Ossicular Fixation - A Pictorial Review of CT Temporal Bone Findings

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Learning Objectives

To discuss the causes of ossicular fixation, illustrate the associated CT temporal bone findings and highlight the diagnostic value of multiplanar reformats.
Background

The purpose of the ossicles in the middle ear is to facilitate hearing by conducting vibration of the tympanic membrane to the oval window. Failure of this system can result in conductive hearing loss.

Abnormalities of the ossicles that result in conductive hearing loss can be broadly classified into 'fixation' or 'interruption' groups. This pictorial review illustrates the CT temporal bone findings seen in association with ossicular fixation. Congenital and acquired conditions are discussed. The diagnostic value of sagittal and coronal oblique multiplanar reformats is highlighted in selected conditions.
Imaging Findings OR Procedure Details

Technique:

Temporal bone CT is performed at our institution using multi-detector CT (16, 64 or 128 detector rows) with a slice thickness of 0.625 to 0.670 mm. The dataset is reconstructed to provide a zoomed field of view on each side. In addition to axial and coronal planes, we routinely reconstruct sagittal and coronal oblique planes. The sagittal plane is reconstructed perpendicular to the long axis of the external auditory canal. The coronal oblique plane is reconstructed perpendicular to the long axis of the 'ice cream cone' (the malleus and incus in the axial plane).

Dedicated reformats for assessment of individual temporal bone structures have been described (1), but these can be complicated to perform and it is not feasible to reconstruct them routinely. The sagittal and coronal oblique reformats we describe are quick and simple to perform, and we find that they often have diagnostic value without adding an unreasonable number of images to evaluate.

Otitis Media:

A common cause of transient middle ear conductive hearing loss is otitis media. This may be acute, chronic or associated with a serous middle ear effusion, the latter leading to the condition known as 'glue ear'. Imaging findings are not specific, CT usually demonstrating partial or complete opacification of the middle ear. In most cases, resolution of the otitis media will return hearing to normal. Complications of otitis media that can result in ossicular fixation include tympanosclerosis and post-inflammatory ossicular fusion.

Tympanosclerosis:

Tympanosclerosis is a process characterised by the deposition of hyaline and calcific deposits within the tympanic membrane or surrounding middle ear structures. It is thought most commonly to arise as a complication of otitis media (2-4). New bone formation (osteoneogenesis) is often considered to fall within the spectrum of tympanosclerosis. Disease involving the tympanic membrane has CT findings of high density foci within the tympanic membrane, often associated with membrane thickening. When the middle ear is involved, findings include high density foci on the surface of the ossicles, thickening of the stapes crura and footplate, thickening and increased density of suspensory ligaments and muscle tendons, and areas of heaped up new bone (Fig. 1 on page 7, Fig. 2 on page 7, Fig. 3 on page 8, Fig. 4 on page 9). Thickened and/or dense suspensory ligaments may be seen incidentally in asymptomatic patients with no history of otitis media (5)(Fig. 5 on page 10). Sagittal reformats are particularly helpful to assess the anterior and superior malleal ligaments.
Ossicular Fusion:

Fusion of the ossicles may be acquired or congenital. Acquired fusion may occur in the post inflammatory or post traumatic setting. Congenital fusion of the ossicles is often seen in association with dysplasia of the external ear (6,7). This condition has a spectrum of middle ear findings depending on severity. In mild disease, findings include an abnormal tympanic membrane, smaller than usual middle ear and variable fusion of the ossicles to each other and the middle ear wall (Fig. 6 on page 11). In more severe disease, the middle ear can be small or absent, the ossicles fused, rotated or absent and the facial nerve may have an aberrant position.

Bony Bar:

One form of congenital fixation is ankylosis of the ossicles to the wall of the middle ear by a bony bar (8,9). Tympanosclerosis can have a similar appearance, with history and other imaging findings important to distinguish these diagnoses. The condition most commonly fixes the malleus (Fig. 7 on page 12), but can affect the incus (Fig. 8 on page 13) and stapes.

Tegmen Abnormalities:

The tegmen tympani is the thin plate of bone that forms the roof of the middle ear and separates the middle ear and middle cranial fossa. The tegmen has a variable slope that can have implications for surgery, and can be associated with ossicular fixation. Pronounced downslope can reduce the air gap between the head of malleus and tegmen, result in malleus head abutment (Fig. 9 on page 14) and potentially conductive hearing loss. The anterior downslope of the tegmen is best appreciated on sagittal reformat. Both sagittal and coronal oblique reformat give good views of the malleus head and its relationship with the tegmen.

Dehiscence of the tegmen may be congenital or acquired, the latter associated with trauma, infection, cholesteatoma and prior surgery. One complication of tegmen dehiscence is cephalocele, a condition that can result in hearing loss due to mass effect of herniated tissue onto the ossicles (Fig. 10 on page 15), CSF effusion, or as a result of the underlying process responsible for the dehiscence (10,11). Both sagittal and coronal oblique reformat are helpful for assessment of integrity of the tegmen, as well as assessing relation of the superior aspects of the ossicles with herniated tissue.

