CT imaging of the temporal bone (TB): making easy what used to be hard.

Poster No.: C-1639
Congress: ECR 2016
Type: Educational Exhibit
Authors: A. Granados, J. F. Orejuela, L. Ospina; Cali/CO
Keywords: Structured reporting, Education, Image manipulation / Reconstruction, CT, Head and neck, Ear / Nose / Throat, Anatomy, Education and training
DOI: 10.1594/ecr2016/C-1639

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method ist strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

The aims of this exhibit are (1) to review the temporal bone anatomy; (2) to review the protocols for acquisition and major indications for CT imaging of the temporal bone; and (3) to provide template reports, standard and advanced reformats for the radiological assessment for each clinical indication.
TEMPORAL BONE ANATOMY

The temporal bone consists of five parts: the squamous, mastoid, petrous, tympanic and styloid portions. The squamous portion articulates with the occipital, parietal and sphenoid bones, and is part of the lateral wall of the middle cranial fossa and medial wall of the temporal fossa. The petrous is a quadrangular pyramid-shaped mass of the inner surface of the temporal bone, it extends to the petrous apex and contains the inner ear structures (vestibule, semicircular canals, cochlea) and virtually most neurovascular compartments (internal auditory canal, carotid canal and the jugular fossa); the apex of the pyramid rests on the clivus in the petro-occipital fissure. The tympanic bone forms the bulk of the ear canal and the middle ear space. It is separated anterior and internally from the petrous bone by the petrotympanic fissure, and anterior and externally from the squamous by the tympanosquamous suture. The mastoid portion contains the mastoid air cells, and articulates laterally with the parietal and occipital bones, and communicates with the nasopharynx through the Eustachian tube. There is continuity between the mastoid air cells and the petrous apex. The mastoid process forms a bony protrusion or eminence on the retro auricular region that protects the facial nerve, and it is not ossified at birth. The Körner's septum is part of the petrosquamous suture that runs posterolaterally through the mastoid air cells. It works as a barrier to the spread of infection from the lateral mastoid air cells to the medial ones. It also functions as a major surgical mark within the mastoid air cells. There is also a rudimentary temporal styloid, which originates in the second branchial arch and forms the posterior tympanum and the styloid process.
The outer and middle parts of the ear are responsible for transferring sound waves into the inner ear, which converts them into nerve impulses and records balance changes. External ear consists of the pinna, the external acoustic meatus and the outer wall of the tympanic membrane. Middle ear consists of three movable ossicles connecting the inner wall of the tympanic membrane and the oval window of the inner ear. Inner ear consists of the vestibulocochlear body in charge of both the hearing and the balance.

**EXTERNAL EAR**

The purposes of the external auditory meatus and canal are to collect and conduct the sound to the tympanic membrane as a resonant tube resulting in a gain from 10 to 20 dB.

The external auditory canal is 25 mm long and is filled with air in its normal state. It has two parts: the lateral third is made up of fibrocartilage with an incomplete ring of elastic cartilage measuring 8 mm long. It is lined by thick skin with hair follicles and glands. The two medial thirds are the bony portion, which is surrounded by the squamous, mastoid and tympanic segments of the temporal bone. It is lined with a thin layer of skin without follicles and glands. Anterior to the osseous part is the mandibular condyle, which
however, is frequently separated from the cartilaginous part by a portion of the parotid gland. Posterior to the osseous part are the mastoid air cells, separated from the meatus by a thin layer of bone.

Fig. 2: External ear anatomy: The pinna (A), the external acoustic meatus and the outer wall of the tympanic membrane in coronal (B) and axial (C, D) views.

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

MIDDLE EAR

It is also filled with air, which is transmitted from the nasal part of the pharynx through the Eustachian tube. It contains a string of moving bones, the ossicles, whose primary role is to mechanically transmit and amplify vibrations received by the tympanic membrane to the cochlea. The tympanic cavity is divided into 3 regions; epitympanum, mesotympanum and hypotympanum. The epitympanum contains the most of the structures.

