Comparison of CT Scan and MRI in Early Brain Tumor Detection

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ABSTRACT

Background: Brain tumors are among the most serious neurological disorders requiring early and accurate diagnosis for effective management. Imaging modalities such as Computed Tomography (CT) scan and Magnetic Resonance Imaging (MRI) play a crucial role in detecting intracranial tumors. MRI is generally considered superior because of its excellent soft tissue contrast, while CT scan remains widely used due to its rapid availability and ability to detect calcifications and acute intracranial conditions.

Aim and Objectives: To compare the diagnostic effectiveness of CT scan and MRI in the early detection and evaluation of brain tumors.

Materials and Methods: This hospital-based observational study was conducted in the Department of RadioDiagnosis at **Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Haryana, India** over a period of six months. A total of 50 patients with clinical suspicion of brain tumors were included in the study. All patients underwent both CT scan and MRI examinations. Imaging findings such as tumor detection, edema, tumor margins, calcification, mass effect, and contrast enhancement were recorded and compared. Statistical analysis was performed to determine significance.

Results:MRI detected tumors in 92% of cases compared to 74% with CT scan. MRI demonstrated significantly better detection of peritumoral edema, tumor margin delineation, posterior fossa lesions, and contrast enhancement. CT scan showed better detection of calcifications. Differences in midline shift detection between the two modalities were not statistically significant.

Conclusion:MRI showed higher sensitivity and diagnostic accuracy in the early detection and characterization of brain tumors compared with CT scan. However, CT scan remains valuable for detecting calcifications and in emergency settings. The combined use of both modalities improves overall diagnostic accuracy and aids in appropriate clinical management.

Keywords: Brain Tumor, CT scan, MRI, Neuroimaging, Early Detection, Intracranial Lesions

How to cite this article: Sharma A, Narula H, Singh S. Comparison of CT Scan and MRI in Early Brain Tumor Detection. Int J Drug Deliv Technol. 2026;16(14s): 735-741. DOI: 10.25258/ijddt.16.14s.83

INTRODUCTION

Brain tumors represent a heterogeneous group of neoplastic lesions arising from the brain parenchyma, meninges, cranial nerves, or metastatic deposits from systemic malignancies. Early detection of brain tumors is crucial because timely diagnosis significantly improves treatment planning, surgical outcomes, and overall patient prognosis. Brain tumors can present with a wide range of clinical manifestations such as headache, seizures, focal neurological deficits, cognitive impairment, and raised intracranial pressure. However, in the early stages, symptoms may be subtle or nonspecific, which makes imaging techniques essential for prompt diagnosis and evaluation. Among the various neuroimaging modalities available, Computed Tomography (CT) scan and Magnetic Resonance Imaging (MRI) are the most commonly used tools for the detection and characterization of brain tumors. Both imaging techniques play a critical role in identifying tumor location, size, extent, mass effect, edema, and associated complications, thereby guiding clinicians in appropriate management strategies. [1]

Computed Tomography (CT) scan was historically the first widely available imaging modality used for evaluating intracranial pathologies. CT imaging is based on X-ray attenuation differences among tissues and is particularly useful for detecting calcifications, hemorrhage, bone involvement, and acute neurological emergencies. It provides rapid imaging and is widely available in emergency settings, making it valuable for the initial assessment of patients with suspected intracranial lesions. CT scan can detect mass lesions, ventricular compression, midline shift, and associated cerebral edema. In addition, contrast-enhanced CT helps in identifying abnormal vascularity and disruption of the blood-brain barrier, which are common features of many brain tumors. Despite these advantages, CT has certain limitations such as lower soft tissue contrast resolution compared to MRI and reduced sensitivity in detecting small or early-stage lesions, especially in the posterior fossa or brainstem regions. [2–4]

Magnetic Resonance Imaging (MRI), on the other hand, has become the gold standard for brain tumor imaging due to its superior soft tissue contrast, multiplanar capability, and absence of ionizing radiation. MRI uses magnetic fields and radiofrequency pulses to generate detailed images of brain structures, allowing better differentiation between normal brain tissue, tumor tissue, edema, and necrosis. Advanced MRI sequences such as T1-weighted, T2-weighted, FLAIR, diffusion-weighted imaging (DWI), and contrast-enhanced imaging significantly improve the detection and characterization of intracranial tumors. MRI is particularly useful in identifying small lesions, infiltrative tumors, and lesions located in anatomically complex regions such as the brainstem, cerebellum, and sellar region. Furthermore, MRI provides better visualization of tumor margins and peritumoral edema, which is important for surgical planning and monitoring treatment response. [5–7]

