Role of multislice computed tomographic scan in management of otosclerosis

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Otosclerosis is the abnormal growth of bone of the middle ear affects endochondral bone of the otic capsule that prevents structures within the ear from working properly and causes hearing loss. To assess the radiological findings in patients with otosclerosis using high-resolution multislice computed tomographic (CT) scan. This prospective study was done at Assiut University hospital during the period from June 2016 to August 2017. Thirty patients were enrolled in this study; 11 (36.7%) males and 19 (63.3%) females. CT was efficient in the diagnosis of otosclerotic foci, showing a high rate of positivity. The multislice CT findings were bilateral in 45 ears and this evidence was statistically significant. Preoperative high-resolution CT scan may serve as a valuable imaging method in the planning of stapes surgery. It helps to avoid serious complications and unnecessary stapes surgeries by the detection of several abnormalities in the middle or inner ear CT density of otosclerotic lesions in any of the CT grades was significantly correlated with hearing loss.

Keywords:
conductive hearing loss, high-resolution computed tomographic scan, otosclerosis

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Introduction

Otosclerosis is the abnormal growth of bone of the middle ear that affects endochondral bone of the otic and capsule causing hearing loss [1]. High-resolution computed tomographic (HRCT) scan could detect very fine architectural changes in the otic capsule and surrounding bone structures [2]. Preoperative detection of otosclerosis specific hypodense lesions has great clinical significance, since it might correspond to the type, severity, and progression of hearing loss [3–6].

Some studies suggested that, there is a relationship between otosclerosis and CT findings. The present study aimed to assess the radiological findings in patients with otosclerosis using high-resolution multislice CT scan.

Patients and methods

Ethical considerations

This prospective randomized cohort study was done after obtaining an Institutional Review Board approval from the Committee of Medical Ethics, Faculty of Medicine, Assiut University. It was conducted in Otorhinolaryngology Department, Assiut University Hospital during the period from June 2016 and August 2017. Before including participants in the study, the purpose and nature of the study were explained to all patients.

They were free to ask about the nature of the study. They agreed that they understand the investigational nature of the study benefits. They were free to terminate participation in this study without affection of clinical service or management. A written informed consent including the explanation was obtained from the patient.

The collected and disseminated data of the patients were confidential. The study and all interventions and investigations including audiological evaluation and radiological studies were done by scientifically qualified and trained personnel.

Inclusion criteria

(1) All patients with conductive or mixed hearing loss with intact tympanic membrane with provisional diagnosis of otosclerosis.
(2) Age group 18–55 years.

Exclusion criteria

(1) Pateint with age group less than 18 or more than 55 years old.
(2) Pregnant patients.
(3) Previous ear surgery.

Methodology

This study was carried out on 30 patients complaining of hearing loss±tinnitus diagnosed clinically, audiologically, radiologically, and confirmed intraoperative as otosclerosis.

All the patients included in the study were subjected to:

(1) Full general history taking: including personal history, family history, complaint, history of present illness, especially symptom of hearing affection
(2) Complete otolaryngologic, head and neck examination: to exclude other causes of conductive hearing loss, otoscopic examination
(3) Full audiological assessment at the time of diagnosis including pure-tone audiometry, tympanometry
(4) High-resolution multislice CT scanning: very thin (0.1 mm) thickness axial sections were obtained on multidetector CT scanner, followed by axial and coronal reformats, respectively in the plane, and perpendicular to the lateral semicircular canal. All cases were examined without contrast injection
    CT grading for otosclerosis [7]:
    Grade 1: solely fenestral, either spongiotic or sclerotic lesions, evident as a thickened stapes footplate
    Grade 2: patchy localized cochlear disease
    Grade 3: diffuse cochlear involvement of the otic capsule
(5) Assessment of ossicular chain intraoperative.

Operative details

Exploratory tympanostomy was done under general anesthesia through endotracheal intubation through an incision of the external canal with Rosen knife elevation of the tympanomeatal flap, exploration of the middle ear, testing of the mobility of ossicles fixed stapes was found in all cases, stapedectomy was done, and Teflon piston applied.

All cases operated in our department by experienced surgeons. The operation was done microscopically in some cases and endoscopically in the others.

Statistical analyses

The data were entered and edited using the statistical package for the social science (SPSS, version 22; SPSS Inc., Chicago, Illinois, USA). Results were expressed as the mean ± SD or frequency (%). The χ^2 test was used to analyze differences among categorical variables.

Results

The study included 30 patients (26 of them with bilateral hearing loss, four patients with unilateral hearing loss, and four of them operated bilaterally), recruited from the Otolaryngology Department in Assiut University. Age ranged from 18 to 55 years, with a mean of 29.27 ± 3.2 years. Table 1 showed basic patient's characteristics. Clinical presentation of patients was summarized in Fig. 1. Otoscopic examination results were summarized in Fig. 2.

