

QUANTITATIVE ANALYSIS OF MALIGNANT BRAIN TUMOR ON MRI IMAGES.

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ABSTRACT

Longitudinal relaxation time (T1)- weighted, Transverse relaxation time (T2)- weighted and flair Magnetic Resonance Imaging (MRI) sequences are used for the study of high grade malignant brain tumors and their surrounding edemas. This study aimed to examine the characteristic of MRI on malignant brain tumor and to evaluate the benefits of Flair and T2 (Transverse relaxation time) -weighted over the T1(Longitudinal relaxation time) -weighted sequence. A total of 25 patients of malignant brain tumors were selected for analysis including 16 women aged 1 to 75 (mean age, 38.31 years) and 9 men aged 1 to 75 (mean age, 19.5 years). All patients had the T1- weighted, T2- weighted and Flair MRI sequences. A Region based segmentation of MATLAB software was performed on each type of tumor and 3D volume was calculated by spheroid volume tool of MATLAB. For all the patients tumor volume was calculated in cubic millimeter and compared with other sequences. The Flair and T2- weighted images volumes were significantly larger than the T1 - weighted image volume. There was also statistical difference of volume occurred in MRI sequences. T2- weighted and Flair MRI sequences showed 100% more volume than T1- weighted in the age group between 51 to 75 years. Similarly, both T2-weighted and Flair MRI sequence showed 61% volume more than T1-weighted in the age groups between 26 to 75 years. Our findings suggest that the volume produced by these techniques are distinct and not interchangeable. Flair and T2-weighted images proved efficient for the measurement of abnormal tissues and CSF fluid in the brain. On the other hand T1-weighted images efficiently locate the tumor in fat and white matter of the brain.

Key Words: Malignant brain tumours, MRI images, Radiology of brain tumours

INTRODUCTION

The most widespread use of Magnetic Resonance Imaging (MRI) is because it utilizes non-ionized electromagnetic radiations and powerful magnetic fields. MRI offers an opportunity for great improvement in the study of the pelvis, heart, lungs, stomach and soft tissues of the brain because it is completely based on the theory of nuclear magnetic resonance. It also provides a good resolution image that helps in getting a clear and distinguished view of the brain tissues (1). The brain tumor images collected by MRI segmentation are carried out using the region based active contour segmentation developed by Chan-Vese. Image segmentation is an effective method in which image pixels are separated dependent on boundaries. The pixels are grouped within the defined boundary limits (2).

Image segmentation is a technique for image processing and is normally used to locate and classify tumors. Image segmentation makes it easier to identify the portion of a tumor in the brain image. Our suggested methodology segments the images of different positions axial, coronal and sagittal sequences of T1-Weighted, T2-Weighted and Fluid attenuated Inversion recovery (Flair) of MRI brain tumor images. In T1-weighted images fat, fluid and tissues all appeared to be dark in color while in case of T2-weighted images tissues and fluid appeared to be bright and only fat to appear as dark color. Flair images appeared to be bright in abnormalities (tumors) but dark in fluid (3).

Standard treatment of high grade malignant brain tumor requires safe resection accompanied by radiations and chemotherapy. Such type of analysis of malignant brain tumor images enables us to evaluate more precisely tumor detection, normal tissue sparing to be enhanced and early assessment of disease (4). Generally T1, T2 and Flair are used to define high grade malignant brain tumors and surrounding edema. The obtained limited data of brain tumor patients was aimed to evaluate the difference of volumes in brain tumor images (5).

MATERIALS AND METHODS

Patient Population

The study includes 25 patients who underwent the segmentation of malignant brain tumors, with the following conditions: Anaplastic astrocytoma (n=5), Gliofibroma (n=2), Lymphoma CNS primary (n=1), Malignant Melanoma Metastases to brain (n=1), Breast Cancer metastases to the brain (n=1), Chondrosarcoma Metastases to the brain (n=1), Gliosarcoma (n=1), Anaplastic Ganglioglioma (n=1), Cerebral Malignant Neoplasm (n=3), Medulloepithelioma (n=1), Atypical Teratoid Rhabdoid Tumor (n=1), Anaplastic Ependymoma (n=1), Glioblastoma Multiforme (n=3), Oligodendroglioma Malignant(n=1), Lung Cancer to brain metastases- Adeno carcinoma (n=1), Malignant Central Neurocytoma (n=1).

