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ORIGINAL ARTICLE – OPEN ACCESS

Evaluation of Cerebellar Volume in Adult Turkish Male Individuals: Comparison of three Methods in Magnetic Resonance Imaging

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ABSTRACT

Objective: Cerebellum plays quite important in our balance by coordinating the control and synergistic movements of the skeletal muscles. There are many studies in which the volume of the cerebellum is measured and different methods are used. Manual measurements are accepted as the gold standard in these studies, but these measurements are not commonly used due to time and difficulty. The present study aims to compare the cerebellum volume using three different methods.

Materials and Methods: In this study, MR images of 18 men aged between 22 and 30 years were used in the Department of Radiology of Erciyes University Gevher Nesibe Hospital. In the total cerebellum volume measurements, sagittal images were calculated using the Manual (ImageJ), MRICloud and VolBrain (CERES) methods.

Results: Manual and VolBrain measurements were performed to determine the volume of the cerebellum. The total volume of the cerebellum was 136.36±12.36 cm^3 in manual calculation 125.46±17.26 cm^3 in VolBrain and MRICloud1 46.81±20.16.

Conclusion: In this study, it was seen that the three methods used to measure the volume of the cerebellum were compatible with each other. Because VolBrain volume values are close to the manual method, cerebellum volumes can be obtained by routinely using them.

Keywords: VolBrain, cerebellum, MRICloud, ImageJ, MRI

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INTRODUCTION

In recent years, many studies have focused on the cerebrum and cerebellum imaging methods and volumetric measurements of various parts of the brain using different methods (1, 2). Since it has many important roles, such as motor coordination, muscle tone, sensitivity, attention and language skills, it is significant to determine these measurement standards in the cerebellum (3). Using the anatomy and morphological features of the brain, the progression of the diseases was examined and significant studies were conducted (4). Standard brain structures for regional volumetric quantification to be considered in manual segmentation techniques (5, 6). Automated measurements to find the volume of various regions in the brain provide more advantages than manual measurements. The amount of medical image data produced in clinical and research settings is rapidly growing, resulting in a vast amount of data to analyze. Automatic and reliable quantitative analysis tools, including segmentation, allow us to analyze brain development and to understand specific patterns of many neurological diseases. There is a high probability of error in manual measurements. Fully automatic multi-atlas measurements, such as VolBrain, provide many advantages (7) have also been applied to address these errors. Some previous studies have evaluated the performance of stereology and automated methods compared to manual segmentation in comparatively small populations (8). It may be useful to establish standards with measurements for individual analysis of different brain and cerebellum structures of MR images. The voxel-based morphometry (VBM) toolbox (an extension of the SPM) is also used to measure local GM changes. Partitioning structures, such as brain, cerebellum, brainstem and brain hemispheres and evaluating brain asymmetry, draws attention in recent studies. Various automated measurement models have been developed in hemispheres and split segmentation for cerebellum volumes clearly determined in some MRI studies (9). MRICloud and VolBrain are a web-based platform for automated brain and cerebellum segmentation and distributed remote computing. Studies based on MRICloud are included in the literature. It is a program used for volumetric calculations of the brain and cerebellum in cognitive disorders and other neurological diseases (10).

Clinical neuromorphometric studies, such as bipolar disorder, were performed and various classes of classification techniques were applied in major depressive disorder and schizophrenia (11–14). It should be examined in neural disorders, such as cerebellar volume, epilepsy, Parkinson's syndrome, sleep apnea, brain atrophy, attention-deficit /hyperactivity disorder, autism and schizophrenia (15). Many diseases can change the morphometric structure of the cerebellum, including neurological trauma, diseases, infection, neuro-psychiatric conditions (16, 17).

The present study aims to compare VolBrain, manual (ImageJ) and MRICloud methods, a new software line for volumetric cerebellum analysis.

MATERIALS and METHODS

Participants

The MRI data in this paper were obtained from the Erciyes University Scientific Research Projects Coordination Unit under the grant (TIR-2017-5045).

Structural MR images were performed at the Department of Radiology of Erciyes University in Gevher Nesibe Hospital. We used 18 men aged between 22 and 30 years. In the total cerebellum volume measurements, sagittal images were first calculated using the manual (ImageJ) method. Clinical valuations and baseline protocols utilize during recruitment were described in advance (4).

Neuroimaging

MR imaging was performed using a 1.5 T Siemens Aera scanner (Siemens, Germany). Constructional images were acquired using the T1-weighted 3D Magnetization Prepared Rapid Gradient Echo (MPRAGE) sequence in a sagittal plane using these parameters: flip angle=5°, number of slices=160 and slice thickness=1.0 mm, acquisition matrix=256x256, 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 a personal computer on a 64-bit Lenovo PC, running Windows 10 operating system.

