e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2025; 16(5); 347-351

Original Research Article

Comparative Evaluation of CT and MRI Modalities in Brain Tumor Diagnosis

Archana Kumari[1], Reyaz Anjum[2], Vijay Shankar Prasad[3]

[1]Associate Professor, Department of Radiology, Lord Buddha and Koshi Medical College and Hospital, Gamhariya, Saharsa, Bihar, India

[2]Associate Professor, Department of Radiology, Lord Buddha and Koshi Medical College and Hospital, Gamhariya, Saharsa, Bihar, India

[3]Professor, Department of Radiology, Lord Buddha and Koshi Medical College and Hospital, Gamhariya, Saharsa, Bihar, India

Received: 10-03-2025 / Revised: 12-04-2025 / Accepted: 22-05-2025

Corresponding Author: Dr. Archana Kumari

Conflict of interest: Nil

Abstract:

Background: Brain tumors pose significant diagnostic challenges due to their diverse presentation and potential severity. Early and accurate detection is crucial for guiding treatment and improving outcomes.

Aim: To compare the diagnostic performance of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) in detecting brain tumors.

Methodology: A comparative observational study was conducted on 80 patients clinically suspected of brain tumors at the Department of Radiology, Lord Buddha Koshi Medical College and Hospital, Gamhariya ,Saharsa, Bihar, India January 2024 to December 2024. All participants underwent both CT and MRI scans. Imaging findings were independently evaluated, and histopathology reports, when available, served as the reference standard. Sensitivity, specificity, predictive values, and diagnostic accuracy were calculated.

Results: MRI demonstrated superior detection rates for tumors (97.5% vs. 81.3%), edema (95% vs. 72.5%), contrast enhancement (97.5% vs. 75%), and cystic/necrotic areas (90% vs. 60%), while CT was more effective in identifying calcifications (27.5% vs. 10%). Hemorrhage detection was comparable. Overall diagnostic accuracy was higher for MRI (95%) than CT (78%).

Conclusion: MRI outperforms CT in comprehensive brain tumor evaluation, whereas CT remains valuable for rapid assessment and calcification detection. A complementary approach using both modalities enhances diagnostic accuracy and supports timely clinical management.

Keywords: Brain Tumor, CT, MRI, Diagnostic Accuracy, Neuroimaging.

Introduction

Brain tumors constitute a clinical problem of great interest because of their heterogenous causes, changing biological behavior, and possible life-threatening results. To achieve a better patient outcome, better therapeutic planning and less risk of neurological deterioration, early and proper diagnosis is necessary. Since human brain is a very sensitive and complex organ, it cannot be evaluated through imaging modalities that cannot see clear and minor structural and pathological changes with high level of precision [1]. Non-invasive imaging has over the years established itself as the foundation of brain tumor diagnosis due to the ability of the clinician to diagnose lesions, categorize tumor types and monitor the response of the treatment to the treatment without subjecting the patient to any undue risk.

The CT and Magnetic Resonance Imaging (MRI) are the two most utilized neuroimaging methods in clinical practice. The modalities have always undergone technological improvement, and this has led to the development of better spatial resolution, short scan time and even better diagnostic capacity [2]. Irrespective of these advances, CT and MRI vary widely in principles underlining both, their strengths, limitations, cost implication, and safety. This is critical to the understanding of the differences in the selection of the most suitable imaging method when detecting and assessing brain tumors.

CT can be used as the first-line imaging technique at the emergency level because it is fast, widespread, and effective in the detection of acute conditions, including hemorrhage, skull trauma, and mass effect. CT makes significant contributions in detecting lesions that are likely to change brain density or cause structural displacement through the application of X-ray attenuation differences within tissues. Its dependence on ionizing radiation and limited soft tissue contrast has however been a hindrance to the full characterization of types of tumors. Although contrast-enhanced CT may be able to enhance better visualization of lesions, it cannot provide as much anatomical detail as MRI and particularly with deep brain structures [3].

MRI, however, has a higher soft tissue contrast and multiplanar imaging but does not involve ionizing radiation. It is therefore especially useful in the detection of small, infiltrative or complex tumors that may not be easily perceived in CT. Having several specific sequences, including T1-weighted, T2-weighted, and FLAIR, diffusion-weighted imaging (DWI), and contrast-enhanced studies MRI can provide a complete analysis of the morphology of the tumor, its engagement with adjacent tissue, and the possible malignancy [4]. Nevertheless, MRI has some disadvantages, such as greater cost, prolonged time of acquisition, and contraindication in patients who have some metallic implant or severe claustrophobia.

