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DETECTABILITY AND ANATOMICAL CORRELATION OF MIDDLE EAR CHOLESTEATOMA USING NON ECHO PLANAR DIFFUSION-WEIGHTED IMAGING AND HIGH RESOLUTION COMPUTED TOMOGRAPHY

Radiology

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ABSTRACT

This study was conducted to evaluate the role of non-echoplanar diffusion weighted imaging with apparent deficient coefficient values and high resolution computed tomography in detection and anatomical extend of middle ear cholesteatoma, the extent of invasion of cholesteatoma using diffusion weighted imaging and high resolution computed tomography, and ability of MRI non-echoplanar DWI sequence unequivocally confirming the diagnosis of cholesteatoma. **Materials and method:** A cross sectional study with a total of 32 patients was conducted at Chettinad Hospitals and Research Institute's Department of Radiology between January 2020 and July 2021 after being diagnosed with chronic otitis media using otoscope as per inclusion and exclusion crietria . Written informed consent was taken to participate in the study, which was authorised by our institution's ethics committee. **Results:** All statistical analyses were carried out on Microsoft Windows PCs using the SPSS, version 17. The descriptive data was represented using numbers and %ages. The data was expressed using the mean and standard deviation. To analyse qualitative data, the chi-square test was used. The screening test was carried out utilising a receiver operating characteristic (ROC) curve developed by the researchers. A p value 0.05 was judged statistically significant on both sides of the equation. **Conclusion:** Combining DWI with HRCT is a valuable method for evaluating the soft tissue of the middle ear. It has high sensitivity and specificity for detecting all primary cholesteatomas in their various stages of development.

KEYWORDS

INTRODUCTION

Middle ear cholesteatoma is a kind of chronic otitis media. Cholesteatoma is defined by the progressive proliferation of epithelial cells and the creation of granulation tissue caused by chronic inflammation or congenital causes. Cholesteasomas are known to induce osseous injury, hemifacial palsy, and hearing loss and brain abscess. Uncontrolled growth of keratinized epithelial tissue inside the mucosa-lined middle ear cavity, which desquamates and accumulates keratin as well as epithelial detritus, is known as cholesteatoma (middle ear cholesteatoma). In response to an inflammatory reaction, it has the potential to cause damage to the ossicles and bone walls of the middle ear cavity by enhancing osteoclastic activity in the middle ear cavity. Because of the risk of substantial cerebral and labyrinthine ramifications, surgery is the preferred therapeutic option, with the objective of removing illness while preserving architecture and function.

Cholesteatomas were identified using computed tomography (CT), a method for assessing bone degeneration. Because of their histological similarities to epidermoid cysts, middle ear cholesteatomas exhibit a high intensity on diffusion-weighted imaging (DWI). DWI can therefore discriminate between cholesteatomas, granulation, and fluid accumulation. The pictures of the middle ear, on the other hand, are blurry as a result of artefacts in standard DWI with echo planar imaging (EPI). Small cholesteatomas are particularly difficult to detect due to their limited sensitivity. Non-EPI DWI can detect the middle ear without artefacts despite having a longer scan duration than EPI DWI. A CT scan is conducted before to surgery in order to confirm the diagnosis and determine the severity of the disease.

CT scans are quite accurate, and in the vast majority of situations, further imaging is not required. Cholesteatoma is diagnosed on the basis of the high specificity of the lesion site and bone erosion patterns exhibited on a patient's bone scan, rather than on the basis of CT opacity, which is nonspecific for the disease. When it comes to other cases, CT opacity is ineffectual on its own, according to the researchers (congenital cholesteatomas, atypical middle ear placements, temporal bone cholesteatoma and occupied postsurgical cavities). A middle ear tumour has shown to be particularly difficult to differentiate from other causes, such as fluid, inflammatory mucosa, granulation tissue, cholesterol granuloma, surgical scar, or encephalocele. Tissue-specific imaging methods (such as magnetic resonance imaging [MRI] and, more particularly, diffusion-weighted imaging [DWI]have shown to be highly useful in this context.

The goal of this research was to see how well non-echo-planar imaging (EPI) DWI techniques using apparent diffusion coefficient values and high-resolution computed tomography could identify and diagnose invasive middle ear cholesteatoma.

MATERIALS AND METHODS

This cross sectional study included a total of 32 patients was conducted at Chettinad Hospitals and Research Institute's Department of Radiology between January 2020 and July 2021 gave written informed consent to participate in the study, which was authorised by our institution's ethics committee.