VolBrain (CERES) (http://VolBrain.upv.es/)

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 IntraCranial Cavity (ICC) tissues (that is white matter, grey matter and cerebrospinal fluid). Furthermore, it 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 webserver (19).

The VolBrain system is based on a developed pipeline providing automatic segmentation of different brain structures from T1-weighted MR images (7).

MRICloud (https://mricloud.org)

MRICloud provides a fully automated cloud service for brain parcellation of MPRAGE images based on multiple atlas likelihood fusion algorithm, an ontology level control technology The atlas used for the processing of our data was the adult_286labels_11atlases_V5L and JHU multi-atlas inventories with 286 defined structures (Fig. 1, 2) (18).

ImageJ

ImageJ is a public domain Java image processing program created by NIH Image for the Macintosh. It runs, as a downloadable application or either as an online applet, on whichever computer with a Java 1.4 or later virtual machine. Downloadable distributions are available for Linux, Windows, Mac OS X and Mac OS. It can print 8-bit, 16-bit and 32-bit images and display, edit, analyze, process, save. It can read plenty of image formats, including FITS, GIF, BMP, JPEG, DICOM, TIFF, and "raw. Its assistance "stacks", a series of images that share a single window (19).

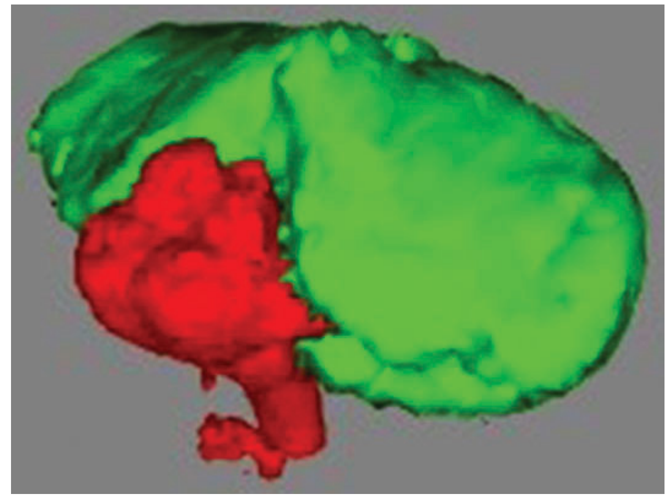

Figure 1. Appearance of cerebellum

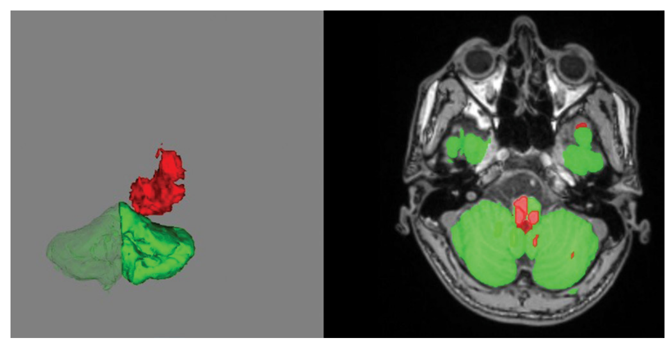

Figure 2. Cerebellum view in MRICloud program

In the images opened in the ImageJ program, the cerebellum volume was calculated by adding CTRL + M areas of cerebellum.

Statistical Analysis

In the data obtained, statistical analysis was conducted on the computer using IBM SPSS 22.0 program. In the data obtained, five parameters were evaluated kurtosis, skewness, mean-standard deviation ratio, histogram plot, Shapiro-Wilko test and normality test were performed. Non-parametric chi-square test was chosen for the comparison between the groups. In statistical analysis, $\alpha=0.05$ was taken and $p<\alpha$ was significant and $p>\alpha$ was considered statistically insignificant.

RESULTS

Using the VolBrain (CERES) web-based program, the brain and cerebellum volumes are calculated automatically, as well as the ratio of white matter and gray matter (Fig. 3).

