

Temporal Bone

An Imaging Atlas

Bearbeitet von
John I Lane, Robert J Witte

1. Auflage 2009. Buch. x, 109 S.
ISBN 978 3 642 02209 8
Format (B x L): 19,3 x 26 cm
Gewicht: 432 g

[Weitere Fachgebiete > Medizin > Vorklinische Medizin: Grundlagenfächer > Anatomie](#)

Zu [Inhaltsverzeichnis](#)

schnell und portofrei erhältlich bei


DIE FACHBUCHHANDLUNG

Die Online-Fachbuchhandlung beack-shop.de ist spezialisiert auf Fachbücher, insbesondere Recht, Steuern und Wirtschaft. Im Sortiment finden Sie alle Medien (Bücher, Zeitschriften, CDs, eBooks, etc.) aller Verlage. Ergänzt wird das Programm durch Services wie Neuerscheinungsdienst oder Zusammenstellungen von Büchern zu Sonderpreisen. Der Shop führt mehr als 8 Millionen Produkte.

As stated in Chap. 1, we attempt to graphically portray the 3D anatomy of the temporal bone directly from volumetric imaging data acquired from research and clinical MR and CT scanners. It is our intent to offer a temporal bone anatomy atlas that accurately demonstrates clinically important anatomical details without primarily relying on the medical artist. It is not our intent to present an exhaustive written description of temporal bone anatomy. There are timeless anatomical texts (e.g., Gray's Anatomy) with which we have no desire to compete. Where we believe we can make a contribution to anatomical and medical education is in the graphic presentation of this anatomy in a form that is as true to the object of our study as is currently possible. For the sake of uniformity, all images will focus on the left temporal bone.

At the end of this book, we have included a Glossary. All structures that appear in italics in the brief anatomical description of the temporal bone that follows below also appear in the Glossary. Any abbreviations used in the Multiplanar Atlas chapter are also listed along side the definition of the structure in the Glossary.

Surface Anatomy

Skin Surface

The external ear or *pinna* is composed of a skin-covered cartilaginous appendage consisting of the helix, anti-helix, tragus, antitragus, and a noncartilaginous lobule or ear lobe (Fig. 1). The depression between ridges of the helix and antihelix is the navicular fossa. The cartilaginous portion of the external auditory canal (EAC) opens deep and posterior to the tragus.

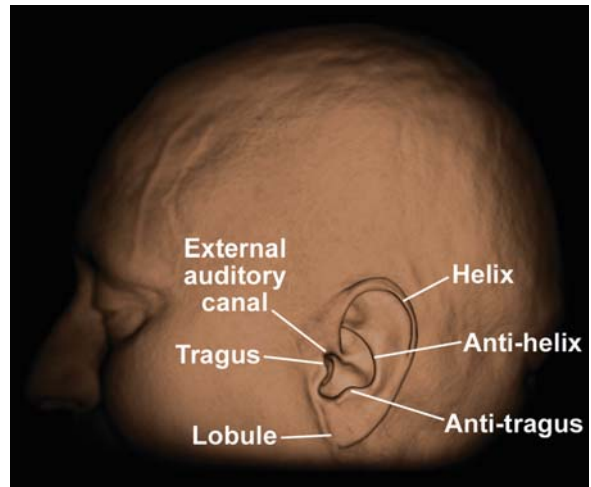


Fig. 1 External ear. 3D skin surface reconstruction of the multi-detector CT (MDCT) dataset. Note anatomical landmarks of the external ear (pinna) and external auditory canal

Bone Surface

The temporal bone consists of five parts: the squamous, tympanic, mastoid, petrous, and styloid portions. The lateral surface of the temporal bone is composed of the thin squamous portion, the tympanic portion (curved plate of bone lying below the squama and in front of the mastoid process), and the mastoid portion, forming the posterior part of the lateral surface and containing an inferior conical projection (mastoid process) (Fig. 2).

The posteromedial surface is composed of the petrous portion of the temporal bone, a pyramidal shaped process wedged in at the base of the skull between the sphenoid and occipital bones and containing the orifices of the *internal auditory canal* (IAC), *cochlear aqueduct*, and *vestibular aqueduct* (Fig. 3).

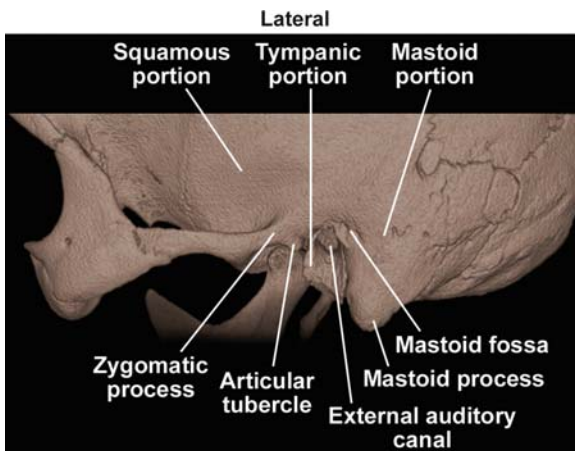


Fig. 2 Temporal bone lateral surface. 3D bone surface reconstruction of the MDCT dataset. Note *three* portions (squamous, tympanic, and mastoid) of the temporal bone comprising its lateral surface

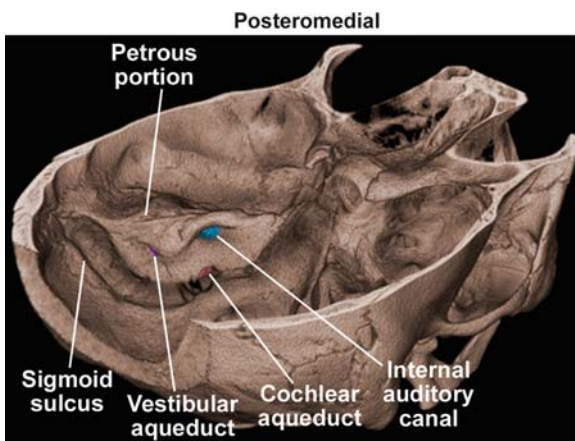


Fig. 3 Temporal bone posteromedial surface. 3D bone surface reconstruction of the MDCT dataset. Note the anatomical relationship among the openings of the internal auditory canal (*blue*), the cochlear aqueduct (*pink*), and the vestibular aqueduct (*purple*)

The petrous portion also forms the superior surface of the temporal bone as well (Fig. 4). Near the center is the *arcuate eminence*, an anatomical and surgical landmark that identifies the location of the superior semi-circular canal. Anterior and lateral to the eminence, is the thin layer of bone separating the middle ear space from the middle cranial fossa, the *tegmen tympani*.

The inferior surface of the temporal bone is composed of the undersurfaces of the petrous, mastoid, tympanic, and styloid portions. Surface landmarks include the styloid process, *stylomastoid foramen of the facial nerve*, openings of the *carotid canal* and *jugular foramen*, and the tip of the mastoid process (Fig. 5).

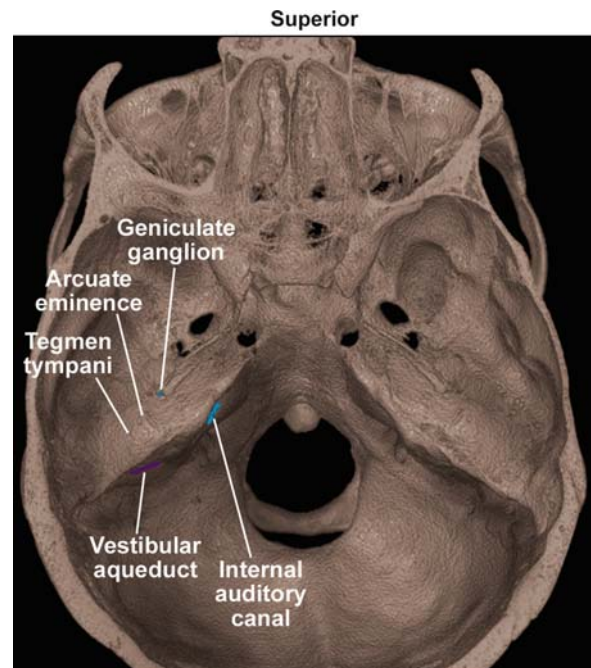


Fig. 4 Temporal bone superior surface. 3D bone surface reconstruction of the MDCT dataset. Note the relationship between the internal auditory canal (*blue*) and opening of the vestibular aqueduct (*purple*). Arcuate eminence marks the location of the superior semi-circular canal. Bony covering of the geniculate ganglion of the 7th nerve is dehiscence, a normal variant

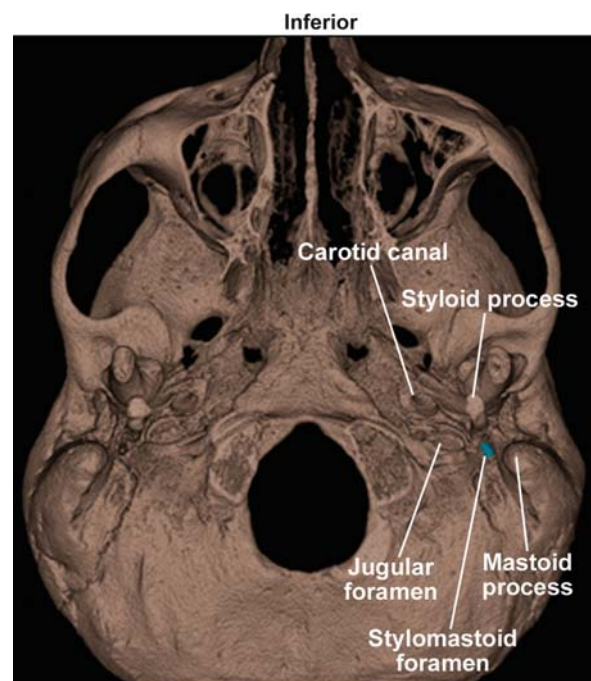


Fig. 5 Temporal bone inferior surface. 3D bone surface reconstruction of the MDCT dataset. Note the anatomical landmarks of the inferior surface of the petrous portion of the temporal bone. Note the relationship between the stylomastoid foramen of the facial nerve (*blue*) and the base of the styloid process

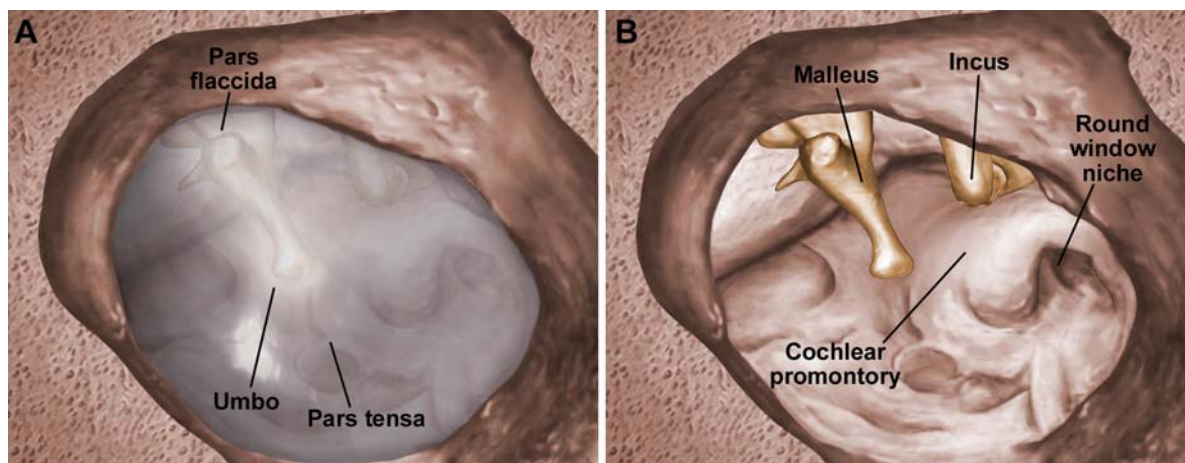


Fig. 6 Otoscopic perspective through the external auditory canal. 3D reconstruction of the microMR dataset. (a) View of the middle ear through the intact tympanic membrane (TM), which is lax superiorly (pars flaccida) because of a defect in the bony ring to which it is attached, and more taut inferiorly (pars

tensa). Note the central depression at the manubrial attachment (umbo). (b) View of the middle ear with the TM removed demonstrates lower segments of the malleus and incus. Note the relationship between the cochlear promontory and the round window niche

Bony External Auditory Canal and Tympanic Membrane

The *tympanic membrane* (TM) transmits sound waves traveling through the EAC to the middle ear ossicles by way of mechanical vibration. Its outer circumference forms a fibrocartilaginous ring that is fixed at the inner edge of the EAC in the tympanic sulcus. This sulcus is deficient superiorly (*notch of Rivinus*). The triangular segment of the TM adjacent to the notch is lax and thin (*pars flaccida*); the remainder is thick and taut (*pars tensa*). Its attachment to the *manubrium* of the *malleus* draws the TM medially toward the tympanic space, producing a concave lateral surface of the TM, the most depressed part of which is called the *umbo* (Fig. 6). In the normal state, the TM is semitranslucent and affords a view of a portion of the ossicular chain and middle ear space through the EAC (Fig. 6).

