3D Visualization of Multiple Sclerosis

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Introduction

Multiple sclerosis (MS), one of the most prevalent immune-mediated neurological disorders, is a chronic demyelinating disease of the central nervous system that affects both white and grey matter (Avasarala et. al.). According to the National Multiple Sclerosis Society, more than two million individuals are affected worldwide, with current estimates suggesting more than 400,000 affected patients in the United States (Reynolds et. al.). Primary demyelinating diseases, i.e., those with an idiopathic etiology, affect not only the myelin sheath, but also have the tendency to affect axons and neuronal cell bodies as well (Smith et. al.).

Data Acquisition

Patient is a 60-year-old Caucasian male who presented to his neurologist with complaints of peripheral neuropathy in his lower extremities in 2007. An MRI was completed at the Cleveland Clinic that showed multiple lesions in both the brain and thoracic spinal column. A diagnosis of Primary Progressive Multiple Sclerosis (PPMS) was made in 2015 and patient has been on disease modifying therapies with no significant improvement since. Disease modifying therapies have included: 2 infusions of Ocrevus (ocrelizumab), oral Mayzent, and multiple courses of solumedrol. Patient has been adhering to strict dietary restrictions, focusing on a version of the Paleolithic diet, the Wahls Protocol. Patient admits to continued gait instability that has become progressively worse sense diagnosis in 2015.

Methods

The study was performed in the Marian University College of Osteopathic Medicine 3D Visualization Laboratory. MRI data sets were obtained from the Cleveland Clinic and Northwest Radiology in Carmel, Indiana. MRI data sets were originally analyzed using the Digital Imaging and Communications in Medicine (DICOM) viewer HOROS and 3D renderings were constructed using the analytical software, Amira. 3D constructs were overlayed onto the cross-sectional images of the MRI slices to verify the accuracy of the construct prior to final renderings. Lesions were differentiated visually, and mathematical algorithms were implemented that allowed us to quantify the lesion load between 2011 and 2019.

Results

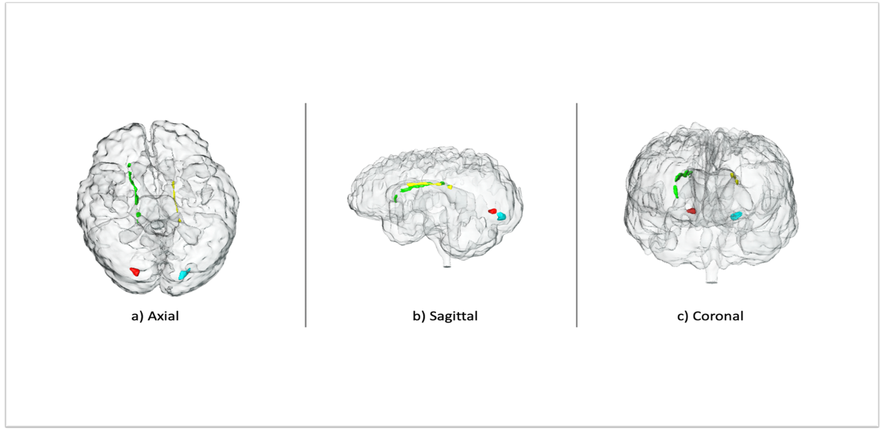

Figure 1. Reconstructed 3D brain images from 9/7/2011 shown in axial, sagittal and coronal views. Lesions depicted in green, yellow, red, and blue.

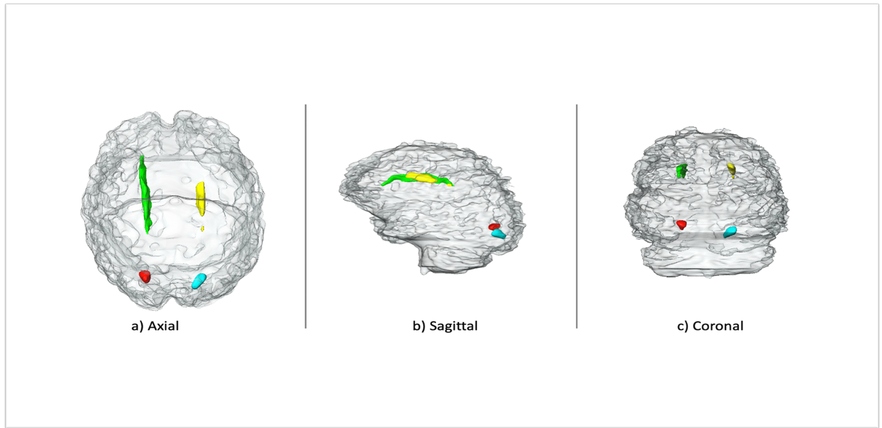

Figure 2. Reconstructed 3D brain images from 12/5/2019 shown in axial, sagittal and coronal views. Lesions depicted in green, yellow, red, and blue.

	2011	2019	Change
Green Lesion Volume	339.108	1457.230	(+) 1118.122
Yellow Lesion Volume	137.758	843.780	(+) 706.022
Red Lesion Volume	205.790	351.220	(+) 145.430
Blue Lesion Volume	275.735	492.440	(+) 216.705
Total Lesion Load Volume	958.391	3144.670	(+) 2186.279

Table 1. Lesion load volume from 2011 and 2019. Volume recorded in millimeters cubed (mm^3).

Discussion

Over an 8-year period, all lesions in this patient increased in size. Of particular interest, the green and yellow lesions surrounding the ventricles had more than quadrupled and sextupled in size, respectively. Due to their proximity to the internal capsule and the surrounding white matter motor tracks, it is likely that the lesions depicted in green and yellow are contributing to the worsening gait instability seen since onset of diagnosis. Total lesion load in this patient was calculated to be 958.391 mm^3 in 2011 and 3144.670 mm^3 in 2019. The total lesion load was significantly reduced when compared to the total lesion load (95,774 mm^3) reported by Avasarala et. al.

Conclusion

Conventional methods of viewing MS lesions have been accomplished primarily using 2D MRI imaging. Using the 3D analytical software Amira, we have created two separate 3D brain renderings that depict the transient nature of MS from 2011 to 2019. Monitoring the progression and regression of MS lesions not only improves patient education, but aids clinicians in the monitoring of this disease, which has no surgical remedies. Research into the efficacy of MS disease modifying drugs makes clinical implementation of 3D constructs applicable and necessary. We hope this study will provide a platform to which demyelinating diseases can be tracked longitudinally in 3D, thereby improving patient care.

Consent

Verbal consent was obtained from the patient prior to the publication of this study and the included images.

Works Cited

Jagannadha Avasarala, Todd Pietila.: **The first 3D printed multiple sclerosis brain: Towards a 3D era in medicine.** *F1000 Research*. 2018, 6; 1603.

Eric Reynolds et. al.: **Multiple Sclerosis and Exercise: A Literature Review.** *Current Sports Medicine Rep.* 2018, 17; 31-35.

Alice Smith, James Smirniotopoulos. **Imaging evaluation of demyelinating process of the central nervous system.** *Postgraduate Medical Journal.* 2010, 86; 218-229.