Imaging Technique

The complete data set was classified into two main categories normal and abnormal tissues by an expert consultant radiologist. MRI image dataset was obtained using a PHILIPS MRI 1.5 Tesla scanner. Obtained data set consisted of malignant brain tumors of various sizes, shapes and orientations and it contained three MRI imaging sequences T1- weighted, T2-weighted and Flair images. Images were viewed under different positions axial, coronal and sagittal (6).

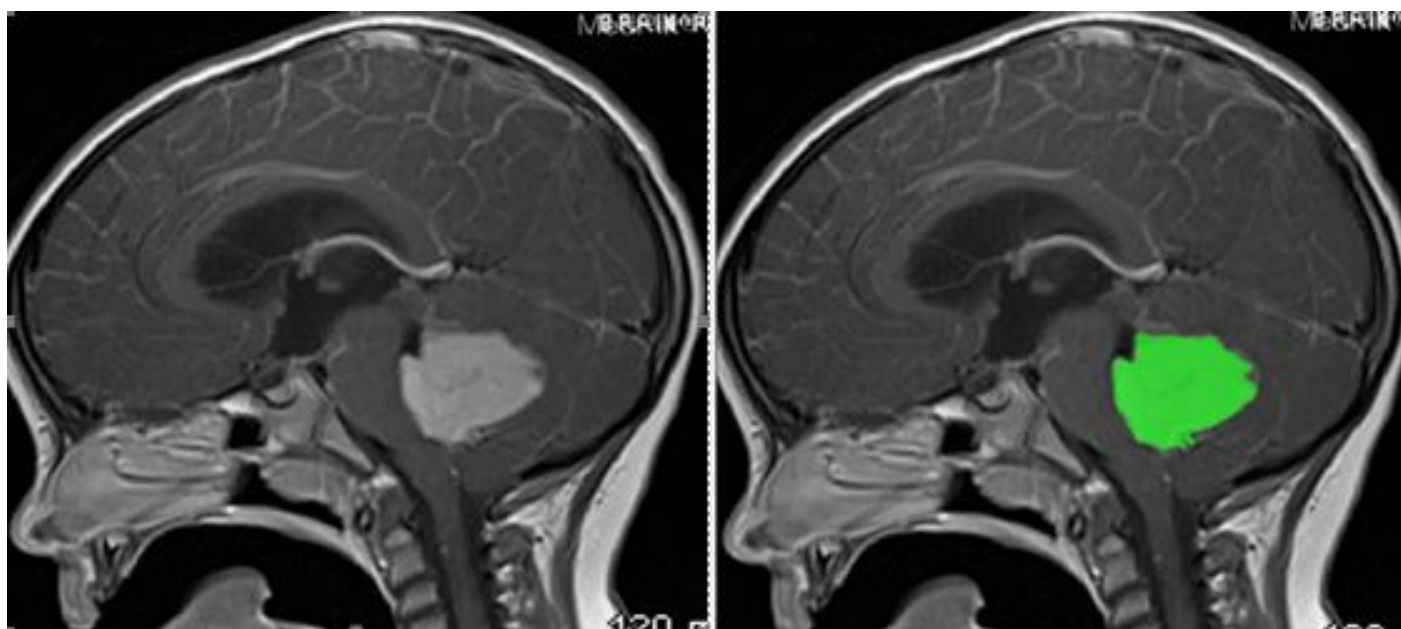


Figure 1. Image of malignant brain tumor before and after segmentation of sagittal axis.

In the above figure malignant brain tumor is expressed in sagittal axis. Similarly, segmentation was done in the brain tumor slice axial and coronal axis.

Data analysis

T1-weighted, T2-weighted and Flair images were segmented by the region based active contour segmentation of MATLAB software. Segmentation algorithm has shown that it operates on a broad range of images (7). Even though all images in this method had taken less than a minute to segment, but for some images it works very slow. Sometimes segmentation could take several seconds to perform segmentation and completely depends upon the width, size and orientation of image. This method has an interesting development in image processing and visualization as it is modernized technique. Such approaches would definitely play an important role in future studies on image processing (8).

