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Research Article

Impact Of Imaging In Management Of Otosclerosis

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ABSTRACT

Introduction: Otosclerosis is a primary otodystrophy characterized by abnormal bone remodelling of the temporal bone. The main symptom of the disease is progressive hearing loss, which is usually bilateral. The disease is diagnosed based on history, clinical examination and specific audiometric findings. However, there is a controversy over the need of imaging in these patients. Here we will be discussing about the need of HRCT (High Resolution Computed Tomography) Temporal bone in patients of suspected otosclerosis.

Materials and Methods: This is a prospective observational study, in 24 patients who presented to our outpatient department having pure conductive hearing loss, intact tympanic membrane on otoscopy, absent stapedial reflex and an A type of tympanogram. Pure tone audiometry and HRCT Temporal bone was done for all patients as preoperative workup, and postoperative follow-up was done with Pure Tone Audiometry.

Conclusion: A specific CT diagnosis of otosclerosis was made in 87.5 % cases. A wide contribution was made by differentiating otosclerosis from other conditions with similar symptomatology, predicting complications and giving a great outcome to these patients suffering from hearing loss in their prime productive years of life.

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INTRODUCTION:

Otosclerosis is a primary otodystrophy characterized by abnormal bone remodelling of the temporal bone. The otic capsule consists of three distinct layers of ossification, with the intermediate layer usually showing enchondral ossification. In patients with otosclerosis, the otospongiosis or active stage is characterized by replacement of enchondral bone with disorganised spongy bone which is less dense and having a greater vascular component. As the disease progresses, the pathologic spongy bone may occasionally re-calcify and exhibit a greater component of sclerosis, which can result in otosclerosis or an inactive stage. It is a genetic disease that is inherited by autosomal dominant pattern, with incomplete penetrance and a variable clinical expression. In 80–85% of the patients, there is bilateral involvement, with a 2:1 female predominance and a peak incidence that occurs between the second and fourth decades of life. With a prevalence of roughly 0.3–0.4%, it is more common in Caucasians.

The main symptom of the disease is progressive loss of hearing, usually in both ears, which can be associated with tinnitus. In rare cases, it can also manifest as a pure sensorineural hearing loss or as a mixed form. The remodelling of the temporal bone primarily takes place in the area of the oval window, specifically in its anterior part, the fissula ante fenestrum (which is a groove between the oval window and the cochleariform process) in the fenestral subtype of otosclerosis. A retro-fenestral variant of the disease, affecting the otic capsule, manifests in 1% to 10% of cases.

Typical otosclerosis-related imaging is useful when evaluating patients with suspected otosclerosis before primary or revision stapes surgery. HRCT (High-resolution computed tomography) temporal bone can identify any other causes of conductive or mixed hearing loss such as ossicular chain discontinuity/fixation (possibly secondary to previous middle ear disease) tympanosclerosis, round window obliteration or cholesteatoma (congenital cholesteatoma still isolated to the attic and hidden medial to an intact scutum).[1]

Preoperative HRCT temporal is recommended before stapes surgery unless patients underwent a successful contralateral stapedotomy. Adopting this policy not only improves expectation management for air-bone gap closure but may also avoid the risk for complications that can be predicted based on HRCT.

MATERIALS AND METHODS:

This is a prospective observational study, where 24 patients who presented to our outpatient department suffering from hearing loss (with findings on examination described below) were evaluated from September 2020 to December 2022.

Study Parameters:

1. Full general history taking (especially family history)
2. General examination: with special emphasis to exclude patients with congenital syndromes that may affect hearing.
3. Complete otolaryngologic, head and neck examination: to exclude other causes of conductive hearing loss, including: otoscopic examination and tuning fork tests.
4. Full audiological assessment at the time of diagnosis including pure tone audiometry, tympanometry and stapedial reflex.
5. HRCT Temporal bone.

