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The accuracy and sensitivity of diffusion-weighted magnetic resonance imaging with Apparent Diffusion Coefficients in diagnosis of recurrent cholesteatoma

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ABSTRACT

Objective: To evaluate the accuracy and sensitivity of diffusion-weighted magnetic resonance imaging with ADC value combined with MDCT in evaluating recurrent cholesteatoma.
Patients: Thirty patients (20 females and 10 males), their age ranged from 10 to 40years, had undergone a tympanomastoid surgery for a cholesteatoma of the middle ear underwent MDCT and MR DWI examination before second- or third-look surgery from May 2015 to October 2016.
Results: CT showed partial opacification of the tympanomastoid cavity in 10 ears and complete opacification in 21 ears. CT detects 10 cases out of 20 cases of recurrent cholesteatoma with sensitivity 47.6%, specificity 100%, and NPP 47.6%. DWI depicted 21 out of 20 cases proved cholesteatoma patients (sensitivity 100%, specificity 90%, PPV 95.2% and P value is 0.001). All MRI of patients without cholesteatoma were correctly interpreted as showing negative findings for cholesteatoma (specificity = 100%). The ADC of cholesteatoma group (21 ears) were ranged from 553 to 759×10^{-3} mm^2/s and the ADCs of non cholesteatoma group (10 ears) was ranged from 1495.8 to 1766.8×10^{-3} mm^2/s. Cut off value of cholesteatoma is $\leq 759 \times 10^{-3}$ mm^2/s.
Conclusion: MR DWI with ADC combined with MDCT has high sensitivity, specificity, accuracy in detecting recurrent cholesteatoma.

1. Introduction

Middle ear cholesteatoma is a benign cystic lesion of aggressive behavior which requiring prompt surgical treatment to prevent local and intracranial complications [1]. Surgery is the mainstay treatment of cholesteatoma However, the risk of residual cholesteatoma and recurrence occurs in a relatively high numbers of patients, whatever the type of surgery used [2,3]. The detection of cholesteatoma in patients who have undergone middle ear surgery is often difficult for the follow-up of patients operated for cholesteatoma [4]. High resolution computerized tomography (CT) scan is considered the basic method for imaging the nonoperated middle ear and can be complemented by magnetic resonance imaging (MRI) [3–6]. However, following mastoid surgery, both imaging modalities cannot reliably distinguish residual or recurrent disease from postoperative changes such as granulation tissue, fluid or fibrous tissue [6].

Diffusion-weighted (DW) sequences are highly promising in differentiating recurrent cholesteatoma from granulation tissue DW MRI depends on the difference in diffusion of water molecules in different biological tissues. Water molecules in cholesteatoma are less mobile giving rise to a hyperintense signal. In granulation tissue, water molecules are more mobile and thus appear less intense on DW sequence [7,8].

Currently, single-shot echo-planar DWI is the most used DWI technique because of its short imaging time (about 2 min). On the other hand, multi-shot non-echo-planar DWI sequences requiring a longer imaging time are associated with decreased susceptibility artifacts [7,8].

The ADC map is free from T1 or T2 effects, and provides a true quantitative display of water diffusion at each voxel [9,10]. ADCs, have not yet been assessed as a diagnostic criterion for the detection of recurrent middle ear cholesteatoma with no clear-cut values exist for differentiation of recurrent cholesteatoma from granulation tissue or fibrosis [11–15]. In this study, we aim to determine

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Table 1
Clinical presentations of 30 patients (31 ears).

Clinical presentation	No. of patients	%
Chronic purulent ear discharge	25	83.4
Chronic discharge with tympanic membrane perforation	3	10
Chronic discharge with signs of increased I.C.T	1	3.3
Chronic discharge with facial paresis	1	3.3
Total	30	100

Table 2
CT findings of 30 patients with previous tympanomastoid surgery (31 ears).

CT finding	No. of patient	%
Type of surgery performed		
Canal wall up	17	54.8 45.2
Canal wall down	14	
Tissue density mass		
Partial opacification	10	32.3
Complete opacification	21	67.7
Size of the tissue density mass	10 mm 30 mm	
Ossicular chain		
Intact	6	19.4
No ossicles	25	80.6
Associated Bony erosion		
Eroded tegmen	1	3.2
Eroded sigmoid sinus plate	1	3.2
Eroded facial nerve canal	1	3.2
Eroded lateral mastoid wall	3	9.6
The other (sound) ear		
Normal	25	83.4
CSOM	4	13.3
Cholesteatoma	1	3.3

the diagnostic accuracy of DWI and the difference between the ADCs of postoperative middle ear cleft cholesteatoma and those of non-cholesteatomatous tissue on single-shot echo planar DW images.

