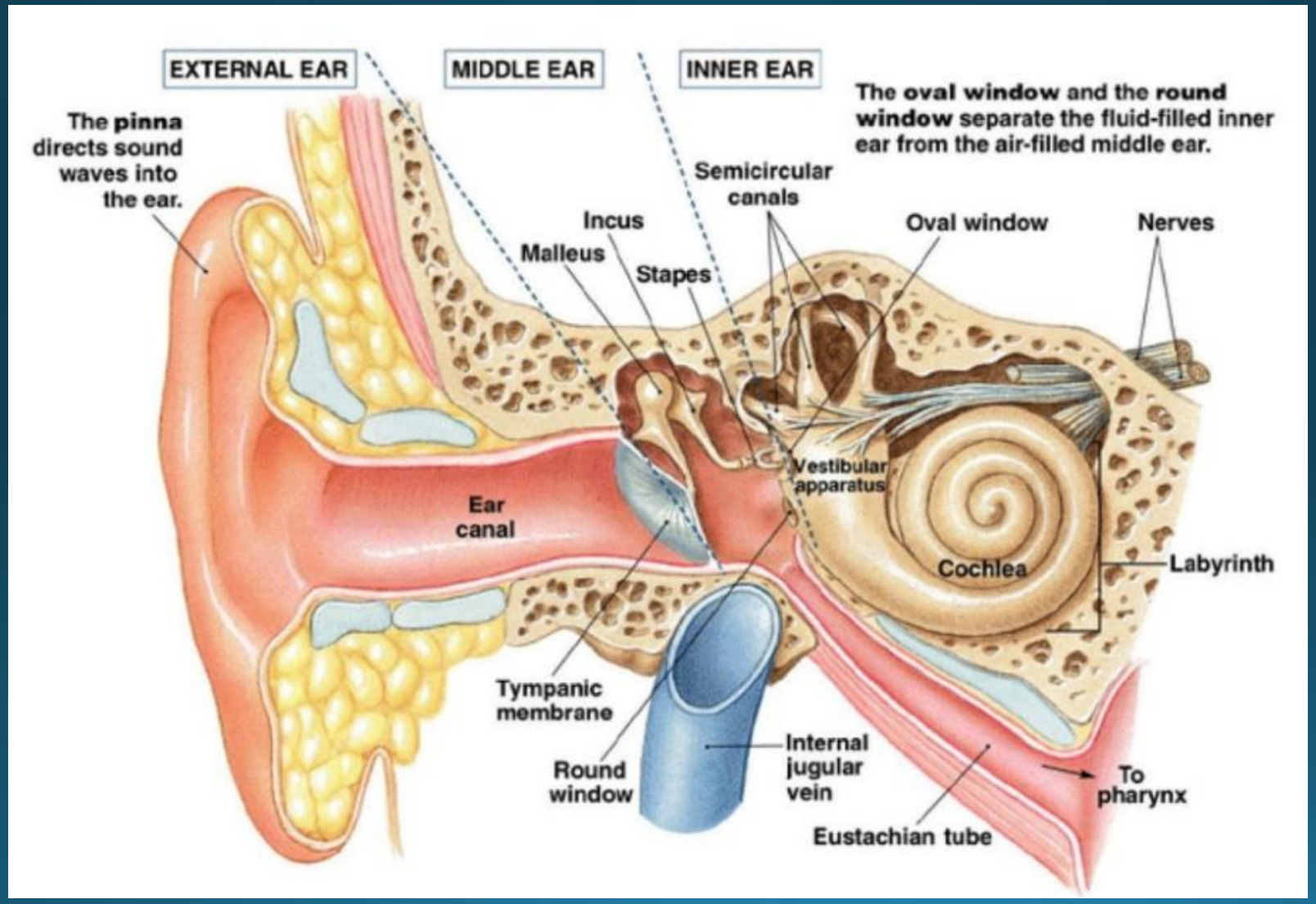
•CT is the preferred first-line modality due to its speed, bone detail, and broad coverage—non-contrast CT is typically sufficient for trauma, while contrast-enhanced studies are useful in infections. Although MRI offers superior soft tissue resolution, it is less suitable as an initial imaging tool in acute settings.

TEMPORAL BONE ANATOMY



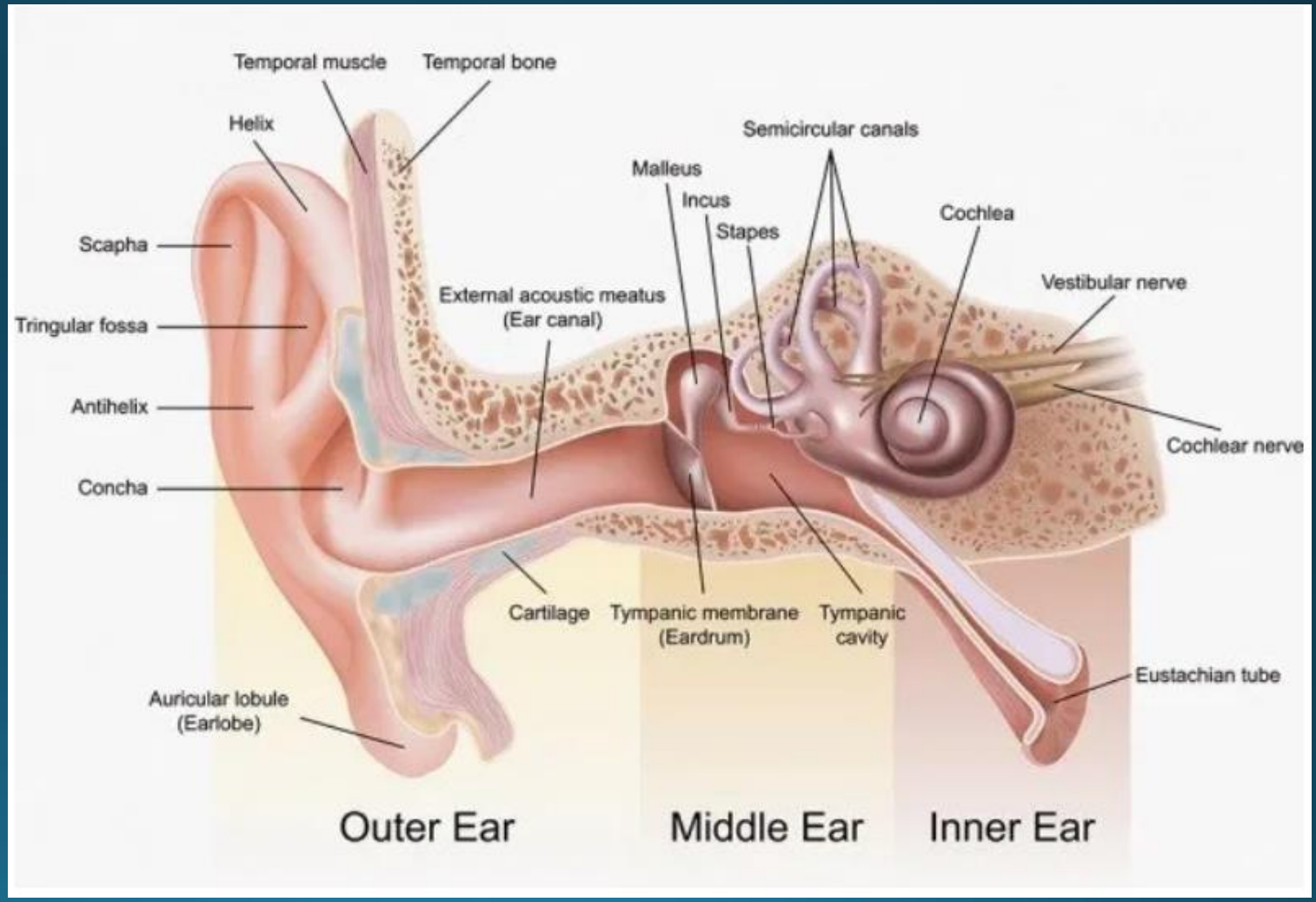


EAR ANATOMY


EXTERNAL EAR
MIDDLE EAR
INNER EAR
The oval window and the round window separate the fluid-filled inner ear from the air-filled middle ear.
The pinna directs sound waves into the ear.
Semicircular canals
Incus
Malleus
Stapes
Oval window
Nerves
Vestibular apparatus
Ear canal
Cochlea
Labyrinth
Tympanic membrane
Round window
Internal jugular vein
To pharynx
Eustachian tube

MIDDLE EAR ANATOMY

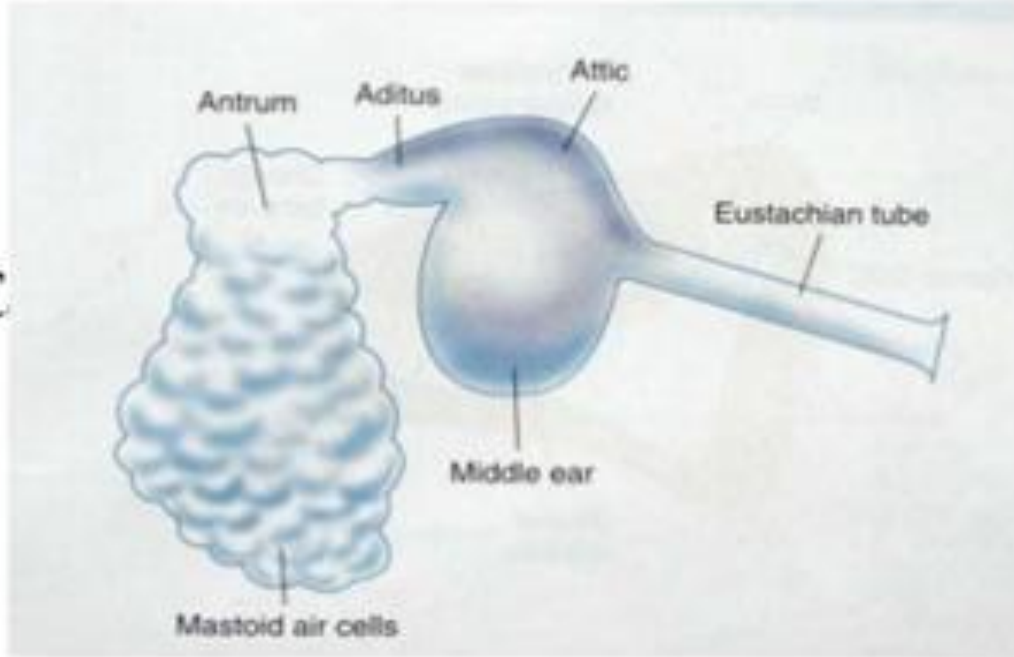
1. Tympanic membrane
2. The tympanic cavity
   - Epitympanum (attic)
   - Mesotympanum
   - Hypotympanum
   - Protympanum
   - Retrotympanum
3. Mastoid process
4. Eustachian tube



MIDDLE EAR ANATOMY

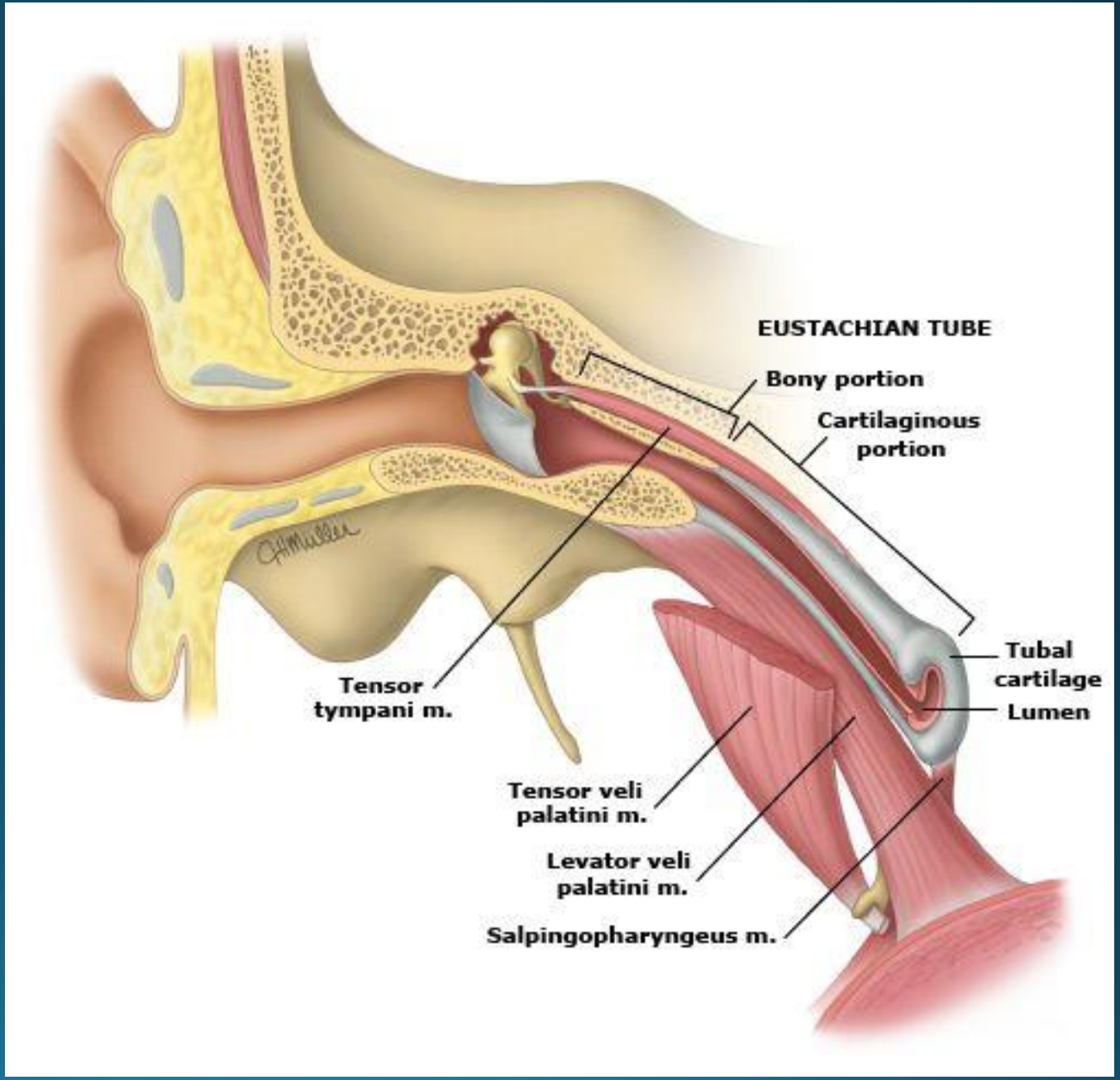
THE MIDDLE EAR CLEFT

- Eustachian Tube anteriorly
- Middle ear Cavity/Tympanic C
- Aditus
- Mastoid Antrum
- Mastoid Air Cells posteriorly

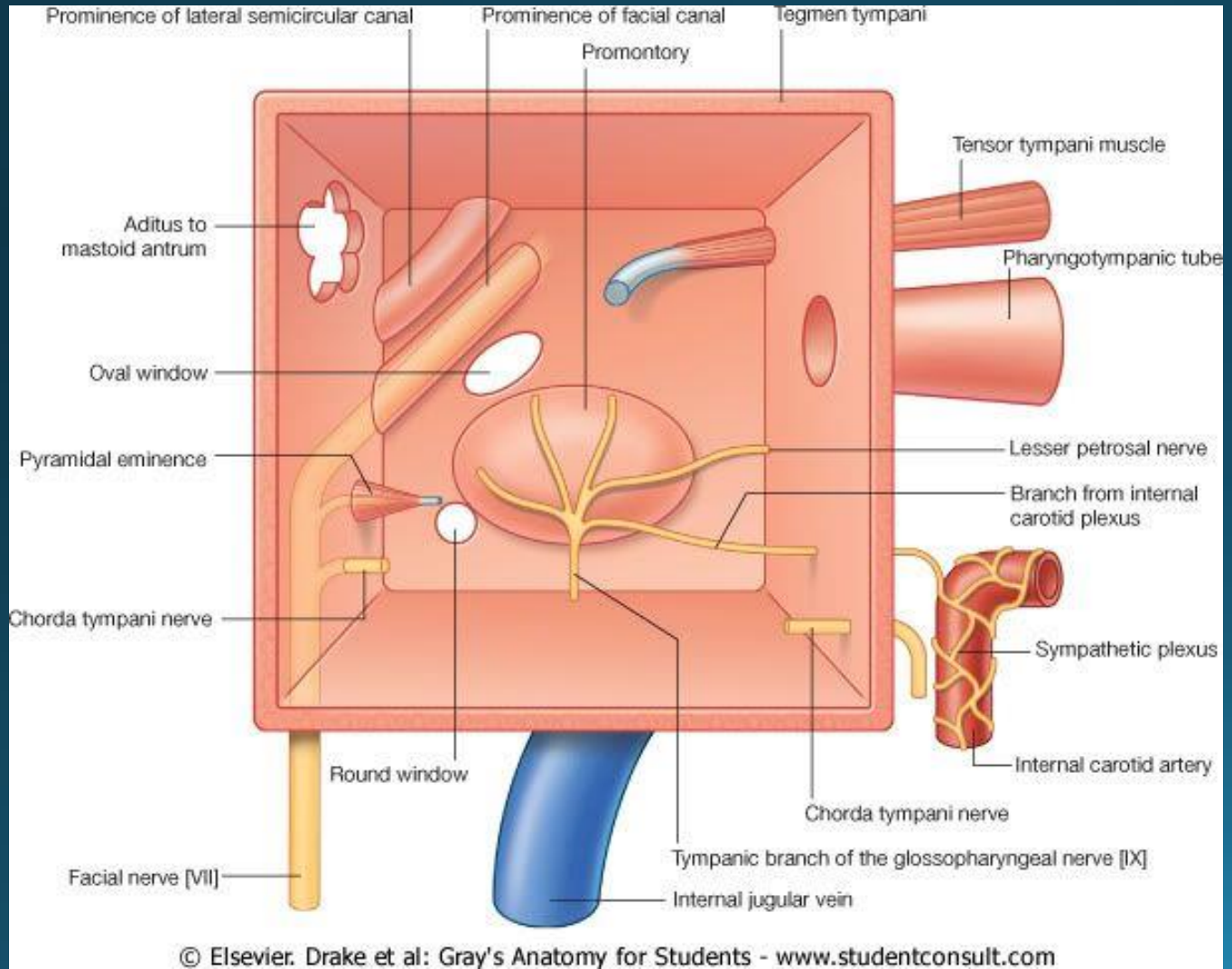


Eustachian Tube

- Pharyngotympanic tube
- Anteromedial to posterolateral
- 36 mm length, medial 2/3 (nasopharyngeal part)-cartilaginous-closed at rest. Lateral 1/3 (tympanic part)-bony and always patent.
- Children : shorter, wider, more horizontal

