

Case Report

Diffusion Magnetic Resonance Imaging of Solid Vestibular Schwannomas

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Abstract: Six patients with solid vestibular schwannomas were studied by diffusion magnetic resonance imaging to assess if this modality adds new information for these tumors, because there is no previous report in the relevant literature. The sizes of the tumors ranged from 2.2 to 4.7 cm with respect to their largest diameters. They were isointense to the normal brain parenchyma on $b = 1,000$ s/mm² images. The apparent diffusion coefficient (ADC) values in the tumors were high (range: $1.14\text{--}1.72 \times 10^{-3}$ mm²/s, mean = $1.42 \pm 0.17 \times 10^{-3}$ mm²/s) compared with normal brain parenchyma ADC values (mean = $0.80 \pm 0.11 \times 10^{-3}$ mm²/s). High ADC values of solid vestibular schwannomas were in conformity with increased diffusion rates, indicating the presence of increased amounts of extracellular water (a relatively loose tissue) in the tumor matrix. **Index Terms:** Vestibular schwannoma—Acoustic neuroma—Diffusion magnetic resonance imaging.

Vestibular schwannomas are the most common intracranial Schwann cell tumors. These tumors have been studied extensively by magnetic resonance imaging (MRI) (1–5). There is no previous report in the literature on the subject using diffusion MRI. In this article, we report echo-planar diffusion MRI findings in six patients with predominantly solid and relatively large vestibular schwannomas.

REPORT OF THE CASES

Six histopathologically confirmed solid vestibular schwannomas are included in this study. The tumors were compact and encapsulated; there was no evidence of gross cystic degeneration, except for a few small cysts, and no evidence of fatty degeneration or hemorrhage. There were three female patients and three male patients, with ages ranging from 22 to 77 years (mean = 42 years). Magnetic resonance examinations were performed by 1.5-T magnetic resonance units (Magnetom Symphony or Magnetom Vision; Siemens, Erlangen, Germany). T1-weighted and T2-weighted images as well

as contrast-enhanced T1-weighted images were acquired. The sizes of the tumors ranged from 2.2 to 4.7 cm with respect to their largest diameters.

Diffusion MRI was obtained in the transverse (axial) plane using the echo-planar imaging sequence. A protocol applied in the three gradients (slice, readout, and phase) with a repetition time of 4,000 milliseconds and an echo time of 110 milliseconds or another protocol with averaging of the gradients (trace sequence) with a repetition time of 5,700 milliseconds and an echo time of 139 milliseconds was used, providing automatically generated apparent diffusion coefficient (ADC) maps. Slice thickness was 5 mm, and $b = 1,000$ s/mm² images and ADC maps were studied. The ADC values from the tumors ($n = 6$) and from the adjacent normal brain parenchyma, including the pons, middle cerebellar peduncle, and cerebellum ($n = 18$), were calculated by direct readings from ADC maps with region of interest evaluations. The Wilcoxon signed rank test was applied ($\alpha = 0.05$) for the ADC values of the tumors and normal brain parenchyma.

The vestibular schwannomas were isointense to the normal brain parenchyma on $b = 1,000$ s/mm² images, which are heavily diffusion-weighted images. Their ADC values calculated by evaluations from ADC maps resulted in values ranging from 1.14 to 1.72×10^{-3} mm²/s, and the mean value was $1.42 \pm 0.17 \times 10^{-3}$ mm²/s (Figs. 1–3). With respect to the normal brain parenchyma

