ORIGINAL ARTICLE
OTOLOGY
DOI: 10.5152/B-ENT.2021.20128

Managing postoperative cholesteatoma: second-look surgery or surveillance with diffusion-weighted magnetic resonance imaging

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Cite this article as: Patel B, Steele K, Pal S, Singh A, Lingam R. Managing postoperative cholesteatoma: second-look surgery or surveillance with diffusion-weighted magnetic resonance imaging. B-ENT 2020; 16(4): 197-201.

ABSTRACT

Objective: To compare second-look surgery with surveillance using serial nonechoplanar diffusion-weighted imaging to detect residual cholesteatoma after canal wall-up mastoidectomy.

Methods: This was a longitudinal observational study. A prospectively collected database was searched for patients who underwent canal wall-up mastoidectomy and had an initial negative diffusion-weighted imaging scan 9-12 months after the surgery. A total of 34 patients were included; 13 patients subsequently underwent second-look surgery, and 21 patients were monitored with serial diffusion-weighted imaging for at least 3 years.

Results: Of the 13 patients who underwent second-look surgery, 11 (85%) had no residual cholesteatoma, but 2 (15%) had residual disease. A total of 3 patients (23%) developed postsurgical complications after the second-look surgery. Of the 21 patients who were planned for serial monitoring with diffusion-weighted imaging, 3 (14%) were lost to follow-up after the first year. Of the remaining 18 patients, the second diffusion-weighted imaging (performed 2 years after surgery) was positive for cholesteatoma in 2 patients (11%). On the third diffusion-weighted imaging (3 years after surgery), 12 of the 16 patients (75%) remained negative, and the other 4 (25%) were lost to follow-up.

Conclusion: If one elects not to perform second-look surgery, a diffusion-weighted imaging surveillance program is necessary to detect residual disease. Surveillance should be for a minimum of 3 years after the initial surgery, and there is a real risk of losing patients to follow-up.

Keywords: Cholesteatoma, diffusion magnetic resonance imaging, MRI, second-look surgery

Introduction

Surgery is the treatment of choice for middle ear cleft cholesteatoma (1, 2). The canal wall-up (CWU) type of mastoidectomy results in an intact posterior canal wall with a closed mastoid cavity and can facilitate the restoration of hearing and comfortable fitting with a hearing aid (3). Contrary to its canal wall-down counterpart, patients operated with the CWU technique do not require a long-term aural toilet or are not restricted in activities such as swimming (2, 4, 5). However, it is associated with a substantial risk of residual cholesteatoma.

Residual disease refers to a nidus of disease that remains in the middle ear or mastoid cavity after primary surgery. This can subsequently serve as a new focus of cholesteatoma, which can grow with time. In patients with an intact tympanic membrane and canal wall, residual disease is not readily visible on clinical examination. Conversely, recurrent disease is visible on clinical examination. Recurrent disease describes the process whereby despite successful clearance of all disease during primary surgery, a new retraction pocket develops, which can evolve into a further cholesteatoma. Thus, long-term follow-up remains important in patients with previous cholesteatoma.

The classic protocol of second-look surgery consists of a new intervention performed 9-12 months after the first surgery to detect residual disease because clinical and otoscopic detection of disease is unreliable (5).

Since it was first described in 2006 for the detection of cholesteatoma, nonechoplanar diffusion-weighted imag-

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Received: December 4, 2020 Accepted: March 14, 2021
Available online at www.b-ent.be

ing (DWI) has established itself as the imaging modality of choice owing to its good diagnostic performance in detecting cholesteatoma (6-11). However, its performance is limited because of its poor sensitivity in detecting cholesteatoma <2-3 mm (10, 12). Serial follow-up monitoring with DWI has been advocated to detect small residual cholesteatoma by allowing time for small cholesteatoma to grow large enough to be detected by DWI (13). Imaging can provide a Non-invasive, safe, and cheaper alternative for detecting residual disease.

In our institution, there has been a gradual shift in replacing second-look surgery with serial DWI follow-up monitoring, notably for cases with a low clinical risk of residual disease. We aim to analyze the performance of the 2 cohorts of patients who had surgery for middle ear cholesteatoma and initial negative DWI for residual disease at 9-12 months after surgery: 1 cohort who had subsequent second-look surgery and another cohort who were followed-up with DWI.