Middle Ear Space

The middle ear space, or *tympanic space*, is commonly compartmentalized into the mesotympanum, epitympanum, and hypotympanum (Fig. 7). The *mesotympanum* is the portion immediately deep to the TM. It contains the *manubrium* of the *malleus*, long process and *lenticu-*

lar process of the incus, the stapes, tensor tympani, and stapes tendons, and the chorda tympani nerve (Fig. 7). The portion of the middle ear space above the roof of the EAC is the *epitympanum*, or *attic*, and contains the head of the malleus and body/short process of the incus. The epitympanum communicates with the mastoid antrum by way of a narrow passage, the *aditus ad antrum*. The *hypotympanum* is the portion of the middle ear below the floor of the EAC and contains the opening of the Eustachian tube anteriorly.

The tympanic space can be considered a six-walled chamber. The superior wall (*tegmen tympani*) or roof of the epitympanum is a thin layer of bone that separates the epitympanum and mastoid antrum from the middle cranial fossa.

The medial wall of the tympanic space separates the middle ear from the adjacent labyrinthine structures and includes several important bony landmarks (superior to inferior): the lateral *semicircular canal*, tympanic segment of the *facial nerve canal*, *oval window*, *cochlear promontory*, and *round window niche* (Figs. 7,8). The cochlear promontory, formed by the basal turn of the cochlear, is lodged between the oval and round windows. Its surface is grooved to accommodate the branches of the tympanic plexus (*Jacobson's nerve*), which enters the temporal bone through the *tympanic canaliculus*, just anterior to the jugular foramen. The posterior wall separates the middle ear from the mastoid air cells, except

Fig. 7 The middle ear. 3D reconstruction of the microMR dataset. The outer surface of the temporal bone including the bony external auditory canal (EAC) has been removed. Note the attic or epitympanum in continuity with the mastoid antrum posteriorly. The mesotympanum is demarcated by the roof and floor of the EAC. The hypotympanum occupies that space inferior to the floor of the EAC. Suspensory ligaments of the ossicles are the illustrator's additions to the original reconstructions. Note the course of the chorda tympani nerve between the long process of the incus and manubrium of the malleus. Note the muscles of the middle ear to include the stapedial muscle and tendon emanating from the pyramidal eminence and its attachment to the neck of the stapes and the course of the tensor tympani muscle within its bony semi canal. Note the view of the *medial wall* of the tympanic cavity including the facial nerve canal, stapes at the level of the oval window, cochlear promontory, and round window niche

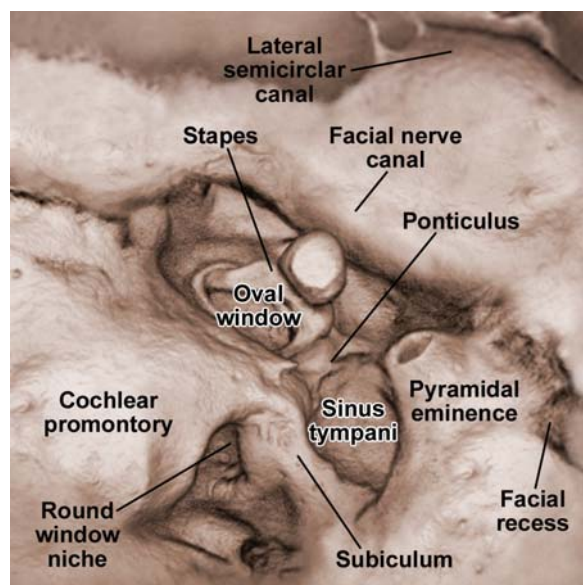
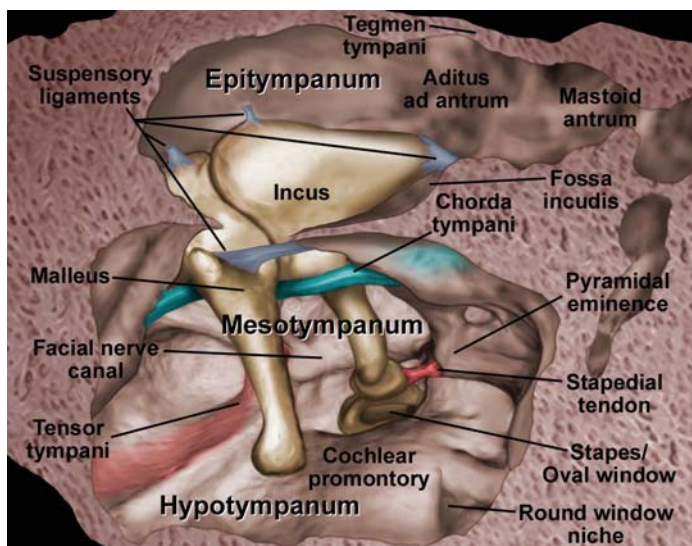


Fig. 8 The posteromedial wall of the middle ear. 3D reconstruction of the microCT dataset. Note the pyramidal eminence projecting from the posterior wall of the middle ear. Its hollow orifice transmits the stapedial tendon. Deep to the eminence is the sinus tympani, a recess separated from the round window niche inferiorly by a bony ridge, the subiculum, and from the oval window niche anterosuperiorly by another bony ridge, the ponticulus. The facial recess is found lateral to the pyramidal eminence. The lateral semicircular canal creates a bony overhang superior to the oval window along the medial wall of the middle ear. Coursing beneath the lateral canal is the tympanic segment of the facial nerve canal. Note the cochlear promontory and round window niche inferior and posterior to the oval window

along its deficient superior margin, where it permits communication between the *attic* and the *mastoid antrum*. It presents several notable features (superior to inferior): the *fossa incudis* (a small recess that receives the short process of the incus), the *pyramidal eminence* (PE), which transmits the *stapedial tendon*, and two additional recesses on either side of the PE, the *sinus tympani* medially and the *facial recess* laterally (Figs. 7, 8). The sinus tympani is separated from the oval window by an anterior bony ridge, the *ponticulus*, and from the round window niche by an inferior bony ridge, the *subiculum* (Fig. 8). Pars tensa cholesteatomas will commonly extend along the posterior wall to involve the sinus tympani. The PE will often obscure this recess at the time of surgical tympanomastoid exposure. Therefore, it is important to evaluate this recess with CT preoperatively to exclude occult extension of disease.

The lateral wall of the middle ear is primarily composed of the TM and the incomplete tympanic ring of bone to which the membrane is attached (Fig. 9). As was mentioned previously, the tympanic ring is deficient superiorly (Notch of Rivinus), resulting in the laxity of the membrane adjacent to the notch (*pars flaccida*). The confluence of the lateral wall of the middle ear and the roof of the EAC form a sharp spur of bone, known as the *scutum*. Deep to the pars flaccida is a small recess, *Prussak's space*, bordered superiorly and laterally by the *scutum*, and medially by the neck of the malleus, which is a common site for pars flaccida cholesteatoma.

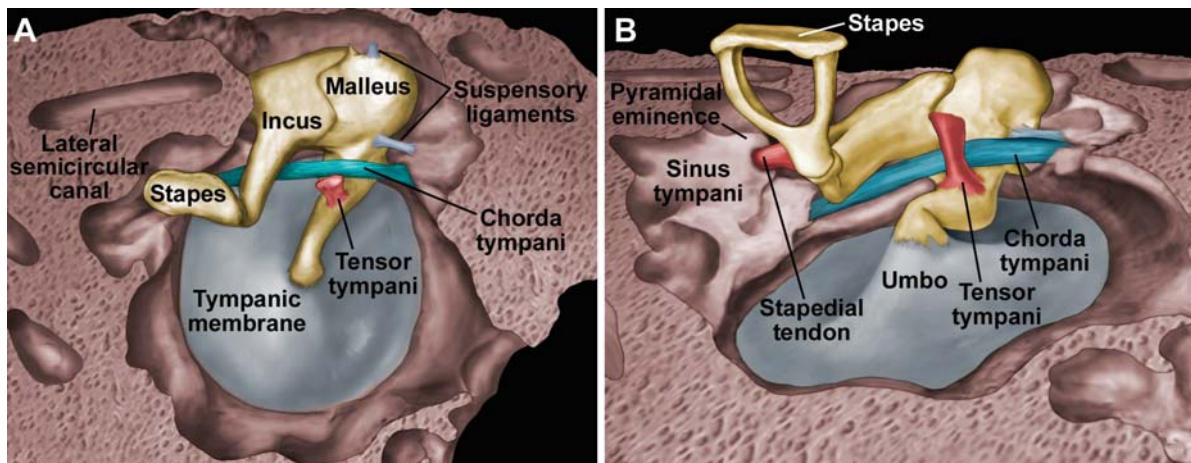


Fig. 9 The lateral wall of the middle ear. (a) 3D reconstruction of the microMR dataset. Note the inner surface of the tympanic membrane, the course of the chorda tympani nerve and the cut edge of the tensor tympani muscle proximal to its attachment to the medial surface of the manubrium of the malleus. (b) Inferior

oblique view of the lateral wall to include a view of the posterior wall demonstrates the pyramidal eminence transmitting the stapedial tendon that attaches to the neck of the stapes. Note the posterior recess medial to the pyramidal eminence, the sinus tympani

Close to the bony ring are the two apertures (posterior and anterior) that transmit the *chorda tympani nerve* into and out of the middle ear space (Fig. 9). The anterior wall separates the middle ear from the adjacent carotid canal. The *Eustachian tube* and *semi canal of the tensor tympani* openings are found along its ventral extent. The inferior wall or floor is narrow and consists of a thin plate of bone that separates the middle ear from the *jugular fossa*. Occasionally, this bone may be dehiscent, with the jugular vein being visible through the TM.

The Auditory Ossicles

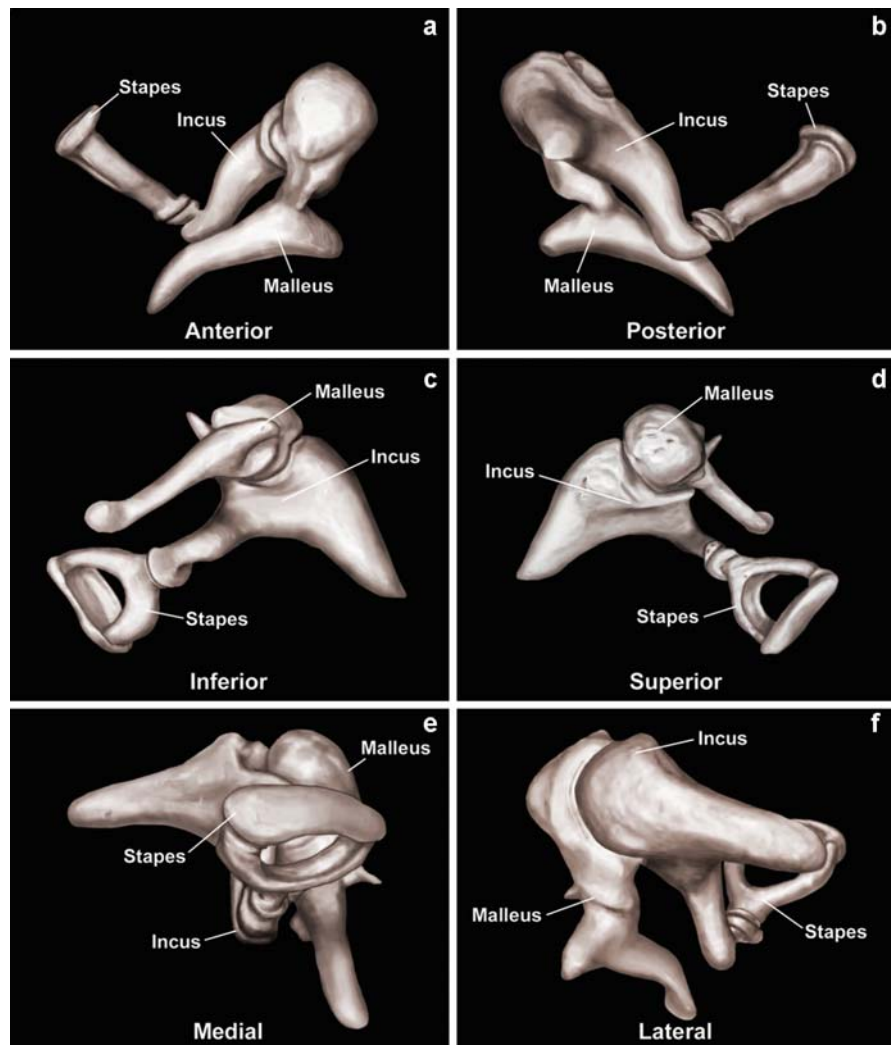
The ossicular chain is responsible for the transmission of sound-induced vibrations of the TM to the oval window. The chain is composed of three bones: the *malleus*, *incus*, and *stapes*, which are named after the (once) common objects they resemble (hammer, anvil, and stirrup) (Figs. 10–13). The malleus consists of a round head, short neck, two small processes (anterior and lateral), and an elongated handle or *manubrium*. The manubrium of the malleus is attached to the TM. The head of the malleus articulates with the body of the incus within the epitympanum or attic. This articulation is therefore not visible on routine otoscopy. The malleus and incus share a saddle-shaped diarthrodial joint at their articulation in

the epitympanum. The incus consists of a trapezoidal body, short and long crura or processes, and a rounded *lenticular process*, projecting medially from the long process, which articulates with the head of the stapes. The stapes consists of a round head, short neck, anterior and posterior crura, and an oval footplate. The ossicles are stabilized by numerous *suspensory ligaments* (Figs. 7, 9), joint capsules, and two tendons: the *tensor tympani tendon*, which attaches to the upper part of the manubrium of the malleus, and the *stapedial tendon*, which attaches to the neck of the stapes. The incus has the least number of stabilizers and is therefore most commonly dislocated with middle ear trauma. The footplate of the stapes is fixed to the edges of the oval window by the *annular ligament*. Vibration of the footplate initiates the displacement of fluid within the vestibule of the inner ear (Fig. 14), which ultimately leads to the stimulation of the hair cells within the cochlea, resulting in a transfer of mechanical energy to electrical energy conducted by way of the cochlear nerve to the brainstem.