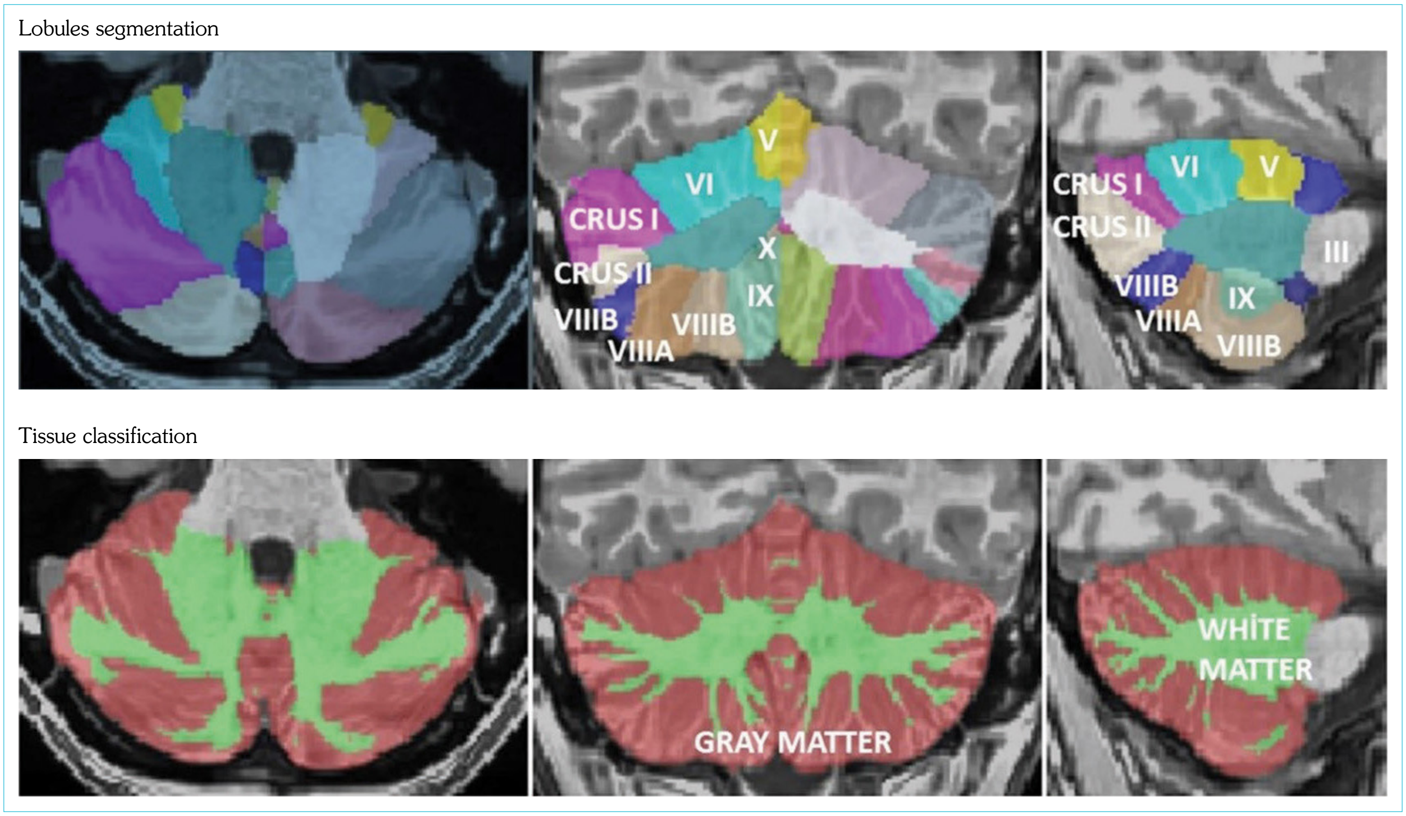

Figure 3. **In our study, the image of a 24-year-old male brain parcel was examined. Lobules can be seen in the V-X middle (coronal) slice and lobules III-IX in the right (sagittal) slice. Gray matter and white matter structure are examined in the following 3-up image**

