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Original Research Article

Diagnostic Accuracy of Diffusion Weighted Magnetic Resonance Imaging (DW-MRI) In Differentiating Brain Abscess from Neoplastic Brain Lesions, Taking Histopathology as Gold Standard

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Name of Author:
Aiman Ashfaq[1], Ifrah Maryam[2], Anis ur Rehman[3]

Affiliation: *[1,2]MBBS, FCPS Postgraduate Trainee Department of Radiology, Shaukat Khanum Memorial Cancer Hospital and Research Centre (SKMCH & RC)*
[3]MBBS, FCPS Consultant Department of Radiology, Shaukat Khanum Memorial Cancer Hospital and Research Centre (SKMCH & RC)

Corresponding Author:
Dr. Aiman Ashfaq

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Abstract: ***Background***: The differentiation of brain abscess from neoplastic brain lesions remains a diagnostic challenge because both lesions may present with similar clinical manifestations and conventional magnetic resonance imaging findings. Diffusion weighted magnetic resonance imaging (DW-MRI) has emerged as a useful non-invasive imaging modality for differentiating these lesions by assessing diffusion characteristics and apparent diffusion coefficient values. ***Objectives:*** To determine the diagnostic accuracy of diffusion weighted magnetic resonance imaging (DW-MRI) in differentiating brain abscess from neoplastic brain lesions by taking histopathology as the gold standard. Study Design & Setting: This cross-sectional validation study was conducted at the Department of Radiology, Shaukat Khanum Memorial Cancer Hospital and Research Centre from 20 September 2025 to 20 December 2025. ***Methodology***: A total of 98 patients aged 20–60 years of either gender presenting with focal brain lesions were included in the study. All patients underwent brain MRI including diffusion weighted imaging sequences. DW-MRI findings were categorized as brain abscess or neoplastic brain lesions and were compared with histopathological findings obtained from biopsy or surgical specimens. Data were analyzed using SPSS version 25.0. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated using a 2 × 2 contingency table. ***Results:*** The mean age of patients was 42.8 ± 11.3 years, with 57.1% males and 42.9% females. Histopathology confirmed brain abscess in 61.2% patients and neoplastic brain lesions in 38.8% patients. DW-MRI demonstrated sensitivity of 91.7%, specificity of 94.7%, positive predictive value of 96.5%, negative predictive value of 87.8%, and overall diagnostic accuracy of 92.9%. ***Conclusion:*** Diffusion weighted magnetic resonance imaging demonstrated high diagnostic accuracy in differentiating brain abscess from neoplastic brain lesions and may serve as a reliable non-invasive imaging modality before histopathological confirmation.

Keywords: Brain Abscess, Diagnostic Accuracy, Diffusion Weighted Magnetic Resonance Imaging, Histopathology, Neoplastic Brain Lesions

INTRODUCTION

An intra-cerebral abscess is a significant healthcare problem in the developing world due to large-scale poverty, illiteracy, and lack of hygiene.[1] It starts as a localized area of cerebritis, which is subsequently converted into a collection of pus within a well-vascularized capsule. Predisposing conditions are present in up to 86% of patients and mostly consist of contiguous or distant foci of infection.[2] Intra-cerebral abscesses constitute up to 8% of the intracranial space-occupying lesions seen in the developing countries. It is most common in the second to third decades of life, with a male to female ratio of 3.4:1 and a mortality rate of about 11.3%. Its prevalence is anticipated to be

2%-14%.[3]

Non-invasive and accurate differentiation of brain mass lesions are important for determining the correct treatment plan and in some cases, may avoid the necessity of performing a biopsy.[4] Conventional magnetic resonance imaging (MRI) is a useful tool in evaluating the tumoral and non-tumoral brain lesions but not really sufficient for diagnosing all conditions. Diffusion-weighted imaging (DWI), which is one of the functional MRI modalities, allows quantitative measurement of the motion of water molecules in lesions and normal tissues.[5] The net diffusion of the water molecules is referred to as the apparent diffusion coefficient (ADC). The high sensitivity and specificity of DWI in the diagnosis of acute cerebral infarction is widely accepted. Also, DWI has a diagnostic potential to evaluate brain tumors by using the ADC values.[6,7] Babar et al[8] has shown the prevalence of brain abscess as 60.0% and the sensitivity of DWI as 91.67%, specificity as 93.18%, positive predictive value as 95.28%, negative predictive value as 88.17% and the diagnostic accuracy as 92.27%, taking histopathology as gold standard. Another study[9] has shown that in diagnosis of abscess in brain, sensitivity, specificity, PPV, NPV and DA of DW-MRI was 92.5%, 80.96%, 87.4%, 88.3% and 87.7% respectively.

