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THE DIAGNOSTIC VALUE OF DIFFUSION-WEIGHTED MR IMAGING IN INTRACRANIAL EPIDERMOID TUMORS

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Purpose: To determine the value of diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) measurements in the diagnosis of epidermoid tumors.

Methods: Six patients with intracranial epidermoid tumors were imaged prospectively in a 1.5 Tesla magnetic resonance (MR) unit. Five lesions were located in the cerebrospinal fluid (CSF) cisterns and one lesion was located in the vermis. Two patients had postoperative residual tumors. T2- and T1-weighted, fluid-attenuated inversion recovery (FLAIR) and echo-planar (EPI) DWI sequences were used. ADC values were obtained from all lesions, normal white matter (WM) and the left lateral ventricle. The qualitative and quantitative assessments were performed by three radiologists in consensus.

Results: All epidermoids were isointense or slightly hyperintense relative to CSF on T2- and T1-weighted and FLAIR sequences. It was difficult to estimate the borders and extensions of the cisternal lesions on FLAIR and conventional MR sequences. FLAIR images revealed CSF flow artifacts that made it difficult to delineate the tumors in two patients. All lesions appeared bright on DWI and could be demarcated clearly from dark CSF. ADC values were slightly higher than CSF values, and ranged from 731 to 931 x 10-6 mm2/s within the lesion.

Conclusion: DWI is the most valuable method in the differential diagnosis of epidermoid tumors from cystic lesions in the preoperative assessment of lesion extensions, and in postoperative follow-up for the detection of residual or recurrent lesions.

Key Words: Epidermoid, Diffusion-Weighted Imaging, Magnetic Resonance Imaging, Apparent Diffusion Coefficient (ADC).

KAFA İÇİ EPİDERMOİD TÜMÖRLERDE DİFÜZYON-AĞIRLIKLI GÖRÜNTÜLEMENİN TANISAL DEĞERİ

Amaç: Epidermoid tümörlerde difüzyon-ağırlıklı görüntüleme (DAG) ve "Apparent Diffusion Coefficient" (ADC) ölçümlerinin tanısal değerini araştırmak.

Metod: Kafa içi epidermoid tümörü olan altı hasta 1.5 Tesla manyetik rezonans (MR) ünitesinde prospektif olarak incelendi. Lezyonlardan beşi beyin omurilik sıvısı (BOS) boşluklarında, biri ise vermiste yer almaktaydı. İki hastanın ameliyat sonrası rezidü tümörü vardı. T2-, T1- ağırlıklı, "fluid-attenuated inversion recovery" (FLAIR) and eko-planar (EPI) DAG sekansları kullanıldı. Epidermoid tümörlerden, normal beyaz cevherden ve sol lateral ventrikülden ADC ölçümleri yapıldı. Niteliksel ve niceliksel değerlendirmeyi üç radyolog birlikte yaptı.

Bulgular: Tüm epidermoid tümörler T2-, T1-ağırlıklı and FLAIR sekanslarda BOS'a gore izointens veya hiperintensti. FLAIR ve konvansiyonel MR sekanslarında, BOS boşluklarındaki lezyonların sınırlarını ve uzanımlarını değerlendirebilmek güçtü. İki hastada FLAIR sekansı lezyonların ayırdedilebilmesini güçleştiren BOS akım artifaktı oluşturdu. DAG'de tümörler parlak olarak izlendi ve hipointens BOS'tan net olarak ayırt edildi. ADC değeri epidermoid tümörlerde BOS'tan hafif derecede yüksek olup, 731 x 10-6 ile 931 x 10-6 mm2/s arasında ölçüldü.

Sonuç: DAG; epidermoid tümörlerin diğer kistik lezyonlardan ayırdedilmesinde, ameliyat öncesi lezyon uzanımlarının değerlendirilmesinde ve ameliyat sonrası dönemde rezidü veya nüks tümor açısından takipte en değerli tanı yöntemidir.

Anahtar Kelimeler: Epidermoid, Difüzyon Ağırlıklı Görüntüleme, Manyetik Rezonans Görüntüleme, Apparent Diffusion Coefficient (ADC).