The Inner Ear

The *labyrinth* is a system of membranous sacs and ducts filled with *endolymph*, surrounded by *perilymph*,

Fig. 10 The middle ear ossicles. 3D reconstruction of the microCT dataset. (a) Anterior and (b) posterior views of the ossicular chain. Note the oblique orientation of the malleus and incus angled superolaterally to inferomedially and the superior angulation of the stapes. (c) Inferior and (d) superior views of the ossicular chain. Note the oblique orientation of the malleus and incus angled anterolaterally to posteromedially and the slightly posterior angulation of the stapes. (e) Medial and (f), lateral views of the ossicular chain. Note the posterior orientation of the short process of the incus and the superior angulation of the stapes



and encased in bone (*otic capsule*) (Figs. 15–20). The auditory component (*cochlea*) occupies the anterior portion of the labyrinth and is shaped like a conch shell. Its lumen consists of 2.5 radial turns (basal, middle, and apical) around a cribriform bony column, the *modiolus*, which transmits the fibers of the *cochlear nerve*. The vestibular apparatus is housed posteriorly in the *vestibule* and *semicircular canals*. These structures are embedded within the otic capsule to which the membranes are fixed at given points.

The endolymphatic compartment of the membranous labyrinth consists of the *cochlear duct* (*scala media*), *sacculle*, *utricle*, *semicircular ducts* (superior, lateral, and posterior), and the *endolymphatic duct* transmitted by the *vestibular aqueduct* to its confluence with the

endolymphatic sac found beneath the dura along the posterior surface of the petrous portion of the temporal bone (Fig. 3). The *cochlear duct* occupies the *scala media* within the lumen of the cochlea and is attached to the outer walls of the cochlear turns. The basilar end of the cochlear duct extends along the floor of the vestibule and communicates with the sacculle by way of the short *ductus reuniens*. Within the bony vestibule, the *sacculle* is attached to the medial wall of the vestibule wherein lies the vertically oriented *saccular macula*, the neurosensory epithelium that acts in concert with the horizontally oriented *utricle macula* to detect linear acceleration. The *utricle* is fixed to the antero-medial wall of the vestibule where the *utricle macula* has its origin, extending posteriorly along the floor

Fig. 11 Anterior–posterior perspectives of the disarticulated ossicles. 3D reconstructions of the microCT dataset. (a) Anterior and (b) posterior views of the malleus demonstrating head, neck, lateral process, and manubrium. Note the articular facet of the mallear head on the posterior view. (c) Anterior and (d) posterior views of the incus demonstrating body, short and long processes, and the lenticular process. Note the articular facet of the incus occupying the anterior surface of the body. (e) Anterior and (f) posterior views of the stapes demonstrating the head, neck, anterior and posterior crura, and the footplate

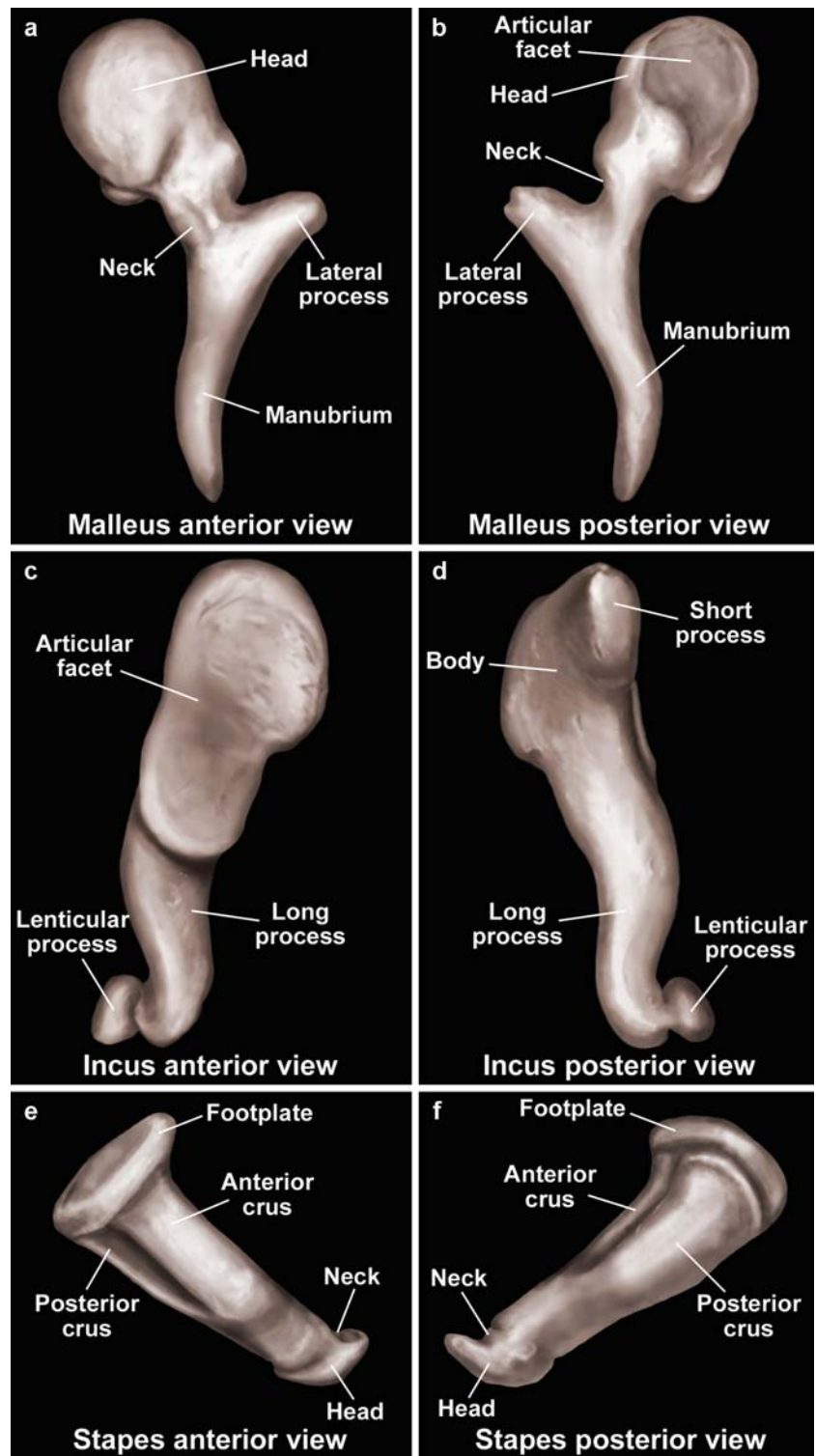


Fig. 12 Superior–inferior perspectives of the disarticulated ossicles. 3D reconstructions of the microCT dataset. (a) Inferior and (b) superior views of the malleus demonstrating the head, neck, lateral process, anterior process, and manubrium. Note the articular facet of the malleolar head. (c) Superior and (d) inferior views of the incus demonstrating the body, short and long processes, and the lenticular process. Note the medial orientation of the lenticular process that articulates with the head of the stapes. (e) Superior and (f) inferior views of the stapes demonstrating the head, neck, anterior and posterior crura, and the footplate. Note that the posterior crus is slightly thicker and has less curvature than the anterior crus

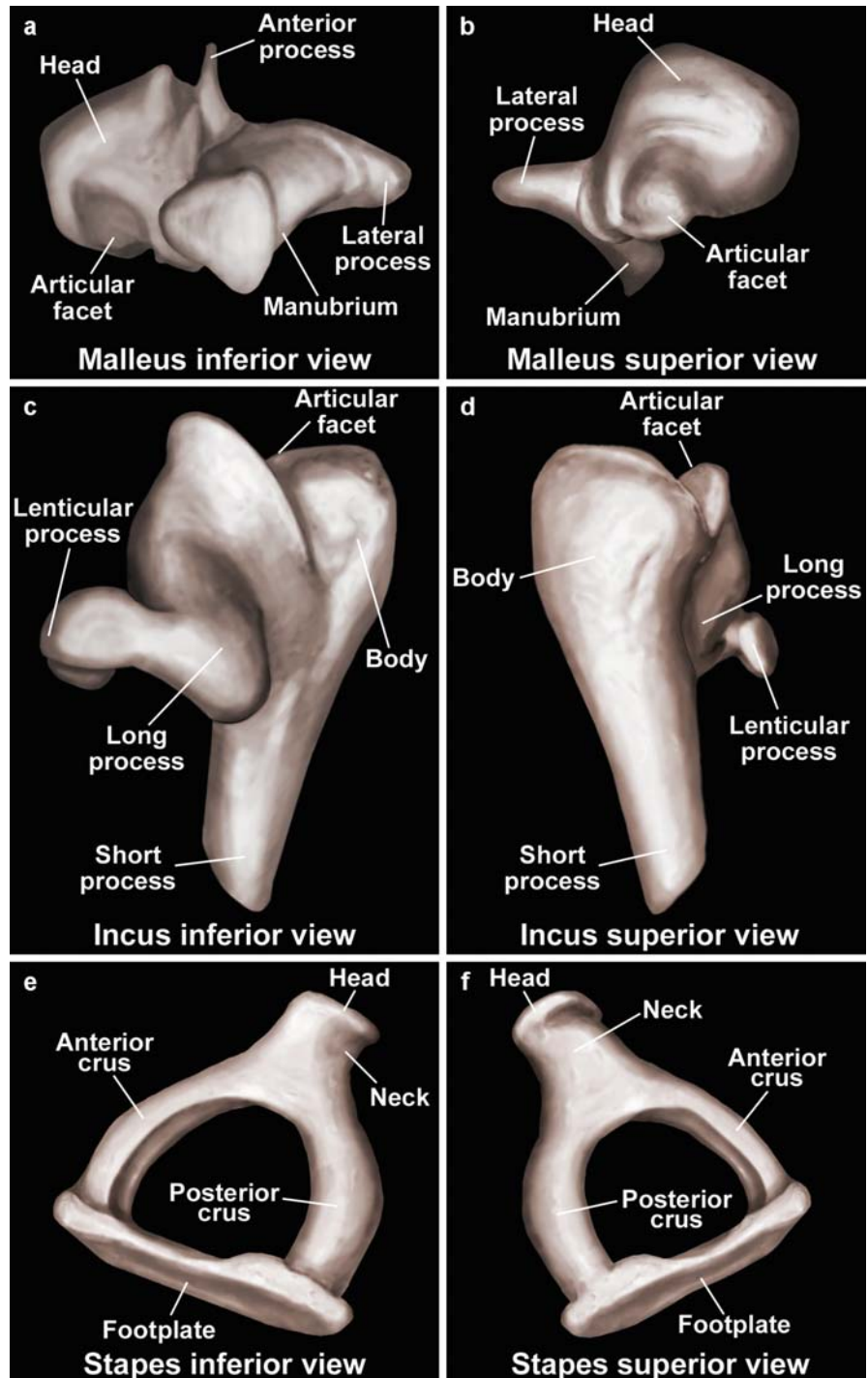


Fig. 13 Medial–lateral perspectives of the disarticulated ossicles. 3D reconstructions of the microCT dataset. (a) Medial and (b) lateral views of the malleus demonstrating the head, neck, lateral process, anterior process, and manubrium. Note the articular facet of the malleolar head on the lateral view. (c) Medial and (d) lateral views of the incus demonstrating the body, short and long processes, and the lenticular process. Note the articular facet of incus, the posteriorly oriented short process, and the articular surface of the lenticular process. (e) Medial and (f) lateral views of the stapes demonstrating the head, neck, anterior and posterior crura, and the footplate. The footplate is convex superiorly and concave inferiorly