The lateral wall is formed mainly by the tympanic membrane that separates the tympanic cavity from the bottom of the external acoustic meatus. It is a thin, semitransparent membrane, nearly oval in form, somewhat broader above than below, and directed very obliquely downward and inward. The greater part of its circumference is thickened, and forms a fibrocartilaginous ring which is fixed in the scutum and annulus at the inner end
of the meatus. The manubrium of the malleus is firmly attached to the medial surface of the membrane as far as its center, which it draws toward the tympanic cavity; the lateral surface of the membrane is thus concave, and the most depressed part of this concavity is called the umbo.

The tegmental roof has two parts; the tegmen tympani, which is made by a thin plate of bone and separates the cranial and tympanic cavities; and the arcuate eminence which is the bony prominence on the superior semicircular canal, is a surgical mark when the neurosurgeon cuts along the floor of the middle cranial fossa.

**Fig. 3**: Middle ear anatomy: Epitympanum, mesotympanum, hypotympanum, tegmen tympani, scutum, lateral wall in coronal view.

**References**: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

The jugular wall or floor is narrow, and consists of a thin plate of bone (fundus tympani) which separates the tympanic cavity from the jugular fossa.
Fig. 4: Inferior wall and jugular bulb in coronal view.

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

There are several marks at the medial wall. The oval window is a reniform opening leading from the tympanic cavity into the vestibule of the internal ear. In the recent state it is occupied by the base of the stapes, the circumference of which is fixed by the annular ligament to the margin of the foramen. The round window is situated below and a little behind the oval window, from which it is separated by a rounded elevation, the promontory and leads into the cochlea of the internal ear.
**Fig. 5:** Middle ear anatomy: Stapes, facial nerve canal, oval and round window in axial view (A, B, C).

**References:** Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

The promontory (promontorium) is a rounded hollow prominence, formed by the projection outward of the first turn of the cochlea; it is placed between the windows, and is furrowed on its surface by small grooves, for the lodgement of branches of the tympanic plexus.

The prominence of the facial canal indicates the position of the bony canal in which the facial nerve is contained; this canal traverses the labyrinthic wall of the tympanic cavity above the oval window.

The aditus ad antrum is located at the upper posterior wall and connects the epitympanum of the middle ear cavity with the mastoid antrum. The bottom portion of the posterior wall consists of three major structures: The facial recess, pyramidal eminence and sinus tympani.
Fig. 6: Middle ear anatomy: Facial recess, pyramidal eminence, sinus tympani and aditus ad antrum in axial views (A, B).

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

The anterior wall is wider above than below; it corresponds with the carotid canal, from which it is separated by a thin plate of bone perforated by the tympanic branch of the internal carotid artery, and by the deep petrosal nerve.

At the upper part of the anterior wall are the orifice for the Tensor tympani muscle and the tympanic orifice of the auditory tube, separated from each other by a thin horizontal plate of bone. These canals run from the tympanic cavity forward and downward to the retiring angle between the squama and the petrous portion of the temporal bone.

The orifice for the Tensor tympani extends on to the labyrinthic wall of the tympanic cavity and ends immediately above the oval window. The auditory tube (tuba auditiva; Eustachian tube) is the channel through which the tympanic cavity communicates with the nasal part of the pharynx. It is formed partly of bone, partly of cartilage and fibrous tissue.

OSSICLES

The normal ossicular chain consists of the malleus, incus and stapes. The first is attached to the tympanic membrane, and it consists of a head, neck, and three processes; the manubrium, the anterior and the lateral (short) processes. The head is the large upper extremity of the bone; and articulates posteriorly with the incus, being free in the rest. The manubrium is connected by its lateral margin with the tympanic membrane.

The incus consists of a body and the short, long and lenticular processes. The body has a deeply concavo-convex facet on its anterior surface, which articulates with the head of
the malleus. The long process ends in a rounded projection, the lenticular process, which is tipped with cartilage, and articulates with the head of the stapes.

The stapes consists of a head, neck, anterior crus and posterior crus, and the footplate. The head (Capitulum) presents a depression, which is covered by cartilage, and articulates with the lenticular process of the incus. The neck, the constricted part of the bone succeeding the head, gives insertion to the tendon of the stapedius muscle. The two crura diverge from the neck and are connected at their ends by the footplate, which is fixed to the margin of the oval window by the annular ligament.