INTRODUCTION

Epidermoid tumors (cysts) are benign extra-axial neoplasms that represent about 1% of all primary intracranial tumors. Signal intensity characteristics of epidermoid cysts on MR imaging (MRI) are hyperintense on T2-weighted images (T2WI) and isointense or minimally hyperintense compared to cerebrospinal fluid (CSF) on T1WI. The diagnosis of epidermoid cysts on MRI is usually very difficult since they frequently exhibit poor contrast from surrounding CSF and resemble other cystic masses, especially arachnoid cysts (1). Several MR sequences have been employed to improve the detection of epidermoids, such as constructive interference in steady-state (CISS) and 3D Fourier transform fast MRI with steady-state free precession (SSFP) sequences. However, these MR sequences have not become popular because of technical difficulties and manufacturer-imposed limitations (1). Fluid attenuated inversion recovery (FLAIR) sequences have been used in the diagnosis of epidermoid cysts, and reported to be superior to conventional MRI in the depiction and differential diagnosis of the lesions (1-4). On the other hand, marked CSF flow artifacts in CSF cisterns and ventricles on FLAIR imaging may make it difficult to delineate epidermoid tumors.

Diffusion-weighted imaging (DWI) has been shown to be a valuable method in the differential diagnosis of epidermoid tumors from arachnoid cysts, by revealing the solid nature of epidermoid tumors according to their apparent diffusion coefficients (ADC) (1). In previous reports on spin-echo DWI, the accuracy of this technique was reduced because of motion artifacts (3, 4). A faster acquisition with echo-planar imaging (EPI) has improved the effectiveness of DWI by decreasing the motion artifacts (1, 2, 5-7).

This study reports EPI-DWI findings and ADC measurements of epidermoid tumors, and evaluates the diagnostic value of DWI by comparing this method with conventional MR sequences.

MATERIALS AND METHODS

This prospective study included six patients with epidermoid cysts, three female and three male, ranging in age from 8 to 53 years (mean, 36 years). The diameter of the tumors ranged from 2 to 6.5 cm. One of the lesions was located in the vermis, while the other five were located in the CSF cisterns: one in the left middle cranial fossa, one in the suprasellar cistern, one in the prepontine cistern, one in the right cerebellopontine angle cistern and one in the right Meckel cave. The diagnoses were confirmed pathologically, except for the lesion located in the vermis. Two patients had been operated on for epidermoid tumors before and had residual tumors. Table 1 summarizes the study population.

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Table 1. MRI and DWI findings of the study population.

Case No	Age (years)/ Sex	Epidermoid tumor location	Signal intensity of the epidermoid tumor relative to CSF				ADC (10^{-6} mm²/s)		
			T2WI	T1WI	FLAIR	DWI	Lesion	WM	CSF
1	37/F	Middle cranial fossa	Hyperintense	Slightly hyperintense	Slightly hyperintense	Hyperintense	931	704	3240
2	38/M	Suprasellar cistern	Hyperintense	Slightly hyperintense	Slightly hyperintense	Hyperintense	878	743	3000
3	36/F	Prepontine cistern	Hyperintense	Isointense	Slightly hyperintense	Hyperintense	756	679	2890
4	43/M	Cerebello-pontine cistern	Hyperintense	Isointense	Slightly hyperintense	Hyperintense	731	723	2830
5	53/F	Meckel cave	Hyperintense	Isointense	Slightly hyperintense	Hyperintense	770	752	2810
6	8/M	Vermis	Hyperintense	Isointense	Isointense	Hyperintense	910	606	2520

