Temporal bone trauma and complications: computed tomography findings*

Trauma dos ossos temporais e suas complicações: aspectos na tomografia computadorizada

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Abstract Most temporal bone fractures result from high-energy blunt head trauma, and are frequently related to other skull fractures or to polytrauma. Fractures and displacements of ossicular chain in the middle ear represent some of the main complications of temporal bone injury, and hence they will be more deeply approached in the present article. Other types of injuries include labyrinthine fractures, dural fistula, facial nerve paralysis and extension into the carotid canal. Computed tomography plays a fundamental role in the initial evaluation of polytrauma patients, as it can help to identify important structural injuries that may lead to severe complications such as sensorineural hearing loss, conductive hearing loss, dizziness and balance dysfunction, perilymphatic fistulas, facial nerve paralysis, vascular injury and others.

Keywords: Temporal bone trauma; Ossicular injuries; Ossicular trauma.

Resumo A maioria das fraturas dos ossos temporais resulta de traumas cranianos bruscos, de alta energia, estando muitas vezes relacionadas a outras fraturas cranianas ou a politraumatismo. As fraturas e os deslocamentos da cadeia ossicular, na orelha média, representam umas das principais complicações das injúrias nos ossos temporais e, por isso, serão abordadas de maneira mais profunda neste artigo. Os outros tipos de injúrias englobam as fraturas labirínticas, fístula dural, paralisia facial e extensão da linha de fratura ao canal carotídeo. A tomografia computadorizada tem papel fundamental na avaliação inicial dos pacientes politraumatizados, pois é capaz de identificar injúrias em importantes estruturas que podem causar graves complicações, como perda auditiva de condução ou neurossensorial, tonturas e disfunções do equilíbrio, fístulas perilinfáticas, paralisia do nervo facial, lesões vasculares, entre outras.

Unitermos: Trauma do osso temporal; Injúrias ossiculares; Trauma ossicular.

INTRODUCTION

Cranioencephalic trauma (CET) is one of the leading morbimortality causes in Brazil and in the world, most commonly occurring in the young adult age group[1].

Most temporal bone fractures result from high-energy blunt head trauma, many times related to other skull fractures or to polytrauma. For such a reason, a multidisciplinary evaluation is generally required, including otolaryngology, radiology and neurosurgery[2–4].

Multidetector computed tomography plays a fundamental role in the assessment of such patients. According to a study published by Morgado et al.[5], in spite of most CET cases (82.4%) being classified as mild, tomographic changes were observed in approximately 80% of their patients. Such data highlight the importance of skull computed tomography as the method of choice in the initial assessment of such patients[1], in addition to the Glasgow Coma Scale and information regarding the accident[5].

Multiplanar reconstructions allow detailed evaluation of the base of the skull, temporal anatomy as well as the extent of injuries involving specific structures[3,4,6].

Currently, in addition to representing the imaging study of choice for the diagnosis and prognosis in cases of CET, computed tomography also plays an important role in the follow-up of injuries[5].

The relationship between types of injuries demonstrated by computed tomography, types of CET (severity of the injury) and prognosis has been described by several authors in the literature, all of them demonstrating approximately the same relationship: the more severe the CET, the more numerous and more severe are the findings at computed tomography[5].

Fractures and displacements of the ossicular chain in the middle ear represent one of the main complications of temporal bone injuries, the latter being frequently observed in cases of severe CET, and for that reason, are more deeply approached in the present study[2,6–8].

The radiologist must be familiar with the possible trauma mechanisms and with the temporal anatomy, allowing the proper classification of fracture types in order to predict possible associated complications and to guide the appropriate treatment.

CLASSIFICATION OF TEMPORAL FRACTURES AND TRAUMA MECHANISMS

The classification of temporal bone fractures is useful in the prediction of complications associated with the trauma, thus providing guidance for the management and treatment of the patient[2,4,6].

It is very important that the radiologist accurately describes the affected anatomic structures, particularly in cases where the injury may cause functional compromising.

The traditional classification indicates the relationship between the fracture line and the longer axis of the petrous portion of the temporal bone[3,4].

Oblique fractures, also called mixed or complex fractures, are the most common types, followed by longitudinal and transverse fractures[4].

