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Different morphological imaging techniques possible for neuroscience

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Abstract

Brain morphology and function have underpinned the vast majority of scientific research since time immemorial. Study trends in this field have increased the demand for neurosciences, a multidisciplinary field. Although the anatomy and functions of the brain, which form the basis of neurosciences, have been studied frequently, they remain mysterious. Brain morphologic areas are prominent in many neurodegenerative diseases. In this study, our aim is to compare different morphological measurement methods in neuroscience using Horos and VolBrain applications from intracranial brain images obtained with the magnetic resonance imaging (MRI) technique.

Our study is a method comparison study based on archive review. The use of these applications, data loading, and reliability of the results were compared. Both radiological imaging programs were useful in the volumetric examination of anatomical structures. Although HOROS is more useful in 2D and 3D imaging than VolBrain, the fact that it is a Mac-based program may reduce its usefulness in volumetric calculations. VolBrain software, on the other hand, performs the calculations automatically and obtains data of many structures at the same time, which provides great convenience to the users.

Both applications give almost the same results in terms of volumetric measurement. This shows that both programs give reliable results. With the development of technology, different software and programs have emerged where morphological area and volume calculations can be made. Using these programs and software, the morphometry of many functional structures in neuroscience can be studied. Thus, we believe that the results obtained from this research will provide the opportunity to save time, ensure reproducibility, and test the reliability of the data for many possible research projects.

Keywords: Brain, Horos, MRI, Neuroscience, Volbrain.

Introduction

Neuroscience is a multidisciplinary approach that attracts the attention of many disciplines and constitutes the field of study by focusing on nerve cells, synaptic connections, and morphological and functional mechanisms [1]. Advancement of technology and scientific developments contribute to the gradual improvement of health services and living standards offered to people. This leads to an increase in the average life expectancy of people. It is possible to say that the incidence of neurodegenerative diseases due to neuronal damage has also increased with the increase in the average life expectancy [2-4]. Today, various imaging methods are used in the diagnosis and follow-up of many diseases [5-8]. One of these methods, magnetic resonance imaging (MRI), has been the mainstay of medical imaging for almost 50 years [9] and serves as the primary diagnostic method for many diseases [10]. MRI is a non-invasive method for mapping the internal structure of the body. It provides high-quality images of the body in any plane using radio frequency (RF) radiation [11]. In the past 40 years, MRI has been developed in terms of hardware both to shorten the image acquisition time and to facilitate more advanced functional and anatomical imaging [10]. Initially limited to the neuro-axis, it now covers all parts of the body [11]. However, MRI has an important value in the imaging of the musculoskeletal system, pelvis, head and neck rather than imaging of the abdomen, where ultrasound and computed tomography are mostly used [12]. Many studies use images of intracranial structures obtained by MRI technique. Volume, area, segmentation and thickness measurements of intracranial structures in these images can be obtained using various programs or software. Programs and software such as HOROS, VolBrain, OsiriX, and MRICloud are some of the frequently encountered applications in the literature [13-16]. Thus, the data obtained provide great convenience for the diagnosis and follow-up of neurodegenerative diseases, the incidence of which is increasing day by day. At the same time, these studies also pave the way for discoveries in the field of neuroscience and neuroanatomy.

Our aim in this study is to determine the advantages and disadvantages of VolBrain software and the HOROS programs, which are frequently used in neuroscience, compared to each other.