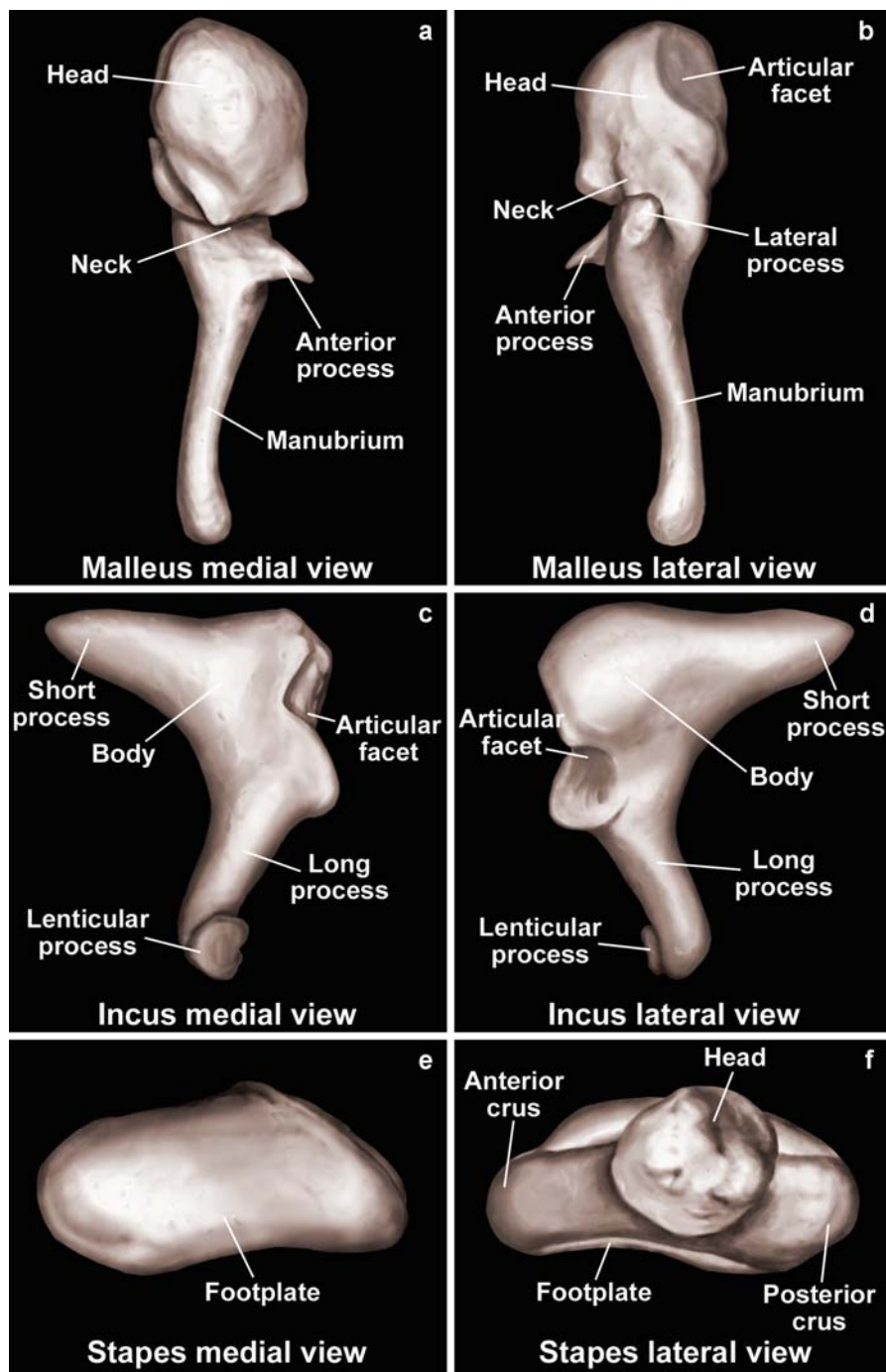


Fig. 14 Relationship between the ossicles and the inner ear. 3D reconstruction from the microMR dataset in a steep inferior anterolateral oblique projection (*inset*). Note the position of the footplate of the stapes at the level of the oval window. The perilymphatic space is segmented in *pink*, and the endolymphatic structures in *purple*. Note the relationship between the tympanic segment of the facial nerve and the lateral semicircular canal and oval window

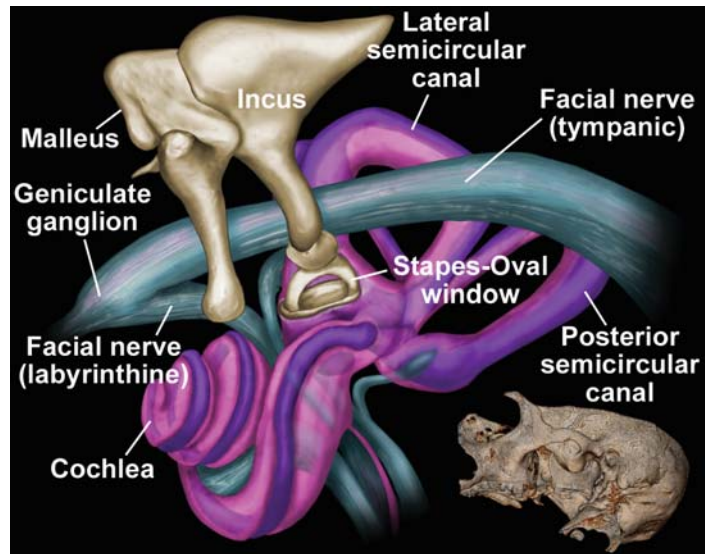


Fig. 15 The inner ear. Inferior views of 3D reconstructions from microscopy datasets. (a) 3D MDCT reference image with superimposed labyrinth. (b) MicroCT reconstruction of the bony labyrinth. (c) MicroMR reconstruction of the membranous labyrinth to include perilymphatic and endolymphatic spaces. (d) MicroMR reconstruction of the endolymphatic structures of the membranous labyrinth only. Note that the semicircular ducts (endolymph) are attached to the outer wall of the canals and occupy about one-fourth of the volume of their respective canals, the remainder being perilymphatic space

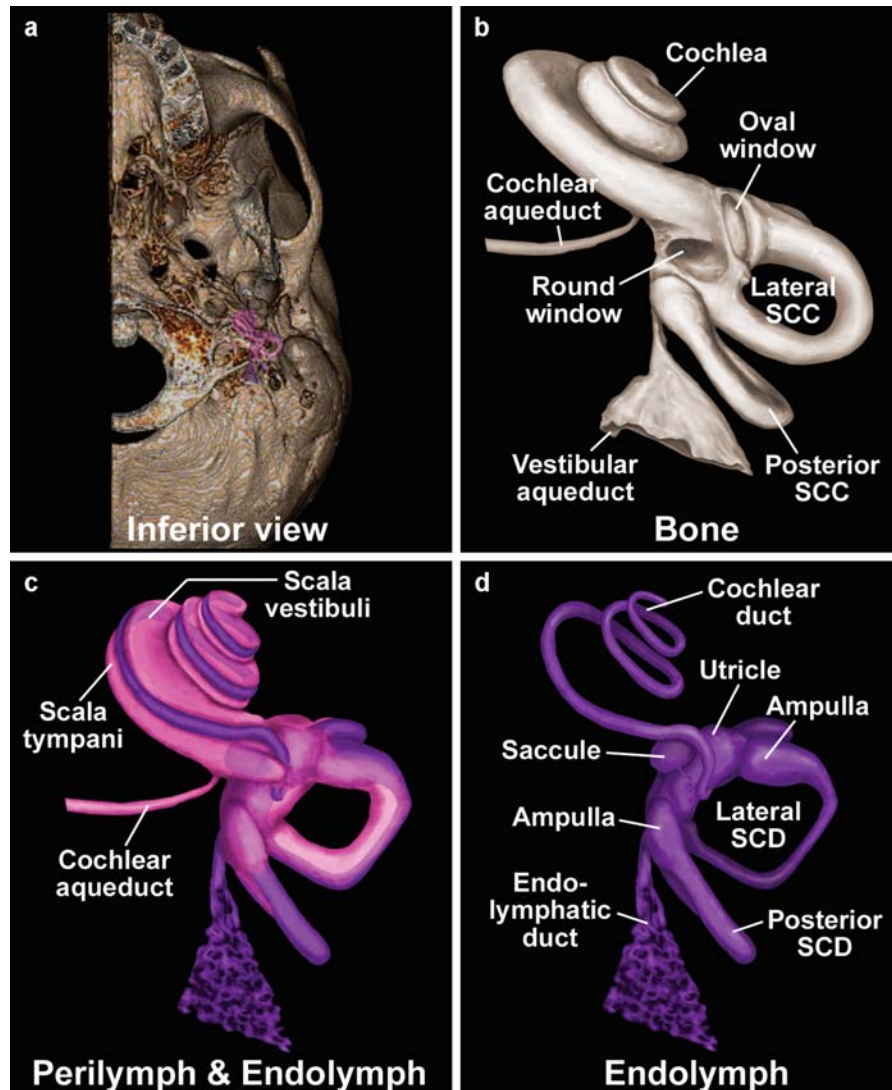
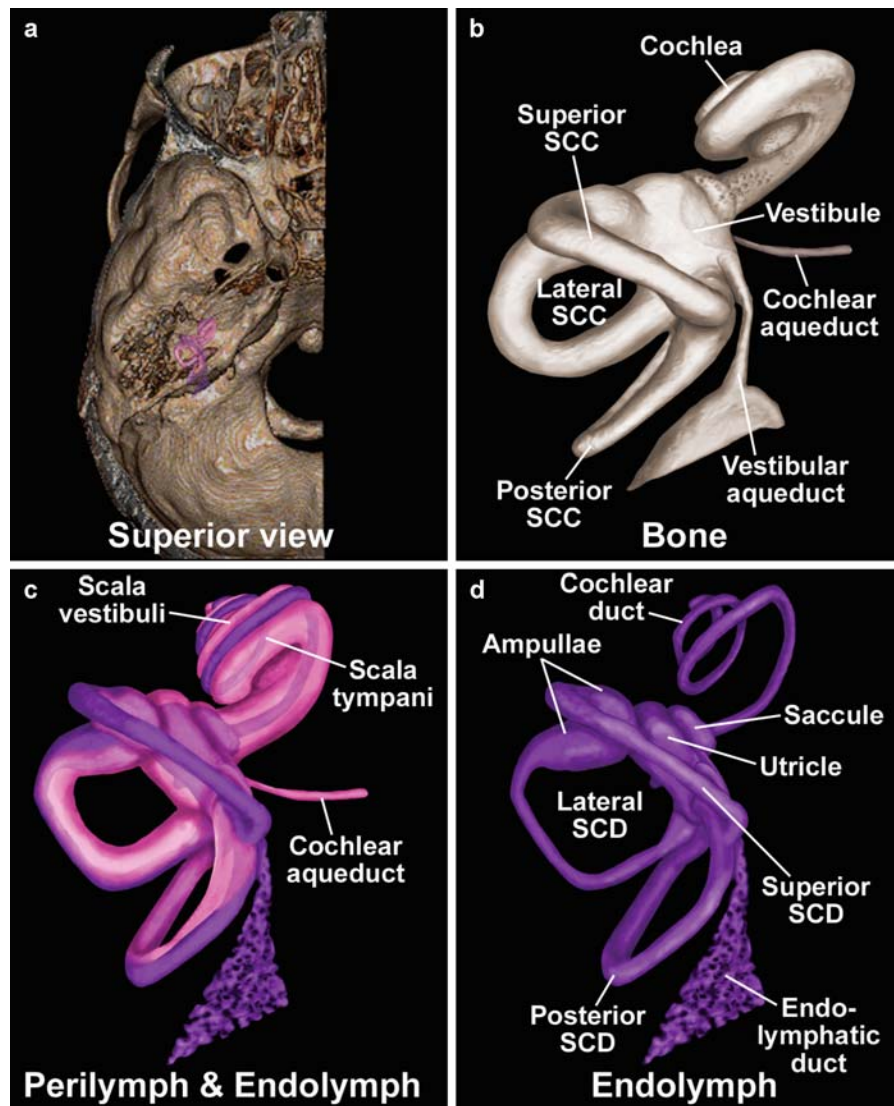


Fig. 16 The inner ear. Superior views of 3D reconstructions from microscopy datasets. (a) 3D MDCT reference image with superimposed labyrinth. (b) MicroCT reconstruction of the bony labyrinth. (c) MicroMR reconstruction of the membranous labyrinth to include perilymphatic and endolymphatic spaces. (d) MicroMR reconstruction of the endolymphatic structures of the membranous labyrinth only. Note the vestibular aqueduct arising from the medial wall of the vestibule posteriorly



of the utricle. The utricle lies within the *elliptical recess*, an ellipsoid depression in the anterosuperior aspect of the medial wall of the vestibule. The saccule lies inferior to the utricle within a rounded depression along the anteroinferior aspect of the medial wall of the vestibule (*spherical recess*). These recesses are separated by a bony ridge, the *vestibular crest* (Fig. 21). The lateral wall of the vestibule is notable for the openings of the *oval window*, and both limbs of the lateral semicircular canal (Fig. 22). The roof of the vestibule receives the ampullated limb of the superior semicircular canal and more posteriorly the *common crus*, the fused nonampullated ends of the superior and posterior

canals (Figs. 21, 22). The ampullated end of the posterior semicircular canal opens up into the inferior aspect of the posterior wall of the vestibule (Fig. 22). The opening of the scala vestibuli of the cochlea is located along the floor of the vestibule just inferior and anterior to the oval window (Fig. 22).