As regards trauma mechanisms and main complications of each type of temporal fracture, they may be summarized as follows: a) longitudinal fractures generally occur in cases of temporoparietal trauma, commonly affecting the extra labyrinthine segment, and presenting as main complications ossicular lesion and hemotympanum[3]; b) on the other hand, transverse fractures generally occur in cases of frontal/occipital traumas, with translabyrinthine involvement, whose main complication is facial nerve weakness[3].

Longitudinal fractures

Such fractures are characterized by a line of force running lateral to medial. In such cases, temporoparietal trauma is most frequently observed[3,4,7,9].

At axial computed tomography, a radiolucent line parallel to the longest axis of the petrous pyramid is observed (Figure 1).

The most common complications of longitudinal fractures include ossicular injuries, tympanic membrane rupture and hemotympanum, with conductive hearing loss. Less commonly, the facial nerve may be affected[3].

Transverse fractures

Such fractures typically result from trauma either in the frontal or occipital regions, as well as in the craniocervical junc-
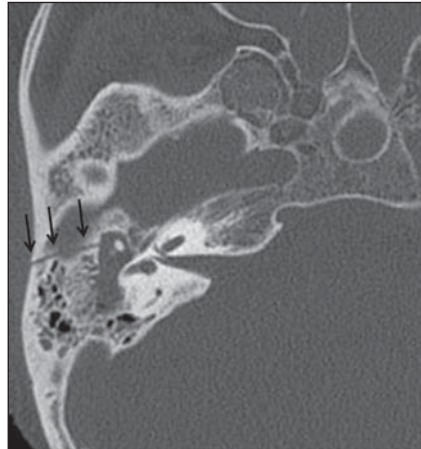

Figure 1. Longitudinal fracture. Axial computed tomography image showing temporal bone longitudinal fracture identified as a radiolucent line parallel to the largest axis of the petrous pyramid.

tion, with a line of force running anterior to posterior[3,4]. The fracture line is perpendicular to the longest axis of the petrous pyramid (Figure 2).

The sensorineural hearing loss is more common in patients with transverse fracture, sometimes secondarily to transection of the cochlear nerve, injuries to labyrinthine structures or to the stapes footplate, which results in labyrinthine fistula[10,11].

Facial nerve paralysis is also more frequently observed in this type of fracture.

Oblique fractures

Such fractures include both elements, longitudinal and transverse (Figure 3), with frequent involvement of the otic capsule, which causes sensorineural hearing loss[3,4,9]. In the event of ossicular injury, it may also cause conductive hearing loss.

IDENTIFICATION OF THE AFFECTED STRUCTURES: INJURIES TO THE OSSICULAR CHAIN

Ossicular injuries represent a frequent complication from temporal trauma, possibly leading to interruption of different segments of the ossicular chain.

In cases of patients who suffered temporal trauma, conductive hearing loss is the most common consequence of this type of injury, with dislocations being more frequently observed than ossicular fractures[3,7,10,12].
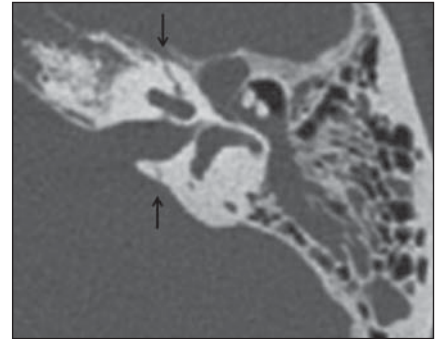

Figure 2. Transverse fracture. Axial computed tomography image demonstrating temporal bone transverse, translabyrinthine fracture, seen as a radiolucent line perpendicular to the largest axis of the petrous pyramid.
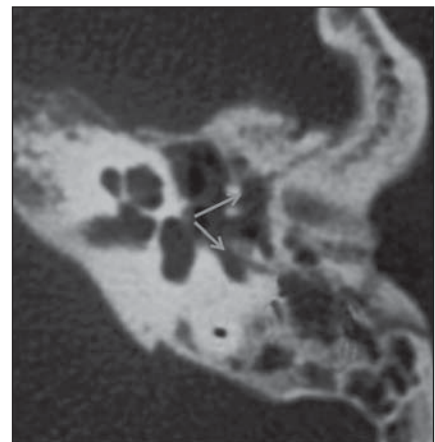

Figure 3. Oblique fracture. Axial computed tomography image demonstrating longitudinal and transverse elements of the oblique fracture.

