HRCT in Conductive Hearing Loss: A Study of One Hundred Cases

Abstract
Background: HRCT (high resolution computerized tomography) is a commonly used tool for diagnosis and confirmation and also to plan for surgery on the ear. This investigative modality gives useful inputs regarding the extent and nature of the disease. With the modern high resolution images, the finer findings such as the state of the ossicles, the presence of signs of erosion can make the surgeon better prepare for the surgery and plan for the same. The study also aims to strategize whether HRCT should be used for all cases of conductive hearing loss.

Objectives: The study aims to evaluate the routine use of HRCT in the diagnosis and management of conductive hearing loss of any cause.

Key words: Conductive hearing loss, HRCT Temporal Bones

1. INTRODUCTION:

The use of HRCT in the diagnosis and management of conductive hearing loss is well documented. Many surgeons have advocated the routine use of HRCT even in cases of chronic suppurative otitis media and otosclerosis. It has been suggested that the HRCT will aid the surgeon in preoperatively diagnosing ossicular dislocations or erosion in cases of CSOM. In the cases of otosclerosis, the otosclerosis foci can be made out many times along with the state of the ossicles. This study aimed to strategize the use of HRCT and discuss the applicability of routinely using the test in the management of conductive hearing loss. Patients seen by the second author in his practice who complained of hearing loss and who were diagnosed as conductive hearing loss in the time period of January 2012 to January 2013 were taken up for study.

2. MATERIALS AND METHODS:

This was a prospective study of one hundred cases of conductive hearing loss due to varying causes which were chronic (greater than three months). These included chronic suppurative otitis media (CSOM), otosclerosis, ossicular dislocation and other chronic causes of conductive hearing loss such as otitis media with effusion. Routine audiometric analysis was performed after clinical examination where a conductive hearing loss was demonstrated. Impedance audiometry was also routinely performed in all cases including the cases of CSOM for uniformity. The patients were then told to undergo HRCT of the temporal bone and the findings were analyzed with the help of an experienced radiologist.

THE FOLLOWING INCLUSION CRITERIA WAS THUS USED FOR THE SELECTION OF CASES:

Inclusion criteria:
1. Patients who demonstrated conductive hearing loss for a period of greater than 3 months.
2. Patients who underwent HRCT after the clinical diagnosis

The exclusion criteria used were:
1. Patient who had acute conductive hearing loss
2. Patients who had mixed or sensorineural hearing loss
3. Patients who failed to report for regular follow up/ and who did not undergo HRCT
3. RESULTS AND DISCUSSION:
Of a total of 100 patients with conductive hearing loss, around 62 had a preoperative diagnosis of CSOM, while 22 were diagnosed with otosclerosis, around 14 with otitis media with effusion and remaining two as others (Figure 1).

**Chronic suppurative otitis media with effusion (CSOM)**
Most of the patients had CSOM as the diagnosis, this was in around sixty two patients. Before the HRCT, in conscripting with the diagnosis, the patients demonstrated a conductive hearing loss in PTA and a type 'b' curve in impedance audiometry in the said ear (unilateral or bilateral as the case may be). In addition, fifty patients were diagnosed to have a safe type or tubotympanic type of perforation while twelve had unsafe types of perforation which included, atticoantral perforation, retraction pockets, frank cholesteatoma and marginal perforations. Of the fifty safe type of perforation, forty six were confirmed to have safe type of perforation with normal ossicles and middle ear with no other abnormal findings. However, four cases diagnosed as safe before the HRCT were found to have abnormal findings. The twelve cases diagnosed before scan as unsafe type of perforation were confirmed by HRCT with abnormal findings. These revelations helped the surgeon to preoperatively prepare himself and the patient for a more extensive surgery. In other cases where the diagnosis was affirmed by HRCT, the HRCT complemented the surgeons findings and preoperative preparation.