Inclusion Criteria:

Patients with complaints of hearing loss along with following findings were included:

1. Intact tympanic membrane on otoscopy
2. Conductive hearing loss on Pure tone audiometry
3. Absent stapedial reflex
4. As/A type of tympanogram

Exclusion Criteria:

1. Patients suffering from pure Sensorineural hearing loss.
2. Patients with accompanying vestibular complaints.
3. Patients with history of chronic otitis media

Patients not willing to participate in the study and patients who are unfit for surgery were not included in the study.

In all these patients preoperatively and postoperatively Tuning fork test and pure tone audiometry was done so as to analyse the outcome on the hearing.

CT Temporal bone was done for all these patients preoperatively. The **various points** noted on CT were:

- To confirm the diagnosis: Otosclerotic focus
- To look for other causes of conductive hearing loss:

a) 3RD window
b) Tympanosclerosis
c) Ossicular discontinuity/ abnormality

- To look for any intraoperative challenges:
  a) Overhanging facial nerve
  b) Persistent stapedial artery
  c) High riding jugular bulb
  d) Biscuit footplate
- Prediction of complications (Gusher):
  a) Cochlear malformations
  b) Enlarged vestibular aqueduct
  c) Enlarged cochlear aqueduct
  d) Enlarged IAM

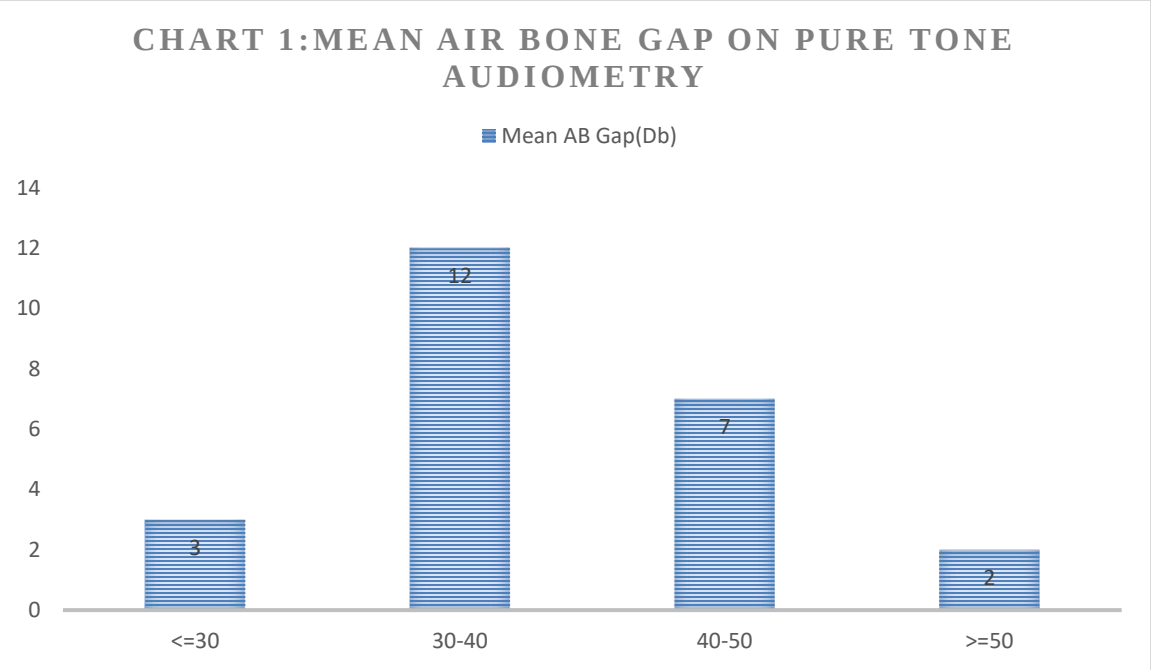
Exploratory tympanotomy was done for all these patients and CT findings were correlated. In our study 21/24 patients underwent stapedotomy by Fisch technique(fenestra created in footplate and piston kept before dislocating incudo-stapedial joint). Teflon or Titanium pistons were used for ossicular reconstruction intraoperatively. Postoperatively patients were in close follow-up and repeat Pure tone audiometry was done for them after 1 month to evaluate the outcome of the procedure done. Datasets for patients included information regarding Tuning fork test, Pure tone audiogram, CT findings and intraoperative findings.

