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Original Article / *Özgün Makale*

The role of diffusion-weighted magnetic resonance imaging using PROPELLER sequence in diagnosis of postoperative cholesteatoma

Ameliyat sonrası kolesteatom tanısında PROPELLER sekansı ile difüzyon ağırlıklı manyetik rezonans görüntülemenin rolü

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ABSTRACT

Objectives: This study aims to evaluate the role of diffusion-weighted imaging (DWI) using periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER) sequence for the diagnosis of residual or recurrent postoperative cholesteatoma.

Patients and Methods: Between June 2015 and December 2018, a total of 30 postoperative ears of 28 patients (18 males, 10 females; mean age 33.5 years; range, 10 to 61 years) with a history of revision surgery for suspected residual or recurrent cholesteatoma who had a PROPELLER DWI before revision operation were included in the study. The presence of a lesion with diffusion restriction at the previous operation site on PROPELLER DWI was accepted as positive for cholesteatoma and the results were compared to the intraoperative and histopathological findings.

Results: On PROPELLER DWI, a lesion with diffusion restriction at the operation site was found in 29 ears. Surgery and histopathologial examination revealed a cholesteatoma in all ears. The sensitivity of PROPELLER DWI was calculated to be 96.7%.

Conclusion: Our study results suggest that PROPELLER DWI may be useful in detection of residual or recurrent cholesteatoma.

Keywords: Cholesteatoma, diffusion-weighted, magnetic resonance imaging, postoperative.

ÖZ

Amaç: Bu çalışmada ameliyat sonrası rezidüel ya da tekrarlayan kolesteatomların tanısında PROPELLER (periodically rotated overlapping parallel lines with enhanced reconstruction) sekansı kullanılarak difüzyon ağırlıklı görüntülemenin (DAG) rolü değerlendirildi.

Hastalar ve Yöntemler: Haziran 2015 - Aralık 2018 tarihleri arasında rezidüel ya da tekrarlayan kolesteatom şüphesi ile revizyon cerrahisi öyküsü olan, revizyon ameliyatından önce PROPELLER DAG'si olan 28 hastanın (18 erkek, 10 kadın; ort. yaş 33.5 yıl; dağılım, 10-61 yıl) toplam 30 ameliyat sonrası kulağı çalışmaya alındı. Daha önceki ameliyat sahasında PROPELLER DAG'da difüzyon kısıtlaması olan lezyon varlığı kolesteatom açısından pozitif kabul edildi ve sonuçlar ameliyat sırası ve histopatolojik bulgular ile karşılaştırıldı.

Bulgular: PROPELLER DAG'da ameliyat sahasında 29 kulakta difüzyon kısıtlayan lezyon izlendi. Cerrahi ve histopatolojik inceleme ile kulakların tümünde kolesteatom saptandı. PROPELLER DAG'ın duyarlılığı %96.7 olarak hesaplandı.

Sonuç: Çalışma sonuçlarımız, PROPELLER DAG'ın rezidüel veya reküren kolesteatomun saptanmasında yararlı olabileceğini göstermektedir.

Anahtar sözcükler: Kolesteatom, difüyon ağırlıklı, manyetik rezonans görüntüleme, ameliyat sonrası.

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Cholesteatoma is a common destructive lesion of the middle ear and mastoid, which consists of keratin deposits surrounded by a squamous epithelium.[1] The imaging modality of choice for suspected middle ear cholesteatomas is computed tomography (CT), which provides an excellent demonstration of the soft tissue lesion and its extension within the temporal bone.[2-5] However, the specificity of CT is low for the differentiation of the nature of soft tissue lesion, and the diagnosis of middle ear cholesteatoma is challenging, when the middle ear is completely opacified on CT.[2-5] Magnetic resonance imaging (MRI) was previously used to reveal the non-enhancing cholesteatoma on delayed post-gadolinium images.[3,4,6] Diffusion-weighted imaging (DWI) has recently gained popularity to differentiate inflammatory or granulation tissue from cholesteatomas owing to the significant diffusion restriction of the latter.[2,5,7-11]