Methods

Our prospectively collected surgical database was retrospectively searched for patients who had CWU mastoidectomy for cholesteatoma from 2011 to 2013 and negative DWI scan for residual disease at 9-12 months after the surgery. A total of 34 patients were identified. There were 23 male patients and 12 female patients, and their median age was 27 years (range: 7-62 years). Second-look surgery was subsequently performed in 13 patients, and the result of the surgery was recorded as the absence or presence of residual disease. Surgery was performed by consultant otologists experienced in cholesteatoma surgery. Patients with perceived less clinical risk of residual disease on the basis of intraoperative findings and confidence of complete disease clearance were allocated to the surveillance group. This cohort of 21 patients had serial follow-up monitoring with DWI; the number of scan episodes was recorded together with the DWI findings for the presence of disease. Because surveillance for recurrent cholesteatoma was through clinical examination, all postoperative cholesteatomas described in this paper are defined as residual cholesteatomas. All the included patients would have had at least 3 years of monitoring because the data were analyzed at the end of 2016. All patients provided informed consent for their data to be included in the database and for subsequent analysis to be performed. Ethical approval was provided by the trust research ethics committee.

Main Points:

- For asymptomatic patients, serial diffusion-weighted imaging (DWI) can be used as an alternative to second-look surgery to detect postoperative cholesteatoma after canal wall-up mastoidectomy.
- Serial DWI allows patients to avoid the inherent risks of second-look surgery while providing a more cost-effective approach to detecting residual cholesteatoma.
- Serial imaging should continue for a minimum of 3 years to capture slowly growing residual cholesteatoma.
- Patients being considered for surveillance with DWI should first be assessed for compliance to ensure that they are not lost to follow-up.

Magnetic resonance imaging was performed on a 1.5-T superconductive unit (Magnetom Avanto; Siemens Medical Solutions, Erlangen, Germany) using a standard Head Matrix coil. Coronal 2-mm-thick Turbo-spin echo (TSE) T2-weighted images (time to repetition [TR] of 4,000 ms, time to excitation [TE] of 101 ms, matrix of 250 × 384, field of view [FOV] of 220 mm, and number of excitations [NEXs] of 2) and coronal 2-mm-thick T1-weighted images (TR of 471 ms, TE of 11 ms, matrix of 250 × 384, FOV of 220 mm, and NEX of 3) were obtained, together with a coronal 2-mm-thick half-Fourier TSE DWI sequence (TR of 1,600 ms, TE of 113 ms, matrix of 134 × 192, FOV of 220 × 220 mm, b factors of 0 and 1,000 s/mm^2, and NEX of 11). An apparent diffusion coefficient (ADC) map was calculated using the diffusion scan raw data after acquisition. The measurement parameters and the slice positions for the various b values were identical (copy referenced) for optimal image registration and the generation of the ADC map (6). The total scanning time was approximately 20 minutes.

The images were reviewed by 2 head and neck radiologists experienced in ear imaging. Cholesteatoma was diagnosed on DWI as a high signal intensity lesion relative to brain tissue on b1000 diffusion-weighted images and corresponding low signal intensity on the ADC map as shown in Figures 1 and 2 (14, 15). On T1-weighted images, cholesteatoma also returns intermediate to low signal. A consensus was achieved in all scans. Patients with a subsequent positive DWI diagnosis for residual cholesteatoma were referred for surgery, and the surgical findings were recorded.

Results

In the 13 patients who had second-look surgery, 11 patients (85%) were found to be free of disease, but in 2 patients (15%), there was residual cholesteatoma. The residual cholesteatoma measured 2 mm and 20 mm. After surgery, 3 patients (23%) developed complications related to undergoing the second-look procedure. A total of 2 patients developed postoperative infections related to the second-look surgery, and 1 patient developed a hypertrophic postauricular scar subsequently. A breakdown of the tympanic membrane was also noted in the third patient, requiring further surgery to repair this.