RESULTS:

The age of the patients ranged from 10 to 56 years shown in graph 1 above. The mean (SD) of the participants was 33 (10.7) years. There were 24 patients out of which 13 were females (54%) and 11 were males (46%).17/24 patients had B/L otosclerosis while remaining 7 patients had unilateral symptoms. The hearing of all patients was documented and was classified according to American Speech-Language-Hearing Association (ASHA) Classification.

Table 1: Distribution according to hearing loss

Hearing loss	No. of cases	%
Slight	0	0
Mild	0	0
Moderate	8	33.33
Moderately severe	12	50.0
Severe	4	16.66
Profound	0	0
Total	24	100.0



The mean (SD) preoperative AB Gap in our patients was 37.8 Db (7.8).

According to Symons and Fanning grading,

- 18 patients had grade 1 otosclerosis
- 3 patients had grade 2a and
- otosclerosis was not detected on CT in 3 patients.

75 % of our patients had grade 1 otosclerosis diagnosed on Ct imaging.

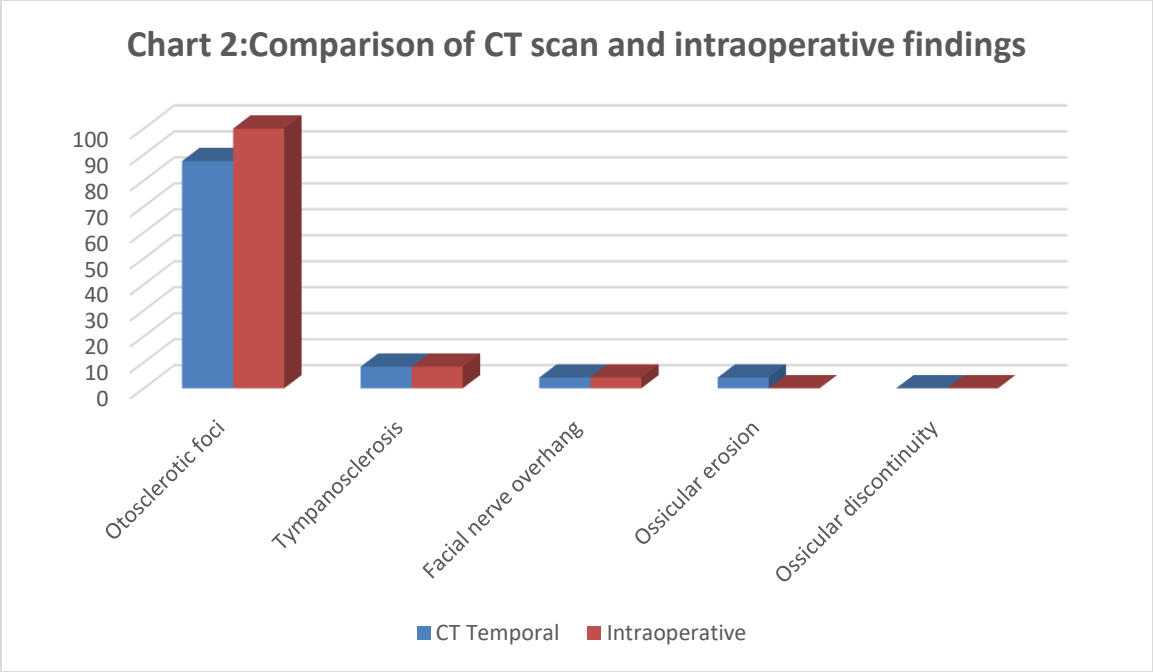
Figure 1: Otosclerotic foci as seen on CT.