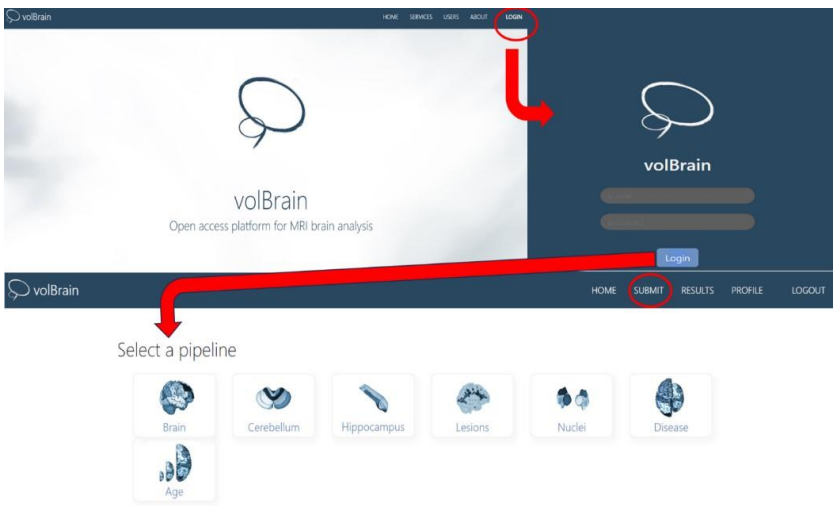

Figure 1. *Loading images into VolBrain software [17].*

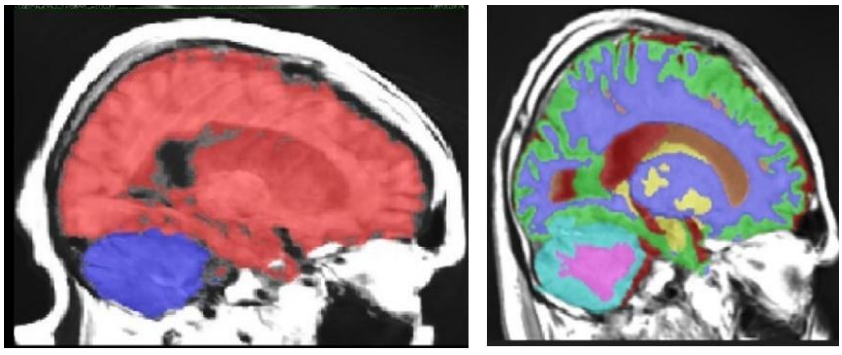

Figure 2. *Intracranial structure segmentation with VolBrain software [18].*

Methods

Our study is a method comparison study based on archive review. It is based on our previous studies using VolBrain software and the Horos program. VolBrain software is an application that researchers can use free of charge over their local networks. However, images in DICOM format must be converted to Nifti format. After this process, the results are obtained automatically by loading the appropriate one from the "pipeline" options of the VolBrain software (Figure 1 [17], Figure 2 [18]). The Horos programme used on Mac computers processes medical images in DICOM format. In the Horos program, researchers must manually select the area to be measured for each section (Figure 3 [18], Figure 4 [18]).

