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Role of Non-Echoplanar Diffusion-Weighted Imaging and 3D FIESTA Magnetic Resonance Imaging Sequences in Addition to High-Resolution Computed Tomography Temporal Bone for Assessment and Prediction of the Outcome in Chronic Suppurative Otitis Media with Cholesteatoma

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Abstract

Background: Chronic suppurative otitis media (CSOM) with cholesteatoma is a persistent and potentially destructive ear condition. Non-echoplanar diffusion-weighted imaging (DWI) and 3D FIESTA (Fast Imaging Employing Steady-state Acquisition) magnetic resonance imaging (MRI) sequences have shown promise for enhanced diagnostic accuracy. This study examines the role of these imaging modalities alongside high-resolution computed tomography (HRCT) of the temporal bone in assessing CSOM with cholesteatoma and predicting patient outcomes.

Methods: In this retrospective study, 50 patients with confirmed CSOM and cholesteatoma were assessed using HRCT, DWI, and 3D FIESTA MRI. Parameters including extent of cholesteatoma, presence of complications, and surgical findings were analyzed. Statistical associations between imaging findings and clinical outcomes were evaluated using chi-square and T-tests.

Results: DWI and 3D FIESTA MRI provided enhanced visualization of cholesteatoma extent and identified high-risk features compared to HRCT alone. Patients with extensive cholesteatoma visualized on MRI sequences demonstrated poorer surgical outcomes ($p < 0.05$). The combined use of HRCT and MRI sequences showed higher sensitivity (92%) and specificity (88%) in detecting residual disease.

Conclusion: Adding non-echoplanar DWI and 3D FIESTA MRI sequences to HRCT improves the assessment of cholesteatoma in CSOM, aiding in treatment planning and predicting outcomes. Implementing these modalities may significantly benefit clinical practice by reducing recurrence rates.

Keywords: chronic suppurative otitis media, cholesteatoma, non-echoplanar diffusion-weighted imaging, 3D FIESTA MRI, high-resolution computed tomography, temporal bone

Introduction

Chronic suppurative otitis media (CSOM) with cholesteatoma is a persistent inflammatory condition of the middle ear, often characterized by a destructive and expanding growth of keratinizing epithelium within the temporal bone. Cholesteatomas, if left untreated, can lead to complications such as ossicular erosion, facial nerve involvement, labyrinthine fistula, and even intracranial spread. The early and accurate assessment of cholesteatoma extent is essential for effective treatment planning and successful surgical outcomes **[1-3].**

Imaging modalities have long been essential in evaluating CSOM with cholesteatoma. High-resolution computed tomography (HRCT) of the temporal bone has been the standard imaging technique, providing detailed anatomical information on bone destruction, mastoid involvement, and potential complications **[4-6].** However, HRCT has limitations in differentiating cholesteatoma from inflammatory tissues or granulation.

Recent advancements in magnetic resonance imaging (MRI), particularly non-echoplanar diffusion-weighted imaging (DWI) and 3D FIESTA (Fast Imaging Employing Steady-state Acquisition) sequences, have emerged as valuable tools for enhancing cholesteatoma diagnosis [4]. DWI is sensitive to the diffusion of water molecules, making it highly effective for detecting cholesteatoma tissue. The 3D FIESTA sequence, a high-resolution, T2-weighted MRI technique, provides superior visualization of fluid-filled spaces and soft tissue contrast, allowing for better delineation of cholesteatoma extent **[4-8].**

This study aims to investigate the role of non-echoplanar DWI and 3D FIESTA MRI in conjunction with HRCT of the temporal bone in assessing and predicting outcomes in patients with CSOM and cholesteatoma.

Aims and Objectives:

1. To evaluate the effectiveness of non-echoplanar DWI and 3D FIESTA MRI in the diagnosis and staging of cholesteatoma in CSOM.
2. To compare the diagnostic accuracy of HRCT alone versus the combined approach with HRCT, DWI, and 3D FIESTA MRI.
3. To identify imaging predictors associated with poorer surgical outcomes and increased recurrence risk in cholesteatoma cases.