In our study, 24 patients of clinically suspected otosclerosis underwent CT imaging:

- 21 patients showed positive finding (area of focal lucency in the region of fissula ante fenestrum) on imaging and all 24 patients showed non mobile incudo-stapedial joint and absent round window reflex intraoperatively. CT scan was 87.5 percent sensitive in the diagnosis of otosclerosis. Specificity?
- Ossicular erosion (only part of head of stapes visualized while rest of stapes not visualized) was seen in 1 patient on CT while entire stapes was visualized intact intraoperatively.
- There was evidence of facial nerve overhang making piston insertion difficult in 1 case which was diagnosed preoperatively on CT scan.
- There was presence of tympanosclerotic patch seen in the middle ear in 2 cases (not causing ossicular fixation) which was diagnosed preoperatively on CT scan.
- Focal superior semicircular canal dehiscence was seen in 2 patients on imaging, but surgery in these patients was uneventful , with air-bone gap closure of <10 db postoperatively.
- Absence of foramen spinosum, enlarged vestibular/ cochlear aqueduct, enlarged IAM, ossicular chain discontinuity, carotid cochlear dehiscence was not seen in any of the 24 patients on imaging. There were 0 cases of CSF gusher intraoperatively.
- 0 surgeries had to be abandoned due to intraoperative complications.
- The diameter of vestibular aqueduct was measured halfway between the common crus and the external aperture. Vestibular aqueduct was measureable in 22 of 24 patients. 2 vestibular aqueducts were too small to be measured on CT scan. The average vestibular aqueduct diameter was 1.06 mm.
- The average internal acoustic meatus diameter in our study was 3.83 mm.

Table 2 : CT findings

CT Findings	**Number of patients [n(%)]**
Otosclerotic foci	21(87.5%)
High riding jugular	8(33%)
Ossicular erosion	2(8%)
Tympanosclerosis	1(4%)
Facial nerve overhang	1(4%)
Facial nerve dehiscence	0
Semicircular canal dehiscence	0
Absence of foramen spinosum	0
Ossicular chain discontinuity	0
Enlarged vestibular / cochlear aqueduct	0
Enlarged IAC	0
Carotid cochlear dehiscence	0



The CT scan had 100 %
sensitivity and specificity in diagnosing:
1.Presence of Tympanosclerosis
2.Facial nerve overhang
3.Superior semicircular canal dehiscence
4.Ossicular discontinuity
5.Enlarged vestibular/ cochlear aqueduct (risk of CSF gusher)

The post-operative air bone gap (ABG) was used as a measure to see the success and efficacy of surgery.

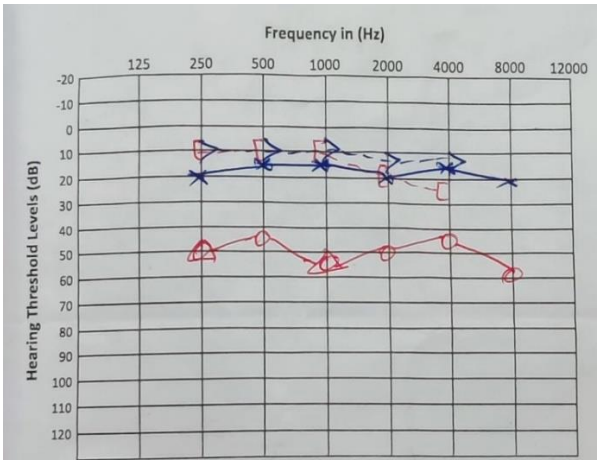
Postoperatively after 4 weeks, pure tune audiogram was done. And Air bone gap was calculated. categorized into 3 groups, viz GRADE A, B, C. It was found that 17 cases (70 %) had air bone gap closure <10 db which implies success of the surgery. 6 cases (25%) had ABG closed to 10 to 20 db which denotes improvement, and in 1 case the air bone closure was >20 db which denotes failure.

