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Analysis of Magnetic Resonance 3d T1 Segmentations of Cerebellum in Vestibular Neuritis Patients

Vestibüler Nörit Hastalarında Cerebellum'un Manyetik Rezonans 3D T1 Segmentasyonlarının Analizi

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ABSTRACT

Vestibular neuritis is one of the most common causes of acute spontaneous vertigo. In our study, we aimed to analyze the cerebellum volume and cerebellum connections in patients diagnosed with vestibular neuritis using the VolBrain program. 10 patients and 9 healthy (control) persons were included in the study. Automatic segmentation and volumetric analysis of cerebellum and cerebellum lobules were investigated using magnetic resonance images (MRI) of 19 people. Results: The volumes of 10 cerebellar regions were measured and compared between the patient and control groups. The total volume of the cerebellum was calculated as 123.82 ± 2.57 cm^3 in the control group and 119.97 ± 4.15 cm^3 in the patient group. In addition, the average amount of gray matter in the cerebellum was 90.63 ± 6.59 cm^3 in the control group and 87.87 ± 16.12 cm^3 in the patient group. We found volumetric changes to be statistically significant. By performing cerebellum segmentation with 3D T1 sequence of MRI images taken from patients diagnosed with vestibular neuritis, volume measurement and more detailed examinations can be performed easily with the help of the volBrain program. Moreover, its low cost and its usefulness in diagnosis suggest that this method will be beneficial.

Keywords: Magnetic resonance, Vestibular neuritis, volBrain, Neurologi, Dizziness

ÖZ

Vestibüler nörit, akut spontan vertigonun en yaygın nedenlerinden biridir. Çalışmamızda VolBrain programı kullanılarak vestibüler nörit tanısı konulan hastalarda serebellum hacmini ve serebellum bağlantılarını incelemeyi amaçladık. Çalışmaya 10 hasta ve 9 sağlıklı (kontrol) kişi dahil edilmiştir. Cerebellum ve loplarının otomatik segmentasyonu ve hacimsel analizi, bu 19 bireyin manyetik rezonans görüntüleri (MRI) kullanılarak incelenmiştir. Toplam 10 cerebellar bölgenin hacimleri ölçülmüş ve hasta ve kontrol grupları arasında karşılaştırılmıştır. Bulgular: Cerebellum'un toplam hacmi kontrol grubunda 123.82 ± 2.57 cm^3, hasta grubunda 119.97 ± 4.15 cm^3 olarak hesaplanmıştır. Ayrıca Cerebellum'daki ortalama gri madde miktarı kontrol grubunda 90.63 ± 6.59 cm^3, hasta grubunda 87.87 ± 16.12 cm^3 olarak ölçülmüştür. Hacimsel değişikliklerin istatistiksel olarak anlamlı olduğunu bulunmuştur. Vestibüler nörit tanısı almış hastalardan alınan MR görüntülerinin 3D T1 sekansıyla cerebellum segmentasyonu yapılarak volBrain yazılımı yardımıyla hacim ölçümü ve daha detaylı incelemeler kolaylıkla yapılabilmektedir. Üstelik düşük maliyeti ve tanı koymadaki faydası da bu yöntemin faydalı olacağını düşündürmektedir.

Anahtar Kelimeler: Manyetik rezonans, Vestibüler nörit, volBrain, Nöroloji, Baş dönmesi

Alanya Alaaddin Keykubat University Faculty of Medicine Clinical Research Ethics Committee, with the decision dated 26.09.2019 and numbered 10/13, permission was obtained.

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INTRODUCTION

Vertigo is one of the most common complaints among the reasons for admission to the hospital. Vertigo can develop in patients with dizziness due to central, peripheral and internal reasons. The symptom here is the sudden appearance of an intense vertigo with no hearing loss or neurological symptoms, imbalance, nausea and vomiting, dizziness that usually lasts for several days. Images are taken from the brain with magnetic resonance imaging (MRI) to distinguish intracranial events during the diagnosis and treatment phase of the patients. Intracranial tumors, acute ischemic events, abscess, hematoma and traumatic events, chronic demyelinating diseases such as multiple sclerosis can lead to acute and chronic vertigo symptoms. In our study, we aim to retrospectively examine the brain MRI images of adult patients with a diagnosis of vestibular neuritis (VN) who have had vertigo, have undergone internal and neurological examination and have no disease. Vestibular neuritis is an infection of the balance organ or balance nerve in the inner ear.[1] It is characterized by the presence of severe dizziness, nausea and vomiting, and neurological symptoms that usually occur followig viral upper respiratory tract infections such as colds and flu. The diagnosis is usually made by excluding other vertigo factors. Changes in the brain and its pathways that may occur during vestibular neuritis have been examined in a few studies in the literatüre.[2,3]