**Fig. 7**: Middle ear anatomy: Ossicles and tympanic membrane in coronal (A, C) and axial (B, D) views.

**References**: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

**INNER EAR**

The inner ear consists of a membranous (endolymphatic) labyrinth containing the functional sensory epithelium surrounded by an osseous labyrinth with an interposed perilymphatic labyrinth.
The membranous labyrinth consists of the utricle, saccule, semicircular ducts, cochlear duct, and endolymphatic duct and sac. All of these structures contain endolymph. The osseous labyrinth is the bony shell that surrounds the membranous labyrinth. The utricle and saccule (membranous labyrinth) are housed within the vestibule (bony labyrinth), the semicircular duct (membranous labyrinth) within the semicircular canals (bony labyrinth), and the endolymphatic duct (membranous labyrinth) within the proximal vestibular aqueduct (bony labyrinth). The perilymphatic labyrinth is interposed between the membranous and bony labyrinth.

The vestibule is the central, rounded portion of the osseous labyrinth. In its lateral or tympanic wall is the oval window, closed, in the fresh state, by the base of the stapes and annular ligament. It is continuous anteroinferiorly with the cochlea and posteriorly with the semicircular canals and the vestibular aqueduct. Within the osseous vestibule the membranous labyrinth does not quite preserve the form of the bony cavity, but consists of two membranous sacs, the utricle, and the saccule.

The vestibular aqueduct is a tubular structure that arises from the vestibule and runs along the posteroinferior aspect of the petrous temporal bone. It contains the endolymphatic duct and sac, which are connected to the utricle and saccule of the vestibule. The vestibular aqueduct is diagonally oriented in relation to the direction of the IAC. The aqueduct, which normally measures less than 1.5 mm in diameter, approximates the size of the posterior semicircular canal, which runs anterior and parallel to the aqueduct.

The cochlea forms the anterior part of the labyrinth, is conical in form, and placed almost horizontally in front of the vestibule. Its base corresponds with the bottom of the internal acoustic meatus, and is perforated by numerous apertures for the passage of the cochlear division of the acoustic nerve. It consists of 2½ to 2 ¾ turns, and it involves a conical shaped central axis, the modiolus; and of a delicate lamina, the osseous spiral lamina that projects outward from the modiolus.

The cochlear aqueduct is a narrow canal which runs towards the cochlea in almost the same direction as the inner auditory canal, but situated more caudally. It extends from the basal turn of the cochlea to the subarachnoid space adjacent to the jugular foramen.
Fig. 8: Inner ear anatomy: Superior, lateral and posterior semicircular canals; internal auditory canal, labyrinthine portion CN7 canal, vestibule, bony vestibular aqueduct, cochlea, facial nerve and tensor tympani muscle in axial views (A - F).

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO
Images for this section:

**Fig. 1:** Squamous, mastoid, petrous, tympanic and styloid portions of the temporal bone.

© Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO
Fig. 2: External ear anatomy: The pinna (A), the external acoustic meatus and the outer wall of the tympanic membrane in coronal (B) and axial (C, D) views.

© Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO
Fig. 3: Middle ear anatomy: Epitympanum, mesotympanum, hypotympanum, tegmen tympani, scutum, lateral wall in coronal view.

© Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

Fig. 4: Inferior wall and jugular bulb in coronal view.

© Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO
Fig. 5: Middle ear anatomy: Stapes, facial nerve canal, oval and round window in axial view (A, B, C).

© Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

Fig. 6: Middle ear anatomy: Facial recess, pyramidal eminence, sinus tympani and aditus ad antrum in axial views (A, B).
**Fig. 7:** Middle ear anatomy: Ossicles and tympanic membrane in coronal (A, C) and axial (B, D) views.
Fig. 8: Inner ear anatomy: Superior, lateral and posterior semicircular canals; internal auditory canal, labyrinthine portion CN7 canal, vestibule, bony vestibular aqueduct, cochlea, facial nerve and tensor tympani muscle in axial views (A - F).

© Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO
Findings and procedure details

PROCEDURE DETAILS

ACQUISITION TECHNIQUE

PATIENT POSITION

Patient must be placed in supine position and the lens of the eyes have to be as far as possible out of the radiation area. The head should be immobilized in a neutral position; for this purpose, it is useful to adjust the patient's head with pillows to establish the correct position taking into account the reference lines. The sagittal reference line must be located in the mid-sagittal plane crossing the glabella and gnathion. The axial reference line must be parallel to the orbitomeatal plane (Figure 9).