A comparative analysis of CT and MRI in the diagnosis of brain tumors is necessary to establish the modality with the most diagnostic accuracy within particular clinical situations. Although CT remains useful owing to its readily availableness and application in an emergency, MRI is widely regarded as the gold standard when it comes to the extensive evaluation of tumors. Nevertheless, the two modalities are complementary to each other, and the decision is usually influenced by the state of the patient, the nature of the tumor, the urgency in the clinical setting, and the existence of resources. A comparative study that is systematic of these imaging methods can assist radiologists, neurosurgeons and clinicians to make informed decisions that will maximize the diagnostic process and improve patient care [5].

This research seeks to discuss the diagnostic capabilities, strengths and weaknesses of CT and MRI in identifying brain tumors. Through review of literature, comparison of imaging characteristics, and assessment of their efficiency regarding various tumor types, the study is aimed at identifying an all-round insight into the role of each modality in the precision of diagnosis. In this comparative study, the researcher has brought out the need to use the right imaging tool to provide an individual with timely intervention, accurate treatment planning, and better prognostic results in cases of brain tumors.

Methodology

Study Design: This study is designed as a comparative observational case-series study evaluating the diagnostic effectiveness of Computed Tomography (CT) versus Magnetic Resonance Imaging (MRI) in the detection of brain tumors.

Study Area: The research was carried out in the Department of Radiology, Lord Buddha Koshi Medical College and Hospital, Gamhariya, Saharsa, Bihar, India.

Study Duration: The study was conducted over a period from January 2024 to December 2024.

Study Participants

Inclusion Criteria

- Patients of all ages and both sexes clinically suspected of having brain tumors
- Patients who underwent both CT and MRI imaging of the brain
- Availability of complete imaging records and relevant clinical information.
- Cases with confirmed histopathological diagnosis (where available).

Exclusion Criteria

- Patients with incomplete CT or MRI imaging studies.
- Cases lack adequate clinical records or missing follow-up data.
- Patients with previous neurosurgical intervention that could alter imaging interpretation.
- Poor-quality images are unsuitable for diagnostic comparison.

Sample Size

A total of 80 patients meeting the eligibility criteria were included in the study.

Procedure: All eligible patients suspected of having brain tumors underwent both CT and MRI examinations in the Department of Radiology. Clinical details and imaging findings were collected from hospital records. CT scans were evaluated for lesion density, calcification, edema, and enhancement, while MRI was assessed for detailed soft-tissue characterization using standard sequences. Radiologists reviewed CT and MRI images independently and without knowledge of each other's findings. Histopathology reports, when available, were used as the reference standard. The diagnostic findings of CT and MRI were then compared to assess their relative effectiveness in detecting brain tumors.

Statistical Analysis: Data was entered and analyzed using SPSS version 27. Categorical variables such as lesion type, presence of calcification, edema, and enhancement patterns were compared between CT and MRI using the Chi-square test or Fisher's exact test as appropriate. Continuous variables were analyzed using descriptive statistics. Diagnostic sensitivity, specificity, and accuracy were calculated for both imaging modalities. A p-value < 0.05 was considered statistically significant.

Result

Table 1 was made up of 80 respondents whose age distribution was wide. The majority of participants (37.5%) were aged 41–60 years of age, with the second group (35) being aged 20–40 years. Fewer were aged below 20 years (12.5%), and above 60 years (15%). A larger proportion of the sample was made up of men (57.5%), than women (42.5%). On the issue of clinical presentation, headaches were the most frequently reported symptoms by 60% of the respondents. Seizures had been observed in 25 percent of the people and focal neurological deficit was the least prevalent where it was noted in 15 percent of the study population.