In the 21 patients who were planned for serial monitoring with DWI, 3 (14%) were lost to follow-up after the first year. In the remaining 18 patients, the second annual DWI (2 years after the initial surgery) was negative for cholesteatoma in 16 patients (89%) and positive for cholesteatoma in 2 patients (11%). The 2 positive cases were confirmed with residual disease on surgery. The cholesteatoma measured 20 mm in maximum dimension in both cases. On the third annual DWI (3 years after the initial surgery), 12 of the 16 patients (75%) remained negative, and the other 4 (25%) were lost to follow-up at this stage. No positive third annual DWI for cholesteatoma was recorded. The rate of residual disease in the patients who had undergone CWU mastoidectomy, allowing for patients lost to follow-up, was between 4 of 27 and 4 of 34 (12%-15%)

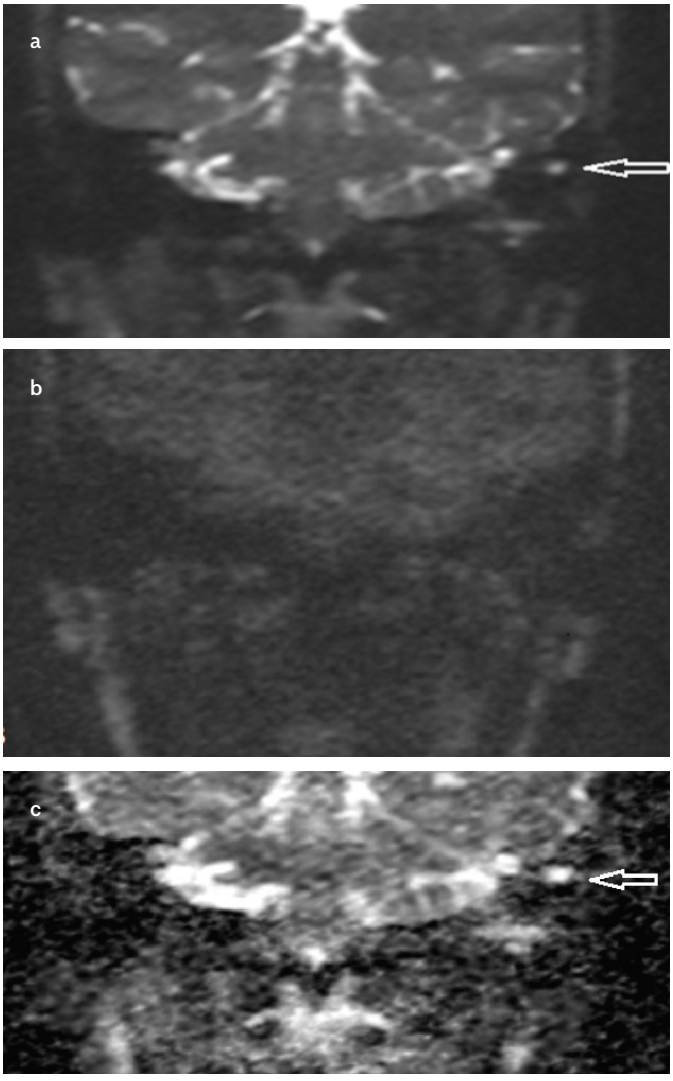

Figure 1. a-c. First-year follow-up DWI examination in a 23-year-old woman after left CWU surgery. Coronal DWI image with b values of 0 sec/mm^2 shows (a) abnormal soft tissue of high signal intensity within left mastoid remnant (arrow), with (b) a signal drop at DWI image with b value of 1,000 sec/mm^2 and corresponds with (c) high signal intensity (ADC value 2,000 × 10^{-6} mm^2/sec) at ADC map in keeping with noncholesteatomatous soft tissue. ADC: Apparent diffusion coefficient, CWU: Canal wall-up, DWI: Diffusion-weighted imaging

