CT findings of different types of middle ear surgery procedures.

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Purpose

1- To describe the most frequent types of surgical procedures performed on the middle ear and its respective findings by using CT.

The anatomy of the temporal bone may seem disrupted by surgical procedures, as well as by pre-existing pathology. In many cases it is difficult to tell the differences between both cases. Therefore, it is important for the radiologist to be able to know the differences between normal postsurgical findings and abnormal ones.

Methods and Materials

We reviewed postsurgical middle ear CT’s that were performed in our clinic since March 2008. We focused on the most common procedures such as, mastoidectomies (canal wall up and canal wall down), tympanoplasties and ossicular reconstruction (stapedectomy, incus interposition and partial or total ossicular reconstruction prosthesis).

We studied our patients with High Resolution CT (HRCT), performed with a multislice helical, 40 slice configuration, obtaining axial and coronal reconstructions (0,75mm sections).

Results

The type of surgery used in each case will depend on the extent of the pathological process, if it is possible by trying to remove the entire diseased tissue and trying to preserve the bony wall of the external auditory canal (EAC) and the ossicular chain.

1. MASTOIDECTION

This is performed in case of middle ear pathologies, mainly in cases of chronic medium otitis and cholesteatoma. There are two types:

1.1 CLOSED MASTOIDECTION (canal wall up). (Fig. 1 on page 8 and Fig. 2 on page 9).
Resection of mastoid cells.

The posterior wall of the external auditory canal (EAC) is preserved.

Uses: mastoiditis, cholesteatoma in antrum or epitympanum, decompression of facial nerve and endolymphatic duct, cochlear implant.

1.2 OPEN MASTOIDECTOMY (canal wall down).

Resection of mastoid cells.

Resection of the posterior wall of the EAC and Scutum.

The newly created cavity allows the mastoid to communicate with the EAC.

Reconstruction of the EAC may or may not be performed.

Types:

- Modified radical mastoidectomy (Fig. 3 on page 10 and Fig. 4 on page 11).

Open mastoidectomy. Neotympanum and the ossicular chain are preserved.

- Radical mastoidectomy (Fig. 5 on page 12 and Fig. 6 on page 13).

Open mastoidectomy.

Malleus and incus are removed, trying to preserve the stapes.

Dissection of the facial canal.

Tympanoplasty is usually associated (Fig. 7 on page 14).

More extensive procedure is used when there is a holotympanic involvement.

Sometimes, the mastoid cavity or the hole of the eustachian cavity is filled with fat. During an MRI, it can be mistaken for a cholesterol granuloma if the type of procedure is unknown.
Both, open and closed mastoidectomy can be combined with tympanoplasty.

2. TYMPANOPLASTY

It is the surgical procedure performed in the reconstruction of the tympanic membrane (TM) and/or the ossicular chain of the middle ear. There are five types of procedures according to the ratio of the graft with useful remnants of the ossicular chain. Type 1 and 3 are the most common. The rest of them are rarely used.

- **Type I** or myringoplasty: Reconstructive process limited to the reparation of a perforated TM, usually by temporal fascia. The ossicular chain is not affected. Post-surgical CT has limited value, you can see thickening or TM perforation. ([Fig. 8 on page 15](#)).

- **Type II**: performed when alteration of the malleus exists. The graft is connected to the body of the incus.

- **Type III**: performed when there are large defects of the malleus and incus. The tympanic membrane is repaired and directly connected to the head of the stapes. ([Fig. 9 on page 16](#)).

It can be performed without mastoidectomy or combined with open or closed mastoidectomy.

In an open mastoidectomy, the neotympanum is leaning on the wall of the nerve facial and head of the stapes, usually cartilage interposition beteween them.

In a closed mastoidectomy there is a gap between the stapes and the neotympanum. It is in a physiological position. For this reason a graft between the malleus and the stapes is required, (maleoloestapediopexia), or between the neotympanum and the stapes (miringoestapediopexia).

However, these procedures can vary according to patients' needs and surgeons' preferences.

- **Type IV**: It describes a repair when the stapes foot plate is movable, but the crura are missing. The graft is connected between the handle of the malleus and the footplate (maleoloplatinopexia) or between the footplate and the TM (miringoplatinopexia).
- **Type V**: It is a repair involving a fixed stapes footplate. The graft is connected with the oval window.

### 3. OSSICULAR RECONSTRUCTION

Its goal is to repair the ossicular chain in order to achieve a functional connection between the tympanum and the sensorial structures of the inner ear. The ossicular chain can suffer secondary damage due to cholesteatoma, chronic otitis media, trauma or congenital malformation.

The materials utilized can be divided in two groups: Grafts and synthetic prosthesis.

**Grafts**: The most frequently used are: incus and cartilage autologous grafts (usually tragal cartilage or from the pinna) they can be modelled and shaped by the surgeon. Homologous grafts obtained from the bodies of deceased people are rarely used nowadays due to the risk of infections.

**Synthetic materials**: There are two distinctive parts in an ossicular prosthesis: the head (It must make contact with the tympanum membrane or with the handle of the malleus) and a stem.