Fig. 9: Prior to the acquisition, the patient must be correctly placed in order to obtain a high quality data. The sagittal reference line must be located in the mid-sagittal plane crossing the glabella and gnathion and the axial reference line must be parallel to the orbitomeatal plane.

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

ACQUISITION TECHNIQUE

Acquisition area must be defined from arcuate eminence to the lower end of the mastoid portion of the temporal bone. As the temporal bone involve small and complex structures,
the imaging resolution is very important. Despite a helicoidal technique provides better resolution, with a thin collimation there is not significant differences between non-helicoidal and helicodal technique. However, the non-helicoidal technique allows to perform better reformats decreasing the susceptibility to motion artifact [Swartz J, Loevner L. Imaging of the Temporal Bone. 4th edition. Thieme.].

STANDARD REFORMATS

Prior to perform the standard and advanced reformats, the raw data must be processed. This is reconstructed individually for each ear into 0.6 mm axial images in bone algorithm at a DFOV of 100 mm. The raw data are also reconstructed into 1 mm axial images in soft tissue algorithm including both ears and the brain. To perform the standard and advanced reformats, the 0.6 mm images are brought up on the CT scanner console where the images are displayed in three orthogonal planes.

AXIAL REFORMAT

In order to perform the axial reformat, the technologist scrolls through the sagittal data to find an image where the anterior and posterior section of the LSC are observed (Figure 10.A). Then, a reference line crossing these sections is traced; if this line is correctly established, the LSC will be entirely displayed in its longitudinal axis (Figure 10.D). A 0.6 mm (image thickness) x 0.5 mm (distance between images) axial dataset is made parallel to such line from the inferior portion of the tympanic membrane (Figures 10.B and 10.E) to the superior portion of the SSC (Figures 10.C and 10.F).
**Fig. 10:** Making an Axial reformat. In the saggital view, a reference line is traced crossing the anterior and posterior section of the LSC (A) and the structure is entirely observed in its longitudinal axis (D); the axial dataset is made parallel to this line from the inferior portion of the tympanic membrane (B, E) to the superior portion of the SSC (C, F).

**References:** Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

If the axial reformat has been performed correctly, the LSC, cochlear fossete, modiolus, and stapes footplate are clearly observed.

**CORONAL REFORMAT**
Similar to the method explained above, the technologist scrolls through the sagittal data until the anterior and posterior section of the LSC are observed and a reference line is drawn crossing both sections (Figure 11.A). A 0.6 mm (image thickness) x 0.5 mm (distance between images) coronal dataset is performed perpendicular to this reference line (Figures 11.A and 11.D) from the anterior portion of the cochlea (Figures 11.B and 11.E) to the posterior portion of the PSC and SSC (Figures 11.C and 11.F).

Fig. 11: Making a Coronal reformat. A reference line is made perpendicular to the reference line used for the axial reformat (A, D). The coronal dataset is then made from the anterior portion of the cochlea (B, E) to the posterior portion of the PSC and SSC (C, F).
When the coronal reformat has been made correctly, the Prussak's space and the facial nerve canal are clearly delineated.

ADVANCED REFORMATS

PÖSCHL REFORMAT

As above, the technologist scrolls in the sagittal data until the anterior and posterior section of the LSC is observed; then, a new axial plane is established by drawing a line crossing both sections. The technologist scrolls through the new axial dataset until the anterior and posterior section of the SSC is displayed as two dots (Figure 12.A). A reference line is traced crossing both dots, and the SSC would be observed enterily in its longitudinal axis (Figure 12.B). The Pöschl dataset is performed parallel to this reference line from the posterior portion of the PSC (Figure 12.C) to the anteromedial portion of the cochlea (Figure 12.D).
Fig. 12: Making a Pöschl reformat. The technologist scrolls in the axial reformat dataset until the anterior and posterior section of the SCC are displayed as two dots. A reference line is traced crossing both dots (A), and the canal will be entirely observed in its longitudinal axis (B). The Pöschl reformat is then made parallel to the reference line from the posterior portion of the PSC (C) to the anteromedial portion of the cochlea (D).

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

Pöschl reformat is useful for the assessment of temporal bone pathologies associated with the SSC, vestibular aqueduct and the long axis of the cochlea.