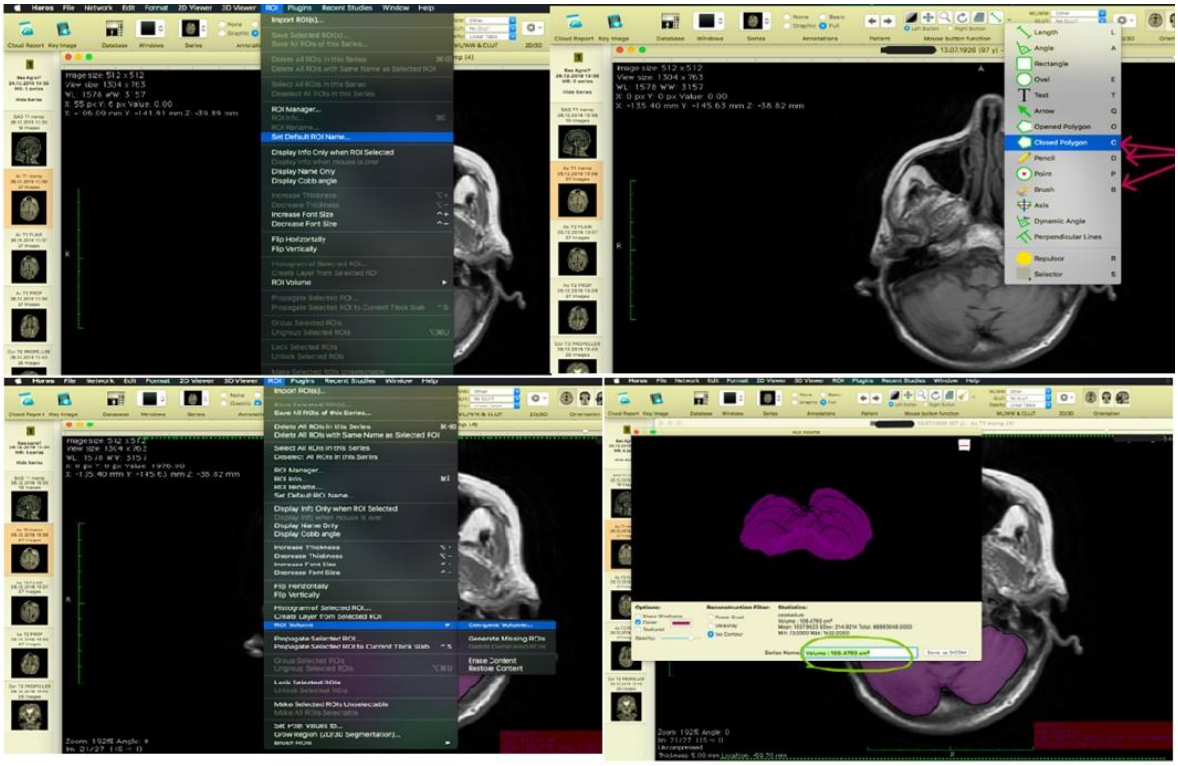

Figure 3. *Loading the images into the HOROS program [18].*

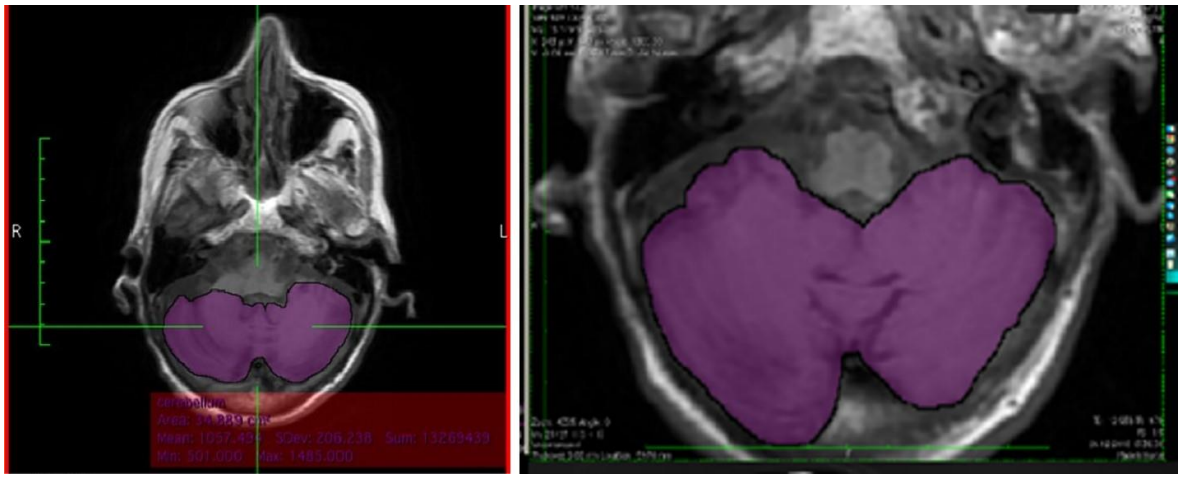

Figure 4. *Intracranial structure segmentation with the HOROS program [18].*

Results

The HOROS program was more useful than VolBrain in 2D and 3D imaging. However, the fact that it is a MAC-based program and requires good image quality for the accuracy of the analysis reduces its usefulness. In addition, to obtain accurate data, the anatomy of the relevant structure should be well-known, and the images should be selected correctly. VolBrain software automatically calculates the data of many structures at the same time. This enables both obtaining different data and saving time in research. However, to use VolBrain software, the minimum accepted number of images of a phenomenon must be 30. This limits the use of VolBrain software. Both applications give almost the same results in terms of volumetric measurement.