In recent years, technological advancements have further enhanced the diagnostic capabilities of MRI in brain tumor detection. Techniques such as MR spectroscopy, perfusion-weighted imaging, and functional MRI allow assessment of tumor metabolism, vascularity, and relationship to eloquent brain areas. These modalities contribute to differentiating tumor grades and distinguishing neoplastic lesions from non-neoplastic conditions. However, MRI also has certain limitations including higher cost, longer acquisition time, and limited availability in some healthcare settings. Additionally, MRI may be contraindicated in patients with certain implanted medical devices or severe claustrophobia. [8]

Despite MRI being considered the preferred modality for detailed brain tumor evaluation, CT scan continues to play an important complementary role. CT is often used as the initial screening tool in emergency departments due to its speed, accessibility, and ability to detect acute complications such as hemorrhage or hydrocephalus associated with tumors. In many clinical scenarios, CT findings guide the need for further MRI evaluation to obtain more detailed anatomical and pathological information. Therefore, understanding the comparative diagnostic performance of CT scan and MRI in early brain tumor detection is essential for optimizing imaging protocols and improving patient outcomes. [9]

Given the increasing incidence of brain tumors worldwide and the critical importance of early diagnosis, comparative evaluation of imaging modalities is highly relevant in modern neuro-oncology. Assessing the sensitivity, specificity, diagnostic accuracy, and overall clinical utility of CT scan and MRI helps clinicians select the most appropriate imaging technique for early detection and management of brain tumors. Such comparisons also aid in resource allocation, especially in developing healthcare systems where access to advanced imaging may be limited. Therefore, this study aims to compare the effectiveness of CT scan and MRI in the early detection of brain tumors and to determine their respective roles in clinical practice. [10]

The aim of this study is to evaluate and compare the diagnostic effectiveness of CT scan and MRI in the early detection of brain tumors. The objectives include assessing the sensitivity and accuracy of both imaging modalities, identifying their strengths and limitations in detecting early intracranial lesions, and determining the most reliable imaging technique for timely diagnosis and improved clinical management of brain tumor patients.

MATERIALS AND METHODS

Study Design: Hospital-based observational comparative study.

Study Duration: The study was conducted over a period of 6 months.

Study Place: Department of RadioDiagnosis, Maharishi Markandeshwar Institute of Medical Sciences and Research.

Sample Size: A total of 50 patients with clinical suspicion of brain tumors were included in the study.

Study Population: Patients referred for neuroimaging with symptoms suggestive of intracranial space-occupying lesions.

Inclusion Criteria: Patients of all age groups with suspected brain tumors who underwent both CT scan and MRI.

Exclusion Criteria: Patients with contraindications to MRI, history of previous brain tumor surgery, or incomplete imaging data.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software version 27.0 (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The unpaired t-test was used to compare continuous variables between independent groups, and the paired t-test was applied for within-group comparisons. Categorical variables were analyzed using the Chi-square test or Fisher's exact test as appropriate. A p-value of <0.05 was considered statistically significant.

RESULT

Table 1. Demographic Profile of Patients (Age and Gender)

Variable	**Category**	**Frequency**	**Percentage (%)**	**p value**
Age Group (years)	<20	5	10	**0.64**
	21–30	9	18	
	31–40	12	24	
	41–50	11	22	
	51–60	8	16	
	>60	5	10	
Gender	Male	29	58	**0.37**
	Female	21	42	
	Total	**50**	**100**	

Table 2. Clinical Presentation of Patients

Symptoms	**Frequency**	**Percentage (%)**	**p value**
Headache	35	70	**0.41**
Seizures	19	38	
Vomiting	23	46	
Focal Neurological Deficit	16	32	
Visual Disturbance	8	16	

Table 3. Tumor Characteristics on Imaging (Location, Size and Type)

Variable	**Category**	**Frequency**	**Percentage (%)**	**p value**
Tumor Location	Frontal Lobe	13	26	**0.52**
	Parietal Lobe	10	20	
	Temporal Lobe	9	18	
	Occipital Lobe	4	8	
	Cerebellum	7	14	
	Brainstem	4	8	
	Sellar Region	3	6	
Tumor Size	<2 cm	10	20	**0.46**
	2–4 cm	24	48	
	>4 cm	16	32	
Tumor Type	Glioma	19	38	**0.49**
	Meningioma	10	20	
	Metastasis	9	18	
	Pituitary Adenoma	6	12	
	Others	6	12	