Despite the development of these non-invasive techniques, histopathology has remained the gold standard, but cannot be used in routine on account of being a difficult procedure. Keeping in mind all this, I have decided to conduct this study to determine the diagnostic accuracy of diffusion weighted magnetic resonance imaging (DW-MRI) in differentiating brain abscess from neoplastic brain lesions, taking histopathology as gold standard. If it's diagnostic accuracy will be found high in these particular patients, then this specific non-invasive modality can be applied routinely in our general practice to determine the exact nature of the lesion which will help the neurosurgeons to select the appropriate treatment plan for these particular patients and also unnecessary biopsies can be avoided in these patients. The objective was to determine the diagnostic accuracy of diffusion weighted magnetic resonance imaging (DW-MRI) in differentiating brain abscess from neoplastic brain lesions, taking histopathology as gold standard.

METHODS

This cross-sectional validation study was conducted in the Department of Radiology at Shaukat Khanum Memorial Cancer Hospital and Research Centre approval of the synopsis from 20 September 2025 to 20 December 2025. A sample size of 98 cases was calculated with a 95% confidence level, 8% margin of error, prevalence of brain abscess as 60.0%, sensitivity of diffusion weighted magnetic resonance imaging (DW-MRI) as 91.67%, and specificity as 93.18% in differentiating brain abscess from neoplastic brain lesions, using an online sample size calculator. The calculated sample size based on sensitivity was 82, whereas the sample size based on specificity was 98.[8] As per standard methodology, the larger calculated sample size was adopted; therefore, the final required sample size was 98 patients. After approval from the Institutional Ethical Review Committee, eligible patients referred to the Radiology Department of Shaukat Khanum Memorial Cancer Hospital and Research Centre with intracranial lesions suspicious for brain abscess or neoplasm were prospectively enrolled during the study period until the required sample size of 98 patients was achieved.

Patients aged 20–60 years of either gender having focal brain lesions, as per operational definition, of duration one week or more were included in the study to encompass subacute presentations with radiologically identifiable focal brain lesions. Previously diagnosed cases of intracerebral abscess or brain tumor, patients without ring-enhancing lesions on brain MRI, patients with a previous history of radiotherapy, chemotherapy, or surgery, patients having contraindications to MRI such as claustrophobia or cardiac pacemakers, and patients with renal failure assessed on history and serum creatinine level greater than 1.5 mg/dl were excluded from the study. Patients without ring-enhancing lesions on MRI were excluded because the diagnostic utility of DW-MRI and apparent diffusion coefficient (ADC) values in differentiating brain abscess from neoplastic lesions had primarily been validated for ring-enhancing focal brain lesions, according to the study operational definition.

All patients had already provided written informed consent at the time of MRI examination, including permission for the use of anonymized imaging and clinical data for research purposes; therefore, no additional study-specific consent was required. Baseline demographic and clinical data including age, gender, duration of symptoms, lesion size, and place of residence were recorded on a predesigned proforma. Brain MRI examinations were performed as part of routine clinical care using a 1.5 Tesla MRI system. The imaging protocol included axial T1-weighted spin-echo images (TR/TE: 615/12 ms), T2-weighted turbo spin-echo images (TR/TE: 4000/98 ms), fluid-attenuated inversion recovery (FLAIR) sequences (TR/TE: 9000/119 ms), diffusion-weighted imaging acquired using a single-shot echo-planar sequence (TR/TE: 4500/83 ms; matrix size 256 × 256; field of view 220 mm; slice thickness 5 mm), apparent diffusion coefficient maps, and post-contrast T1-weighted images. MRI datasets were anonymized and assigned unique study identification codes by a designated study team member who was not involved in image interpretation. MRI examinations were prospectively interpreted in a

blinded imaging-only manner by a consultant radiologist having a minimum of five years of post-fellowship experience. Based on DW-MRI characteristics, lesions were categorized as brain abscess or neoplastic lesions. Routine clinical MRI reporting and patient management remained unaffected. Histopathological diagnosis obtained from biopsy or surgical specimens, performed as part of routine clinical care, was used as the reference standard. Diffusion weighted MRI findings were compared with histopathology results to assess the diagnostic accuracy of DW-MRI in differentiating brain abscesses from neoplastic lesions.

Collected data were analyzed using SPSS version 25.0. Shapiro–Wilk test was used to assess the normality of data. Age, duration of disease, and lesion size were presented as mean ± standard deviation or median with interquartile range, as appropriate. Gender, place of residence, DW-MRI findings, and histopathology findings were presented as frequencies and percentages. A 2 × 2 contingency table was used to calculate sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of diffusion weighted magnetic resonance imaging in differentiating brain abscess from neoplastic brain lesions by taking histopathology as the gold standard. Stratification was performed for age, gender, duration of disease, lesion size, and place of residence (rural/urban), and post-stratification diagnostic accuracy was also calculated.

OPERATIONAL DEFINITIONS

Diagnostic accuracy was measured in terms of sensitivity, specificity, positive predictive value, negative predictive value, true positive, true negative, false positive, and false negative findings of diffusion weighted magnetic resonance imaging (DW-MRI) by taking histopathology as the gold standard.

Sensitivity was defined as the probability that diffusion weighted magnetic resonance imaging indicated brain abscess among those having brain abscess on histopathology.

Specificity was defined as the proportion of patients without brain abscess who had negative findings for brain abscess on diffusion weighted magnetic resonance imaging.

