Analysis of brain lesions in multiple sclerosis using invivo5.4 medical design suite by anatomage

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**Abstract:**

Invivo5.4 medical design suite was chosen to analyze an early case of multiple sclerosis (MS) through the use of secondary scan abstraction. The objective of this research was to generate a ground on which the use of Invivo5.4 could be incorporated into medicine, pathology, and forensic case analysis. The main goal was to gain insight on the usefulness of the Invivo features and to capture digital images of the enhanced MRI scans of patients and compare those scans to before they were enhanced with Invivo5.4. Three lesions were found in the 3D volume of the brain MRI and characterized, as well as marked for location. The central grey matter was isolated, and the volume was measured to be 23.1 cc. 3D visualization of the brain scans allowed for more detail to be observed and could be applied successfully to future forensic investigations and manipulation for better viewing by physicians. These techniques have a promising future in the field of pathology and medicine.

**Keywords:** Invivo 5.4, Anatomage, Magnetic resonance imaging, Computerized Tomography, Forensic medicine, Forensic pathology, Virtual Autopsy, Multiple Sclerosis

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Introduction

Virtual autopsy, or “Virtopsy,” is a new innovative approach in the medical field where CT scans, MRIs, and other three-dimensional computing technology is utilized to scan and recreate an internal image of the body for analysis. Using a scalpel and blade to physically dissect and observe the organs internal to the body is not necessary in the virtopsy approach; therefore, there is a growing area of research in forensics and pathology for the future uses of these techniques. The virtual autopsy approach can replace the need to investigate a body internally without damaging human tissues. Modern imaging technology has allowed clinicians to observe bodily structures that would have been otherwise difficult to view without dissection or surgery. The advantages of virtual scans are that they can be stored and examined years later, which is especially useful for forensic investigators looking into an older case or pathologists who want to review a case a second time. The initial state of the body can be captured before an internal examination and stored, which allows for the opportunity for a second expert opinion if required. With technology constantly advancing, new methods are being implemented in the study of forensics and medicine that need to be researched and accepted before being put into practice.

At the University of Windsor, research students have access to some of the latest software. Invivo 5.4 Medical Design Suite by Anatomage is an advanced 3D medical imaging software for medical and dental applications. This software is able to open up CT, MRI, and other medical scans to digitally enhance them. Invivo can take 2D medical scans and make them appear 3D through its volume rendering reconstructions. This software can be utilized by medical professionals such as surgeons, orthodontists, and forensic pathologists to accurately view a section of the body. The Invivo software can easily manipulate images for better viewing by physicians and forensic investigators. Invivo can also be used in education and is a great source for medical students and researchers. Invivo and Virtopsy are some new ways to visualize a body, and these methods have potential to be effective in presenting clear images to the courts as well as being a useful tool when traditional autopsies are not ideal.

Multiple sclerosis (MS) is a disease of the nervous system which disrupts the communication of neurons due to plaques and lesions that develop in the brain.
the progression of MS with medication and physical therapy. Why these plaques form and demyelinate neurons is unknown and there is no cure. Diagnosis can be made through neuroimaging in conjunction with presenting symptoms, however early diagnosis may be difficult as symptoms are not specific and may go unnoticed. In this single study, Invivo5.4 was used to analyze an early case of multiple sclerosis by enhancing the MRI scans to observe the effectiveness in the software to identify the demyelinating lesions.

![Image 10: A healthy brain (left) versus a brain exhibiting multiple sclerosis (MS) (right)]

**Materials and Methods**

After two months of studying the program and how to use the Invivo features, the first steps taken in this study were obtaining DICOM file data. Early stage multiple sclerosis MRI scans were chosen for analysis with the Invivo5.4 software in this study. An MRI disc was obtained from an anonymous donor containing MRI scans of the brain and head region from an early stage multiple sclerosis patient. The DICOM files were then extracted onto the computer containing the Invivo5.4 software by importing the files from the disc onto the computer.