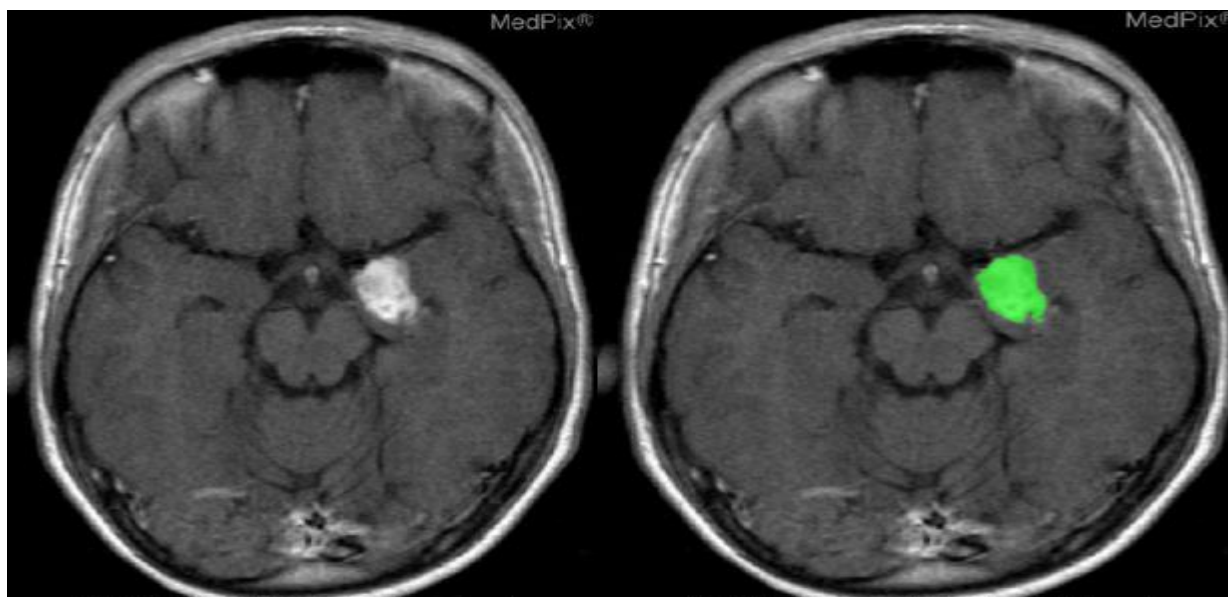


Figure 2 . Image of malignant brain tumor before and after segmentation of axial axis.

Spheroid Volume calculation

Spheroid sizer is a tool of MATLAB software which automatically and accurately measured the major and minor axis length of 3D tumor image. It computed the volume for each 3D spheroid image and provides the output in the form of a spreadsheet. The volume of spheroid image ($V = 0.5 * Length * Width^2$) was calculated on the basis of minor and major axis length (commonly referred as width and length) (9). The key benefit of this software is its accurate image analysis, which is optimized for a large number of images. This software was used for high throughput 3D image analysis and it significantly reduced the manpower and speeds up the process of research (10).

RESULTS

The malignant brain tumor patients were 16 women aged 1 to 75 years (mean age 38.31 years) and 9 men aged 1 to 75 years (mean 19.5 years). Overall age of the analyzed patients ranged from 1 to 75 years (mean age 38.1years). The age of patients considered at the time of treatment. The study of 25 patients with high grade malignant brain tumor was reviewed before treatment and the majority (n=20) of patients have WHO grade IV brain tumor. The remaining 5 patients had anaplastic astrocytoma. The highest volume percentage difference was seen in the age between 51 to 75 years which was 117 %. The second highest volume difference was observed in age of 26 to 50 years which was 61%. The lowest volume difference was seen in the age

group of 1 to 25 which was only 13%. T2 weighted showed significantly more value of volume than T1 weighted in all age groups.