Various examination methods such as Flair Mr and Pzoitron Emission Tomography have been used in different studies. Many researchers in the literature have tried to image vestibular neuritis using T1-weighted images, but they could not obtain significant results.[4] Helmchen, Klinkenstein Found structural changes based on gray matter differences by measuring MRI images of 15 patients diagnosed with VN in various areas of the brain and cerebellum with the voxel-based morphometry (VBM, SPM2) program evaluated the MRI images of 9 patients with acute VN in the acute period and in the period after 3 months.[5] Significant increases in Gray Matter were observed in the vestibular cortex, bilateral hippocampus, visual cortex and cerebellum. They stated that GMV decreased in the cerebellar regions including vermis and in the prefrontal cortex. In the literature, increases in gray matter density have been reported in vestibular cortical networks and visual cortical areas after VN. In addition, studies comparing the differences in brain activity between acute and chronic stages of VN report that vestibular areas are more active than visual fields.[6]

A VolBrain is an open access platform that can be used for automatic segmentation of various brain structures.[7,8] Cui, Zhang measured the volume changes in the cerebellar region with the VolBrain method in their study and evaluated the relationship between lobules at different ages and their reduced memory recall abilities.[9]

We used the segmentation method with the default volBrain T1 volumetric images. We analyzed the total cerebellum volumes of patients with vestibular neuritis and those in the control group. As far as we can see, there is no study in the literature addressing the cerebellum segmentation of vestibular neuritis patients. We predicted that there would be structural differences in cerebellar and cerebellar lobule volumes between patients with vestibular neuritis and normal individuals, so we performed segmentation in a homogeneous group using the volBrain platform.

We think that in brain MRI images taken from patients diagnosed with vestibular neuritis, by performing brain segmentation with 3D T1 sequence, a more detailed investigation of their volumes with the MATLAB program will contribute to the literature.

MATERIAL AND METHOD

The MRI data in this paper were obtained from the Alanya Alaaddin Keykubat University. Structural MRI images were performed at the Alanya Alaaddin Keykubat University Hospital. Alanya Alaaddin Keykubat University Faculty of Medicine Clinical Research Ethics Committee, with the decision dated 26.09.2019 and numbered 10/13, permission was obtained. In our study, the PACS archive of Alanya Alaaddin Keykubat (Retrospectively) between January 2018 and August 2019 was scanned. At the end of the screening, a total of 19 patients between the ages of 18-60, 10 (5 females / 5 males) diagnosed with vestibular neuritis and 9 (5 females / 4 males) without any diagnosis were evaluated.

Inclusion criteria: Adult patients who presented to the ENT outpatient clinic with a complaint of vertigo were included in the study. The patients underwent internal, neurological and ENT examinations. Positional tests were applied to rule out positional dizziness. Whole blood and laboratory analysis, audiometry, and brain MRI examinations were performed. Adult patients who were followed up with a diagnosis of vestibular neuritis as a result of anamnesis, examination and examinations were included in the study.

Exclusion criteria: Individuals with organic pathology causing dizziness, those with hearing loss, those with diabetes mellitus, those with additional internal diseases such as hypertension, and those with diagnosed neurological diseases were excluded from the study. Patients with recent head trauma and patients using chronic medications for hypertension were excluded.

Neuroimaging

MRI imaging was performed using a 1.5 T Siemens Aera scanner (Siemens, Germany). Constructional images were acquired using T1-weighted 3D Magnetization Prepared Rapid Gradient Echo (MPRAGE) sequence in sagittal plane, using these parameters: flip angle=5^{o}, number of slices=160 and slice thickness=1,0 mm, acquisition matrix= 256 x 256, FOV=280 mm^2, TE/TR=1900 ms/2,84s.

We downloaded MR T1 data from the scanner, transferred and processed using different software. We saved MR images as NIFTI format. For this purpose, we used personal computer on a 64-bit Lenovo PC, running Windows 10 operating system (Figure 1).

