ORIGINAL ARTICLE

Diffusion Weighted Imaging and Enhanced MRI in Diagnosing Primary and Residual/Recurrent Cholesteatoma

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Abstract

Background: ***It is still challenging to recognize a primary or residual cholesteatoma using imaging methods. Otoscopic abnormalities, hearing loss, and otorrhea are the main clinical suspicions for cholesteatoma.***

Aim of the study: ***To determine and assess the specificity and sensitivity of the diffusion weighted imaging (DWI) with magnetic resonance imaging (MRI) for the identification of primary acquired and residual cholesteatoma, with confirmation from surgy in every case.***

Patients and methods: ***Using MRI and non-echoplanar DWI. Forty individuals were assessed. The first 22 subjects were evaluated to diagnose primary acquired cholesteatoma. A total of 18 patients were evaluated for residual cholesteatoma 12–24 months after initial cholesteatoma surgery in the group that underwent second-look surgery. Surgical outcomes were contrasted with pre surgical DWI and MRI result.***

Results: ***Of the 21 patients undergoing primary surgery, a cholesteatoma-related DWI high signal was identified in 95.45% of cases, having a specificity of 100% and a positive predictive value of 95.45%. The DWI showed a false negative case for cholesteatoma smaller than 3 mm. The DWI high signal related to residual cholesteatoma in the second-look surgery group was seen in 17 cases having a positive predictive value of 94.4%, a sensitivity of 94.4%, and a specificity of 100%. Due to a movement artifact, the DWI displayed a false negative case. Our study discovered no false positive or no true negative cases.***

Conclusions: ***This retrospective analysis concluded that diffusion-weighted MRI is an effective diagnostic method for primary cholesteatoma and for evaluating postoperative cases.***

Keywords: Cholesteatoma; Non-echoplanar diffusion weighted(Non-EPI-DWI); Enhanced MRI

1. Introduction

It is still difficult to identify a primary or residual cholesteatoma using imaging methods. Otoscopic abnormalities, hearing loss (conductive, sensory neural, or mixed), and otorrhea are the main clinical suspicions used to diagnose a primary cholesteatoma. Computed tomography (CT) can provide more details about extension and ossicular and bony degradation. In certain situations, magnetic resonance imaging (MR) might be helpful in describing potential problems and providing additional soft tissue characterization.[1]

Evidence suggests that high-resolution CT and MR imaging are insensitive enough to identify residual cholesteatoma after cholesteatoma surgery, rendering their use in this regard misleading.[2,3]

Nevertheless, new findings suggest that MR imaging becomes even more effective in cholesteatoma detection when combined with DWI and delayed post-contrast T1WI.[4,5]

The purpose of this research is to determine how well non-echoplanar-DWI using 3 mm slice thickness with enhanced MRI can detect primary acquired and residual cholesteatoma, and whether or not surgical confirmation is always necessary for a correct diagnosis.

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2. Patients and methods

Case Selection:

Forty patients were evaluated. The initial group of 22 individuals was assessed to determine whether a primary acquired cholesteatoma was present in the proper clinical situation. Before undergoing second-look surgery, 18 individuals in the second group had their residual cholesteatoma assessed 12–24 months following cholesteatoma surgery. We compared the DWI results before surgery with the postoperative outcomes. Analysis was conducted on the sensitivity, the specificity, and the positive predictive values in each group. The radiology and otorhinolaryngology departments of Al Azhar University Hospitals performed the research from May 2022 to June 2024.

MR Imaging Technique:

In order to conduct the 1.5 T MRI, the Philips Achieva Medical Systems (Netherlands) 4-channel head coil was utilized. The identical protocol was administered to all patients and comprised:

Coronal and axial T1 weighted images, pre-contrast: The repetition time is 760 milliseconds. Time to Echo (TE): 12.5 milliseconds. The field of view is 20 millimeters. NEX: 5. The matrix is 320 by 225, and the slice thickness is 3 mm.

The time required for the coronal T2WI SE is 3650 ms. TE: 90 milliseconds. NEX: 5. Thickness of the slices: 3 mm. 20 mm field of view. The matrix: 320 by 225.

Axial non-echoplanar DWI in single-shot turbo spin echo (non-EP DWI SS TSE) : TR: 6260 milliseconds. TE: 130 milliseconds. Field of view (FOV): 22 mm. The b factor: 0, 500 & 1000 mm^3/s. Thickness of the slices: 3 mm.

The 3D FIESTA (Fast Imaging Using Steady State Acquisition) technique has a TR of 9 milliseconds. TE: 5 milliseconds. The slice is 2 mm thick. The matrix has dimensions 512 × 512. Field of view: 170x170 mm. T1WI delayed post-contrast pictures (axial and coronal).

MR Imaging interpretation:

In cases of cholesteatoma, we found a diffusion restriction pattern that was hyper-intense in DWI and hypo-intense in the ADC. An ADC value of 859.4 × 10^{-6} mm^2/s was averaged. In contrast, there was marginal or no enhancement. In T1WI, the signal was low to intermediate, but in T2WI, it was hyper-intense.