STENVERS REFORMAT

The Stenvers reformat is performed in the same axial dataset used for Pöschl reformat. The technologist scrolls until the anterior and posterior section of the SSC is displayed as two dots, and a reference line perpendicular to the long axis of the SSC is drawn. The long axis of the SCC may be established by tracing a line crossing both dots (Figure 13.A). If the reference line has been made correctly, the SSC would be observed in a cross-
sectional view (Figure 13.B). The Stenvers reformat is made parallel to this reference line from the posterior portion of the PSC (Figure 13.C) to the anterolateral portion of the cochlea (Figure 13.D).

![Figures A, B, C, D showing Stenvers reformat](image)

**Fig. 13:** Making a Stenvers reformat. The Stenvers reformat is made perpendicular to the reference line traced for the Pöschl reformat (A, B) from the posterior portion of the PSC (C) to the anterolateral portion of the cochlea (D).

**References:** Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

The Stenvers reformat is useful in the morphology assessment of the cochlea, facial nerve and round window.

**TYMPANOSQUAMOUS SUTURE REFORMAT**

This reformat is performed in the 1 mm axial images in soft tissue algorithm which includes both ears and the brain. The images are brought up on the CT scanner console where the images are displayed in three orthogonal planes. The technologist scrolls
through the axial dataset until right and left petrous portion of the temporal bone are displayed, and a coronal plane is established crossing them (Figure 14.A).

Fig. 14: Making a Tympanosquamous suture reformat. The technologist scrolls through the 1 mm axial dataset until right and left petrous portion of the temporal bone are displayed, and a coronal plane is established crossing them (A). Then, the technologist scrolls through the new coronal dataset until both EAC are displayed (B).

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

Then, the technologist scrolls through the coronal dataset until both EAC are displayed (Figure 14.B). A reference line is traced parallel to the cartilaginous portion of the EAC of the ear which is going to be assessed (Figure 15.A). Perpendicular to this reference line, in the sagittal view, the measurement of the maximum and minimum distances between the tympanic and the squamous portions of the temporal bone are performed (Figures 15.B and 15.C).

Fig. 15: Making a Tympanosquamous suture reformat. In the coronal view, a reference line is traced parallel to the cartilaginous portion of the EAC of the ear which
is going to be assessed (A). Perpendicular to this reference line, the measurement of the distances between the tympanic and the squamous portions of the temporal bone are performed (B, C).

**References:** Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

This reformat is useful in the clinical assessment of patients diagnosed with attic cholesteatoma where maximum and minimum distances have been reported to be increased compared to healthy subjects [Girons-Bonells J, Fontes-Carame D, Fité-Gallego A, Masuet-Aumatell C, Maños-Pujol M. Estudio comparativo mediante tomografía computarizada de la morfología de la sutura timpanoescamosa entre colestatoatama atical y oídos sanos. Acta Otorrinolaringológica de España. 2010. DOI 10.1016/j.otorri.2009.05.008].

**COCHLEAR REFORMAT**

In the axial dataset, a reference line is traced through the longitudinal axis of the basal turn of the cochlea (Figure 16.A) and an oblique plane is established parallel to this line. If the plane is correctly established, the cochlea will be displayed entirely (Figure 16.B). In the oblique plane, a curved plane is performed through the cochlea (Figures 16.B and 16.C), and it will be displayed unrolled (Figure 16.D).
CLINICAL INDICATIONS

As CT imaging is useful for the characterization of bone involvement, it allows to evaluate the external auditory canal, middle ear cavity and mastoid air cells. For some inflammatory and neoplastic lesions, contrast material may be given and images processed with soft tissue window settings. MR imaging generally is better for differentiation between soft tissue and fluid that allows a better visualization of the nerves.
and enhancement of the small structures. MR imaging is also sensitive for detection of bone marrow edema, and it can demonstrate bone involvement not suspected by CT.

There are particular indications for each study; for example, in facial paralysis, if a patient persists for more than 3 weeks with symptoms, a neoplasm must be suspected and investigation should include contrast-enhanced MR imaging. Also, in cholesteatoma, MRI is indicated particularly diffusion weighted imaging, which helps to differentiate a recurrent cholesteatoma from cholesterol granuloma, granulation tissue, or scar. For congenital lesions, if disorders of the first and second branchial arches are being studied, CT should be performed, MR imaging can be used as a complementary study. On the other hand, if an inner ear malformation requires characterization, an MRI should be the study of choice. In patients who had undergone surgery, CT is safe and allows depiction of the type of procedure, prosthesis and electrodes, its localization and relationships. Also, in acute trauma CT is the study of choice.

