Heschl's Transverse Gyri: Anatomy and Morphological Variations*

Heschl'in Transvers Giruslarının Anatomisi ve Morfolojik Varyasyonları

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ABSTRACT

Objective: Heschl's gyrus is the primary auditory cortex in humans. It is located in the posterior part of the area on the superior surface of the temporal lobe, or the planum temporale. The number and shape of this gyrus may differ. In this study, we aimed to investigate the number and shape variations of the Heschl gyrus in normal subjects by using MRI.

Material and Methods: Eighty hemispheres in 40 subjects were evaluated. Of these subjects, 18 were patients with headache, evaluated in our MR imaging unit, and 22 were healthy volunteers. After the routine sequences, three dimensional transverse T1-weighted fast field echo images were obtained. The shape of the gyrus was classified as omega or heart shaped according to the images. The number of gyri in each hemisphere was noted. Number and shapes were analyzed according to right/left and dominant/non-dominant.

Results: Of the 80 hemispheres, a single gyrus was present in 67 (%84) and two gyri were present in 13 (%16). Three or more Heschl gyri were not seen. Of the total 93 Heschl gyri, 79 (%85) were omega shaped and 14 (%15) were heart shaped. With regard to dominance; thirty-six of the dominant hemispheres had one and 4 had two Heschl gyri. Thirty-one of the non-dominant hemispheres had one and 9 had two gyri.

Conclusion: Our study shows that, among normal subjects, the number and shape of Heschl's gyrus may show variations. In clinical investigations where the identification of this gyrus is needed, such as functional MRI studies, these variations should not be overlooked.

Key Words: Brain, Anatomy, Heschl's gyrus, MR imaging

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ÖZ

Amaç: Heschl'in transvers girusları temporal lobun üst yüzününün arka kısmında yer alır. Primer işitme merkezi burada bulunur. Heschl'in transvers giruslarının morfolojisi işitme ile ilgili semptomları olan hastaların değerlendirilmesi sırasında önemli olabilmektedir. Çalışmamızın amacı Heschl'in transvers giruslarının morfolojik varyasyonlarını tanımlamak ve bu varyasyonların klinik önemini vurgulamaktır.

Gereç ve Yöntemler: Çalışmaya, Radyoloji Anabilim Dalı MRG ünitesinde değerlendirilen ve başvuru yakınması başağrısı olan 18 hasta ve 22 sağlıklı gönüllü olmak üzere toplam 40 olgu dahil edilmiştir. Patolojisi bulunmayan ve çalışmaya alınan olgulara transvers düzlemde 3 boyutlu ince kesitli T1 ağırlıklı gradient eko görüntüler alındı. Girus, sagittal ve koronal reformat görüntülere göre omega ya da kalp şekilli olarak sınıflandı. Ayrıca girus sayı ve şekilleri hemisferik dominansa göre de analiz edildi.

Bulgular: Kırk olgudaki 80 hemisferin 67'sinde (%84) tek, 13'ünde (%16) ise 2 adet Heschl girusu saptandı. Üç veya daha fazla Heschl girusu olan hemisfer yoktu. 93 Heschl girusunun 79'u omega, 14'ü ise kalp şeklinde idi. Hemisferik dominans açısından değerlendirildiğinde otuzaltı dominant hemisferde dört, otuzbir nondominant hemisferde 9 tanesinde iki Heschl girusu saptandı.

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Sonuç: Çalışmamızda Heschl giruslarının normal populasyondaki varyasyon gösterilmiştir. Fonksiyonel MRG gibi araştırmalarda bu girusların tanımlanması ve gözden kaçırılmaması önemlidir.

Anahtar Sözcükler: Beyin, Anatomi, Heschl girusları, MR görüntüleme

INTRODUCTION

The auditory cortex is a network of fields that receives input from the subcortical pathways in the brainstem and thalamus. The auditory cortex is provide conscious perception of sound (1). Heschl's gyrus is the primary auditory cortex in human. It is located in the posterior part of the area on the superior surface of the temporal lobe or, the planum temporale. Heschl's gyrus is also known as transverse temporal gyrus (2, 3). The morphology of this gyrus has been reported to be variable (3). The number and shape of this gyrus may differ. Demonstration of Heschl's gyrus is important for the evaluation of patients with auditory symptoms. Bilateral Heschl's gyrus lesions may cause cortical deafness. Since auditory cortex in each hemisphere receives impulses from both hemispheres, unilateral auditory cortical lesions have only a slight effect on sound sensitivity. However, unilateral lesions in auditory cortex may lead to auditory agnosia. Determination of auditory cortex is also important for the functional magnetic resonance (MR) imaging studies (4). Besides auditory disorders, Heschl's gyrus morphology may be affected in different diseases. For example, it has been reported that the volume of Heschl's gyrus is reduced in patients with schizophrenia (2). Therefore, identification of Heschl's gyrus on sectional imaging techniques, especially on MR imaging is important. In this study, we aimed to investigate the number and shape variations of the Heschl's gyrus by using MR imaging technique.

