Introduction
Cholesteatoma of the temporal bone usually occurs in the middle ear and can cause serious intrapetrous complications [1,2]. This dangerous disease results from ingrowth of keratinizing squamous epithelium from the external to the middle ear [3]. Bone resorption is still the most characteristic feature of this chronic otitis media [4]. To date, temporal bone CT-scan is the preferred radiological exam to precisely determine, preoperatively, the extension of the disease and petrous bone complications [4–6].

Materials and methods
We present a retrospective study, carried out over a period of 12 years (2001–2012), of 96 patients followed and treated for cholesteatomatous otitis media at the ENT Department of the Military Hospital of Tunis, Tunisia. All the patients benefited from a temporal bone CT-scan in the coronal and axial planes before surgery. In order to precisely determine the real performance and limits of CT-scan in the preoperative workup, we performed a correlation between the radiological data and the surgical findings using the sensitivity (Se), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV) for many factors.

Results
Our study included 35 men and 25 women. Their mean age was 35 years (12–64). Cholesteatoma was diagnosed through an otoscopic examination and all the patients benefited from a temporal bone CT-scan before surgery to evaluate the extension of the disease and to look for intrapetrous or extrapetrous complications. The main abnormalities found were ossicular lysis (81%), tegmen tympani erosion (28%), scutum lysis (61%), labyrinthine fistula (8%), and Fallopian canal erosion (27%).

Scutum erosion is valuable in the diagnosis of attic cholesteatoma. It was used by the radiologist in 59 cases...
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and verified peroperatively in 24 cases (Fig. 1). CT-scan has an excellent sensitivity to determine this complication (100%), but with a low specificity (51%) as scutum lysis can occur in simple chronic otitis media (Table 1).

Preoperative CT-scan also provides information about temporal bone anatomic conditions and variants that may incur additional surgical risks. Superficial or prolapsed sigmoid sinus and/or meningeal dehiscence are considered anatomic difficulties (AD) for the surgical approach. The sensitivity of CT-scan in the detection of these abnormalities is 83% (Table 2). This sensitivity is lower for tegmen tympani lysis (Fig. 2 and Table 3).

CT-scan objectively an ossicular chain lysis (OCL) in 81% of the cases (Fig. 3). The incus, the stapes, and the malleus were involved, respectively, in 91, 82, and 75% of the cases. The sensitivity of CT-scans were sensitive for visualization of OCL (Se = 90%). However, as ossicular lysis is frequent even in simple chronic otitis media, the specificity of CT-scan is relatively low (71%) (Table 4).

The fallopian canal was eroded in 23% of our patients (Fig. 4). It seems that CT-scan is not very sensitive in showing this complication (Se = 45%). Yet, when used by the radiologist preoperatively, Fallopian canal

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**Table 1 Scutum lysis**

<table>
<thead>
<tr>
<th>Scutum lysis (CT-scan)</th>
<th>Absence of scutum lysis (CT-scan)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scutum lysis (peroperative)</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Absence of scutum lysis (peroperative)</td>
<td>35</td>
<td>37</td>
</tr>
</tbody>
</table>

Se = 100% Sp = 51% PPV = 41% NPV = 100%

**Table 2 Anatomic difficulties**

<table>
<thead>
<tr>
<th>AD (CT-scan)</th>
<th>Absence of AD (CT-scan)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD (peroperative)</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>Absence of AD (peroperative)</td>
<td>24</td>
<td>44</td>
</tr>
</tbody>
</table>

Se = 85% Sp = 65% PPV = 50% NPV = 92%

**Table 3 Lysis of tegmen tympani**

<table>
<thead>
<tr>
<th>Lysis of TT (CT-scan)</th>
<th>Absence of lysis of TT (CT-scan)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysis of TT (peroperative)</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Absence of lysis of TT (peroperative)</td>
<td>16</td>
<td>62</td>
</tr>
</tbody>
</table>

Se = 61% Sp = 79% PPV = 41% NPV = 90%

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CT, computed tomography; NPV, negative predictive value; PPV, positive predictive value; Se, sensitivity; Sp, specificity.

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Figure 1

Figure 2

Lysis of the scutum (arrow).

Lysis of the tegmen (arrows).
Erosion is often confirmed during surgery (Sp = 78%) (Table 5).

Finally, we found, during surgery, a lysis of the lateral semicircular canal (LSCC) in 13% of our patients (Fig. 5). CT-scan showed this complication in only eight patients (Se = 46%), but with an excellent specificity (98%) (Table 6).

**Discussion**

Abnormal extension of the keratinizing epithelium of the external acoustic meatus into the middle ear cavity through the tympanic membrane is considered to be the main cause of middle ear cholesteatoma [1,5]. This dangerous disease can also be because of a squamous epithelium trapped within the middle ear during embryogenesis. Resulting in congenital cholesteatoma [7]. Ingrowths of cholesteatoma result in erosion of the surrounding bony structures. Bony erosion is related to the combined effects of the cholesteatoma mass and collagenase activity [3]. The possible consequences of such an osteolysis are complications including ossicular destruction, automastoidectomy, meningitis, dural sinus thrombosis, facial nerve palsy, labyrinthine fistula, and extension to the petrous bone [5,6]. For several years, imaging of the ear has been a routine test in the preoperative workup of the disease and most recent reports recommend a CT-scan as part of the preoperative workup of the disease [3,8,9]. CT-scan imaging allows a comprehensive preoperative evaluation of the anatomic variations and bone details of the middle ear as well as the ossicular chain and soft tissue [10–12].