The endolymphatic *semicircular ducts* (superior, lateral and posterior) are attached to the outer walls of their respective canals (Figs. 15–20). They each have an ampullated end, which contains the *crista ampullaris*, the neuroepithelial sensory organ that detects angular or rotational acceleration. They define three planes of rotation: a horizontal plane defined by the

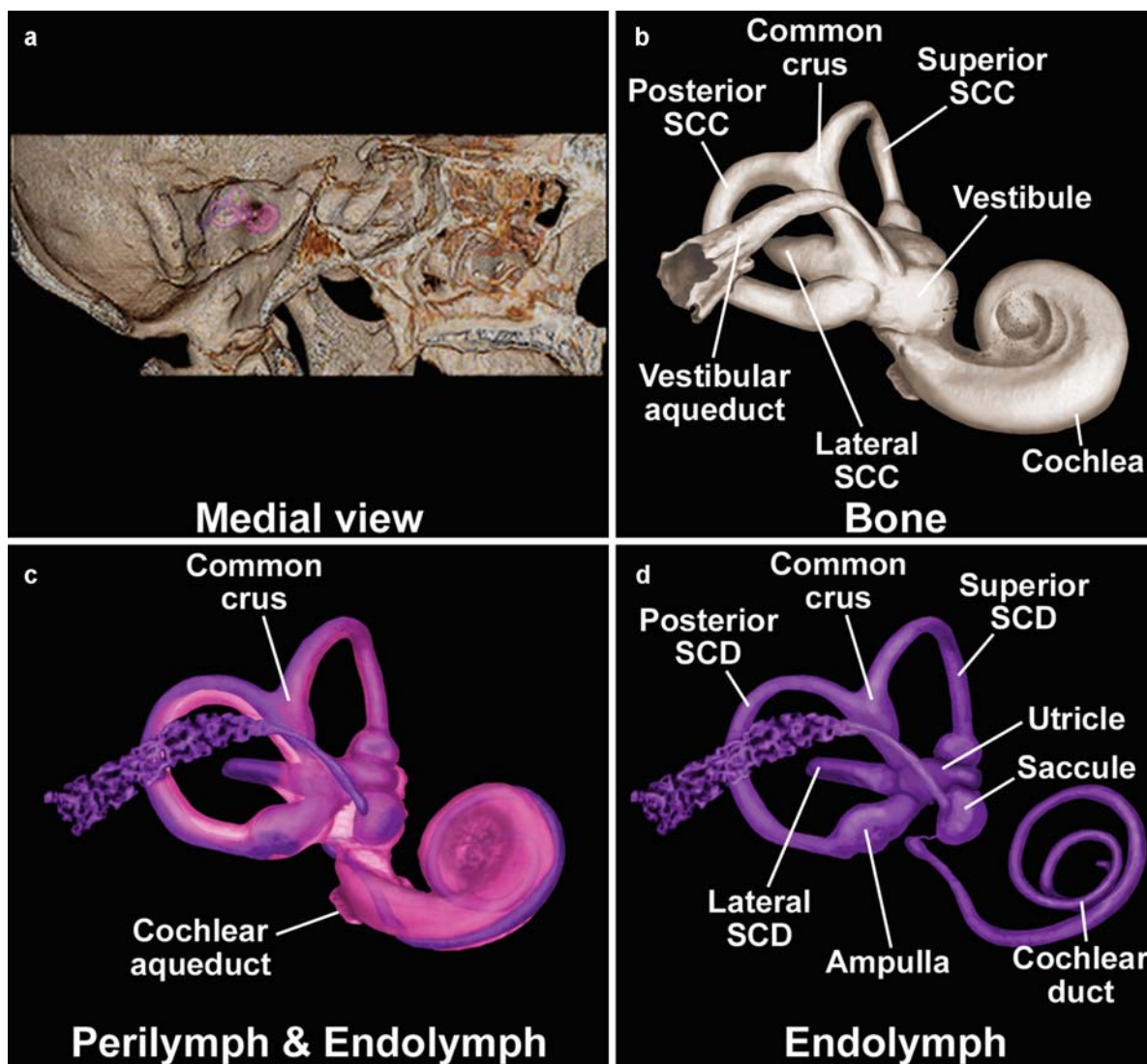


Fig. 17 The inner ear. Medial views of 3D reconstructions from microscopy datasets. **(a)** 3D MDCT reference image with superimposed labyrinth. **(b)** MicroCT reconstruction of the bony labyrinth. **(c)** MicroMR reconstruction of the membranous labyrinth to include perilymphatic and endolymphatic spaces. **(d)** MicroMR reconstruction of the endolymphatic structures of the membranous labyrinth only. Note the relationship between the ellipsoidal

utricle superiorly and the spherical saccule inferiorly within the vestibule. Also note that the vestibular aqueduct opens into the posteromedial wall of the vestibule just anterior to the opening of the common crus. The endolymphatic duct arises from the posterior wall of the saccule, is joined by the short utriculosaccular duct (not shown) coming from the utricle, and exits the vestibule by way of the vestibular aqueduct

paired lateral canals, and two pairs of oblique vertical planes, oriented at 90° to each other, defined by the ipsilateral superior and the contralateral posterior ducts. The semicircular ducts occupy approximately one-fourth of the volume of their respective canals. Both nonampullated ends of the superior and posterior ducts (and canals) are fused, forming the *common*

crus. The semicircular ducts each communicate with the utricle within the upper portion of the vestibule. The *endolymphatic duct* (Figs. 15–20) arises from the posterior wall of the saccule, communicates with the utricle by way of the short *utriculosaccular duct*, and exits the vestibule through a small opening just anterior and inferior to the opening of the common

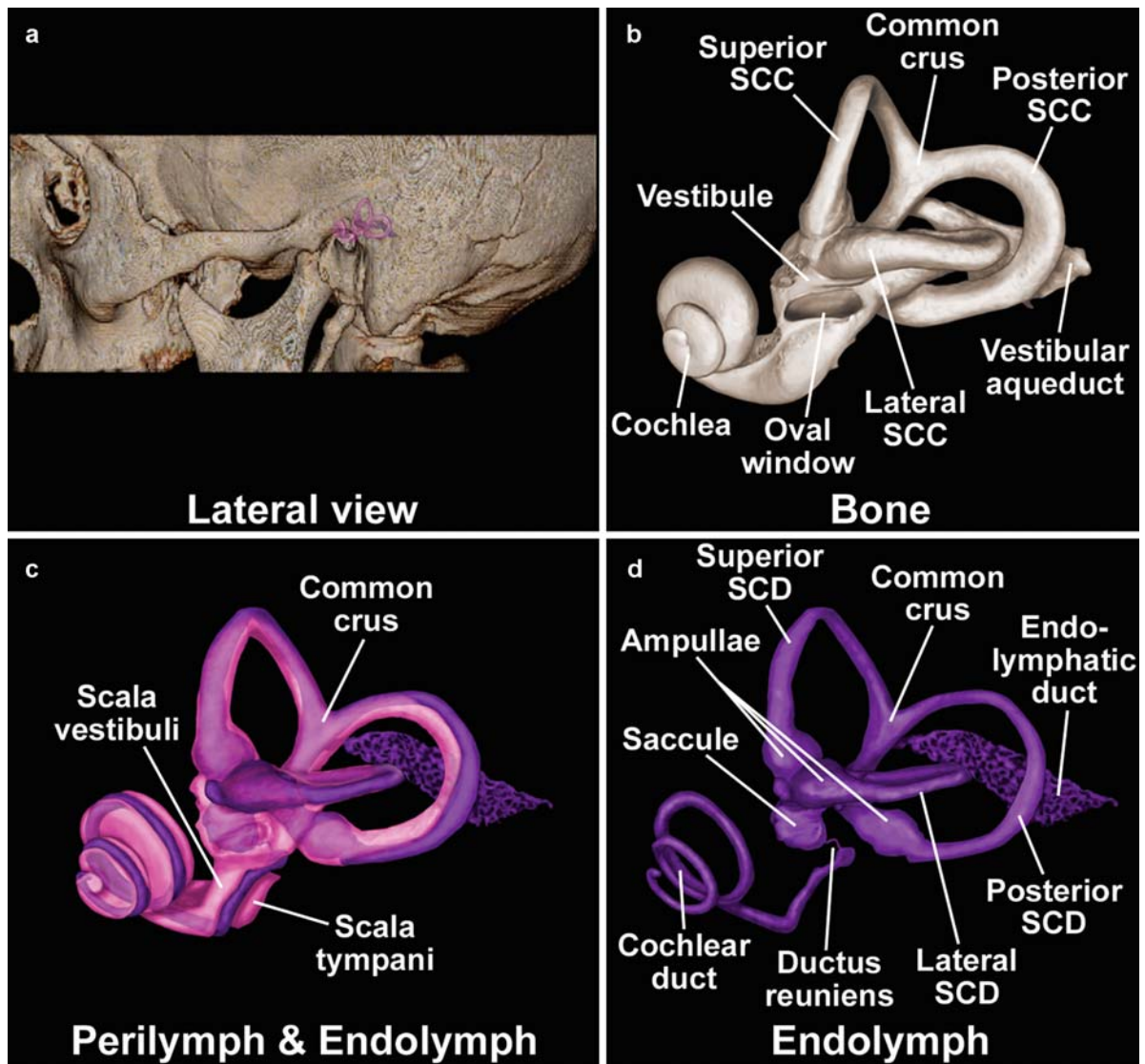


Fig. 18 The inner ear. Lateral views of 3D reconstructions from microscopy datasets. (a) 3D MDCT reference image with superimposed labyrinth. (b) MicroCT reconstruction of the bony labyrinth. (c) MicroMR reconstruction of the membranous labyrinth to include the perilymphatic and endolymphatic spaces. (d) MicroMR reconstruction of the endolymphatic structures of the membranous labyrinth only. Note the fusion

of the nonampullated ends of the superior and posterior semicircular canals and ducts to form the common crus. Also note the extension of the cochlear duct out of the basal turn of the cochlea along the floor of the vestibule and its connection to the saccule by way of the ductus reuniens. Third, note the proximity of the ampullae of the superior and lateral semicircular ducts

along the posterior superior aspect of the medial wall of the vestibule (Fig. 21). It is transmitted through the petrous portion of the temporal bone by way of the *vestibular aqueduct* and terminates in the endolymphatic sac (Fig. 22). Thus, the common crus serves as a landmark for identifying the location of the proximal segment of the vestibular aqueduct.

The perilymphatic compartment fills that portion of the labyrinth not occupied by the endolymphatic structures (Figs. 15–20). It is similar in composition to the subarachnoid spaces of the central nervous system with which it may potentially communicate by way of the cochlear aqueduct (Fig. 2). The reported patency of the cochlear aqueduct varies, one study demonstrating

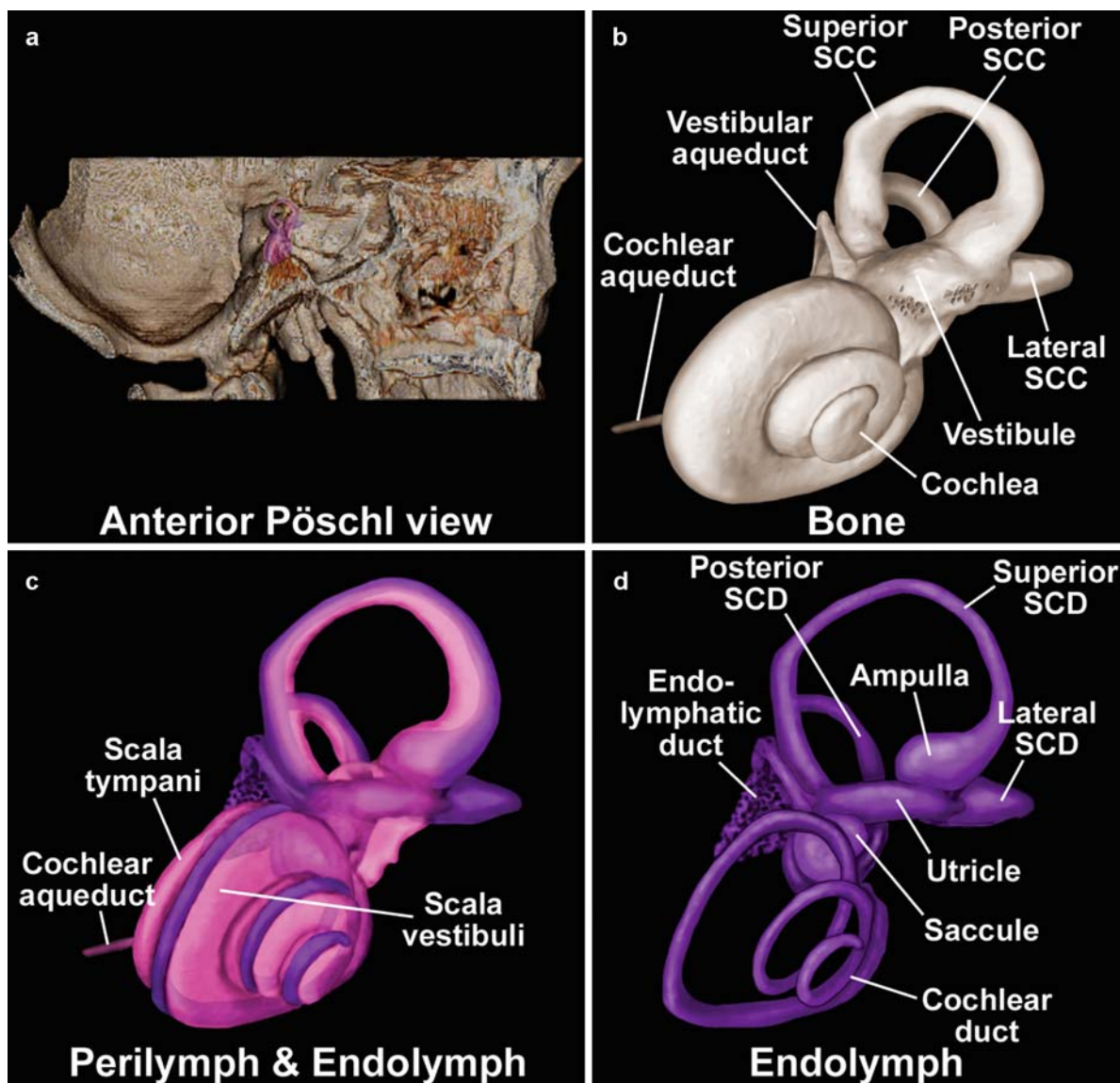


Fig. 19 The inner ear. Right anterior oblique (anterior Pöschl projection) views of 3D reconstructions from microscopy datasets. (a) 3D MDCT reference image with superimposed labyrinth. (b) MicroCT reconstruction of the bony labyrinth. (c) MicroMR reconstruction of the membranous labyrinth to include the perilymphatic and endolymphatic spaces. (d) MicroMR