A list of abnormal findings is enumerated in table 1

<table>
<thead>
<tr>
<th>Table 1: abnormal/ special findings in CSOM</th>
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<tbody>
<tr>
<td>Ossicular erosion</td>
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<tr>
<td>Erosion of the scutum</td>
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<tr>
<td>Presence of cholesteatoma or features suggestive of the same</td>
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<tr>
<td>Oto-mastoiditis</td>
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<td>Cavity formation</td>
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<td>Retraction pockets especially in the prussacks space</td>
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Otosclerosis

Otosclerosis is a fairly common diagnoses after CSOM and is a common chronic cause of conductive hearing loss both bilateral or unilateral as the case may be. The said diagnosis was pre-scan made in around twenty two patients. The audiometric analysis conformed conductive hearing loss in all the cases while the impedance was type As in around eighteen of the twenty two cases and type Ad in the remaining four. Of the twenty two cases, the loss was bilateral in twenty and unilateral in two cases. One of them had type Ad curve while the other had As curve. The hallmark of otosclerosis has been As curve. In twenty of these cases the HRCT demonstrated a normal and intact ossicular chain and demonstrated an Otosclerotic foci in around five cases in the foot plate area. All these confirmed the diagnosis of otosclerosis in these twenty patients. In the remaining two however, the HRCT demonstrated ossicular disruption and loss of the classical ice cream cone appearance which has been classically described. The diagnosis in these cases was then moved to conductive hearing loss due to ossicular dislocation. Both these cases had unilateral hearing loss and on deeper probing revealed history of head injury. Since ossicular dislocation needed a slight deviation to the routine stapes surgery, the surgeon was preoperatively prepared in dealing with the same due to the HRCT report. He could also explain preoperatively to the patient about the change in the diagnosis and prognosis of the surgery.

Radiologist often even grade the otosclerosis foci according to the Symons/Fanning grading system as described in the table 2 below:

| Grade 0: normal. |
| Grade 1: small lucent lesion at the fissula ante fenestram. |
| Grade 2A: sclerosis and narrowing of the basal turn (also has spongiotic fenestral disease). |
| Grade 2B: lucent lesion extending from the fissula ante fenestram to the middle turn of the cochlea. |
| Grade 2C: patchy lucency around the lateral aspect of basal, middle, and apical turns of the cochlea, the medial aspect of the cochlea appears spared. |
| Grade 3: severe, confluent lucency around the cochlea. |

Otitis media with effusion

The hallmark findings before scan in these cases were conductive hearing loss with type 'b' curve in impedance. This was seen in around 14 patients, although this is a self limiting condition in most of the cases, rarely it may persist beyond three months inspite of active medications. The HRCT in these cases confirmed the presence of fluid in the middle ear. In fact, even small amounts of fluid was picked up by the HRCT in every case.

Other causes

Two of the remaining patients had history of trauma and unilateral conductive hearing loss in right and left sides respectively. Both these were diagnosed as having conductive hearing loss in audiometry and having type 'Ad' curve in impedance. The HRCT revealed ossicular dislocation in the
first and incus fracture in the second case. The classical loss of "ice cream cone" appearance was well appreciated and compared with the opposite normal side.

In addition to the routine findings that the HRCT demonstrated as described above, the scans also demonstrated potential surgical hazards such low lying dura (12 cases), high jugular bulb (10 cases), anterior lying sigmoid sinus (1 case) and facial nerve dehiscence (1 case). These findings served to warn the surgeon before opening up the middle ear for surgery.

**Discussion**

A summary of pre scan and post scan findings is presented in the Figure.2 below

![Figure 2](image-url)

The figure clearly demonstrated the change in diagnosis even before the surgery was performed which cautioned or prepared the surgeon against any surprises in the operating table.

Zhonghua et al performed a study to evaluate the efficacy of high-resolution CT(HRCT) in differential diagnosis and treatment of chronic suppurative otitis media and cholesteatoma otitis media by soft-tissue shadows. HRCT scanning was performed in 120 cases, 153 ears, with chronic otitis suppurative media and cholesteatoma otitis media, of which original data were processed with multi-planar reconstruction (MPR) and maximum intensity projection (MIP), the characteristics of the soft-tissue shadows' growth, window width or window levelling and bony destruction were respectively observed, as well as compared with the surgery findings. In 120 patients (153 ears), 109 ears were diagnosed as cholesteatoma otitis media, and 44 ears were diagnosed as chronic suppurative otitis media, among which 33 ears had granulation tissue and 11 ears had secretion. One hundred and seven ears were postoperatively diagnosed as cholesteatoma otitis media, among which 25 ears had granulation tissue. Among 46 ears of chronic suppurative otitis media, 35 ears had granulation tissue, and only 11 ears had secretion. A 98.6% diagnostic accuracy can be reached with HRCT in diagnosing cholesteatoma otitis media and chronic suppurative otitis media. The Youden's index was 0.98, 0.98 and 1.00 respectively with HRCT in diagnosing cholesteatoma, granulation tissue and secretory otitis media. They concluded that combination of the three different imaging methods, axial images, coronal MPR images and MIP images, can improve the efficacy of the HRCT diagnosis and definite chronic otitis media, which can be routinely used for surgery plan.1