In inflammatory or postoperative granulation tissue that is not cholesteatomatous, we found a free diffusion pattern (iso to low signal in DWI and bright signal in ADC map), with an average ADC value of 2216.3 × 10^{-6} mm^2/s After contrast, there was homogenous enhancement. In T1WI the signal was iso to low, but in T2 WI, it was hyper-intense.

Table 1. MRI signal pattern that allows cholesteatoma and inflammatory/postoperative granulation tissue lesions to be distinguished:

SEQUENCE	CHOLESTEATOMA	INFLAMMATORY / POSTOPERATIVE GRANULATION TISSUE
SS TSE DWI	hyper-intense in DWI and hypo-intense in the ADC	iso to hypo-intense signal in DWI and hyper-intense in ADC
DELAYED POST-CONTRAST T1WI	Marginal or No enhancement	Homogeneous enhancement
T1WI SIGNAL	low to intermediate signal	Iso to low signal
T2WI SIGNAL	hyper-intense	hyper-intense

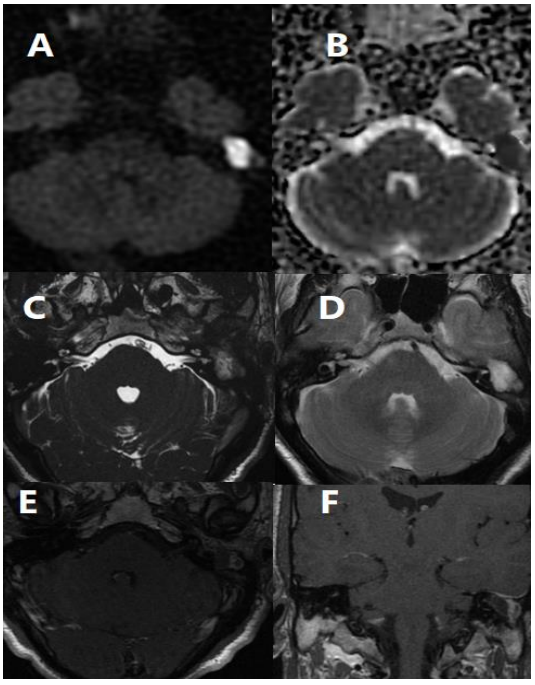

Figure 1. Selected MRI images that were typical for cholesteatoma: DWI (A). ADC (B). Axial T2 high-resolution (C). Axial T2 SE WI (D). Post-contrast axial T1 (E). Post-contrast coronal delayed T1WI (F). A left petrous bone abnormality, a bright DWI signal, a dark ADC signal (restricted diffusion), a bright T2 signal, and high-resolution T2 WI with marginal post-contrast enhancement in the delayed phase. Co-existing complication findings include infiltration of the facial nerve tympanic bony canal, tegmen tympani as well as dural enhancement are present. Intracranial extension does not exist.

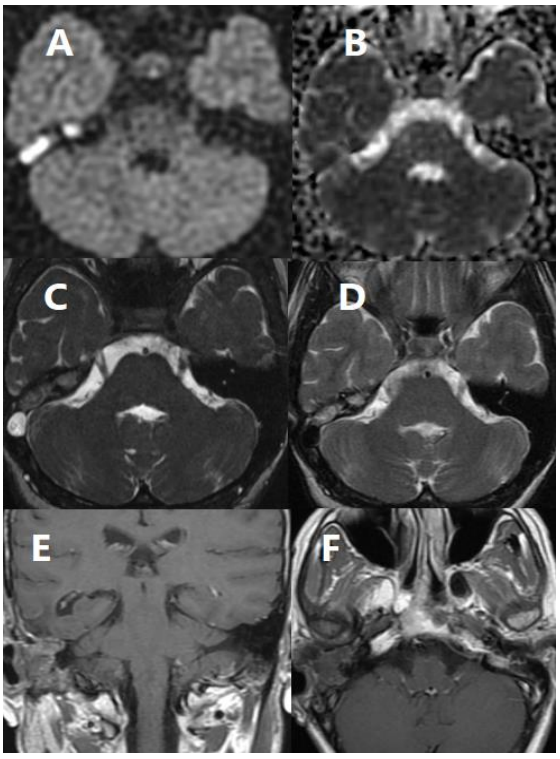

Figure 2. Selected MRI images that were verified during surgery and showed a signal of postoperative recurrent/residual cholesteatoma: DWI (A). ADC (B). Axial T2 high-resolution (C). Axial T2 SE WI (D). Post-contrast coronal T1 (E). Post-contrast axial delayed T1WI (F). An opacified right mastoid antrum with a soft tissue signal lesion without intracranial extension displays a confined diffusion restriction pattern (High DWI signal and low ADC map signal), high signal in T2, high-resolution T2 WIs, and a slight non-uniform post-contrast enhancement.