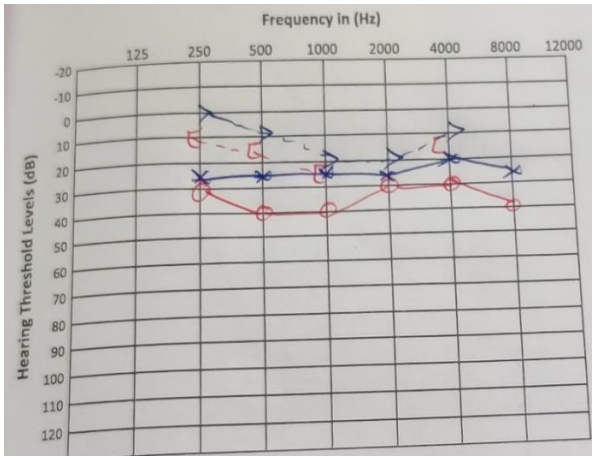
Table 3: Descriptive analysis of postoperative AB Gap in study population(N=24)

Air-bone gap	No. of patients	Percentage
Grade A (≤10)	17	70%
Grade B (11-20)	6	25%
Grade C (≥20)	1	5%
Total	24	100%

The mean AB gap of patients postoperatively was 7.8 dB and 17 patients had AB gap <10 dB proving excellent outcome of surgery.

Figure 2a and 2b: Pre-operative and post-operative Pure Tone Audiometry of patient who underwent right Stapedotomy.





DISCUSSION:

No specific routine imaging criteria have been established to evaluate technical intraoperative difficulties in stapes surgery. Our present study is to analyse the need of CT imaging in patients of otosclerosis.

In our study we found a cluster around the age group of 20 years and above, where 21 patients were in the range of 20-50 years and mean age of presentation was 33 years.

In our study there was a slight female predominance with females forming 54 % of our study population. According to a study by Hueb et al., [2] a sex ratio prevalence of 1:1 should be expected. The apparent higher incidence of clinical otosclerosis in women has prompted some authors to postulate that endocrinologic factors play a stimulating role in the activity of the lesions, whereas others have suggested that women are more prone to seek medical advice than men.[3] In our study 17/24 patients (70.8%) had B/L otosclerosis. et al. [2] had similar results in his study in which Bilateral otosclerosis was present in 75.6% of the 82 individuals, whereas it was unilateral in 24.4%.

The Pure tone averages of preoperative and postoperative hearing were assessed for comparing Hearing gain. The average hearing loss of patients in our study was 51-60 dB with mean preoperative AB gap of 37.8 dB. All 24 patients underwent stapedotomy with piston placement and postoperative pure tone audiometry was done in follow-up. The mean AB gap of patients postoperatively was 7.8 dB and 17 patients had AB gap <10 dB proving excellent outcome of surgery.

In our study around 90% presented with A type of curve (including A and As). Even though otosclerosis is more typically associated with A ‘s’ type of Jerger curve. In the study by GG Browning [4] in 1985, in a paper title,”The Doubtful Value of Tympanometry in the Diagnosis of Otosclerosis“, only 38% were below the lower 90th percentile of normal compliance of 0.2ml and additionally 10% of the normal ears had a compliance of 0.2ml, thus concluding that tympanometry was not necessarily helpful to arrive at a diagnosis is otosclerosis. And thus, the clinical role of tympanometry in the diagnosis of otosclerosis is doubtful. In our study all patients had absent stapedial reflex. In a study of 95 otosclerotic ears, Jerger (1975) found reflexes were absent in 80% of cases. Of the remaining 20% that showed reflexes, about half showed a pronounced biphasic pattern. He suggested that the stapedial reflex possibly undergoes a progressive change with time in the otosclerotic ear.

The reversal stapedotomy is a safe procedure for treatment of Otosclerosis with excellent improvement of hearing levels in comparison with other stapes surgery, based on literature review. Stapedotomy under sedation was done in all our patients after preoperative evaluation and work up. Hearing of patient was tested intraoperatively after piston insertion and placement. Fisch technique was used in 21/24(87.5 %) patients while conventional stapedotomy was done in 3/24(12.5%) patients. Facial nerve overhang was encountered in 1 patient which was seen on CT.

The CT provides visualization of bony demineralization as hypodense or radiolucent lesions at the fissula ante fenestrum and cochlear otic capsule. CT is done for all patients of suspected otosclerosis in France.