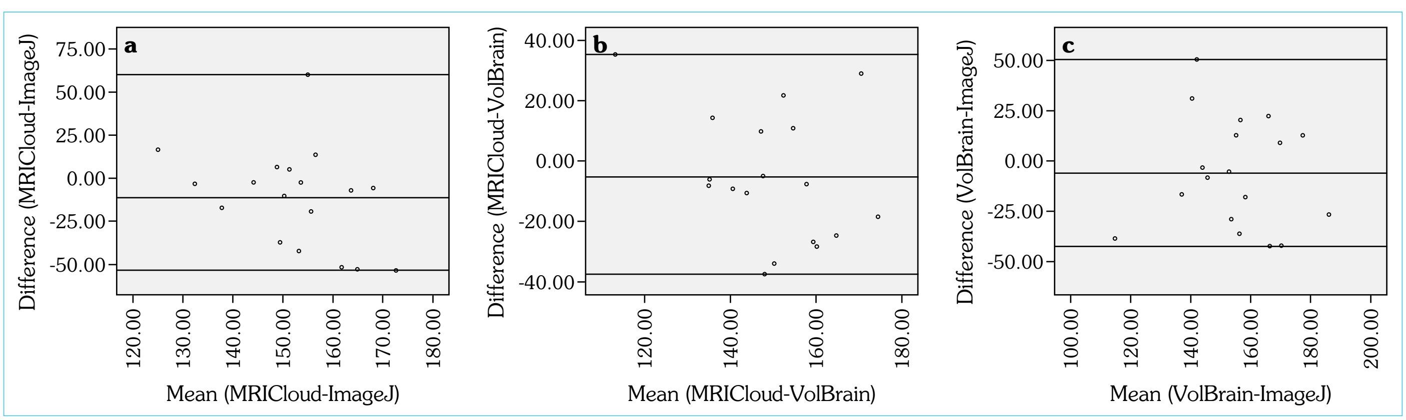

Figure 4. **(a) MRICloud-ImageJ Bland-Altman graphic. (b) MRICloud-VolBrain Bland-Altman graphic. (c) VolBrain-ImageJ Bland-Altman graphic**

Cerebellum volumes were measured using MRICloud, VolBrain and ImageJ programs. There was no statistically significant difference between these three different methods (p>0.05). The results of these three methods were close to each other. The methods can be used interchangeably.

Graphical comparisons of MRICloud-ImageJ, MRICloud-VolBrain and VolBrain-ImageJ Bland-Altman were performed (Fig. 4).

Cerebellar segmentation was accomplished with CERES (25). T1 data were loaded at http://VolBrain.upv.es web address and results were obtained.

Internal software extracted volumetric data from downloaded CERES results tables. The data obtained on the CERES website included left and right measurements for the whole cerebellum volume.

In the MRICloud program, total cerebellum volume, right cerebellum volume and left cerebellum volume were calculated in 18 men (Tables 1, 2).

When the mean cerebellum volume in this study is compared with the three methods, the results are similar. Cerebellum volume was measured as 152.101 cm^3 in VolBrain (CERES) software, 154.504

Table 1. Cerebellum volume measurement through three separate programs

Number of people	MRICloud total cerebellum volume cm³	MRICloud right cerebellum volume cm³	MRICloud left cerebellum volume cm³	VolBrain total cerebellum volume cm³	VolBrain right cerebellum volume cm³	VolBrain left cerebellum volume cm³	ImageJ total cerebellum volume compatibility these analyses cm³
1	145.89	72.47	73.42	150.15	74.99	75.16	155.41
2	163.28	82.06	81.22	141.51	69.75	71.77	149.72
3	160.09	80.87	79.21	149.20	74.30	74.90	167.19
4	145.94	73.08	72.85	172.73	86.8	85.94	199.40
5	132.11	65.94	66.16	138.16	68.19	69.97	174.27
6	129.24	63.78	65.46	166.76	82.66	83.65	146.36
7	130.78	66.45	64.33	95.45	46.20	49.25	133.99
8	146.01	72.46	73.54	174.34	87.16	87.19	165.28
9	135.95	67.82	68.12	145.18	71.51	73.67	187.52
10	185.02	93.24	91.78	156.06	77.50	78.57	124.93
11	153.94	77.53	76.41	161.59	80.65	80.94	148.72
12	165.20	83.09	82.11	183.72	91.02	92.70	170.93
13	133.26	66.49	66.77	167.25	83.97	83.27	116.74
14	138.48	69.70	68.78	149.13	74.13	75.00	191.23
15	142.99	71.09	71.90	128.66	65.11	63.55	145.31
16	130.88	64.60	66.28	139.05	69.20	69.85	167.95
17	152.04	75.68	76.35	142.25	71.15	71.10	145.57
18	152.38	76.02	76.36	177.08	88.28	88.8	154.79

Table 2. Average values of measurements

Measurements	Mean±SD	Min.–Max.
MRICloud total cerebellum volume cm³	146.81±14.49	129.24–185.02
MRICloud right cerebellum volume cm³	72.79±8.09	60.47–93.24
MRICloud left cerebellum volume cm³	72.50±7.88	57.42–91.78
VolBrain total cerebellum volume cm³	152.12±20.40	95.45–183.72
VolBrain right cerebellum volume cm³	75.69±10.41	46.20–91.02
VolBrain left cerebellum volume cm³	76.40±10.00	49.25–92.70
ImageJ total cerebellum volume cm³	158.07±21.54	116.74–199.40

Min.: Minimum; Max.: Maximum

cm³ in MRICloud software, and 158.077 cm³ in the ImageJ program. As a result of the studies obtained, there was no difference between the three different measurement parameters.