ADC: Apparent Diffusion Coefficient

All MR examinations had been performed on the same 1.5 T unit (Signa Excite, General Electric Medical Systems, Milwaukee, Wisconsin, USA) with the head coil. The standard imaging protocol consisted of the following sequences: sagittal and axial T1-weighted (TR/TE: 400/9), axial T2-weighted (3040/108), axial and coronal FLAIR (8002/95, inversion time 2000) sequences. In all sequences, the field of view was 18 x 24 or 24 x 24 cm and the slice thickness was 5 mm with no gap. DWI was obtained in the axial plane using a single shot, spin-echo T2-weighted EPI sequence. In the diffusion protocol, we used the parameters of 10000/94 (TR/TE), a matrix of 128 x 128, a slice thickness of 3 mm with no interslice gap, and a field-of-view of 28 x 28 cm. Diffusion-sensitizing gradients were applied sequentially in all three orthogonal planes (frequency, phase, and slice selection encoding directions). A diffusion trace image (average of the three diffusion directions) was then generated. ADC maps were acquired using b values of 0 and 1000 mm2/s. In two of the six patients, contrast-enhanced T1WI with the same parameters of precontrast scans were obtained in the three planes following an intravenous injection of the standard dose of gadolinium (0.1 mmol/kg).

The signal intensity characteristics of epidermoid cysts were evaluated on T1WI, T2WI and FLAIR sequences and on diffusion trace images. ADC calculations were performed on an independent workstation using the Functool option of the Advantage Windows 4.1 (General Electric Medical Systems). Regions of interest (ROI) of similar size (approximately 100 mm2) were drawn within the lesion, normal appearing deep white matter (WM) and left lateral ventricle with caution to avoid partial volume effects from neighboring structures. All evaluations were performed by three radiologists in consensus.

RESULTS

All epidermoid cysts appeared hyperintense on T2WI (Figs. 1A and 2A). All lesions were slightly hyperintense or nearly isointense relative to CSF on T1WI, and did not show contrast enhancement on postcontrast T1WI, obtained in two patients (Figs. 1B and 2B). Although five lesions located in the CSF cisterns were slightly hyperintense relative to CSF on FLAIR images, it was difficult to estimate the borders and extensions of the lesions on this sequence (Fig. 1C). The lesion located in the vermis appeared isointense to CSF on FLAIR imaging (Fig. 2C). In two patients, FLAIR images revealed CSF flow artifacts that made it difficult to delineate the lesions (Fig. 1C).

Axial T2- (A) and postcontrast T1- (B) weighted images show a cystic lesion in the right Meckel cave that is isointense to CSF (white arrow), and also demonstrates a widened prepontine cistern on the right side (arrowhead). The lesion (white arrow) does not show contrast enhancement on postcontrast T1W1 (B). On FLAIR imaging (C), the residual tumor in the Meckel cave (white arrow) cannot be delineated exactly, and there is a heterogeneously hyperintense signal in the prepontine cistern (arrowhead) and Meckel cave (white arrow). DWI (D) enables the confident detection of the borders of the residual lesion in the Meckel cave (white arrow), and reveals that the lesion extends towards the prepontine cistern (arrowhead). The lesion has a characteristic bright signal on DWI (D).

All epidermoid cysts appeared brighter than CSF on DWI with b = 0 and were far brighter on DWI with b = 1000. The diffusion trace image demonstrated the borders and extensions of the lesions in all patients (Figs. 1D and 2D). ADC values ranged from 731 to 931 x 10-6 mm2/s within the epidermoid (mean value: 829 x 10-6 mm2/s), from 606 to 752 x 10-6