MATERIALS and METHODS

We included 18 patients who were referred to our MR imaging unit and 22 healthy volunteers in this study. The complaint of the patients referred for MR imaging examination was headache. Inclusion criteria for patients and volunteers were: 1) No history of neurologic disease, head trauma or cranial surgery and, 2) completely normal brain MR imaging findings. Of the 40 subjects included, 21 were female and 19 were male. Ages were between 16 and 77 years, the mean age was 33.5 ± 12.8 years. Edinburgh handedness inventory was applied to the subjects for the determination of hemispheric dominance. Informed consent was obtained from all patients and volunteers.

MR Imaging protocol

All MR imaging examinations were performed with a high-field (1.5 T) superconductive unit (Philips, Intera, Best, The Netherlands). Head coils were used for image acquisition. After obtaining survey images, sagittal T1-weighted images were obtained. Transverse T2-weighted, T1-weighted and fluid-attenuated inversion recovery (FLAIR) images were obtained thereafter. Transverse sections were oriented along the anterior-posterior commissure line. These sequences were our routine protocol for brain examination. If the patient was selected for the study, a transverse three-dimensional T1-weighted fast-field echo (FFE) sequence was obtained. These three-dimensional images were stored on magneto-optical discs.

Analysis of the images

For the MR analysis of Heschl's gyrus, T1-weighted FFE images were retrieved to the workstation of the MR unit (EasyVision). Thin section slices were reconstructed in three orthogonal planes (transverse, coronal and sagittal). One millimeter slice thickness without gaps was used for the reconstruction. Reconstructed images were analysed by 2 radiologists' consensus. Planum temporales on each hemisphere were searched for gyrus-shaped structures on their surface. In each hemisphere, the number and shapes of Heschl's gyrus were recorded. The shape of the gyrus was classified as omega or heart shaped according to its appearance on coronal and sagittal images.

Statistical analysis was conducted by using the Chi-square test for the comparison between the results obtained from the right and left hemispheres, as well as the dominant and non-dominant hemispheres.

RESULTS

According to the Edinburgh handedness inventory, 37 subjects were right handed (left hemispheric dominance) and 3 subjects were left handed (right hemispheric dominance).

Eighty hemispheres were evaluated totally and in 67 hemispheres (84%) with a single Heschl gyrus were identified. In 13 hemispheres (16%), 2 Heschl gyri were seen. There was no hemisphere with 3 or more Heschl gyri.

Of the 40 right hemispheres, 31 had one and 9 had two Heschl gyri. Of the 40 left hemispheres, 36 had one and 4 had two Heschl gyri. Evaluation was also performed according to hemispheric dominance. Thirty-six of the dominant hemispheres had one and 4 had two Heschl gyri. Thirty-one of the non-dominant hemispheres had one and 9 had two Heschl gyri (Table I). These differences were not statistically significant ($p > 0.05$).

Table I: Number of gyri with regard to right/left and dominant/non-dominant hemispheres.

	Number of Hemispheres			
Number of gyri	**Right Hemispher**	**Left Hemispher**	**Dominant Hemispher**	**Non-dominant Hemispher**
1	31	36	36	31
2	9	4	4	9

The shapes of the Heschl gyri were also noted. The 40 right hemispheres contained a total of 49 Heschl gyri. Of these, 41 were omega shaped and 8 were heart shaped. The 40 left hemispheres contained a total of 44 Heschl gyri. Of these, 38 were omega shaped and 6 were heart shaped. Therefore, 93 Heschl gyri were present in total with 79 of them omega shaped and 14 heart shaped. Examples of Heschl gyrus shapes are presented in Figures 1, 2 and 3.

DISCUSSION

Evaluation of the morphology of the Heschl gyrus is important in patients with auditory problems, since this is the primary auditory cortex in humans. This gyrus in each hemisphere receives impulses from both ears, and unilateral hemispheric lesions therefore have slight effect on hearing. However, lesions in both hemispheres, such as bilateral temporal lobe infarctions, may cause cortical deafness. Unilateral lesions may cause auditory agnosia (3, 5). Heschl gyrus is an important anatomical landmark for functional MRI applications, which is a relatively new method showing cortical activation (4, 6). Heschl gyrus and planum temporale morphology have been studied in various psychiatric disorders, especially schizophrenia. In a study by Hirayasu et al., planum temporale and Heschl gyrus volumes were found to be decreased in the left hemispheres in schizophrenic patients (7). In another study by Kwon et al., a decrease in volume was found only in the planum temporale and Heschl gyrus volume was found to be unaffected (8). Gaser et al. found that a decrease in Heschl gyrus volume is correlated with the severity of auditory hallucinations (9). In schizotypal personality disorder, a decrease in left Heschl gyrus volume was also found to be present (10).