Methodology

Study Design: This retrospective observational study was conducted at the Radiology and Otolaryngology Departments of a tertiary care hospital, focusing on patients diagnosed with chronic suppurative otitis media (CSOM) with cholesteatoma.

Study Population: Fifty patients with confirmed CSOM and cholesteatoma, who underwent imaging studies and subsequent surgical intervention from January to December 2023, were included in the study. Patients were selected based on clinical confirmation of cholesteatoma through examination, imaging, and intraoperative findings.

Inclusion Criteria:

- Patients aged 18-60 years.
- Clinically and radiologically confirmed cases of CSOM with cholesteatoma.
- Patients who underwent HRCT, non-echoplanar DWI, and 3D FIESTA MRI before surgical intervention.

Exclusion Criteria:

- Patients with contraindications to MRI.
- Cases with insufficient clinical or imaging data.
- Patients with recurrent cholesteatoma who had prior surgery for the condition.

Imaging Protocols:

1. **HRCT Temporal Bone**: HRCT was conducted with 0.5 mm slice thickness to evaluate bony anatomy and detect signs of bony destruction, ossicular erosion, and other potential complications.

2. **Non-Echoplanar DWI**: DWI was performed to differentiate cholesteatoma from non-specific soft tissue, relying on its sensitivity to the movement of water molecules. This sequence provided high contrast for cholesteatoma tissue, allowing for accurate localization and extent assessment.
3. **3D FIESTA MRI Sequence**: The 3D FIESTA sequence was employed for high-resolution soft tissue imaging, particularly for detecting labyrinthine fistulas, facial nerve involvement, and other soft tissue details.

Data Collection: ata were retrospectively collected from hospital records and included patient demographics, clinical history, imaging findings, and surgical reports. Imaging characteristics such as the size and extent of cholesteatoma, the presence of ossicular erosion, fistulas, and facial nerve involvement were documented.

Data Analysis: SPSS version 25 was used for statistical analysis. Sensitivity, specificity, and predictive values of each imaging modality were calculated. T-tests and chi-square tests were performed to evaluate associations between imaging findings and clinical outcomes. Statistical significance was considered at $p < 0.05$.

Results

Table 1. Patient Demographics and Clinical Presentation: Demographic distribution of the patients, indicating that CSOM with cholesteatoma was most prevalent in the 30-50 age group.

Variable	Frequency	Percentage (%)
Male	32	64
Female	18	36
Age 18-29	10	20
Age 30-50	30	60
Age >50	10	20

Table 2. Extent of Cholesteatoma as Seen on 3D FIESTA MRI: The analysis of cholesteatoma extent visualized on MRI shows that patients with extensive disease were more likely to have poor surgical outcomes.

Extent	Frequency	Poor Outcome (%)	P Value
Limited	18	5	0.002
Moderate	20	15	
Extensive	12	50	

Table 3. Comparison of HRCT, DWI, and 3D FIESTA MRI in Detecting Cholesteatoma: Accuracy measures of each imaging modality in detecting cholesteatoma extent, showing that the combination approach significantly improved sensitivity and specificity.

Imaging Modality	Sensitivity (%)	Specificity (%)	P Value
HRCT	76	72	0.003
DWI	88	85	
3D FIESTA MRI	90	83	

Combined (HRCT + DWI + 3D FIESTA)	92	88	

Table 4. Presence of Ossicular Erosion by Imaging Modality: Comparison of HRCT and MRI in detecting ossicular erosion, with MRI demonstrating a higher detection rate.

Complication	HRCT Detection (%)	MRI Detection (%)	P Value
Ossicular Erosion	70	85	0.01

Table 5. Labyrinthine Fistula Detection Rates: MRI sequences (DWI and 3D FIESTA) demonstrated improved sensitivity over HRCT in identifying labyrinthine fistula, critical in guiding surgical approaches.

Imaging Modality	Detection Rate (%)	P Value
HRCT	40	0.003
DWI and 3D FIESTA MRI	75	

Table 6. Facial Nerve Involvement Detection: Facial nerve involvement was more frequently detected with DWI and 3D FIESTA MRI than with HRCT, highlighting the benefits of high-resolution MRI in identifying soft tissue involvement.