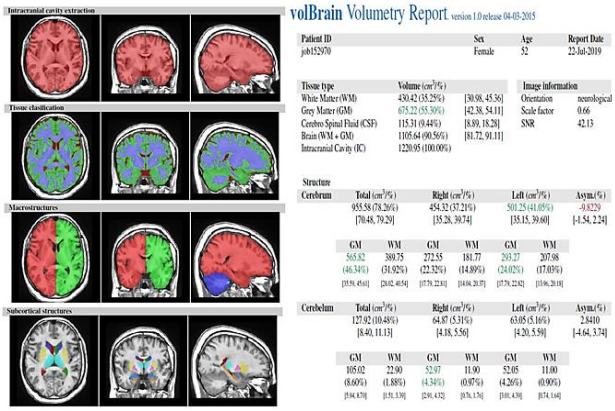

Figure 1. volBrain volumetric measurement results

VolBrain (CERES)

VolBrain is a web-based volume computation of processes aimed to automatically investigate MRI brain data. It works as a black box from the user point of view as it gets an anonymized MRI brain volume in produces and NIFTI format a pdf report with the volumes of the principal Intra Cranial Cavity (ICC) tissues (that is white matter, grey matter and cerebro spinal fluid). Furthermore, provides volume information of some macroscopic areas such as cerebellum, brainstem and brain hemispheres. Automatic subcortical structure segmentation is performed, label maps and related volumes are provided. Processing time is about ten minutes. This time may vary in proportion to the density of jobs on the web server.[10]

The VolBrain system is based on a developed pipeline providing automatic segmentations of different brain structures from T1-weighted MRI images.[11]

Cerebellar segmentation was accomplished with Ceres.[12] T1 data were uploaded and

retrieved from (http://volbrain.upv.es). Data comprised left and right measures of the whole cerebellum volume and gray matter, and 12 lobules (I II, III, IV, V, VI, Crus I, Crus II, VIIB, VIIIA, VIIIB, IX, X). The cerebellar volume of the total white matter was determined from the difference between whole volume and whole gray matter volume. In-house software extracted volumetric data from the downloaded Ceres result tables; pdf rendering of Ceres fits was inspected for quality, and all images were acceptable. Included in the Ceres downloads were estimates of intracranial volume (ICV) (Figure2).

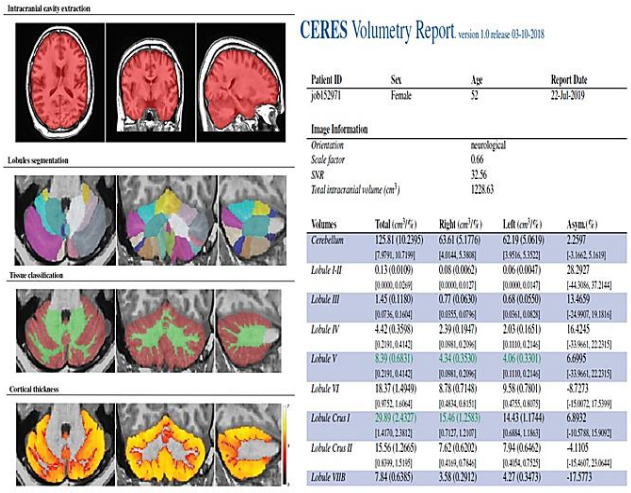

Figure 2. The sample of the segmentation of the cerebellar lobules is shown in volBrain Ceres Volumetry report.

RESULTS AND DISCUSSION

In our study, there were 9 people in the control group and 10 people in the vestibular neuritis patient group. While the total volume of cerebellum was 123.82 ± 2.57 cm^3 in the control group, it was calculated as 119.97 ± 4.15 cm^3 in the patient group.

When the cerebellum lobes were examined, the mean volume value in the Crus I control group was 26.18 ± 1.23 cm^3 and in the patient group, it was 23.36 ± 3.54 cm^3. In Crus II, when the average volume values were examined, the mean volume value of the control group was 15.47 ± 1.84 cm^3, whereas it was 15.42 ± 3.60 cm^3 in the patient group. When the data of the VIIIA lobe were examined, the average volume of the control group was 12.09 ± 1.93 cm^3, while the average volume of the patient group was 11.36 ± 3.56 cm^3. When the X. Lobe was examined, the average volume of the control group was 1.20 ± 0.20 cm^3, and the average volume was 1.19 ± 0.22 cm^3 in the patient group.