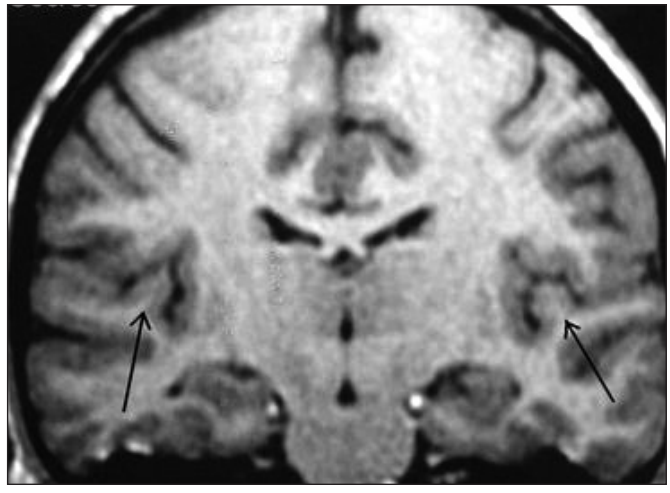

Figure 2: Omega shaped Heschl's gyrus on both hemispheres, coronal reformatted image.

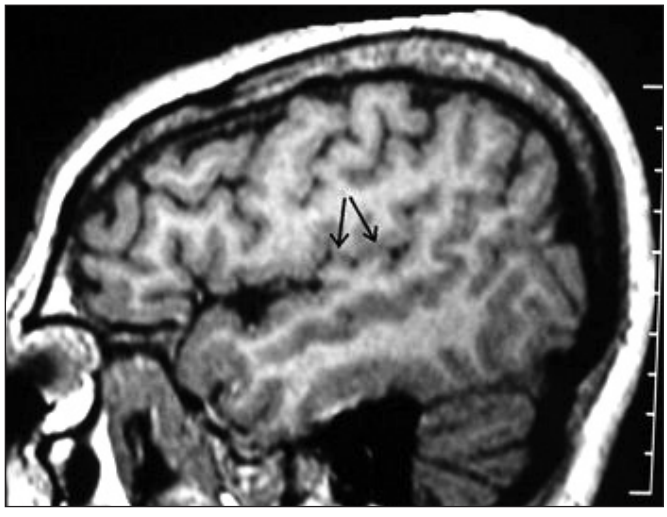

Figure 1: A heart shaped Heschl's gyrus on sagittal reformatted image..

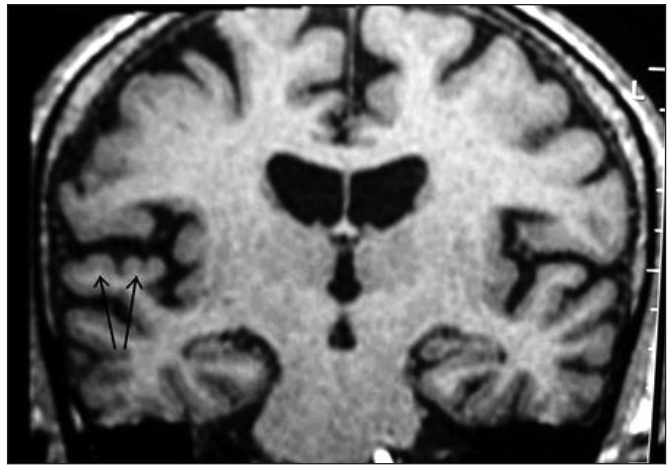

Figure 3: Two Heschl's gyri on the right planum temporale, coronal reformatted image. The lateral gyrus is omega shaped, the medial gyrus is heart shaped.

It is known that the number and shape of Heschl gyri are variable among normal subjects. The presence and depth of the Beck sulcus determines the shape and number of Heschl gyrus (3). If a Beck sulcus is absent, a single Heschl gyrus is present and it is omega shaped. If a Beck sulcus divides the Heschl gyrus incompletely, a single gyrus is seen and it is heart shaped. If the Beck sulcus is deep enough, the Heschl gyrus is divided completely; in this case, two different Heschl gyri are seen on MR images and the Beck sulcus is named as Heschl sulcus. In our study, we evaluated these variations in normal subjects. A single gyrus was seen in 84 % of all hemispheres and two gyri in 16%. Marie et al. have described the gyrification patterns and surface areas of Heschl's gyrus in 430 healthy volunteers mapped with magnetic resonance imaging. Among the 232 right-handers, they found a 64 % occurrence of duplication (11). Yousry et al. used the same MR imaging technique in the evaluation of 100 hemispheres and observed single gyrus in 66, two gyri in 33 and three gyri in 1 hemisphere (3). In our study, we did not observe three or more Heschl gyri in one hemisphere. In the results of a very old anatomic study, which was cited in Yousry et al.'s study, a single gyrus was present in 2.8%, two gyri in 20.5%, three gyri in 56.1 % and four gyri in 19.2% of all hemispheres (3). In anatomic dissection studies, the frequency of two, three or more Heschl gyri appears to be higher than in MR imaging studies. The cause of this difference may be the difficulty in the detection of shallow gyri on MR imaging. Our results are closer to Yousry et al.'s MR imaging study (3).

In conclusion, our study shows that, among normal subjects, the number and shape of Heschl's gyrus may show variations. In clinical investigations where the identification of this gyrus is needed, such as functional MRI studies, these variations should not be overlooked.

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