After surgical treatment for cholesteatoma, follow-up imaging may show a non-specific soft tissue in the operation cavity and the differentiation of a residual or recurrent cholesteatoma may not be possible on conventional CT or MRI.[2,3] Due to high recurrence rate of cholesteatomas postoperatively, second-look surgery is considered standard for the detection of residual or recurrent postoperative cholesteatoma; however, a less invasive method for the diagnosis of a residual or recurrent cholesteatoma is needed.[7,10-13] Diagnosis of a residual or recurrent cholesteatoma in a postoperative middle ear by DWI has been promising.[5-8,10,13-15]

In the present study, we aimed to evaluate the role of DWI using periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER) sequence for the diagnosis of residual or recurrent postoperative cholesteatoma.

PATIENTS AND METHODS

Between June 2015 and December 2018, a total of 30 postoperative ears of 28 patients (18 males, 10 females; mean age 33.5 years; range, 10 to 61 years) with a history of revision surgery for suspected residual or recurrent cholesteatoma following a previous middle ear surgery for cholesteatoma and who had a PROPELLER (GE Healthcare, Milwaukee, WI, USA) DWI before the revision operation were retrospectively analyzed. Patients who did not undergo revision surgery were excluded. Images were reviewed on a workstation (Extreme PACS, Ankara, Turkey) by a head and neck radiologist who was blinded to the surgical and histopathological results. The study protocol was approved by the Ümraniye Training and Research Hospital Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Magnetic resonance imaging was performed in all patients on a 1.5 T scanner (Optima 450W, GE Healthcare, Milwaukee, WI, USA) using a head and neck coil with 16 channels. The study protocol included a whole brain axial fast-spin echo (FSE) T_2-weighted (repetition time/echo time 4025/102, echo train length 24, flip angle 160, field of view 24 cm, matrix 320×224, slice thickness 5.5 mm, gap 1.5 mm, NEX 1) sequence followed by temporal bone centered coronal FSE T_2-weighted (repetition time/echo time 4700/102, echo train length 24, flip angle 160, field of view 24 cm, matrix 320×224, slice thickness 3 mm, gap 0.5, NEX 2), coronal FSE T_1-weighted (repetition time/echo time 735/12.2-24.4, echo train length 3, flip angle 160, field of view 24 cm, matrix 288×224, slice thickness 3 mm, gap 0.5 mm, NEX 2), axial FSE T_1-weighted fat suppressed (repetition time/echo time 746/13.2-26.4, echo train length 3, flip angle 160, field of view 24 cm, matrix 224×192, slice thickness 3 mm, gap 0.5 mm, NEX 2), axial 3-D FIESTA (repetition time/echo time 6.4/2.5, flip angle 55, field of view 24 cm, matrix 288×288, slice thickness 0.6 mm, gap 0, NEX 2), contrast enhanced T_1-weighted fat suppressed LAVA-FLEX (repetition time/echo time 6.9/2.4, flip angle 12, field of view 24 cm, matrix 288×192, slice thickness 1 mm, gap 0, NEX 1) and axial PROPELLER DWI (b=0 and 1000, repetition time/echo time 3000/85, echo train length 16, field of view 24 cm, matrix 128×128, slice thickness 3 mm, gap 0.5, NEX 1.5) sequences and apparent diffusion coefficient (ADC) map.

The presence or absence of a lesion with diffusion restriction at the previous operation site on PROPELLER DWI was noted and accepted as positive for cholesteatoma, if present. Diffusion restriction was defined as a markedly increased signal intensity on b=1000 images brighter than the neural parenchyma on the same image with a corresponding low intensity on ADC map. These findings were compared to the surgical and histopathological results. The definitive diagnosis of the presence or absence of a cholesteatoma was based on intraoperative and histopathological findings.

Statistical analysis

The findings on PROPELLER DWI were compared to intraoperative and histopathological results and the sensitivity of PROPELLER DWI was calculated.