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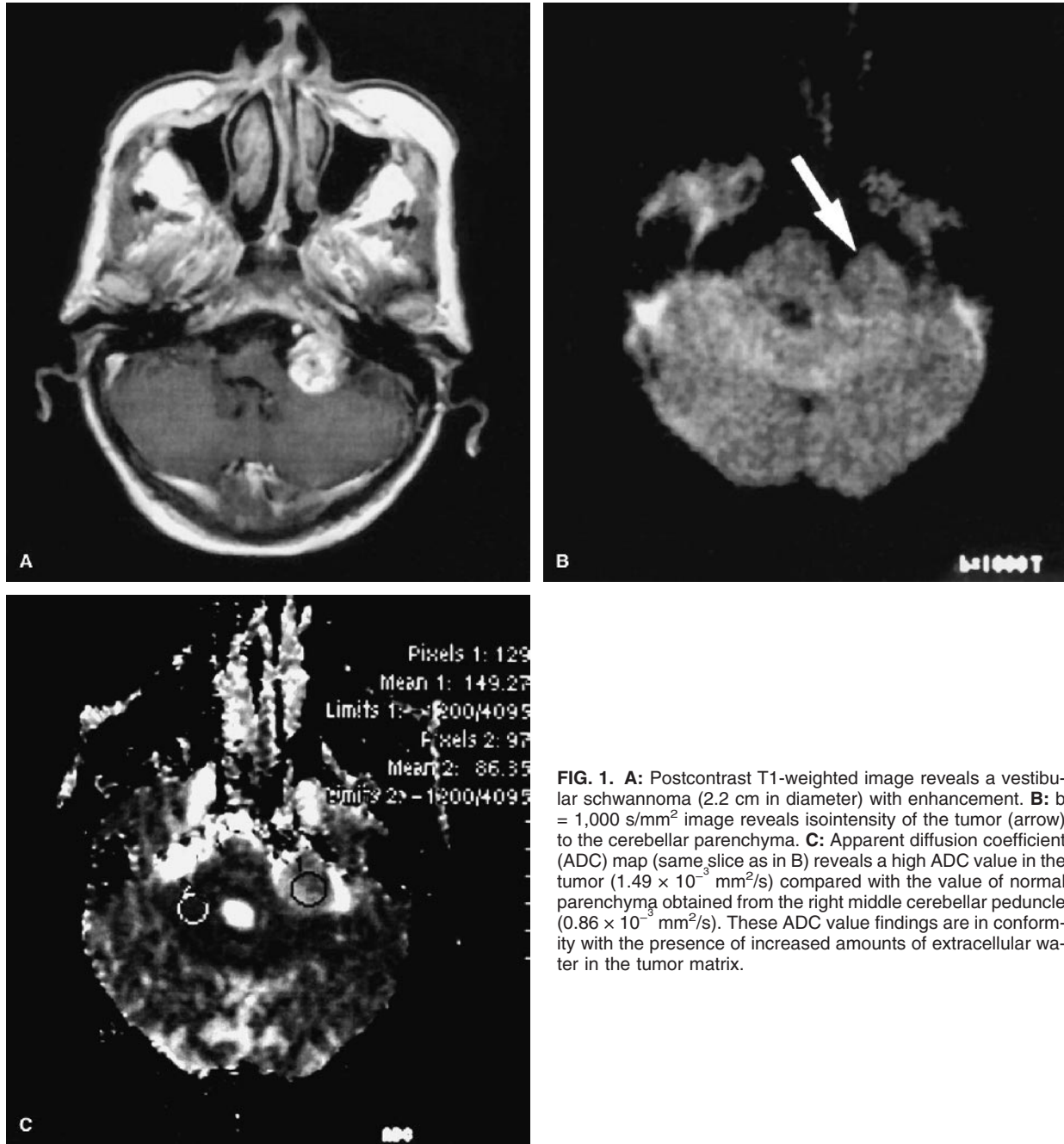


FIG. 1. **A:** Postcontrast T1-weighted image reveals a vestibular schwannoma (2.2 cm in diameter) with enhancement. **B:** $b = 1,000$ s/mm² image reveals isointensity of the tumor (arrow) to the cerebellar parenchyma. **C:** Apparent diffusion coefficient (ADC) map (same slice as in B) reveals a high ADC value in the tumor (1.49×10^{-3} mm²/s) compared with the value of normal parenchyma obtained from the right middle cerebellar peduncle (0.86×10^{-3} mm²/s). These ADC value findings are in conformity with the presence of increased amounts of extracellular water in the tumor matrix.

measurements from the pons, middle cerebellar peduncle, and cerebellum, the ADC values ranged between 0.64 and 0.98×10^{-3} mm²/s (mean = $0.80 \pm 0.11 \times 10^{-3}$ mm²/s). Therefore, the ADC values of the vestibular schwannomas were prominently higher than that of the normal brain parenchyma, and this difference was statistically significant ($P < 0.0001$).

DISCUSSION

Vestibular schwannomas are well-capsulated round or lobulated masses (1–3). Cystic degeneration and hemor-

rhagic necrosis are commonly seen in these tumors (4,5). In the patients included in this study, the tumors were grossly solid ones with minimum cystic degeneration; therefore, diffusion MRI findings mainly reflected the motion rate of water molecules related to the matrix of the tumor. It has been reported that solid tumors are generally isointense to brain parenchyma on heavily diffusion-weighted ($b = 1,000$ s/mm²) MRI images and reveal high signal on ADC maps, reflecting increased motion of water molecules (6–8). Conversely, the matrix of tumors with relatively high nuclear-to-cytoplasmic ratios (e.g., meningiomas) tends

