Magnetic Resonance Spectroscopy Features of Heschl's Gyri in Patients with Unilateral Acoustic Neuroma:

Preliminary Study

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Rationale and Objectives: To evaluate neurochemical alterations in Heschl's gyri and determine the most affected side in case of unilateral acoustic neuroma using magnetic resonance spectroscopy (MRS).

Materials and Methods: Fifteen patients with unilateral acoustic neuroma were studied. Following routine cranial MRI sequences, MRS of Heschl's gyri on tumor and nontumor sides was obtained. MRS metabolite values of both Heschl's gyri were statistically compared.

Results: The values of N-acetylaspartate (NAA) and Cr on nontumor side Heschl's gyrus (HG) were significantly lower than that on tumor side.

Conclusions: We found nontumor side HG more affected with lower NAA and Cr values, suggesting neuronal damage and decreased energy metabolism compared to the tumoral side.

Key Words: Acoustic neuroma; MR spectroscopy.

Acoustic neuromas arise from the vestibular nerve and are caused by an overproliferation of Schwann cells. The incidence of acoustic neuroma is estimated to be about 0.7–1 per 100,000 per year. The mean age of those affected is usually about 45–50 years (1–3). The most common symptom observed in patients with acoustic neuroma is a progressive asymmetric or unilateral sensorineural hearing loss. About 90% of patients present with gradual progressive hearing loss in one ear. However, about 5% will present with a sudden hearing loss and many of them experience tinnitus in one ear (4). About 3% of patients with acoustic neuroma will have normal hearing at presentation (1–3). Tumor growth within the internal auditory canal (IAC) and resultant compression of cranial nerves VII and VIII cause associated symptoms (5). There is a significant correlation between the site of origin of the tumor and the incidence of subjective hearing loss (1).

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The mechanisms of hearing loss and affected regions by the disease are still unclear. Hearing impairment in patients with acoustic neuroma has been associated with a retrolabyrinthine disturbance because the tumor originates in the vestibular nerve and impairs cochlear nerve function. Tumor-related hearing loss may be due to direct cochlear nerve damage, sensory organ impairment resulting from disruption of the circulation by vascular compression in the IAC, or a combination of these two factors (6). Because of the bilateral projections from the ears, it is believed that unilateral lesions have no effect on hearing, although minor and transient hearing loss in the contralateral ear resulted from acoustic neuroma. The effect of acoustic neuroma on the primary auditory cortex is critical. Because lesions in the Heschl's gyrus (HG) may cause symptoms similar to those caused by lesions in other parts of the auditory pathway, radiologists may need to localize the lesions in relation to the HG (7).

Magnetic resonance imaging (MRI) has significantly increased detectability even in the case of small acoustic neuromas. Pre- and post-contrast T_1-weighted (T_1W) MRI sequences with a slice thickness of 2–4 mm have been used for the detection of different tumors of the cerebellopontine angle and IAC. Three-dimensional constructive interference in steady state (*CISS*) enables a detailed study of the normal cerebellopontine angle, IAC, and membranous labyrinth (8,9). Magnetic resonance spectroscopy (MRS) is a sensitive and noninvasive imaging method for monitoring chemical

and metabolic changes in areas of interest within the brain. It may provide neurochemical information on subtle and overt brain parenchymal changes. This information is used to discriminate normal and pathologic tissues (10).

Many studies have been performed on tumor using MRI (8–10), also few studies have argued for probably effects of vestibular disorders on auditory cortex using a variety of methods such as voxel-based morphometry (VBM), positron emission tomography (PET), and neuropsychiatric tests (11,12). However, to our knowledge, there is no study searching for the effect of acoustic neuroma on auditory cortex in the vicinity of the HG using MRS. We investigated to examine whether there are changes in metabolites of HG in patients with acoustic neuroma and investigate which side being more affected on single-voxel proton MRS.

MATERIAL AND METHODS

A total of 15 right-handed patients (eight females and seven males) referred for sensorineural hearing loss and tinnitus. MRI was performed on 1.5-T system (Siemens, Avanto, Erlangen, Germany) in patients. The MRI protocol included T_1W (repetition time [TR]/echo time [TE], 460/14 milliseconds) and T_2W (TR/TE, 2500/80 milliseconds) sequences in the axial and coronal planes and FLAIR images (TR/TE, 8000/90 milliseconds) in the axial plane with 5-mm thick sections and 3D CISS sequence (TR/TE, 16/8 milliseconds) was applied in the axial plane with a slice thickness of 1 mm. Then, T_1W 3D MP-RAGE (TR/TE, 12.5/5 milliseconds) sequences with and without contrast medium (Gd-DTPA, 0.1 mmol kg^{-1} body weight, IV) were applied.

