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A Role of Medical Imaging Techniques in Human Brain Tumor Treatment

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Abstract*: Early finding and analysis of brain tumor are essential to enhance the surgical planning and thus extend the survival of patients. Medical imaging techniques (MIT's) are useful to view the internal structure of the brain which makes the medical professional to diagnose abnormal conditions and guide therapeutic procedures. Few MIT's are handling in the medical industry to identify the brain tumor and each technique has different risks and benefits. The concerning techniques are single photon emission computed tomography (SPECT), computed tomography (CT), positron emission tomography (PET), magnetic resonance imaging (MRI), functional MRI (fMRI), and blood oxygen level dependent (BOLD). This paper presents the importance of MIT's in brain tumor treatment.

***Keywords*: Human brain, brain tumor, medical imaging, medical modalities, Neuro-imaging, Oncology treatment**

I. INTRODUCTION

The brain is a vital organ and that controls all other parts of the human body that. The human brain is fully covered by soft tissues like neurons, cerebrospinal fluid, gray matter, and white matter. Early finding and diagnosis of brain-related diseases such as a tumor, Alzheimer, Alcoholism, Bipolar disorder, Epilepsy, Schizophrenia and Sclerosis, increase the survival rate of the patients. Abnormal and unpredictable cells development in the brain makes the brain tumor. Brain tumor may be a benign type or a malignant type. Benign is a non-cancerous and malignant is a cancerous. It can be categorized into two classes namely primary and secondary [1]. Primary brain tumor originates from the brain whereas secondary start any part of the body and spreads inside the brain. Primary brain tumor may be either benign or malignant, whereas secondary are all malignant.

Medical imaging techniques (MIT's) are producing visual representations of human organs inside the body to diagnose and monitor the treatment [2]. MIT's are help to capture the structural brain image to identify the brain related diseases. MIT's have two types of methods to produce the medical images of organs such as ionizing and non-ionizing radiation that carries energy from an external source to break the bonds between molecules such as X-rays, radioactive materials. Non-ionizing is does not carry enough energy to break the bonds between the molecules such as MRI [3]. The non-ionizing technique is more suggestible for the human body. Some non-ionizing radiation are optic (ultra violate) and electromagnetic field (microwave or radio frequency) [4]. The goal of finding brain pathology with MIT's improves the treatment planning, accuracy, and saves time [1]. Treatment without MIT's makes a time-consuming, inter, and intra rate error and can't service to people by the physician on time when the massively populated country.

MIT's used to learn more knowledge about the neurobiology and disease behaviours of the brain with ionizing or non-ionizing radiation. Following MIT's are playing a vital role in the human brain diseases treatment such as SPECT (1960), CT (1972), PET (1975), MRI (1977), fMRI and BOLD (1990) [5]. Each modality has its own merit and demerit for brain treatment procedures. The acquiring process of the brain consists of sensors that emit the energy which can be penetrating the human head. The acquiring process has five major components are patient, imaging system, operator, image and observer. The imaging systems have a set of detectors which convert the energy to image with the support of mathematical algorithms. The imaging system has a considerable number of parameters to adjust the quality of an image which is done by the operator. These techniques are used in brain tumour treatment briefly discussed in the following sections.

Table1: Comparative of MIT's

Modality	Year	Materials	Advantage	Disadvantage
SPECT	1960	Radioisotopes	Lower cost, good sensitivity	Harmful
PET	1975	Radioisotopes	High resolution images	Harmful
CT	1972	X-ray source	cancer diagnosis and treatment	Harmful
MRI	1977	Radio waves & Magnetic force	Non-invasive & High contrast	Harmless
fMRI	1990	Radio waves & Magnetic force	Function analysis & High contrast	Harmless

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II. SPECT

SPECT uses nuclear medicine imaging (NMR) technique with a gamma camera [6]. It is the best technique in a sense cheap and worldwide availability. SPECT can help to estimate the tumor grade and tumor recurrence, tumor aggressiveness, determine the extent of disease, degree of malignancy and volume delineation for radiation therapy planning [7]. SPECT estimates the treatment response from the patient in the postsurgical and post radiation evaluation. Modern SPECT-CT scanner provides both functional and structural images simultaneously.