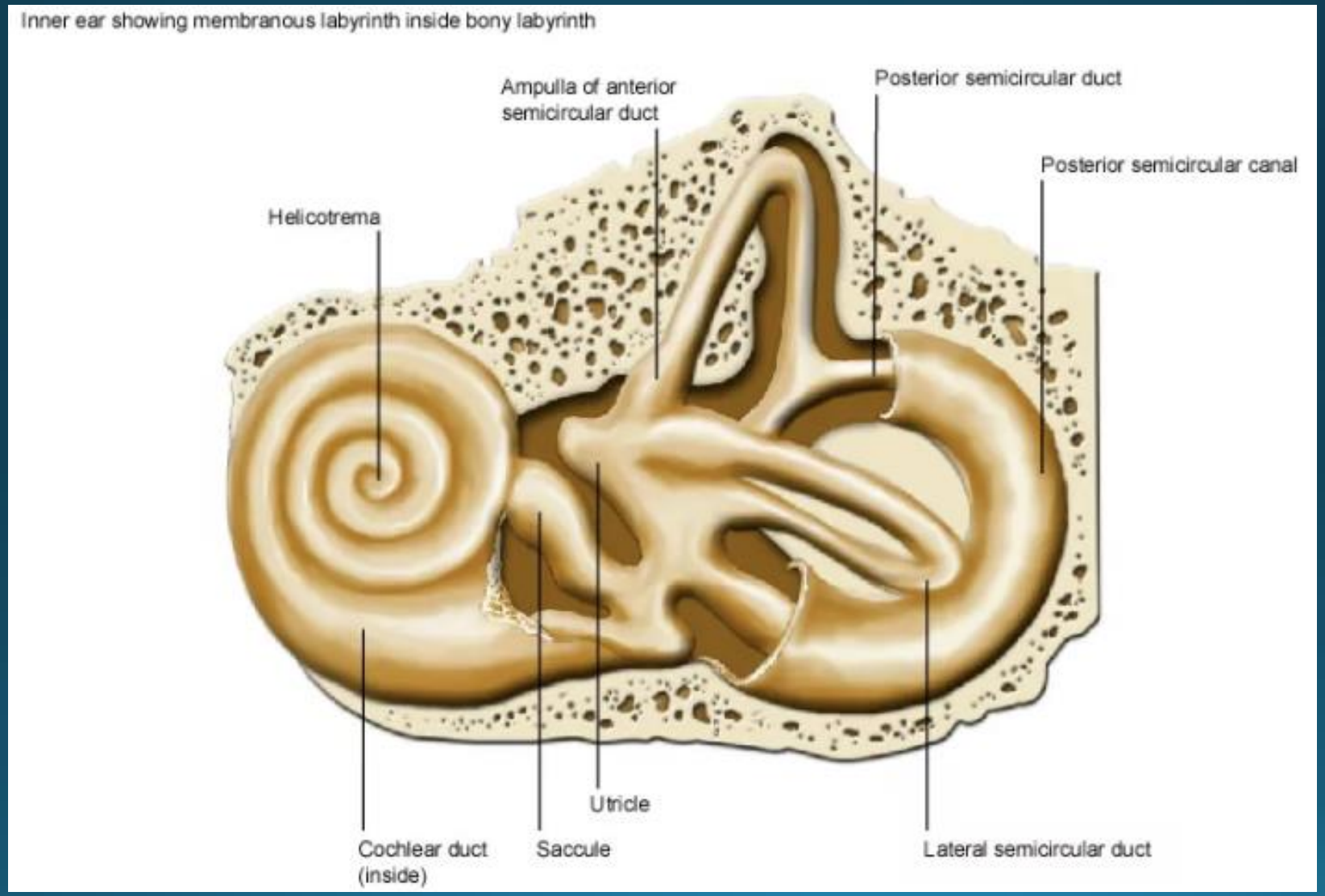


Tympanic Cavity



- Roof : tegmen tympani
- Floor : wall of jugular canal
- Medial : lateral wall of inner ear
- Lateral : tympanic membrane
- Anterior : wall of internal carotid artery
- Posterior : wall of mastoid

INNER EAR ANATOMY



MODALITIES

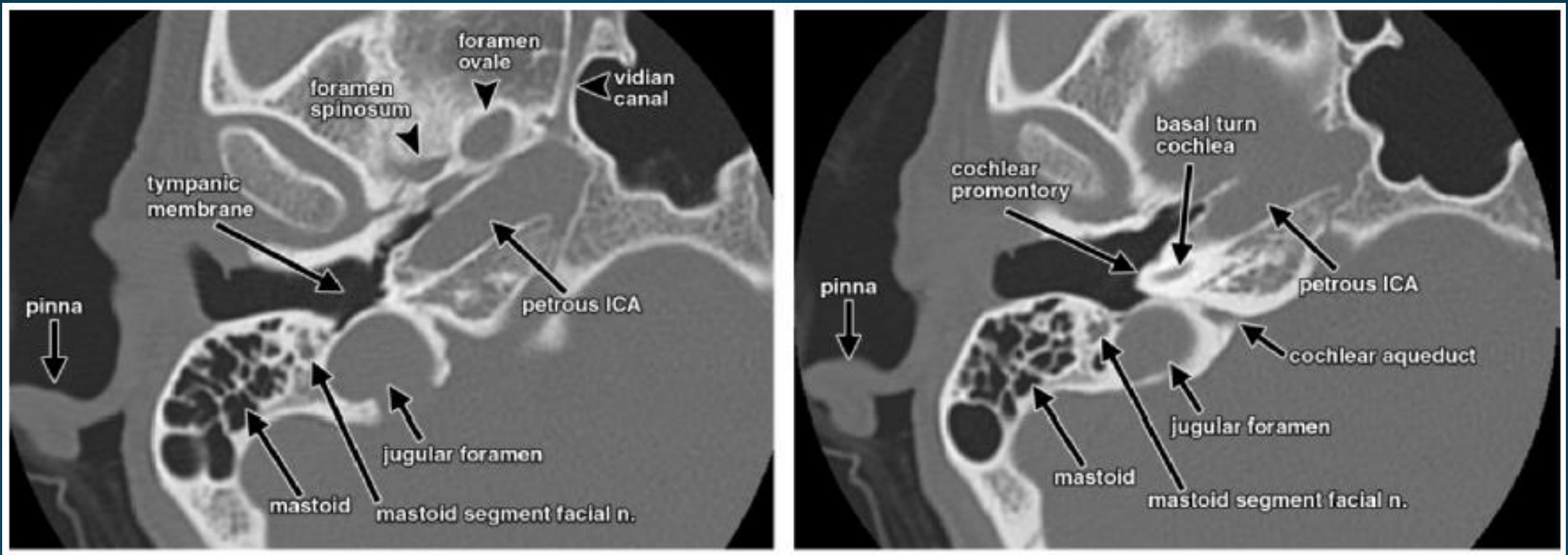
- Radiography : Schuller, Stenvers
- MDCT (HRCT) : collimation/slices thickness 0,5 mm, kV 120, mAS 100, WW/WL 4000/800, voxel 0,2 mm cubic.
- CBCT : less 3 to 10 times irradiation, very high resolution, voxel 0,08-0,125 mm cubic.
- MRI : non EPI DWI

MODALITIES

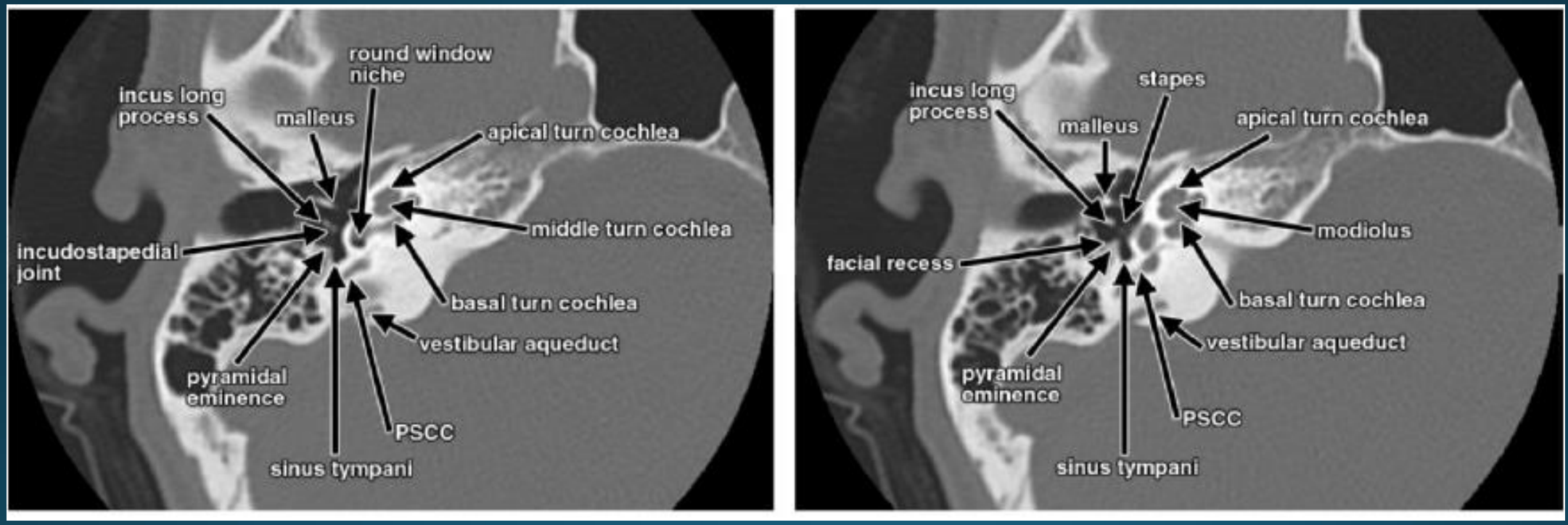
HRCT Imaging :

- Axial (orbitomeatal plane)
- Coronal
- Poschl plane
- Stenvers plane
- Sagittal oblique plane

AXIAL CT IMAGES OF THE TEMPORAL BONE FROM INFERIOR TO SUPERIOR



IAC = internal auditory canal, ICA = internal carotid artery, LSCC = lateral semicircular canal, n. = nerve, PSCC = posterior semicircular canal, SCC = superior semicircular canal.



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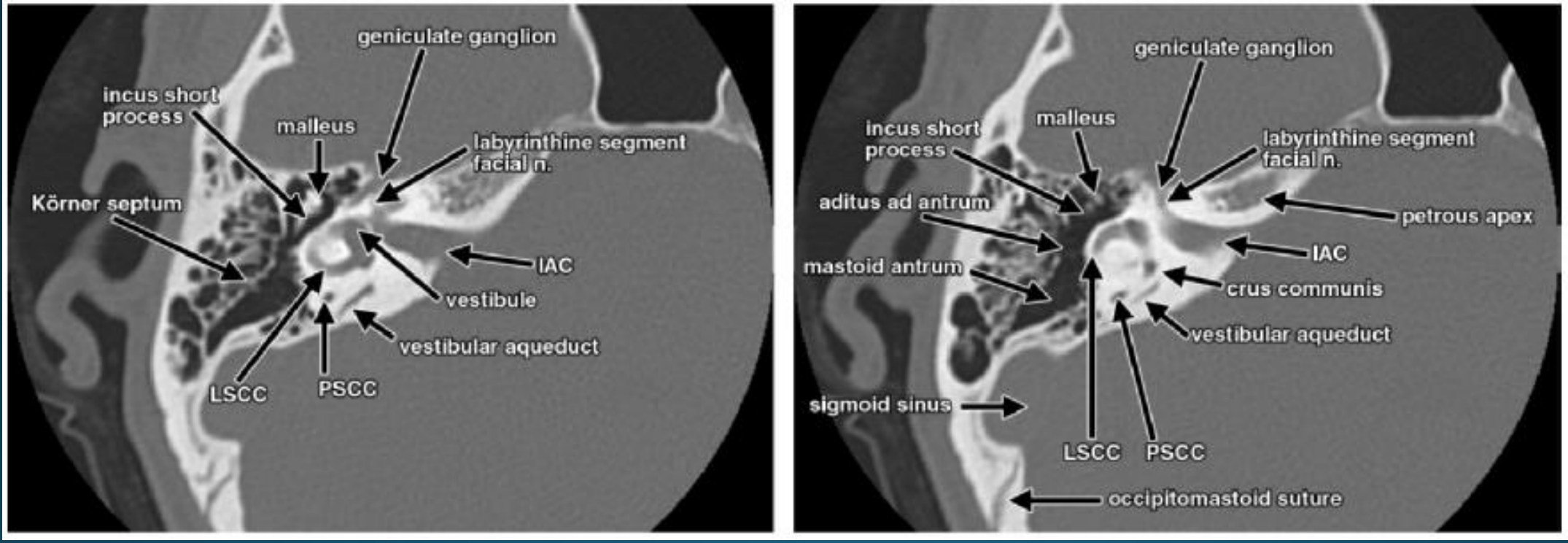

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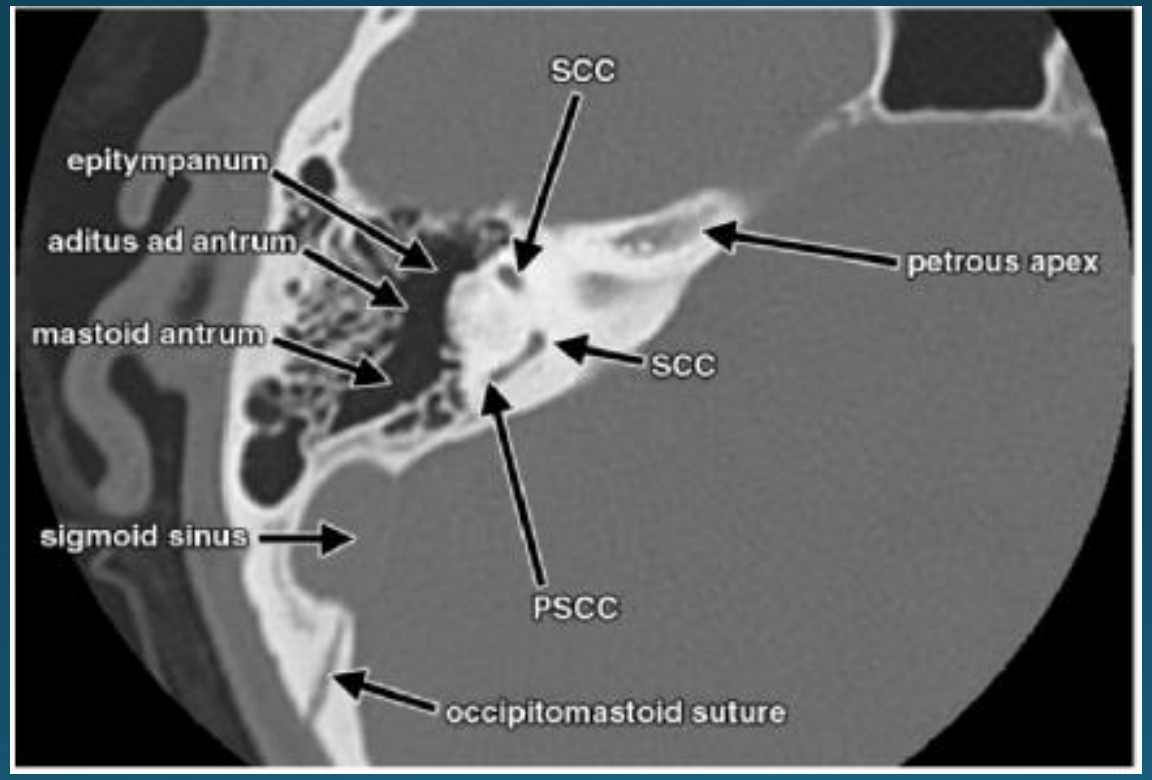
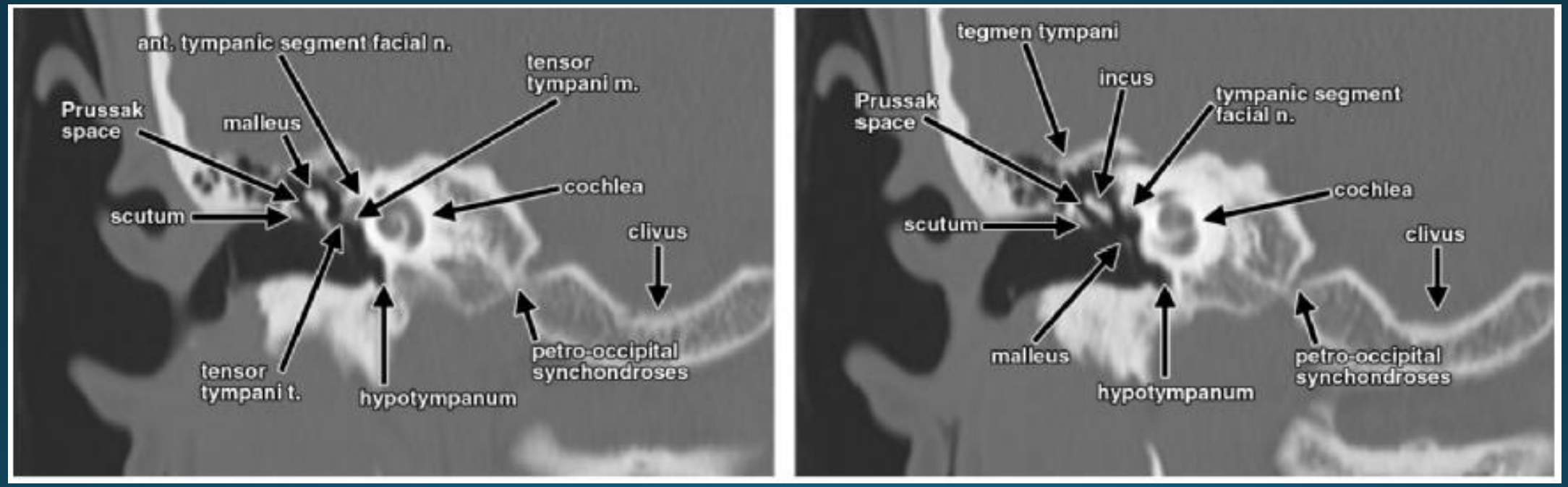
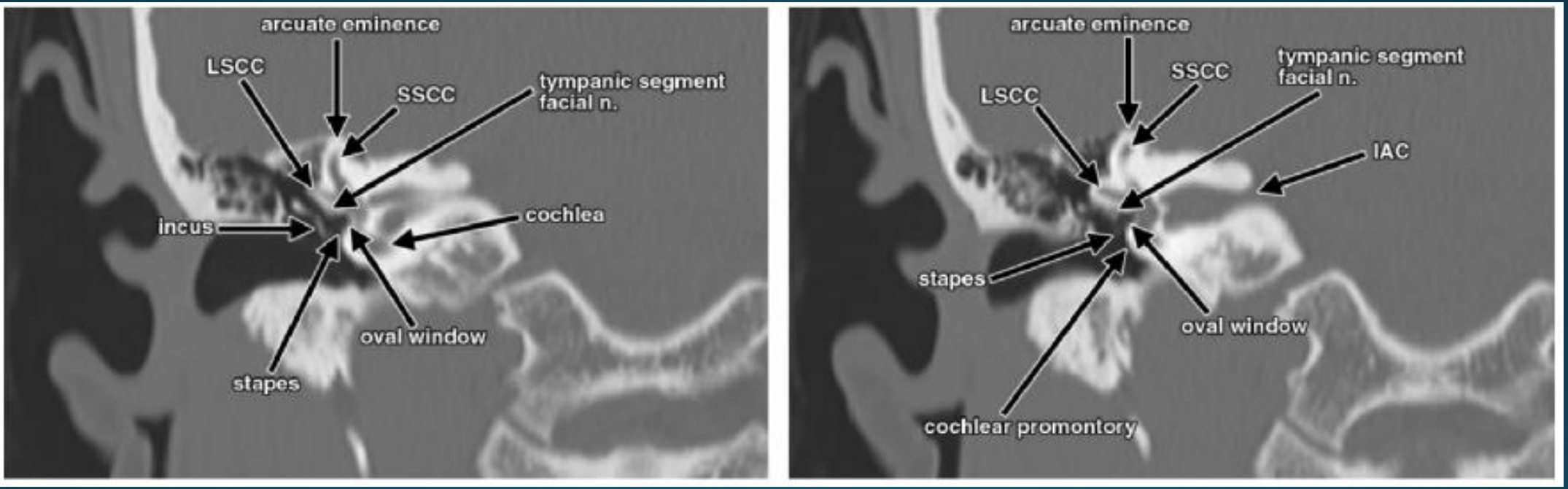


PSCC = posterior semicircular canal, SCC = superior semicircular canal

CORONAL CT IMAGES OF THE TEMPORAL BONE FROM ANTERIOR TO POSTERIOR



ant. = anterior, LSCC = lateral semicircular canal, m. = muscle, n. = nerve, SSCC = superior semicircular canal, t. = tendon



