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The Role of MRI in Diagnosing Brain Tumors

Nagwa R. Bochwal[1], Huda M. Ibrahim[2*], Eman.Y. Abdelsameh[3], Wfa. A. A. Nweh[4], Retaj.N. saad[5], Salwa.F. Ahmed[6], Najat.S. Shref [7], Retaj. M. Jomaa [8], Firdous N. Saad [9], Haneen F. Awad[10], Nedaa M. Mohammed[11]

[1- 9] College of Health Sciences, University of Tobruk, Tobruk, Libya

*Corresponding author: E-mail: hm1295577@gmail.com

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ABSTRACT

Background: Magnetic resonance imaging (MRI) is a cornerstone diagnostic tool for intracranial neoplasms, owing to its superior tissue contrast resolution and spatial resolution. Early identification of lesions is critical to optimizing therapeutic strategies and enhancing overall survival rates. Aim: To assess the diagnostic utility of MRI in detecting, characterizing, and localizing brain tumors. Methods: This cross-sectional study evaluated 45 individuals suspected of harboring brain tumors at Tobruk Medical Center between November 2025 and January 2026. Scans were performed using a 1.5-Tesla MRI system with standard T1- and T2-weighted and FLAIR protocols, with intravenous gadolinium contrast administered as clinically indicated. Data extracted from radiological archives and clinical records were processed via Microsoft Excel. Results: Among the 45 participants (age range: 18–80 years), males comprised 51.1% and females 48.9%, with a predominant occurrence in individuals over 40 years old. Utilizing a combined protocol of T1, T2, and FLAIR sequences markedly enhanced lesion detection, whereas contrast-enhanced imaging provided superior definition of tumor borders and vascularity. A substantial majority of patients were diagnosed at advanced disease stages. Conclusion: MRI remains a highly reliable imaging technique for evaluating brain tumors and guiding clinical management. Nevertheless, delayed clinical presentation substantially limits its efficacy. Enhancing diagnostic awareness and radiological training is essential to improve outcomes.

1. INTRODUCTION

Intracranial tumors represent some of the most lethal human malignancies, contributing to nearly 1.35% of all cancer diagnoses and 29.5% of cancer-related mortality (Lapointe et al., 2018). Central nervous system (CNS) neoplasms encompass lesions arising from the brain parenchyma, cranial nerves, spinal cord, and surrounding meninges. The World Health Organization (WHO) classifies these tumors into benign and malignant categories, utilizing a grading scheme where grades III and IV designate high-grade malignancies (Clifton and Reimer, 2019).

