Sensitivity of High-resolution Computed Tomography of Temporal Bone in the Diagnosis of Otosclerosis

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ABSTRACT

Background

Otosclerosis is a common cause of hearing loss and manifests as stapedial and cochlear variant on computed tomography.

Objective

To determine the sensitivity of High-Resolution Computed Tomography of temporal bone in patients with surgically confirmed otosclerosis.

Method

A cross-sectional study was performed between October, 2020 to March, 2024 in a tertiary center. Patients aged 18 to 60 years who underwent stapedotomy were included in the study and pre-operative High Resolution Computed Tomography of the temporal bone were interpreted. Sensitivity of the Computed Tomography to detect otospongiotic focus was calculated.

Result

Sixty-three patients were enrolled with mean age of 32.2 ± 8.6 years. Fifty had otospongiotic focus on computed tomography. The sensitivity of High-Resolution Computed Tomography of temporal bone to identify otosclerosis was 79%. Fissula ante fenestram and cochlea were most commonly involved sites.

Conclusion

The sensitivity of scan of the temporal bone in patients with surgically confirmed otosclerosis is good when evaluated by an experienced radiologist.

KEY WORDS

Cochlear, Computed tomography, Otosclerosis, Sensitivity, Stapedial

INTRODUCTION

Otosclerosis is a focal osteodystrophic disease of the otic capsule.[1] It is a common cause of conductive, mixed and sensorineural hearing loss. The two variants of clinical otosclerosis are stapedial (fenestral) and cochlear otosclerosis.[2] The active stage is termed as otospongiosis, which is visible on the HRCT (High-Resolution Computed Tomography) scan as radiolucent or hypodense areas due to bony demineralization.[3] The inactive stage is termed as otosclerosis, which is difficult to visualize in the HRCT scan as it has same density as the surrounding bone.[3] The sites for otosclerotic foci are the area anterior to oval window (ante fenestram), round window niche, stapes footplate, area posterior to the oval window (post fenestram), internal auditory canal and cochlea.[4,5]

Traditionally, otosclerosis is diagnosed clinically and CT (Computed Tomography) scan is done preoperatively to identify possible difficulties during surgery. HRCT temporal bone aids to identify ossicular abnormalities, facial nerve anomalies, enlarged vestibular aqueduct, high jugular bulb and other inner ear anomalies. HRCT temporal bone helps the surgeon in preoperative planning and predicting post-operative results of stapedotomy.[3,6]

The sensitivity of CT scan to diagnose otosclerosis is quite variable.6 There are no such studies conducted in Nepalese population till date. Moreover, its essential to know the sensitivity of CT scan in our context to prevent economic overburden to patients. The aim of this study is to determine the sensitivity of HRCT scan of the temporal bone in patients with surgically confirmed otosclerosis.

METHODS

It was a cross-sectional study conducted in the ENT and Radiology department of Tribhuvan University Teaching Hospital from October, 2020 to March, 2024. Ethical clearance was obtained from Institutional Review Committee of the hospital prior to initiation of the study. Written informed consent was taken from the patients.

Patients of age between 18 years and 60 years with conductive or mixed hearing loss, who consented for stapedotomy were included in this study. After history taking and thorough otological examination, these patients underwent routine audiological evaluation, tympanogram and HRCT of temporal bones. Patients with sensorineural hearing loss, tympanosclerosis, ossicular discontinuity, congenital ossicular anomalies and malleus-incus fixity were excluded.

A total of 74 patients, who fulfilled the inclusion criteria were enrolled into this study. However, pre-operative CT of 11 patients were not available for evaluation in the post-operative period.

CT acquisition of the temporal bone were done with Siemens Somatom Definition AS+, using HRCT protocol. Axial and Coronal sections of bilateral temporal bones of 61 patients were evaluated by a radiologist with > 5 years of experience in the related field. The otospongiotic lesions were identified by their characteristic hypodensity or radiolucent areas in the otic capsule. The positive findings were divided as: lesions of focal hypodensity in the area of fissula ante fenestram, thickening of the stapes footplate, round window obliteration and hypodense lesion involving cochlea.10 Patients without such hypolucent lesions were categorized to have negative findings.