There are five types of dislocations as follows: incudostapedial joint dislocation; malleoincudal joint dislocation; dislocation of the incus; dislocation of the malleoincudal complex; stapediovestibular dislocation[7,8,12,13].

Fractures of the malleus, incus and stapes are uncommonly observed.

High resolution computed tomography is the method of choice to evaluate ossicular trauma. Axial images allow a better evaluation of ossicular continuity. Coronal and oblique reconstructions may be used in the evaluation of the long process of the incus as well as its relationship with the malleus, as it can be seen below[3].

Incudostapedial joint dislocation

Incudostapedial dislocation is the most common post-traumatic abnormality of the ossicular chain, on account of the tenuous

suspension of the incus between the firmly attached malleus and the stapes[3,8,12].

On axial or oblique reconstructions, the interruption of such joint is seen as an enlarged space between the head of the stapes and the long process of the incus (Figure 4).

Malleoincudal joint dislocation

The malleoincudal joint is protected by the epitympanic recess. The malleus is the most firmly attached ossicle, and such an attachment is guaranteed by the tympanic membrane, by the anterior and lateral ligaments of the malleus and by the tensor muscle and tendon of the tympanic membrane. Usually, in cases of trauma, the malleus remains at its position or moves slightly. On the other hand, the incus, the heaviest ossicle, is not attached to any muscle structure and its ligaments are rather weak[3,12,13].

The malleoincudal dislocation is clearer seen at axial computed tomography images, which show the dislocation of the malleus head from the body/long process of the incus (Figure 5).

Reconstructions are important to highlight the position of the ossicles in those cases of significant dislocation.

Dislocation of the incus

The incus is relatively vulnerable to traumatic dislocations, on account of its weakly anchored position between the firmly attached malleus and stapes[3,12]. After severe skull trauma, the incus may suffer dislocation on account of its inertia[14].

Penetrating traumas through the external ear canal may also cause dislocation of the incus. The incus may remain in the epitympanic recess, dislocate to the most inferior portion of the tympanic cavity or of the external ear canal, or even be destroyed[13].

A thorough evaluation by means of computed tomography in axial and coronal planes of the middle ear and external acoustic meatus is necessary to identify the exact position of the incus in relation to the malleus and the stapes (Figure 6).

Stapediovestibular dislocation

The annular stapedial ligament firmly attaches the stapes to the oval window, and for this reason the stapediovestibular dislocation is not common[7,14].
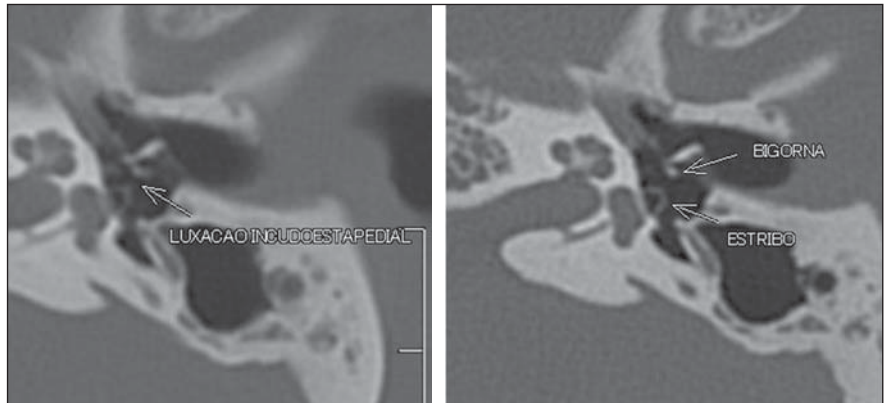