Audiological evaluation

Basic audiological evaluation characteristics are composed of pure-tone audiometry results which included in Table 2 and tympanometry results that are shown in Fig. 3.

CT findings are summarized in Table 3, and Figs. 4–7 represent CT findings in our study. CT grading is summarized in Table 4 with grade 1 represents narrowed or enlarged the round or oval window, grade 2 characterizes patchy localized cochlear disease (with or without fenestral involvement), and grade 3 denotes diffuse confluent cochlear involvement of the otic capsule (with or without fenestral involvement).

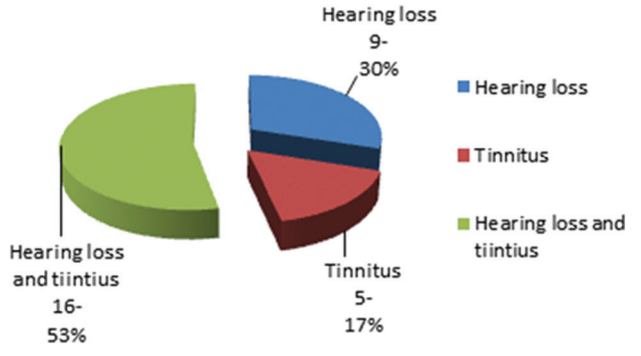
Table 1 Patient characteristic

Number of patients	*n* (%)
Sex	
Male	11 (36.7)
Female	19 (63.3)
Family history	
Positive	13 (43.3)
Negative	17 (56.7)

Table 2 Pure-tone audiogram evaluation results

Type of deafness	*n* (%)
Conductive hearing loss	
Unilateral	4 (13.3)
Bilateral	24 (80)
Mixed hearing loss	
Unilateral	- (-)
Bilateral	2 (6)
Acoustic reflex	
Absent	30 (100)

Figure 1



Clinical presentation.

Audiological and computed tomographic findings correlation

Patients with normal findings include 15 (25%) ears and their main conductive gap 22.59 ± 13.18, while patients with grade 1 include 13 (21.7%) ears and their main conductive gap 27.14 ± 8.09 and patient with grade 2 include 13 (21.7%) ears with main conductive gap 26.25 ± 9.54 with *P* value of 0.148. Finally, patients with grade 3 include 19 (31.7%) ears with main conductive gap 32.78 ± 7.32. A significant relationship was detected between the CT findings and audiological findings of all grades with *P* value of 0.029 as shown in Table 5.

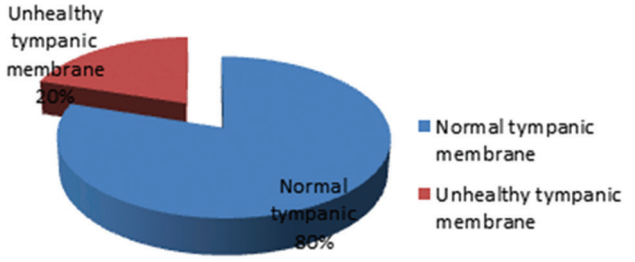
Intraoperative and CT findings correlation are explained in Table 6.

Table 3 Computed tomographic findings

CT finding	Number of affected ears [*n* (%)]
Obliterated oval window	
Positive	34 (56.7)
Negative	26 (43.3)
Obliterated round window	
Positive	32 (53.3)
Negative	28 (46.7)
Presence of cochlear foci	
Positive	33 (55)
Negative	27 (45)
Mastoid pneumatization	
Pneumatized	47 (78.8)
Sclerotic	13 (21.7)
Normal facial nerve canal	60 (100)
Middle ear pathology	- (-)
Normal ossicular chain integrity	60 (100)
Other inner ear pathology	- (-)
Normal sinus plate and jugular bulb	60 (100)

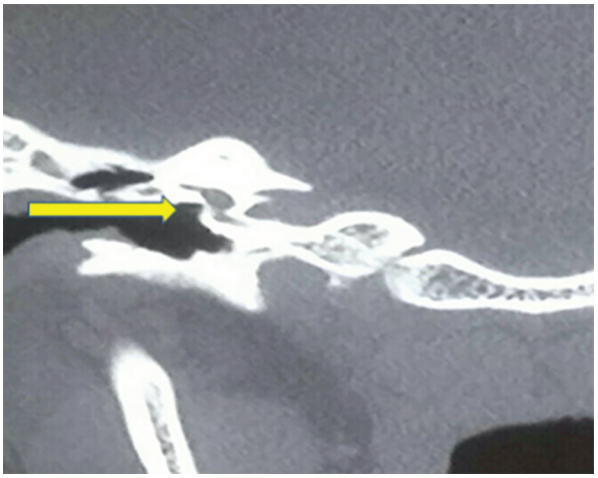
CT, computed tomography.