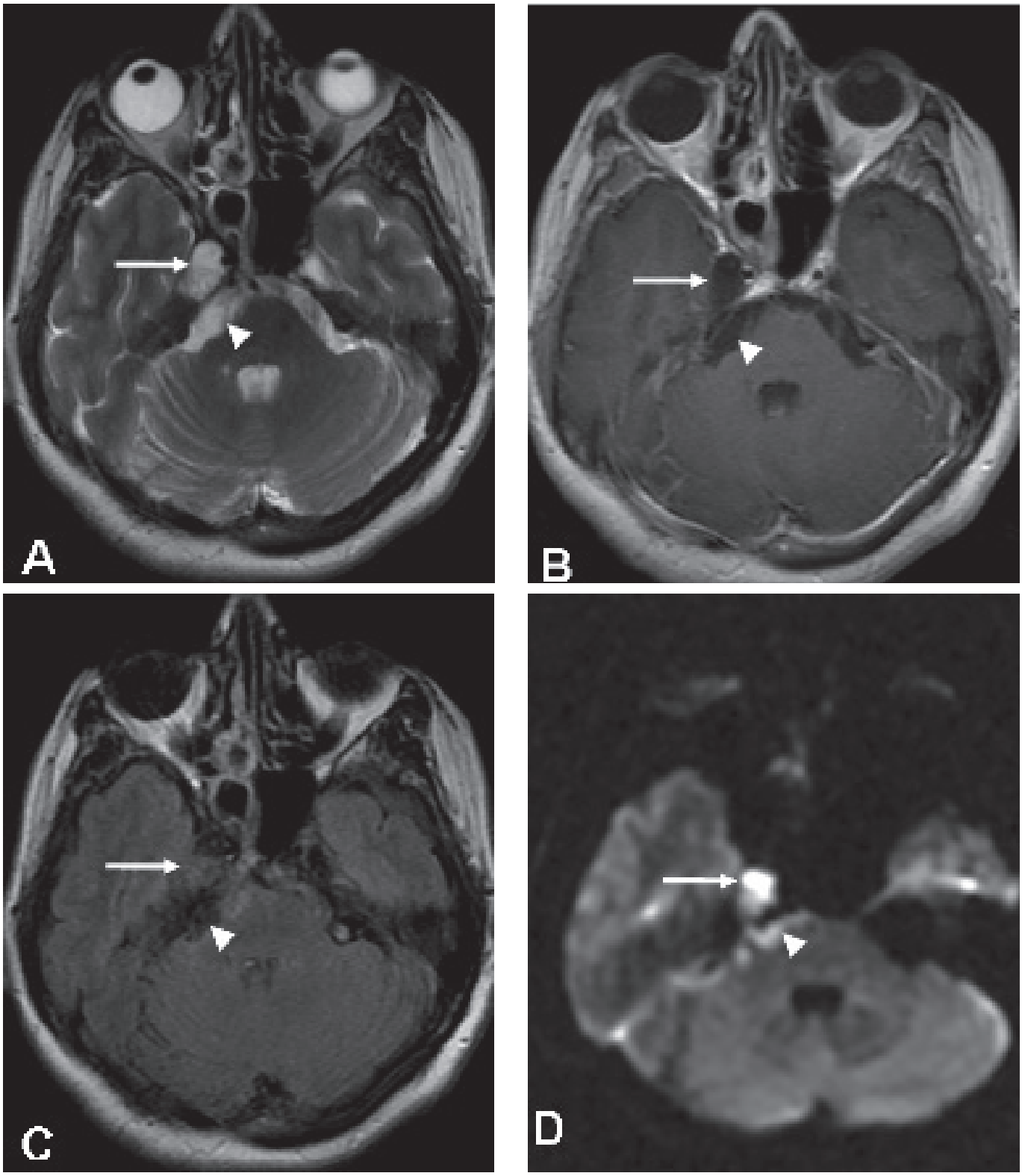

Figure 1: A 43-year-old male operated on for an epidermoid tumor two years before has a residual tumor in the right Meckel cave.

mm2/s within the deep WM (mean value: 701 x 10-6 mm2/s) and from 2520 to 3240 x 10-6 mm2/s within the CSF (mean value: 2882 x 10-6 mm2/s). The ADC values were slightly higher in epidermoid tumors compared to WM.

DISCUSSION

Epidermoid tumors (cysts) are benign slow-growing extra-axial neoplasms of ectodermal origin with stratified a squamous epithelial capsule and keratinaceous debris. The cerebellopontine angle cistern is the most common location of