RESULTS

All patients included in this study underwent revision mastoidectomy for suspected residual or recurrent cholesteatoma following a previous ear surgery, of these three were third-look surgeries, and the remaining

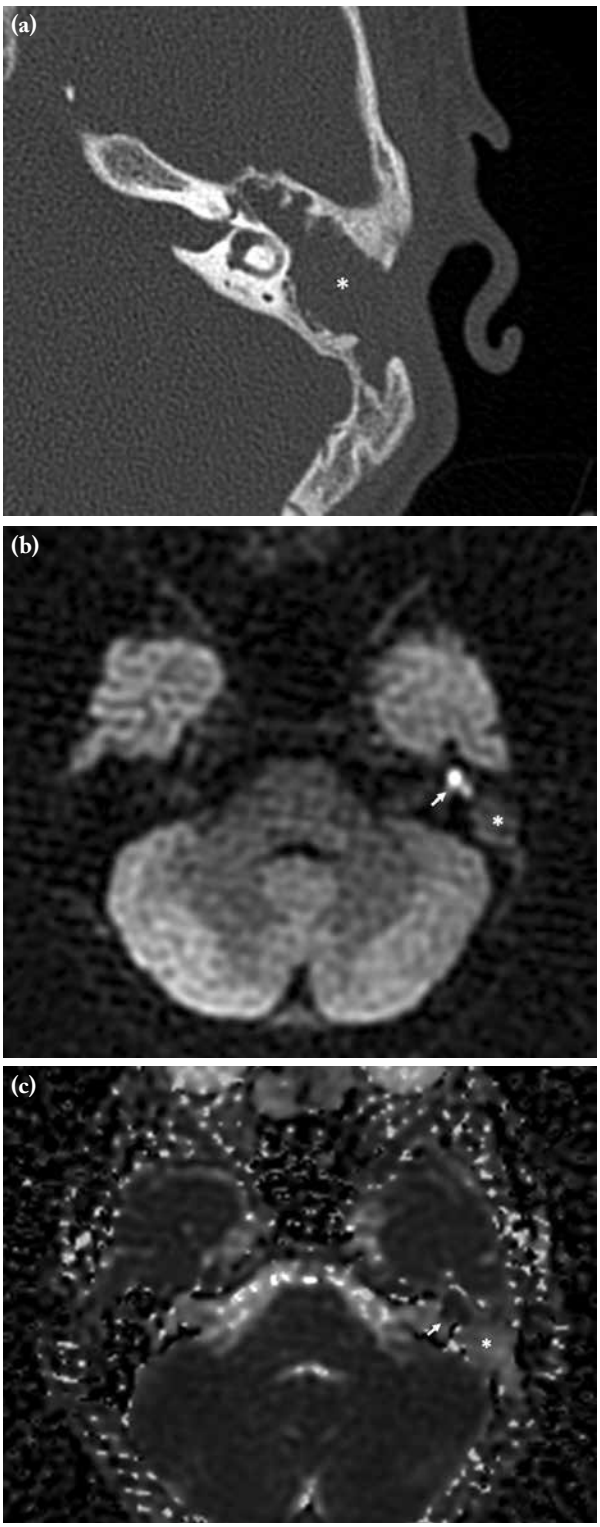

Figure 1. A 12-year-old male patient with an axial computed tomography image **(a)** showing a soft tissue filling previous mastoidectomy cavity (asterix). PROPELLER diffusion-weighted image (b=1000) **(b)** and apparent diffusion coefficient map **(c)** clearly discriminates the diffusion restriction of a small cholesteatoma (arrow) within the inflammatory tissues (asterix).

27 were second-look surgeries. Two patients with third-look surgery had both revisions in the same ear included in this series. One patient with third-look surgery had only the last revision included in the study, as no DWI MRI was obtained before the second revision.

On PROPELLER DWI, a lesion with diffusion restriction at the operation site was found in 29 ears, while no diffusion restriction was found in one patient (Figure 1). The largest dimension of the lesions varied between 5 mm and 33 mm (mean: 16.72 mm). The DWI-MRI diagnosis of cholesteatoma was confirmed by intraoperative and histopathological results in 29 ears. Surgery and histopathological analysis revealed a cholesteatoma in all 30 ears. There were 29 true positive ears. One patient with false negative result on MRI had a surgically and histopathologically proven cholesteatoma which showed no diffusion restriction on DWI MRI. The sensitivity of PROPELLER DWI was calculated to be 96.7%.

