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"Investigation of patients with brain tumor using CT scan and MRI"

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ABSTRACT

Imaging Strength of different tissues could be scanned by taking attenuation factor of these tissues. CT scans create images by passing X-rays through brain and measuring how much radiations are absorbed by these organs. Absorbing difference is marked and processed. Aim is to highlight the current trends in imaging techniques, admissible to tumor infected brain. The approach used for evaluation of tumor in clinical Imaging should be used on standard basis. Ended up by discussing crucial trends and future work are discussed. This dissertation relates CT and MRI imaging. Uses of MRI technique turn out to be much better when compared with CT scanning. Betterments include no exposure to ionizing radiations which in turn could damage healthy tissues as well.

Keywords: CT scans; X-rays; MRI; radiations

Introduction:

In the past few decades, almost diagnosis and cure of every disease is introduced due to advances in medical science, but the cancer still remains burden to the mankind. Taking medical images is noninvasive diagnosis of tumor. It is based on numerous software Based algorithms to detect cancerous region from the healthy one in image. Treatment planning is aided by the taken image to cure the suspected part leaving behind the healthy part as it is. Computer based diagnosis method upgrades diagnostic ability and provides accuracy in no time. Currently a vast majority of algorithms are used to identify brain tumor **[1].** Two most important and commonly used imaging modalities are Computed tomography (CT scan) and Magnetic resonance imaging (MRI). When brain tumor is suspected, radiologic imaging is required to find the extent, location of tumor and its relationship to surrounding tissues. After imaging it is decided to cure using surgery, radiation and chemotherapy. A PET scan is usually used to get image of tumor that reappear after treatment. [2].

CT scan:

Computerized axial tomography (CAT) or Computerized tomography (Ct scan) helps to visualize tumors that cannot be seen with plain film X-ray [3]. It is a x-ray machine combined with computer [5]. It gives description of white matter and grey matter. Before CT partial volume effect and CT value should be decided [4]. It works on x-rays obtained from multiple angles and guides these rays to computer to create cross sectional image of inside body and reveals detailed images comparative to plain x-rays.[5] , industries tried to follow some variations in the instrumentation of CT scanner which lead to seven generations of CT scanner. Each generation has a unique arrangement of x-ray source and detector and movement of both these varies in each.

Techniques in CT scanning

There are two methods to use CT scanning.

1. Plain CT scanning
2. Contrast CT scanning

Plain CT (Non contrast CT)

Simple CT is used for detecting tumor without using any sort of contrast agents.

Contrast Enhanced CT

Contrast agents are used in combination of CT for enhancement of image to detect the tumor. To show clarity different agents are used for this purpose. Bones are visible in this technique. Identification of some soft tissues and organs is tough in CT scanning. To visualize difference of densities in various organs contrast agents are used. Contrast agents are used in CT angiography to visualize vessels for abstracting information about supply of blood (e.g in liver) . Barium and ionic compounds are employed for contrast agents. Using contrast agents CT time is reduced and more improvements are made for achieving data [6]

Types of CT scanner:

64 MDCT

Moving towards 4 slice to 16 slices and recently to 64 slices substantial changes are made in computed tomography. 64 slice multidetector systems are used for this purpose. MDCT reduces the scan time and increased number of detectors. 64 slice CT scanners with gantry rotation in 0.33s and gives resolution of 0.4mm are used clinically. Cardiac imaging is feasible using ECG with 16 slice CT and now produce highly examination with 64 slice CT. This is MDCT with 64 detectors along z-axis. Practically this is used in BVH Bahawalpur. It contains many collimators. Image thickness is acquired by collimation beams. This system is squillion scanner by Toshiba Japan [7].

Helical CAT scanner

Early scanners provide just one image at one time before going to the next. Slice thickness is strongly dependent on the thickness of scanner. Recently a modification Helical CAT scan also termed as spiral CT scan or CT scan is used. In the late 1990s only one slice CT image is obtained at a given time. By helical CT scanning acquisition time is reduced significantly.

SDCT

This technique is also named as single spiral CT (SSCT). It contains one row of detectors and nonstop image acquisition is procured by using it. Detector arrays are 1 dimensional. Fan shape beam is generated and processed to record data. One complete rotation covers the slice to provide data in one second. Nearly

500 to 900 detector elements are combined to generate one row of detectors. Body is irradiated by a fan shaped beam of x-ray generated by system [8].