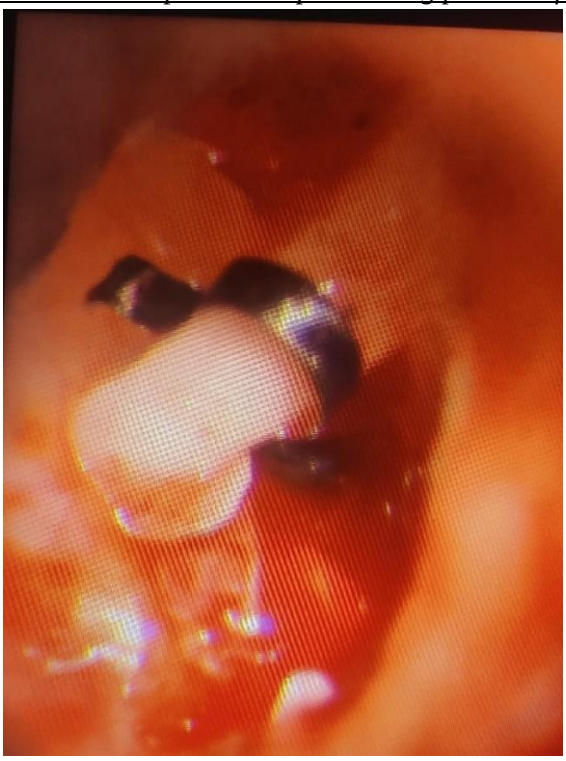
In the last decade, the role of HRCT in ruling out other causes of conductive deafness has been better defined. Lately, however, radio-diagnostic studies have approached 90 percent or higher sensitivities in diagnosing otosclerosis.[5]

In the present study, CT was able to identify otosclerotic foci in 21/24 ears (87.5%). Various sensitivities of CT for the diagnosis of otosclerosis have been reported. Shin et al.[6] found positive CT findings in 399 out of 437 ears (91.3%).Naumann et al.[7] found otosclerotic foci visualized in 85% of cases. The main cause for a negative CT is the presence of infra-millimetre lesions and/or inactive otosclerotic foci in the otic capsule and density variations of less than 200 Hounsfield (HU) which are invisible to the naked eye.

In the present study, those cases of otosclerosis that were not picked up by HRCT may be due to the abovementioned limitations of HRCT or to an annular type of fixation. Thickness of footplate of stapes could not be measured in our study due to non-availability of Ultra-high-resolution computed tomography (U-HRCT) scanning with ultra-small detector elements (0.25 × 0.25 mm) at our centre.

The piston diameter used was 0.4mm in 20 cases and 0.6 mm in 4 cases , in the study by Goode and Hato[8] in 2000 they reported that pistons with larger diameter gave better hearing results .Titanium piston prosthesis was used in 14 pateints while fluoroplastic was used in 10 patients and both showed similar results in improvement of hearing postoperatively on pure tone audiometry.

Figure 3: Titanium piston crimped on long process of incus



In the immediate post-operative period three patient had giddiness (12.5%) , other than that there were no other complaints recorded. After discharge, Post-operative follow up was done at the end of 1month,none of the patients had vertigo . PTA was performed . And post op air bone gap was calculated, when pre- operative and post-operative ABG were compare, it was significant which denotes success or improvement of the surgery.

Figure 4: Titanium implant as seen on postoperative CT scan axial cut

CONCLUSION:

- CT Temporal bone should be done in all cases of suspected otosclerosis as it has a high degree of diagnostic efficacy and an important therapeutic impact in the evaluation of patients. A specific CT diagnosis of otosclerosis was achieved in 87.5 % cases.
- CT made a wider contribution by eliminating other causes of conductive hearing loss, predicting intraoperative challenges and risk of complications. Hence reducing surgical risk.
- Pre and postoperative assessment of hearing by pure tone audiometry showed the successful outcome of surgery with significant reduction in AB Gap and no complications intra or postoperatively.

The routine use of imaging for diagnosis and preoperative evaluation is necessary.

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