Figure 2



Otoscopic examination results.

Figure 4

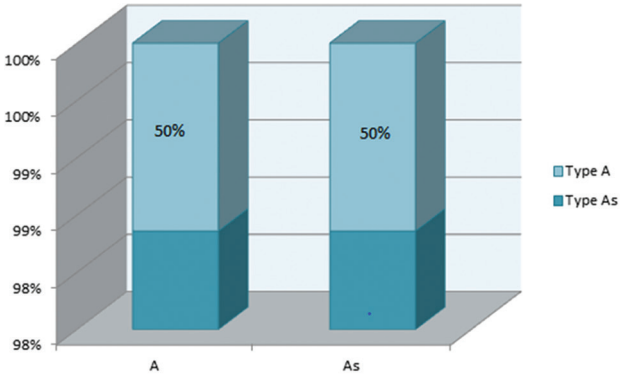


CT temporal bone, coronal cut of obliterated right oval window (yellow arrow). CT, computed tomography.

Discussion

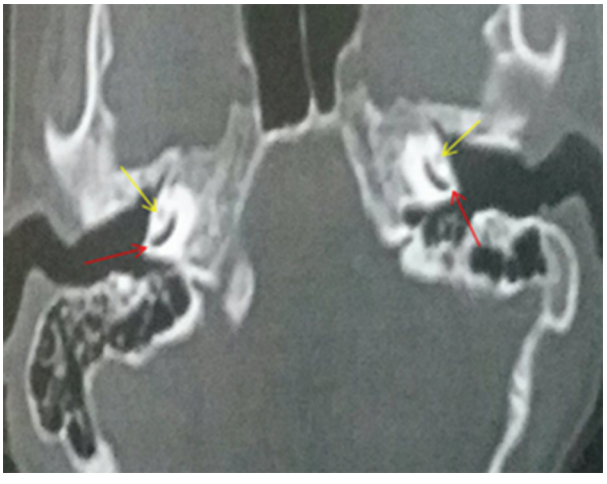
A suspicion of otosclerosis is evoked by a combination of history and audiometric findings. Confirmation of the diagnosis typically requires surgical middle ear exploration. The objective of this study is to review the usefulness and the role of HRCT imaging for the diagnosis of otosclerosis to decrease the surgical risk.

Figure 3



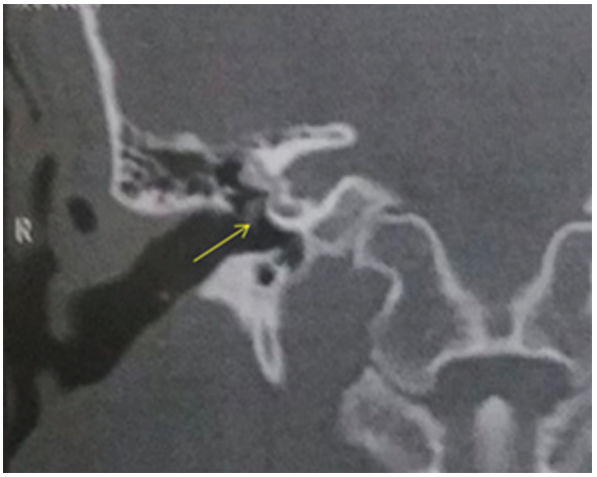
Tympanogram evaluation results.

Figure 5



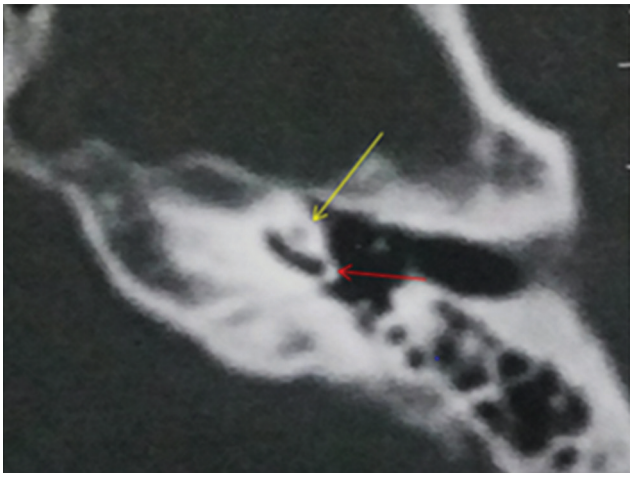
CT temporal bone, axial cut of obliterated round window (red arrow) and cochlear (yellow arrow) foci bilaterally. CT, computed tomography.