MDCT

Latest version MDCT also called as multi slice computed tomography providing three dimensional imaging is more advanced technique in which whole body is scanned in time less than one second. There is a major disadvantage of using this technique is that dose distribution is 4-5 times as compare to single slice CT. [9] Hence more development is required in computed tomography so that acquisition is obtained in less time with low dose distribution and more accuracy. There are multiple rows of detectors in this system which allows multiple slices to be accessed in one rotation of gantry. This is latest scanner. There are 16 rows of detectors which access 16 slices of 1.25mm thickness. 16 rows contain 800 detectors so it gains data briskly. In one rotation thirteen million measurements are attained in just 0.5s. Alternatively single row of detector is replaced by multiple rows which are parallel to each other [10].

Magnetic resonance imaging:

It is a large machine with strong magnetic field combined with computer provides images of tumor. It does not use x-rays in its operation [11].This is a three dimensional image providing technique that works on detecting emitted signals from normal and abnormal tissues. In the past few years' new technology of MRI is developed PWI, DWI, DTI, FMRI and MRS [12].

DWI Scan (Diffusion Weighted Image)

DWI is a method that relies on Brownian motion of water in tissues. When the diffusion of water molecules is at high rate signal will be lower. In primary diagnosis, Diffusion weighted imaging contributed in finding small dimensional and sensitive tumors [13].

DTI Scan (Diffusion Tensor Imaging)

This is a recent MRI imaging that relies on weighted images. It shows fiber structure of cerebral white matter. DTI is somehow similar to DWI with the difference that a tensor is required by diffusion to describe its direction and magnitude.

PET Scan (Positron Emission Tomography)

Positron emission tomography is a metabolic imaging technique that discriminates between benign and malignant tumors. It predicts the stage of brain tumor. It is an imaging test that uses special dye that contains radioactive tracers. This dye is injected into veins in arms. Organs and tissues absorb the tracers. PET scan describes brain activity by measuring rate of absorption of glucose (sugar) into a tumor. Deoxy glucose is injected in patient; activity of brain is measured by scan and feeds this information to computer creating a live image of brain. This scan discriminates between infected tissues, necrosis (damaged cells by radiation absorption) and the healthy ones. PET scans are used to detect heart problems, brain disorders and central nervous system problems. Unlike MRI and CT, PET shows problems at cellular level [12].

i. **Magnetic Resonance Spectroscopy (MRS)**

It is noninvasive technique that works on detecting chemical abnormalities in tissues. This is similar to MRI but far better than CT and MRI lacking the ability to measure the function of brain.MR spectroscopy measures the chemical composition of normal tissues with abnormal tissues of brain.MR needs the same machine as conventional MRI. To create detail images MRI uses a powerful magnet, radio waves and a computer. Spectroscopy refers to a series of tests that are added to measure chemical metabolism of suspected tumor. Different metabolites are used for this purpose. Commonly used metabolites are choline, lactate, amino acids, lipid and NAcetyl-Aspartate (NAA).

ii. Functional Magnetic Resonance Imaging (fMRI)

It gives image of brain by chasing use of oxygen by brain. It describes that which part is handling severe functions which is much needed in treatment. It provides a road map before surgery [11]

Inference of Magnetic Resonance imaging

When the magnetic field is removed, protons come in relax mode. Protons realigned with magnetic field and protons loss resonance. Images obtain from Magnetic resonance imaging fall in two categories

1. T1 weighted image
2. T2 weighted image
3. T2* weighted image

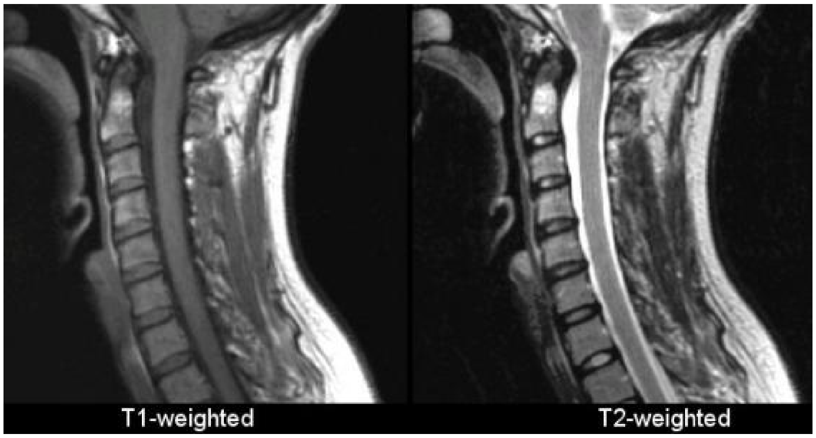
Areas of high signal (white) and low signal (dark) generates contrast in image. A specified portion is differentiated into fat, muscle and cerebrospinal fluid [14]