reconstruction of the endolymphatic structures of the membranous labyrinth only. Note the relationship between the ellipsoidal utricle superiorly and the spherical saccule inferomedially within the vestibule. Also note the anterior position of the scala vestibuli and the posterior position of the scala tympani within the cochlea

patency in only 34% of normal postmortem exams [1]. There are two perilymphatic compartments within the cochlea; the *scala vestibuli*, which opens into the floor of the vestibule and conducts the fluid wave produced at the oval window, and the *scala tympani*, which communicates with the scala vestibuli through a small defect at the cochlear apex (the *helicotrema*) and ends

at the *round window* membrane. Perilymphatic fluid displacement at the *oval window* is accommodated by the perilymphatic fluid displacement at the *round window* membrane. The two perilymphatic scala of the cochlea are separated by a partial bony partition, the *spiral lamina*, which extends outward from the modiolus of the cochlea. The partition is further extended to

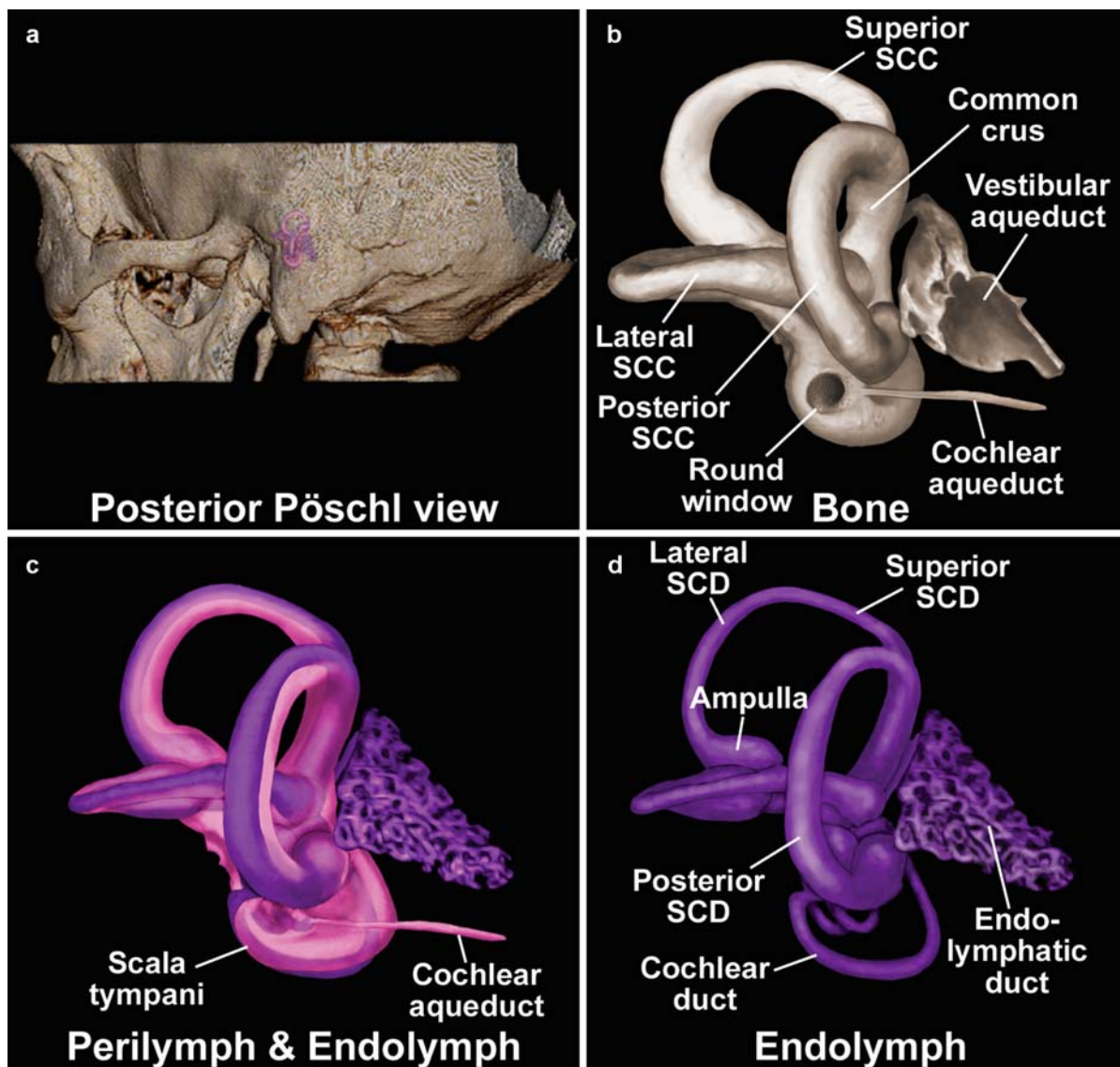


Fig. 20 The inner ear. Left posterior oblique (posterior Pöschl projection) views of 3D reconstructions from microscopy data-sets. (a) 3D MDCT reference image with superimposed labyrinth. (b) MicroCT reconstruction of the bony labyrinth. (c) MicroMR reconstruction of the membranous labyrinth to include the peri-

lymphatic and endolymphatic spaces. (d) MicroMR reconstruction of the endolymphatic structures of the membranous labyrinth only. Note the cochlear aqueduct opening into the scala tympani of the cochlea just inside the round window. Also note the location of the vestibular aqueduct medial to the common crus

the outer wall of the cochlea by way of the *basilar membrane*. The modiolus is anchored to the surrounding otic capsule by the *interscalar septa*, complete bony partitions that separate the cochlear turns. The previously mentioned endolymphatic cochlear duct (scala media), distributed along the outer wall of the cochlear lumen, is separated from the scala vestibuli

by a thin membrane (*Reissner's membrane*) and from the scala tympani by the more substantial basilar membrane. Perilymph fills much of the lateral aspect of the vestibule and approximately three-fourths of the volume of the semicircular canals.

Innervation of the neurosensory epithelium of the inner ear is by way of the VIIIth cranial nerve, or

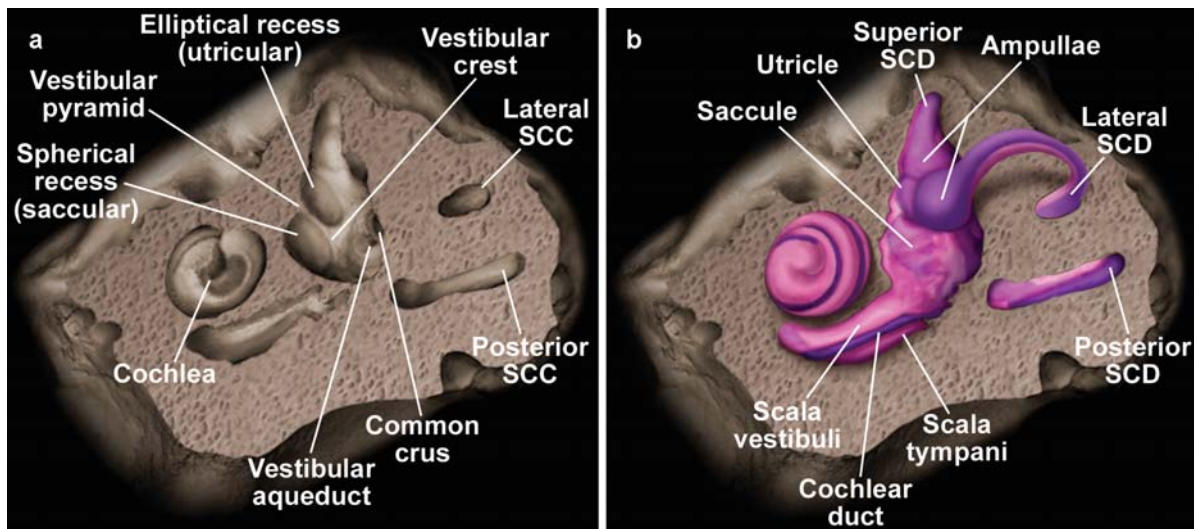


Fig. 21 Medial wall of the labyrinth. (a) 3D reconstruction of the microCT dataset demonstrating the exposed medial wall of the bony labyrinth and (b) superimposed 3D reconstruction of the membranous labyrinth from the microMR dataset. Note the elliptical and spherical recesses accommodating the medial surfaces of the utricle and saccule respectively. They are separated by a bony ridge, the vestibular crest. The vestibular pyramid, a

small projection of cribriform bone accommodating the superior vestibular nerve fibers innervating the utricular macula, is found at the superior edge of the vestibular crest. The ampullated end of the superior semicircular canal opens into the roof of the vestibule. Note the opening of the vestibular aqueduct anterior and inferior to the opening of the common crus

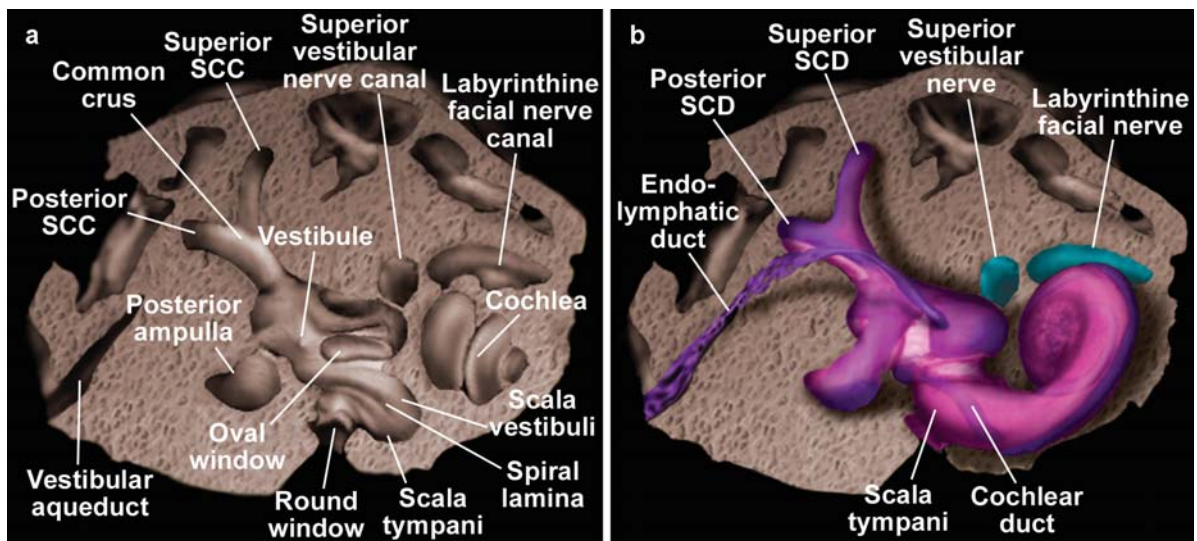


Fig. 22 Lateral wall of the labyrinth. (a) 3D reconstruction of the microCT dataset demonstrating the exposed lateral wall of the bony labyrinth and (b) superimposed 3D reconstruction of the membranous labyrinth from the microMR dataset. Note footplate of the stapes in the oval window. The spiral lamina is in continuity with the floor of the vestibule. The vestibule communicates with the scala vestibuli of the cochlea through a

small oval-shaped aperture. Inferior to the spiral lamina, the scala tympani terminates at the round window. The ampullated end of the posterior semicircular canal opens into the posterior wall of the vestibule. Note the opening of the fused nonampullated ends of the superior and posterior semicircular canals, known as the common crus, along the posterior wall of the vestibule.