Primary brain tumors and metastatic lesions exhibit significant histological heterogeneity. Glioblastoma, derived from glial lineage, constitutes the primary high-grade lesion observed in adults (Udaka and Packer, 2018). Gliomas account for approximately one-third of all primary brain neoplasms; because they infiltrate adjacent parenchyma without clear demarcations, they are categorized as intra-axial lesions. Glioblastoma (formerly Glioblastoma Multiforme or GBM) presents major therapeutic and diagnostic challenges for clinical neuro-oncologists (Hill et al., 2002; Saman and Jamjala Narayanan, 2018). Metastatic brain tumors (MBTs) represent the most prevalent intra-axial neoplasms in the adult population. Evidence indicates that up to 33% of patients with systemic cancer will eventually develop secondary CNS metastases (Jelski and Mroczko, 2021). Prompt identification of intracranial neoplasms is critical to minimize irreversible neurological damage and prevent mortality. Advanced medical data processing relies heavily on feature extraction and classification techniques to differentiate physiological tissue from pathological lesions (Mehta et al., 2017). Microscopic visualization often occurs at advanced stages, compromising patient prognosis; hence, early diagnostic markers are vital. Standard management options for brain metastases include systemic corticosteroids, surgical resection, chemotherapy, whole-brain radiation therapy (WBRT), and stereotactic radiosurgery (SRS) (Kumar et al., 2019). Clinical manifestations depend largely on lesion size, anatomical location, growth velocity, and accompanying peritumoral edema. Cephalea is a universal symptom, typically presenting in spatial and temporal correlation with the tumor mass and often resolving within a week following surgical excision or corticosteroid therapy (Nelson and Taylor, 2014). Headache is reported as the primary complaint in up to 41% of cases, frequently co-occurring with emesis, gait ataxia, behavioral changes, visual disturbance, dysphasia, and cranial neuropathies. Focal lesions produce specific neurological deficits, while rapidly expanding masses induce severe intracranial hypertension. Early clinical identification is imperative to expedite diagnostic neuroimaging (Lecler et al., 2018). Epileptic seizures occur in 30–100% of brain tumor cases, depending on histology and location, with indolent tumors displaying higher epileptogenicity (Rigi et al., 2015). Seizure disorders in this cohort lead to substantial morbidity, functional impairment, and elevated mortality (Vargo, 2011). MRI contrast depends on manipulating radiofrequency (RF) pulse sequences. T1-weighted sequences highlight tissues with short longitudinal relaxation times as bright regions, whereas T2-weighted sequences emphasize transverse relaxation, rendering tissues with longer relaxation times hyperintense. Utilizing short Echo Time (TE) and Repetition Time (TR) parameters yields T1 contrast, while longer TE and TR values generate T2 contrast. Fluid-Attenuated Inversion Recovery (FLAIR) sequences utilize prolonged TE and TR settings to suppress signal from free fluid, thereby enhancing the visibility of pathological lesions (Amin et al., 2020). Magnetic Resonance Imaging is widely favored for clinical neuroimaging due to its exceptional soft-tissue resolution, absence of ionizing radiation, and versatility in monitoring treatment response (Dekker and Sijbers, 2005). Unlike ionizing techniques like CT or radiography, MRI allows repeated scans without radiation-induced risks (Nibib.nih.gov, 2016). It provides distinct anatomical detail without compulsory contrast administration by leveraging intrinsic tissue parameters (Patient, 2016).
Fundamentally, MRI maps hydrogen nuclei orientation within an externally applied magnetic field using non-ionizing RF pulses, translating released energy into high-resolution cross-sectional images across any anatomical plane (Revett, 2011).

2. METHOD

Study Design and Setting: A cross-sectional analytical study was conducted at Tobruk Medical Center between November 2025 and January 2026 to evaluate the diagnostic capability of MRI in intracranial neoplasms. Population and Data Acquisition: A cohort of 45 patients suspected of having brain tumors underwent MRI examination using a 1.5-Tesla scanner. Image acquisition protocols included standard multiplanar T1-weighted, T2-weighted, and FLAIR sequences, with gadolinium-based contrast administered based on clinical indication. Patient demographics, clinical features, and radiological findings were systematically retrieved from medical archives and analyzed.

3. ETHICAL APPROVAL

We have ethical approval from the research studies office of Tobruk University.

4. RESULT

Forty-five patients diagnosed with brain tumors were included in these advanced studies. The patients' ages ranged from 18 to 80 years, and the majority, as shown in Table 1, were older males

Table 1. Sample Age Characteristics

Total	45
Mean	51.80
Median	50.00
Sid Deviation	14.533
Minimum	18
Maximum	80

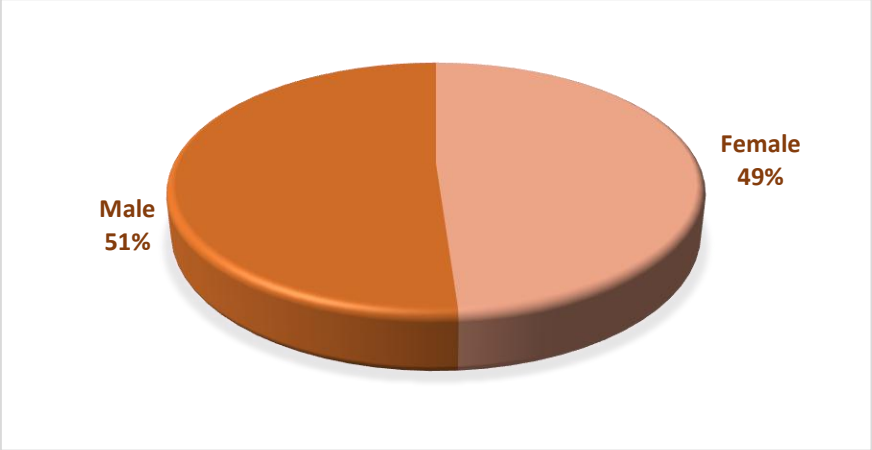

Figure 1. Sample Gender

A significant proportion of cases were male (23 patients, or 51.1%), while females comprised 22 patients (approximately 48.9%) (Figure 1). For MRI, T1 and T2 imaging were combined (Figure 2). Contrast was also used in most cases, while a smaller number of scans were performed without contrast (Figure 3).