In our study, we attempted to precisely determine...
images reconstructed using the multislice scan CT, which allows a slice thickness of 0.5 mm [15]. High-resolution computed tomography (HRCT) is most valuable for the detection of early erosive changes in the ossicles, particularly in the smaller parts such as the incudostapedial junction [13].

The erosion of the Fallopian canal along its pathway through the temporal bone, especially of the tympanic segment of the canal, may be difficult to interpret [8]. In our study, the sensitivity of CT-scan to objective a Fallopian canal erosion was 42%. High-resolution inframillimetric CT slices and complete immobilization of the head of the patient during radiological exploration are necessary for an accurate and complete study of the facial nerve canal [11,12,14]. To clearly visualize this part of the canal, coronal images must be analyzed meticulously [12].

Labyrinthine fistulae because of LSCC erosion complicate cholesteatoma in 5–20% of the cases [2,16–18]. This canal is the most frequently eroded because of its close proximity to the medial wall of the attic anatomically.

The bony lysis of the LSCC can be either cortical or total and necessitates the combination of coronal and axial inframillimetric slices to appreciate it to avoid a false impression of a labyrinthine fistula [8,13,19,20]. A comparative study with the controlateral temporal bone may be helpful to avoid false-positive results [11,12,21]. For our patients, the sensitivity of CT-scan was 50% but with a good PPV (80%).

For the assessment of all these variations and abnormalities, an adequate technique and a good radiologic interpretation of temporal bone CT-scan are needed.

In our study, we used a conventional CT-scan with 1 mm section thickness. However, the middle ear structures are very small and fine; thus, a HRCT with inframillimetric slices may offer a best topographic study [22]. HRCT has clearly shown its superiority in the evaluation of the temporal bone, particularly utilizing thin-section, high-resolution techniques. HRCT provides a more precise definition of the anatomic extent of the disease of the middle ear and

<table>
<thead>
<tr>
<th>Table 6 LSCC lysis</th>
<th>LSCC lysis (CT-scan)</th>
<th>Absence of LSCC lysis (CT-scan)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSCC lysis (peroperative)</td>
<td>6</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Absence of LSCC lysis (peroperative)</td>
<td>2</td>
<td>81</td>
<td>83</td>
</tr>
<tr>
<td>8</td>
<td>88</td>
<td>96</td>
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</tbody>
</table>

CT, computed tomography; NPV, negative predictive value; PPV, positive predictive value; Se, sensitivity; Sp, specificity.

![Figure 5](image_url)

Lysis of the lateral semicircular canal with labyrinthine fistula (arrows) in coronal (a) and axial (b) view.

the performance of CT-scan in different temporal bone variations and complications in the presence of cholesteatoma. Thus, a correlation was performed between preoperative radiological data and surgical findings using four statistical tests: sensitivity (Se), specificity (Sp), PPV, and NPV.

The most frequent radiological signs of cholesteatoma are middle ear mass and bony lysis [1].

Our comparison of radiological and surgical findings, it was found that CT-scan yields, overall, an adequate anatomical confirmation of the tympanomastoid cavities.

For the lysis of the tegmen tympani, which is a thin bony roof, radiological data seem imprecise, requiring thinner CT-scan slices on coronal sections [1,4,13].

In contrast, the lysis of the scutum, which represents a thick bony relief, is well visualized in frontal CT-scan images [4,14].

For middle ear content, CT seems to be the examination of choice for identifying areas of osteolysis and screening for the main complications associated with cholesteatoma [8]. The predictive value of CT-scan depends on the anatomic structure studied.

Even if OCL is frequent in cholesteatoma otitis, it remains nonspecific and can be found in other forms of chronic otitis media [1,4]. Fine structures of the auditory ossicles could be delineated clearly in the
the relationship of these cholesteatoma masses with the contiguous structures [13].

Conventional CT-scans also have other limitations and usually cannot differentiate a cholesteatoma from granulation tissue, pus, and fluid, which are present in chronic otitis media without the presence of a cholesteatoma [23].

In some cases, CT assessment should be supplemented by MRI when meningococcal infection, intracranial extension, or sigmoid sinus thrombosis is suspected. Depending on the clinical presentation, venous angi-MRI or venous angi-CT may be used to detect sigmoid sinus thrombosis [24]. In addition, a number of articles in the literature suggest that diffusion-weighted MRI may be able to distinguish between recurrent or persistent middle ear cholesteatoma and to differentiate scar tissue from granulation tissue [25,26].

Conclusion
CT scanning must be systematic in the preoperative workup of cholesteatomatous otitis media. By improving its resolution, CT may offer an excellent topographic study of the tympanomastoid cavities and the middle ear structures.

Acknowledgements

Conflicts of interest
None declared.

References
3 Tran Ba Huy P. Chronic otitis media. Natural history and clinical features. EMC Otorhinolaryngol 2005;2:26-61.