Figure 6



CT temporal bone, coronal view, stapedectomy was done to right ear and Teflon piston applied it appears in place (yellow arrow). CT, computed tomography.

Figure 7



CT temporal bone, axial view of left ear of a male patient 28 years showing obliterated round window (red arrow) and cochlear foci (yellow arrow). CT, computed tomography.

Several factors were found to be involved in the prediction of the outcome of the otoslerotic patient that includes a clinical presentation with particular concern to the presence of tinnitus, hearing loss, or combination of both. In addition, audiometric findings playing a pivotal role through pure-tone audiometry, that can demonstrate the type of hearing loss whether conductive hearing loss, sensorineural hearing loss, or mixed hearing loss. Finally, CT findings that can show the status of the oval window, round window, cochlea, mastoid, facial nerve canal, middle ear pathology, ossicular chain integrity, other inner ear pathology, sinus plate, and jugular bulb. In our study, we found that otosclerotic patients presented at the mean age of 29.27 years. This finding is in agreement with studies done by Virk *et al.* [8] and Rudic *et al.* [9] who found that most otosclerotic patients are presented between second and fourth decade.

Regarding sex, our data revealed that otosclerosis showed slight female predominance with a female to male ratio of 1.7: 1 which is in agreement with other studies [3,10] who found a female predominance with a female to male ratio of 1.4: 1 and 1.3: 1, respectively. This finding could be attributed to genetic factors, hormonal imbalance, immune system disorder and autoantibodies that are more common among females.

Our work detected grade 1 otosclerosis in 21.7%, grade 2 in 21.7%, and grade 3 in 31.7%, so grade 3 was the predominant form. This is in agreement with Wycherly *et al.* [5] who found that 76% of their cases were grade 3. This also agrees with Marx *et al.* [6] who found that 79.8% of their cases were grade 3. Our findings were in controversy to study done by Lee *et al.* [11] that studied a number of cases, 82% of them

Table 4 Computed tomographic grading

CT grading	Number of ears (*n*=60) [*n* (%)]
Normal findings	15 (25)
Grade 1	13 (21.7)
Grade 2	13 (21.7)
Grade 3	19 (31.7)

CT, computed tomography.

Table 5 Audiological and computed tomographic findings correlation

CT finding	Audiogram Mean±SD	*P*
Grade 1	22.59±13.18	
Grade 2	27.14±8.09	0.029
Grade 3	26.25±9.54	
Grade 4	32.78±7.32	

CT, computed tomography.

Table 6 Intraoperative and computed tomographic findings correlation

Operated ears	*n* (%) (*N*34)
Positive CT findings	28 (82.4)
Negative CT findings	6 (17.6)

CT, computed tomography.

was grade 2. This difference could be attributed to the genotypic variation between our population sample and other groups.

Our study showed that significant association presents between CT findings of the otosclerotic patient and audiological finding (pure-tone audiometry and tympanometry) with *P* value 0.029. This agrees with Shin *et al.* [3] who found preoperative and postoperative bone conduction thresholds significantly lower ($P < 0.05$) in patients with pericochlear foci on the CT scan. Gredilla Molinero *et al.* [12] found that HRCT is the modality of choice for radiological

diagnosis of patients with otosclerosis and it allows us to perform differential diagnosis with other conditions of similar symptomatology. It provides us with prognostic information and allows us to identify cases with higher surgical risk.

Vicente Ade *et al.* [13] who stated that CT was efficient in the diagnosis of otosclerotic foci, showing a high rate of positivity, especially for fenestral lesions. Moreover, their data showed that tomographic findings were bilateral in most patients and this evidence was statistically significant and agreed with our results.

Finally, our study showed an evident association between the CT findings and intraoperative diagnosis of otosclerosis as 82.4% of the operated patient have positive CT findings. Negative finding does not exclude the involvement of stapes footplate by otosclerotic foci as Shin *et al.* [3] found a significant association between doubtful or negative CT scan with the risk of complications of the stapes footplate. Thus, in cases of negative or doubtful HRCT scan otosclerosis, the surgeons have to be alerted to the higher risk of encountering a stapes footplate problem. That there are several middle and inner ear disorders that must be distinguished from stapes fixations to avoid unnecessary stapes surgery or serious intraoperative complications, such as large vestibular aqueduct, enlarged cochlear canaliculus, superior semicircular canal dehiscence syndrome, embryonic disorders of the hearing ossicles, stapes malformations, persisting stapedial artery, or prolapsing facial nerve into the oval window niche [14–16].

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Nil.

Conflicts of interest
There are no conflicts of interest.

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