STRUCTURED REPORT

The report should start with the technical descriptions of the acquisitions and the reformats that are made; we acquire 0.6 mm axial scans of the temporal bone using a high-resolution bone technique. The scans are reconstructed in the axial, coronal and sagittal planes having the lateral semicircular canal as a reference for right and left sides. Stenvers and Poschl reformats are also made. Then, the clinical information and previous studies should be mentioned.

For each side, it must be described the presence of a normal, deformed or absent pinna and the appearance of the external auditory canal and tympanic membrane. The middle ear cavity, the ossicles and their articulations and the stapes superstructure have to be also detailed. A description of the inner ear including the cochlea, vestibule and semicircular canals as well as the oval and round windows need to be informed. Finally, the vestibular and cochlear aqueducts and internal auditory canal are evaluated and described.

We depict the course of the facial nerve, the carotid canal and the jugular foramen, especially if there are any variants. A description of whether the mastoids are well pneumatized and aerated, and the anatomic structure of the temporomandibular joint are included. If there is a congenital aural atresia, we include the Jahrsdoerfer classification and conclude with our impression with key points.

FINDINGS
Between January-2013 and August-2015, 682 temporal bone CT studies were performed. Out of 682 studies, 248 (36.4%) were normal; 233 (34.2%) had a chronic inflammatory pathology, 123 (52.8%) otomastoiditis, 75 (32.2%) mastoiditis, 29 (12.4%) thickened tympanic membrane; 87 (12.8%) congenital, 49 (56.3%) semicircular canal thinning or dehiscence, 9 (10.3%) high jugular bulb, 9 (10.3%) atresia, 6 (6.9%) otosclerosis; 24 (3.5%) fractures; 23 (3.4%) acute inflammatory; and 10 (1.5%) tumors. 58 (8.5%) studies were performed for postoperative assessment. Complementary study was requested in 33 (4.8%) cases to confirm diagnosis. Structured report and reformats were detailed for each clinical indication.

**CLINICAL APPLICATIONS**

**CHRONIC INFLAMMATORY**

In the evaluation of patients diagnosed with a chronic inflammatory pathology of the ear, the goal of the CT imaging is to guide the clinical approach and to evaluate for complications. In addition to the detailed above, the radiologist should include in the report if there is a cholesteatoma, or any complication such as perilymphatic or canals fistulas, tegmen dehiscence and fallopian canal dehiscence. The size and status (healthy or diseased) of the mastoid should be described including the additus ad antrum. The radiologist also has to evaluate and to describe in the report if the external auditory canal is eroded and if the middle cavity ear is well aerated. Finally, the state of the ossicles should be also reported.

**CHRONIC OTOMASTOIDITIS**

*Case 1:* 45 years-old male patient with right chronic otitis and trigeminal neuralgia. CT findings showed occupation of the middle ear and mastoid air cells, with sclerotics changes in the walls of the mastoid air cells. Coronal standard reformat shows dehiscence of the tegmen tympani, retracted tympanic membrane and opacification of the middle cavity (Figure 17). These findings are related to chronic otomastoiditis.
Fig. 17: Chronic otomatoiditis. Coronal standard reformat shows dehiscence of the tegmen tympani (black arrow), retracted tympanic membrane (outlined white arrow) and opacification of the middle cavity (short white arrow).

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

ACQUIRED CHOLESTEATOMA

Case 1: 24 years-old male patient with clinical suspicion of cholesteatoma. CT imaging findings showed right chronic otomastoiditis. Soft tissue lesion within the middle ear including the attic, with erosion and retraction of the ossicles were also observed (Figures 18.A and 18.B). These findings may be associated with cholesteatoma. MR imaging was performed to confirm diagnosis. MRI findings showed permeability of the external auditory canal with occupation of the right mastoid air cells and middle ear due to inflammatory process. A restricted area in the right Prusack space is observed in coronal ADC and diffusion MRI images (Figures 18.C and 18.D), which confirms the diagnosis of cholesteatoma.
Fig. 18: Attic cholesteatoma. Coronal and axial standard reformats CT images shows soft tissue lesion within the middle ear including the attic (black arrows), with erosion and retraction of the ossicles (short white arrows) (A, B). Restriction in the attic is observed in coronal ADC and diffusion MRI that confirms the diagnosis (outlined white arrow) (C, D). Axial CISS MRI images confirms the location of the lesion (white arrow) (E).