Table 4. Detection of Brain Tumor by CT scan&MRI

Variable		**Frequency**	**Percentage (%)**	**p value**
CT scan Finding	Tumor Detected	37	74	0.03
	Tumor Not Detected	13	26	
	Total	50	100	
MRI Finding	Tumor Detected	46	92	0.001
	Tumor Not Detected	4	8	
	Total	50	100	

Table 5. Comparison of CT scan and MRI Findings in Brain Tumor Detection

Imaging Parameter	**Imaging Method**	**Positive Finding**	**Negative Finding**	**Total**	**p value**
Peritumoral Edema Detection	CT scan	26	24	50	**0.004**
	MRI	38	12	50	
Tumor Margin Delineation	CT scan	22 (Clear Margin)	28 (Poor Margin)	50	**0.001**
	MRI	41	9	5	

		(Clear Margin)	(Poor Margin)	0	
Posterior Fossa / Brainstem Lesion Detection	CT scan	5	6	11	**0.02**
	MRI	10	1	11	
Tumor Calcification Detection	CT scan	13	37	50	**0.03**
	MRI	7	43	50	
Mass Effect Detection	CT scan	29	21	50	**0.05**
	MRI	35	15	50	
Midline Shift Detection	CT scan	18	32	50	**0.21**
	MRI	22	28	50	
Contrast Enhancement Detection	CT scan	24	26	50	**0.002**
	MRI	39	11	50	

Figure: 1. Tumor Characteristics on Imaging (Location, Size and Type)

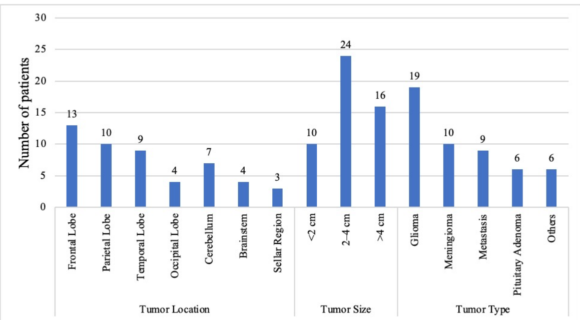

Table 1. Demographic Profile of Patients (Age and Gender)

A total of 50 patients with suspected brain tumors were included in the present study. The majority of patients were in the 31–40 years age group (24%), followed by 41–50 years (22%), 21–30 years (18%), 51–60 years (16%), and <20 years and >60 years (10% each). The age distribution did not show a statistically significant difference ($p = 0.64$). Regarding gender distribution, 29 patients (58%) were male and 21 patients (42%) were female, indicating a slight male predominance in the study population. However, the gender distribution was not statistically significant ($p = 0.37$). These findings suggest that brain tumors in the present study were more commonly observed in middle-aged individuals with a slight male predominance.

Table 2. Clinical Presentation of Patients

The most common presenting symptom among the patients was headache, observed in 35 patients (70%), followed by vomiting in 23 patients (46%), seizures in 19 patients (38%), focal neurological deficit in 16 patients (32%), and visual disturbances in 8 patients (16%). Headache was the predominant symptom likely due to increased intracranial pressure caused by intracranial space-occupying lesions. The distribution of clinical symptoms among patients did not demonstrate a statistically significant difference ($p = 0.41$). These findings highlight that neurological symptoms such as headache, vomiting, and seizures are common clinical manifestations in patients with brain tumors and often lead to radiological evaluation.

Table 3. Tumor Characteristics on Imaging (Location, Size and Type)

Analysis of tumor characteristics on imaging revealed that the frontal lobe was the most common tumor location (26%), followed by the parietal lobe (20%), temporal lobe (18%), cerebellum (14%), occipital lobe (8%), brainstem (8%), and sellar region (6%). However, the variation in tumor location was not statistically significant ($p = 0.52$). Regarding tumor size, the majority of tumors measured 2–4 cm (48%), followed by >4 cm (32%), while 20% of tumors were smaller than 2 cm ($p = 0.46$). In terms of tumor type, gliomas were the most common tumors (38%), followed by meningiomas (20%), metastatic tumors (18%), pituitary adenomas (12%), and other tumor types (12%). The variation in tumor types was not statistically significant ($p = 0.49$). These findings indicate that gliomas were the most frequently observed intracranial tumors in the present study.