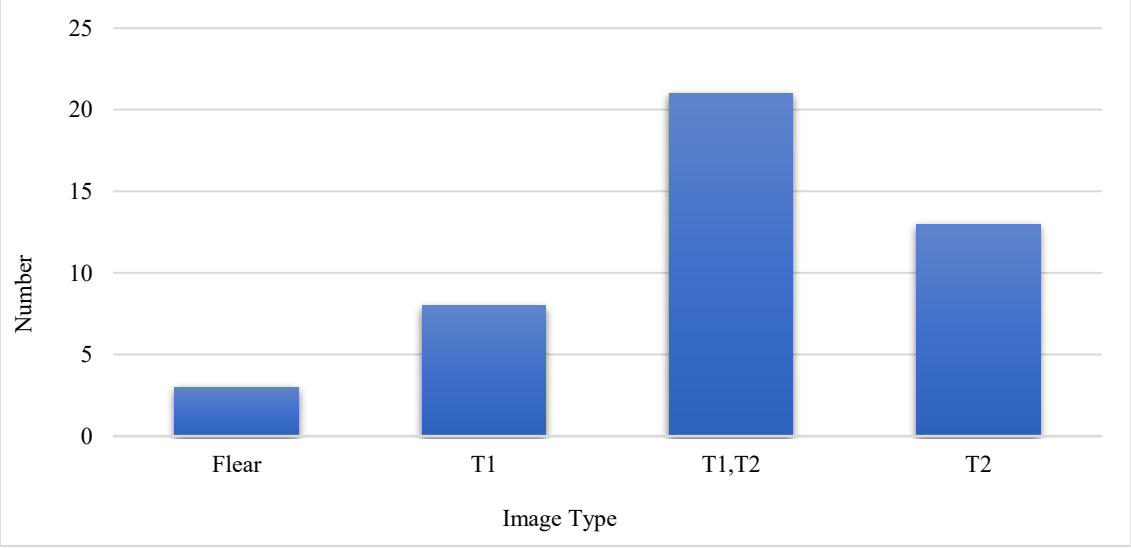

Figure 2. Image Types

The most commonly used protocol was the combination of T1, T2, and FLAIR sequences, accounting for 46.7% of cases. This is clinically justified, as contrast-enhanced T1-weighted images accurately delineate tumor margins, T2-weighted images reveal peritumoral edema, and FLAIR sequences are essential for detecting small lesions by suppressing cerebrospinal fluid (CSF) signal (Figure 3).

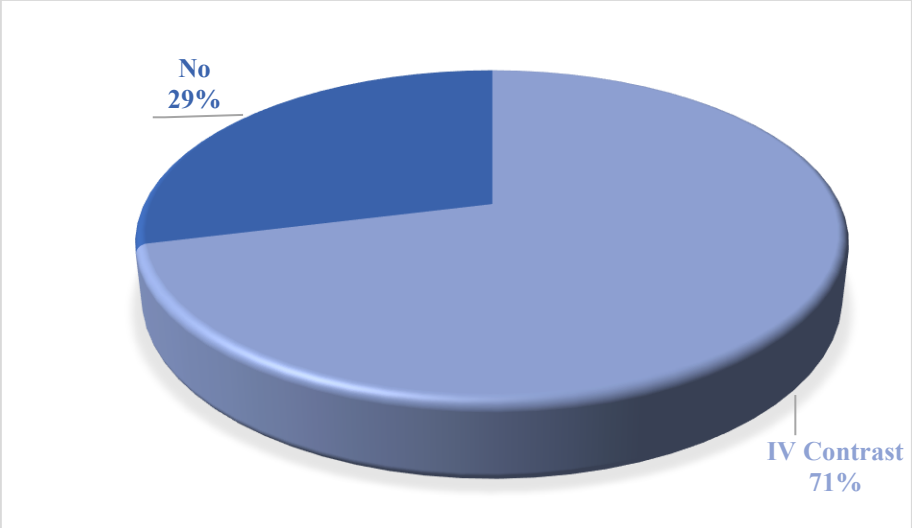

Figure 3. Image Contrast

The study revealed that 77.8% of cases were diagnosed at Stage IV, a very high percentage that indicates a significant delay in diagnosis, as observed (Figure 4). This delay is critical because Glioblastoma, the most aggressive type of Glioma, has a very poor therapeutic outcome when detected at advanced stages and is associated with major neurocognitive and functional decline**.**