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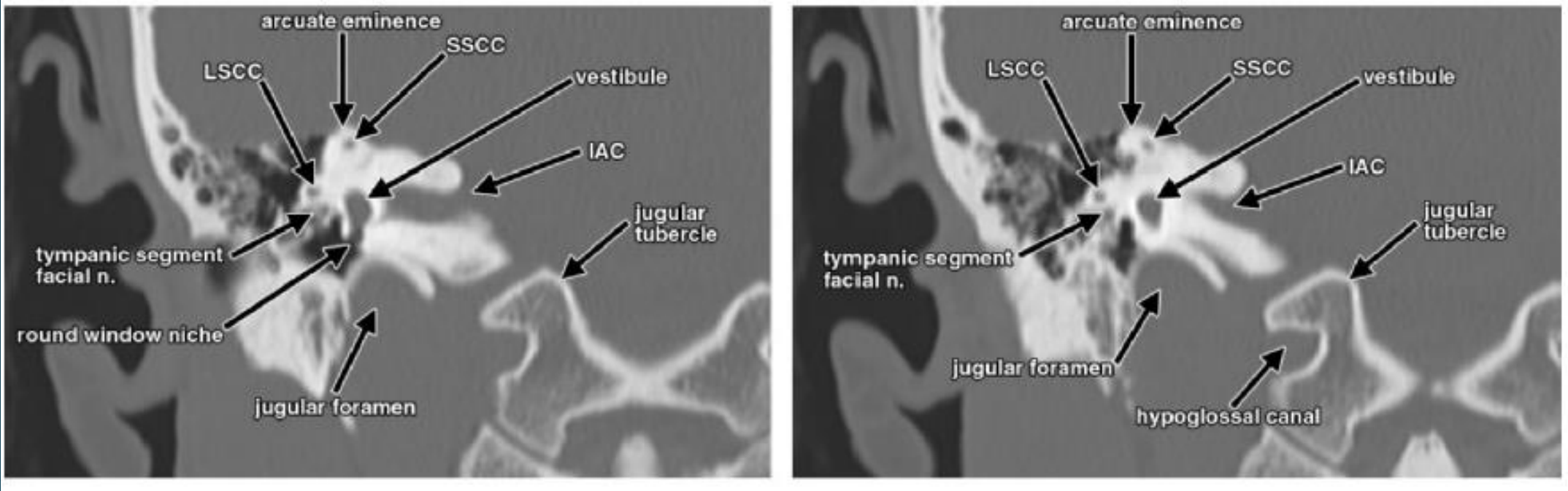
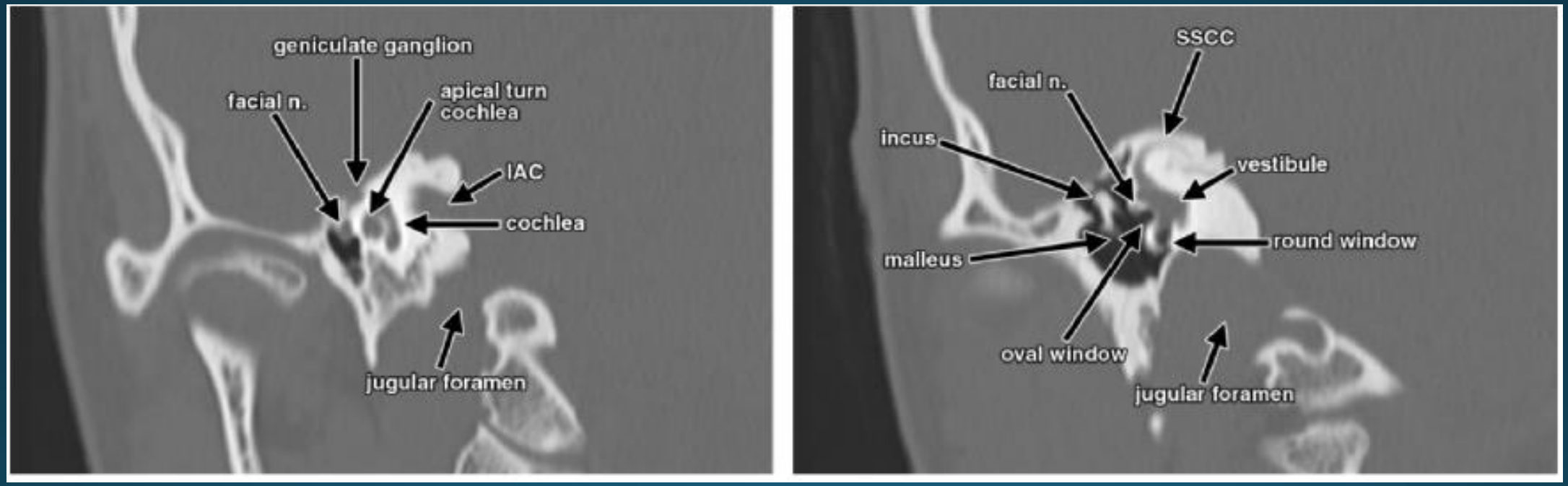
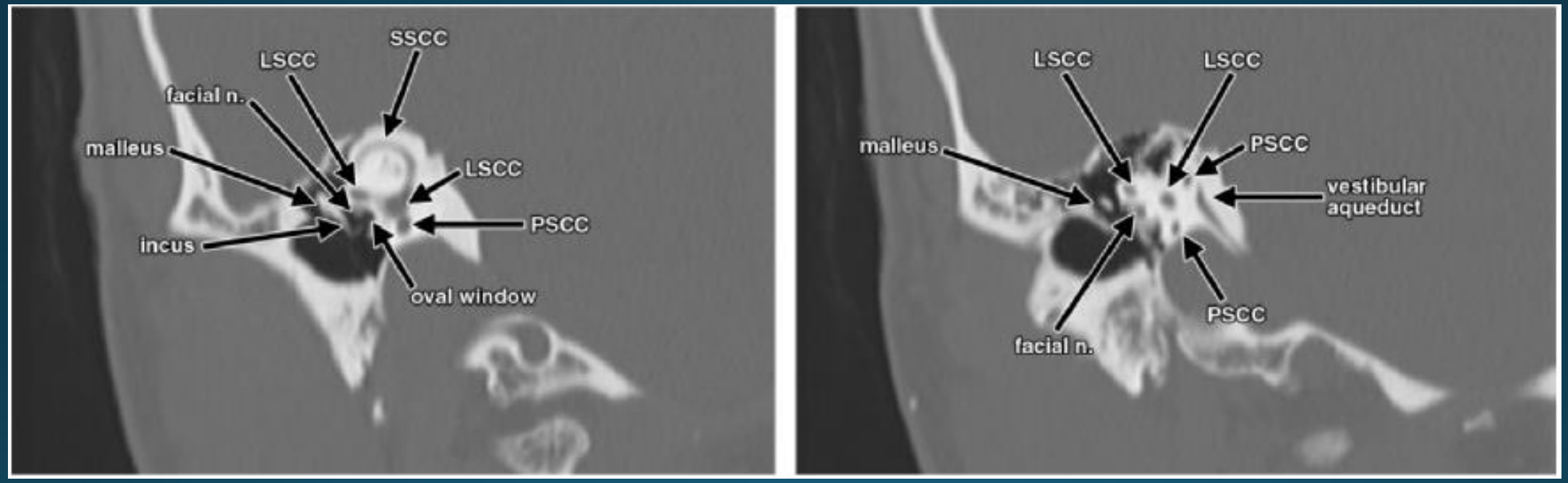


ant. = anterior, LSCC = lateral semicircular canal, m. = muscle, n. = nerve, SSCC = superior semicircular canal, LSCC = lateral semicircular canal, t. = tendon, IAC = internal auditory canal

CT IMAGES IN A PLANE PERPENDICULAR TO THE LONG AXIS OF THE PETROUS BONE OF THE TEMPORAL BONE FROM ANTEROMEDIAL TO POSTEROLATERAL



This plane is also known as the Pöschl projection. LSCC = lateral semicircular canal, n. = nerve, PSCC = posterior semicircular canal, SSCC = superior semicircular canal.



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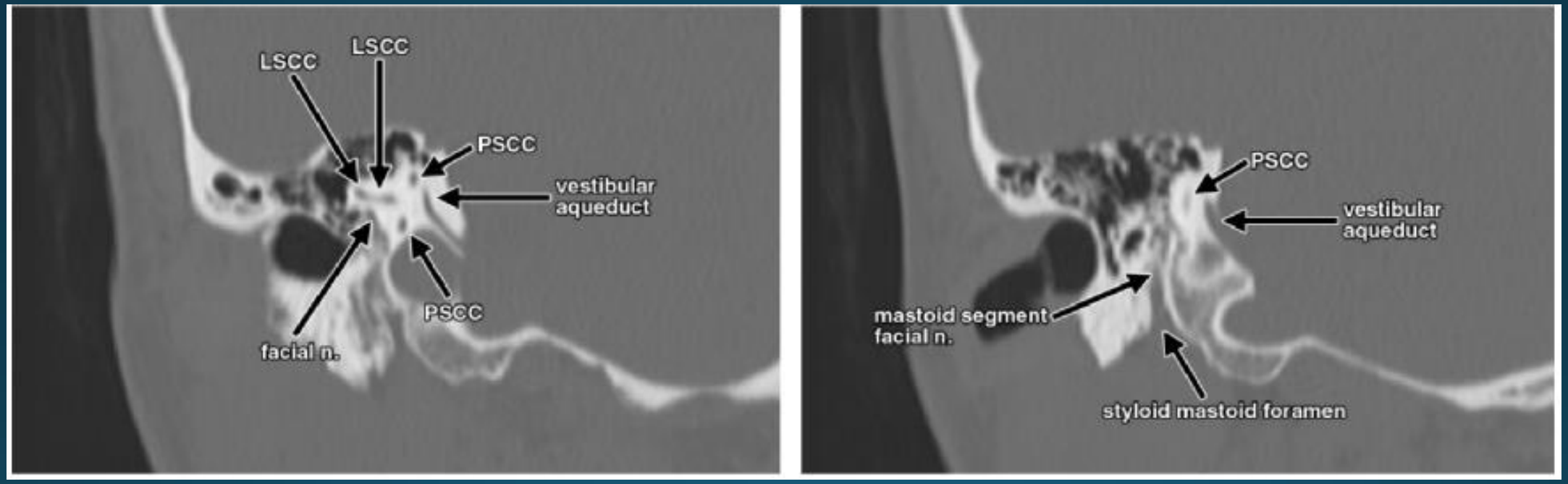
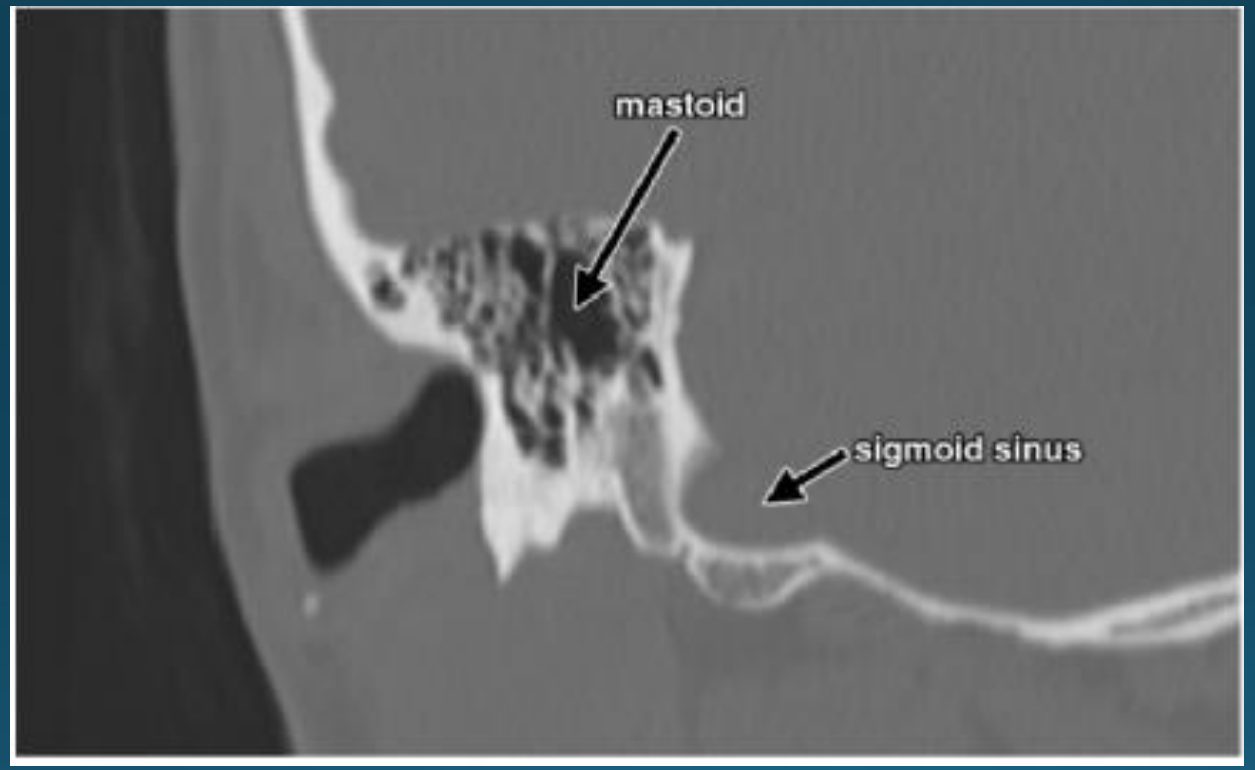


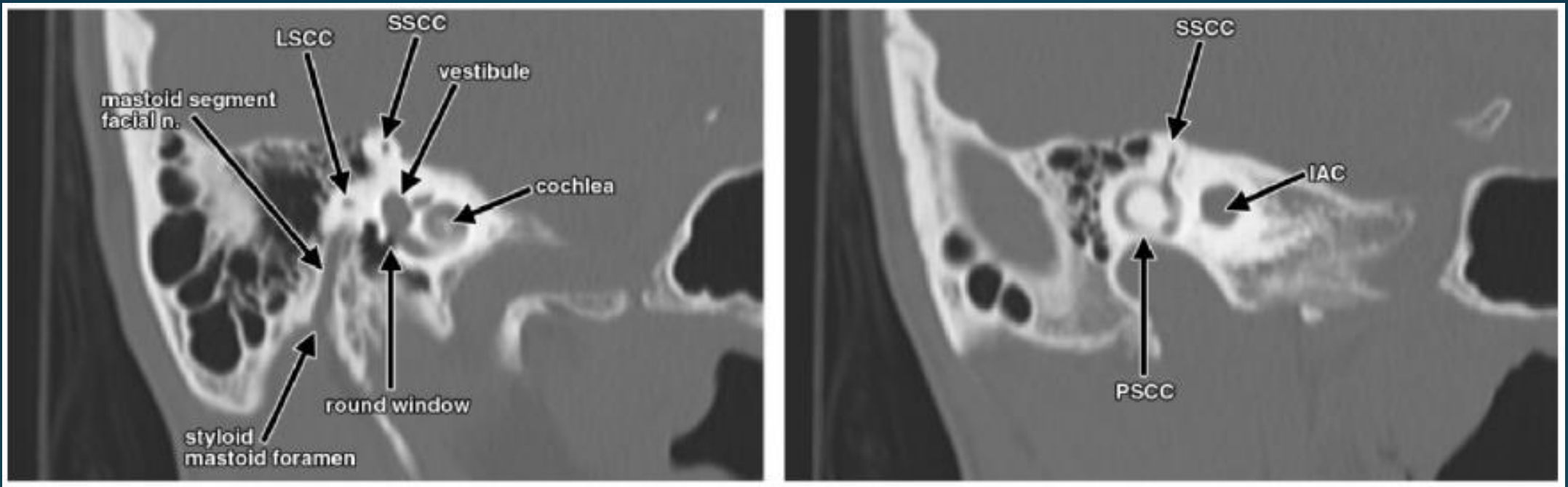
LSCC = lateral semicircular canal, n. = nerve, PSCC = posterior semicircular canal, SSCC = superior semicircular canal.


mastoid
sigmoid sinus

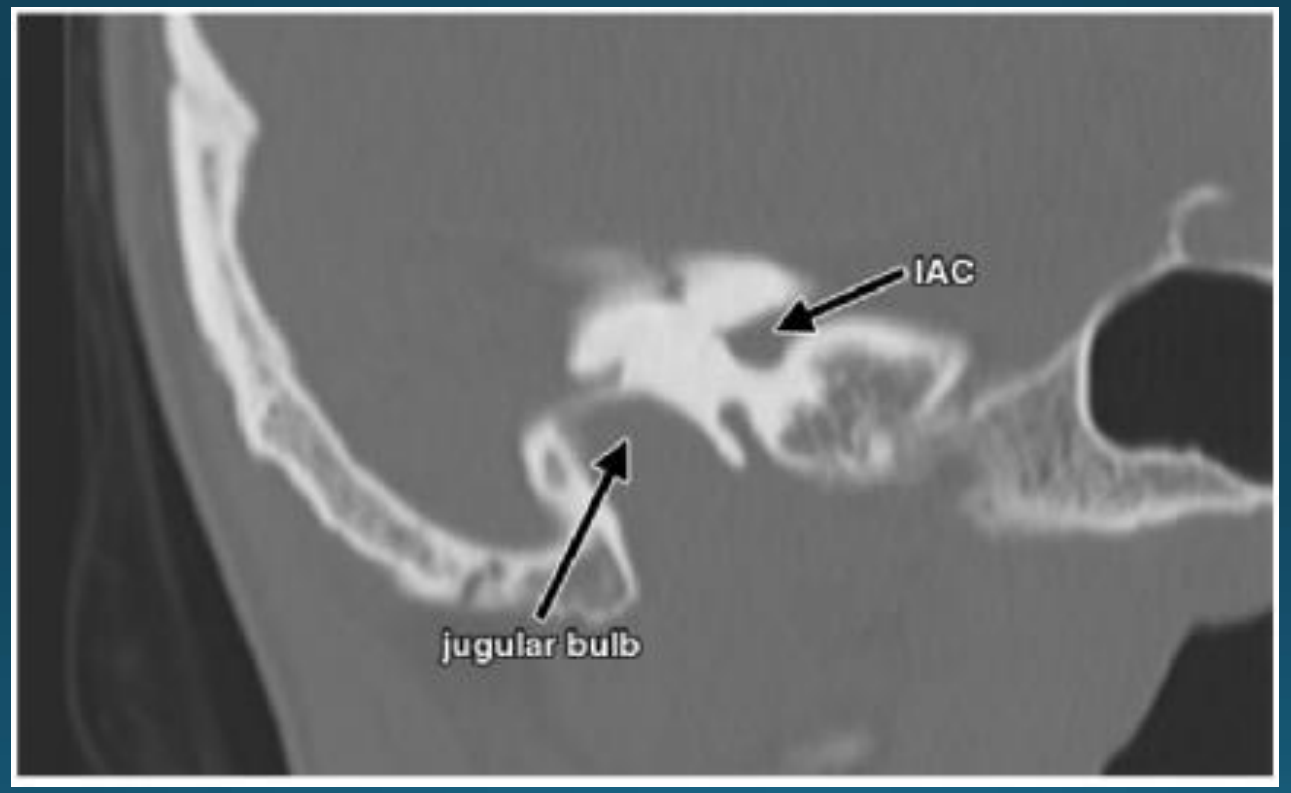
CT IMAGES IN A PLANE PARALLEL TO THE LONG AXIS OF THE PETROUS BONE OF THE TEMPORAL BONE FROM OBLIQUE ANTERIOR TO OBLIQUE POSTERIOR

This plane is also known as the Stenvers projection. ant. = anterior, EAC = external auditory canal

ant. = anterior, LSCC = lateral semicircular canal, n. = nerve, PSCC = posterior semicircular canal, SSCC = superior semicircular canal



ant. = anterior, LSCC = lateral semicircular canal, n. = nerve, PSCC = posterior semicircular canal, SSCC = superior semicircular canal, IAC = internal auditory canal



IAC = internal auditory canal

PATHOLOGICAL

Traumatic

Fracture types:

- Longitudinal
- Transverse
- Complex
- Otic capsule violating (more severe)