Facial Nerve Dehiscence:
An uncommon cause of ossicular fixation is dehiscence of the facial nerve canal with prolapse of the nerve into the middle ear (12). Conductive hearing loss may occur if the prolapsed nerve abuts the ossicles (*Fig. 11 on page 16*).

**Otosclerosis:**

Otosclerosis is a disease affecting the bones of the middle and inner ear, characterised by the formation of spongy, vascular and irregular bone. Depending on location, the disease can result in conductive and/or sensorineural hearing loss. Findings on CT are that of lucent or 'ground glass' bone (*Fig. 12 on page 17*), usually seen at the fissula antefenestram (13,14), the cleft of fibro-cartilaginous tissue just anterior to the oval window. Disease can spread along the medial wall of the middle ear and extend to surround the otic capsule. Abnormal bone can extend onto the stapes footplate resulting in fixation (15), and can narrow or occlude the oval and round windows. Coronal oblique reformats usually profile the stapes better than the routine coronal views.
Fig. 1: Axial (top row) and coronal (bottom row) temporal bone images demonstrate tympanosclerosis, with areas of calcification and new bone surrounding the incus and malleus head (red arrows). The patient has chronic otitis media. Note dehiscence of the tegmen (blue arrows), possibly the result of chronic inflammation.

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Fig. 2: Axial (top row) and sagittal (bottom row) temporal bone images demonstrate a thickened and dense anterior malleal ligament (arrows) in a patient with conductive hearing loss. The patient had a history of recurrent otitis media. The anterior malleal ligament is well profiled in the sagittal plane.

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Fig. 3: Axial (top row), coronal (middle row) and sagittal (bottom row) temporal bone images demonstrate increased density of the superior malleal ligament (arrows) in a patient with conductive hearing loss and a history of middle ear infection.

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Fig. 4: Axial (top row), coronal (middle row) and coronal oblique (bottom row) temporal bone images demonstrate a thickened and dense stapedius tendon (arrows) in a patient with conductive hearing loss and a history of chronic middle ear infection.

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**Fig. 5:** Axial (top row), coronal (middle row) and sagittal (bottom row) temporal bone images demonstrate a dense but normal sized superior malleal ligament (arrows). The patient was not symptomatic in this ear and had no history of infection. The ligament is well profiled in the sagittal plane.

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Fig. 6: Axial (top row) and coronal (bottom row) temporal bone images in a 4 year old with external ear atresia. The external ear is hypoplastic (not shown) and the external auditory canal absent. Although there is no tympanic membrane, there is a bony aperture at its expected site (blue arrows). The malleus is hypoplastic and fixed to the lateral wall of the middle ear (red arrows).

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Fig. 7: Axial (top row), coronal (middle row) and coronal oblique (bottom row) temporal bone images demonstrate fixation of the malleus to the lateral wall of the middle ear by a bony bar (arrows). The bar is well profiled in both coronal and coronal oblique planes. The patient had no history of middle ear infection, suggesting that the bar is a form of congenital fixation.

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Fig. 8: Axial (top row), coronal (middle row) and sagittal (bottom row) temporal bone images demonstrate a bony bar fixing the incus to the lateral wall of the middle ear (arrows). The patient had no history of middle ear infection, suggesting that the bar is a form of congenital fixation. The bar is not well seen in the coronal plane, but better appreciated on the sagittal views.

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**Fig. 9:** Axial (top row), coronal (second row), coronal oblique (third row) and sagittal (bottom row) temporal bone images demonstrate anterior downsloping of the tegmen (blue arrows) with loss of air gap between the malleus head and tegmen as well as malleus head abutment (red arrows). The slope of the tegmen is best appreciated in the sagittal plane. Both sagittal and coronal oblique planes aid is assessing relationship of the malleus head to the tegmen and the interval air gap.

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**Fig. 10**: Paired axial (top left), coronal (top right), sagittal (bottom left) and coronal oblique (bottom right) temporal bone images demonstrate a downsloping tegmen (blue arrows), tegmen dehiscence (red arrows) and a cephalocele surrounding the malleas head and malleo-incudo articulation. Both sagittal and coronal oblique planes aid in assessing integrity of the tegmen and the relationship of the cephalocele to the superior aspect of the ossicles.

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Fig. 11: Axial (top row), coronal (second row), sagittal (third row) and coronal oblique (bottom row) temporal bone images demonstrate a dehiscent facial nerve canal with prolapse of the facial nerve onto the stapes superstructure (red arrows). There is fluid or soft tissue within the epitypanum. Both findings may contribute to conductive hearing loss.

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**Fig. 12:** Axial (top row), coronal (middle row) and coronal oblique (bottom row) temporal bone images demonstrate abnormally lucent or ‘ground glass’ bone (red arrows) at the fissula antefenestrum consistent with otosclerosis. There is extension to the margin of the oval window (blue arrows) resulting in fixation of the stapes footplate in this patient with conductive hearing loss.

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Conclusion

Many causes of conductive hearing loss due to ossicular fixation can be diagnosed with CT. Multiplanar reformats are helpful for diagnosis and evaluation of selected conditions.
References