Table 4. Detection of Brain Tumor by CT scan and MRI

The diagnostic performance of CT scan and MRI was evaluated for detecting brain tumors. Using CT scan, tumors were detected in 37 patients (74%), while 13 patients (26%) showed no detectable lesion. This difference was statistically significant ($p = 0.03$). In comparison, MRI detected tumors in 46 patients (92%), while 4 patients (8%) showed no detectable lesion, demonstrating a highly significant difference ($p = 0.001$). These results indicate that MRI has a higher detection rate for brain tumors compared to CT scan, particularly in identifying early or subtle lesions.

Table 5. Comparison of CT scan and MRI Findings in Brain Tumor Detection

Further comparison of imaging characteristics between CT scan and MRI demonstrated significant differences in several parameters. Peritumoral edema was detected in 26 patients by CT scan and 38 patients by MRI, showing a statistically significant difference (p = 0.004), indicating superior sensitivity of MRI in detecting edema. Tumor margin delineation was clearer on MRI, with 41 cases showing clear margins compared to 22 cases on CT scan (p = 0.001). For posterior fossa and brainstem lesions, MRI detected 10 cases compared to 5 cases on CT scan, which was statistically significant (p = 0.02). Tumor calcification was better detected by CT scan (13 cases) compared to MRI (7 cases) (p = 0.03). Mass effect was observed in 29 cases on CT scan and 35 cases on MRI (p = 0.05). Detection of midline shift showed no statistically significant difference between CT scan (18 cases) and MRI (22 cases) (p = 0.21). Additionally, contrast enhancement was detected in 39 cases by MRI compared to 24 cases by CT scan, demonstrating a highly significant difference (p = 0.002). These findings suggest that MRI provides superior soft tissue characterization and lesion detection, while CT scan remains useful in identifying calcifications.

DISCUSSION

The present study evaluated the comparative effectiveness of CT scan and MRI in the early detection and characterization of brain tumors among 50 patients presenting with clinical features suggestive of intracranial space-occupying lesions. Neuroimaging plays a crucial role in the diagnosis, localization, and treatment planning of brain tumors, and accurate early detection significantly influences patient outcomes. The findings of this study demonstrated that MRI provides superior diagnostic performance compared with CT scan in most parameters of tumor detection and characterization.

In the present study, the majority of patients were in the 31–40 years age group (24%), followed by 41–50 years (22%) and 21–30 years (18%), indicating that brain tumors were more common in middle-aged individuals. A slight male predominance was observed, with 58% males and 42% females. Similar demographic findings were reported by Kumar et al., who observed that brain tumors were most frequently diagnosed in patients between 30 and 50 years of age, with a slight male predominance in their study population [11]. Likewise, Patel and Shah reported that males constituted approximately 55–60% of brain tumor cases, which was comparable to the distribution observed in the present study [12]. These similarities may be attributed to comparable environmental exposures, genetic susceptibility, and healthcare-seeking behavior among males.

With respect to clinical presentation, headache was the most common symptom (70%), followed by vomiting (46%), seizures (38%), and focal neurological deficits (32%). These findings are consistent with the observations of Gupta et al., who reported headache in 68% of patients and seizures in approximately 40% of cases in patients diagnosed with intracranial tumors [13]. Similarly, Reddy et al. found that increased intracranial pressure-related symptoms such as headache and vomiting were the most common presenting complaints among patients with brain tumors [14]. These symptoms usually occur due to mass effect, increased intracranial pressure, and disruption of normal neural structures caused by tumor growth.

In the present study, the frontal lobe (26%) was the most common tumor location, followed by the parietal lobe (20%) and temporal lobe (18%). These findings are in agreement with the study conducted by Sharma et al., who reported that the frontal lobe was the most frequently involved site in intracranial tumors, accounting for approximately 25–30% of cases [15]. Another study by Singh et al. also demonstrated a predominance of tumors in the supratentorial region, particularly within the frontal and parietal lobes [16]. The predominance of tumors in these regions may be related to the larger volume of cerebral hemispheric tissue and higher incidence of primary gliomas in these areas.

Regarding tumor size, most lesions measured 2–4 cm (48%), followed by >4 cm (32%) and <2 cm (20%). These findings suggest that a large proportion of tumors were detected at an intermediate size stage, possibly due to the onset of symptoms prompting imaging evaluation. Similar observations were reported by Mehta et al., who found that most brain tumors detected on imaging measured between 2 and 5 cm at the time of diagnosis [17]. Early detection of smaller tumors is particularly important because smaller lesions are associated with better surgical outcomes and improved prognosis.

