

MRI BASED DIAGNOSTIC TECHNIQUES FOR EARLY DETECTION OF BRAIN DISEASES

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ABSTRACT

Brain tumors are dangerous conditions that can disrupt the normal functioning of the brain. Early detection is crucial, as timely treatment can help save lives and improve recovery outcomes. Magnetic Resonance Imaging (MRI) is considered one of the most effective and safest techniques for identifying brain tumors. It provides detailed images of the brain without using any harmful radiation. In this article, study to compares various imaging procedures and examines clinical case studies to illustrate the diagnostic precision, benefits, and drawbacks of each method. According to the results, MRI-based technologies have the potential to greatly improve early diagnostic capabilities and direct patients' individualized treatment plans for brain tumors.

Keywords: *Magnetic Resonance Imaging (MRI), Brain tumor and malignant (cancerous).*

INTRODUCTION

1.1 Brain tumors:

Tumors of the brain are a major medical problem that can impair neurological function and often are life-threatening. They are classified as primary or secondary tumors. The brain is the site of primary brain tumors, whereas secondary tumors,

or metastatic tumors, grow from other organs into the brain. This is a critical factor needed for both prognosis and survival due to the detection of tumors is one of the most complex problems in early detection of these tumors[1] [2].

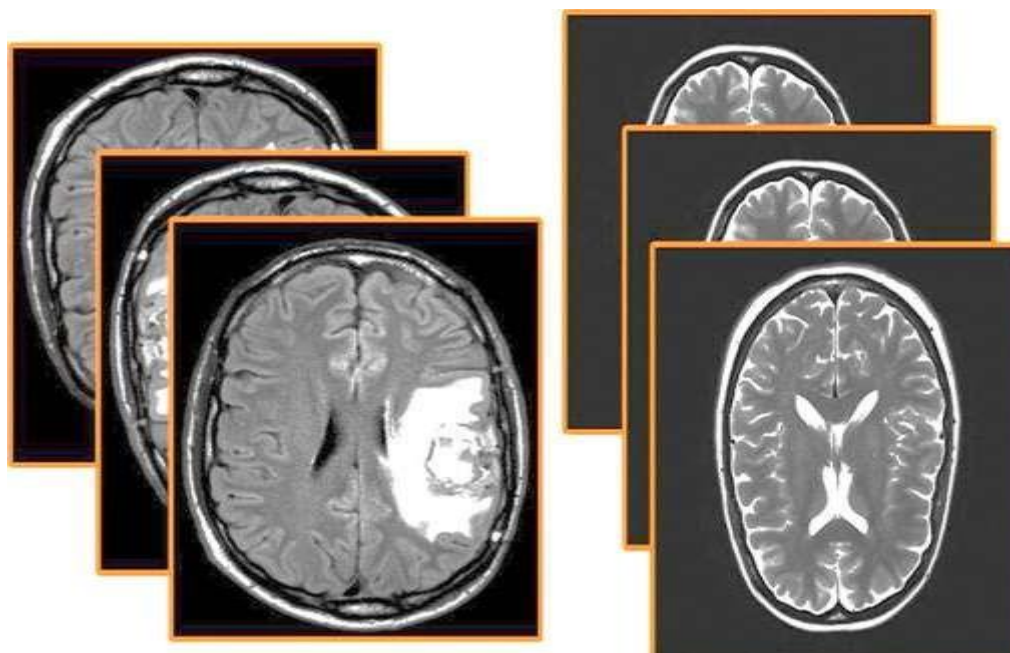


Figure 1.1.: Visual contrast between healthy brain and brain with tumors on MRI scans.

1.2 MRI (Magnetic Resonance Imaging):

Magnetic resonance imaging (MRI) is a non-invasive method for visualizing inner structures and is one of the most powerful imaging techniques available, especially for soft tissue such as the heart and organs, and for imaging the brain and surrounding structures. In this article, study's main goal is to investigate, assess, and evaluate MRI-based imaging methods to enhance early brain tumor identification and precise diagnosis. Early brain tumor detection is among the biggest advantages as the treatment can be initiated before the tumor grows to be an advanced stage. Many brain tumors, especially malignant ones such as glioblastomas, grow increasingly aggressive with time [3]. Tumors in the brain apply pressure to adjacent brain tissue, resulting in

neurological deficits memory loss, speech difficulties, an impaired ability to see, an inability to move. If a tumor is detected early enough, physicians can treat it before it deuces irreversible brain damage, allowing cognitive and physical functions to continue [4].

T1-weighted imaging is prominently used while determining anatomical structures, providing detailed demarcation of tumor boundaries (and edema), and T2-weighted imaging is favored for outlining areas of edema and tumor infiltration. This mixed pattern is due to gadolinium-based agents commonly used in contrast-enhanced magnetic resonance imaging (MRI), the latter significantly improving the visibility of tumors by highlighting the areas of disturbance of A common characteristic of malignant tumors is the blood-brain barrier [5].