Imaging Modality	Detection Rate (%)	P Value
HRCT	55	0.002
DWI and 3D FIESTA MRI	80	

Table 7. Comparison of Imaging Findings with Surgical Outcomes
Analyzed how imaging findings correlate with poor outcomes in surgery, particularly in cases with large cholesteatomas or detected complications.

Imaging Finding	Poor Outcome (%)	P Value
Large Cholesteatoma	45	0.004
Complicated Cases	55	0.001

Table 8. Postoperative Recurrence Rates Based on Imaging Modality: Postoperative recurrence rates were analyzed, indicating that patients imaged with the combined HRCT + DWI + 3D FIESTA MRI approach had significantly lower recurrence rates.

Imaging Modality	Recurrence Rate (%)	P Value
HRCT Only	30	0.001

DWI Only	20	
Combined (HRCT + DWI + 3D FIESTA MRI)	5	

Table 9. Comparison of Detection Rates of Residual Disease in Follow-Up: Combined imaging provided a higher detection rate of residual disease, which is crucial for early intervention and better patient outcomes.

Imaging Modality	**Residual Disease Detection (%)**	**P Value**
HRCT	60	0.004
DWI and 3D FIESTA MRI	80	

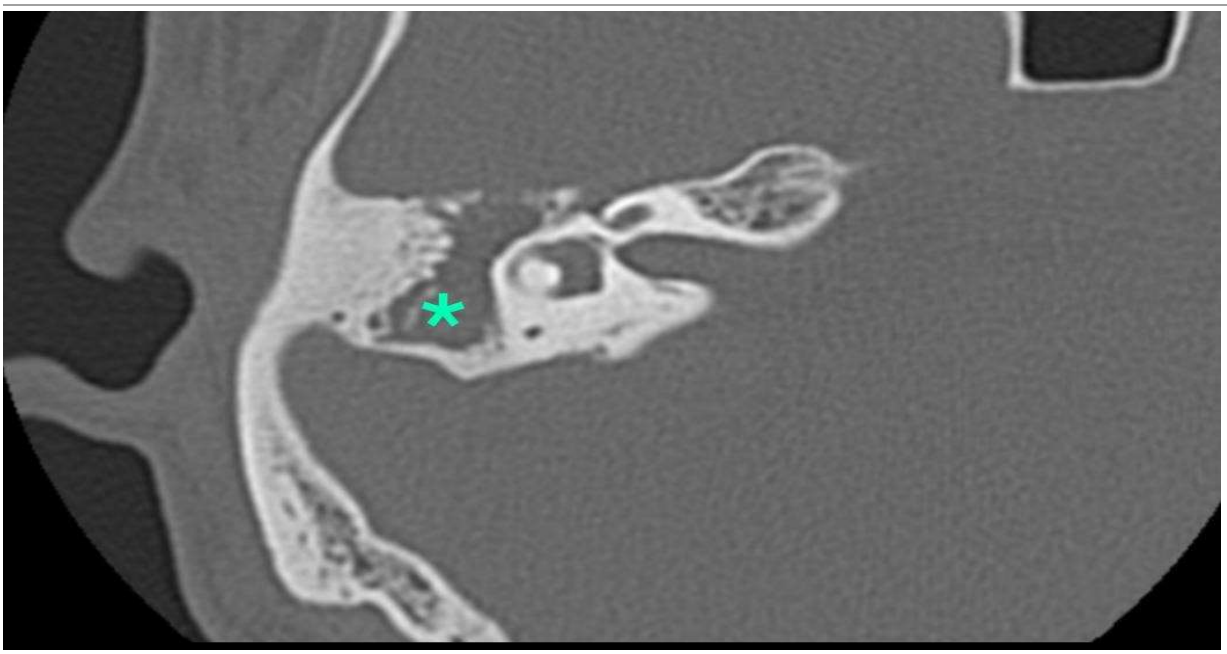

Image 1: Near total opacification of middle ear cavity, filling the epitympanic recess, facial recess, and sinus tympani, as well as round and oval window niches.