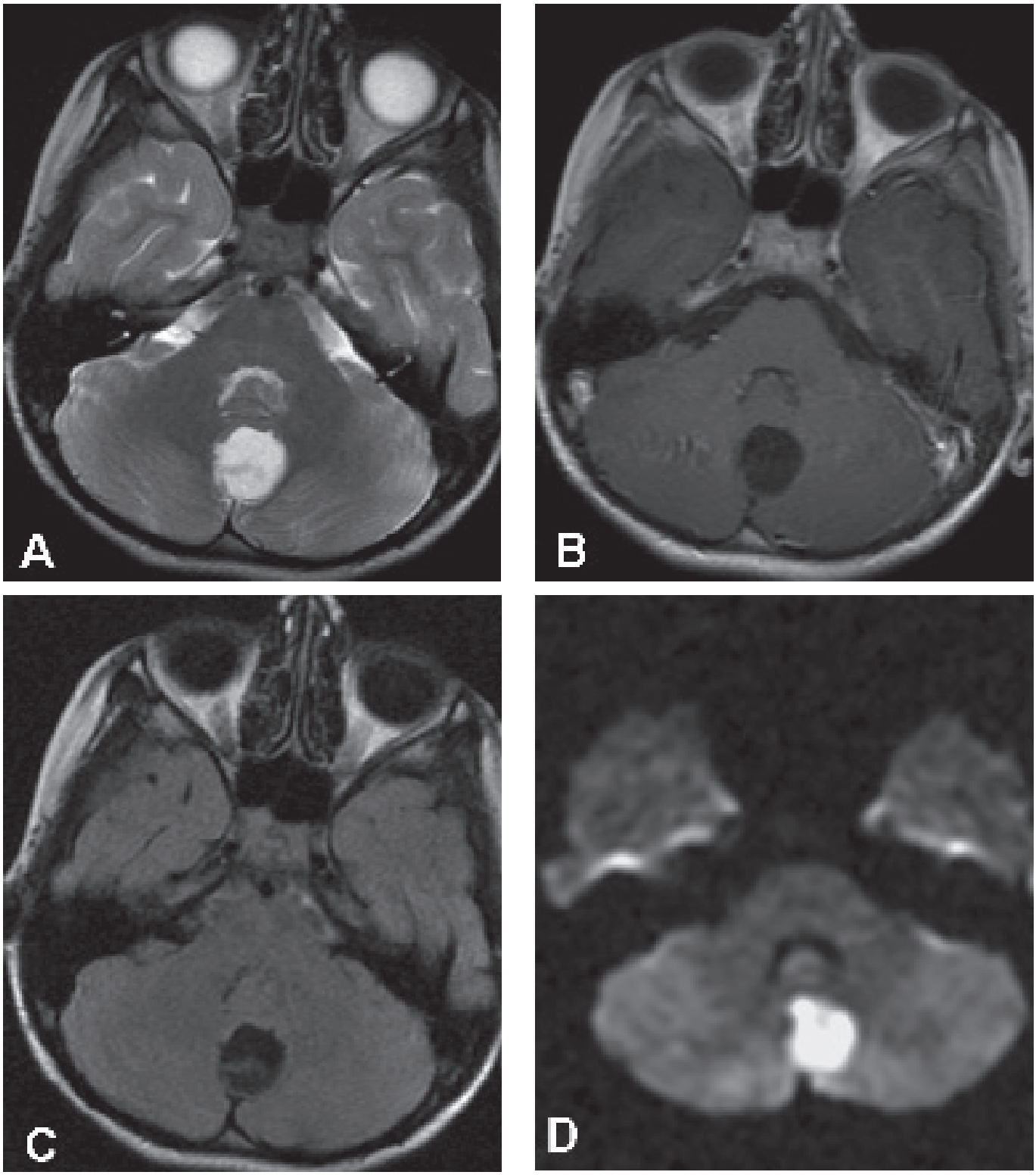

Figure 2: An 8-year-old boy with a vermian epidermoid cyst. Axial T2- (A) and postcontrast T1- (B) weighted images show a well-marginated cystic lesion in the vermis that does not show contrast enhancement on the postcontrast image (B). On the FLAIR image (C), the lesion is isointense to CSF. DWI (D) shows that the cyst has bright signal intensity, which causes a clear contrast with the dark signal of the CSF.

this lesion, as it is the site of 40% of intracranial epidermoid tumors (5). Other common locations are sellar and suprasellar regions, middle cranial fossa and the fourth ventricle. Symptoms appear after the second decade and are caused by displacement of adjacent neural and vascular structures.