Figure 4. Incudostapedial dislocation. Axial computed tomography image of the incudostapedial joint reveals separation between the incus lenticular process and the stapes head.
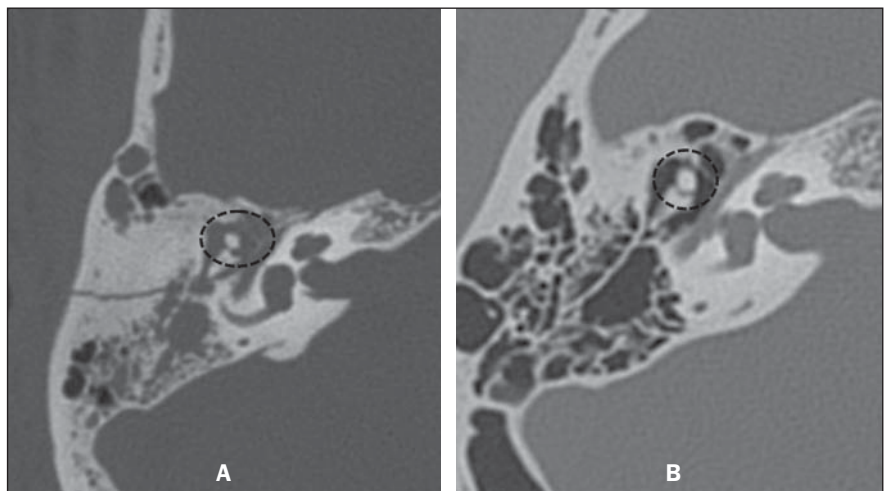

Figure 5. Malleoincudal dislocation. Axial Computed tomography image demonstrates dislocation of the malleoincudal joint (**A**) in a comparative analysis with a normal joint (**B**).
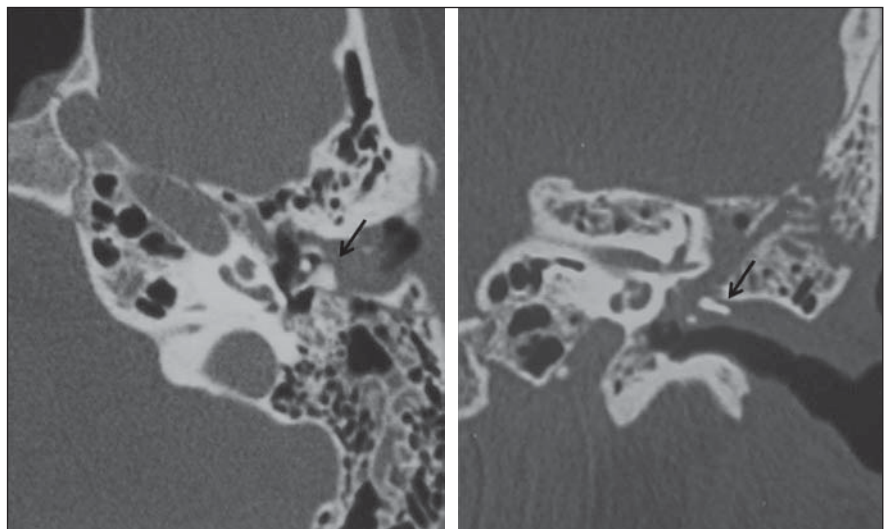

Figure 6. Incus dislocation. Axial and coronal computed tomography images demonstrating incus dislocation with rotation and displacement of the ossicle toward the external ear canal (arrows).
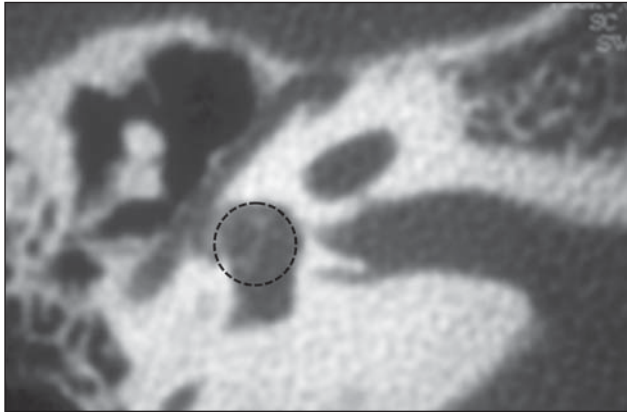
Figure 7. Stapedial dislocation. The stapes has been displaced into the vestibulum.

Penetrating injuries through the external ear canal (manipulation with cotton swabs) can dislocate the stapes through the oval window into the vestibulum (internal dislocation) (Figure 7).