2. Patients and methods

The study was approved by the institutional review board and informed consent was obtained from all patients. We included 30 consecutive patients in our study, previously subjected to tympanomastoid surgery for the treatment of cholesteatoma with clinical and CT suspicion of recurrence and scheduled for second look operation, during the period from May 2015 to October 2016. Twenty patients were females and 10 were males, with an age ranging from 9 to 45 years old (mean = 27 years). One patient had bilateral middle ear surgery for cholesteatoma. Canal wall-up technique was already done for 17 ears, while 14 ears had canal wall-down technique. The main clinical presentation of the patients was a recurrent purulent discharge (n = 25), perforated tympanic membrane with and without discharge (n = 3), chronic ear discharge with sign of increase intracranial tension (n = 1), chronic discharge with facial paresis (n = 1) (Table 1). All patients were scheduled for revision surgery and the intraoperative findings were compared to imaging results.

The mean interval between the first tympanomastoid surgery and CT examination was 12–30 months; all patients were further assessed by MRI imaging of the petrous temporal bone on an average of 1–2 weeks after CT examination. Positive cases of recurrent cholesteatoma were referred for second-look surgery, while −ve cases received medical treatment. The second-look surgery was performed within 2–3weeks after the MR examination.

Inclusion criteria include: Patient with history of tympanomastoid surgery for cholesteatoma with clinical suspicion of recurrent cholesteatoma or infection during follow-up.

Exclusion criteria include: patient with unclear operative history, active infection or mastoid abscess.

2.1. All patients are subjected

1. **Full history taking including**: Age, sex, chronic ear discharge, conductive hearing loss, headache, vomiting (signs of increased intracranial tension) and facial palsy.
2. **Through clinical examination**: All Patients are subjected to otoscopic examination at the ENT Department.
3. **Operative history**: (mastoidectomy, otoscope and otoendoscope)

4.1: MDCT examination using multi-detector CT scanner 16 channel (GE CT/Bright speed Elite scanner, General Electric Medical System, USA).

CT technique: The images were obtained with 0.5 mm collimation, 0.5 mm thickness, 320 mAs, and 120kVp. The obtained data was reconstructed in the axial plane using high resolution bone algorithm (extended window sitting at around 4000HU and window level around 300HU) with 0.5 mm section thickness, 0.05 mm increments, and a FOV of 100, with a matrix size of 512 × 512. At this collimation, an isotropic voxel (which measure 0.5 mm per side) was obtained. The axial data were then transferred to a separate workstation for post-processing, with a commercially available 3D reformatting software (Baxara 3D). Sections was taken at 1 mm increments beginning at the level of the floor of hypotympanum and jugular fossa extending to the level of arcuate eminence using line for localization.

4.2: MRI examinations were performed with 1.5-T MRI unit (Philips, Achiva, Philips Medical Systems, Eindhoven, Netherlands) following patients' informed consent and exclusion of contraindications. The following sequences were acquired on the middle ear using an 8 channel head coil and applying the Parallel SENSE imaging is used to obtain better resolution, faster dynamic scans and to reduce susceptibility artifacts. DWI parameters includes (FOV, 230 × 230 mm; Epi factor, 61; thickness/gap, 5/1 mm; acquisition matrix, 112 × 89) was performed by using b values of 800 and 1000 s/mm^2 in axial, multisection, single-shot, echo-planar imaging sequence. TE was taken as short as possible for the acquisition of the highest signal-to-noise ratio. The ADC maps were reconstructed with commercially available software.

The following sequences were acquired on the middle ear.

1. 3D CISS (constructive interference in steady state) with a gradient echo component tilt angle: 70°, slice thickness: 0.7 mm,

Table 3
Sensitivity and specificity of MR DWI, MDCT, both, operative in diagnosing recurrent cholesteatoma.

Examination	Recurrent cholesteatoma	Sensitivity	Specificity	PPV	NPP
MR DWI	21	100%	90.9%	95.2%	100%
MDCT	10	50%	100%	100%	52.4%
Combined DWI and MDCT	21	100%	90.9%	95.2%	100%
Operative	20	100%	100%	100%	100%