i. T1 weighted image

The pulsation sequence of radiofrequency signal dominates in fatty tissues in the body produces T1 images. Images contain white colored fats. Protons realigned with magnetic field generating T1 signal. The more quickly the realignment the more will be T1 signal. Proton energy inside fatty tissues are mapped in T1 images. As CSF (cerebrospinal fluid) contains no fat so it appears to be black in image.

ii. T2 weighted image

In T2 weighted images proton energies inside fatty and water tissue are mapped. Protons loss resonance and phase coherence resulting to generate T2 signal. The more slowly they dephase greater will be the signal. Fluid tissues can be distinguished from fatty tissues by comparing t1 image with t2 image. As cerebrospinal fluid is distinguished by comparing image which is black in t1 image and white in t2 image. Indication of abnormal behavior is marked by blackening of fats or either whitening of fluids [9].

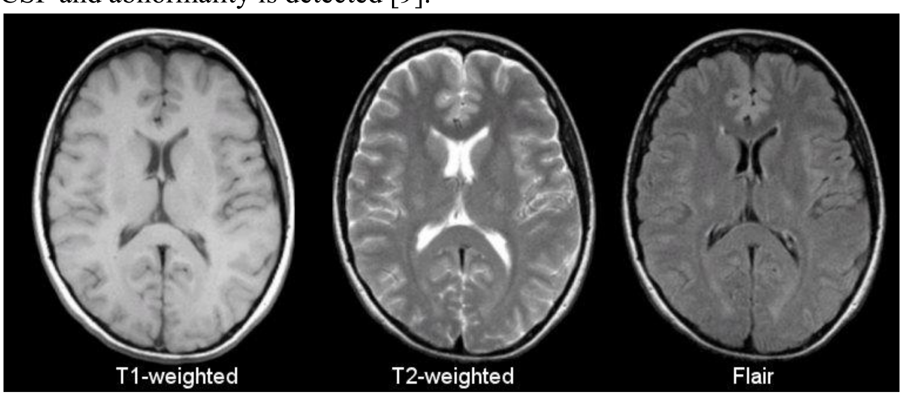


iii. Short Tau Inversion Recovery (STIR image)

These are water sensitive images which results that water appear bright. Ratio of fats and water contents are compared in T1 and STIR images.

iv. Flair images

Fluid attenuated inversion recovery is used mostly in brain imaging. A signal from free fluid is detected and suppressed and further processed with T2 weighted image. Infection and tumor areas are marked and processed for cure or therapy of brain. Normal CSF fluid remains dark which made an easy distinction of CSF and abnormality is detected [9].



v. T2* (Gradient Echo) images

Blood products are highlighted using T2* weighted images. As in the case of cerebral Hemangioma. This decay is combination of two effects

1. T2 decay
2. Dephasing due to inhomogeneities

Inhomogeneities are areas which do not match with external magnetic field.

According to Larmor equation, Larmor frequency is proportional to exterior field. For high field, frequency increases speeding up the precession. At low field, frequency decreases decreasing the precession. This dephasing due to inhomogeneities is recommended at 180˚ called as spin echo pulse sequences.

vi. Diffusion weighted image

Diffusion weighted image also called as apparent diffusion coefficient images. Obtained images from this technique indicate restricted diffusion in the specified area. Movement of water molecules is restricted in intracellular space as compare to diffusion outside cell where it moves freely. When there are ischemic tissues of brain diffusion of water molecules is strictly prohibited due to intracellular accumulation of sodium. Water molecules are then shifts to intracellular space where there is restriction on their movement and generates a bright signal in the form of DWI. As indicator of cell death, this technique is used commonly in infarction or cancer images of brain [9].

Echo Time TE

The time point measured in milliseconds is the time in which we measure the radiofrequency signal which returns from the tissue after the initiative RF pulse.