Vlastarakos PV et al performed a study was to evaluate the accuracy of the preoperative radiological assessment regarding 10 different middle ear structures in patients with chronic otitis media (COM) in a Tertiary university hospital. Fifty patients scheduled for a primary operation for COM. All patients underwent preoperative temporal bone high-resolution CT-scan (HRCT). AC(1)-statistics between the radiological report and the intra-operative findings were calculated. There was no correlation between the radiological assessment and the surgical findings in the scutum, attic area, and oval window. There was a poor or fair agreement on the condition of the malleus-incus complex, the status of the tympanic cavity, and the round window. There was a moderately strong agreement regarding the
status of the lateral semicircular canal (LSCC) and tegmen tympani. This agreement was primarily observed, when no erosion/exposure was present in the LSCC or the dura. There was a very strong agreement in the mastoid air-cell complex and the sigmoid sinus, especially when the former was abnormal and the latter had no pathology. There are significant difficulties in radiological imaging for reliably assessing the middle ear in patients with chronic otitis media, using HRCT. The preoperative CT scan generally underestimates the actual pathology found by the surgeon in certain middle ear areas. The researchers concluded that the decision for surgical intervention should not be based on the radiological interpretation of certain middle ear structures, and ENT surgeons should be prepared to encounter conditions which are not reported by the radiologist preoperatively, and modify the operating strategy accordingly.  

The CT grading system for otosclerosis was proposed by Symons and Fanning in 2005. The purpose of this study by T.C. Leea et al was to determine if this CT grading system has high interobserver and intraobserver agreement. All 997 petrous bone CTs performed between December 2000 and September 2007 were reviewed. A total of 81 subjects had CT evidence of otosclerosis on at least 1 side; 68 (84%) had bilateral disease. Because otosclerosis was clinically suspected in both ears of all 81 subjects even if CT evidence was only unilateral, both petrous bones (162 in total) were included. Two blinded neuroradiologists independently graded disease severity using the Symons/Fanning grading system. One reviewer repeat-graded the petrous bone CTs to determine intraobserver agreement with a 7-month intervening delay to mitigate recall bias. It was reported that there were 154 agreements (95%) comparing the first grading of reviewer 1 with that of reviewer 2 ($\kappa = 0.93$). When the repeat 7-month delayed grading of reviewer 1 was compared with that of reviewer 2, there were 151 (93%) agreements ($\kappa = 0.90$). Therefore, mean interobserver agreement was excellent (mean $\kappa = 0.92$). There were 155 agreements (96%) comparing the original grading of reviewer 1 with the delayed grading ($\kappa = 0.94$), demonstrating excellent intraobserver agreement. The authors concluded that the Symons/Fanning grading system CT grading for otosclerosis on the basis of location of involvement yielded excellent interobserver and intraobserver agreement.  

Karosi T et al conducted a study To estimate the correlations between high-resolution computed tomography (HRCT) scans, preoperative audiometric findings and histopathologic results in stapes ankylosis. A total of 57 patients with stapes ankylosis, who underwent unilateral stapedectomies were analyzed. Preoperative HRCT examinations were performed in all cases. Findings of HRCT were categorized according to Marshall's grading system. Preoperative air-bone gaps (ABGs) and bone conduction (BC) thresholds were determined. Stapes footplates removed surgically were processed using hematoxylin and eosin staining. Nonotosclerotic stapes fixations were characterized by pure conductive hearing loss that was not associated with HRCT findings. HRCT grades showed statistically significant association with BC levels at the averages of 0.5-1-2 kHz frequencies in the group of ears with inactive otosclerosis, exclusively ($p < 0.05$).