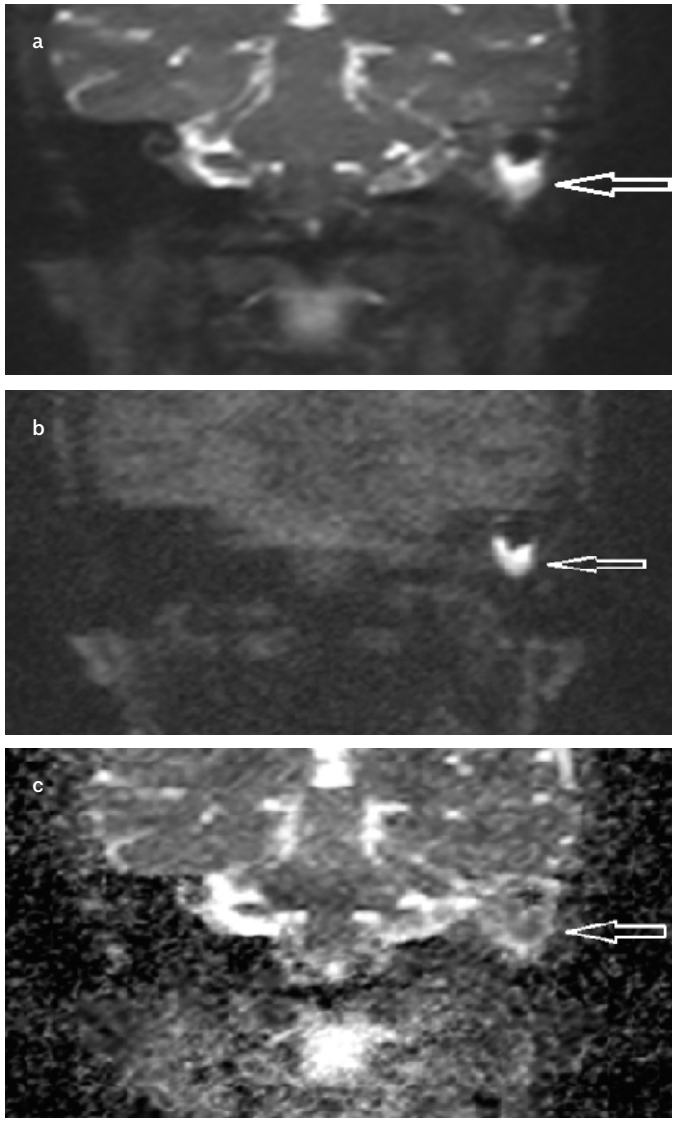

Figure 2. a-c. The second follow-up DWI examination in a 23-year-old woman shows a surgically confirmed recurrence of cholesteatoma. Coronal DW images with (a) b values of 0 sec/mm^2 and with (b) b value of 1,000 sec/mm^2 show abnormal soft tissue of high signal intensity (arrow) within the mastoid and corresponds with (c) low signal intensity at ADC map in keeping with the area of restricted diffusion (ADC value 755 × 10^{-6} mm^2/sec).
ADC: Apparent diffusion coefficient, DW: Diffusion-weighted, DWI: Diffusion-weighted imaging

Discussion

Our results support surveillance with DWI for possible residual cholesteatoma after CWU mastoidectomy if second-look surgery is to be avoided. This is in recognition of the limitation in the sensitivity of the nonechoplanar DWI technique in detecting small residual pearls <2-3 mm (10). In our cohort of patients who underwent surveillance after initial surgery, 2 of 18 patients (11%) with negative DWI later became positive for residual disease on the second annual follow-up scan. Our findings suggest that a DWI surveillance program should run for 3 years after initial surgery as an absolute minimum, although a longer period of follow-up is advisable (16).

In the cohort of patients who underwent second-look surgery, 2 patients had residual disease despite an initial negative DWI, giving a false-negative rate of 15% (2 of 13). In the cohort of patients who underwent serial imaging, there were no patients who had a negative DWI with subsequent cholesteatoma seen intraoperatively. Although a rate of 15% overall is comparable with false-negative rates reported in the existing literature, this should be interpreted with caution given that 7 patients were lost to follow-up after their initial negative DWI (10, 11).