Table 1.1 Comparison of T2-weighted axial and T1 weighted axial 3D Spheroid Volume

Age : 1 to 25 years			Age : 26 to 50 years			Age : 51 to 75 years		
No of Obs	T1 weighted axial Volume	T2 weighted axial Volume	No of Obs	T1 weighted axial Volume	T2 weighted axial Volume	No of Obs	T1 weighted axial Volume	T2 weighted axial Volume
	mm ³	mm ³		mm ³	mm ³		mm ³	mm ³
1	40658	58111	1	11098	171397	1	68007.26	729986.1
2	131599	247308.2	2	679877.4	3331088	2	147197	1031979
3	1407294	1507017	3	1538375	3886424	3	322539	500591
4	1501305	1792470	4	2664290	7218033	4	847669	2577948
5	1766250	1958272	5	4852131	8987430	5	1731159	6977228
6	2571136	2890284	6	6735553	7465175	6		
Mean Value	1236374	1408910	Mean Value	2746887	5176591	Mean value	623314	2363546

T2 weighted axial volume shows 13 percent more value than the T1 weighted axial volume	T2 weighted axial volume shows 61 percent more value than the T1 weighted axial volume	T2 weighted axial volume shows 117 percent more value than T1 weighted axial volume
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The highest volume percentage difference came in the age of 51 to 75 years was 132%. The second highest volume difference came in age of 26 to 50 years was 80%. The lowest volume difference came in age of 1 to 25 that is only 15%. Flair showed significantly more value of volume than T1 weighted in all age groups. Comparison of T1 and T2 weighted volume is presented in figures 3-8.

DISCUSSION

Quantitative analysis has been achieved by comparing the 3D volumes of T1-weighted axial and T2-weighted axial images, similarly 3D volumes of Flair axial and T1-weighted axial images are compared and for that purpose graphs and tables are drawn. A very careful examination of T2-weighted images seems to provide more accurate information about many anatomical and pathological lying aspects that was not apparent on T1-weighted images (11). T2-weighted images eventually revealed the intracellular mass which indicates the presence of malignant brain tumor that was not shown in the T1-weighted images.

Table 1.2 Comparison of Flair axial and T1 weighted axial 3D Spheroid Volume

Age : 1 to 25 years

Age : 26 to 50 years

Age : 51 to 75 years

No of Obs	T1 weighted axial Volume	Flair axial Volume
	mm ³	mm ³
1	14101	40515
2	40658	163105
3	283407	292567
4	379352	523333
5	871491	1000941
6	1407294	1617924
7	1501305	1931491
8	2571136	2683161
Mean Value	883593	1031630

No of Obs	T1 weighted axial Volume	Flair axial Volume
	mm ³	mm ³
1	11098	299992
2	679877.4	3899809
3	1492131	3482644
4	1558352	3977977
5	1748646	3818613
6	6735553	13319409
Mean Value	2037609	4799740

No of Obs	T1 weighted axial Volume	Flair axial Volume
	mm ³	mm ³
1	68007.26	936200.8
2	147197	1044870
3	322539	688985
4	1731159	8335090
Mean Value	567225	2751286

Flair axial volume shows 15 percent more value than the T1 weighted axial volume.

Flair axial volume shows 80 percent more value than the T1 weighted axial volume.

Flair axial volume shows 132 percent more value than the T1 weighted axial volume.

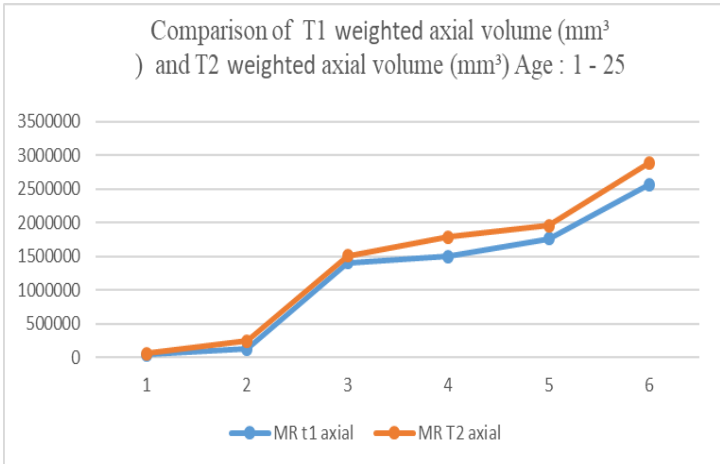


Figure 3 : Comparison of T1-weighted and T2-weighted Volume in age (1 - 25)