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

POSTSURGICAL EAR

In the assessment of postsurgical ear, the report should includes the type of surgical procedure, if a mastoidectomy has been performed, it should be described if it was simple or radical. In cases of tympanoplastia, prosthesis type and its location, the state of the ossicular chain and tympanic membrane should be described.

Case 1: 70 years-old female patient with history of otosclerosis and left stapedectomy. CT imaging findings showed evidence of postsurgical changes in the ossicles and thickening of the oval window. A hyperdense object is observed which corresponds to the stapes
prosthesis. Pöschl (Figure 19.A), coronal and axial standard-reformats (Figures 19.B and 19.C) show the tip of the prosthesis has migrated into the vestibule.

Fig. 19: Stapes prosthesis, wire. Pöschl (A), coronal standard (b), and axial standard (c) reformats show the tip of the prosthesis (white arrows) has migrated into the vestibule.

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

CONGENITAL

In the interpretation of CT imaging of the temporal bone in patients with congenital abnormalities, the report should be addressed to describe the extent of the external auditory canal atresia and if it is membranous, bony or mixed; the thickness of the atresia plate, the pneumatization of the mastoid, the middle cranial fossa level, the temporomandibular joint location, and the presence or absence of cholesteatoma. In the evaluation of the ossicular chain, it should be detailed if there is ossicle fusion describing the incudomalleal and incudostapedial joints, or if the ossicles are fused to the atresia plate. In addition, the stapes should be detailed if present, dysplastic or absent because it may be useful information if a prosthesis placement is required. Size of the oval window and middle ear cavity in all three axis should be included as they may be crucial in the surgical planning. The inner ear structures and size of the internal auditory canal should also be mentioned in the radiology report.

In patients with clinical symptoms of dizziness, vertigo or hearing loss; or clinical suspicion of third-window, the semicircular canals should be evaluated looking for dehiscence
or thinning. Stenvers and Pöschl reformats may be useful for this purpose, mainly in confusing cases where the SSC is not clearly delineated in the standard reformats.

In the evaluation of the jugular bulb, the radiologist should describe if it is high, dehiscent and if there is any pathology associated.

HIGH JUGULAR BULB.

Case 1: 17 years-old female patient with pulsatile tinnitus and hearing loss. CT imaging findings showed focal outpouching of the jugular bulb extending to the level of the internal auditory canal with bony dehiscence and protrusion into the middle ear cavity (Figure 20).

Fig. 20: High-riding jugular diverticulum, dehiscent. Focal outpouching of the jugular bulb extending to the level of the internal auditory canal with bony dehiscence and protrusion into the middle ear cavity (white arrows).

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

ATTIC CHOLESTEATOMA (PRIMARY)

Case 1: 41 years-old male patient with clinical suspicion of attic cholestatoma. CT images show an occupation of the epitympanum and enlargement of the tympanosquamous suture. In the tympanosquamous suture reformat (Figure 21), maximum and minimum distances were measured where an increase was observed in the pathologic ear (dA
= 0.17 mm and dB = 0.13 mm) compared to the healthy ear (dA = 0.08 mm and dB = 0.06 mm).

Fig. 21: Cholesteatoma attic. Maximum and minimum distances between the tympanic and the squamous portions of the temporal bone are increased in the pathologic ear (B) (dA = 0.17 mm and dB = 0.13 mm) compared to the healthy ear (A) (dA = 0.08 mm and dB = 0.06 mm).

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

ATRESIA

Case 1: 17 years-old male patient with right aural atresia. In the CT images the pinna is observed diminished with atresia of the external auditory canal without pneumatisation of the atresic plate. Non-aerated middle ear with decreased size and occupied with material of soft tissue density. Dysplastic malleus and incus with incudomalleal ankylosis and horizontal oriented incus long process, which is attached to the atresic plate. Normally shaped stapes. Incudostapedial articulation cannot be depicted (Figures 22 and 23).
**Fig. 22:** Atresia. Non-aerated middle ear with decreased size and occupied with material of soft tissue density. Dysplastic malleus and incus with incudomalleal ankylosis and horizontal oriented incus long process, which is attached to the atresic plate.