These patients underwent stapedotomy under local anaesthesia following its routine steps. Intraoperatively, the ossicular chain was palpated to ensure stapes fixation. Similarly, the macroscopic otosclerotic foci were noted.

Demographic data, HRCT findings and intraoperative data were entered in MS Excel and the sensitivity of HRCT of temporal bone to identify otosclerotic lesion was calculated.

RESULTS

A total of 63 patients were enrolled in this study. There were 36 female and 27 male patients. The mean age of patient was 32.2 ± 8.6 years (range: 19 years to 56 years).

Fifty patients (79%) had positive findings of otosclerosis on HRCT temporal bone whereas 13 patients had negative findings. Therefore, the sensitivity of HRCT temporal bone was found to be 79% in patients with otosclerosis.

Among 50 patients with positive findings, the most common site of hypolucency was fissula ante fenestram, seen in 46 patients (92%). Six patients had hypolucency in cochlea. Three patients had hypolucency at multiple sites on the CT scan. The findings on HRCT temporal bone is elaborated in table 1 and CT findings are illustrated in figure 1.

Table 1. Location of hypolucent lesion on HRCT temporal bone

Location of hypolucent lesion	Number of patient
Fissula ante fenestram	46 (92%)
Cochlea	6
Cochlea + Fissula ante fenestram	2
Round window niche + Fissula ante fenestram	1

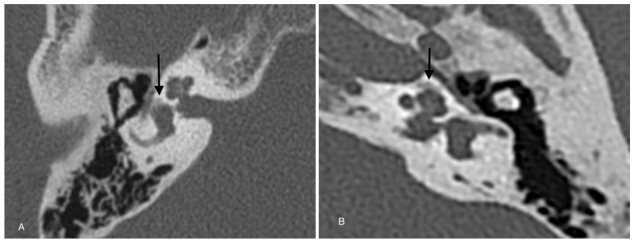

Figure 1. Otospongiotic focus (arrow) in A. Right fisula ante fenestram (fenestral type) and B. Anterior to left cochlea (cochlear type).

Intraoperatively, 38 patients (60%) had annular otosclerotic focus, 12 had obliterative, 10 had biscuit type focus, two had anterior and one had posterior otosclerotic focus.

DISCUSSIONS

Otosclerosis is categorized by histology into active phase, otospongiosis, and inactive phase, otosclerosis. In otospongiotic phase, enchondral bone of otic capsule is demineralized and replaced by foci of hypervascular spongiotic bone. This is seen on CT scan as area of radiolucency. In otosclerotic phase, the bone becomes dense and sclerotic. This type of foci could be missed on CT due to its isodensity with normal bone.[11]

The sensitivity of HRCT temporal bone to identify otosclerotic foci was 79% in this study. Fifty surgically proven otosclerosis patients had positive findings on CT scan while 13 patients had negative findings. The role of CT scan to diagnose otosclerosis pre-operatively is quite debatable. The CT sensitivity varies from 34% to 95% in different studies.[6,11,12] Naumann et al. found 85% sensitivity of CT scan to detect otosclerotic foci.[13] Maraghy et al. found 69% sensitivity while Maxwell found only 47.1% sensitivity.[3,11] A systematic review done by Kanzara has reported a relatively low sensitivity of 58%.[2] In our study, the 13 negative findings may be due to annular type of otosclerotic foci or minute superficial lesions which could be easily missed on CT scan.