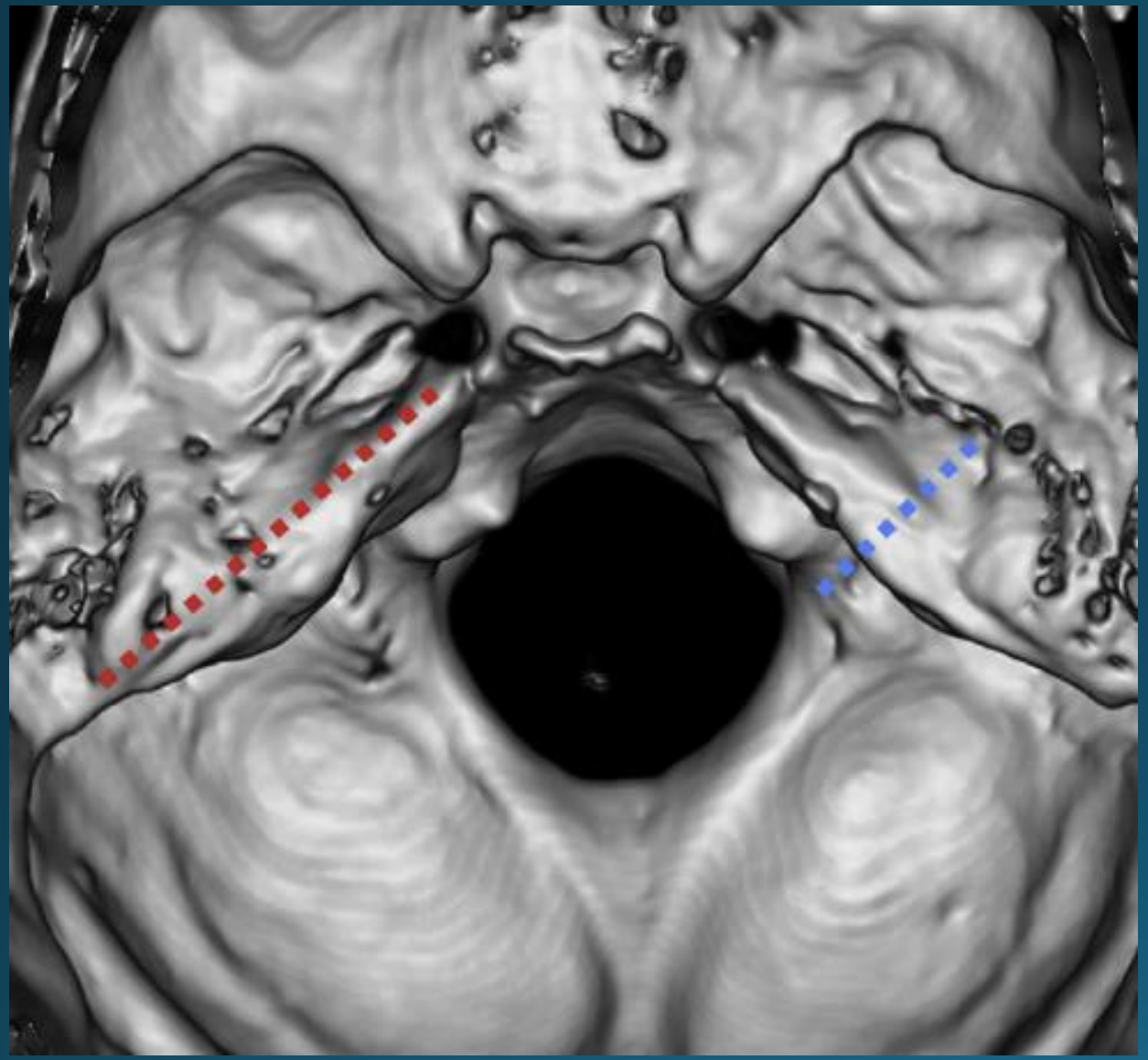
Ossicular injury

Infection

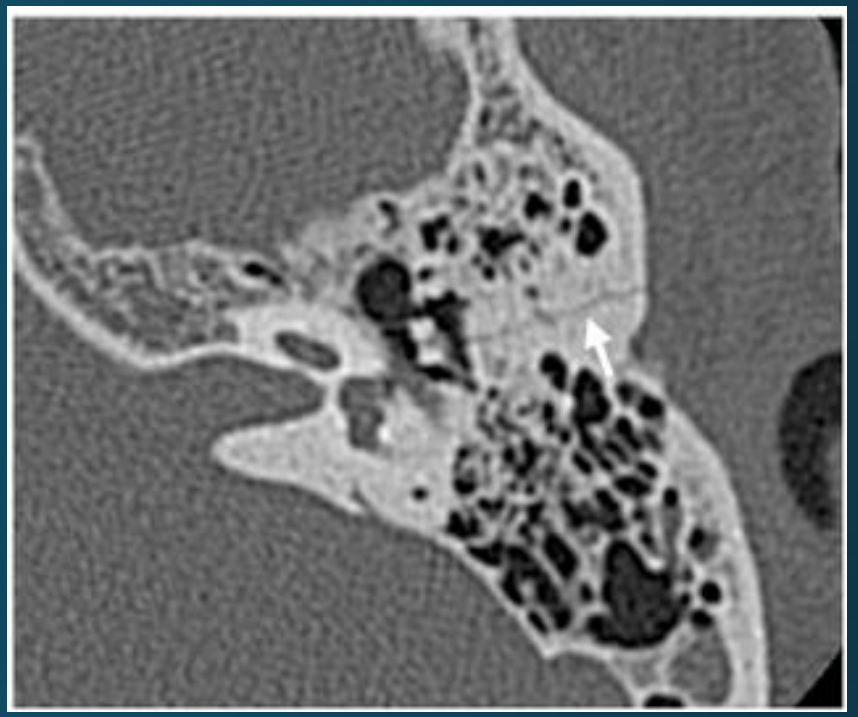
Middle ear infection and its complication

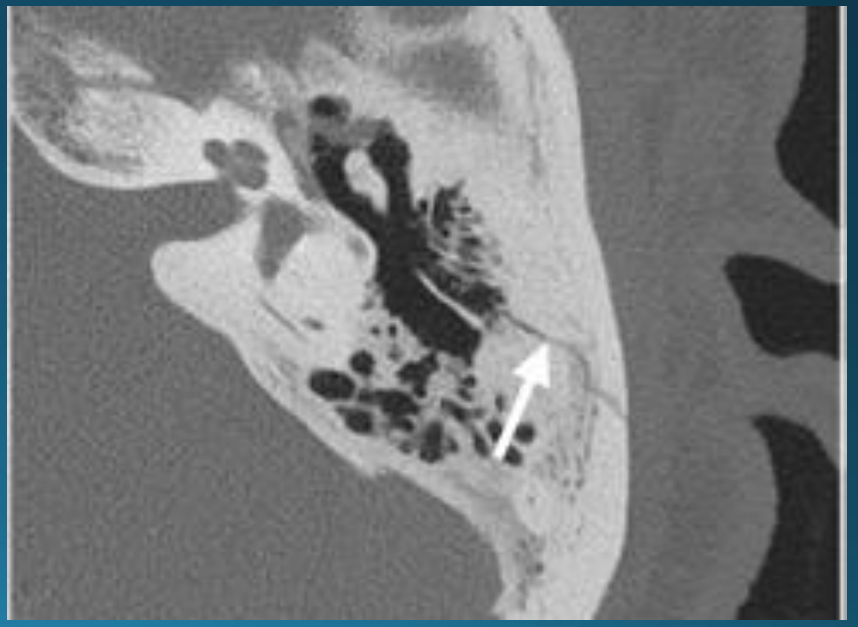
Traumatic

- Temporal bone fractures are classified as longitudinal, transverse, or mixed based on their orientation to the long axis of petrous ridge. longitudinal if parallel to the petrous pyramid and transverse if perpendicular to the petrous ridge. A mixed subtype was subsequently incorporated into this scheme if there were components of both fracture plane
- Longitudinal fractures (50–80%) are most common and often present with hearing loss and otorrhagia, with lower risk of facial nerve injury but possible ossicular disruption. Transverse fractures (10–20%) are less common but pose greater risk to the facial nerve and inner ear structures.



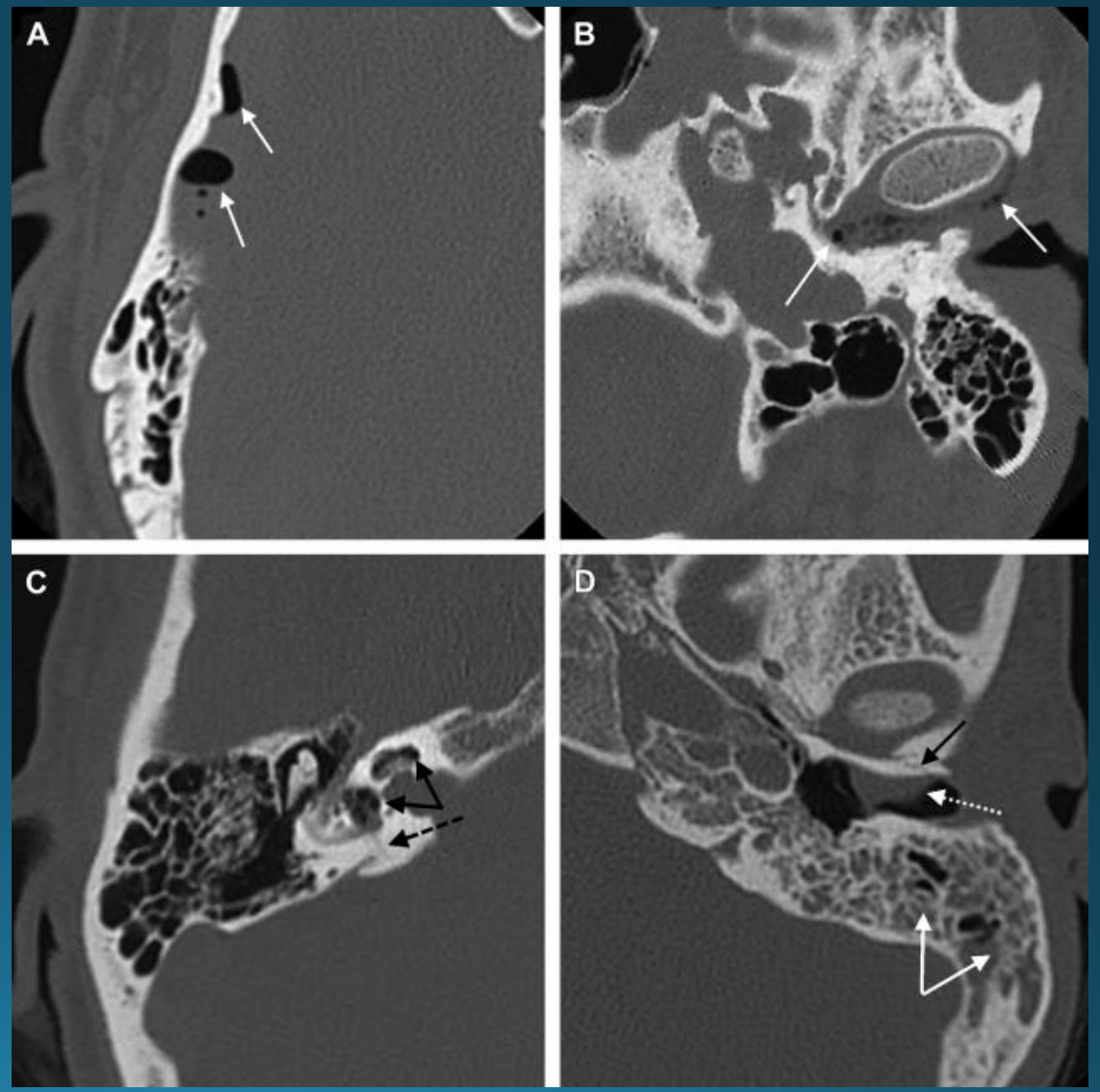
The trajectory of a longitudinal fracture of the right temporal bone (red dashed line) and a transverse fracture of the left temporal bone (blue dashed line)





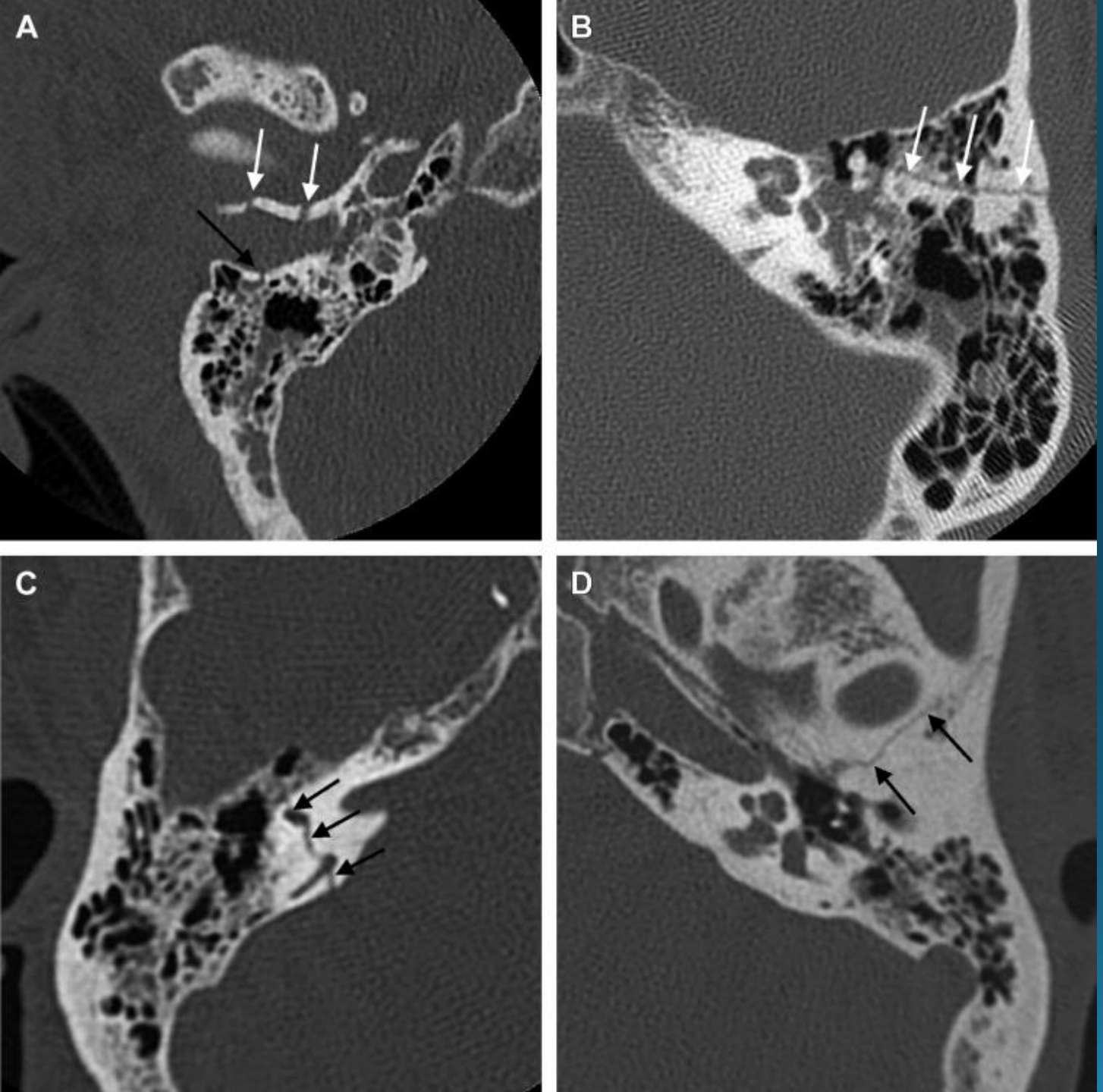
INDIRECT SIGNS OF TEMPORAL BONE FRACTURE

- Intracranial air adjacent to the temporal bone
- Air within the temporomandibular joint
- Pneumolabyrinth
- Opacification of the mastoid air cells
- Opacification of the external auditory canal



TEMPORAL BONE TRAUMA CHECKLIST

- Location and direction of temporal bone fracture
- Violation of otic capsule: cochlea, vestibule, semicircular canals, vestibular aqueduct
- Ossicular integrity: malleus, incus, stapes
- Facial nerve canal: internal auditory canal, fallopian canal, geniculate fossa, tympanic, mastoid
- Tegmen: tympani, mastoideum
- Vascular: carotid canal (petrous, cavernous), venous sinus (transverse, sigmoid, jugular bulb)

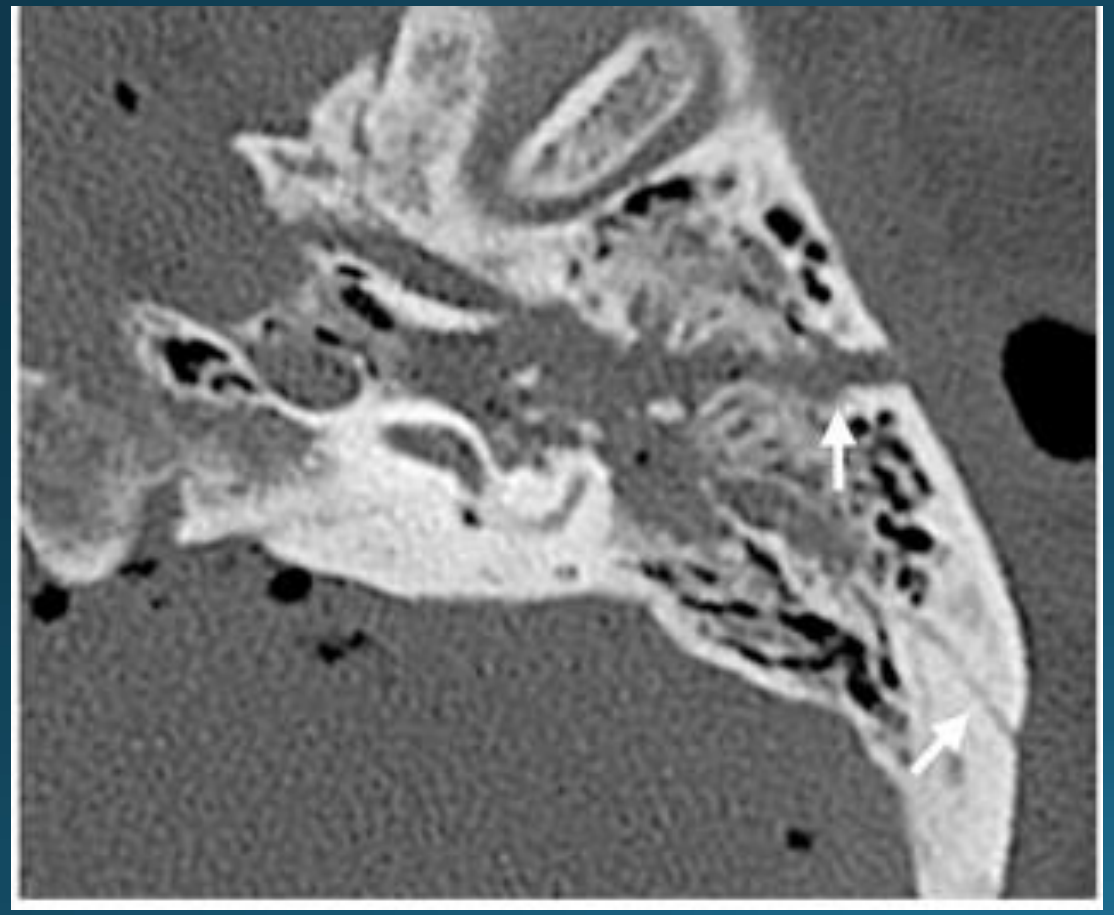


(A) A segmental longitudinal fracture of the tympanic ring (A, white arrows) with an additional fracture that extends through the mastoid (A, black arrow) with associated hemorrhage in the external auditory canal.

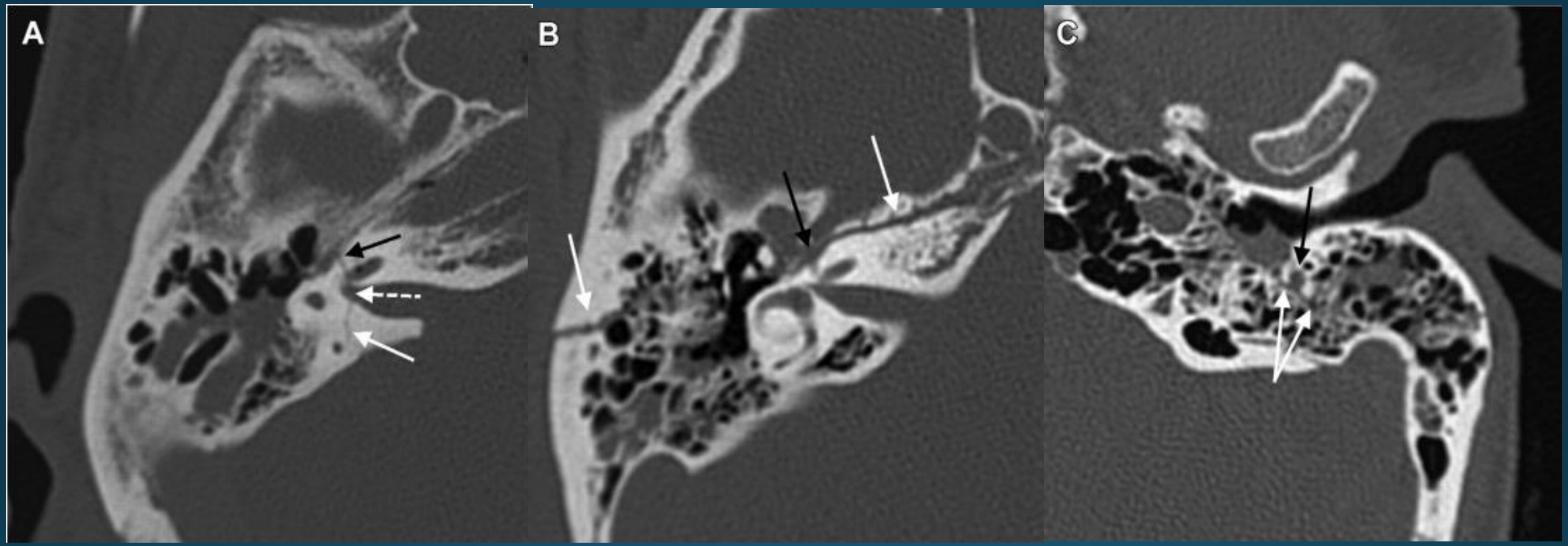
(B) A characteristic longitudinal extralabyrinthine fracture of the mastoid that extends into the middle ear cavity (B, white arrows).

