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Magnetic resonance imaging at one year for detection of postoperative residual cholesteatoma in children: Is it too early?

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Objective: To compare the residual cholesteatoma detection accuracy of diffusion-weighted (DW) and T1 delayed sequences for magnetic resonance at one year postoperative with second-look surgery in pediatric patients who have undergone primary middle ear surgery for cholesteatoma.
Methods: This was a prospective monocentric consecutive study conducted in a tertiary academic referral center. Children were referred for MR imaging (MRI) one year after surgery. A 1.5 T MRI was utilized, using nonecho-planar DW images and delayed gadolinium-enhanced T1-weighted images. Accuracy of magnetic resonance imaging was assessed by two radiologists before surgery. Interobserver and intraobserver agreements were assessed using the κ test. Magnetic resonance imaging data were compared with surgery, which was considered as the gold standard.
Results: Twenty-four consecutive unselected pediatric patients were included. Sensitivity, specificity, positive predictive value, and negative predictive value for the first observer were of 40%, 86%, 67%, and 67%, respectively, and those for the second observer were 30%, 86%, 60%, and 63%, respectively. The only two cholesteatoma with a size superior to 3 mm were diagnosed before surgery, but the majority of small cholesteatoma were not detected.
Conclusions: MRI is a key examen to diagnosed the residual cholesteatoma but is limited by the size of the lesion under 3 mm. Delaying the realization of MRI during follow-up could increase sensitivity, thus avoiding misdiagnosis as well as unnecessary second look surgery.

1. Introduction

Cholesteatoma is a non-neoplastic but destructive cystic lesion of keratinizing stratified squamous epithelium, which can lead to labyrinthine, facial or cerebromeningeal complications. Surgery, mainly canal wall-up tympanomastoidectomy, is therefore necessary to eradicate cholesteatoma of the middle ear. Besides cholesteatoma disease presents several major differences in children compared with adults. It is more aggressive in children. There is a higher residual rate after surgery: 30% in children vs 3%–15% in adults [1]. Otoscopic evaluation may be more challenging because of the frequent use of cartilaginous graft for tympanic membrane repair in children, which prevents an optimal detection of retrotympanic cholesteatomas.

Thus, the main objective of the follow-up after initial surgery is to rule out the presence of a residual cholesteatoma. Because of the frequent use of cartilaginous tympanic membrane repair, "second-look" surgery is currently the gold standard to detect and

Abbreviations: DW MRI, diffusion-weighted magnetic resonance imaging; EPI, echo planar imaging; TSE, turbo spin echo; CT, computed tomography; PPV, positive predictive value; NPV, negative predictive value; TR, time of repetition (ms); TE, time echo (ms).

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treat residual disease in children. However, imaging plays a major role in the follow-up. CT can be useful to detect a residual cholesteatoma; a lobulated or heterogeneous soft tissue mass associated with focal bony erosion is highly evocative. Unfortunately, CT becomes unreliable when the postoperative cavity is partially or completely opacified, which is more frequent in children [2,3].

Conversely, magnetic resonance imaging (MRI) has progressively gained importance in the follow-up because of performing sequences, such as delayed gadolinium-enhanced T1-weighted images (WI) and diffusion-weighted (DW) images. Diffusion-weighted magnetic resonance images (DW MRI) relies on the signal produced by the diffusion motion of water protons in biologic tissues. Stratification of keratin in residual cholesteatoma has high signal intensity, whereas other tissues that can be found in the middle ear after surgery show low or intermediate signal intensity on DW images [4]. Delayed gadolinium-enhanced T1 WI relies on the nonenhancement of residual cholesteatoma, whereas surrounding inflammatory fibrous tissue is enhanced. This allows a correct distinction between disease and reactive tissue [5].

Despite the well documented follow-up with MRI in adults, there is too few studies evaluating MRI in pediatric follow-up, and the number of pediatric patients included is too small to provide reliable data [6–9]. Cholesteatoma residual disease presents major differences in children versus adults, preventing a reliable extrapolation from adult series.

The aim of our study was to compare MRI performances to "second-look" surgery in the evaluation of postoperative residual cholesteatoma in children. Our goal was to use MRI follow-up as a reliable tool to delay or prevent second-look surgery.