The sensitivity of CT scan is 76.3% in active otospongiosis, while its only 61.9% in inactive otosclerosis.[11] The false negative reading may be due to inactive sclerotic phase of disease. In sclerotic phase, the density of otosclerotic foci increases, thereby causing difficulty in its visualization. However, there may be some irregularities or scalloping in the bone contour in otosclerotic stage.[14,15]

Other causes of false negative results in CT scan may be inframillimeter lesion, superficial lesion, density varations of less than 200 Hounsfield unit (which is invisible to naked eyes), disease limited to annular ligament, poor reformatting or poor resolution of CT scan.[2,3,6,14] Furthermore, the experience of radiologist is vital to obtain a correct report. Maxwell et al found that otosclerosis was reported by a local radiologist in only 29.4% of their cases. Further interpretation of the negative scan by neuroradiologist confirmed otosclerosis in additional 25% of these cases.[11] Bassiouni et al. reported detection rate by general radiologist as 36.1% while that by neuroradiologist as 82.5%.[16]

Tailored protocol and checklist for otosclerosis while evaluating CT aids to improve its sensitivity. Similarly, CT tissue density measurements of suspicious focal areas of temporal bone may help in positive identification of otospongiotic foci.[14] CT interpretation in computer workstation with multiplanar reconstruction and zooming the image improves sensitivity of CT scan.[13]

There are classification systems like Symons/Fanning, Rotteveel and Veillon, which have graded otosclerosis into different grades.[10,17,18] Symons/Fanning classification has graded the otosclerotic foci according to its location.[10] It has graded otosclerotic foci into fenestral, patchy cochlear and diffuse/confluent cochlear sites. This classification system has less intra and interobserver bias.[14,20]

In our study, the most common site of otospongiotic lesion on the CT scan was fissula ante fenestram as seen in other studies.[1,3] Fissula ante fenestram is a slit like space within bony otic capsule, anterior to the oval window and its the most common site of otosclerosis.[20]

Cochlear involvement was observed in six patients. Two of these patients had hypolucency in fissula ante fenestram as well. One patient had hypolucency in round window niche and fissula ante fenestram. Three patients had multiple sites involvement. Lagleyre et al. found simiar results where fissula ante fenestram and cochlea were most commonly involved in otosclerosis.[8] On CT scan, the classical appearance of hypolucent double ring around the cochlea may be visualised. However, such extensive cochlear involvement was not observed in this study. We observed patchy localised lesions around cochlea in six patients. Extensive cochlear involvement is associated with possibility of sensorineural hearing loss. Rarely, Paget's disease and osteogenesis imperfecta may mimic cochlear otosclerosis. However, clinical picture and extensive other bony involvement helps to differentiate them.[21]

Intraoperatively, the most common site of otosclerotic focus was in the annular ligament. This might be the cause for false negative CT scan findings in our study. Due to variablity in sensitivity of HRCT, other imaging modalities such as cone beam CT and ultra high resolution CT are being evalutaed.

The role of cone beam CT has been explored for active stage of fenestral otosclerosis.[22] The radiation exposure and time of image acquisition with cone beam CT is relatively less than mutidetector CT scan.[14] However, extensive study of cone beam CT for otosclerosis is still lacking in the current literature.

Xu et al. has explored the possibility of ultra high resolution CT scan as compared to high resolution CT scan in patients with fenestral otosclerosis.[23] Ultra high resolution CT has resolution upto 0.05 mm. Its sensitivity was found to be 100% and 87.5% when evaluated by a neuroradiologist and a general radiologist respectively.[23]

HRCT temporal bone aids in preoperative diagnosis of otosclerosis if scan is interpreted by an experienced radiologist. CT scan helps to predict anatomical difficulties, other possible differential diagnosis and counsel about

possibility of sensorineural hearing loss in cochlear or round window radiolucency.

The limitation of this study is its limited sample size and lack of correlation between intraoperative and radiological findings. Further study may be conducted with more sample size. Similarly, role of CT scan in fenestral and retrofensestral types of otosclerosis may be studied segregated.

CONCLUSION

The sensitivity of HRCT scan of the temporal bone in patients with surgically confirmed otosclerosis is good when evaluated by an experienced radiologist. However, negative findings on CT scan doesn't rule out its diagnosis. Therefore, clinical diagnosis along with CT findings should be correlated and CT scan may not be used as a sole tool for its diagnosis. CT scan has high value in preoperative planning and patient counselling.

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