Ear study with 64 slices Multidetector CT

María Lourdes Mallo, Cecilia C. Giordanengo, Carlos A. Bertona, Juan José Bertona, Cecilia Gigena, María Paula Florez

Abstract
The ear is a complex anatomic structure. Its study and understanding represent a constant challenge for the radiologist. As a consequence, the computed tomography becomes an essential tool for its examination. The conventional tomographic examination with both axial and coronal reconstruction of the image allows a satisfactory visualization of different structures. However, the study requires long periods of time for its acquisition and uncomfortable or intolerable positions for some patients. Besides, the characterization of some ear’s structures becomes limited. The 64 slices multidetector computed tomography enables an optimal study of the ear’s small and complex anatomy, performing volumetric acquisitions with 0.5 mm slices, which leads to accurate multiplanar reconstructions in the three basic planes, in curved planes and three dimensional reconstructions. These make a detailed visualization of its structures in few seconds, avoiding discomfort in the patients. Our purpose in this article is to demonstrate the utility of reconstructions particularly in oblique planes, reaching an optimal visualization of the temporal bone. 

Key words: Inner ear. Multidetector computed tomography. Temporal bone.

INTRODUCTION
From the advent of Computed Tomography (CT), the study of temporal bone structures is limited to axial and coronal orientations, with slices of the lowest thickness (usually of slices between 1 and 3 mm) in that way, the identification of smallest and most complex anatomic ear structures is limited. Furthermore, it is necessary to consider time exploration in order to avoid movements and uncomfortable position in coronal plane orientations.

The incorporation of 64 slices Multidetector Computed Tomography (64MDCT), by reconstructing the image in any space plane, with acquisition in few seconds and with a tolerable position for all patients, enables a detailed observation of the ear’s anatomic repairs and progress in addressing different diseases.

64 MDCT PROTOCOL

Data Acquisition: The temporal bone CT SCAN was performed in our institution using a 64 channels multidetector scanner Aquilion Toshiba. The exploration was conducted in the standard axial plane with helicoidal technique and volumetric acquisition (120 kv, 200 mA, rotation time of 0.5 seconds, thickness of the section of 0.5mm, matrix 512 x 512). The head of the patient was located in a neutral position and the time of study was of 4 to 6 seconds. Image reconstruction and post-processing: The data analysis was performed in a Vitrea® work station. The temporal bones were visualized in three basic planes (axial, sagital and coronal), reconstructed in isometric way (with the same resolution as the original acquisition) every 0.5, 1 or 2 mm. In addition, there were performed 3D reconstructions, multiplanar and oblique curves, and Maximum Intensity Projections (MIP), according to the structure of clinical interest or as the findings: ossicular chain, round and oval windows, the cochlea, vestibular aqueduct, semicircular canals and facial nerve canal.

EXTERNAL EAR
It comprises the pinna and external auditory canal (EAC). The EAC has an italic S shape on its way to the tympanic membrane. Its two internal thirds are osseous and slightly narrower than the lateral third, which is cartilaginous. The tympanic membrane shows the intermediate limit of EAC, separating the external ear from the tympanic cavity.

The exploration of these structures with 64 MDCT, with volumetric and 3D reconstructions allowed a very detailed view of them (Fig. 1), resulting a valuable help in the detection of pathological features (Fig. 2).
MIDDLE EAR

Ossicular chain

Hammer and incus

The handle of the hammer and the incus are not clearly defined by conventional scan of the temporal bone, which consists on axial and coronal acquisitions\(^1\).

Oblique coronal planes (Figs. 3-4), oriented along long axis of these two ossicular structures provide a better identification of them.

The oblique sagittal plane (Fig. 5) also enables its visualization and provides an alternative to the axial plane for the examination of incude-maleolar joint\(^8\). The reconstruction of this plane of hammer and incus, resemble a molar tooth\(^9\) (Fig. 6). These reconstruction planes can be helpful for studying the erosions of the ossicular chain, coelesteatoma, traumatic dislocations, and congenital anomalies of the ossicular chain and oval window\(^10\).

Stapes-oval window

The oval window is located laterally to the vestibule, above and behind the promontory. It connects the tympanic cavity with the vestibule and it is occupied by the stapes footplate\(^2\). Its longitudinal diameter is of 3-4 mm and its vertical is of 1,5-2 mm. Its conventional topographical visualization is optimum on the coronal plane, and it is not satisfactory visualized on the axial plane\(^1\).

A double-oblique orientation of the reconstruction’s axial plane enables an optimum exhibition of the stapes and oval window (Fig. 7). An oblique sagittal reconstruction is useful to confirm the presence of both branches of the stapes, next to the oval window.

The combination of sagital, axial and oblique planes...
reconstructions can assist in the evaluation of congenital anomalies, in traumatic dislocations and in fixation of the stapes in patients with hearing loss (10).

Round Window

The round window is located behind and below the oval window, in a shallow pit. It corresponds to the tympanic orifice of the cochlea’s tympanic scale and its diameter is 2 mm (2). It can be clearly represented on axial images (Fig. 8), while it is not possible to do it on the coronal plane, due to its orientation (1). It is more convenient to use oblique sagittal reconstructions (Fig. 9). The radiological study of both windows is important in several pathologies, such as otosclerosis and malformations (13).