**References:** Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

**Fig. 23:** Atresia. CT three-dimensional reformations in a patient with unilateral microtia with deformed residual pinna (C) and external auditory canal atresia (D).
**References:** Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

**SEMICIRCULAR CANAL DEHISCENCE**

**Case 1:** 68 years-old female patient with chronic otomastoiditis and conductive hearing loss. Coronal standard reformats (Figure 24.A and 24.B) and Pöschl reformat (Figure 24.C) show dehiscence of the superior semicircular canal.

![Fig. 24: Superior Semicircular Canal Dehiscence. Coronal standard reformats (A, B) and Pöschl reformat (C) show dehiscence of the SSC.](image)

**References:** Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO
ENLARGED VESTIBULAR AQUEDUCT

Case 1: 19 years-old female patient diagnosed with conductive hearing loss. Pöschl reformat shows a dilatation of the left vestibular aqueduct, which has a diameter of approximately 17 mm (Figure 25).

Fig. 25: Enlarged vestibular aqueduct. Pöschl reformat show a dilatation of the left vestibular aqueduct, which has a diameter of approximately 17 mm.

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO
MONDINI SPECTRUM

Case 1: 13 years-old female patient with right hearing loss. Coronal CT images show an absence of the modiolus (Figure 26.A) and the vestibule was observed dilated (Figure 26.B and 26.C). These findings are suggestive of Incomplete Partition type 1 of the Mondini Spectrum.

Fig. 26: Coronal CT images show an absence of the modiolus (A) and the vestibule was observed dilated (B). These findings are suggestive of Incomplete Partition type 1 of the Mondini Spectrum.

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

FRACTURE

Case 1: 48 years-old male patient with head trauma and hearing loss. CT imaging shows a longitudinal fracture of right temporoparietal bone that extends to the mastoid portion longitudinally, with involvement of the bone walls of the external auditory canal with displacement of fragments into the lumen (short white arrows), and dislocation of the ossicular chain associated with discontinuity of the stapes (white arrow). Extension of the fracture line to the sphenoid, with involvement of the walls of the lacerated foramen, foramen ovale, carotid canal (outlined black arrow) and lateral wall of the sphenoid sinus. There is occupation of mastoid air cells with material of soft tissue density. Facial nerve and otic capsule are also involved (black arrow) (Figure 27).
Fig. 27: Fracture, head trauma and hearing loss. CT imaging shows a longitudinal fracture of right temporoparietal bone that extends to the mastoid portion longitudinally, with involvement of the bone walls of the external auditory canal with displacement of fragments into the lumen (short white arrows), and dislocation of the ossicular chain associated with discontinuity of the stapes (white arrow). Extension of the fracture line to the sphenoid, with involvement of the walls of the lacerated foramen, foramen ovale, carotid canal (outlined black arrow) and lateral wall of the sphenoid sinus. Facial nerve and otic capsule are also involved (black arrow).

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO

TUMORS

In the assessment of patients with tumors, CT imaging is useful to evaluate the bone involvement of the external, middle and inner ear; however, in order to define and to characterize the soft tissue, brain and dural extension, contrast-enhanced MRI imaging is the gold standard.

Fig. 28: Tumors. Coronal and axial CT images show a mass with bone erosion which involves external, middle and inner ear (A, B). Contrast T1-weighted coronal and T2-weighted axial MRI imaging shows involvement of soft tissue and intracranial extension.

References: Fundación Valle del Lili, Fundación Valle del Lili - Cali/CO
Conclusion

CT imaging is an useful technique for the assessment of pathologies of the temporal bone. As the temporal bone involves complex and small structures, the knowledge of the anatomy by the radiologist and a high quality of the CT imaging are very important in order to achieve the imaging goals and to answer the clinician questions. Although the conventional reformats are sufficient in most cases, the advanced reformats are helpful in order to improve the diagnostic accuracy for the characterization of temporal bone pathologies, mainly in confusing cases.
References