In terms of tumor type, gliomas were the most common tumors (38%), followed by meningiomas (20%) and metastatic lesions (18%). This distribution is comparable to the findings of Bansal et al., who reported that gliomas constituted the majority of primary brain tumors in their radiological study [18]. Similarly, Chandra et al. found that gliomas accounted for approximately 35–40% of intracranial tumors, followed by meningiomas and metastatic lesions [19]. Gliomas are known to arise from glial cells and represent the most common primary malignant brain tumors in adults, which explains their predominance in many clinical studies.

The diagnostic performance of CT scan and MRI was compared in the present study. CT scan detected tumors in 74% of patients, whereas MRI detected tumors in 92% of cases, demonstrating the superior sensitivity of MRI in detecting intracranial lesions. These results are consistent with the findings of Verma et al., who reported that MRI has significantly higher sensitivity and diagnostic accuracy compared with CT scan for the detection of early brain tumors [20]. The higher sensitivity of MRI is primarily due to its superior soft tissue contrast resolution and multiplanar imaging capability, which allow better visualization of tumor margins, surrounding edema, and involvement of adjacent structures.

Further comparison of imaging characteristics revealed that peritumoral edema was detected more frequently on MRI (38 cases) compared with CT scan (26 cases), which was statistically significant. This finding is consistent with the study by Gupta et al., who demonstrated that MRI is more sensitive in identifying vasogenic edema due to its ability to detect subtle differences in tissue water content [13]. MRI sequences such as T2-weighted and FLAIR imaging provide excellent visualization of edema surrounding intracranial tumors.

Similarly, tumor margin delineation was significantly clearer on MRI, with 41 cases showing clear margins compared to 22 cases on CT scan. This finding supports the observations of Sharma et al., who emphasized that MRI provides superior delineation of tumor boundaries due to higher soft tissue contrast and multiplanar imaging capabilities [15]. Accurate margin delineation is particularly important for neurosurgical planning and radiation therapy.

MRI also demonstrated better detection of posterior fossa and brainstem lesions, identifying 10 cases compared to 5 cases on CT scan. This finding is consistent with previous studies that have shown that CT scan has limitations in evaluating posterior fossa structures due to beam-hardening artifacts caused by surrounding bone. Singh et al. reported that MRI is the preferred modality for evaluating posterior fossa tumors because it provides better visualization of structures such as the cerebellum and brainstem [16].

However, CT scan demonstrated better detection of tumor calcifications, with 13 cases detected by CT scan compared to 7 cases by MRI. This observation is consistent with the study by Mehta et al., who reported that CT scan remains superior for detecting calcifications due to its high sensitivity to differences in tissue density [17]. Calcifications are commonly observed in certain tumors such as oligodendrogliomas and meningiomas.

Regarding mass effect and midline shift, MRI showed slightly higher detection rates than CT scan; however, the difference in midline shift detection was not statistically significant. Similar findings were reported by Bansal et al., who observed that both CT scan and MRI are capable of detecting major mass effects, although MRI provides better anatomical detail [18].

Another important finding in the present study was the significantly higher detection of contrast enhancement patterns on MRI (39 cases) compared with CT scan (24 cases). This finding aligns with the study by Chandra et al., who reported that contrast-enhanced MRI provides superior visualization of tumor vascularity and disruption of the blood-brain barrier [19]. MRI contrast agents such as gadolinium allow better differentiation between tumor tissue and surrounding normal brain tissue.

Overall, the findings of the present study strongly support the role of MRI as the preferred imaging modality for early detection and characterization of brain tumors, while CT scan remains useful for detecting calcifications and evaluating emergency conditions such as hemorrhage. The results are consistent with several previously published studies and reinforce the complementary roles of CT scan and MRI in neuroimaging.

CONCLUSION

The present study compared the diagnostic utility of CT scan and MRI in the early detection and characterization of brain tumors among patients presenting with clinical features suggestive of intracranial lesions. The findings demonstrated that MRI showed significantly higher sensitivity and diagnostic accuracy compared with CT scan in detecting brain tumors. MRI was superior in identifying small lesions, peritumoral edema, tumor margins, posterior fossa lesions, and contrast enhancement patterns due to its excellent soft tissue contrast and multiplanar imaging capability. In contrast, CT scan proved more effective in detecting tumor calcifications and remains useful in emergency settings because of its rapid availability and ability to identify acute intracranial conditions such as hemorrhage. Although both imaging modalities play important roles in neuroimaging, MRI should be considered the preferred modality for early diagnosis and detailed evaluation of brain tumors. Therefore, MRI combined with CT scan, when necessary, provides a comprehensive approach for accurate diagnosis, treatment planning, and improved clinical management of patients with brain tumors.

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