Repetition Time TR

The time point which is measured in milliseconds is the time of excitation pulse sequence of the same slice. (pulses are usually repeated for each line of pixel in final image)

Slice Thickness ST

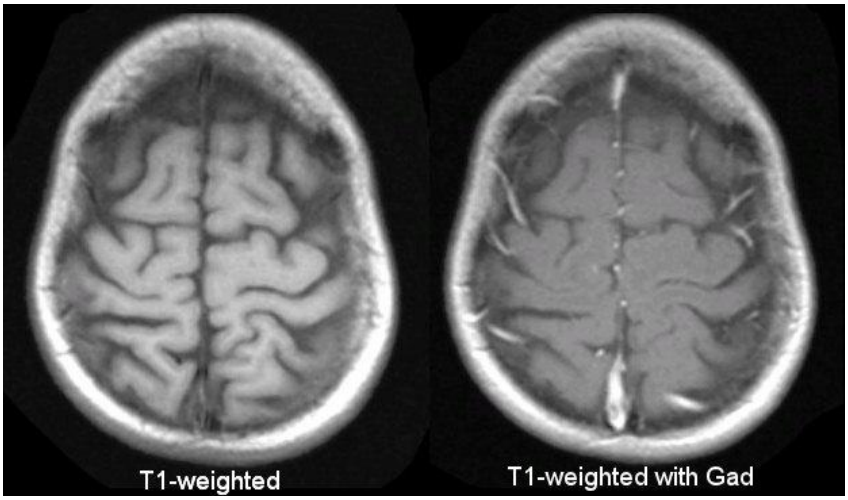
Thickness or width of slices seen on the screen of computer [9].

k-space

The area which contain the stored area is called k-space.it contains two axis one is horizontal other is vertical. Horizontally we have frequency and vertically we have phase. Raw data is contained in it and after some changes it gives images. Its central portion reflects about contrast and outer region indicates about resolution.

Contrast agents

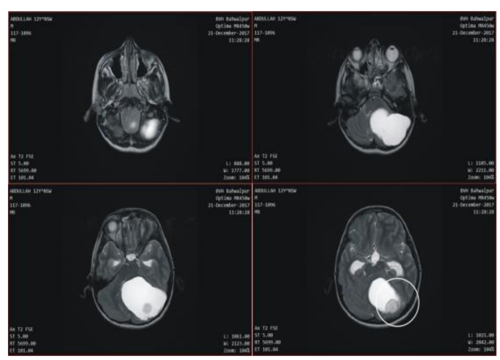
To get more information sometimes contrast agents are used. Gadolinium is randomly used agent for this purpose. Gadolinium is a paramagnetic substance which results in a very high detection of T1 signal. It is given to the body by the way of vein and can also be injected into body parts directly as joints. T1 image is obtained called as pre gadolinium image. When gadolinium is given, T1 image is obtained which is now post gadolinium image. Post gadolinium causes the more brighten and enhanced effect on tissues. This enhancement is used to detect malignancy in tissues. Delayed enhancement is also used in cardiac MRI in which gadolinium is retained in abnormal part resulting in its glow [9]. Its risk factor is low compared to iodinized contrast agents. X-ray attenuation is same for both at 70KV. At 120KV attenuation factor for gadolinium is double compare to iodine. So Gadolinium is better than iodine. These agents are used for both CT and MRI but dose distribution is different in both cases [10].



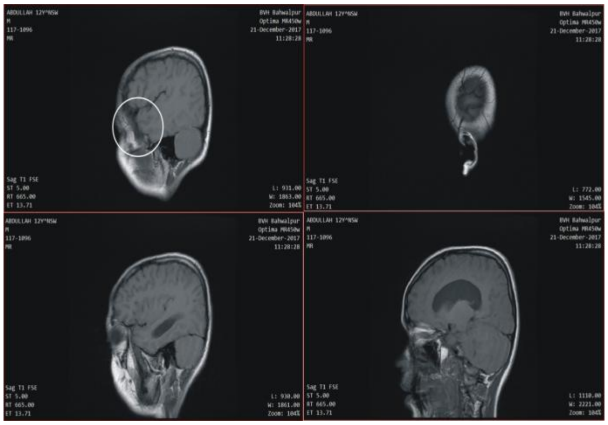
Results and Discussion:

The basic purpose of this research is to study the brain tumor with two imaging modalities. For this purpose, CT and MRI of patients are performed in Bahawal Victoria Hospital Bahawalpur. MRI can give T1, T2 weighted images, Sagittal and coronal images. Contrast agents can also be used in MRI to enhance the image quality. For this purpose, contrast agent used is Gd+3. T1 axial and sagittal images show poor calibration of tumor but T2 scans provide much better quality of images with clarity of tumor volume. Enhancement in normal and tumor volume is obtained by using T1 images with contrast.

