



Editorial

Diffusion-Weighted Magnetic Resonance Imaging of Cholesteatoma: Navigating the Multifarious Techniques

Jyoti Kumar¹

¹ Department of Radiology, Maulana Azad Medical College, New Delhi, India

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Cholesteatoma is a benign inflammatory pathology that affects the middle ear as well as other pneumatized areas of temporal bone and can be highly aggressive in its spread pattern. It is characterized histologically by keratinizing squamous epithelium lining a cystlike structure filled with desquamated keratin. The epithelium, also known as the matrix, is surrounded by the perimatrix consisting of inflammatory cells and fibroblasts. The surrounding bone erosion has been ascribed to multiple factors such as induced pressure effect and release of inflammatory mediators that recruit osteoclastic activity. If not treated in time, destruction can advance and extend to surrounding structures that include the labyrinth, petrous apex, mastoid, and external auditory canal (EAC), and can further lead to facial nerve paralysis and intracranial complications.

Nearly 98% of middle ear cholesteatomas are acquired. The acquired form is related to eustachian tube dysfunction and chronic inflammatory middle ear disease. Congenital cholesteatoma is rare (2% of cases) and has a variable location in the temporal bone. With no history of ear infection and intact tympanic membrane, otoscopic diagnosis of congenital cholesteatoma is difficult.¹

Cholesteatoma is managed surgically either using a canal wall down (CWD) or canal wall up (CWU) tympanoplasty. CWD tympanoplasty offers better removal of the disease from various potential sites of recurrence and the resultant cavity is easily accessible on otoscopy. The flipside of this procedure is the myriad cavity problems, like persistent ear discharge and wax/debris retention. The CWU technique maintains the posterior wall of the EAC and is less disfiguring. Hearing aids can be easily accommodated in the preserved EAC. It is the preferred technique, especially in younger patients with limited disease. However, the chances of recidivistic (residual/recurrent) disease are much higher after CWU tympanoplasty, which is difficult to evaluate on clinical examination and otoscopy. Hence, routine “second-

look” surgery is most often performed within 6 to 18 months of the CWU technique.

Imaging plays a key role in the evaluation of cholesteatoma. High-resolution computed tomography (HRCT) of temporal bone remains the mainstay of investigation for newly diagnosed cholesteatoma. While the opacity of the lesion on HRCT is not specific, the diagnosis is based on the location of the lesion, ossicular displacement, and bone erosion pattern. The detailed osseous anatomy depicted on HRCT also provides a surgical road map. In primary cholesteatoma, the use of magnetic resonance imaging (MRI) is restricted to few clinical situations that include high-risk retraction pockets, impaired otoscopic examination owing to EAC stenosis, and monitoring of disease in the rare subset of patients in whom surgery cannot be performed. In the evaluation of recidivistic cholesteatoma, the diagnostic dilemma is higher. HRCT cannot distinguish between granulation tissue, cholesterol granuloma, or cholesteatoma in the postoperative ear. Diffusion-weighted (DW) MRI is considered the most accurate investigation for detection of cholesteatoma in this setting. Whether DW MRI can replace routine “second-look” surgery is being widely investigated.

Diffusion-weighted imaging (DWI) can be obtained using echoplanar imaging (EPI) and non-EPI techniques. The single-shot EPI DWI sequence, the most widely used DW sequence in clinical practice, is prone to susceptibility and distortion artifacts owing to multiple airborne interfaces at the level of the skull base. Non-EPI DWI lacks image distortion and susceptibility artifacts and provides superior spatial resolution. Various studies demonstrate that the sensitivity and specificity of non-EPI DWI lies between 80 and 100% in the diagnosis of cholesteatoma.²

RESOLVE (read-out segmentation of long variable echo trains) DWI is a relatively new multishot EPI-based diffusion technique that was first described by Porter and Heidemann.³ It enables high spatial resolution images by dividing

Address for correspondence
Jyoti Kumar, MD, DNB, MNAMS,
FICRI, Department of Radiology,
Maulana Azad Medical College,
New Delhi, India
(e-mail: drjyotikumar@gmail.
com).

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the k trajectory into multiple segments in the read-out direction. The susceptibility and distortion artifacts also get significantly reduced. Also, multishot EPI DWI is widely available as it requires no special installation.