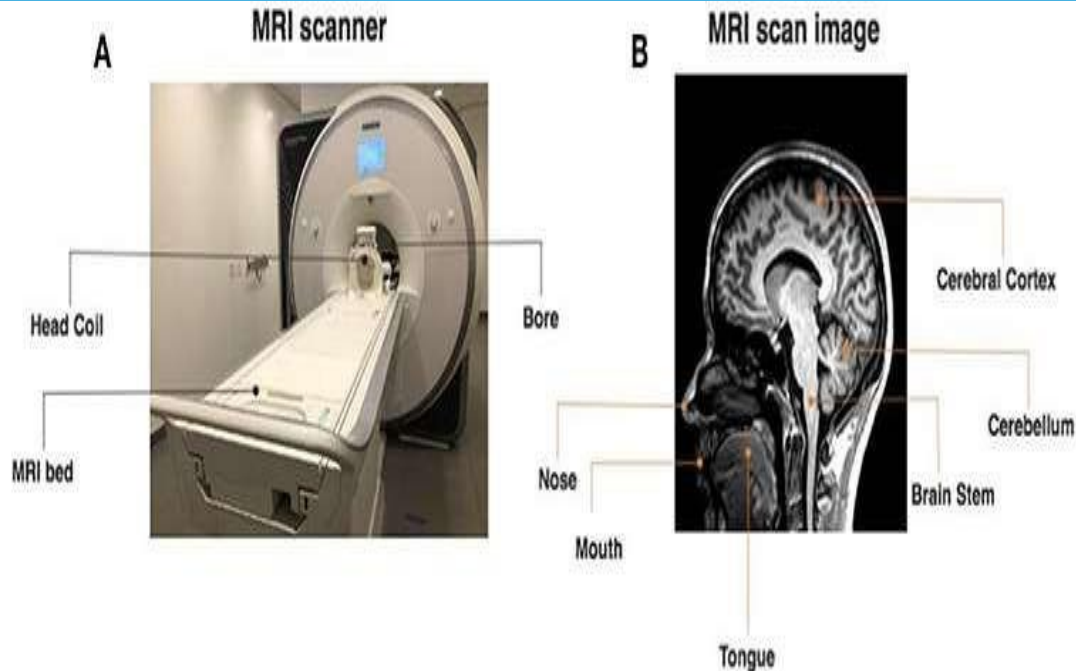


Figure 1.2: Advanced imaging technology for detailed visualization of internal body structures[5].

MRI is centred around a powerful magnetic field. This field is generated by the MRI machine, generally between 0.5 and 3 Tesla. This magnetic field interacts primarily with hydrogen atoms, which are plentiful in the human body (since a significant part of human tissues consists of water). Hydrogen atoms have protons in their nuclei, and these protons act like little magnets. Once the external magnetic field causes the body's hydrogen protons to align with the magnetic field in a parallel (lower energy state) or antiparallel (higher energy state) manner while the patient is within the MRI scanner [6].

To create images that are accurate in space, MRI requires a relationship between frequency and space, achieved through the Fourier Transform of the emission data by detecting signals through emitted pulse signals. This data is then processed

by a computer and converted into a tissue structures visual representation inside the body [7, 8].

1. Material and Methodology

The MRI was conducted with a high-field MRI scanner (such as 1.5T or 3T) that has the appropriate software and hardware to obtain both standard and advanced imaging sequences. To produce intricate pictures of the spinal cord and brain, the scanner employs powerful magnetic fields and radiofrequency pulses. For certain patients, intravenous administration of gadolinium-based contrast agents was performed to augment the visualization of neoplastic lesions and enhance the differentiation between normal and abnormal tissues.



Figure 2.1: MRI machine setup inside the scan room.

Standard imaging sequences of the brain and spinal cord, such as post-contrast imaging, FLAIR, T1-weighted, and T2-weighted, were conducted based on clinical indication. After the contrast injection, imaging was redone to check for enhancement of any abnormal masses or lesions. For viewing and analysing medical pictures saved in the DICOM (Digital Imaging and

Communications in Medicine) format, Radiant DICOM Viewer is a popular software program. It offers radiologists, medical students, and healthcare professionals an effective platform for accessing and interpreting imaging data from a variety of modalities, such as MRI, CT, X-ray, ultrasound, and PET scans.



Figure 2.2: Scan image displayed on diagnostic monitor.

The images were examined across various planes (axial, sagittal, coronal) to gather detailed data about the structures of the brain and spinal cord.

For MRI, different sequences—T1-weighted, T2-weighted, FEEL, and post-contrast T1-weighted

images—were analyzed to detect abnormalities like tumors, edema, hydrocephalus, or haemorrhage. The study included four patients who received MRI and Computed tomography scans at the Department of Radiology, Bahawalpur Victoria Hospital, which is associated with Quaid-e-Azam Medical College in Bahawalpur. Patients were chosen based on clinical symptoms indicative of

intracranial or spinal neoplastic lesions or a documented history of brain tumors.