Discussion

The aging of the world population has led to an increase in the incidence of many neurodegenerative diseases. The increase in neurodegenerative diseases seriously damages the life ergonomics of both patients and their relatives. For this

reason, when we look at scientific studies in recent years, studies in the field of neurosciences, which constitute the common working area of many different disciplines, stand out [4, 19-22]. All molecular and morphological data on neuronal activity are very valuable in determining neural deformation. In determining and preventing the deformations that occur or may occur in the nervous system, knowing the standard anatomy of that region is very important in detecting the existing damage. Based on this idea, we can say that archives and literature studies in which normal volumes and areas of neural structures are available are important in guiding neuroscience.

Although MRI-based volume measurement studies are currently used in many science-based studies to evaluate anatomical structures, volume measurement studies of the central and peripheral nervous system are prominent [23-26]. The reliability of the measurements and the opportunities offered to researchers are critically important. For this reason, it is necessary to investigate the reliability of the measurement method and compare it with another accepted measurement method in the literature. Samara et al. compared FreeSurfer v6.0 and volBrain for automatic segmentation. Samara et al. reported that the applications were compatible in some intracranial structure measurements but showed incompatibility in some measurements [27]. In another study, it was reported that there were volumetric differences between FreeSurfer and manual segmentation [28]. Studies in the literature have also stated that FreeSurfer is an important application for automatic segmentation and emphasized that its reliability should be tested [29]. In another study we presented as an oral presentation, which is still in the publication phase, we analyzed the cerebellum volumes of Alzheimer's patients, and both methods gave similar results [18]. When we look at the existing studies comparing FreeSurfer v6.0 and volBrain, it is reported that there are incompatible data in addition to similar results. At the same time, it is thought that the findings obtained when volBrain is not compared with HOROS overlap more.

Malilay et al. used HOROS for 3D reconstruction of DICOM format images. The researchers stated that the measurements made in this study were accurate, up to 0.1 mm. They also emphasized that neurosurgical planning using HOROS allows surgeons to reconstruct patients' anatomy before surgery, highlight pathological conditions, and create a safe and appropriate surgical plan without expensive equipment [30]. Based on this study and similar studies, it is possible to say that in many pathologies subject to neuroscience, it is necessary to know the morphometry of that region well. We believe that the methods of such volume studies, their compatibility with each other, and the homogenization of the results will contribute to the neuroscience studies at the forefront of current science.

Zeppa et al. compared the tumor volumes obtained with automatic, semi-automatic, and manual segmentation tools. In this study, they used HOROS for manual segmentation, SmartBrush for semi-automatic segmentation, and BraTumIA software (NeuroImaging Tools and Resources Collaboratory) for automatic segmentation. While all 3 applications gave compatible results before surgery, it was reported that the automatic segmentation software BraTumIA was incompatible with the others in postoperative measurements [31]. In a study using NeuroQuant and volBrain software, various brain segments were analyzed, and significant differences were found in all brain segments tested except the hippocampus [32]. Zamani et al. compared the volumes of cortical and subcortical brain segments using HIPS, volBrain, CAT, and BrainSuite. In this study, while a strong correlation was observed between VolBrain and CAT, no significant correlation was observed between these two methods and BrainSuite [33]. In the literature, there are many studies evaluating different measurement programs and software used in morphometric analyses. There is no clear information about their interchangeability. The comparison of VolBrain and HOROS, which constitutes our field of study, will start with this preliminary study and continue with other studies on many pathological cases with neurodegeneration. We can say that there is a need for techniques and research in this field.

Study Limitation

As a limitation of this study, it is possible to say that studies involving comparative measurements in many different tissues and areas are needed.

Conclusion

The results of this study clearly show that the researcher's data, software, and hardware capabilities are important in the selection of programs. Both applications were useful in the volumetric examination of anatomical structures. The results of the measurements made using VolBrain software and the Horos program are very close, and almost the same results are obtained. We believe that the results obtained from this research will provide the opportunity to save time, ensure reproducibility, and test the reliability of the data for many possible research projects.

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M.E.Y. presented (poster) this study at the 11. Cellular Neuroscience Days held in Istanbul between 5-7 July 2024.

Conflicts of interest

The authors have no conflicts of interest associated with the publication of this article

Ethics committee approval

The study is not subject to ethics committee approval.

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