Inclusion Criteria:

Clinically suspected cholesteatomas patients undergoing HRCT temporal bone, showing soft tissue opacity in middle ear with or without bhony erosion.

Exclusion Criteria:

- Calustrophobic patients
- Patients with MRI incompatible metallic implants/prosthesis in the head and neckregion.
- Patients not giving consent

HR Computed Tomography

The CT scan was usually done 5-10 days before surgery. Surgery was scheduled for all patients based on the CT staging of Cholesteatoma. A 16-slice multidetector CT scanner was used for all imaging operations. The scans were performed with a slice thickness of 0.5mm, spacing of 0.3mm with overlap, current of 250mA, voltage To provide the most realistic representation of temporal bone architecture, the obtained data was reconstructed using the bony algorithm.

Cholesteatoma was staged using computed tomography according to its position within
- Tip of the tympanic cavity (T)
- Involvement of the mastoid (M) and
- problems that may occur (C)

The involvement of the tympanic cavity (T) is further categorised into

- Cholesteatoma in the Attic (T1)
- Cholesteatoma of the Tympanum (T2)
- Cholesteatoma atticotympanic (T3)

Mastoid involvement is divided into the following categories:
- Non-involvement of the mastoid (M0)
- Cholesteatoma spreading to the antrum of the mastoid (M1)
- Cholesteatoma that has spread to the mastoid air cells (M2)

The reporting method divided complications (C) into the following categories:
- Simple Cholesteatoma (Co)
- Cholesteatoma with problems on the extracranial (intratemporal) level
(C1), for example, a mastoid abscess or a labyrinthine fistula.
- Cholesteatoma associated with an intracranial complication (C2) such as a brain abscess or sinus thrombosis

MRI
The following sequences were utilised with a three-tesla MRI scanner.
AXIAL AND CORONAL AXES
AXIAL AND CORONAL FST2
AXIAL & CORONAL DWI
STIR

DWI
Postoperative patients and patients with inconclusive HRCT temporal bone scans were subjected to a variety of MRI procedures, the most common of which is DWI axial scans with b-values ranging from zero to one thousand seconds per millimetre squared (b-values ranging from zero to one thousand seconds per millimetre squared). The DW images were taken, and the ADC maps were generated automatically on a voxel-by-voxel basis by the algorithm on the basis of the obtained DW images.

The data was analysed using statistical tools after the postoperative findings were compared to the preoperative findings.

RESULTS
The ages of the patients varied from 16 to 65 years, with a mean of 15 to 30 years between them. Most patients were between the ages of 21 and 30 years, with the youngest being under 21. It was made up of 23 men (49 %) and 27 women (51%).

Among study group 54% were female and 46% were male gender. According to the side involved, 16 patients (50 %) have right side pathology and 16 patients (50 %) have left side pathology, suggesting that there is no majority in either way in this group.

In 23 patients out of 32, attic involvement was detected on HRCT, and comparable findings were discovered intraoperatively (Table 1 & fig 1). Tympanum involvement was found in 19 of 32 patients on HRCT, with comparable findings seen intraoperatively. (Table 2& fig 2)

Table 1: Distribution of Attic involvement

Attic involvement	DWI with HR CT	CLINICAL/ SURGICAL FINDING
YES	23	23
NO	9	9

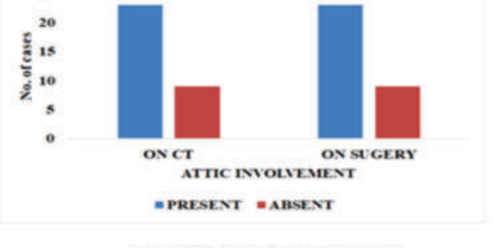

Fig 1: Distribution of Attic involvement

Table 2: Distribution of Attic involvement tympanum involvement

TYMPANUM INVOLVEMENT	DWI with HR CT	CLINICAL/ SURGICAL FINDING
YES	19	19
NO	13	13

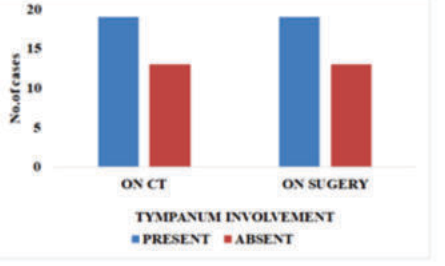

Fig 2: Distribution of Attic involvement tympanum involvement

On HRCT, involvement of the Mastoid Antrum was identified in 24 of 32 patients, and similar findings were described intraoperatively in the same patients. Scutum erosion was found in 18 of 32 patients on HRCT, with comparable findings seen intraoperatively. (Table 3& fig 3).