In our study, in the measurements we made about the cerebellum and its lobul, a difference was observed between the patient group and the control group in total cerebellum volume, crus I and lobular X. but there was no difference between other cerebellum lobules. In general, in our study, the volume of the mean cerebellum lobes of the patient group was less than the average volume of the cerebellum lobes in the control group (p <0.05).

When cortical thickness was examined, the total cerebellum cortical thickness was found as 4.53 ± 0.13 mm/norm in the control group. In the patient group, it was calculated as 4.52 ± 0.18 mm/norm. When Lobe VI was examined from the cerebellum lobes, the average thickness was 5.02 ± 0.06 mm / norm, while it was calculated as 4.85 ± 0.36 mm / norm in the patient group. When the VIIIA lobe was examined, the average cortical thickness in the control group was 4.87 ± 0.20mm / norm, while it was calculated as 4.74 ± 0.60 mm / norm in the patient group. When cortical thickness was examined, a significant difference was observed between the groups in lobular IV, V, VI, IX and Crus II (p <0.05).

When the gray matter ratio was examined, the average gray matter amount of the cerebellum was 90.63 ± 6.59 cm^3 in the control group and 87.87 ± 16.12 cm^3 in the patient group. VI. While the average gray matter ratio in the control group in the lobe is 14.98 ± 1.64 cm^3, it is 14.60 ± 2.37 cm^3 in the patient group (Table I).

Table 1. Cerebellum Lobular Volum Values

Regional Volumes	Total Cerebellum Volume		Cortical thickness		Grey Matter	
	Control Mean (cm^3)+SD	Patient Group (cm^3)+SD	Control Mean (mm/norm)+SD	Patient Group (mm/norm)+SD	Control Mean (cm^3)+SD	Patient Group (cm^3)+SD
Total(cerebellum)	123.82±2.57*	119.97±4.15*	4.53±0.13	4.52±0.18	90.63±6.59	87.87±16.12
I-II	0.12±0.02	0.11±0.03	1.92±0.43	2.15±0.70	0.06±0.01	0.07±0.01
III	1.29±0.26	1.26±0.30	3.62±0.26	3.62±0.52	1.01±0.19	1.01±0.21
IV	4.32±0.63	4.03±0.53	4.99±0.06*	4.87±0.14*	3.81±0.25*	3.52±0.30*
V	7.30±0.78	7.66±0.95	4.93±0.08*	4.82±0.11*	6.49±0.76	6.57±0.90
VI	16.72±1.77	16.31±2.19	5.02±0.06*	4.85±0.18*	14.98±1.64	14.60±2.37
CRUS I	26.18±1.23*	23.36±3.54*	4.20±0.24	4.22±0.29	20.71±1.95*	17.65±3.77*
CRUS II	15.47±1.84	15.42±3.60	3.69±0.08*	3.85±0.14*	12.07±1.65	12.14±2.62
VIIB	8.86±1.13	8.37±2.12	4.57±0.30	4.62±0.58	7.46±1.18	7.21±1.66
VIIIA	12.09±1.93	11.36±3.56	4.87±0.20	4.74±0.60	10.49±1.91	10.11±2.95
VIIIB	7.92±0.92	7.29±2.11	5.06±0.15	4.97±0.41	7.11±0.94	6.57±1.87
IX	6.37±0.48*	6.91±0.44*	4.52±0.07*	4.61±0.08*	5.54±0.70	2.82±1.30
X	1.19±0.20	1.19±0.22	2.90±0.29	2.92±0.26	1.10±0.14	1.18±0.22

**There is difference between groups (p <0.05)*

When the amount of gray matter in the cerebellum was examined, a statistical difference was found between the groups in lobules IV and Crus I, but not in other measurements.

In the data obtained, statistical analysis was done on computer using IBM SPSS 22.0 program. In the data obtained, 5 parameters were evaluated kurtosis, skewness, mean-standard deviation ratio, histogram plot, Shapiro-Wilk test and normality test were performed. Parametric Independent Samples T-Test was chosen for comparison between the groups. In statistical analysis, $\alpha = 0.05$ was taken and $p < \alpha$ was significant and $p > \alpha$ was considered statistically insignificant.