Of the 45 ears included in the study by Steens et al. (13), a second follow-up postoperative DWI 3was positive (*n*=8) or equivocal (*n*=6) for cholesteatoma in 14 ears (31%). Of the 8 patients with a positive DWI, 6 underwent surgery, and 5 were found to have cholesteatoma intraoperatively (13). In addition, of the 31 ears that were DWI negative on the second scan, 2 ears turned positive on a third scan, with residual cholesteatoma subsequently confirmed surgically. Their study has a higher incidence of residual disease than our study, but similar to our

study, their study supports the use of DWI surveillance for at least 3 years after surgery if second-look surgery is to be avoided. Contrary to their study, we did not observe any false-positive DWI findings. This may be in part due to the small size of our study but also due to our radiologic interpretation, which interrogates and correlates false-positive DWI signals with the T1-weighted images (9).

Because it is a non-invasive and readily available form of monitoring, post-operative surveillance with DWI is a cheaper and safer technique than the traditional mandatory second-look surgery (8). Second-look surgery carries risks of complications as with the primary mastoid surgery. Alongside the risk of residual cholesteatoma, other potential complications include persistence of damage to the facial nerve, persistence of tympanic membrane perforation, otorrhoea or infection, as well as hearing loss, including a dead ear with no perceptible hearing (17). DWI is an especially attractive imaging tool because it is a relatively quick examination to perform (approximately 20 minutes) and does not require radiation or administration of intravenous contrast, both of which are associated with risks to the patient (9). In our series, 11 of 13 patients (85%) with second-look surgery had no evidence of residual disease and could have been spared the morbidity, risk, and cost of surgery if they were monitored with DWI instead. In children, cholesteatoma can be more aggressive than in adults (18), and otologists may be inclined to perform second-look surgery than to commit to DWI surveillance. However, given the safety of DWI and the equally good diagnostic performance of DWI in detecting residual disease in children compared with that in adults, several authors have proposed annual regular surveillance in children but with a more frequent, 6-monthly-interval surveillance given their more aggressive disease (9, 19).

Despite its advantages, surveillance with DWI does have its drawbacks. A total of 7 of 34 patients (21%) were lost to follow-up, despite 3 attempts to contact the patient and reschedule their follow-up. This may be due to several reasons, which include a mobile and diverse population with patients moving frequently out of the area, nonattendance of follow-up hospital visits, and premature discharge from care. A lack of awareness and/or commitment to a dedicated and lengthy follow-up program with the need for continuing surveillance even though the patient is asymptomatic may have contributed to this. On this basis, we would recommend that all patients should receive clear counseling on the risk of residual disease before primary surgery, on the need for postoperative monitoring over a number of years, and on the potential sequelae of undetected residual or recurrent disease.

The danger of patients being lost to follow-up is that they may present later with an extensive disease with a consequent higher risk of complications, with higher morbidity, and with difficulty in clearance.

Given the advantages and disadvantages of the two ways of managing postoperative patients, one way forward is to spare patients with a lower risk of residual disease from surgery by allocating them to the DWI surveillance program for at least 3 years after the initial surgery. The risks of residual disease can be assessed in part by the surgeon's confidence in disease clearance and the extent of the initial disease. Assessment for compliance with clinical follow-up and DWI scanning is also crucial to minimize loss to follow-up.

The limitations of the study include a retrospective observational study with a small cohort of patients. The small size of the study may be a reason why false-positive cases did not surface. There is inherent bias because patients with perceived less clinical risk of residual disease were allocated to the surveillance group. Having said this, to our knowledge, this is the only longitudinal study to date comparing the 2 arms of management of postoperative cholesteatoma: second-look surgery versus surveillance with DWI. The results require further validation ideally with a prospectively randomized controlled multicenter trial comparing the cost effectiveness of DWI surveillance with that of second-look surgery.

In conclusion, we have shown that a DWI surveillance program is necessary to detect residual disease if second-look surgery is to be avoided after CWU mastoidectomy. This surveillance needs to last at least 3 years after the initial surgery, and there is a real risk of losing patients to follow-up.

Ethics Committee Approval: This study was approved by the trust research ethics committee at Northwick Park Hospital as a retrospective review of outcomes.

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Supervision – A.S., R.L.; Design – A.S., R.L.; Data Collection and/or Processing – B.P., K.S.; Analysis and/or Interpretation – B.P., K.S.; Writing Manuscript – B.P., K.S., S.P.; Critical Review – S.P., A.S., R.L.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

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