Temporal Bone and Auditory Pathways

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**Introduction**

Today, the anatomy of the temporal bone can be evaluated in detail. Computed tomography (CT) is the method of choice for examining the external and middle ear. However, CT also provides a great deal of information about the inner ear. The most recent high-end CT systems, using helical scanning and multidetector technology, enable scanning of the temporal bone in detail. Images with a spatial resolution of 230 μm can be acquired on these systems, and these images can be reformatted so that they overlap every 0.1 mm. On these very thin images, partial volume is no longer a problem, and small structure can therefore be seen. Moreover, excellent multiplanar reconstructions (MPRs) can be made. Temporal-bone imaging is now also possible with high-end cone-beam (CB) CT systems, which allow images with a resolution of 75-85 μm. Structures such as branches and the footplate of the stapes, chorda tympani, Jacobson’s nerve, and tympanic nerve branches, etc. can now be reliably visualized.

Magnetic resonance (MR) is used to image the inner ear. In particular, T2-weighted gradient-echo [constructive interference in steady state (CISS)] or turbo spin-echo [driven equilibrium (DRIVE), 3D turbo spin-echo (3D-TSE), fast-imaging steady-state acquisition (FIESTA)] can be used. These images show the intralabyrinthine fluid in detail and enable visualization of the scala tympani and vestibuli separately inside the cochlea. Another advantage is that the facial nerve, the cochlear branch, and the inferior and superior vestibular branch of the eighth nerve can all be distinguished on these images. Even the posterior ampullar nerve, the ganglion of Scarpia, the macula utriculi, etc. can be seen on 0.7-mm-thick images made every 0.35 mm using a 1,024 matrix (Fig. 1).

MR is also the only technique that can visualize lesions along the auditory pathway. Selective images through the cochlear nuclei, trapezoid body, lateral lemniscus, inferior colliculus, medial geniculate body, and auditory cortex often detect the cause of deafness when selective CT and MR studies of the temporal bone are negative. The myelinated structures of the auditory and vestibular pathways are best recognized on multiecho sequences [e.g., multiecho fast-field echo (m-FFE), multiple-echo data image combination (MEDIC), multiple echo recombined gradient echo (MERGE)].

**What to Use: CT or MR?**

As a general rule patients with conductive hearing loss (CHL) should be examined with CT; patients presenting with sensorineural hearing loss (SNHL), vertigo, or tinnitus should immediately get an MR study. There are, of course, exceptions, and in many cases, both CT and MR can contribute. The most frequent indications for imaging the temporal bone are discussed below. For each indication, the choice between CT and MR is discussed.

**Pathology**

**Otosclerosis**

In otosclerosis, the dense ivory-like endochondral bone layer around the labyrinthine capsule is replaced by foci of spongy vascular irregular new bone. The cause of this
replacement is a matter of discussion. Patients with otosclerosis present with mixed hearing loss. However, the conductive component is most often predominant, and the lesions are often only visible on CT. Hence CT is the method of choice. Otosclerosis/otospongiosis can be fenestral and retrofenestral.

In fenestral otosclerosis, the promontory, facial nerve canal, and oval and round window are involved. The most frequent lesion is a hypodensity or even hypodense mass at the fissula ante fenestram. These lesions can also occur on the promontory or at the round window. At the level of the oval window, otospongiosis can block the anterior branch of the stapes, so that the stapes can no longer move freely, causing conductive hearing loss. Thickening of the footplate can also occur and has the same result. Lesions near the footplate are difficult to visualize, and a double oblique technique is needed to see both branches of the stapes and the footplate in one plane (Fig. 2). To achieve this, helical acquired images should be reconstructed every 0.1 mm so that double oblique images with sufficient quality can be made. The round window should always be checked, as some studies have shown that surgery of the stapes and oval window are less successful when the round window is obliterated.

Retrofenestral otosclerosis involves the cochlea or the bone around the membranous labyrinth (with the exception of the lateral wall of the labyrinth). A hypodense ring can develop around the complete cochlea and is then called the fourth ring of Valvassori. However, the lesions can also be more subtle, and frequently a small hypodense spur can be seen anterior to the anteroinferior wall of the fundus of the internal auditory canal (IAC).

**Trauma**

Fractures of the temporal bone can best be seen on CT. Both longitudinal and transverse fractures can be distinguished. Longitudinal fractures follow the long axis of the temporal bone, from the surface of the petrous-mastoid bone to the middle ear cavity and geniculate ganglion area and even the petrous apex. In transverse fractures, the fracture runs perpendicular on the long axis of the petrous bone and petrous apex and hence nearly always involves the inner ear. Posttraumatic CHL is most often explained by CT findings, and posttraumatic obliteration of the middle ear cavity and/or fractures (Fig. 3a) or luxation of the ossicles can easily be recognized on CT. However, CT sometimes cannot explain the posttraumatic SNHL and/or facial nerve palsy. In these cases, MR of the temporal bone can often provide the answer, but CT is and remains the most important and first study in case of trauma.

Unenhanced T1-weighted images must be used to recognize posttraumatic intralabyrinthine hemorrhage, which represents inner ear concussion (Fig. 3b). Cloth formation or fibrosis formation in the labyrinth can be excluded using thin T2-weighted images (DRIVE, CISS, 3D-TSE, FESTA). The high signal intensity of the fluid will disappear in case of fibrosis or cloth formation; the fluid will,

![Fig. 2 a-c. The only reliable way to evaluate fenestral otosclerosis is the double oblique technique. Paracoronal images are made on the axial image (a) through the incudostapedial joint and perpendicular on the footplate (yellow line). Then, double oblique images are produced when reconstructions are made parallel to the incudostapedial junction on the paracoronal images (b) (blue line). The resulting double oblique image (c) clearly shows the otospongiosis at the fissula ante fenestram (blue arrow) encasing the anterior branch of the stapes. Normal footplate (red arrow) (for color reproduction see p 328)