(C) A transverse intralabyrinthine fracture with involvement of the semicircular canals (C, black arrows).

(D) A transverse extralabyrinthine fracture traversing the squamous portion of the temporal bone (D, black arrows



Mix fracture, axial CT image through the left temporal bone demonstrates a comminuted fracture (arrows) oriented perpendicular and parallel to the long axis of the petrous temporal bone



Injury of the facial nerve canal (A) A transverse intralabyrinthine fracture (A, solid white arrow) that extends through the fundus of the internal auditory canal (A, dashed white arrow) and subsequently propagates through the tympanic segment of the facial nerve canal (A, black arrow). (B) An otic capsule–sparing longitudinal fracture (B, white arrows) that extends through the mastoid, middle ear cavity, geniculate fossa of the facial nerve (B, black arrow), and through the petrous apex. (C) A nondisplaced longitudinal fracture of the left mastoid (C, white arrows) that extends through the medial aspect of the mastoid segment of the facial nerve canal (C, black arrow).

OSSICULAR INJURY

The ossicular joints may be described as subluxed if there is only mild separation of the ossicles, and dislocated if there is frank separation of the ossicles

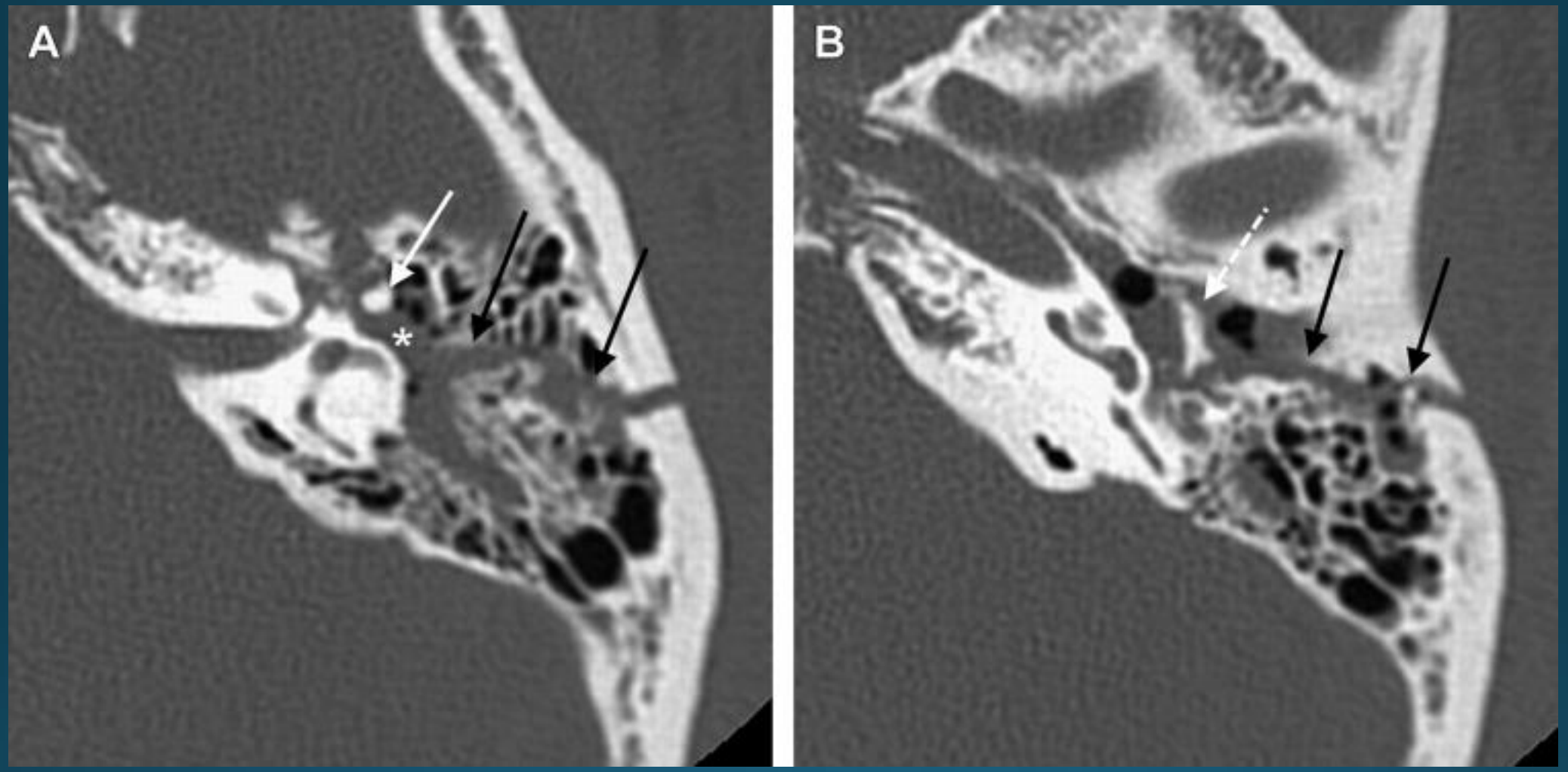
Injury of the incudomalleolar joint

(A) The normal incudomalleolar joint in the axial plane

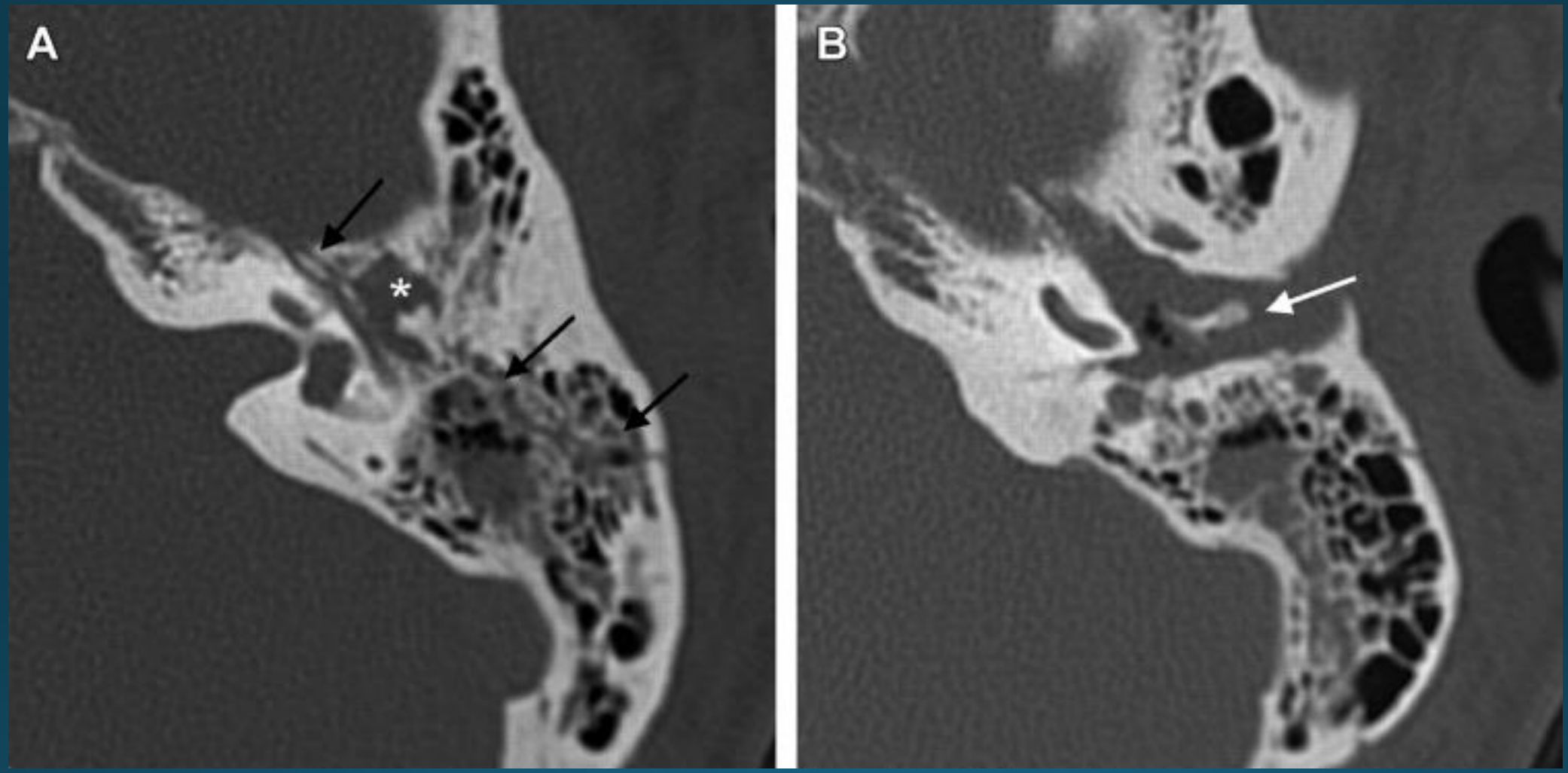
(B) Mild subluxation of the incudomalleolar joint space (B, dotted arrow) related to an extralabyrinthine longitudinal fracture (B, solid arrow).

(C) Frank dislocation of the incudomalleolar joint (C, dotted arrow) related to an extralabyrinthine longitudinal fracture (B, solid arrow). A transverse fracture of the petrous temporal bone is also present in this patient (C, arrowheads).

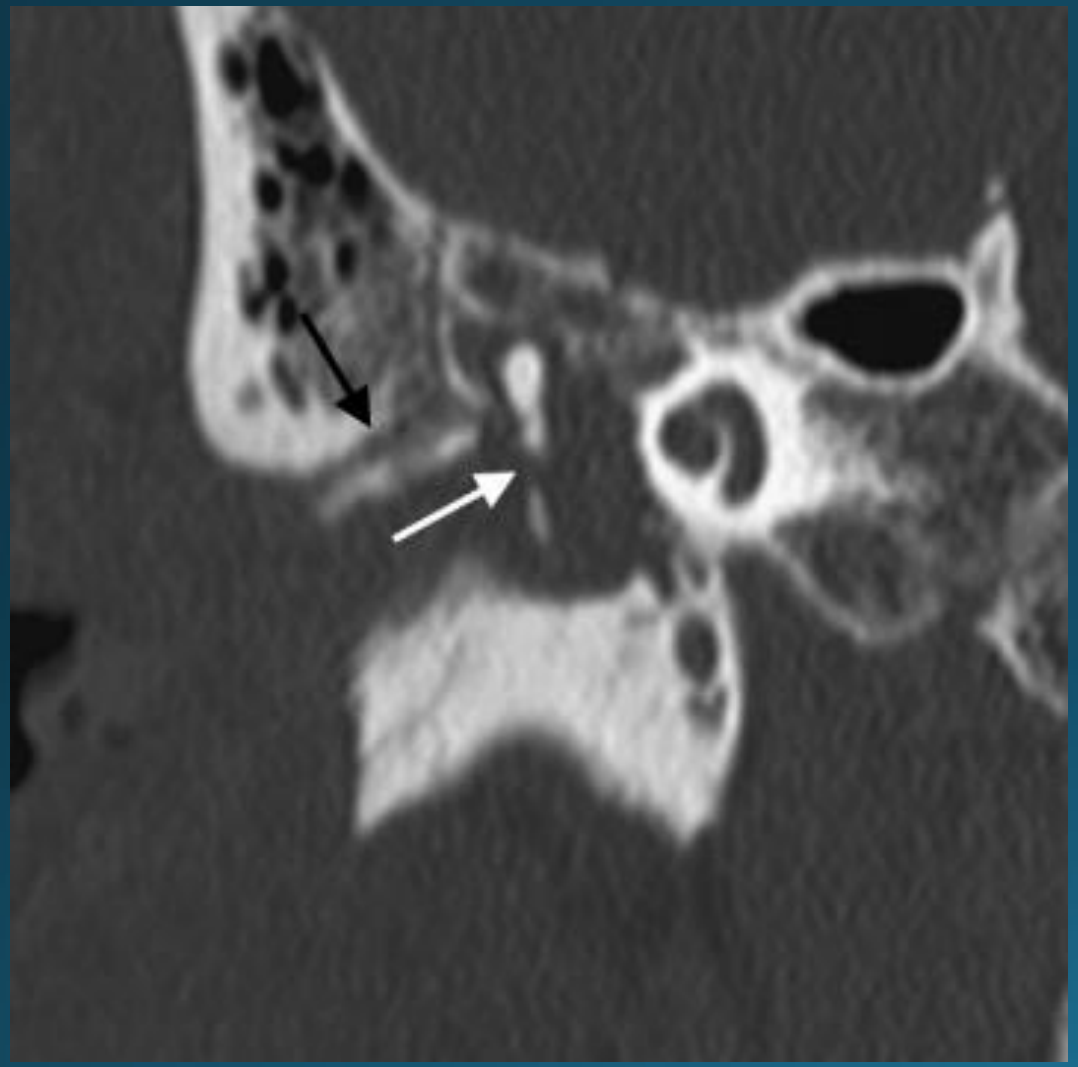
(D) Dislocation of the incudomalleolar joint can be seen in the coronal plane and has been described as the Y sign (D). There is lateralization of the incus (D, dashed white arrow) with respect to the malleus (D, solid white arrow) with an intervening gap. Also note the wide fracture gap through the tegmen (D, solid black arrows).



Total incus dislocation. Axial CT images of the left temporal bone (A, B) show absence of the incus from its normal position within the incudal fossa (A, asterisk) with preservation of the normal position of the malleus (A, white arrow) related to a longitudinal extralabyrinthine fracture (A, B, black arrows). The incus is rotated and inferiorly positioned within the tympanic cavity (B, dashed arrow).

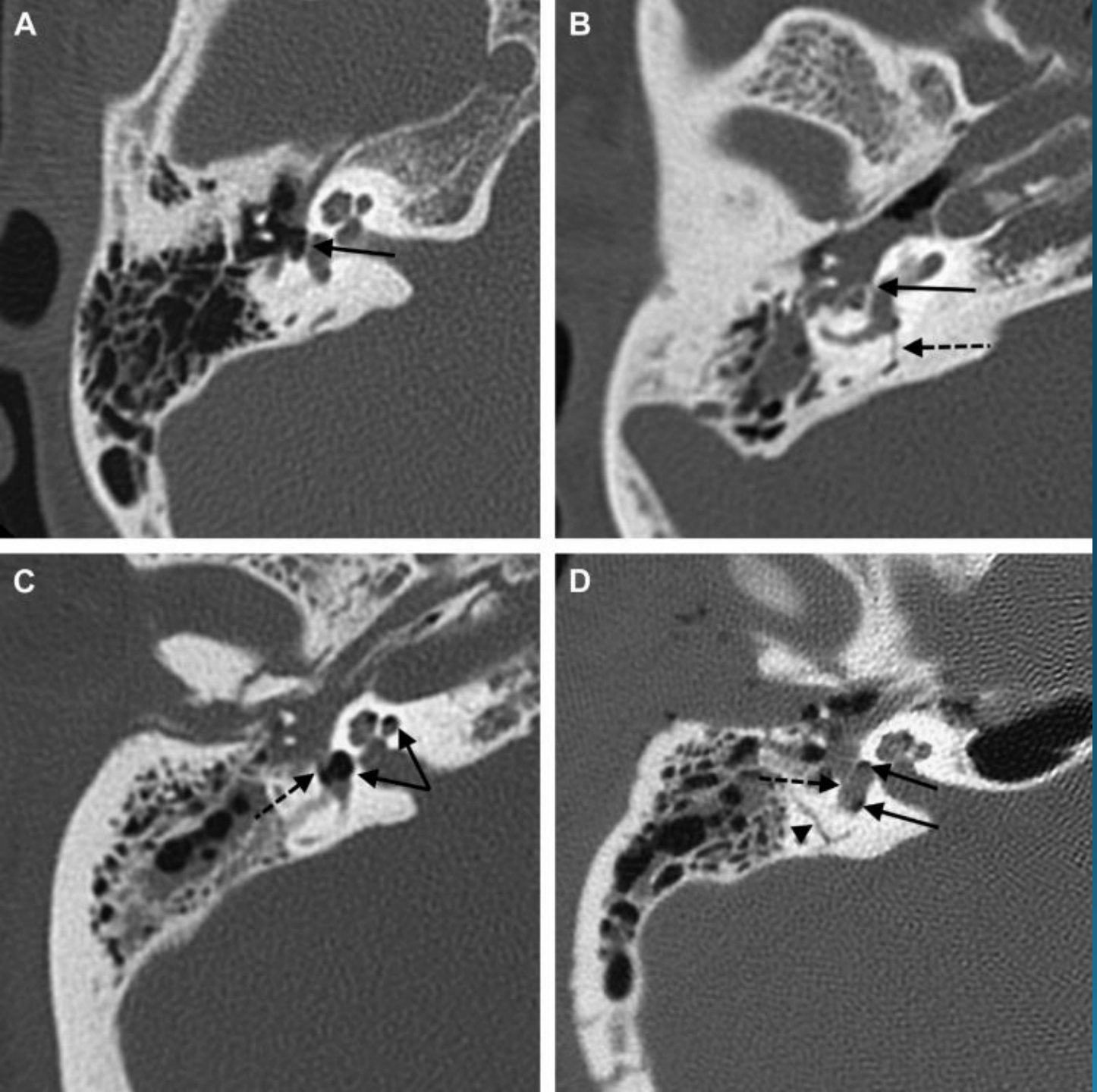


Malleus dislocation. Axial CT images of the left temporal bone show malleus dislocation (A, B) related to a longitudinal otic capsule–sparing fracture (black arrows). The malleus is externally rotated and inferiorly dislocated (B, white arrow) from its normal position within the tympanic cavity (A, asterisk).



Malleus fracture

A fracture of the manubrium of the malleus with inferior positioning of the lower fracture fragment (white arrow) related to a longitudinal otic capsule–sparing temporal bone fracture (black arrow).



Stapes footplate fractures

(A) The normal appearance of the stapes footplate and oval window in the axial plane (A, arrow).

(B) A transverse otic capsule–violating fracture of the right temporal bone (B, dashed arrow). The fracture extends through the anterior margin of the stapes footplate (B, solid arrow).

(C) A subtle depressed fracture of the stapes footplate (C, dashed arrow) with extensive associated pneumolabyrinth in the cochlea and vestibule (C, solid arrows). Although the fracture is subtle, the presence of air within the otic capsule should raise the suspicion for injury.