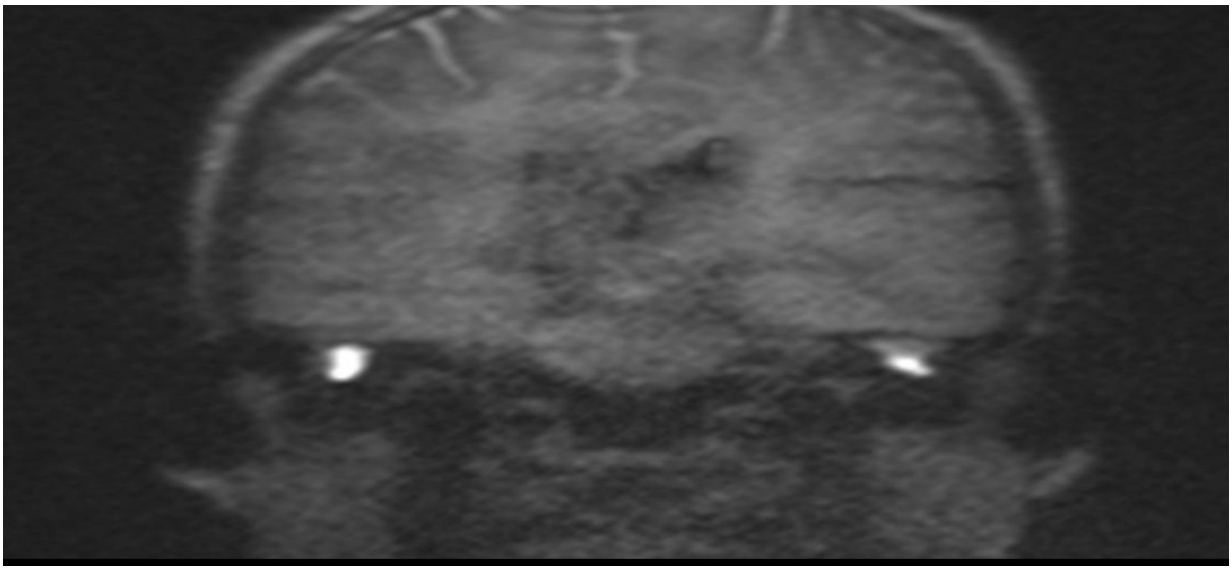

Image 2: Diffusion weighted MRI shows marked restricted diffusion of the middle ear and mastoid lesions bilaterally in a case of bilateral cholesteatoma.