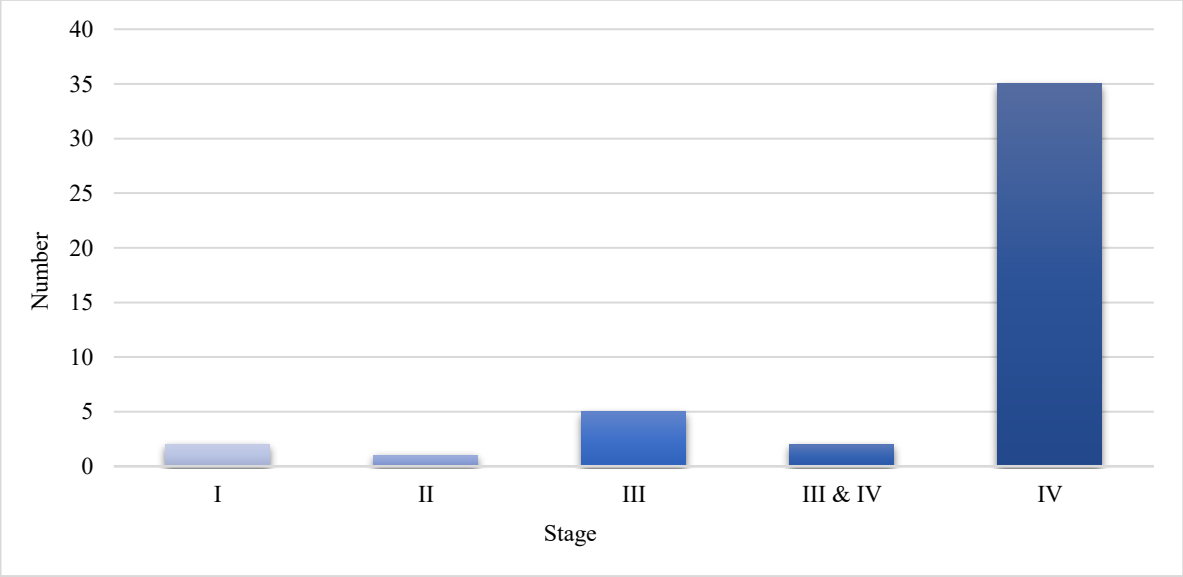

Figure 4. Tumour Stage

5. DISCUSSION

Brain neoplasms remain among the most fatal human cancers, accounting for ~1.35% of total malignant tumors and 29.5% of oncological deaths (Lapointe et al., 2018). The WHO grading system stratifies these lesions, assigning high-grade status to grades III and IV (Clifton and Reimer, 2019). Early clinical identification significantly improves patient survival metrics (Afridi et al., 2022). Multi-sequence MRI delivers critical tissue details via proton density (PD), T1/T2 relaxation rates, chemical shift imaging (CSI), and flow dynamics (Fraioli and Punwani, 2014).

The high proportion of Stage IV presentations in Tobruk highlights limited community awareness regarding initial symptoms like persistent headaches and late-onset seizures. Although 1.5-Tesla scanners provide adequate routine evaluation, upgrading to 3-Tesla systems alongside advanced functional protocols like Diffusion-Weighted Imaging (DWI) and MR Spectroscopy (MRS) would enhance non-invasive differentiation between benign and malignant lesions.

6. CONCLUSION

This investigation confirms that MRI is an indispensable diagnostic tool for brain tumor evaluation, though its efficacy is constrained by late patient presentation. The integration of T1, T2, and FLAIR protocols provides optimal anatomical definition, with FLAIR proving particularly effective for identifying small hyperintense lesions against suppressed CSF background. Contrast-enhanced T1 imaging (T1c) remains key for mapping tumor boundaries and evaluating malignancy grade. Given the high rate of late-stage diagnoses, public health measures focusing on symptom recognition and expanded imaging access are necessary to optimize management.

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