2. Materials and methods

2.1. Patients

This is a monocentric study in a tertiary academic referral center. All consecutive children with cholesteatoma requiring second-look surgery and managed in our institution between June and October 2010 were retrospectively included. Decision for the second-look surgery was made by the surgeon on the basis of findings at first-stage surgery and on clinical follow-up [10].

We collected information on clinical, radiological, surgical, and pathological findings. Children underwent an MR imaging before "second-look" surgery, which was programmed 12 months after the initial surgery.

This study was approved by the local ethical committee. Informed consent was obtained from all individual participants included in the study.

2.2. Imaging technique

MR imaging was performed with a 1.5 T MRI scanner (Achieva; Philips Medical Systems, Best, The Netherlands), using spin echo DW (SE-DW) images and delayed contrast-enhanced T1-weighted images. A head coil was used.

Coronal 2.5-mm-thick SE-DW sequences were obtained with the following parameters: ECG triggering; RT (repetition time)/ET (echo time), 3000/106; field of view (FOV), 230 × 230; matrix 176 × 100; *b* factors of 0 and 800 s/mm^2; and acquisition time, 3 min 12 s.

Axial 4.5-mm-thick dual turbo SE T2-weighted images were obtained with the following parameters RT/ET, 2293/110; FOV, 230 × 230; matrix, 256 × 168; acquisition time, 1 min 45 s.

Coronal 1.7-mm-thick turbo SE T2-weighted images were obtained with the following parameters: RT/ET, 3500/120; FOV, 230 × 230; matrix, 336 × 212; acquisition time, 4 min 26 s.

Axial and coronal 2-mm-thick SE T1-weighted images were performed 30–45 min after intravenous contrast injection of 0.1 mmol per kilogram of body weight of gadoterate meglumine (Dotarem®; Guerbet, Roissy, France): RT/ET, 526/20; FOV, 180 × 180; matrix, 205 × 204; acquisition time, 3 min 36 s (Table 1).

Light sedation, consisting of 5 mg/kg of pentobarbital, was used in children above the age of five, and no sedation was used for younger children. No general anesthesia was used.

2.3. Imaging and surgical evaluation

Criteria for diagnosis of residual cholesteatoma was very high signal intensity in the middle ear or in the mastoid cavity on DWI sequence compared with brain tissue, corresponding to restricted diffusion on ADC maps. Unenhanced intermediary to low signal mass of the soft tissue mass within the postoperative cavity on delayed contrast-enhanced T1-weighted images was considered as a residual cholesteatoma. A complete (homogeneous) enhancement of the mass was conclusive for noncholesteatomatous postoperative tissue [11].

All images were analyzed by two radiologists blinded to any surgical and clinical information about patients. Imaging data were classified into two groups: "residual cholesteatoma" and "no cholesteatoma." Radiologists described precise localization and measured diameter of all detected residual cholesteatoma.

Second-look surgery was performed by one of 6 experienced surgeons (2–30 years of experience in cholesteatoma surgery). Surgical results were classified as "residual cholesteatoma" and "no residual cholesteatoma." Cholesteatoma localized in the middle ear was measured during surgery.

Histologic evaluation was systematically performed, and cholesteatoma were measured again.

2.4. Statistical analysis

Nonweighted kappa statistics with the 95% confidence interval (CI) was used to test for interobserver agreement of the 3-step classification system using arbitrary interpretation by Landis and Koch (0, poor agreement; 0.00–0.20, slight agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, substantial agreement; and 0.80–1.00, almost perfect agreement) [12].

Sensitivity, specificity, positive (PPV), and negative predictive values (NPV) were assessed. We decided to keep statistical values from the most experimented radiologist to discuss our results and to compare our statistics with those of other series.

Table 1
MRI parameters.

Sequence	Dual SE T2	SE T2	DWI B = 0 and B = 800 s/mm^2	Delayed contrast enhanced T1 WI
FOV (mm)	230	230	230	180
Slice thickness (mm)	4.5	1.7	2.5	2
TR (ms)	2293	3500	3000	526
TE (ms)	110	120	106	20
Number of excitations	2	6	1	2
Number of slice/partition	12	14	9	11
Acquisition plane	Axial	Coronal	Coronal	Axial and coronal
Acquisition time (min)	1.45	4.26	3.12	3.36
Matrix	256 × 168	336 × 212	176 × 100	205 × 204