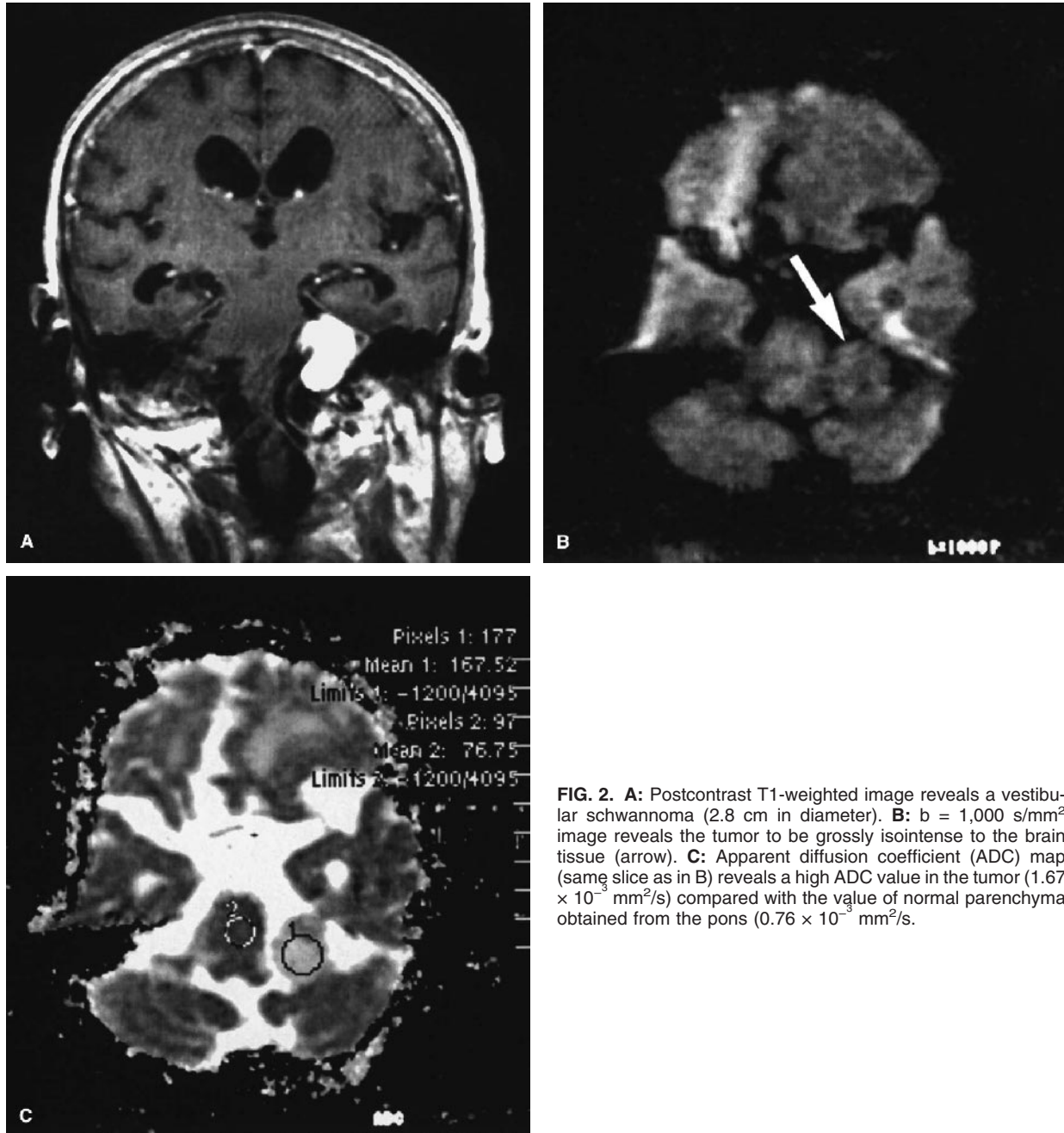


FIG. 2. **A:** Postcontrast T1-weighted image reveals a vestibular schwannoma (2.8 cm in diameter). **B:** $b = 1,000$ s/mm² image reveals the tumor to be grossly isointense to the brain tissue (arrow). **C:** Apparent diffusion coefficient (ADC) map (same slice as in B) reveals a high ADC value in the tumor (1.67×10^{-3} mm²/s) compared with the value of normal parenchyma obtained from the pons (0.76×10^{-3} mm²/s).

to be isointense on heavily diffusion-weighted images associated with relatively low ADC values, consistent with relative restriction of movement of water molecules (8–10). In this series of patients, the solid vestibular schwannomas appeared isointense on $b = 1,000$ s/mm² images compared with the normal brain parenchyma. At the same time, however, the mean of ADC values was high ($1.42 \pm 0.17 \times 10^{-3}$ mm²/s) compared with that of normal brain parenchyma ($0.80 \pm 0.11 \times 10^{-3}$ mm²/s). High ADC values are consistent with increased amounts of extracellular water associated with increased motion of water molecules (representing relatively loose tumor

tissue). Therefore, in the light of these diffusion MRI data, the tissue integration of the solid acoustic neuromas in this study can be defined as solid tumors having a relatively loose matrix. Based on the findings in this preliminary study, it is thought that diffusion MRI findings may aid in differentiating acoustic neuromas at least from other tumors with a high nuclear-to-cytoplasmic ratio. The role of diffusion MRI in the evaluation of smaller and intracanalicular vestibular schwannomas and in their distinction from other tumors in the cerebellopontine angle requires investigation in further studies.