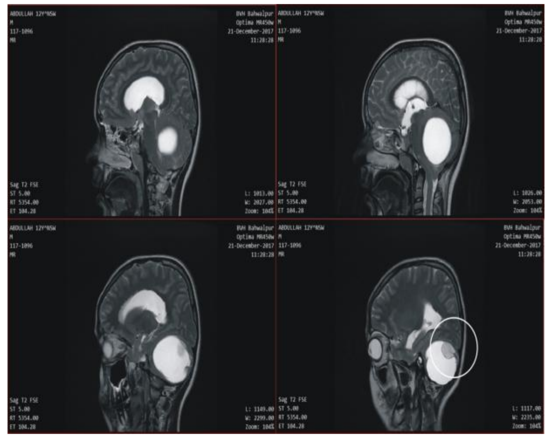
MRI



T1 axial view **T2 Axial View**



T1 sagittal view

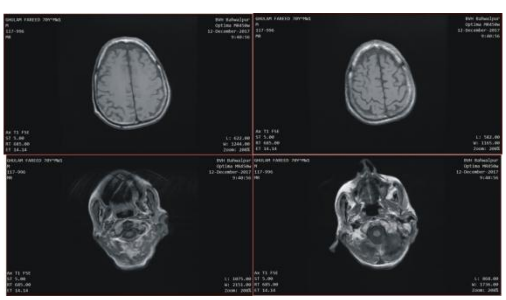


T2 Sagittal view

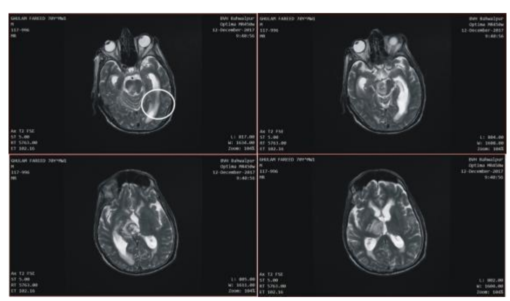
CT scan

There is a well-defined abnormal signal intensity lesion seen involving left cerebral hemisphere iso-intense on T1 hyper-intense on T2 weighted images causing mass effect on fourth ventricle and brain stem no surrounding edema noted in a 11 years old boy.