(D) A subtle stapes footplate fracture (D, dashed arrow) with associated subtle pneumolabyrinth (D, solid arrows). An additional transverse fracture is identified coursing through the vestibular aqueduct (D, arrowheads). Fractures of the footplate should raise the concern for associated perilymphatic fistula

INFECTION

- The most common cause of middle ear morbidity is benign chronic suppurative otitis media (2,7 %)
- Middle ear infection = Otitis media : inflammation of mucoperiosteal lining of the middle ear cleft
- Middle ear infection complication : Infection spreads beyond muco-periosteal lining of middle ear cleft to involve bone & neighboring structures like facial nerve, inner ear, dural venous sinuses, meninges, brain tissue & extra-temporal soft tissue

TUBOTYMPANIC TYPE

- Anteroinferior part of middle ear cleft
- Mucosal
- Safe (no risk of serious complications)
- TM perforation : central (pars tensa)
- Sign : CHL, otorrhea (profuse)

ATTICOANTRAL TYPE

- Posterosuperior of middle ear cleft
- Osteal/ bony
- Unsafe (dangerous type)
- TM perforation : marginal
- Sign : CHL, otorrhea (scanty), retraction pocket, cholesteatoma

MIDDLE EAR INFECTION COMPLICATION

Intracranial Complication

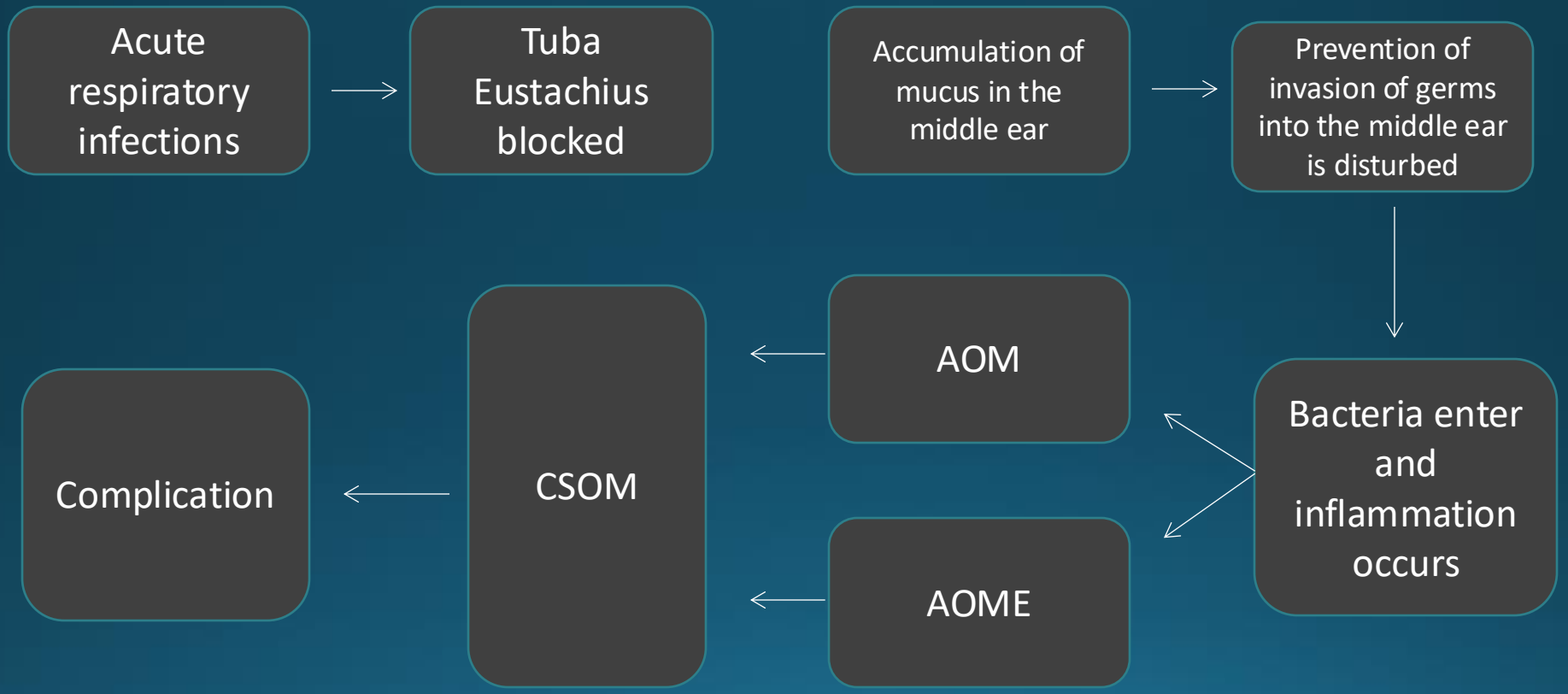
- Meningitis
- Extradural abscess
- Subdural empyema
- Lateral sinus thrombophlebitis
- Brain abscess
- Otitic hydrocephalus

Extracranial

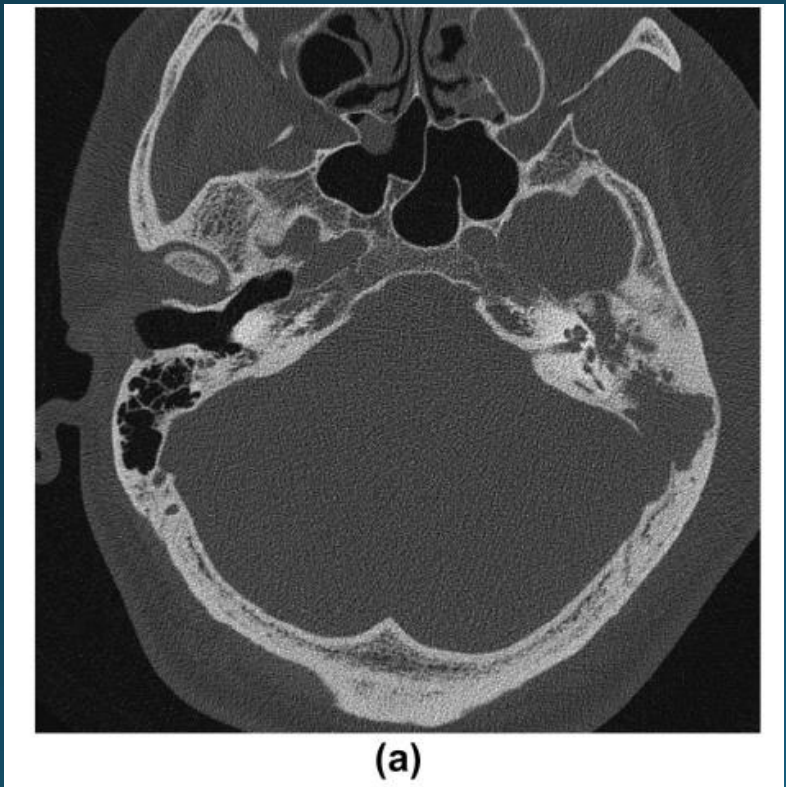
Extratemporal
- Subperiosteal abscesses

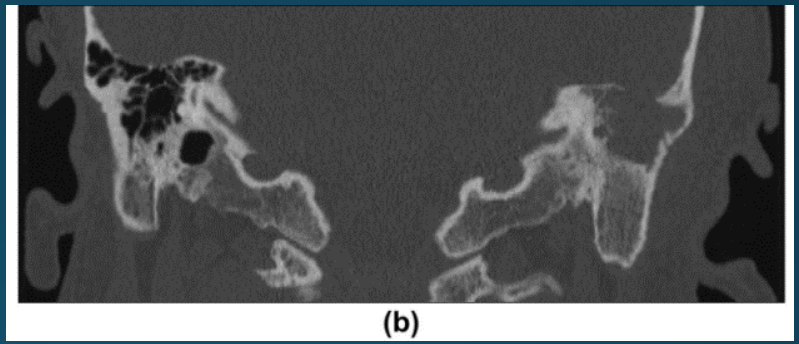
Intratemporal
- Mastoiditis
- Labyrinth involvement
- Petrous apicitis
- Facial nerve paralysis
- Sensonneural hearing loss

PATHOPHYSIOLOGY



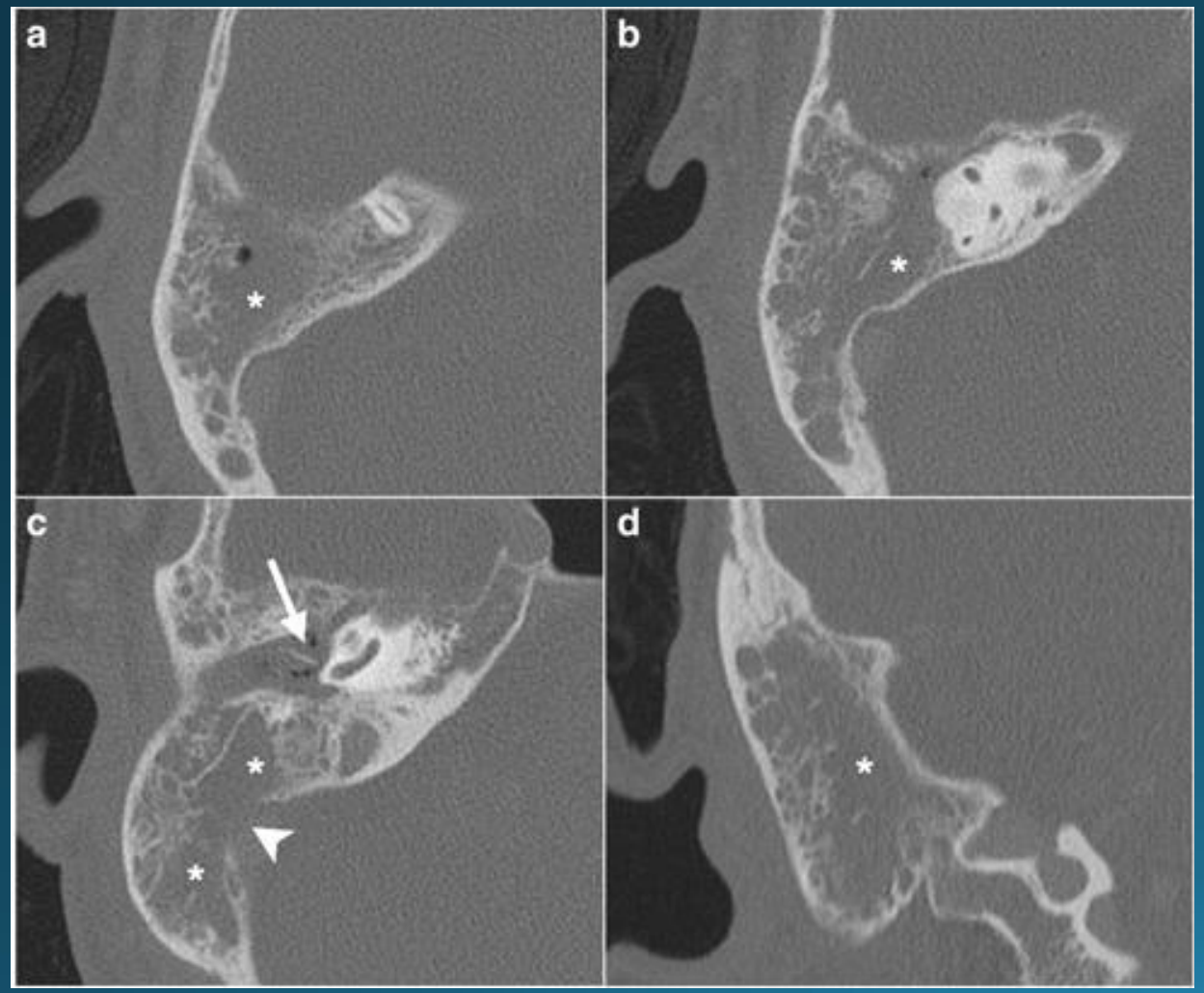
ACUTE OTOMASTOIDITIS





(a) Axial and (b) coronal reconstruction CT images of the mastoid. The right mastoid air cells are well aerated and the fine bony septa are clearly visible. In comparison the left mastoid cavity and middle ear are opacified. There is almost complete loss of the mastoid bony septa, and there has been erosion though the cortical wall of the mastoid into the middle cranial fossa. There is also soft-tissue swelling overlying the left face and mastoid process.

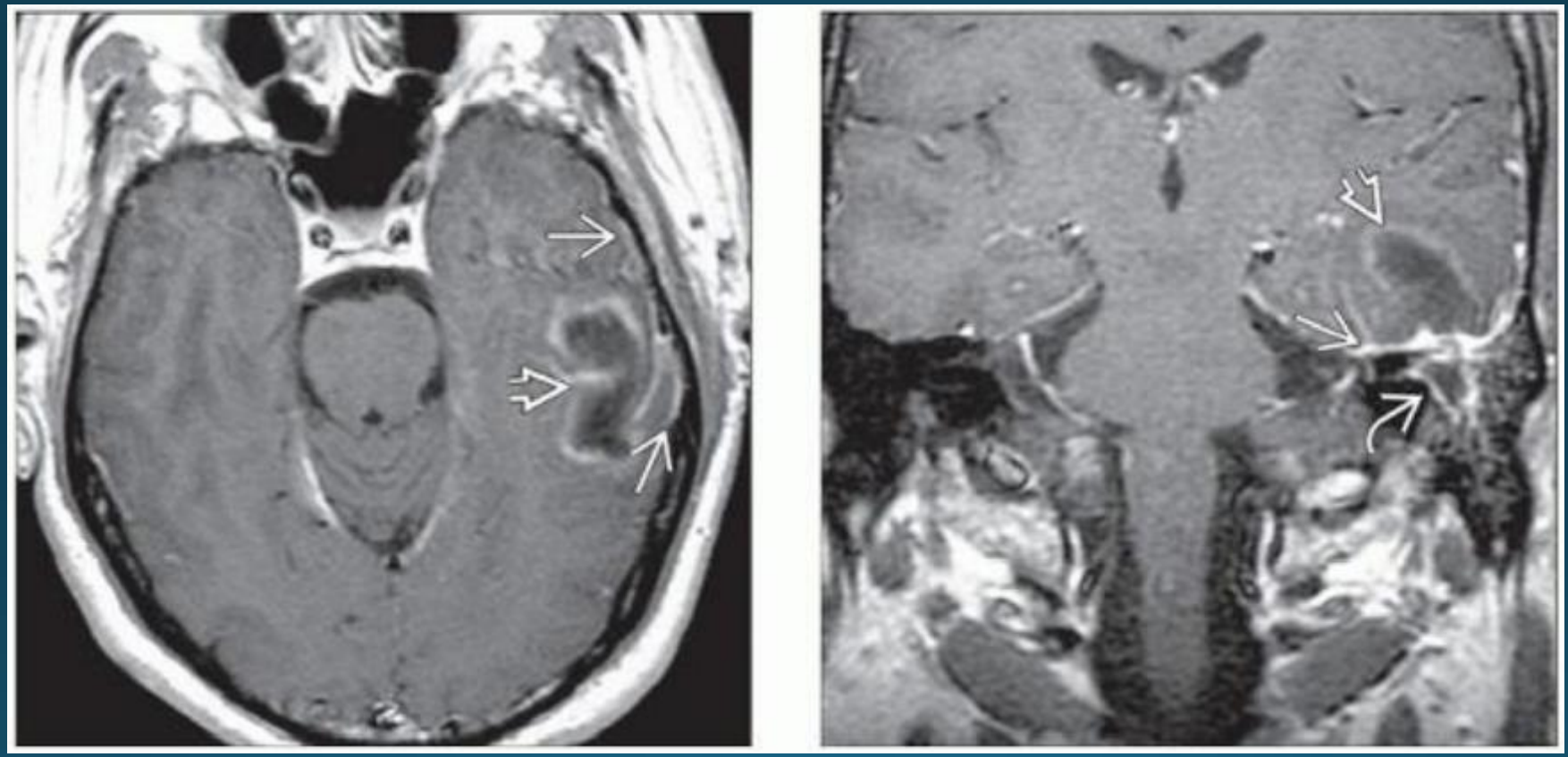
COALESCENT MASTOIDITIS



Right temporal bone CT axial images from cranial to caudal (a c) and coronal reconstruction (d) demonstrate complete opacification of the mastoid air cells with erosion of the osseous septa (asterisk). There is also fluid within middle ear cavity (arrow) and erosion of the sigmoid plate (arrowhead)

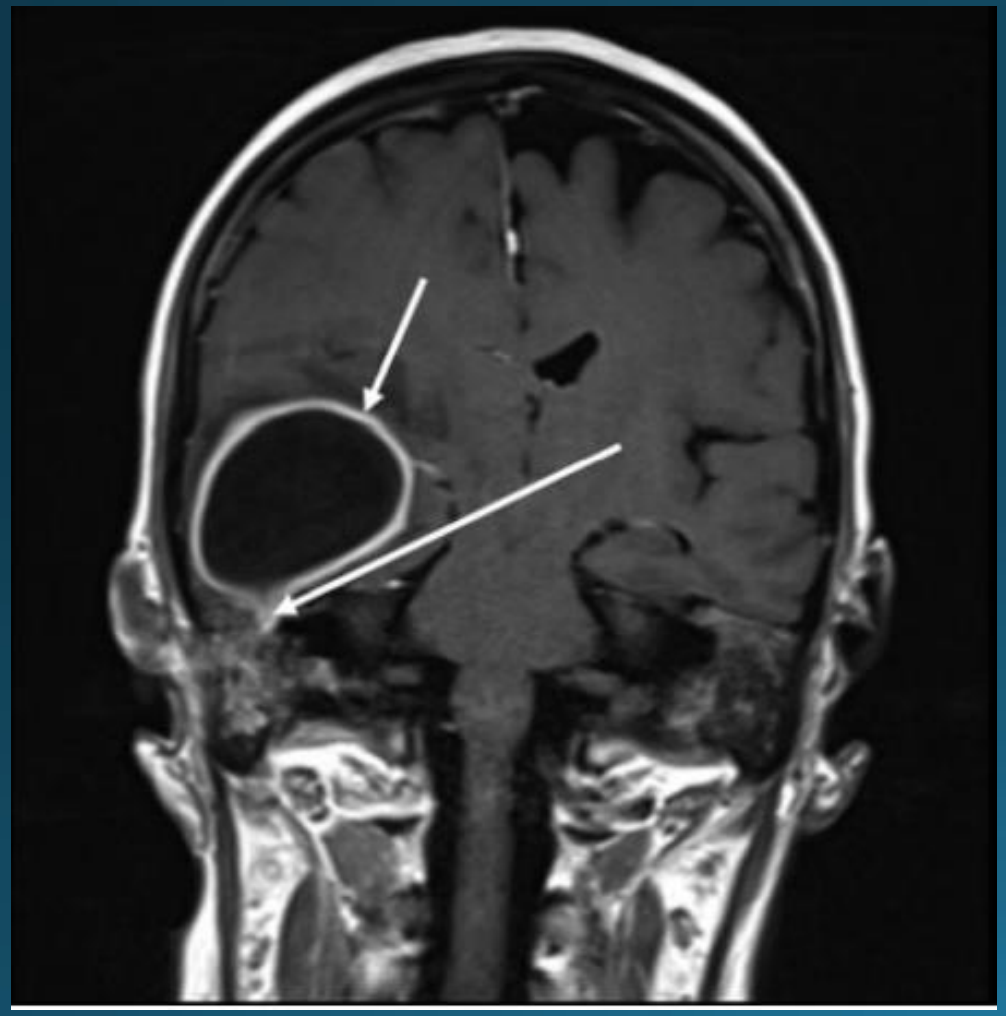
INTRACRANIAL COMPLICATION

MENINGITIS AND BRAIN ABSCESS



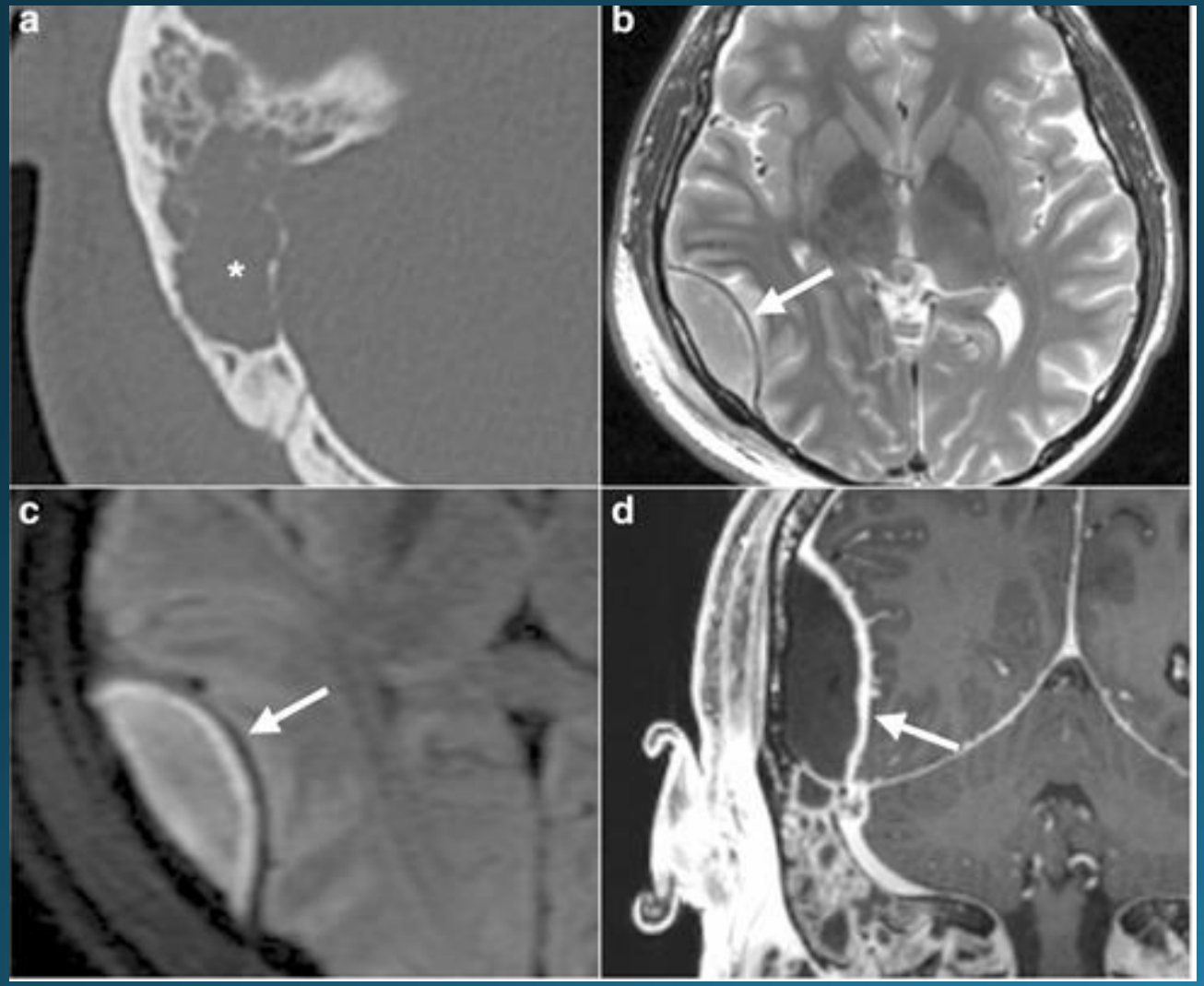
(Left) Axial T1 enhanced MR demonstrates a bilobed, ring enhancing temporal lobe abscess , along with meningeal enhancement secondary to meningitis. (Right) Coronal T1 enhanced MR in the same patient reveals acute otomastoiditis with a confluent area of suppuration. A direct connection between the mastoid abscess and the temporal lobe abscess is seen with associated meningitis