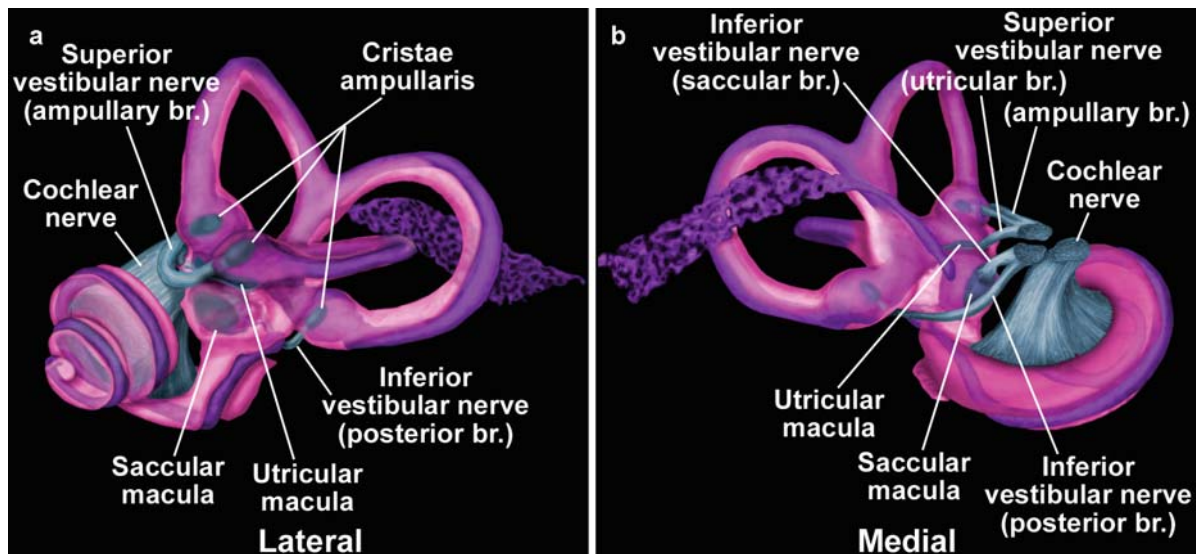


Fig. 23 Innervation of the inner ear. (a) Lateral and (b) medial views of the membranous labyrinth including nerve supply. 3D reconstructions from the microMR dataset. Intracanalicular nerve segments, avulsed during dissection, have been added to the original images. Superior and inferior vestibular nerves innervate the vestibular apparatus and the cochlear nerve innervates the auditory apparatus of the cochlea. Note that the superior vestibular nerve has an ampullary branch supplying the cristae ampullaris of the superior and lateral semicircular ducts and a utricle branch supplying the utricle macula. The infe-

rior vestibular nerve has two branches, the saccular branch innervating the saccular macula, and the posterior branch, innervating the crista ampullaris of the posterior semicircular duct. The cochlear nerve is composed of efferent fibers from all the spiral ganglia cells found at the base of the spiral lamina. They arborize through multiple small channels within the modiolus and coalesce within the cochlear nerve aperture at the apex of the internal auditory canal (IAC). Spiral ganglia cell afferent fibers transmit input from the hair cells of the organ of Corti within the cochlear duct (scala media)

vestibulocochlear nerve, which enters the temporal bone through the IAC (Figs. 23–27). The *cochlear nerve*, a division of the VIIIth cranial nerve, contains nerve fibers that originate from the neurons of the spiral ganglia located within small channels (*Rosenthal's canal*) at the root of each spiral lamina within the modiolus. They project peripherally to the cochlear hair cells in the cochlear duct and centrally through the small channels within the cribriform bone of the modiolus to the cochlear nuclei of the brainstem. A small posterior branch of the cochlear nerve supplies the vestibular end of the cochlear duct within the floor of the vestibule. The *vestibular nerve*, the other major trunk of the VIIIth cranial nerve, is composed of bipolar cells originating in the vestibular ganglion (*Scarpa's ganglion*) within the fundus of the IAC, sending efferent fibers to the neurosensory epithelium of the vestibular apparatus (utricle, saccule, and semicircular ampullae) and afferent fibers to the vestibular nuclei of the brainstem. It has an inferior and a superior division. The *inferior vestibular nerve* is composed of two

branches, a posterior branch that innervates the ampullae of the posterior semicircular duct (Figs. 23, 24) and a saccular branch that innervates the saccular macula of the saccule. The *superior vestibular nerve* also has two branches, a utricle branch that innervates the macula of the utricle and an ampullary branch that supplies the ampullae of the superior and lateral semicircular ducts. The utricle branch enters the vestibule at the *vestibular pyramid*, which is a raised area of cribriform bone at the superior end of the *vestibular crest* (Fig. 21).

The cochlear nerve, inferior and superior divisions of the vestibular nerve, and facial nerve are arranged in separate quadrants within the IAC (Figs. 26–28). The canal is partitioned at its apex into superior and inferior halves by a horizontal bony shelf, the *crista falciformis* (Figs. 25–28), separating the facial nerve and superior division of the vestibular nerve superiorly from the cochlear nerve and inferior division of the vestibular nerve inferiorly. The superior half is further partitioned by *Bill's bar* (named after renowned

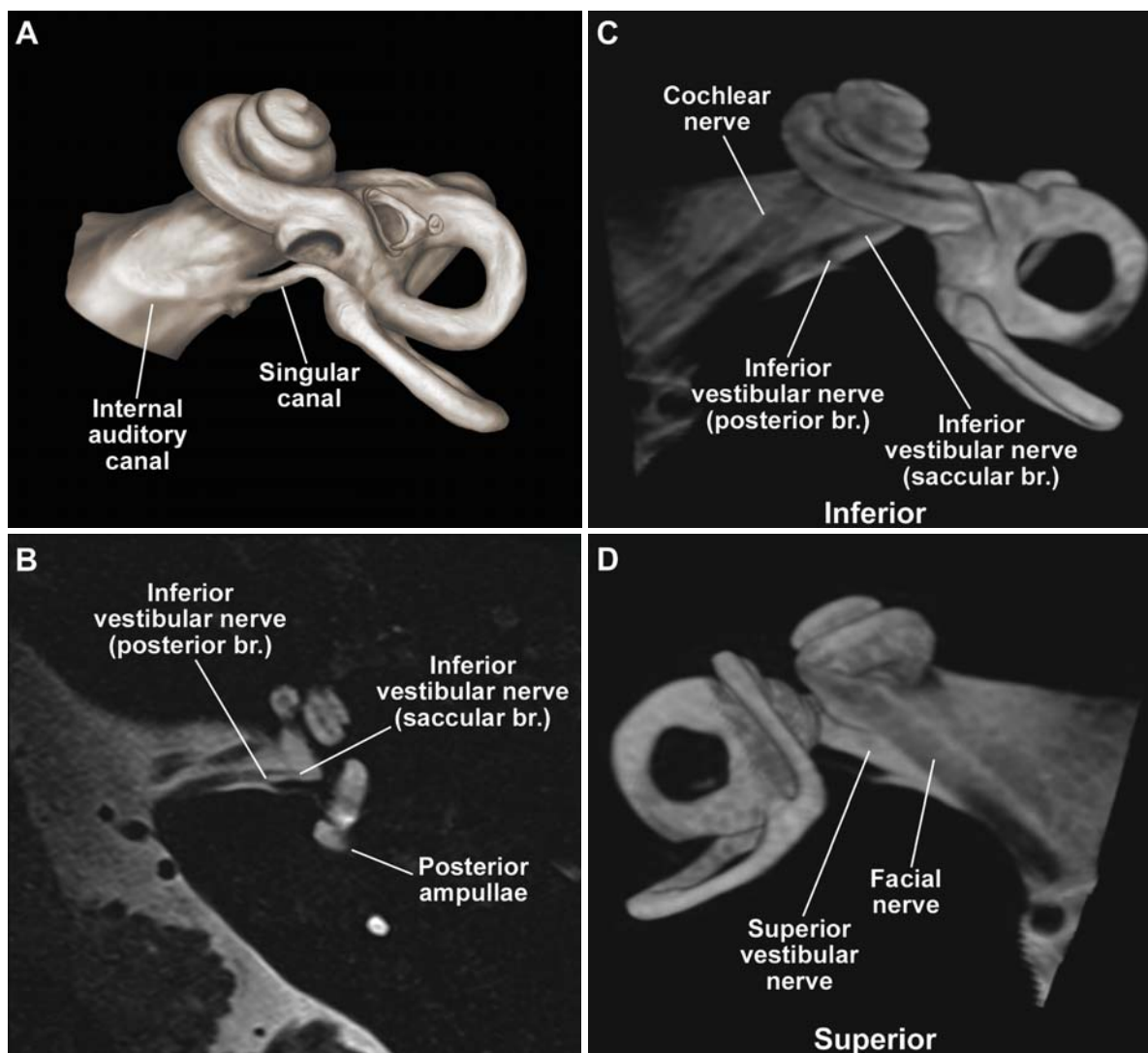


Fig. 24 IAC. (a) Inferior view of a 3D reconstruction from the microCT dataset demonstrating the relationship between the IAC and the bony labyrinth. Note the origin of the singular canal from the posterior wall of the IAC proximal to the apex. The singular canal transmits the posterior branch of the inferior vestibular nerve to the ampulla of the posterior semicircular duct. (b) 3T MR axial image demonstrates the length of the singular

canal from its origin in the IAC to its entry at the base of the posterior ampulla. (c) Inferior view of 3D maximum intensity projection (MIP) reconstructed from 3T MR. Note the cochlear nerve anteriorly and both saccular and posterior branches of the inferior vestibular nerves posteriorly. (d) Superior view of 3D MIP reconstructed from 3T MR. Note the facial nerve anteriorly and the superior vestibular nerve posteriorly

neurotologist, Dr. William House), a vertically oriented crest of bone separating the facial nerve anteriorly from the superior vestibular nerve posteriorly (Fig. 27). The two branches of the inferior vestibular nerve transverse separate bony canals, the posterior branch transmitted to the posterior ampullae by way of the *singular canal* (Figs. 23, 24) and the saccular

branch transmitted through a short foramen to the saccular macula (Fig. 23). The nerves exit the IAC through the *porus acusticus* on the posterior surface of the petrous portion of the temporal bone, superior and lateral to the opening of the *cochlear aqueduct* and superior and medial to the opening of the *vestibular aqueduct* (Fig. 28).

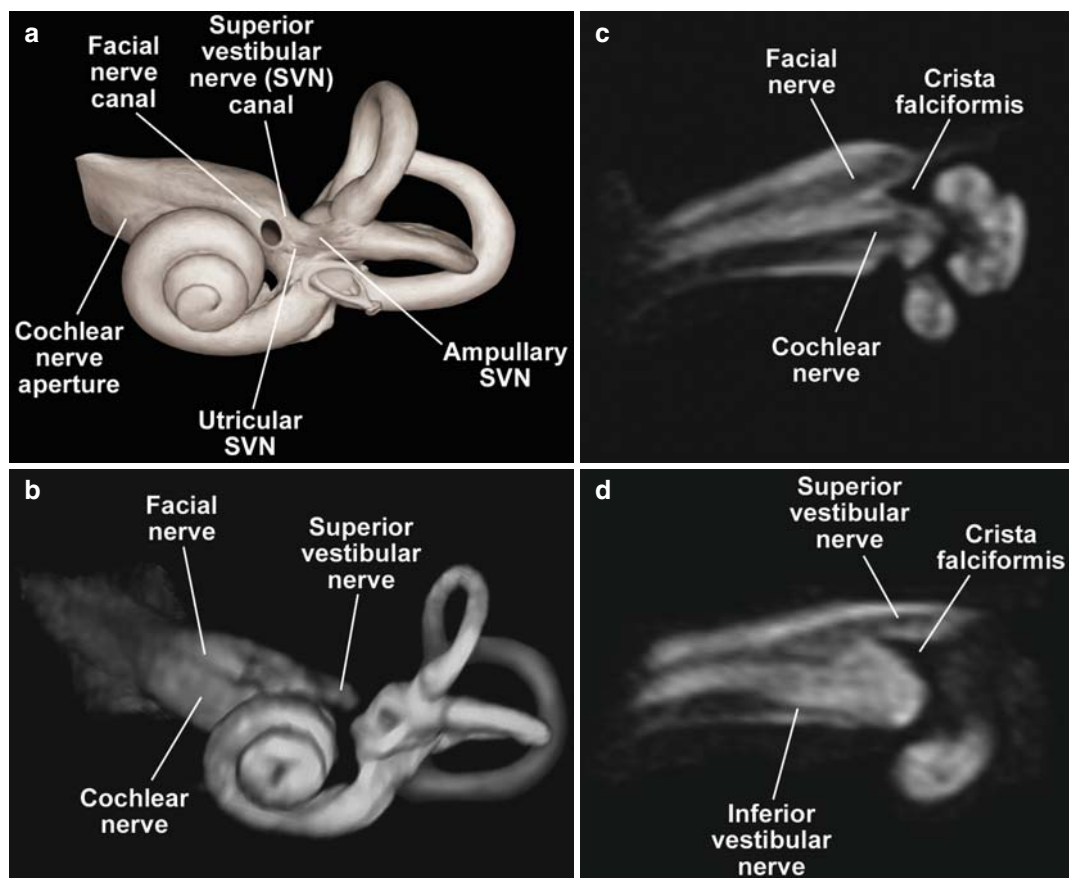


Fig. 25 IAC. (a) Anterior view of 3D reconstruction of the microCT dataset demonstrating the relationship between the IAC and the bony labyrinth. Note the cut surface of the labyrinthine segment of the facial nerve canal. The superior vestibular nerve canal can be seen to bifurcate into ampullary branches supplying the superior and lateral ampullae, and utricular branches inferiorly supplying the utricular macula. Note the cribriform bone at

these sites of innervation. (b) 3D Maximum intensity projection (MIP) from in vivo 3T MR dataset in the same projection as (a). (c) Curved Multiplanar Reconstruction (MPR) of 3T MR along the course of the facial and cochlear nerves within the anterior IAC. (d) Curved MPR of 3T MR along the course of the vestibular nerves in the posterior IAC. Note the crista falciformis creating a bony partition at the IAC apex