*Analysis of Brain MRIs in Generic DICOM viewer*

To view the files without manipulation, the disc was loaded onto the computer and a generic DICOM file reader was booted up, which was installed on the disc previously. Slices of the brain were able to be viewed by scrolling through each slice with the mouse. Tools such as markers for coordinates were available for the generic software. Two small lesions were found; however, viewing could not be enhanced through contrast and brightness settings.


*Analysis with Invivo5.4 Medical Design Suite*

The uploaded DICOM files onto the Invivo software produced the original 2D images alongside a 3D reconstruction of the head region. Using the volume render feature in grayscale, a 3D reconstruction of the brain was created, and lesions were identified by clipping the 3D volume in the axial plane to view the internal anatomy. Each slice was analyzed in this plane. The locations of the lesions were marked, and exact coordinates were determined. Using the polygon sculpture feature, the central grey matter in the axial slice was isolated and volume was measured.

*IMAGE NAVIGATION KEY for 3D Images*

*Zoom In/Out*: control + left button of mouse – move mouse up and down

*Pan (Shift)*: shift key + left mouse button – move mouse in any direction

*Free Rotate*: Hold down left button and move anywhere

*Free Rolling*: Hold down space key + left button – move mouse up and down

*Increment Rotate*: keyboard arrows

*Increment Roll*: control key + left and right arrows; control key + up and down arrows roll image up and down

*Anatomical Plane Clipping*: scroll mouse wheel forward and back to set the plane

*The Move/Rotation Widget*: changes the patient’s position – click either the ring or arrows

*Quick Zoom*: click the zoom icon, then the point on volume to zoom in. Reset to go back to normal.

*Information taken from the Invivo5.4 Medical Design Suite manual*.

*In Section View*

Section view is the main screen view when one first opens Invivo. Here the 2D views are given and the X, Y, and Z sections of the image are displayed. The rendering window divides the screen into four sections, which displays the image in each plane (coronal, axial, sagittal). In the fourth window a 3D volume of the DICOM data is displayed. In this view the image was enhanced with a colour preset for soft tissue in the view control tab.

*In Volume Render View*

Volume render is a feature on Invivo5.4 that allows DICOM files to be viewed in three dimension (3D) and allows the user to explore the internal features. On the control panel tab to the side of the program, there is a view control option that allows the user to choose different colour presets for specific tissues. In this case, the soft tissue of the brain was targeted, so the grayscale setting was
picked for optimal visualization. The 3D reconstruction was flipped in the axial view, and using the clipping setting on the control panel, the image was cut in half allowing for the exposure of the internal structures. The clipping setting allows the user to slice the image through scroll to clip. The contrast was set to 100% (850/0.25) and the brightness settings were 88% (585/0.10). The 3D volume slices were then scrolled through in the axial plane until the white lesions surfaced. This was at about 66% clipping of the volume. The marker feature can mark a certain spot and give the coordinates in the plane. All lesions were marked and labelled. The central grey matter was isolated, and the volume was measured in cc. For this, the polygon sculpture tab was used to outline the area of interest by placing a series of points around the target to remove the outside volume. Images were captured onto “gallery” and exported as an JPEG image. Files were saved using “full save” as to not lose any information in Invivo files.

Results

Invivo5.4 produced detailed images of the brain lesions for this case analysis. The 2D images of the MRI were first uploaded onto Invivo to correct the contrast and brightness of the image. Negative areas were identified as lesions after searching through each slice on the axial clipping option (Figures 1 and 2). The lesions were labelled. The volume render feature in Invivo5.4 was used to create a 3D reconstruction of the head and brain (Figure 6). Exact location coordinates in the X, Y, and Z planes were obtained with lesion 1 (Figure 3) [29.29, -42.08, 12.93] and lesions 2 [-34.39, 46.68, 8.20] and 3 [-19.19, 16.60, 16.54] (Figure 4). The distance between the central grey matter was measured to be 31.68 mm (Figure 5) and grey matter volume was measured to be 23.1 cc (Figure 7).

Figure 1 - 2D Axial slice in Invivo without manipulation: Original image opened up in Invivo5.4 view section tab, but with brightness and contrast enhancements. This allowed for 2 lesions that appear lighter in colour to be viewed clearly, and both were circled with the marker tool.
Figure 2 - 2D Axial slice soft tissue enhancement showing lesions: Here the axial slice of the brain was enhanced with contrasting colours by the colour preset for soft tissue. Colours represent different densities of tissue, and the lesions appear yellow.