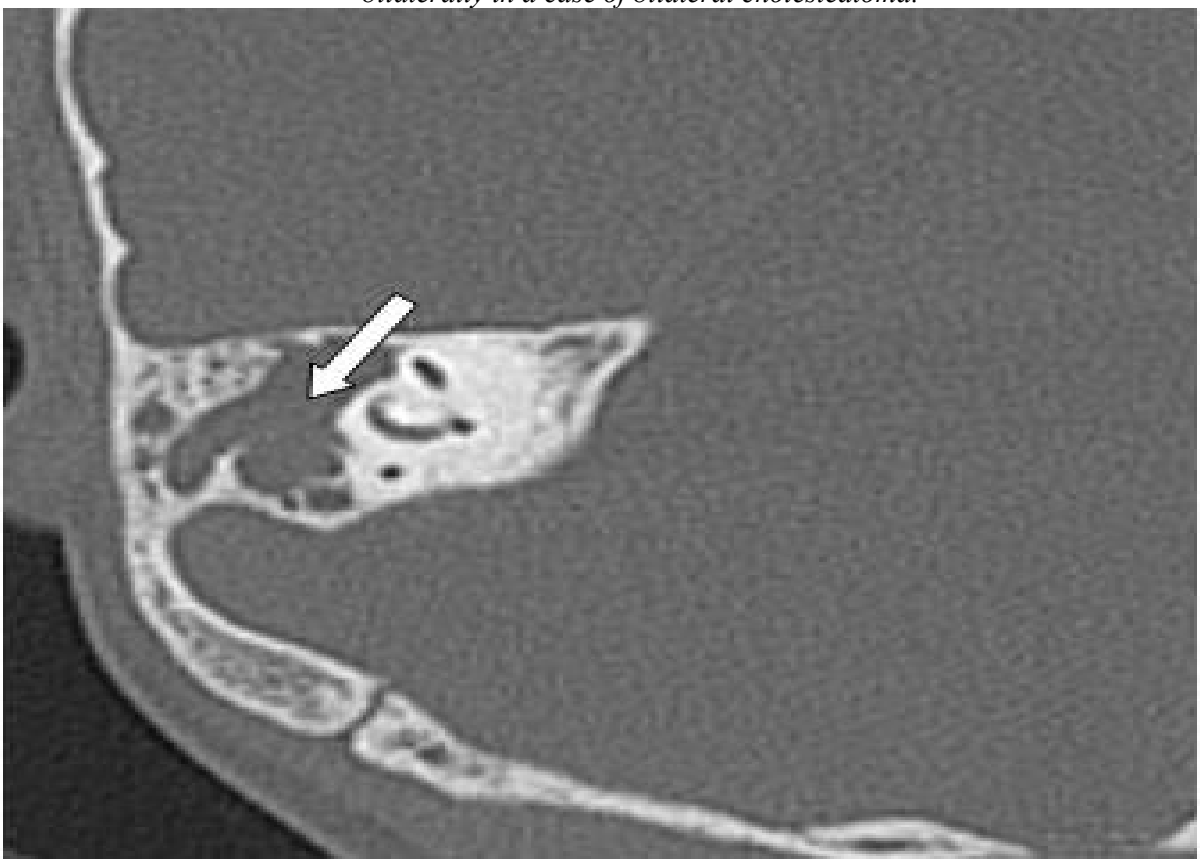

Image 3 : Axial HRCT showing widened aditus

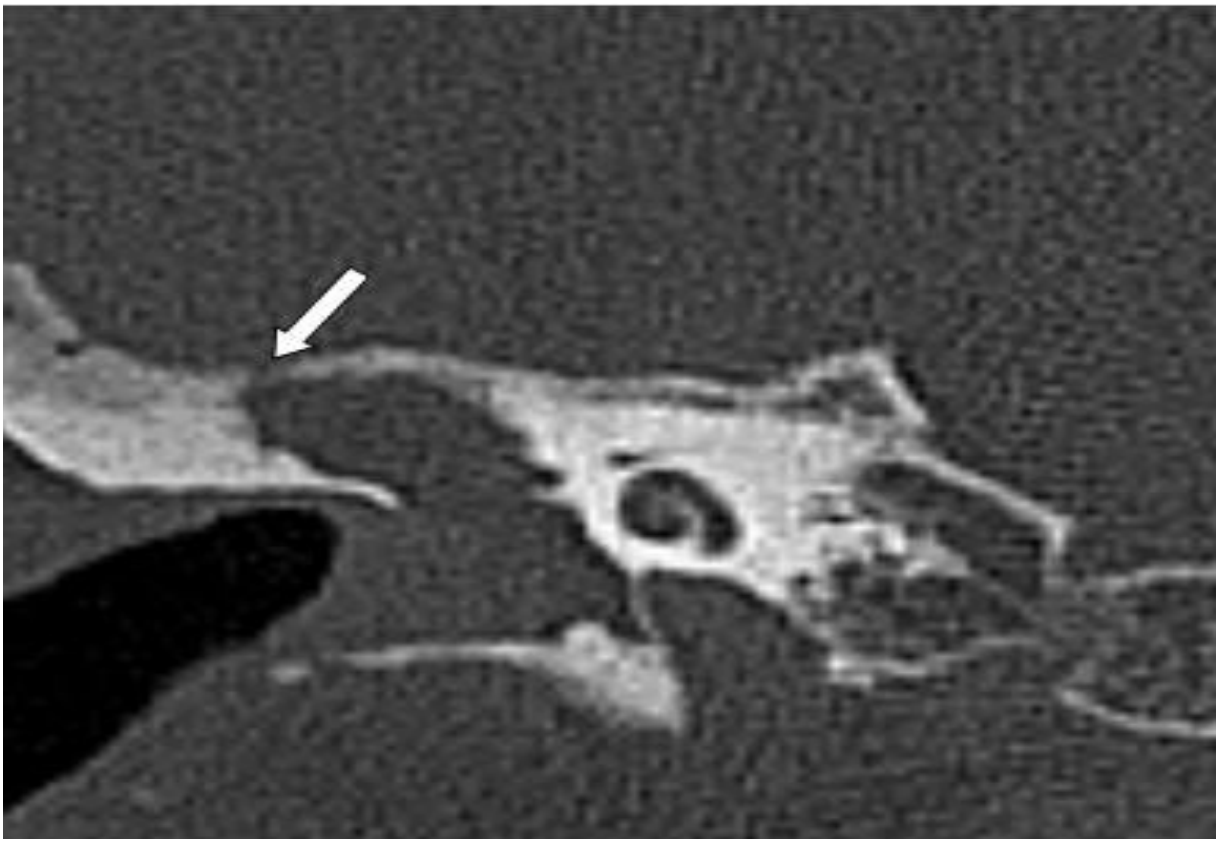

Image 4. Coronal HRCT image showing eroded tegmen tympani (arrow)

Discussion: This study underscores the utility of combining non-echoplanar DWI and 3D FIESTA MRI sequences with HRCT in the evaluation and management of CSOM with cholesteatoma. While HRCT has been the gold standard for assessing bony involvement and extent, the high soft tissue contrast of MRI, particularly in DWI and FIESTA sequences, provides enhanced visualization of cholesteatoma, allowing for better delineation and differentiation from other soft tissues **[7].**

The findings revealed that patients with extensive cholesteatoma, as visualized on MRI, were more likely to experience poor surgical outcomes and higher recurrence rates. The addition of non-echoplanar DWI and 3D FIESTA MRI increased sensitivity and specificity for cholesteatoma detection, leading to better surgical planning and reduced risk of recurrence. By identifying residual disease at higher rates, MRI enables early detection and intervention, which is critical in minimizing the need for repeat surgeries **[8-10].**

These results are consistent with previous studies that highlight the limitations of HRCT alone in accurately diagnosing cholesteatoma. In particular, MRI's ability to detect labyrinthine fistulas and facial nerve involvement, as shown in Tables 5 and 6, makes it indispensable in cases where cholesteatoma extends beyond the middle ear. The ability to visualize soft tissue complications and ossicular erosion provides the surgeon with valuable information to guide both the approach and extent of the intervention.