A SPECT scan combines with two technologies such as CT and radioactive material. The radioactive material allows the physicians to sense the flow of blood on tissues of the human body. Radio element will inject into patient organs before the SPECT scan. In the image acquisition process, a high end computer system gathers all the information and converts them into 2D images [8]. These 2D images reconstruct into a 3D image. Famous non-invasive radioisotopes are SPECT are iodine-123, technetium-99m, xenon-133, thallium-201(^{201}T1), and fluorine-18.

SPECT image has been acquisition only 20min after intravenous radiotracer administration. ^{201}T1 is the first radiotracer that was widely used. These tracers are not taken up by e normal brain and provide a greater background contrast, thus differentiate the tumor from normal brain. SPECT brain scan image with tumor is shown in Fig.1.

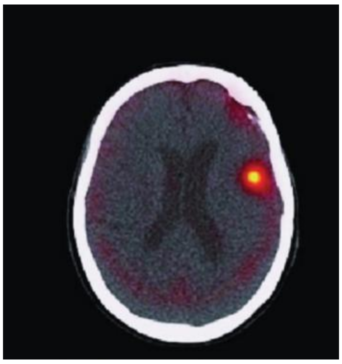

Fig. 1 SPECT brain scan with tumor [9]

III. PET

PET is a 3D diagnostic imaging procedure used to visualize the internal organs and skeleton. PET has conjunction with other imaging techniques like CT and MRIs to produce more comprehensive results because tumor cells have a low glucose level compare than normal cells and will appear less intensity on PET images. It has a procedure of injecting a small amount of radioisotopes called tracers, which are designed to capturing an image of specific organ of the body. A frequently used PET radiotracer is fluorodeoxyglucose (FDG). Before PET scan a small amount of FDG inject to the body [10]. Generally, tumor cells grow faster than the normal cell, tumor cells absorb more FDG. During scanning, PET scanner detects the more FDG from the tumor and produce colour-coded image, which is deviated from normal cells.

Researchers take the advantages of additional radiotracers to analyze the brain tumor. At present, PET contributes more than SPECT due to produce high-resolution images. PET scans are used to diagnose cancers, multiple sclerosis, Epilepsy, brain disorders, Alzheimer's disease, and blood flow. PET brain tumor image is shown in Fig. 2.

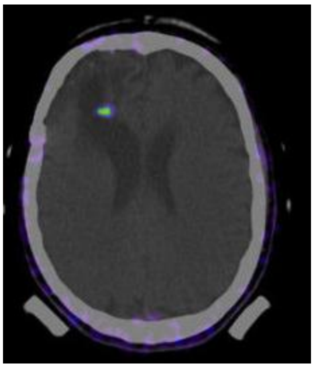

Fig. 2 PET brain slice imaging

IV. CT

CT scanners make millions of scans that are performed worldwide to diagnosis variety disease. It provides fast and accurate information and suitable for emergency cases. Advantages of CT scan include taking decide on about surgeries, improving cancer diagnosis and treatment, reducing the treatment period, guiding treatment for an injury, cardiac disease and stroke. Acquisition of CT images is using X-ray source and detector unit rotating synchronously around the patient body. The detector will rotate around the patient for continuously receiving the data about the organs. As the scanner rotates, several thousand of sectional images of the patient's body are generated [11]. These 2D images generate to create 3D visualization and views from various angles. CT image with a brain tumor is shown in Fig. 3.

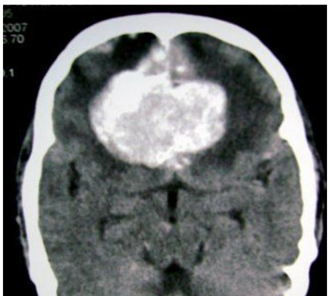

Fig. 3 CT brain scan with tumor

CT provides the structural information of the brain tumor which helps the doctors to identify the location of the tumor and regulate the dose of radiation. CT scans may show detailed information of bone near the tumor. An enhanced CT scans are effective in pituitary tumours. But CT scanning gives fewer details of soft tissues in the tumor and normal tissue, in comparison to MRI. CT underestimates the tumor in size when start and ending of the brain tumor.