BRAIN ABSCESS



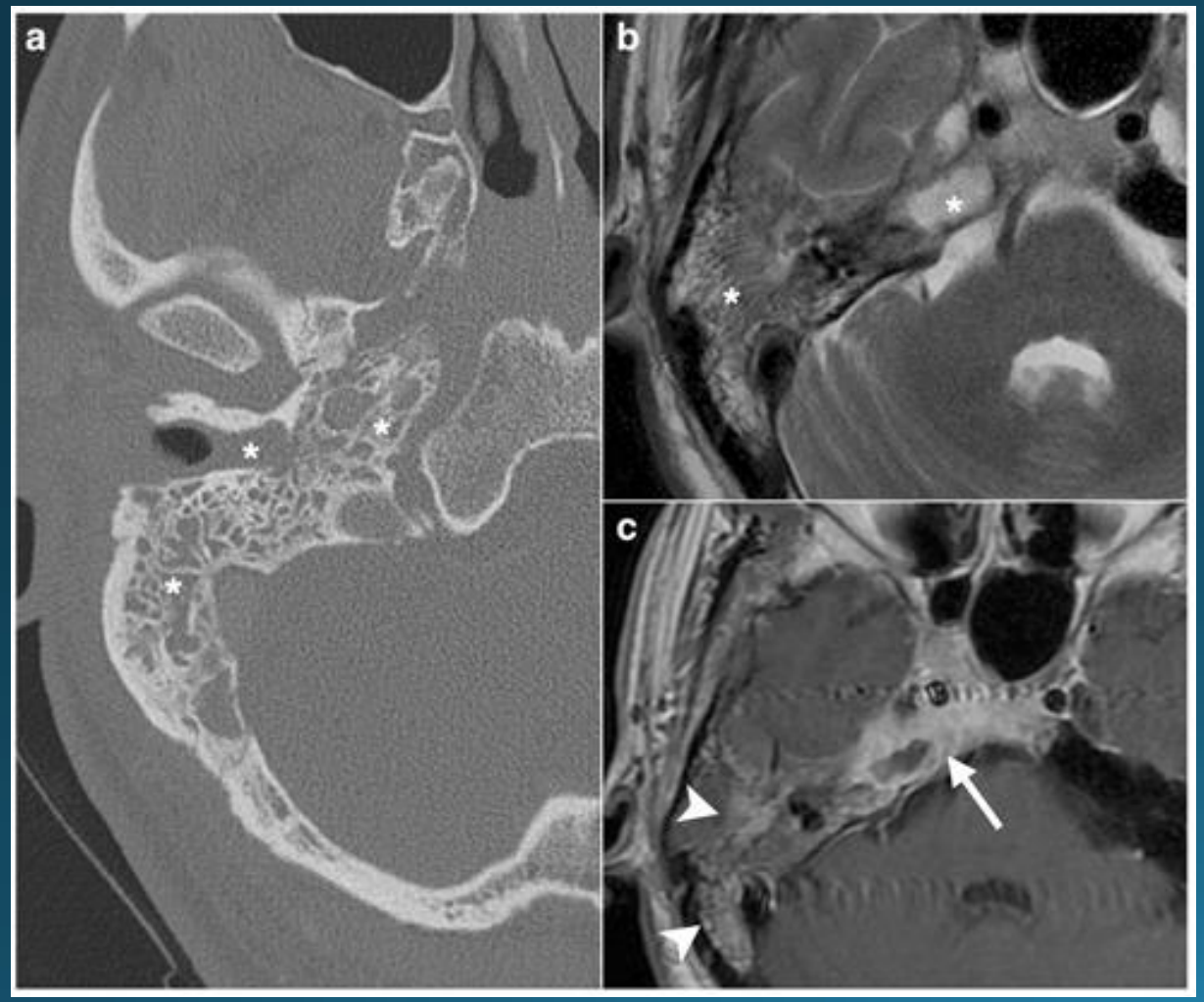
Coronal, contrast-enhanced, T1-weighted magnetic resonance imaging scan, showing right temporal lobe abscess (short arrow), with 'beak enhancement' extending into the epitympanum suggesting tegmen dehiscence (long arrow).

EPIDURAL EMPYEMA



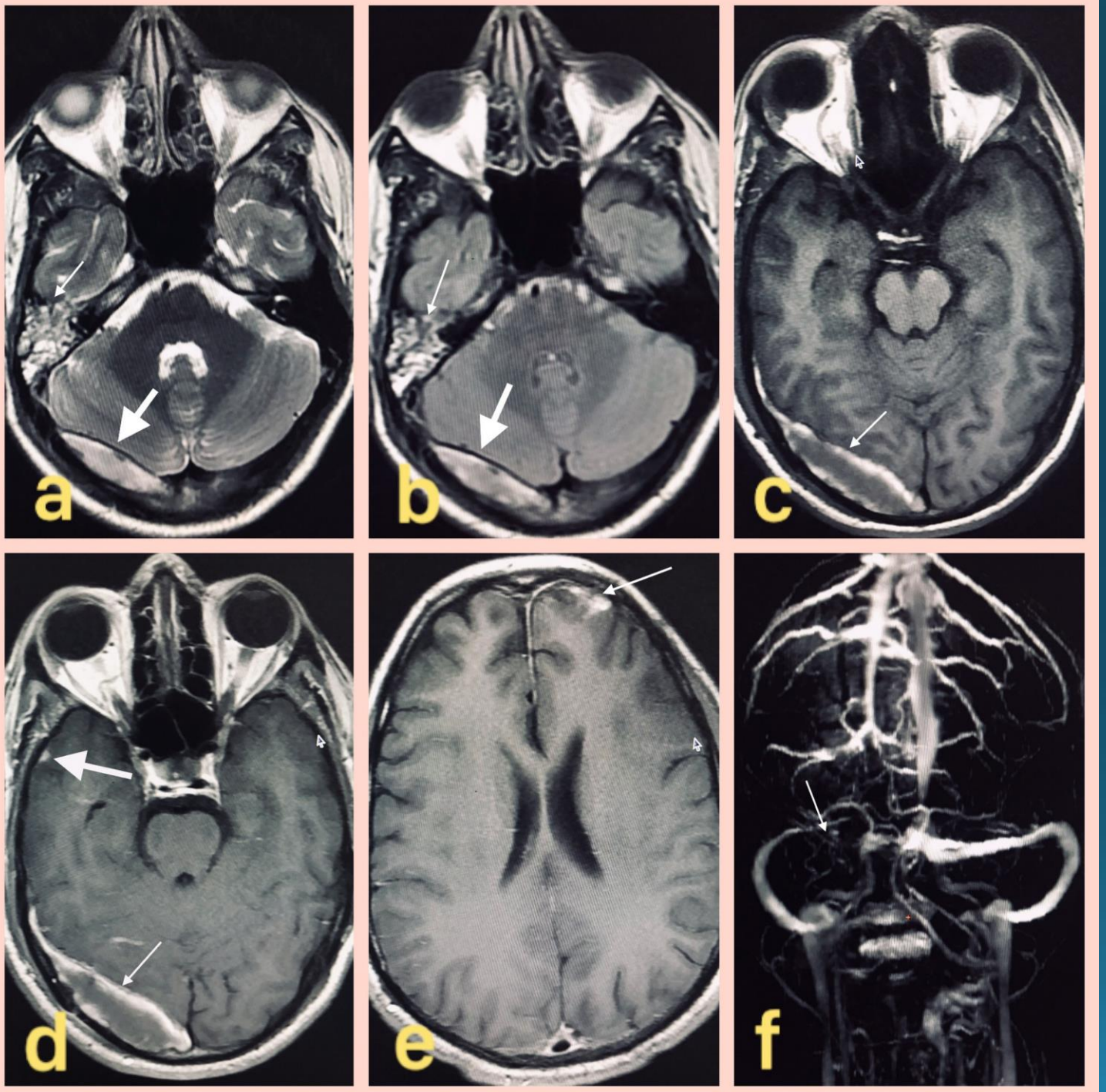
(a) Opacification of the mastoid air cells (asterisk) with erosion of the internal septations, consistent with coalescent mastoiditis. Axial T2-weighted and diffusion weighted MR images just above the mastoid bone (b and c) demonstrate a lentiform shaped extraaxial diffusion restricting collection (arrow), hypointense to CSF and slightly hyperintense to white matter, consistent with epi dural empyema (abscess). Coronal T1–weighted fat sup pressed postcontrast image (d) shows a thick rind of enhance ment surrounding the collection (arrow)

PETROUS APICITIS



(a) Right temporal bone demonstrates opacification of the mastoid air cells, middle ear cavity, and petrous apex (asterisks). MRI confirms fluid within these areas with hyperintense signal on T2 weighted images

(b) Postcontrast fat suppressed T1-weighted image demonstrates marked enhancement of the petrous apex (arrow) and mastoid air cells (arrowheads)



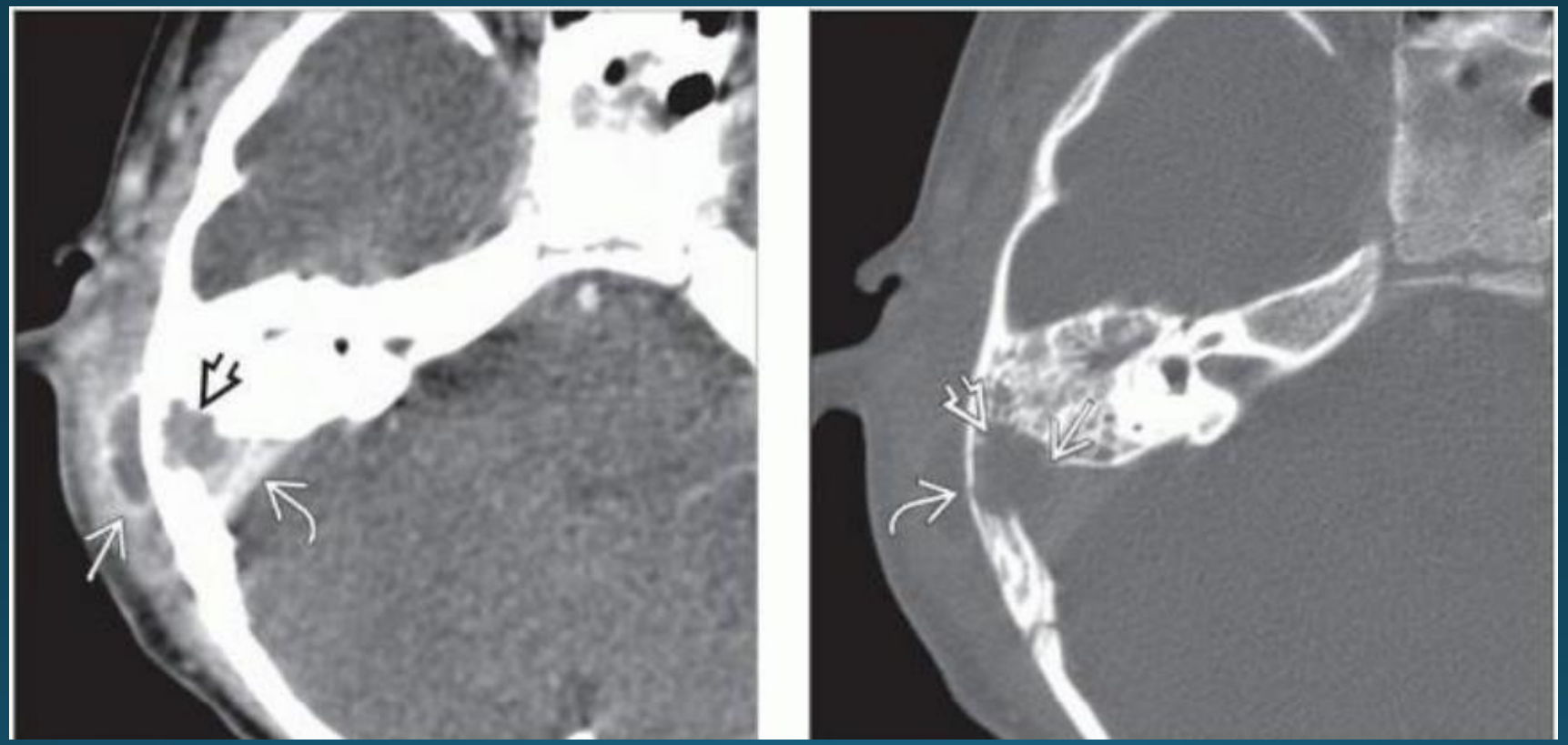
(a) Fluid intensity in the right mastoid air cells (thin white arrow) and T2 hyperintense distended right transverse sinus (denoted by thick white arrow). (b) T2 FLAIR of the brain showing similar signal characteristics involving the right mastoid air cells (thin white arrow) and right transverse sinus (thick white arrow). (c) T1 non-contrast image showing distended right transverse sinus (white arrow). (d) T1WI post-contrast image showing a non-enhancing filling defect in the right transverse sinus (thin white arrow) and a focus of abnormal parenchymal enhancement in the right temporal lobe (thick white arrow). (e) Axial T1WI post-contrast images showing a nodular focus of leptomeningeal enhancement in the left frontal lobe (thin white arrow). (f) 3D TOF-MRV image showing the non-visualization of the right transverse sinus and portion of the right sigmoid sinus (white arrow).

EXTRACRANIAL COMPLICATION

SUBPERIOSTEAL ABSCESS

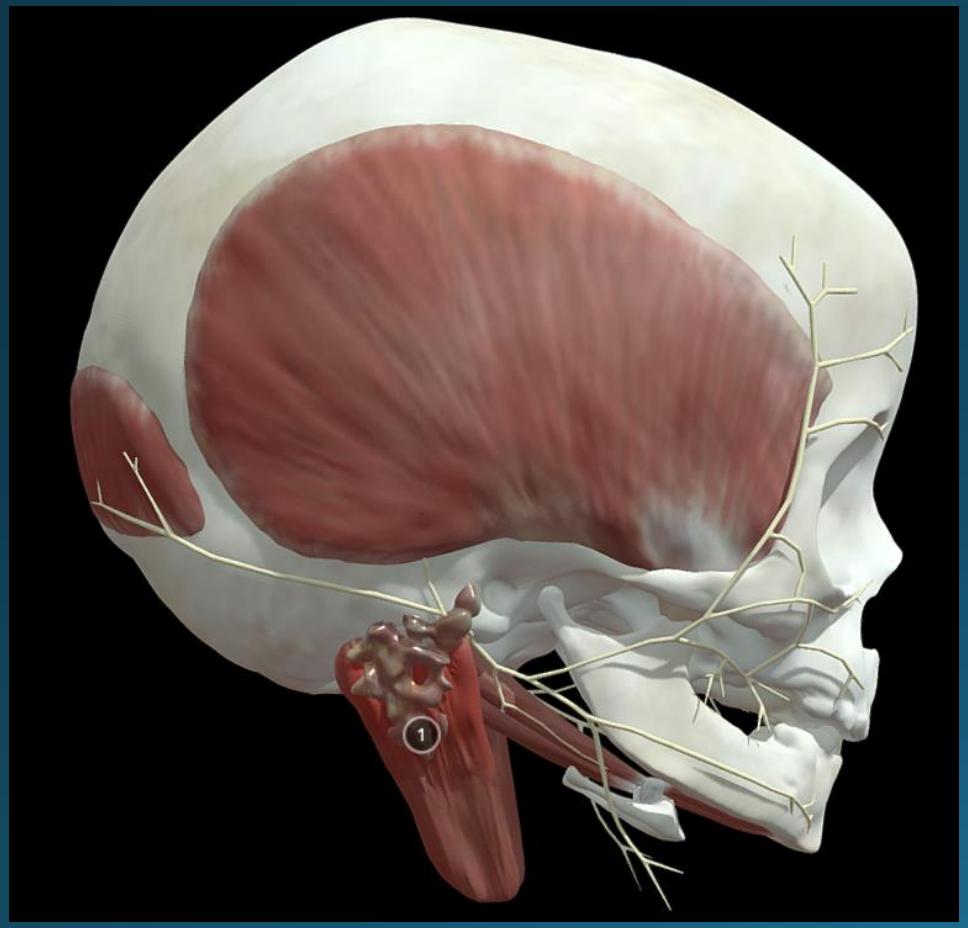
Spreads from the medial aspect of the mastoid process posterior to the auricle in turn infecting the temporalis muscle

ACUTE OTOMASTOIDITIS WITH SUBPERIOSTEAL ABSCESS



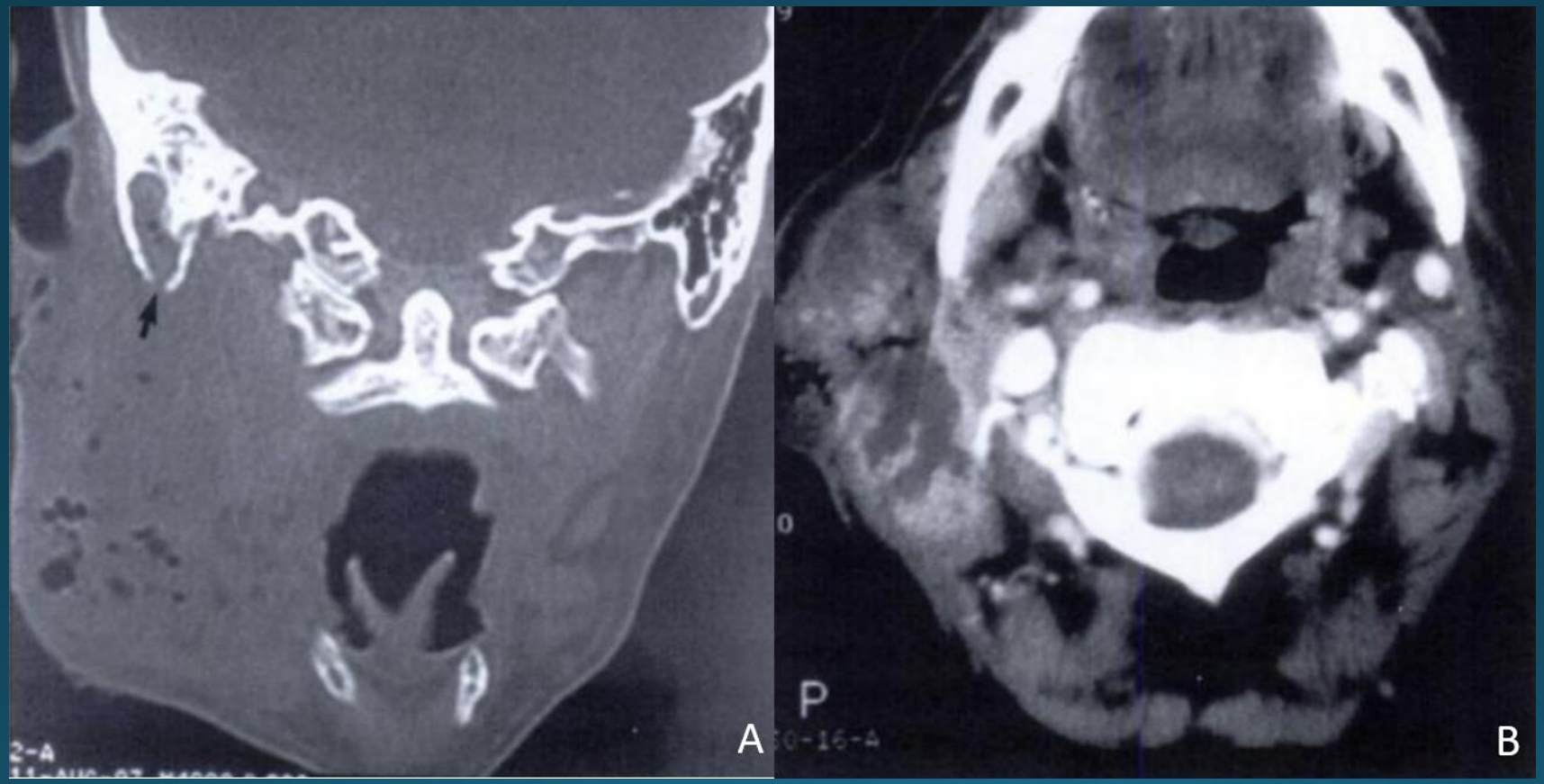
(Left) Axial CECT in a patient with post-auricular tender mass with headache and fever reveals post-auricular abscess , confluent mastoiditis , and nonthrombosed transverse sinus . (Right) Axial bone CT in the same patient demonstrates the loss of mastoid trabecula along with a dehiscent sigmoid plate diagnostic of confluent mastoiditis. A subtle gap in the lateral mastoid cortex indicates the site where the mastoid pus communicates with the post-auricular abscess