3. Results

With a sensitivity of 95.45%, specificity of 100%, and positive predictive value of 95.45%, a high DWI signal matches with cholesteatoma was depicted in 21 cases among the primary surgery patients using DWI. The DWI showed a false negative case when the size of the lesion was less than used 3 mm slice-thickness. Neither true negatives nor false positives were found in our study.

In 17 cases within the group of patients who underwent second-look surgery, a DWI signal consistent with recurrent cholesteatoma was identified. A positive predictive value of 94.4%, a sensitivity of 94.4 percent, and a specificity of 100%. The DWI showed a false negative case because of a motion artifact. Our research did not find any instances of either false positives or real negatives.

These findings support the usefulness of DWI in identifying both small residual cholesteatoma and primary cholesteatoma.

4. Discussion

When it comes to diagnosing cholesteatoma and assessing its location, extent, and related issues, the gold standard imaging technique is the petrous bone High-Resolution Computerized Tomography (HRCT). On the other hand, HRCT isn't perfect and can't tell the difference between granulation tissue, inflammatory tissue, and recurring or residual cholesteatoma after surgery.[6,7]

MRI is helpful for pre- and postoperative cholesteatoma identification. Furthermore, cholesteatoma and postoperative granulation/inflammatory tissue can be clearly distinguished using MRI with DWI and delayed enhancement.[8]

In the diffusion study, the aim is to depict tissue water molecule mobility that is stochastic. We compared the diffusion coefficients of different kinds of tissue with the water diffusion coefficient. As an example, cholesteatomas show restricted diffusion patterns and a high DWI signal.[9]

Either non-echoplanar DWI in single-shot turbo spin echo (non-EP DWI SS TSE) or echoplanar (EP) imaging can be used for diffusion-weighted (DW) purposes. In terms of cholesteatoma diagnosis, only a small number of studies have compared the two DWI methods.[10]

There is less chance of mistaking high signals at the bone-brain or air-bone boundary for raised diffusion signals suggestive of cholesteatoma when using the non-echoplanar DWI in SS TSE instead of EP DWI since it shows fewer susceptibility artifacts.[11] Furthermore, tiny cholesteatomas measuring 3 mm or larger can be identified early with the help of the non-echoplanar DWI in SS TSE sequence, which offers more spatial and contrast resolution than the echoplanar DWI.[12]

Because of their shared histology, cholesteatoma and epidermoid cysts are easy to detect with non-echoplanar DWI in SS TSE, which was used in our study.[13]

Khemani et al.,[14] treated postoperative residual cholesteatoma with delayed 45 minutes T1 WI post-intravenous contrast administration of gadolinium to identify it and differentiate it from scar tissue or inflammatory tissue. While scarring tissue and inflammation showed homogenous delayed enhancement, recurrent and residual cholesteatoma showed either no or very delayed enhancement. Cholesteatoma cases showed delayed marginal enhancement or minimal to no enhancement at all, whereas scarring tissue and inflammatory showed homogenous delayed enhancement.

When it comes to the inner ear and/or cerebral region, MRI can detect associated problems.[15]

According to De Foer et al.,[16] MRI is a reliable tool for the diagnosis of inner ear and cerebral problems, such as tegmen tympani erosions, labyrinthine fistulas, and intracranial extension.

Limitations: When it comes to seeing bone, HRCT is more trustworthy than diffusion MRI sequences. For cholesteatomas smaller than 3 mm or those that have been surgically emptied, DWI may give an inaccurate negative result.[17,18]

False positives in DWIs, displaying an artificially high signal, can also occur in cases involving prior surgical procedures and the existence of Silastic sheeting material. Radiologists must have access to comprehensive patient records regarding surgical procedures.[19,20]

Besides the time allotted for the pre-contrast evaluation, the thorough examination period requires a further 45 minutes following the injection of contrast. In addition, there are a number of general restrictions, such as the fact that contrast and diffusion studies are relatively expensive, the need for a 1.5 tesla MRI machine at least, and general anesthesia is required for extremely young children and patients who are not cooperative. In order to better assess bone structures, it is crucial to conduct a temporal bone HRCT on every patient.[21]

4. Conclusion

By preventing potential complications, the early radiological and clinical diagnosis improves the surgical outcome and prognosis. Radiologists can more accurately evaluate the petrous bone, detect cholesteatomas early, and evaluate possible complications before surgery thanks to the availability of HRCT machines. HRCT is still unable to distinguish between different petrous bone pathologies, particularly in the aftermath of surgery.

In both preoperative and postoperative settings, the MRI examination is essential for identifying cholesteatoma. Utilizing DWI, ADC map, T1 WI, T2 WIs, and delayed post-contrast T1 WIs can considerably facilitate the early diagnosis of cholesteatoma as well as the distinction of residual/recurrent cholesteatoma from postoperative granulation tissue.

Disclosure

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Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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