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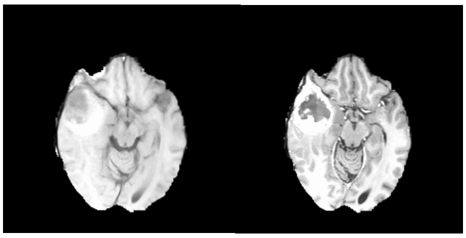
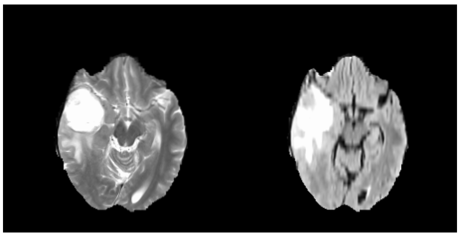
V. MRI

MRI uses a magnetic field and radio waves (NMR principles) to imaging the soft tissues of human organs [12]. The MR scanner has three major parts such as strong magnet and gradient system with radio frequency system. The strong magnet generates a magnetic field around the patient body. The gradient system is essential for signal localization. The radio frequency system receiver coil converts the magnetic field into an electrical signal.

By applying an appropriate radio-frequency pulse B_{rf} which is equal to the Larmor frequency, a long magnetization component M_L and transverse magnetization component M_T are produced. Once the radio frequency signal is removed, M_L recovers to M_0 with a time constant characterizing the signal decay called T1 or spin–lattice relaxation time. Similarly, M_T decays to zero with a relaxation time T2 or spin–spin relaxation time. During relaxation, the nuclei lose the energy by emitting their radio frequency signal named as free induction decay (FID). FID signal detected by conductive field coil placed around the object helps to obtain three dimensional (3D) gray images. MR image contrasts will controlled by the repetition time (TR) and time to echo (TE) [13] [14]. These parameters produce the sequences namely T1-weighted, T2-weighted, FLAIR and are shown in Fig. 4.



(a) (b)



(c) (d)

Fig. 4. MRI brain scan with tumor (a) T1 Scan (b) T1c Scan (c) T2 Scan (d) FLAIR Scan

The normal human brain slice has three major components as WM, GM and CSF. The abnormal MRI brain slices having a tumor with high intensities. T1-weighted makes good contrast difference between GM and WM tissues, and CSF is a void signal. T2-weighted make good contrast between CSF and brain tissue.

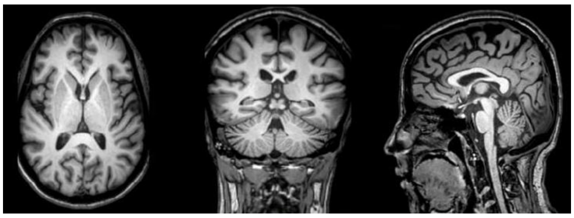


Fig.5. MRI planes for MRI head scan (a) Axial (b) Coronal (c) Sagittal

MR scanner can generate three types of orientations of human head. The basic planes of MRI: from top to down (axial plane), from front to back (coronal plane), and side to side (sagittal plane). In the X-Y-Z coordinate system, axial is an X-Y plane, parallel to the ground, the head from the feet. A coronal is an X-Z plane, the front from the back. A sagittal is a Y-Z plane, which separates left from right. The MRI head scans can be taken in any one of the orientations: axial, coronal, sagittal and are shown in Figure 5.

VI. FMRI AND BOLD

fMRI measures the brain activity from changes related to blood flow [15]. fMRI detects the brain abnormalities such as stroke, tumor, etc., to guide the treatment. Especially, fMRI is a pre-surgical tool for localization of brain tumor to guide the physicians to treatment and surgical approach.

BOLD signal is the MRI contrast of blood deoxyhemoglobin. fMRI takes advantage of the endogenous BOLD contrast to brain imaging without non-invasive radiation and basic study for children's brain activity. The technique is essential for finding and curing children's autism. Fig.6 shows the BOLD image of the human brain.

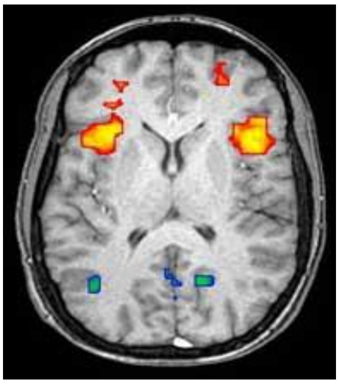


Fig. 6. BLOD scan brain slice

VII. CONCLUSION

The paper presented an overview of MIT's for handling brain tumor has been presented with details. A detailed comparison between these MIT's with the point of view, image quality, safety, and system availability has presented. This paper created a deep knowledge of varying brain tumor treatment planning based on MIT's. At the end of the conclusion, we found that MRI is a suitable and safest modality for structural analysis and, fMRI is best one for functional analysis.

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