Ossicular fractures

Among the ossicular fractures, the most relevant one fracture of the stapes arch, which occurs secondarily to its torsion[8,14]. Fracture of the stapes footplate occurs mainly in cases of transverse fractures (translabyrinthine fractures) crossing the oval window. Footplate fracture (either with or without fragments displacement) may cause perilymphatic fistula with pneumolabyrinth[14].

OTHER TYPES OF INJURIES

Labyrinthine fractures

Generally related to transverse fractures with sensorineural hearing loss[11], such fractures are followed by pneumolabyrinth[12,14] and perilymphatic fistulas. Perilymphatic fistulas may also cause vertigo, and occur on account of injury to the otic capsule[9,15] (Figures 8 and 9).

Dural fistulas

Generally related to injuries of the tegmen tympani or of the sphenoid sinuses walls, dural fistulas evolve with otoliquorrhea or rhinoliquorrhea. Such lesions should not be neglected, because of the risk for meningitis[7,12,15] (Figure 10).

Facial paralysis

The facial nerve pathway may be evaluated along its entire extent in the axial plane, with oblique reconstructions being
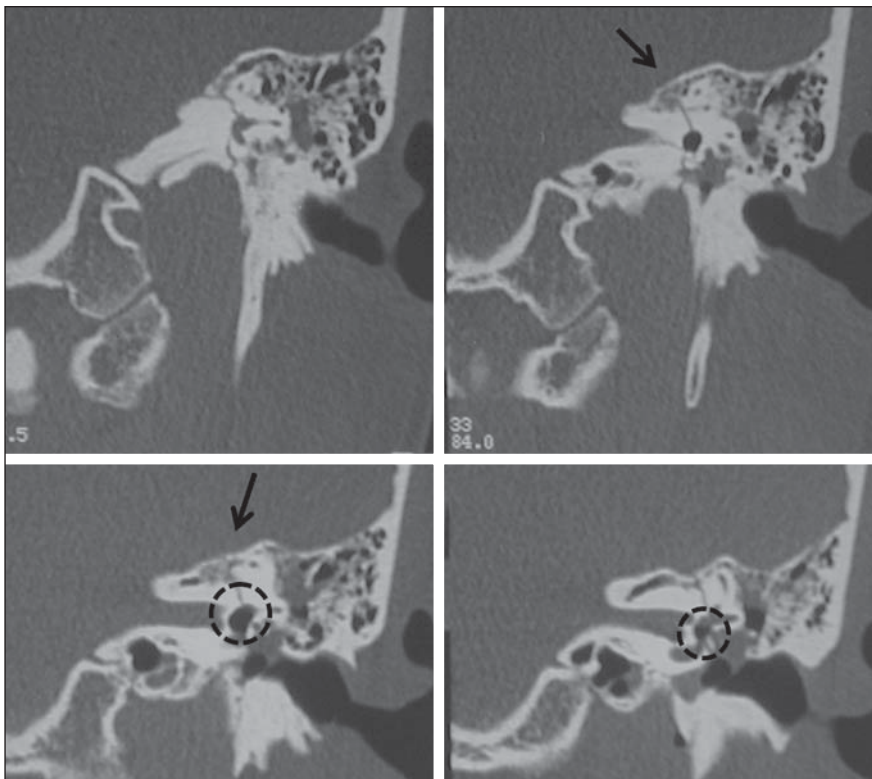

Figure 8. Labyrinthine fractures. Coronal computed tomography image shows transverse fracture extending into the osseous labyrinth (arrow) and with pneumovestibule (circle).
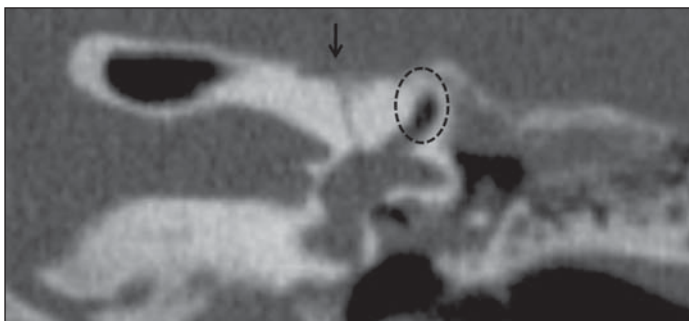