INTERNAL EAR

Cochlea

It is a spiral-shape structure with two and a half turns. It is located anterolateral to the IAC and contains the organ of Corti. Its long axis can be represented in axial or coronal standard images. The 64 MDCT, by oblique reconstructions (Fig. 10), enables the evaluation of superior, middle and inferior turns, as well as the evaluation of the opening of the cochlear nerve. Curve reconstructions enable to ‘unroll’ the cochlea, getting insight into its morphology and dimensions. Finally, volumetric imaging provides morphological and anatomical detail, which allows to visualize the total of its turns (2-4).

RAR - Volumen 74 - Número 4 - 2010
**Semicircular Canals**

They are constituted by three conducts (superior, posterior and lateral), situated behind and above the vestibule. The superior semicircular canal is orientated in an approximately 90° angle to the long axis of the temporal bone. Coronary images are enough to determine its integrity.

**Vestibule and vestibular aqueduct**

The vestibule is part of the internal ear’s labyrinth, situated between the semicircular conducts and the cochlea. It contains the utriculus and sacculus, which are part of the membranous labyrinth.

The aqueduct or vestibular conduct contains the endolymphatic conduct and communicates the vestibule’s sacculus with the endolymphatic sacculus. It is not usually visualized in coronary images and it is hard to see it in axial images (Fig. 11). The vestibular conduct’s course is better identified in the sagittal plane (Fig. 12), which is useful in the diagnosis of dilated vestibular aqueduct syndrome, an anomaly more common of the osseous labyrinth observed in patients with a deep sensorineural hearing loss.

**Facial nerve canal**

It is a bony channel where the facial nerve is located in its intratemporal course. It starts at the back of the internal auditory canal. Its first portion, of 4 mm in length, is between the cochlea (front) and the semicircular canals (back). It is often injured in longitudinal bone fractures.

The second portion or tympanic portion starts when it bends back, almost at right angle, to follow a parallel path to the lateral semicircular canal. It measures 10 mm long and may be dehiscent.

The third portion or descending portion, is 15 mm long and continues to the stylomastoid foramen.

With the image reconstruction in an oblique sagittal plane, the cochlea’s short axis can be observed (Fig. 10).
tal plane (Figs. 14-15) and curve reconstructions, the whole longitude between the tympanic and mastoid segments of the facial nerve can be represented in just one image. The use of this reconstruction plane can help in the diagnosis of the nerve anomalies and fractures in the path of the facial nerve canal.

Carotid conduct

The intrapetrosal path of the internal carotid artery (ICA) is perfectly visible with a tomography regarding its bone repairs. With 64 MDCT it is also possible to perform angiographic reconstructions for suspected arterial injuries. This requires iodinated contrast injection (Figs. 16, 17 and 18).

Cochlear implant

64 MDCT in presurgical study for cochlear implant is an excellent method for anatomical and pathological detail of the temporal bone region (Fig. 18). Volumetric images provide information about the anatomy of the ossicular chain, the inner ear and its relationship to vascular structures, the carotid artery and the internal jugular vein. Curve reconstructions enable to ‘unroll’ the cochlea, getting insight into its morphology and dimensions. This information is very useful for the surgeon.

In the postsurgical study, 64 MDCT is an excellent method to control the correct positioning of the electrodes of the implant, since it avoids image artifices.

Fig. 11. CT, standard axial image. Vestibule (V) Posterior semicircular canal (CSP) and lateral (CSL).

Fig. 12. CT with MPR, oblique sagital image, where the vestibular conduct is visualized (CV) in its origin, common area of CSS and CSP (ZC).

Fig. 13. 3D reconstruction: semicircular canals CCS: superior CCL: lateral CCP: posterior.

Fig. 14. CT with MRP, oblique sagital image where superior semicircular conducts (CSS) and lateral (CSL) and facial nerve canal (NF) are visualized.
Ear study with 64 slices Multidetector CT

with an acquisition of submillimetre slices and optimum resolution in just a few seconds.

CONCLUSION

64 Channels MDCT is an excellent imaging method for the study of the ear’s anatomy and pathology.

It enables through volumetric acquisition with submillimetre slices in just a few seconds and with a comfortable position for the patient, a display on different planes of the space, with three dimensional reconstructions of the ear’s anatomy. Therefore, they allow a more comprehensive approach to different pathologies and optimized the planning for possible surgery.

Bibliography

1. Verema HW, Phoa SS, Mirck PG, Hulsmans FJ, Majoie CB, Verbeeten B Jr. Petrosal bone: coronal reconstructions from axial spiral CT data obtained with 0.5-mm collimation can replace direct coronal sequential CT scans. Radiology 1999;213(2): 375–82.
4. Calhoun PS, Kuszyk BS, Heath DG, Carley JC, Fishman EK. Three-dimensional volume rendering of spiral CT data: the-


Fig. 18. CT, 3D images and MPR. Cochlear implant. EXTERNAL: microphone, speech processor, transmitter. INTERNAL: receiver-stimulator: sends signals to the electrodes. Electrodes: stimulate nerve cells inside the cochlea.