As it is a relatively new technique, there are very few studies in the literature that have evaluated RESOLVE DWI for its diagnostic utility in the setting of cholesteatoma. In this issue of IJRI, Zaman et al⁴ have evaluated RESOLVE in middle ear cholesteatoma, correlating with surgical and histopathological findings. They acquired RESOLVE in the axial plane at three *b*-values of 0, 800, and 1,000 s/mm² with a slice thickness of 2.5 mm with no interslice gap and an acquisition time of approximately 5 minutes on a 3-T MRI scanner. Out of 100 temporal bones evaluated with RESOLVE DWI, there were nine postoperative temporal bones. They reported an overall sensitivity of 94.8%, specificity of 95.2%, positive predictive value (PPV) of 96%, negative predictive value (NPV) of 93%, and diagnostic accuracy of 95%. However, the performance in recurrent cholesteatoma was not at par. They acknowledged their limitation of very few postoperative temporal bones in the study set and reported a sensitivity of 50%, specificity of 60%, and diagnostic accuracy of 55.56% in cases of recurrent cholesteatoma.

Zaman et al⁴ have not evaluated the utility of apparent diffusion coefficient (ADC) values in diagnosis of cholesteatoma as the high signal intensity of cholesteatoma on DWI is attributed to a combination of restricted molecular diffusion and T2 shine-through effect. Review of the published literature also reveals varied opinions on the value of ADC calculation.

Fischer et al⁵ performed a retrospective study, evaluating 50 patients (including 26 postoperative patients) with RESOLVE DWI, using 3-mm slice thickness in both axial and coronal planes, on a 1.5-T MRI scanner. The authors felt that 1.5-T MRI was the superior choice owing to reduced susceptibility artifacts at this strength. RESOLVE DWI had an overall accuracy of 92%, sensitivity of 88%, specificity of 96%, PPV of 96%, and NPV of 89% in detection of cholesteatoma. In cases of recidivistic disease, RESOLVE DWI depicted a sensitivity of 92%, specificity of 93%, PPV of 92%, and NPV of 93%. They found their results to be comparable with the pooled sensitivity and specificity of 91 and 92% in the largest meta-analysis (including 26 studies and 1,152 patient episodes) on non-EPI DWI in the detection of recidivistic cholesteatoma.⁶ The performance of RESOLVE DWI was much superior to that seen by Zaman et al⁴ in the postoperative setting.

In a study done on 135 postoperative patients using non-EPI DWI for detecting recidivistic cholesteatoma, Lips et al⁷ advocated the use of 1.5-T scanners over 3-T scanners as sensitivity and specificity for detection of cholesteatoma were lower for 3-T scanners compared with 1.5-T scanners.

Apart from usage of different field strengths, different planes of acquisition (axial/coronal/both) for DWI in different studies also compound the literature results.

Zaman et al⁴ have reported three false-negative cases owing to the small size (<3 mm) of cholesteatoma. Various studies on non-EPI DWI also report nonvisualization of cholesteatoma in the size range of 2 to 3 mm.^{8,9} It is believed

that missing such a small cholesteatoma is of low risk owing to the slow growth rate of cholesteatoma.⁸ The mean growth rate of cholesteatoma has been estimated to be 2.74 mm/y.¹⁰ To mitigate the risk of missed disease in the postoperative setting, Steens et al¹¹ have recommended routine use of two follow-up DW MR scans. In their study, they found that 31% of cholesteatomas were missed on the first postoperative DW scan performed 6 to 24 months after surgery. The second follow-up DWI done at least 6 months later picked up these cases and was found to be extremely useful at their institution to replace “second-look surgery.”

DWI is a nonmorphological imaging technique and combined utility of T1- and T2-weighted images to obtain morphological information, as performed by Zaman et al,⁴ comes at the cost of decreased sensitivity although the specificity increases. Advanced software that can fuse DWI with T2-weighted sequences/CT images or create color-coded translation of DW images is also being investigated for adding value to the diagnostic ability of this technique.

The study by Zaman et al⁴ adds to the current body of literature in this field. However, further studies using larger number of patients are required to explore the full potential of RESOLVE DWI in the diagnosis of primary cholesteatoma and precluding unnecessary second-look surgeries in recidivistic disease.

Conflict of Interest

None declared.

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