Computerized tomography (CT) reveals low-density lesions with densities ranging from + 20 to –50 HU (5). MRI is superior to CT in the diagnosis of intracranial epidermoid cysts because of its multiplanar imaging capacity, the lack of artifacts from bony structures, and the clear depiction of ne-

ighboring neurovascular structures. On MRI, the lesions are hyperintense on T2WI and isointense to slightly hyperintense relative to CSF on T1WI. The lesions do not show contrast enhancement in imaging studies. Although in most cases the signal intensity of epidermoid cysts differs to some degree from that of CSF on conventional MRI, this difference usually is slight and inconstant (1). As a result, the differential diagnosis of epidermoid cysts from other cystic lesions, i.e. arachnoid cysts, and the delineation of their exact extensions are usually difficult.

A FLAIR sequence, characterized by heavy T2 weighting and nulled-CSF signal, has been proposed in the diagnosis of epidermoid cysts. Ikushima et al. reported that although epidermoid cysts showed slightly or moderately hyperintense signal relative to CSF on FLAIR, it was difficult to delineate the exact extension of the lesions (8). In our study, although all epidermoids located in the cisterns appeared hyperintense to CSF on FLAIR imaging, the exact extension of the lesions could not be delineated on this sequence. Chen et al. reported that CSF flow artifacts, attributable to inflow of noninverted CSF, could make it difficult to delineate small epidermoids on FLAIR imaging (9). They also reported that CSF flow artifacts occasionally simulated epidermoid tumors in shape and signal intensity (1). Despite using flow compensation sequences and a nonselective inversion pulse on FLAIR imaging, they could not completely exclude these artifacts, especially in the infratentorial subarachnoid cisterns and fourth ventricle, which are common locations of epidermoid tumors (1). Similarly, in our study FLAIR images revealed CSF flow artifacts that caused difficulties in the delineation of the lesions in two cases.

DWI has been found to be very useful in the diagnosis of epidermoid tumors, as it separates the bright epidermoid tumor from dark CSF spaces and arachnoid cysts (1-7). DWI characteristics of epidermoid cysts may be partially explained by restricted diffusion caused by keratinaceous debris within the lesion (1, 7). As all epidermoid tumors display very bright signal intensity on “native” T2WI at b = 0 of the DWI, a T2 shine-through effect might be speculated to play a role in the bright signal on diffusion trace images at b = 1000 (1, 7). Tsuruda and Maeda et al. used a non-echo-planar DWI in the diagnosis of epidermoids, and reported that the accuracy of this imaging technique was reduced by motion artifacts (3, 4). A faster acquisition with an EPI sequence improved the effectiveness of DWI by decreasing the motion artifacts (1, 2, 5-7). ADC measurements are very important in the differential diagnosis of epidermoid tumors, by revealing the solid nature of lesions. The ADC values of epidermoids were reported to range from 807 to 1461 x 10-6 mm2/s in the literature (1, 2, 5, 7). In our study, the tumors appeared bright on DWI, and ADC values ranged from 731 to 931 x 10-6 mm2/s. The ADC values of epidermoids in our study were lower than those reported in the literature, which can be explained by the different chemical components and physical states of the tumors (1).

The total excision of epidermoid cysts is difficult due to many factors, including their capsular adhesion to the brain stem, close proximity to cranial nerves, and extension to potential subarachnoid spaces (10). Incomplete excision of the lesion can lead to recurrence, often after a long time, as a result of slow growth. On conventional MRI, postoperative changes in the surgical cavity usually make the detection of residual or recurrent lesions more difficult (9). DWI was found to be effective in postoperative evaluations and during follow-up imaging to reveal residual or recurrent lesions (1, 2, 9). Comparing with the FLAIR and conventional MR sequences, DWI provided us with additional information for the delineation of borders and extensions of postoperative residual tumors in our study.

In conclusion, EPI-DWI is the most valuable method in the differential diagnosis of epidermoid tumors from cystic lesions, in preoperative assessments of the lesion extensions, and in postoperative follow-up for the detection of residual or recurrent lesions.

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