Table 3: Scutum involvement

SCUTUM INVOLVEMENT	DWI with HR CT	CLINICAL/ SURGICAL FINDING
YES	18	18
NO	14	14

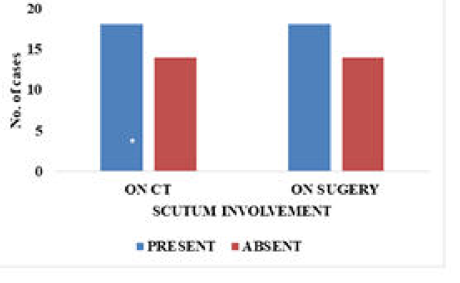

Fig 3: Distribution of scutum involvement

Malleus erosion was identified in 27 of 32 patients on HRCT, while it was found in 29 patients intraoperatively. Incus erosion was shown on HRCT in 24 of the 32 patients, however it was discovered intraoperatively in 28 of them.

Stapes erosion was shown on HRCT in four of the 32 patients, but it was discovered intraoperatively in six of them . Aditus involvement was found in 21 of 32 patients on HRCT, and a comparable result was also seen intraoperatively (Table 4& fig 4).

Table 4: Aditus involvement

ADITUS INVOLVEMENT	DWI with HR CT	CLINICAL/ SURGICAL FINDING
Yes	21	21
No	11	11

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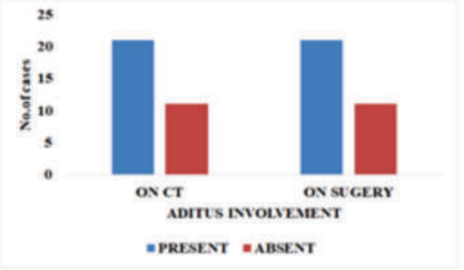

Fig 4: Distribution of aditus involvement

Facial Nerve canal involvement was seen on HRCT in 10 of the 32 patients, however it was only identified intraoperatively in 9 of them. LSCC erosion was seen on HRCT in three of the 32 patients, but it was discovered intraoperatively in four of them.

Tegmen erosion was shown on HRCT in 7 of the 32 patients, however it was discovered intraoperatively in 8 of them. Sigmoid plate erosion was identified in 1 patient out of 32 on HRCT, and comparable results were confirmed intraoperatively (Table 5 & fig 5).

Table 5: Sigmoid plate erosion

SIGMOID PLATE EROSION	DWI with HR CT	ON SURGERY
Yes	1	1
NO	31	31

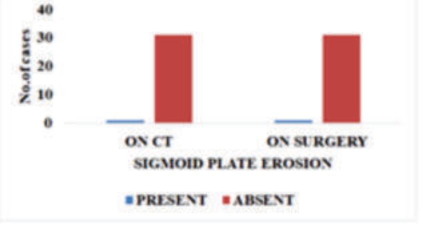

Fig 5: Distribution of Sigmoid plate erosion

Intracranial problems were identified in two individuals out of 32 on HRCT, with comparable results in other examinations. Extracranial complication was recognised in one patient out of 32 in HRCT data, however it was discovered in three patients intraoperatively. During an HRCT, it was observed that one patient had an extracranial complication of postauricular abscess, while two other patients experienced intraoperative extracranial complications of labyrinthine fistula and mastoid abscess (Table 6 & fig 6).

Table 6: Extra cranial complication

EXTRA CRANIAL COMPLICATIONS	DWI with HR CT	CLINICAL/ SURGICAL FINDING
Yes	1	3
No	31	29

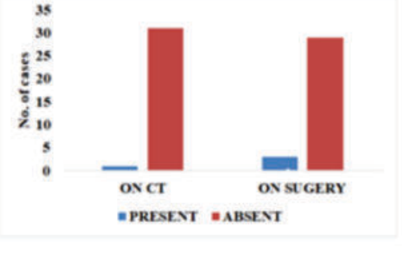

Fig 6: Distribution of Extra cranial complication

STAGING

According to the staging, stage-II was the most prevalent (53.1%), followed by stage-III (21.9%), stage-I (18.%), and stage-IV (6.3%). Comparison of CT finding of middle ear cholesteatoma vs surgical finding. (Table 7).