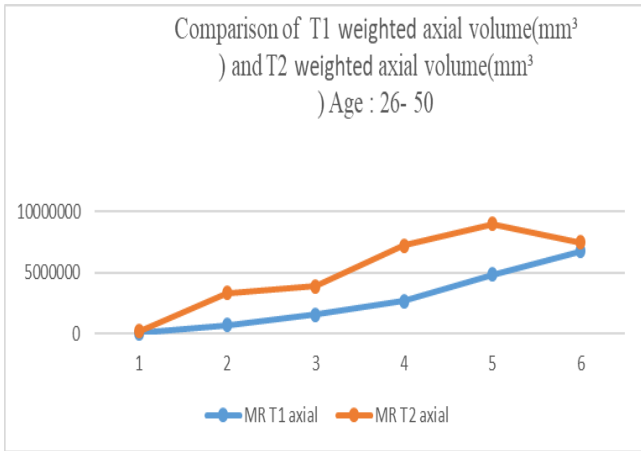


Figure 4 : Comparison of T1-weighted and T2-weighted Volume in age (26 - 50)

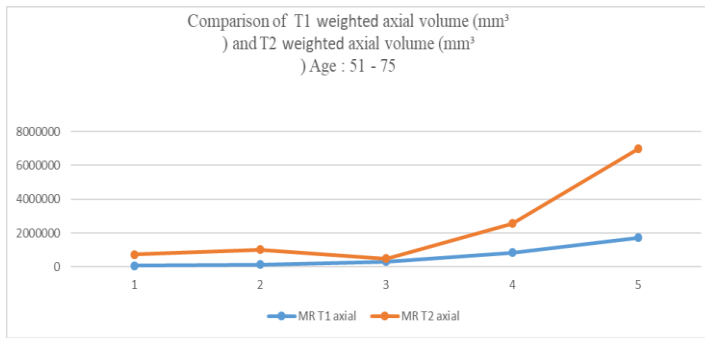


Figure 5 : Comparison of T1-weighted and T2-weighted Volume in age (51 - 75)

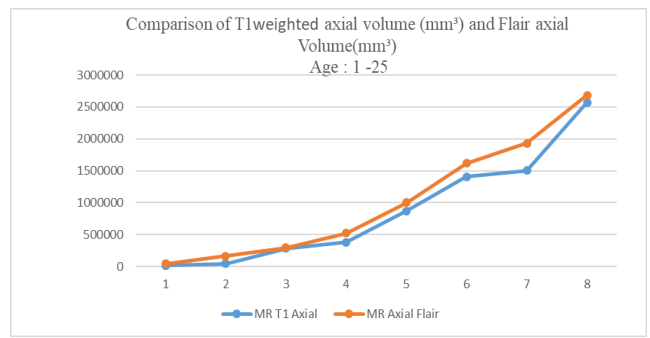


Figure 6 : Comparison of T1-weighted and Flair Volume in age (1 - 25)

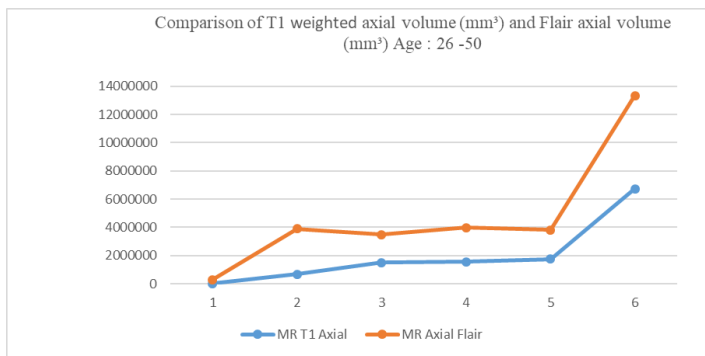


Figure 7 : Comparison of T1-weighted and Flair Volume in age (26 - 50)