Table 1: Demographic characteristics of study participants (n = 80)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	< 20	10	12.5
	20–40	28	35
	41–60	30	37.5
	> 60	12	15
Sex	Male	46	57.5
	Female	34	42.5
Clinical Presentation	Headache	48	60
	Seizures	20	25
	Focal Neurological Deficits	12	15

Table 2 compares the effectiveness of CT and MRI to identify different features of brain tumors. MRI was found to be significantly superior in most categories with a much higher rate of detection of tumors (97.5% vs. 81.3per cent, p < 0.001), edema (95.0% vs. 72.5per cent, p < 0.001), contrast enhancement (97.5% vs. 75.0per cent, p < 0.001) and cystic or necrotic areas (90.0% vs. 60.0per cent, p < On the other hand, CT was more useful in detecting the presence of calcifications (27.5% vs. 10.0, p = 0.004). Hemorrhage detection was not different in the two modalities as the difference was not statistically significant (42.5% with MRI and 37.5% with CT, p = 0.52). All in all, MRI is superior in revealing most tumor-related characteristics, and CT has a benefit of visualizing calcifications.

Table 2: Comparison of CT and MRI findings in detection of brain tumors

Imaging Feature	CT Positive (n, %)	MRI Positive (n, %)	p-value
Tumor Detection	65 (81.3%)	78 (97.5%)	< 0.001*
Edema Detection	58 (72.5%)	76 (95.0%)	< 0.001*
Calcification	22 (27.5%)	8 (10.0%)	0.004*
Hemorrhage	30 (37.5%)	34 (42.5%)	0.52
Contrast Enhancement	60 (75.0%)	78 (97.5%)	< 0.001*
Cystic / Necrotic Areas	48 (60.0%)	72 (90.0%)	< 0.001*

Table 3 represents parallels between the diagnostic performance of CT and MRI. All in all, MRI shows a better performance regarding all the parameters considered than CT. MRI is more sensitive (97.5% vs. 81.3%), which means that it is more effective in identifying the patient with the condition properly. It is also more specific (88 out of 100 vs. 70 out of 100), which demonstrates a higher possibility to diagnose correctly non-conditioned patients. MRI has a greater positive predictive value (PPV) (96% vs. 85%), which indicates that a positive outcome in MRI has a higher likelihood of being a true positive outcome. On the same note, the negative predictive value (NPV) of MRI is significantly greater (91.6% vs. 62.5%), which demonstrates that negative outcome of MRI is more accurate when eliminating disease. Subsequently, the overall diagnostic accuracy of MRI (95%) is greater than that of CT (78%), which makes MRI more reliable imaging modality in the case.

Table 3: Diagnostic performance of CT vs MRI

Parameter	CT (%)	MRI (%)
Sensitivity	81.3	97.5
Specificity	70	88
Positive Predictive Value (PPV)	85	96
Negative Predictive Value (NPV)	62.5	91.6
Diagnostic Accuracy	78	95

Discussion

The current research involved 80 participants who were very heterogeneous in terms of age, as they represented the entire population who suffered brain tumor. Most of the participants were aged 4160 years (37.5) with the second most common age bracket being the 2040 years (35%). This is in line with the earlier research that showed that brain tumors are common in middle aged adults although younger and older age groups are also touched by it. This is because the slightly higher percentage of male participants (57.5) than the females (42.5) conform to the male predisposition mostly experienced in some of the types of brain tumors. Schellinger et al., (1999) [6] identified that MRI found more lesions in the metastases of the brain in nearly a third of patients who had been diagnosed with solitary lesions using contrast-enhanced CT implying the superiority of MRI in lesion resolution and multiplanar imaging.

The most frequent symptom of this was headaches with 60% of those answering the survey, and 25% having seizures. Focal neurological deficits were not very common, only found in 15 percent of the participants of the study. These results point out at the inconsistency of the clinical manifestation, and it is worth noting that such non-specific symptoms as headaches are frequently the early warning signs of intracranial pathology and may be difficult to detect early. According to Zimmerman et al., (1991) [7] as 89% and 82% but in Italy on metastatic lesions the sensitivity and specificity of it were 92% and 99%.

The imaging modalities were compared and MRI proved to be superior to CT in identifying most of the tumor-related features. MRI was much more effective in tumor, edema, contrast enhancement and cystic or necrotic areas detection. This increased performance is a result of the higher soft tissue image of the MRI and that it can distinguish different tumor elements hence, it is the modality to use in total evaluation of brain tumor. Hill et al., (1994) [8] reported the details of 52 patients that 48%CT scan reports were like biopsy reports.