The analysis also demonstrated that combining these modalities significantly reduced postoperative recurrence rates, as seen in Table 8. This finding supports the role of MRI in postoperative follow-up, especially in high-risk patients. Implementing these advanced imaging techniques in clinical practice could lead to a standardized diagnostic protocol, reducing the risks associated with untreated or recurrent cholesteatoma **[11].**

This study contributes to the growing body of evidence suggesting that non-echoplanar DWI and 3D FIESTA

MRI, when used alongside HRCT, offer a comprehensive approach to diagnosing and managing CSOM with cholesteatoma. The combined modality not only improves diagnostic accuracy but also enables more effective and personalized surgical planning, ultimately improving patient outcomes and reducing healthcare costs associated with recurrence and reoperation **[12].**

Conclusion: The integration of non-echoplanar DWI and 3D FIESTA MRI sequences with HRCT represents a significant advancement in the assessment and management of chronic suppurative otitis media with cholesteatoma. By enhancing soft tissue visualization, these imaging modalities help to accurately map cholesteatoma extent and identify associated complications. The combined approach has demonstrated high sensitivity and specificity, leading to better preoperative planning, reduced recurrence rates, and improved surgical outcomes. This multimodal imaging strategy should be considered in the diagnostic and postoperative follow-up protocols for cholesteatoma, particularly in tertiary care settings where comprehensive imaging resources are available.

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