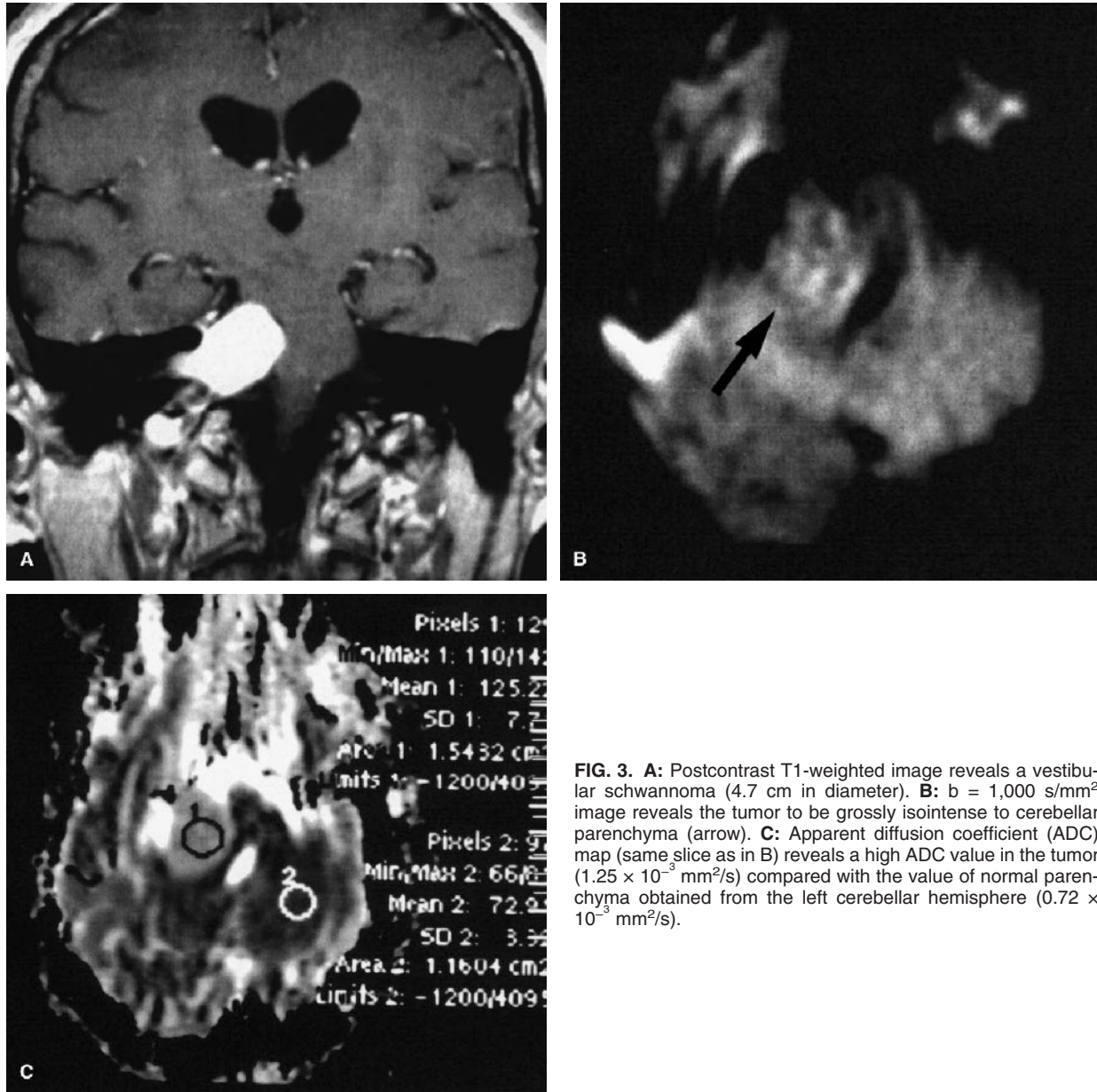


FIG. 3. **A:** Postcontrast T1-weighted image reveals a vestibular schwannoma (4.7 cm in diameter). **B:** $b = 1,000$ s/mm² image reveals the tumor to be grossly isointense to cerebellar parenchyma (arrow). **C:** Apparent diffusion coefficient (ADC) map (same slice as in B) reveals a high ADC value in the tumor (1.25×10^{-3} mm²/s) compared with the value of normal parenchyma obtained from the left cerebellar hemisphere (0.72×10^{-3} mm²/s).

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