DISCUSSION

Diffusion-weighted imaging, a technique based on the diffusion of water molecules in tissues, has been shown to be useful in diagnosis of cholesteatomas, in which the tightly organized matrix of the lesion restricts the diffusion of water molecules significantly compared to other soft tissue lesions.[2,5,8,16] The most commonly used DWI technique is the echo-planar (EP) DWI; however, the susceptibility artifacts caused by air-bone interfaces, particularly in the temporal bone, limit the use of this technique.[2,5,14,16] Non-EP DWI was previously shown to improve image quality by significantly reducing the artifacts and to increase detection of cholesteatomas, even as small as 2 to 3 mm in size.[5,10,11,13,15,17-20] Different non-EP DWI techniques were reported to be useful previously, including half fourier acquisition single shot turbo spin echo (HASTE, Siemens, Erlangen, Germany) and PROPELLER techniques.[5,10-12,15,17-21] The DWI technique we used in the current series was the PROPELLER sequence. Reported sensitivities and specificities by non-EP DWI varied from 43 to 100% and from 58 to 100%, respectively.[5,7-12,18-21] One reason for this was the variability in the methods, such as inclusion of DWI-negative patients who did not undergo surgery.[9] In our series, only patients who underwent surgery were included and the surgical and histopathological findings were accepted as the gold standard for presence of a cholesteatoma. We found a sensitivity of 96.7% which is consistent with the previous literature.

Following surgical treatment for cholesteatoma, a non-specific soft tissue lesion may be found in the operation cavity at routine imaging by CT or MRI; however, the differentiation of a residual or recurrent cholesteatoma from other possible soft tissue lesions such as granulation, fibrosis, secretions, cholesterol granuloma or inflammation may be challenging in an already defective bone with postoperative changes.[3,18] The role of DWI in postoperative ears have been also studied in the literature previously.[5,7,8,10,13-15,17] Non-EPI DWI was found to be more reliable in detection of residual or recurrent cholesteatoma with sensitivity, specificity, and positive and negative predictive values of 91%, 96%, 97%, and 85%, respectively.[10] The increasing use of DWI may reduce the need for second-look surgery in postoperative ears. The use of DWI as an alternative for second-look surgery was not recommended by some series, which found a relatively high rate of false positive and negative results.[12]

Second-look surgery is not routinely performed at our institution and, therefore, all of our patients had a clinical indication for surgical revision. As a consequence, there were no true negative patients in our series, as we only included the patients who underwent revision surgery and those who had no clinical or imaging findings suggesting cholesteatoma not operated. The specificity of our series was not calculated due to the lack of inclusion of true negative patients; however, since there were no false positive patients, we believe that the actual specificity of the technique would be high. Previous studies evaluating only patients who underwent either primary or revision surgery and reported a specificity ranging between 58 and 90%.[9,12]

In our series, false negativity was found in only one patient and no false positivity was found. Previous studies reported that false negative results by DWI could be attributed to small size (<5 mm) of cholesteatomas, retractions without soft tissue and artifacts.[5,8,12,16] False positive diagnoses were previously reported to be due to the use of bone powder, silastic sheets, cartilage grafts, and keratin containing substances as cerumen.[7,9,18] In the literature, a relatively high number of false positive and false negative results were reported in small series and they concluded that PROPELLER DWI should not replace second-look surgery. Due to very low rate of false results in our series, we suggest evaluation by PROPELLER DWI combined with clinical findings, before planning a revision surgery. To determine the specificity and the actual true negativity of the PROPELLER DWI technique, further studies in larger series with long term follow-up results and/or routine second-look surgery in postoperative ears are needed.

In conclusion, PROPELLER DWI may be useful in the detection of residual or recurrent cholesteatoma in postoperative ears in addition to clinical and conventional CT and MRI findings. Nonetheless, further large-scale and long-term studies are needed to identify the role of PROPELLER DWI in detection of residual or recurrent cholesteatomas as an alternative to second-look revision surgery after surgical treatment.

Declaration of conflicting interests

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