Figure 3 - 3D Axial slice showing lesion 1: In the Volume Render tab in Invivo5.4, a 3D reconstruction of the head and brain was created. This view shows the axial slice after brightness, contrast, and opacity were adjusted. Three larger lesions were found and labelled. This slice shows lesion 1 in the upper left quadrant of the brain.
Figure 4 - 3D Axial slice of lesions 2 and 3: Axial slice volume of brain showing negative (white) lesions 2 and 3 (labelled) near the center of the brain.

Figure 5 - 3D Axial slice volume with coordinates: Axial slice volume of brain showing negative (white) lesions and coordinates to mark location within the Invivo program. The width of the central grey matter was measured with the distance marker to be 31.68 mm.
Figure 6 - 3D Volume reconstruction of soft tissue: An alternate view of the 3D volume of the brain with soft tissue colour preset. Clipping was enabled to cut the head axially.

Figure 7 - Isolated grey matter volume: The central grey matter was isolated with the polygon sculpture tool and the volume was measured to be 23.1 cc.
Discussion

The 3D volume render feature allowed for more detail to be obtained compared to the original scans without manipulation. In the generic viewer, 2 lesions were found but could not be enhanced or isolated as with the Invivo software. The ability to rotate, measure and clip different volumes of the 3D reconstruction proved to be useful in gathering more information about the lesions. Exact location coordinates in the X, Y, and Z planes were obtained with lesion 1 (figure 3) \([-29.29, -42.08, 12.93]\) and lesions 2 \([-34.39, 46.68, 8.20]\) and 3 \([-19.19, 16.60, 16.54]\) (figure 4). The distance between the central grey matter was measured to be 31.68 mm (figure 5) and grey matter volume was measured to be 23.1 cc (figure 7). This has medical applications when analyzing cases of multiple sclerosis, as there tends to be a loss of volume in the brain as the disease progresses\(^6\). Brain atrophies can be assessed by measuring their volume of grey matter and comparing them to previous MRI scan volume measurements in Invivo.

This qualitative study was done to observe the benefit of incorporating Invivo5.4 into the field of pathology. The use of Invivo5.4 as a diagnostic tool was proven, as the case of MS analyzed is undiagnosed, as this was an early stage MS MRI to screen for the disease. The researchers conducted the study blind, as it was unknown if lesions would be detected or not, which protected against confirmation bias. Because lesions on the brain were found and characterized in this early case, this points to the powerful application of Invivo5.4 as a diagnostic tool to assist physicians.

Some limitations for the Invivo5.4 software are that it cannot stand alone in assessing disease and diagnosis. A hands-on approach in specimen analysis and dissection will always be the most valuable to the diagnostic value. One of the criticisms of digital software in medicine is that it is limited by its image resolution and cannot capture fine textile details with touch, nor can it capture sensory information such as smell. However, not every case will allow for the dissection of tissues and organs, which is why this new emerging digital software, such as Invivo5.4 medical design suite, proves to be a good alternative tool in assessing cases such as brain abnormalities where surgery is not ideal. Another limitation is that reference scans are needed for comparison in many medical cases. These methods point to promising results in future forensic analysis and pathology; however, technological advancement still needs to be done to capture fine details in image processing and resolution\(^2\). In the future, it is ideal that more case analysis be done using Invivo5.4 to better establish this software as an accurate tool to advance the field of pathology.

Conclusion

In conclusion, it can be deduced that the software Invivo5.4 medical design suite by the company Anatomage proves to be a useful tool in cases pertaining to the brain and lesion detection for medical professionals. Lesions were easily detected in an early case of multiple sclerosis, labelled with coordinates to determine exact location. It has proved useful in assessing the progressive deterioration of brain matter volume, detecting a grey matter volume of 23.1 cc. Overall, Invivo5.4 points to a bright future in assisting an early diagnosis of multiple sclerosis.
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References