2. Results and discussion:

In figure 3.1(a), the cerebellum, brainstem, and fourth ventricle of a 46-year-old female patient are located in the later fossa region, which is dyed in this axial T2-weighted brain MRI.

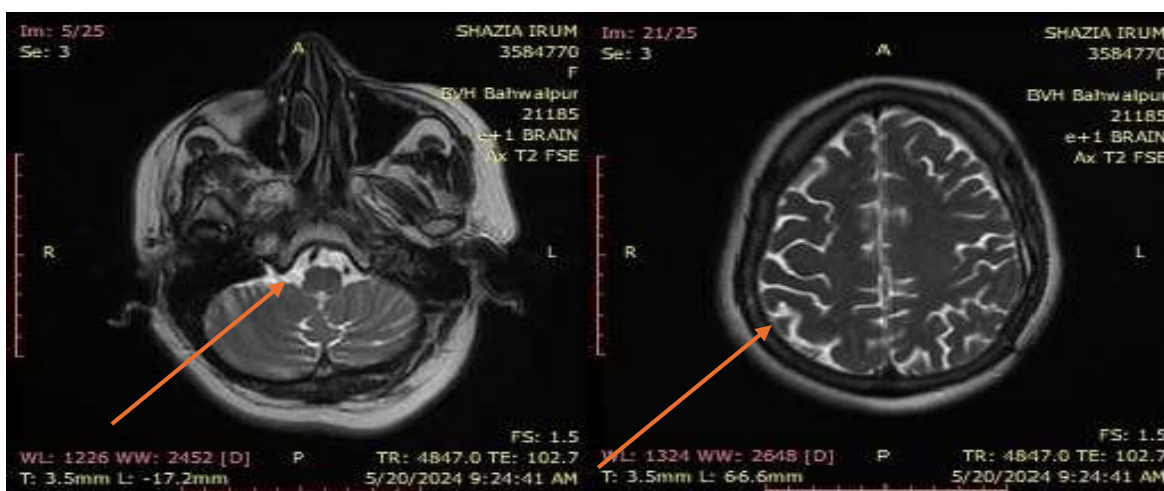


Figure 3.1(a): Axial T2-weighted brain MRI showing detailed cross-sectional anatomy of the posterior fossa region. Figure 3.1(b): Axial T1-weighted MR image shows an isointense lesion in the diploic space.

In figure 3.1(b) An isointense lesion in the skull's diploic space is shown on an axial T1-weighted MRI. The lesion's intensity on T1-weighted imaging suggests that its signal properties are comparable to those of the surrounding soft tissue,

which could indicate metastases, intraosseous hemangiomas, or fibrous dysplasia. This picture demonstrates how useful T1-weighted imaging is for determining the pathology of the skull bones.



Figure 3.2.: A localization scan of the coronal T2-weighted contrast-enhanced brain MRI reveals precise anatomy with highlighted areas

In figure 3.2, the coronal T2-weighted contrast-enhanced brain MRI of a 39-year-old female patient shows the structure of the brain in depth and highlights specific locations. The lesion is located at the right posterior temporal-parietal-

occipital junction, where anatomical anomalies can have a major impact on sensory and cognitive abilities. This makes lesions that could be harder to see on traditional T2-weighted images more visible.



Figure 3.3: Pre-operative axial and sagittal MRI cystic and solid mass

In figure 3.3, the Hyperintense lesions in the periventricular and subcortical of a 58-year-old patient are visible with white matter on an axial T2 FLAIR MRI. This MRI Shows that axial and sagittal MRI pictures taken before to surgery that

show a solid and cystic mass inside the brain. A complicated cerebral tumor is suggested by the lesion's mixed makeup, which includes both thick tissue (solid) and fluid-filled (cystic) components.



Figure 3.4: Sagittal T2-weighted MRI shows Chiari I malformation with cerebellar tonsil herniation compressing the brainstem

In figure 3.4, the Alzheimer's disease of a 61-year-old female patient is evaluated with computing

techniques in conjunction with MRI analysis. A sagittal T2-weighted MRI showing a Chiari I

malformation. Due to reduced cerebrospinal fluid flow and brainstem compression, this disorder can cause neurological impairments as well as symptoms including headaches and neck pain. The diagnosis of Chiari I malformation, which may necessitate additional testing and treatment, including surgery to relieve pressure and avoid problems, depends heavily on the results of the MRI.

3. Conclusion:

Magnetic Resonance Imaging (MRI) continues to play a crucial role in the early detection and characterization of brain tumors due to its superior soft-tissue contrast, non-invasive nature, and versatility. To sum up, MRI techniques provide substantial enhancements for the early discovery and characterization of brain tumors when compared to conventional imaging methods. The incorporation of advanced MRI into everyday clinical practice could revolutionize the diagnostic workflow, lessen the reliance on invasive procedures, and enhance patient outcomes.

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