After diagnosis of acoustic neuroma by conventional MRI sequences, the study protocol was approved by the institutional ethical committee, and all subjects were fully informed and gave their written informed consent, and then single voxel spectroscopy was applied.

The point resolved spectroscopy sequence (PRESS; TR/TE, 2000/135 milliseconds) was performed. Single-voxel spectroscopy was used as MRS methods. Before the PRESS sequence, after placement of volume of interest (VOI) in the appropriate site, automatic shimming was performed with 3–7 Hz line width for optimum intravoxel signal and obtained long TE single-voxel spectroscopy. Ninety degrees Gaussian pulse was applied after the spoiler gradient for water suppression. Following Fourier transformation, linear baseline values were corrected. We used similar indicator and diagnostic criteria with the study of Barta et al. for determining the HG (13). To determine the HG, we first used axial image. We defined the HG as the posterior margin of the insula and terminating in the lateral border of superior temporal gyrus (STG). The HG was anatomically identified as a Ω-shaped protrusion in the superomedial aspect of the temporal lobe, bilaterally. The most posterior image with a mark was found in the coronal series. Finally, VOI's were checked in the sagittal images to confirm the accuracy of the HG boundaries. Voxel sizes were approximately 4.5 cm^3 (15 × 15 × 20 mm) in the bilateral HG from tumor and nontumor sides. To avoid partial volume effect, VOI was centered in HG in axial, sagittal, and coronal images. Outer volume suppression slab was placed over the skull.

MRS features of HG on nontumor and tumor side of the same patients were compared. Resonances of metabolites were assigned as follows: N-acetylaspartate (NAA) at 2.0 ppm; creatine (Cr) at 3.02 ppm; and choline (Cho) at 3.2 ppm. Peak areas of metabolites (NAA, Cr, and Cho) in bilateral HG from tumor and nontumor sides were calculated by a sum of Gaussian curves. The total time taken for imaging and spectroscopy ranged between 60 and 70 minutes. For each patient, two authors assessed whether the spectra were diagnostic (R.K and A.A) and the measurements on tumor and nontumor sides were compared.

Statistical analysis was carried out using the Statistical Package for the Social Sciences version 15.0 software for Windows (SPSS Inc, Chicago, IL). All quantitative variables were estimated using measures of central location (ie, mean and median) and measures of dispersion (ie, standard deviation [SD]). Data normality was checked using the Kolmogorov–Smirnov tests of normality. The Mann–Whitney U test was used for the comparison of metabolite values between bilateral HG from tumor and nontumor side MR spectrums in the patients with acoustic neuroma. $P < .05$ was accepted as significant.

RESULTS

Fifteen patients were included in this study. The mean age of the patients was 54.6 ± 12 years. Fifty-three percent of the patients were male, 47% of the patients were female. There was no difference in age between subjects ($P < .005$). On right side, 66.7 % of tumor was located, and 33.3% was located left side. Of the 15 patients assessed in this study, seven gyral duplications were recorded. Of our 15 subjects, seven were leftward asymmetry. We found HG asymmetry distribution with leftward asymmetry more common.

The metabolite ratios obtained from tumor and nontumor sides are presented in Table 1. The values of metabolites of a patient included in this study are presented in Figures 1 and 2.

The NAA resonances (2.0 ppm) were significantly decreased in nontumor side compared to tumor side ($P < .05$). The NAA highest peak values from the tumor and contralateral non-tumor sides were 137.87 ± 29 and 120.67 ± 32, respectively. The Cr highest peak values (3.02 ppm) were found to be 79.99 ± 11 in tumor side and 69.68 ± 13 in nontumor side. There was a statistically significant difference on Cr resonances between tumor and nontumor side ($P = .023$). There was no statistically significant difference on the Cho highest peak values (3.2 ppm) between tumor (69.91 ± 10) and nontumor sides (62.29 ± 14; $P = .69$).