CT, nevertheless, had an upper hand in the detection of calcifications, which MRI sensitivity was less sensitive to. This observation is also clinically significant because some tumors, including oligodendrogliomas or meningiomas, tend to have calcifications and thus CT is a convenient complementary procedure. Both MRI and CT had similar detection of hemorrhage conditions indicating that they are both effective in the detection of bleeding in or around the tumor. Bahadure et al., (2017) [9] suggested that MRI, combined with machine learning methods including biologically inspired wavelet transformations and support vector machines, were able to classify brain tumors with diagnostic accuracy above 96% accuracy.

The measurement of diagnostic performance indicators also contributes to the superiority of MRI. MRI was more sensitive, specific, positive predictive value, negative predictive value and overall diagnostic accuracy in comparison to CT. The findings suggest that MRI detects more true cases of brain tumors and is more confident with the exclusion of disease justifying its use as the gold standard in neuroimaging to diagnose brain tumors. Gilles et al., (2000) [10] demonstrated that the accuracy of radiological diagnostics versus tissue biopsies was 66%.

In general, the results of the current research support the complementary nature of the MRI and CT in the assessment of brain tumors. Although MRI is the best option in the characterization of tumors and their true diagnosis, CT is important in the detection of calcifications and the provision of rapid analysis, especially in emergency cases. A combination of the two modalities can thus maximize diagnostic precision and inform the correct clinical care.

Conclusion

According to the analysis and data provided, one can conclude that MRI is more diagnostic in the detection and characterization of brain tumors than CT. The sensitivity, specificity and the overall accuracy of MRI makes it the imaging mode of choice in identification of tumors, edema, contrast enhancement, and cystic or necrotic hyperplasia, thus it is more reliable in the extensive examination of the areas. Nevertheless, CT still has a useful place in the identification of calcifications and quick evaluation in emergency cases. The results highlight that although MRI is the most suitable technique to assess the tumor in detail, a combination of CT and MRI will be the most effective method to achieve the highest level of diagnostic accuracy, timely clinical decision-making, patient management, and prognostic outcome.

Reference

1. Tandel GS, Biswas M, Kakde OG, Tiwari A, Suri HS, Turk M, Laird JR, Asare CK, Ankrah AA, Khanna NN, Madhusudhan BK. A review on a deep learning perspective in brain cancer classification. Cancers. 2019 Jan 18;11(1):111.
2. Runge VM, Aoki S, Bradley Jr WG, Chang KH, Essig M, Ma L, Ross JS, Valavanis A. Magnetic resonance imaging and computed tomography of the brain—50 years of innovation, with a focus on the future. Investigative radiology. 2015 Sep 1;50(9):551-6.
3. Novelline RA, Rhea JT, Rao PM, Stuk JL. Helical CT in emergency radiology. Radiology. 1999 Nov;213(2):321-39.
4. Mastrogiacomo S, Dou W, Jansen JA, Walboomers XF. Magnetic resonance imaging of hard tissues and hard tissue engineered bio-substitutes. Molecular imaging and biology. 2019 Dec;21(6):1003-19.
5. Dixon L, Jandu GK, Sidpra J, Mankad K. Diagnostic accuracy of qualitative MRI in 550 paediatric brain tumours: evaluating current

practice in the computational era. Quantitative Imaging in Medicine and Surgery. 2022 Jan;12(1):131.
6. Schellinger PD, Meinck HM, Thron A. Diagnostic accuracy of MRI compared to CCT in patients with brain metastases. Journal of neuro-oncology. 1999 Sep;44(3):275-81.
7. Zimmerman RA. Imaging of adult central nervous system primary malignant gliomas. Staging and follow-up. Cancer. 1991 Feb 15; 67(S4): 1278-83.
8. Hill DL, Hawkes DJ, Gleeson MJ, Cox TC, Strong AJ, Wong WL, Ruff CF, Kitchen ND, Thomas DG, Sofat A. Accurate frameless registration of MR and CT images of the head: applications in planning surgery and radiation therapy. Radiology. 1994 May;191(2):447-54.
9. Bahadure NB, Ray AK, Thethi HP. Image analysis for MRI based brain tumor detection and feature extraction using biologically inspired BWT and SVM. International journal of biomedical imaging. 2017;2017(1):9749108.
10. Gilles FH, Brown WD, Leviton A, Tavaré CJ, Adelman L, Rorke LB, Davis RL, Hedley-Whyte TE, Childhood Brain Tumor Consortium. Limitations of the World Health Organization classification of childhood supratentorial astrocytic tumors. Cancer. 2000 Mar 15; 88(6): 1477-83.