Figure 9. Labyrinthine fractures. Coronal computed tomography reveals translabyrinthine transverse fracture (arrow) Pneumolabyrinth (circle) and fluid inside the middle ear (perilymphatic fistula) are highlighted.
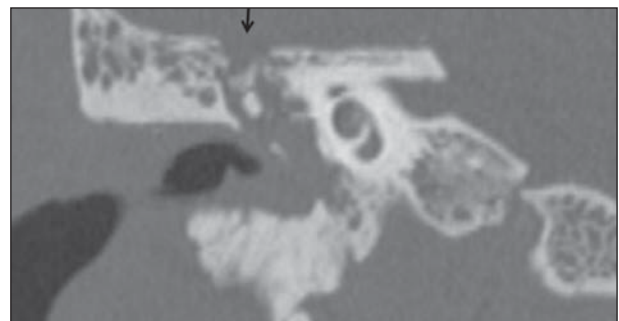

Figure 10. Dural fistulas. Coronal computed tomography image demonstrating tegmen tympani rupture (arrow).

of great relevance to analyze the integrity of the mastoid and tympanic segments. The facial nerve is affected in up to 7% of patients with temporal fracture. Most injuries occur in the labyrinthine portion, in the region of the geniculate ganglion, and manifest as nerve contusion, edema and hematoma of the neural sheath and partial or complete nerve transection[7,9,15].

Immediate-onset post-traumatic paralysis frequently indicates presence of nerve transection or compression by a bone fragment (Figure 11).

Carotid canal

The petrous portion of the temporal bone includes the petrous segment of the internal carotid artery, which is located in the carotid canal, medially to the styloid process and anteriorly to the jugular fossa. The carotid canal thoroughly evaluated in the axial plane. Patients with fractures extending to the carotid canal present increased risk for injuries to the internal carotid artery. Associated complications include arterial dissection, pseudoaneurysm, complete transection, occlusion and arteriovenous fistulas[7,15] (Figure 12).

CONCLUSION

Computed tomography plays a fundamental role in the initial evaluation of polytrauma patients, as it is capable of identifying injuries to important structures which may lead to severe complications such as conductive or sensorineural hearing loss, dizziness and balance disorders, perilymphatic fistulas, facial nerve paralysis, vascular injuries, among others[3].

Investigations by means of computed tomography also allow the radiologist to classify temporal fractures and to predict such possible complications, providing guidance for treatment.

The temporal bone anatomy is rather complex, with several critical structures associated to each other[3,7,8,11]. It is important for the radiologist to be familiar with such anatomy and by team-working with other specialists, such as otolaryngologists and neurosurgeons, allowing the appropriate management of cases of temporal bone trauma, thus reducing the risk for severe sequels in such patients.
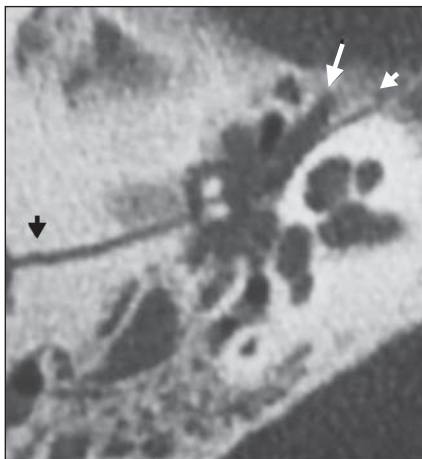

Figure 11. Facial paralysis. Axial computed tomography image showing longitudinal fracture (arrow heads) crossing the tympanic segment of the facial nerve (arrow).
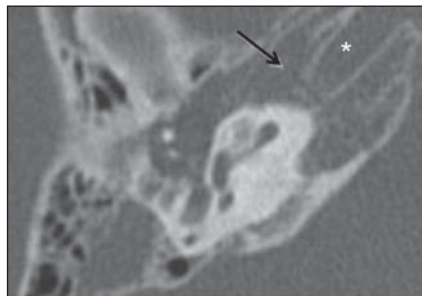

Figure 12. Carotid canal. Axial computed tomography image showing transverse fracture (arrows) crossing the carotid canal (asterisk).

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