Over the years, many prosthesis have been developed, materials and designs have improved (especially in the head of the prosthesis). These improvements allow them to be adapted according to the conditions of each patient, therefore the great variety of prosthesis. There is no point in studying each one of them because there can be little variations between each of the various prosthesis, which are not recognized by the CT.

Plastic, ceramic, polimaleinato ionomers and metals are the most common materials used. (3) (table1).

**Table 1. Types of synthetic materials**

<table>
<thead>
<tr>
<th>Materials</th>
<th>types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic</td>
<td>Teflon, (Polyethylene,polytetrafluoroethylene)*</td>
</tr>
<tr>
<td></td>
<td>Proplast, (polytetrafluoroethyleneand glassy carbon)</td>
</tr>
</tbody>
</table>
### Ceramics
- Frialit (aluminum oxide), bioinerts
- Ceravital y bioglass (aluminum dioxide), bioactive
- Hidroxyapatite (calcium phosphate)*, bioactive

### Polimaleinato ionomers
- IONOCEM (bone cement)

### Metals
- Steel wire (Used in the past)
- Gold
- Stainless steel
- Titanium*

### Combined
- Stainless steel and platispore
- Hidroxyapatite and platispore or silastic. Etc.

(*) Currently the most utilized.

(**) Silastic is used to avoid mucus inflammation and fibrous adherences, generally in media otitis procedures or when a second surgical time is planned. (Fig. 10 on page 17 and Fig. 11 on page 18).

The prosthesis employed are: incus transposition, stapedius prosthesis and synthetic prosthesis

### 3.1 INCUS INTERPOSITION

Used in cases of necrosis of the long branch of the incus. The incus is disjointed. The body is perforated in order to articulate it to the head of the stapes and manubrium of the malleus.

It can be associated or not to incus remodelling techniques (the short apophysis and the remainders of the Long branch are reduced) leaving the incus with block morphology.
However, this can vary according to the shape intended by the surgeon. (Fig. 12 on page 18 and Fig. 13 on page 19).

Its appearance on a CT is undistinguishable from a post-traumatic incus dislocation. For this reason, a co-relation with the patient's background is indispensable. (Fig. 12 on page 18 and Fig. 14 on page 20).

When the incus cannot be preserved it is usually replaced by partial ossicular reconstructive prosthesis.

3.2 STAPADECTOMY

It is usually performed in cases of otosclerosis.

Stapes superstructure (head and crura) and footplate are dried by placing a prosthesis from the incus to the oval window- generally a synthetic prosthesis. (Fig. 15 on page 21, Fig. 16 on page 22, Fig. 17 on page 23, Fig. 18 on page 23, Fig. 19 on page 25 and Fig. 20 on page 25).

The stapedectomy can be total or partial, based upon whether the stapes footplate is dried totally or partially. As an alternative, a stapedotomy can be performed. This consists of perforating the stapes footplate and placing piston prosthesis between the long apophysis of the incus and the base of the stapes.

3.3 TORP AND PORP SYNTHETIC PROSTHESIS

-Total ossicular reconstructive prosthesis (TORP): it spans from the tympanum membrane (TM) to the stapes footplate. ( Fig. 21 on page 26 and Fig. 22 on page 26).

- Partial ossicular reconstructive prosthesis (PORP): Spans from the tympanum membrane or from the malleus to the head of the stapes. (Fig.13A, Fig.13B, Fig.14).

Cartilage is generally placed between the tympanum membrane and the prosthesis to avoid extrusion of the latter one.

It is used in an individual in whom the stapes superstructure is maintained.
There are many types of prosthesis (cima oval Black, Richards, Goldenberg, García - Ibáñez, etc.). This great variety makes it difficult for the radiologist to know the differences between them, since a single type can have several modifications. Moreover, new prosthesis appears frequently (3).

The most relevant findings that should be reviewed on post-operative middle ears CT's are:

Type of mastoidectomy performed (closed or open).

Status of the bony margin of the mastoid bowl, tegmen tympani, sigmoid sinus plate and facial nerve canal.

Absence or residual osicular chain.

Type of ossicular reconstrucción (Incus interposition, stapedectomy, PORP or TORP).

Position of the prosthesis and possible complications such as the extrusion or subluxation. Ensuring that there is no lateral movement out of the oval window or the stapes platen. Also the stem cannot be superficial to the oval window or too deep in the vestibule.

Amount of soft debris in the middle ear cavity, and any other potential complications such as damage of the tympanum membrane, otomastoiditis, cholesteoma, postsurgical granuloma, incus necrosis, tympanum fibrosis and perilymphatic fistula have to be detected too.