It was concluded that HRCT is a reliable imaging method in the preoperative diagnosis of different types of stapes fixations. Imaging findings should be evaluated together with clinical history and audiometric data for obtaining as precise diagnosis for stapes fixation as possible.  

The goal of a study by Shin YJ et al was to assess the reliability of CT-Scan in the cases of conductive hearing losses with normal tympanic membrane. A computed tomography of the temporal bone (CT-Scan) was performed in a prospective manner in all patients who underwent surgery for a conductive hearing loss with a normal tympanic membrane. Out of 474 cases, 437 cases (92.2%) presented with otosclerosis. In 25 cases a minor malformation (5.3%) was found at surgery, and in 12 cases (2.5%), another diagnosis was made. Sensitivity of CT-Scan was 91.3% in otosclerosis and 57% in minor malformations. In 8.7% of cases, a superficial and beginning surgical focus was put in evidence whereas CT-Scan was normal. Theses cases represent infra-radiological cases of otosclerosis. CT-Scan was found specific on the operated and deaf side, but in 11.3% of the cases, a radiologic focus did not have a clinical consequence on the controlateral side. A radiological focus is not systematically responsible for a hearing loss. Finally it was concluded that CT-Scan remains a reliable, sensitive and
specific exam in the diagnosis of cases of conductive hearing losses with normal tympanic membrane.\(^5\)

Cholesteatoma is traditionally diagnosed by otoscopic examination and treated by explorative surgery. The need for imaging in an uncomplicated case is contentious. This by N W Chee and T Y Tan assesses the usefulness of a pre-operative high-resolution CT scan in depicting the status of the middle ear structures in the presence of cholesteatoma. The surgical findings of 36 ears with cholesteatoma operated on by the first author were retrospectively compared with the CT findings reported on by the second author. All cases had at least 1, and 30 cases (83.3\%) had all, of the following radiological features: (a) a non-dependent tissue mass, (b) a location typical for cholesteatoma and (c) bony erosion. The radiosurgical agreement was excellent for the malleus (kappa statistics, \(k=0.83\)), stapes (0.94) and semicircular canals (0.8), good for the incus (0.62) and tegmen (0.65), but poor for the facial nerve canal (0.3). The researchers concluded that there is good to excellent radiosurgical correlation in cholesteatoma for most middle ear structures except for the integrity of the facial canal. The scan alerts the surgeon to potential surgical dangers and complications of disease. High-resolution CT scan is an important investigative tool prior to cholesteatoma surgery.\(^6\)

4. CONCLUSION

HRCT is an important imaging modality which has become the repertoire of Otologists before surgery and which can guide the surgeon both in diagnosis and management of the cause. It is a necessary tool in all cases of conductive hearing loss for proper diagnosis and also to plan the proper modality of treatment. Furthermore, HRCT guides the surgeon on the possible surgical hazards before the surgery so that the surgeon is prepared to face the same. The surgeon must however not depend completely on the findings of the scan and rely more on his surgical expertise and clinical judgement in treating the patient. Needless to say, HRCT could be one of the most important tools of pre-operative assessment of CSOM, otosclerosis and other causes of hearing loss.

6. REFERENCES


AUTHOR'S BRIEF BIOGRAPHY:

Dr Minutha R: She is the associate professor in the department of ENT with over six years experience in both teaching and as a practicing clinician. She has special interest in the fields of otology and rhinology.
Dr Sriram Nathan: ENT and head and neck surgeon with experience of treating thousands of patients and performing many surgeries. A gold medalist from Bangalore medical college (RGUHS), he has been extensively trained in all the fields of ENT. He has to his credit over three thousand cases of tonsillectomy, over thousand cases of FESS and over thousand cases of middle ear surgeries. Not including the many thousand cases done such as vocal cord surgeries, EAC stenosis, pre auricular sinus to name a few. Dr Sriram Nathan has single handedly removed more than four thousand documented cases of foreign bodies of nose, ear and throat.

Dr Satheesh PV: He is an experienced and senior radiologist at the Narayana Hospital Whitefield. His special interest lies in the Ultrasonography though he is also an expert in the CT of the temporal bones.