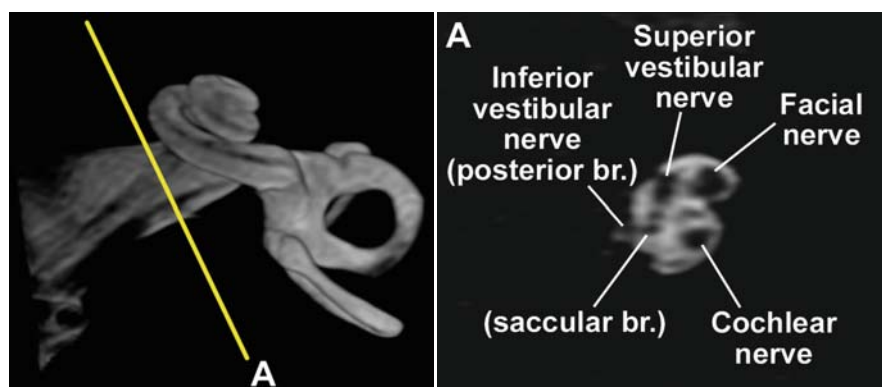
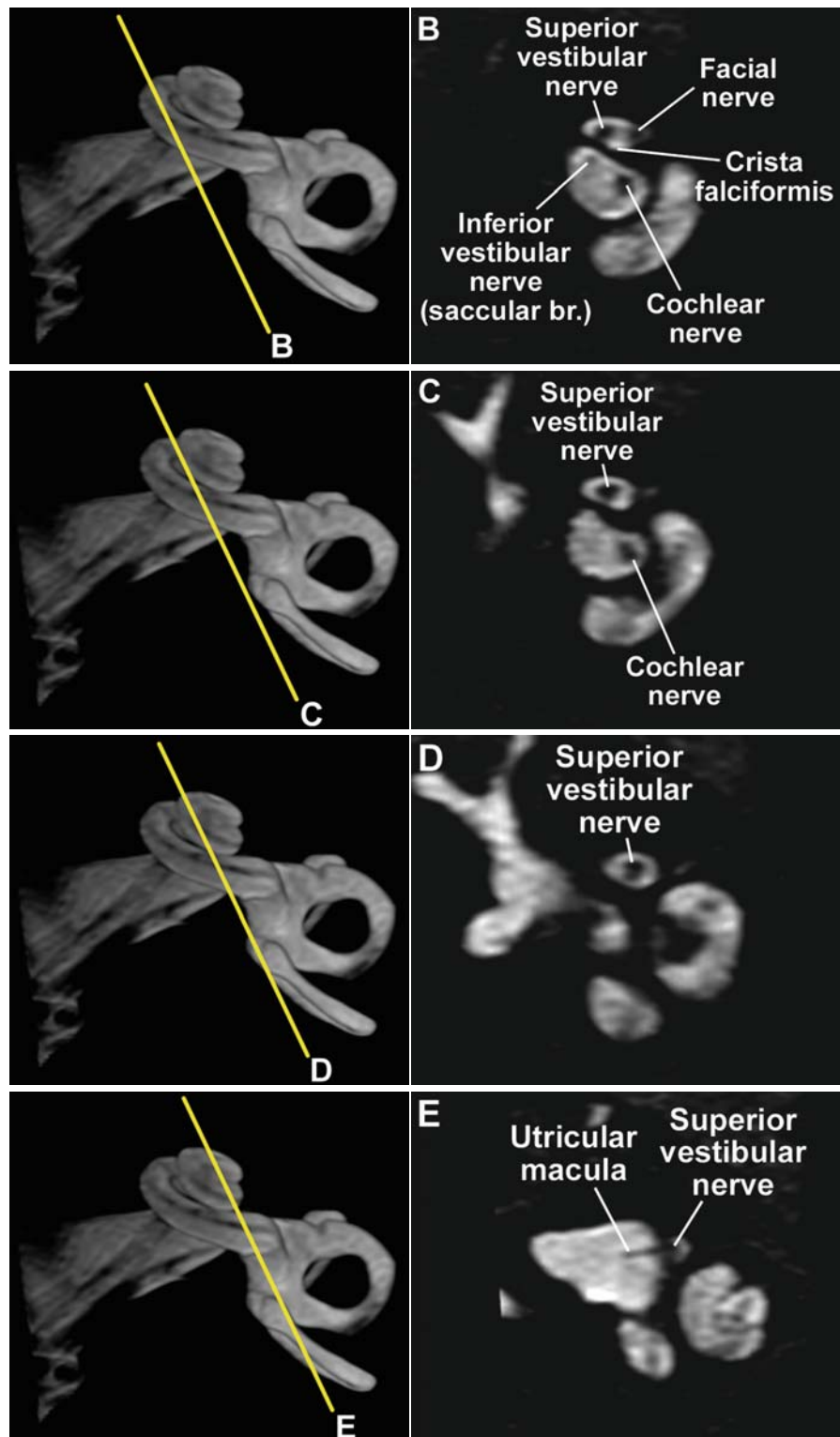


Fig. 26 IAC. Oblique cross-sectional reconstructions from in vivo 3T MR through the IAC demonstrating the relationship between the intracanalicular segments of the VIIth and VIIIth cranial nerves. (a–e) Progressive cross-sections from fundus to apex. Note the four-quadrant distribution of nerves within the fundus, with the facial nerve occupying the anterior–superior

quadrant, the cochlear nerve in the anterior–inferior quadrant, the superior vestibular nerve in the posterior–superior quadrant, and the inferior vestibular nerve in the posterior–inferior quadrant (a). Also note the horizontal bony partition, the crista falciformis (b), and the superior vestibular nerve innervating the utricular macula (e)

Fig. 26 (continued)

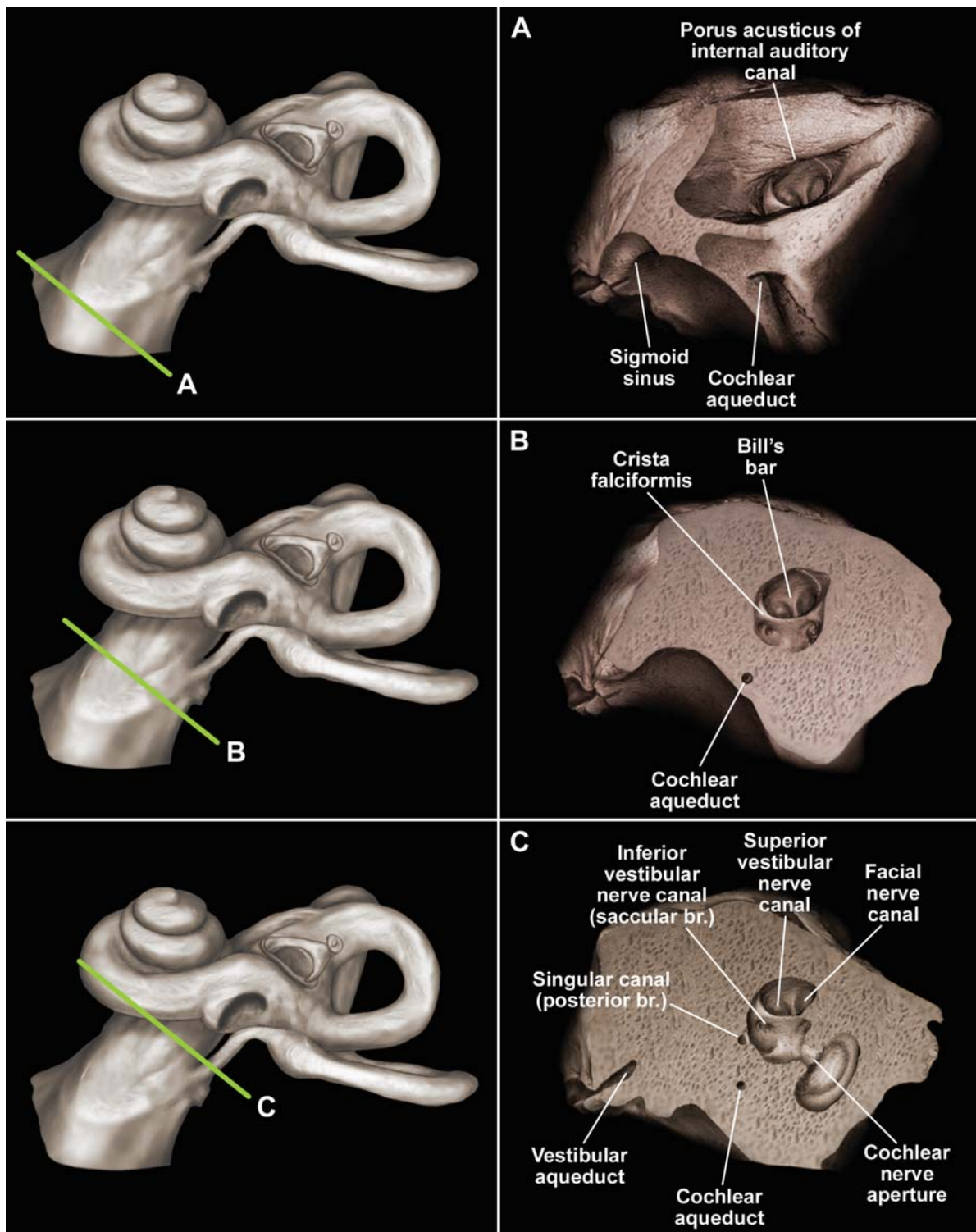


Fig. 27 IAC. Oblique cross-sectional reconstructions from the microCT dataset through the IAC demonstrating the exit points of the intracanalicular nerves into the bony labyrinth at the IAC apex. (a–c) Progressive cross-sections from the porus acusticus (the opening of the IAC) to the apex of the IAC. Note the horizontal

and vertical divisions of the IAC by the crista falciformis and Bill's bar (after the renowned neurotologist Dr. William House) (b). Note the proximal exit of the posterior branch of the inferior vestibular nerve (supplying sensory fibers to the crista ampullaris of the posterior semicircular duct) by way of the singular canal (c)

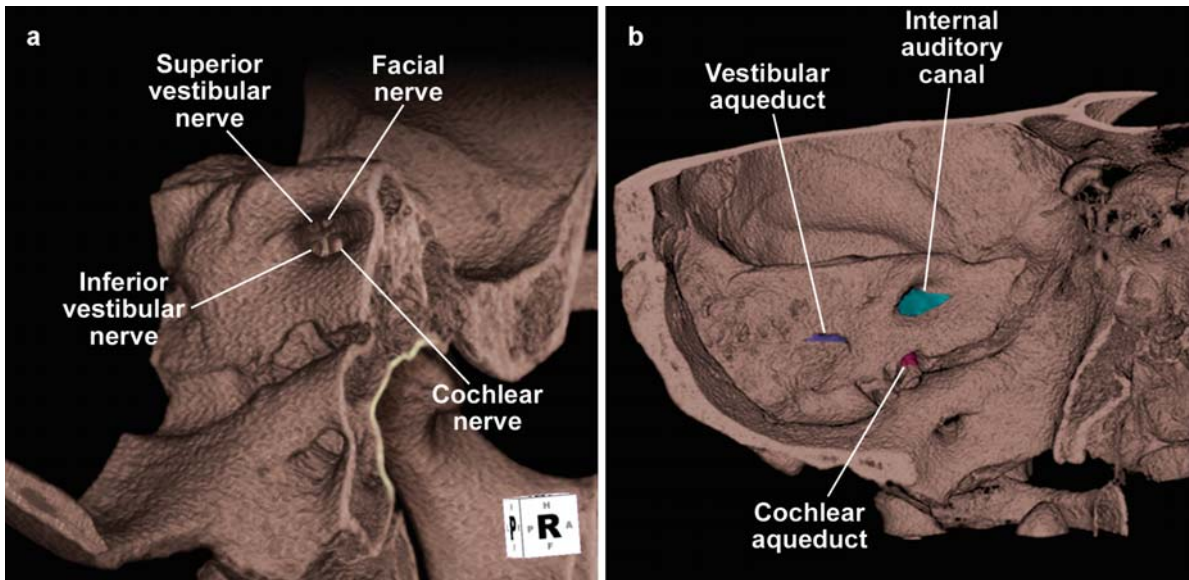


Fig. 28 IAC. Multidetector CT reconstruction of the posteromedial surface of the petrous portion of the temporal bone. **(a)** Exposed view of the left IAC demonstrating nerve exit points at the IAC apex. **(b)** Posteromedial surface of the temporal bone

demonstrating the location of the porus acusticus of the IAC in relation to the opening of the cochlear aqueduct inferiorly and the opening of the vestibular aqueduct posteriorly

Reference

1. Gopen Q, Rosowski JJ, Merchant SN. Anatomy of the normal human cochlear aqueduct with functional implications. *Hear Res* 1997;107:9–22