Images for this section:
Fig. 1: Canal-wall-up mastoidectomy. Axial CT, at the level of mesotympanum shows removal of the mastoid air cells (M), with preservation of the posterior wall of the external auditory canal (CAE).
Fig. 2: Canal-wall-up mastoidectomy. Coronal CT, at the level of mesotympanum shows removal of the mastoid air cells (M), with preservation of the posterior wall of the external auditory canal (CAE).
Fig. 3: Modified radical (canal-wall-down) mastoidectomy. Axial CT, shows a mastoidectomy defect (*), with preservation of ossicular chain (black arrows) and absence of the external auditory canal wall.
Fig. 4: Modified radical (canal-wall-down) mastoidectomy. Coronal CT shows a mastoidectomy defect(∗), with preservation of the ossicular chain (black arrows) and absence of the external auditory canal wall.
**Fig. 5:** Radical mastoidectomy. Axial CT, shows a mastoidectomy defect (*), with absence of the ossicular chain.
Fig. 6: Radical mastoidectomy. Coronal CT, shows a mastoidectomy defect (*), with absence of the ossicular chain.
Fig. 7: Radical mastoidectomy, type III tympanoplasty. Axial CT, demonstrates a mastoidectomy defect. Malleus and incus have been resected, with preservation of stapes suprastructure. There is tympanoplasty in direct apposition to the head of the stapes (arrow).
**Fig. 8:** Tympanoplasty type I. History of myringoplasty (arrow) with inferior perforation (small arrow).
Fig. 9: Tipe III tympanoplasty. Axial CT, the neotympanum (white arrow) is in direct apposition to the head of the stapes (black arrow).
**Fig. 10:** Silastic implant. Axial CT. There is a Silastic tube (arrow) in place to prevent adhesions.

**Fig. 11:** Silastic implant. Coronal CT. There is a Silastic tube (arrow) in place to prevent adhesions.
**Fig. 12:** Incus interposition. Axial CT. Remodeling and interposition of the incus (white arrow), malleus (black arrow) and stapes (gray arrow).
**Fig. 13:** Incus interposition. Sagittal CT. Remodeling and interposition of the incus (white arrow) and malleus (black arrow).
Fig. 14: Incus interposition. Axial CT, malleoincudal articulation (arrow).
**Fig. 15:** Stapes prosthesis. Axial CT from top to bottom. (A) head of the malleus, incus body. (B, C, D) metallic prosthesis (white arrow) is directed to the oval window. Handle of the malleus (black arrow). (B) long process of incus (gray arrow). (C) incus, lenticular process (gray arrow).
**Fig. 16:** Stapes prosthesis. Coronal CT, anterior to posterior (A, B, C, D). Stapes prosthesis (white arrow) is directed to the oval window, incus (gray arrow).

**Fig. 17:** Stapes prosthesis. Axial CT, the tip of this prosthesis (white arrow) is well seated centrally within the oval window. Malleus head (black arrow) and incus (gray arrow).
**Fig. 18:** Stapes prosthesis. Coronal CT, same patient as in Fig. 17, Stapes prosthesis. Axial CT, the tip of this prosthesis (white arrow) is well seated centrally within the oval window. Malleus head (black arrow), incus (gray arrow).

**Fig. 19:** Stapes prosthesis. Axial CT, prosthesis of plastic material (black arrow), look at the lower density compared with a metallic prosthesis (Fig. 15). Incus (white arrow), oval window (thick arrow).
**Fig. 20:** Stapes prosthesis. Coronal CT, prosthesis of plastic material (black arrow), look at the lower density compared with a metallic prosthesis (Fig. 15). Incus (white arrow).

**Fig. 21:** Total ossicular reconstructive prosthesis (TORP). Axial CT, shows prosthesis (arrow) extending from oval window to tympanic membrane, which is encased by debris.
**Fig. 22**: Total ossicular reconstructive prosthesis (TORP). Coronal CT, shows prosthesis (white arrow) extending from oval window (black arrow) to tympanic membrane, which is encased by debris.
Fig. 23: Partial ossicular reconstructive prosthesis (PORP). Axial CT, tympanic membrane (gray arrow), PORP (white arrow) articulates with the stapes head (black arrow). Canal wall up mastoidectomy.

Fig. 24: Partial ossicular reconstructive prosthesis (PORP). Coronal CT scan, PORP (white arrow), extending from the tympanic membrane (gray arrow) to the stapes head. Canal wall up mastoidectomy.
**Fig. 25:** Partial ossicular reconstructive prosthesis (PORP). Axial CT, PORP (black arrow), extending from the tympanic membrane to the stapes head (white arrow).
Conclusion

It is important for the radiologist to know the different middle ear surgical procedures and recognize the different findings, by using CT, in order to differentiate them from persistent or recurrent pathologies and to detect other possible complications.

Among the basic radiological concepts, we must know the different kinds of mastoidectomy, the most common type of tympanoplasty as well as the different types of ossicular reconstruction.

References


Personal Information
Ossaba Vélez, Silvia*; Blanco Cabellos, Juan Antonio*; Diezhandino Gallo-Ruiz, M. Pilar*; Teba Luque, Jose Miguel***; Paniagua Bravo, Alvaro**; Torréns Martínez, Javier*.

* Hospital Infanta Cristina, Parla, Madrid, Spain- Department of Radiology.

** Hospital del Norte, San Sebastián de los Reyes, Madrid, Spain- Department of Radiology.

*** Hospital Infanta Cristina, Parla, Madrid Spain- Department of Otorhinolaryngology.

S. Ossaba Vélez.

Department of Neuroradiology, Hospital Infanta Cristina, Parla, Madrid, Spain.

e-mail: silviaossaba@hotmail.com