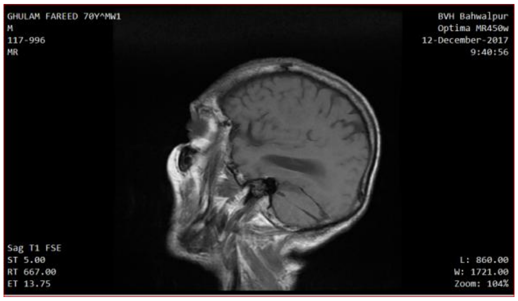
MRI

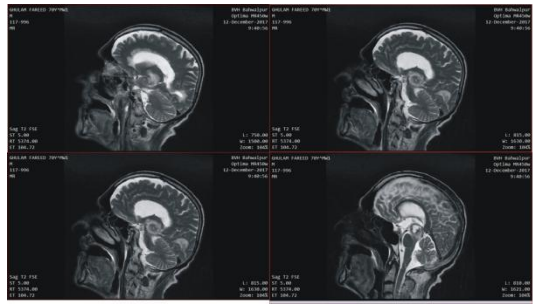


T1 axial view



T2 axial view



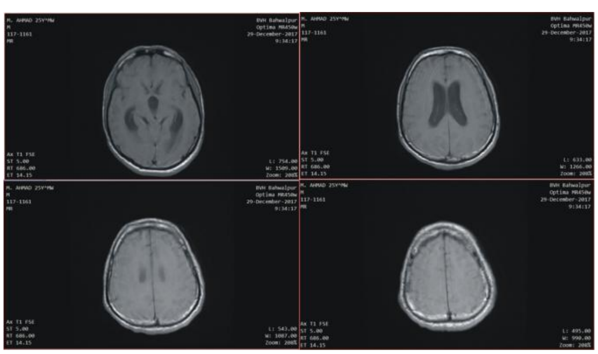


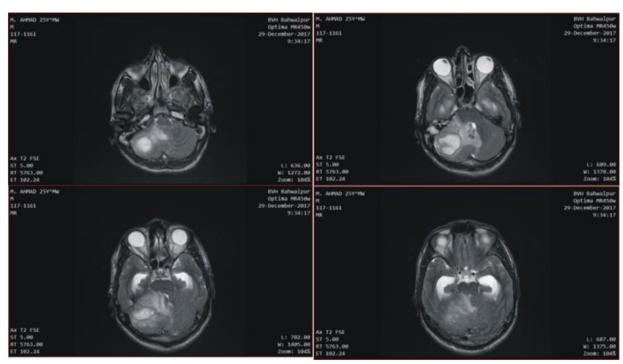
T1 sagittal view **T2 sagittal view**

CT Scan

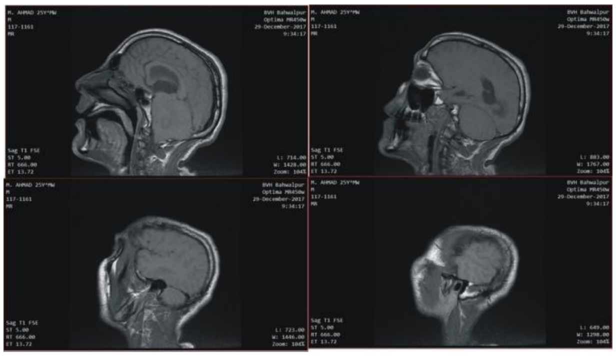
Abnormal signal intensity lesion right thalamic region causing compression on third ventricle appearing hypo-intense on T1 and heterogeneously hyper-intense on T2 surrounding edema is noted i-e ventricular chain is dilated in a 70 years old patient.

MRI

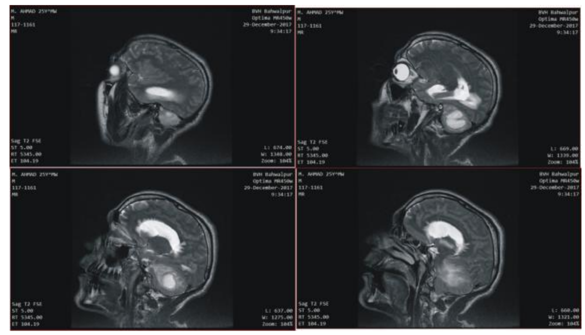




T1 Axial view **T2 Axial view**



T1 Sagittal view



T2 sagittal view

CT scan

Abnormal signal intensity area is seen which involves right cerebral hemisphere with surrounding edema appearing hypo-intense on T1 and hyper-intense on T2 causing compression on fourth ventricle with dilation on rest of ventricular chain in 25 Years patient.

On the other hand, CT is used to generate three dimensional images of infected area. But unfortunately, CT is not able to generate high resolution of soft tissues (brain) and for better resolution it requires a large amount of radiation exposure to relevant area. CT uses 100 – 1000 times radiations as in x-rays. While CT is still in use, it should be used infrequently to avoid much radiation exposure. High quality images of brain are produced using a cylindrical magnet which is able to create magnetic field around the head part of patient. MRI is much better in the sense that it produces high resolution of images working on radio waves without exposing excessive radiations to patients. For this purpose, a recent innovation termed as functional magnetic resonance imaging is used. It allows taking various images of brain by focusing on oxygenated blood in the brain. Hence CT is best technique for viewing bony parts, injuries, and chest and lung problems and for detecting cancers. MRI is best suited for viewing soft tissues like brain tumors, spinal cord injuries, etc. CT scans takes fewer time approximately 5 minutes whereas MRI takes up 30 minutes for a scan. MRI is a cost demanding technique. Effective radiation dose of CT ranges from 2-10mSv, which is nearly same as a person receives background radiations in 3-5 years. CT is much damaging for pregnant ladies because of its radiation exposure nature. MRI is allergic to some patients due to dye used in it which are inappropriate for those having kidney and liver distortions.

Conclusion:

In the end it is concluded that CT scans are able to outline bones inside the body of patients. MRI is more versatile to examine soft tissues. For any sort of Brain tumor MRI proves to better in providing high resolution image. Isotropic imaging is possible using MDCT. MRI machines are able to produce images in any plane 3D isotropic imaging is also possible to generate multi planar reformations. MRI also has the ability to change the contrast of images by making a small change in magnetic field and radio waves contrast of image is totally change. These contrast settings are used to highlight different types of tissues in the body. Capabilities of CT can be enhanced by using elements having high atomic number as contrast agents such as iodine and bromine. MRI is also performed by using paramagnetic substances such as gadolinium as contrast agents.

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Data Availability Statement: The associated data is available upon request from the corresponding author.

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