Comparison of CT finding of middle ear cholesteatoma vs surgical finding

SENSITIVITY IN DIFFERENT TYPES

Classification	DWI with CT	Surgery	Sensitivity
Involvement of Tympanic cavity			
Attic cholesteatoma- T1	3	3	
T2- Tympanic cholesteatoma	8	9	
T3- Atticotympanic cholesteatoma	20	20	100%
Involvement of Mastoid cavity			
M0- No involvement of mastoid cavity	8	8	
M1: Cholesteatoma extending through the mastoid antrum	24	24	
M2: Cholesteatoma extending through the mastoid air cells	0	0	100%
Complications seen			
C0- Uncomplicated	29	27	
C1- Extracranial complications	1	3	
C2- Intracranial complications	2	2	60%

DISCUSSION

An investigation into middle ear cholesteatoma indicated that HRCT staging was very sensitive (86.6 %) and consistent with surgical results (excellent agreement and consistency). HRCT scans may miss the presence of cholesteatoma sacs, accompanying granulation tissue, mucosal edoema, and effusion, resulting in an underestimating of the presence of cholesteatoma on CT. On DWI HR CT, cholesteatoma had a lower attenuation value than granulation tissue, but the difference was insignificant, and cholesteatoma could not be differentiated from granulation tissue using attenuation values alone. In addition to conventional imaging, non-echo planar diffusion weighted MR imaging is required to discriminate between cholesteatoma and liver scar tissue.

Among the patients, 20 % had attic cholesteatoma; 18 % were found to be suffering from tympanic cholesteatoma; and 62% were found to be suffering from atticotymapnic cholesteatoma. Attic cholesteatoma appears on HRCT as a soft dense mass opacity in the lateral Prussak's space, which is inferior to the middle ear ossicles; on HRCT, tympanic cholesteatoma occupies the tympanic space, which is superior to the middle ear ossicles and frequently involves the facial recess and sinus tympani. Cholestatomia atticotympanica is a kind of cholesteatoma that takes up most of the tympanic cavity, as the name implies.

It was discovered in this research that CT scans were completely sensitive for detecting mastoid involvement. Cholesteatoma patients may have symptoms that are both extracranial and intracranial in nature. The occurrence and location of a complication are important factors in treatment decisions. Among cholesteatoma patients, 4 % had a labyrinthine fistula that included part of the lateral semicircular canal, according to the researchers. Despite the fact that it is uncommon, the presence of a pneumolabyrinth is an unmistakable indicator of fistulas. It has been shown that the most frequent extratemporal consequence of infection spreading from the mastoid to the periosteal space via mastoid cortical erosion is a subperiosteal abscess [(1–3)].

In patients with cholesteatoma, the most common intracranial consequence is brain abscess, which occurs most often in the temporal lobe and cerebellum [(3–8)]. The results of this investigation revealed that one patient had extracranial problems, whereas the other two patients had intracranial abnormalities due to cholesteatoma.

For otologists, deciding whether to do a whole canal wall removal, a canal wall down removal, or a transcanal atticotomy may be problematic when dealing with cholesteatoma. A more accurate and potentially less invasive surgical procedure, as well as better clinical outcomes, may be achieved through the use of this staging system. There has to be more study done to understand if there is a relationship between this stage and outcomes.

There are a number of limitations to the findings of this study. For starters, only a small number of patients participated in the trial; multicenter studies including a large number of patients have shown that CT staging for cholesteatoma is effective and safe. A total of 16 multi-detector CT scanners were employed in this investigation, which is the second point to mention. Better picture quality will be achieved by the increased use of multi-detector CT scanners such as 64 or 256-detector CT scanners, dual-energy CT scanners, and cone beam CT scanners [9–11]. Another advantage of merging CT data with diffusion and contrast MR imaging is that the results in tough cases will be enhanced as well.

CONCLUSION

Combining DWI with HRCT is a valuable method for evaluating the soft tissue of the middle ear. It has high sensitivity and specificity for detecting all primary cholesteatomas in their various stages of development. The technique may be used to identify granulation tissue, scar tissue, and cholesteatoma in postoperative patients, especially when the results of HRCT temporal bone are ambiguous. Modern non-echoplanar diffusion methods using smaller slices aid in the identification of minor lesions in the brain. This research developed a novel non-invasive HRCT staging system for middle ear cholesteatoma that may assist surgeons in determining the optimum kind of surgery to do in order to decrease complication rates.

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