DISCUSSION

One of the significant features of cloud-based analysis methods is that the user does not have to install the software on his personal computer, so it does not put any strain on the version or operating system compatibility. These analysis methods also make it easy to access shared high-level computing resources and do not have to be limited by the memory capacity of the user's own computer. In addition, cloud-based analysis methods allow more efficient implementation of the software update and error correction (20).

This study aims to calculate and compare these methods using three different methods in measuring cerebellum volume. VolBrain, MRICloud and ImageJ programs were used for measurement. Findings obtained from this study are highly reliable and time-saving. With its role in balance, other motor skills and coordination, the cerebellum is believed to make significant contributions to various cognitive and emotional functions (2). Regarding the clinical significance of non-motor functions of the cerebellum, it becomes important in patients who demonstrate the relationship between behavioral changes and cerebellar injury. Cerebellum has many cognitive roles, such as dysprosodia, agrammatism, visual impairment, diffuse vision, verbal fluency, reduced working memory and abstract reasoning. Our findings can help inform another investigator about the considerable advantages and caveats the same noted in adult populations, as in advance reported. These core properties of spatial, executive and linguistic describe the cerebellar cognitive affective syndrome and accepted notions of dementia. Cerebellar cognitive affective syndrome is distinguishable from other subcortical syndromes by virtue of the symptom complex consisting of disturbances in spatial, executive affective functions and linguistic, routinely evaluated on MRI in diseases, such as X-linked adrenoleukodystrophy, 4H syndrome (hypomyelination, hypodontia and hypogonadotropic hypogonadism) and metachromatic leukodystrophy Pelizaeus-Merzbacher's disease (21). MRI images can be assessed for determined criteria like localization of lesions, progression or regression of the disease, along with changes in brain volume. In recent years, brain volumes have been investigated for diseases, such as hydrocephalus, atrophy, Huntington and Parkinson's disease, multiple sclerosis, human immunodeficiency virus

(HIV) -related leukoencephalopathy and progressive supranuclear palsy (22). Caviness et al. measured cerebellum volumes in 15 males and 15 females between 7 and 11 years of age. They reported that the cerebellum volume of the boys was less than that of the cerebellum in females but that the cerebellum volume of the girls was close to the cerebellum of the adults. The reason for this was that males' cerebellum volumes developed later than females (23). Baykan et al. reported that cerebellum volume was 103.3 cm^3 for infants, 148.8 cm^3 for children and 153 cm^3 for adolescents (24).

Acer et al. (2008) used the point-counting and planimetry methods for cerebellum volume estimation. They found that the planimetry method was 116.69±10.1 and 114.41±9.3 cm^3 in males and females, respectively. The mean results of the point-counting method were 116.34±10.6 and 113.48±8.8 cm^3 in males and females, respectively. Total cerebellar volumes obtained by two different methods were not statistically different (25).

Tiemeier et al., in a study of 50 people aged 5–24 years, reported that cerebellar volume was 10 to 13% higher in males (26).

Sullivan et al. examined cerebellum segmentation in alcohol users and correlations between 6 and 10 lobules were determined using high glu-glutamyl transferase (GGT) levels, CERES and suites that reflect liver function (27).

Romero et al. another important feature of CERES in another study performed its adaptability. As it uses the similarity of manually segmented templates as an information segment, it can learn new anatomy by adding new cases to the library (28).

In individuals with the pathology of the anterior superior delivery of the cerebellum, postural balance is disturbed. Sullivan et al., in another study they conducted, they pointed out this balance, which provides a suitable model to study the relationship between known vermian pathology and chronic alcoholism, cerebellar pathology, and postural stability.

CONCLUSION

In this study, cerebellum volumes were calculated using three different methods using MR images of 18 people between the ages of 22–30. The results of three different methods used were seen close to each other. Thus, rapid automated methods for measuring cerebellum volume in MR images can be used. The use of brain volume determination with automatic calculation can be a rapid radiological guide to diagnose or monitor disease status in the posterior fossa and brain stem.

Ethics Committee Approval: The Erciyes University Clinical Research Ethics Committee granted approval for this study (date: 21.02.2014, number: 2014/122).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: S. Bastepe-Gray, N. Acer designed the study. L. Degirmencioglu, H. Donmez and N. Acer collected the data. S. Yılmaz, N. Acer, A. Tokpınar and Ş. Ateş analyzed the data. All authors wrote this paper. All authors contributed to the data interpretation, review and revision of this manuscript.

Conflict of Interest: The authors have no conflict of interest to declare.

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