BEZOLD'S ABSCESS



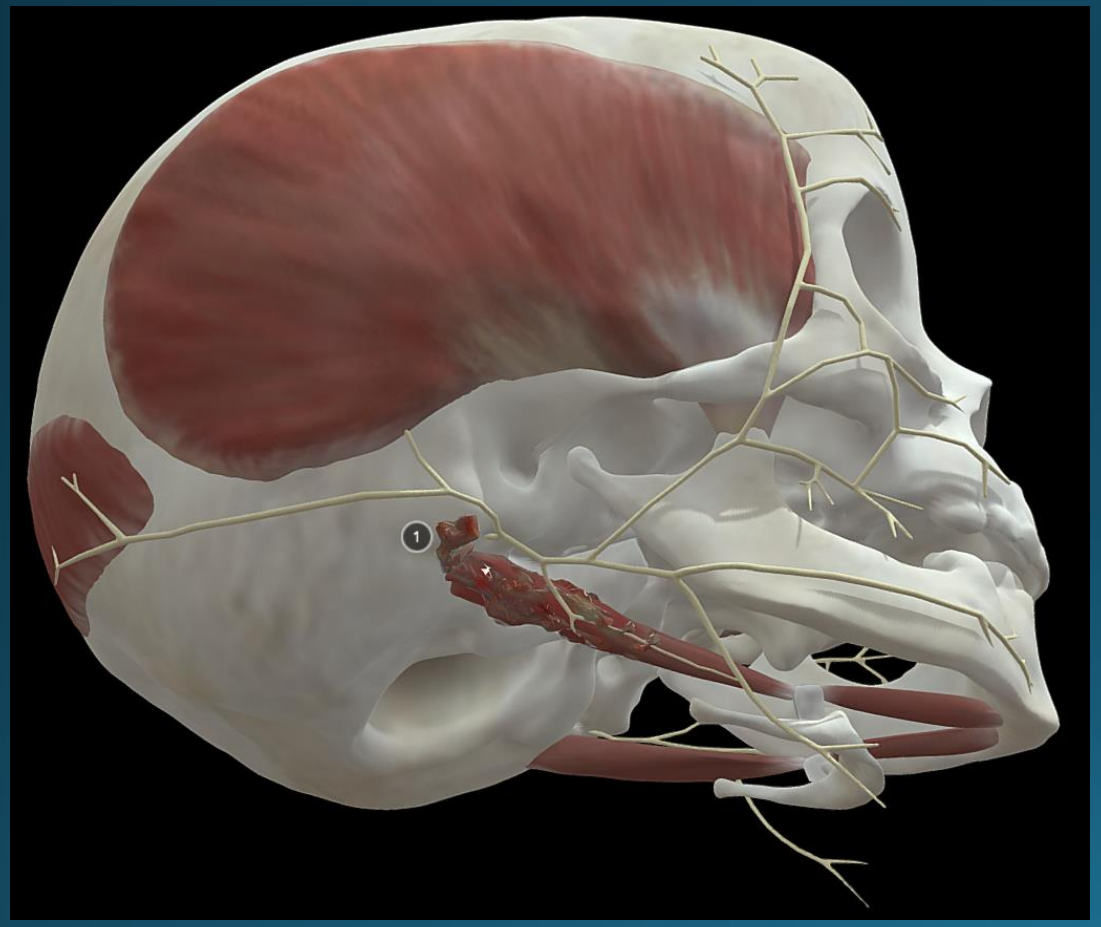
Bezold abscesses originate on the tip of the mastoid and progress down into the fascia of the sternocleidomastoid

ACUTE OTOMASTOIDITIS WITH BEZOLD'S ABSCESS



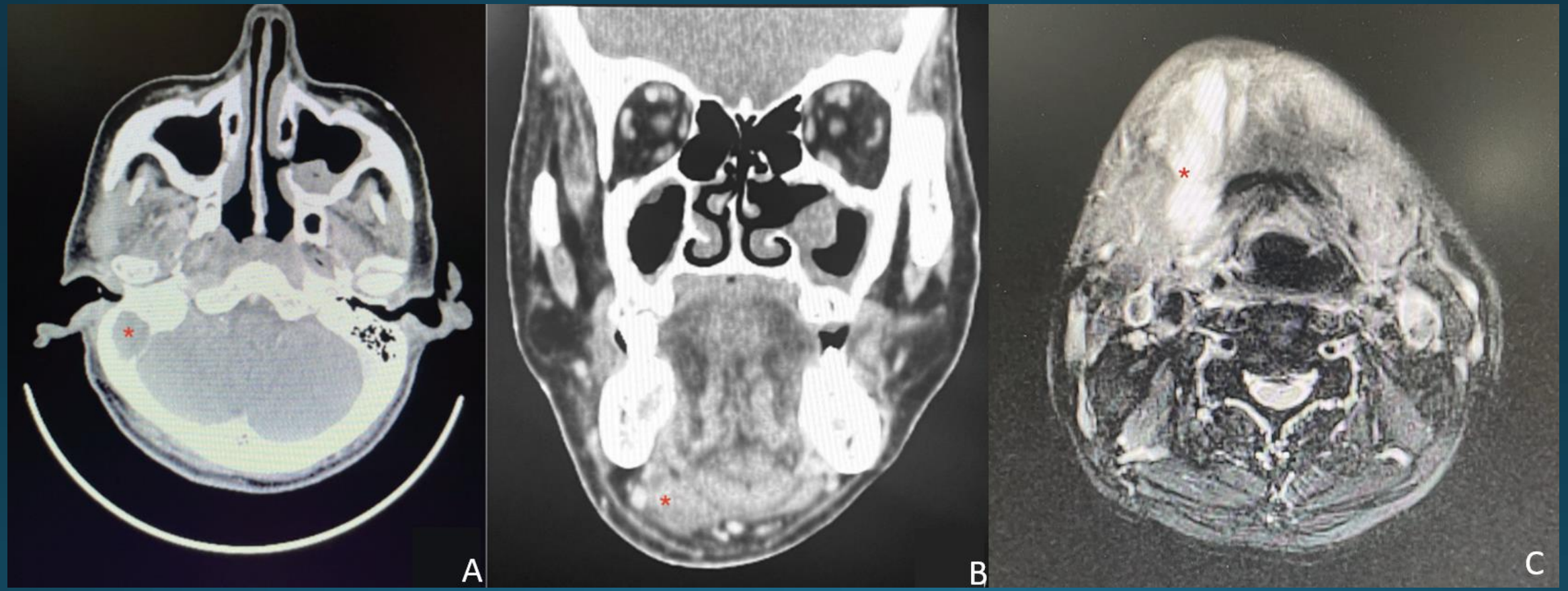
(a) coronal CT scan shows opacification of right mastoid with erosion (arrow) of its tip. Note large neck abscess containing gas. (b) axial contrast-enhanced ct scan shows large right-sided neck abscess that was eroded laterally through skin.

CITELLI'S ABSCESS



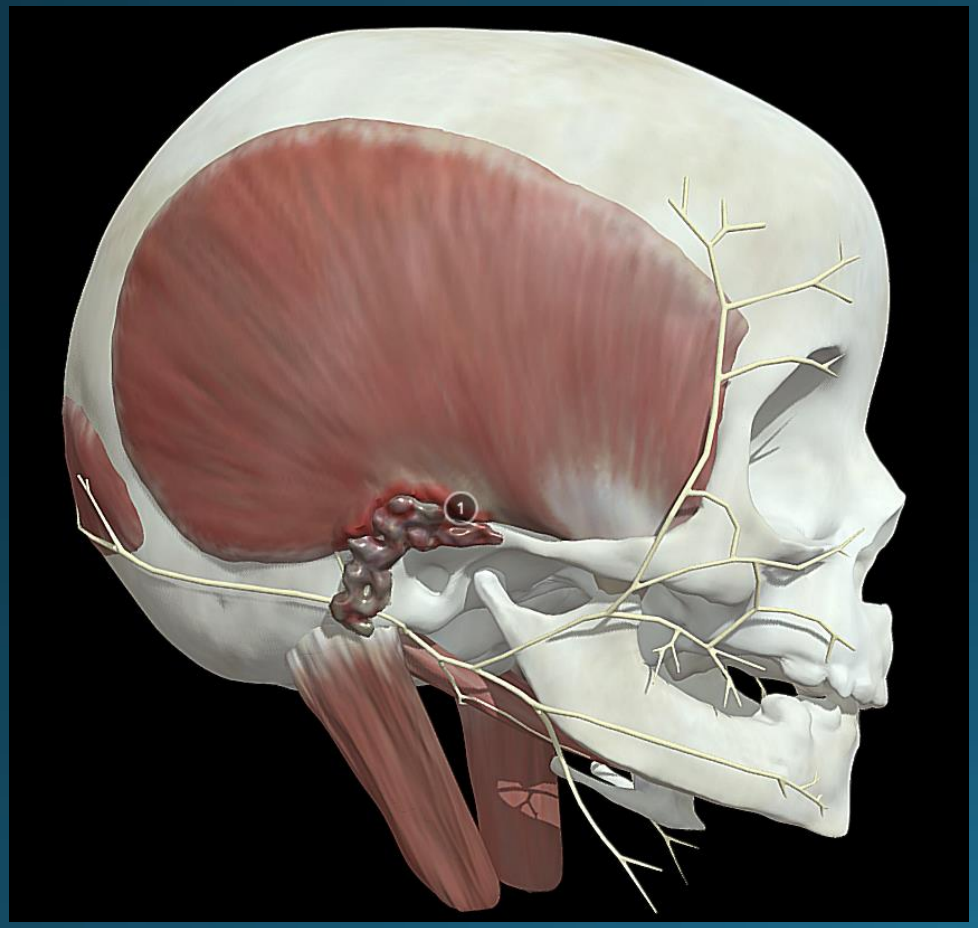
Citteli's abscesses spread from the tip of the mastoid process to the posterior digastric muscles and the digastric triangle.

ACUTE OTOMASTOIDITIS WITH CITELLI'S ABSCESS



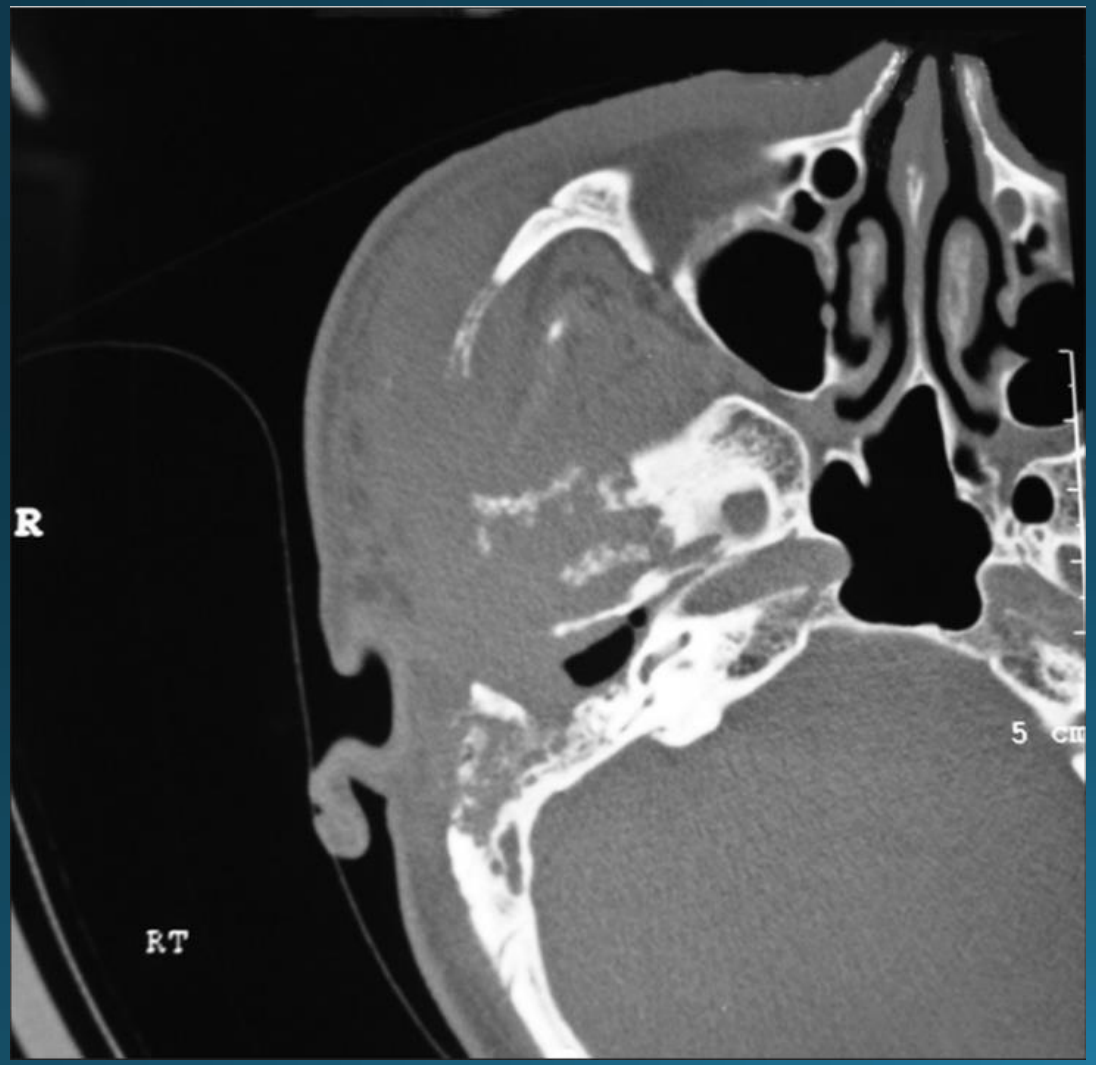
(A) CECT head axial section * showing obliteration of right mastoid air cells; (B) CECT head coronal section * showing mastoid abscess extension into right digastric muscle; (C) MRI neck axial section * showing right digastric muscle abscess

ZYGOMATIC ABSCESS



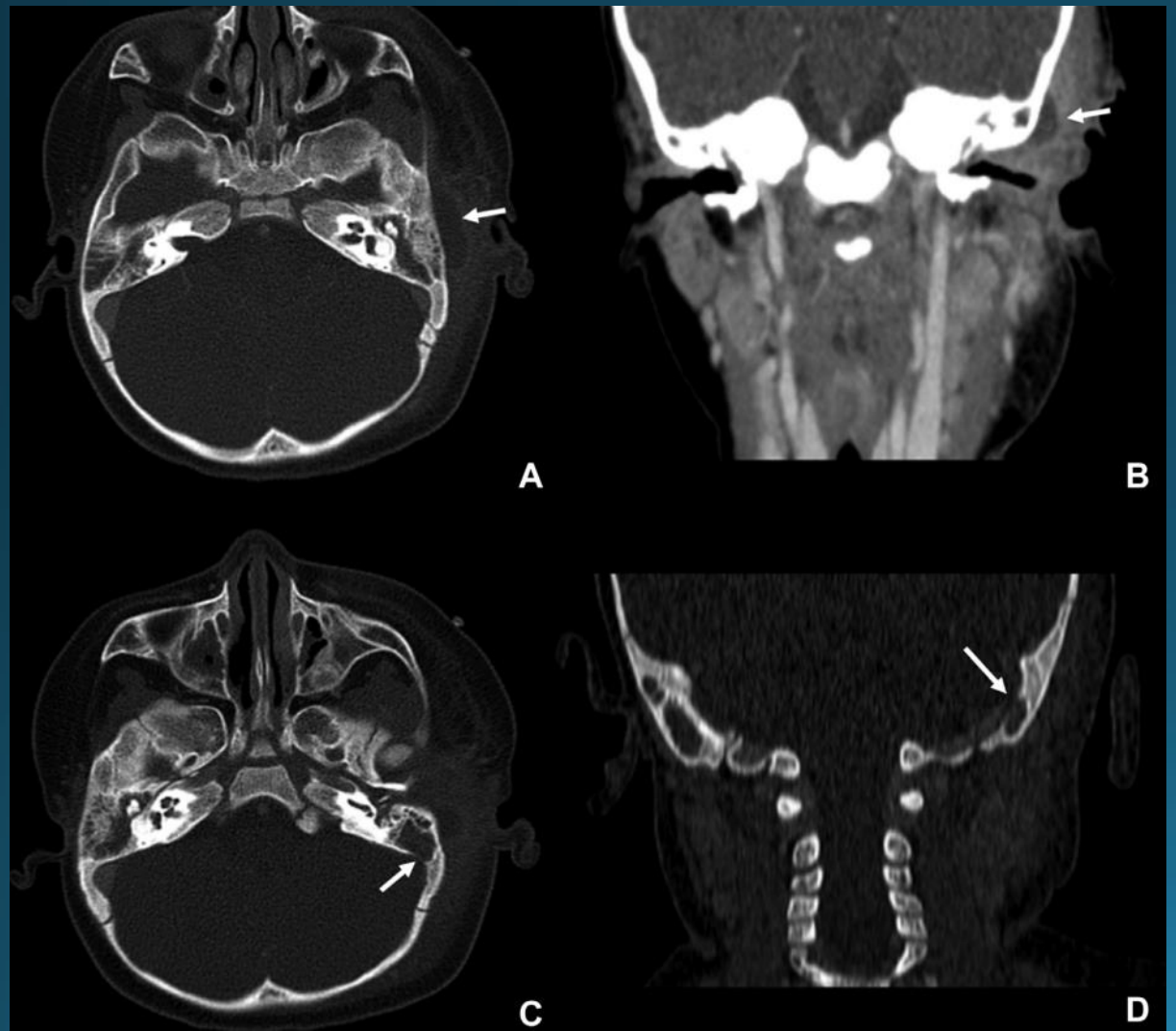
Zygomatic abscesses originate on the anterosuperior surface of the mastoid process and progress anteriorly towards the zygomatic arch

ACUTE OTOMASTOIDITIS WITH ZYGOMATIC ABSCESS



High-resolution computed tomography of temporal bone irregular osteolytic area involving the posterior portion of the right zygomatic process and zygomaticotemporal junction, mastoid air cell, middle ear cavity with erosion of anterior, lateral, and superior wall

LUC'S ABSCESS



Axial and coronal ct scan. (a) and (b) show a purulent collection deep to the left temporalis muscle, that extends superiorly to the left external ear canal (white arrow). no signs of cortical bone erosion of the lateral aspect of mastoid and zygomatic process are evident. signs of cellulitis of the soft tissues of the left infratemporal fossa, left inferior eyelid and cheek are present. (c) and (d): complete opacification of the middle ear and mastoid cells. the erosion of the mastoid trabeculae and the partial erosion of the cortical bone overlying the left sigmoid sinus (whit e arrow) give rise to suspicions of a coalescent mastoiditis

SUMMARY

- Temporal bone emergencies need timely and accurate imaging.
- CT: first-line in trauma and infection.
- MRI: essential for soft tissue and intracranial evaluation.
- Radiologists play a key role in guiding clinical management.

THANK YOU