Vestibular neuritis is usually unilateral acute dysfunction of the peripheral vestibular system. Sudden onset of vertigo, usually lasting several days, associated with imbalance, nausea, and vomiting without any hearing loss or neurological symptoms. Vestibular neuritis is the most common cause of vertigo after Benign Positional Paroxysmal Vertigo.[13] Vertigo is not a disease alone, it is the main symptom of different diseases with varying etiology and it is a disease of brain stem, inner ear, cerebellum or psychic origin. It may result from side effects of drugs such as antihypertensive, anticonvulsive or orthostatic disorder.[14]

Strupp, Zingler, in a study they conducted, they stated that methylprednisolone alone significantly improved the degree of improvement of peripheral function in patients with vestibular neuritis.[15] It is known that drug therapy only reduces symptoms and vestibular tests form the basis of treatment. MRI is also performed on patients who are admitted to the hospital with a suspicion of vestibular neuritis. In our study, in the MR

images of 9 control and 10 vestibular neuritis patients, the volumes of the lobes of the cerebellum, the cothical thickness and the gray matter regions were examined using the VolBrain method. It occurs in cases with cerebellar artery infarction in sudden hearing loss and vertigo.[16]

In a study, conducted in 2019, when they examined the cerebellar lobes of 182 people with schizophrenia and 322 people from the control group, they stated that the cerebellum volume, the volumes of Crus II and Lobe VIIB were less than the control group Psychic illnesses likewise trigger vestibular neuritis. The cerebellum is connected to almost every region of the brain except the visual cortex and represents a potential therapeutic target.[17,18] Understanding the exact location of cerebellar changes in bipolar disorders and schizophrenia is essential. Because it affects the cerebellar stimulation site and brain stimulation in the cerebellum and distant cortical regions.[19]

Lithium is seen as the gold standard treatment in psychic disorders, especially in bipolar disorder. Cerebellar tremor is seen as a side effect in cases with long-term cerebellar toxicity due to lithium.[20]

In recent studies, it is seen that MR images give more reliable results in various brain segmentations with volBrain (Ceres) software.[12,17,21]

Acer and Sahin used two different methods for cerebellum volume estimation. The cerebellum volume was found to be 116.34 ± 10.6 cm^3 in males and 114.41 ± 9.3 cm^3 in females by Planimetry method.[22] In his second method, he applied the point counting method and found it to be 116.34 ± 10.6 cm^3 in men and 113.48 ± 8.8 cm^3 in women. There was no statistically significant difference between the total cerebellar volume obtained by two different methods. This study and the results of our study are similar.

Tiemeier, Lenroot In a study they conducted in 2010, they stated that the cerebellar volume in 50 people between the ages of 5-24 was 10-13% higher in men than in women.[23] In our study, again, the total cerebellum volume of men was found to be slightly higher than the total cerebellum volume of women. In the study conducted by Wurthmann, Naegel on permanent postural perceptual dizziness, a decrease in the volumes of temporal cortex, cingulate cotex, precentral gyrus, hippocampus, caudate nucleus was observed.[24] In our study, the gray matter ratio of the cerebellum was calculated as 90.63 ± 6.59 cm^3 in the control group and 87.87 ± 16.12 cm^3 in the vestibular neuritis group. In our study, it is seen that the amount of gray matter of the vertigo group decreased compared to the control group. In our study, the mean total cerebellar volume in vestibular neuritis patients was 123.82 ± 2.57 cm^3, while it was 119.97 ± 4.15 cm^3 in the control group.

There are some limitations in our results. We used automated segmentation procedures in our study and manual. We did not compare the method, but there is no significant difference between the automatic segmentation method and manual monitoring of the brain volume. Akudjedu, Nabulsi reported that manual segmentation and automatic segmentation in volBrain are equally sensitive in detecting group volume differences.[25]

CONCLUSION AND RECOMMENDATIONS

In our study, the volumes of the lobular structures of the cerebellum were calculated separately using the volBrain software. When the cerebellar segmentation volumes were compared, it was seen that the mean cerebellum volume of vestibular neuritis patients was less than the control group. Finally, volBrain can be used in the future for analysis, diagnosis and treatment of vestibular neuritis patients. We chose to do our analysis with this platform due to the availability of easy to use webbased software, and we recommend its use in the treatment of vestibular neuritis patients. We hope that our study will be a reference for other studies to be done by increasing the number of patients in the future.

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