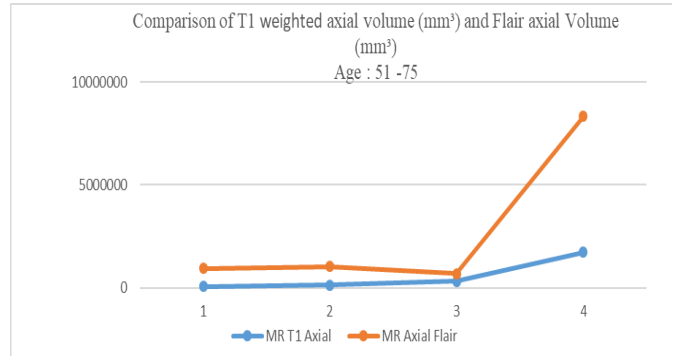


Figure 8 : Comparison of T1-weighted and Flair Volume in age (51 - 75)

Three graphs have sketched of T2 - weighted axial and T1-weighted axial in three different age sectors. The first age sector was (1 – 25 years) in figure 3, second (26 -50 years) in figure 4 and the last (51 -75 years) is represented in figure 5. because T2 weighted takes long repetition time (i.e. 4000 m/sec) and echo time (19 m/sec) to produce the image and it showed better and brighter results in case of soft tissues, fluid, CSF and in inflammation (11-12). On the other side T1 weighted takes short repetition time (500 msec) and echo time (14 m/sec) to produce image. T1 weighted only showed better result in brain structure and white matter. Number of patients are represented on the horizontal axis and T1 weighted axial and T2-weighted axial volume is represented on vertical axis in all three figures 1, 2 and 3. All the volumes were calculated in cubic millimeter. Observed that T2-weighted images were superior to T1-weighted images because T2 weighted takes long repetition time and echo time to produce the image and it showed better and bright results in case of soft tissues and fluid. On the other side T1 weighted takes short repetition time and echo time to produce image and only showed better result in brain anatomical structure. Our findings suggested that volume produced by these techniques are unique and cannot be interchanged.

Flair imaging is recognized as the sensitive technique for the identification of chronic, acute and subacute malignant brain tumor. Very few parts of the Flair images are dependent on the T1 relaxation time. Flair showed the much better and enhanced images than T1-weighted. Three graphs have sketched of Flair axial and T1-weighted axial in three different age groups. The first age group was 1 to 25 years of age, second was 26 to 50 years and third group was 51 to 75 years. Because Flair takes very long repetition time (9000 m/sec) and echo time (114 m/sec) to produce the image and it showed far better and bright results specially in case of abnormalities like malignant brain tumor tissues, soft tissues, and cortex. On the other hand T1 weighted

takes very short repetition time (500 m/sec) and echo time (14 m/sec) to produce image [14-15]. T1 weighted only showed better result in brain structure and white matter. Results show that the volumes produced by these techniques are unique and cannot be interchanged, these findings are consistent with existing literature(16).

Number of patients are represented on the horizontal axis and T1 weighted axial and Flair axial volume is represented on vertical axis in all three figures 6, 7 and 8. It was observed that Flair images were superior to T1-weighted images. Discovered that Flair images have shown the bright results in cerebrospinal fluid malignant brain tumor patients and more clear than T1-weighted images where cerebrospinal fluid remain the hyper intense (17). Since Flair images were collected after the T1-weighted images, a factor may have been the effect of long delayed enhancement. In all three figures 6, 7 and 8, long TR (Repetition time) and TE (echo time) of Flair images than T1-weighted TR (Repetition time) and TE (echo time) is also responsible for the better results of Flair. Such facts suggested that contrast enhanced flair images may facilitate the diagnosis of high grade malignant brain tumor (18). The study provided a clear evidence. However a small sample size is the limitation of this study.

CONCLUSION

T1-weighted, T2-weighted and flair MRI sequences are used to define high grade malignant brain tumor and their surrounding edemas. Our findings suggest that the volume produced by these techniques are distinct and not interchangeable. Flair and T2-weighted images proved efficient for the measurement of abnormal tissues and CSF fluid in the brain. On the other hand T1-weighted images very efficient if tumor is located in fat and white matter of brain. Further large scale study are required for confirm findings of this study.

Conflict of Interest

The authors declared that no competing interests.

Ethical Consideration

The Study was approved by Institutional Research Ethics committee, no ethical issue involved.

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