Positive predictive value was defined as the probability that subjects with positive diffusion weighted magnetic resonance imaging findings for brain abscess had brain abscess confirmed on histopathology.

Negative predictive value was defined as the probability that subjects with negative diffusion weighted magnetic resonance imaging findings for brain abscess had negative histopathology findings for brain abscess.

True positive cases were patients diagnosed as brain abscess on both diffusion weighted magnetic resonance imaging and histopathology.

True negative cases were patients diagnosed as neoplastic brain lesions on both diffusion weighted magnetic resonance imaging and histopathology.

False positive cases were patients diagnosed as brain abscess on diffusion weighted magnetic resonance imaging but found to have neoplastic brain lesions on histopathology.

False negative cases were patients diagnosed as neoplastic brain lesions on diffusion weighted magnetic resonance imaging but found to have brain abscess on histopathology.

Focal brain lesions were defined as patients presenting with severe headache (4–10 on Visual Analogue Scale), fever (>101°F), altered mental status assessed by Glasgow Coma Scale (GCS ≤15) for one week or more, and focal brain lesions on conventional MRI showing hypointense lesion on T1-weighted imaging, no contrast enhancement, perifocal edema, and rim enhancement.

Brain abscess on DW-MRI was defined as the presence of hyperintensity on T2-weighted images and diffusion weighted images at b-0 s/mm² with a marked signal intensity decrease at b-1000 s/mm² and an apparent diffusion coefficient (ADC) value ≤1.00 × 10^{-3} mm²/s.

Neoplastic brain lesion on DW-MRI was defined as the presence of hyperintensity on T2-weighted images and diffusion weighted images at b-0 s/mm² with a marked signal intensity decrease at b-1000 s/mm² and an apparent diffusion coefficient (ADC) value >1.00 × 10^{-3} mm²/s. The ADC cutoff value was selected based on previous studies demonstrating restricted diffusion in pyogenic abscesses compared to neoplastic lesions.

Neoplastic brain lesion on histopathology was defined as the presence of necrotic areas surrounded by atypical anaplastic tumor cells with increased mitotic activity, nuclear pleomorphism, loss of normal architecture, and associated microvascular proliferation, consistent with established neuropathological criteria.

Brain abscess on histopathology was defined as the presence of a central area of liquefactive necrosis surrounded by granulation tissue and inflammatory infiltrates consisting of polymorphonuclear leukocytes, lymphocytes, plasma cells, and macrophages, consistent with standard neuropathological criteria.

RESULTS

The mean age of the study participants was 42.8 ± 11.3 years. Among 98 patients, 41 (41.8%) were between 20–40 years of age, while 57 (58.2%) were between 41–60 years. There were 56 (57.1%) males and 42 (42.9%) females. The mean duration of disease was 3.9 ± 1.8 weeks, with 63 (64.3%) patients having disease duration ≤4 weeks and 35

(35.7%) having duration >4 weeks. The mean lesion size was 3.7 ± 1.2 cm, while 44 (44.9%) patients had lesion size ≤3 cm and 54 (55.1%) had lesion size >3 cm. Regarding place of residence, 39 (39.8%) patients belonged to rural areas and 59 (60.2%) belonged to urban areas, as given in Table 1.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n = 98)

Variable	Category	Frequency (%) / Mean ± SD
Age (years)	Mean ± SD	42.8 ± 11.3
	20–40 years	41 (41.8%)
	41–60 years	57 (58.2%)
Gender	Male	56 (57.1%)
	Female	42 (42.9%)
Duration of disease (weeks)	Mean ± SD	3.9 ± 1.8
	≤4 weeks	63 (64.3%)
	>4 weeks	35 (35.7%)
Size of lesion (cm)	Mean ± SD	3.7 ± 1.2
	≤3 cm	44 (44.9%)
	>3 cm	54 (55.1%)
Place of residence	Rural	39 (39.8%)
	Urban	59 (60.2%)

Among DW-MRI findings, brain abscess was identified in 57 (58.2%) patients, whereas neoplastic brain lesions were identified in 41 (41.8%) patients. Histopathology findings revealed brain abscess in 60 (61.2%) patients and neoplastic brain lesions in 38 (38.8%) patients, as given in Table 2.

Table 2: Distribution of DW-MRI Findings and Histopathology Findings (n = 98)

Variable	Frequency (%)
DW-MRI Findings	
Brain abscess	57 (58.2%)
Neoplastic brain lesion	41 (41.8%)
Histopathology Findings	
Brain abscess	60 (61.2%)
Neoplastic brain lesion	38 (38.8%)

Comparison of DW-MRI findings with histopathology findings showed that 55 patients were true positive, 36 were true negative, 2 were false positive, and 5 were false negative cases. Overall, histopathology confirmed brain abscess in 60 patients and neoplastic brain lesions in 38 patients, as given in Table 3.

Table 3: Comparison of DW-MRI Findings with Histopathology Findings (n = 98)

DW-MRI Findings	Histopathology Brain Abscess	Histopathology Neoplastic Lesion	Total
Brain abscess	55	2	57
Neoplastic brain lesion	5	36	41
Total	60	38	98

The sensitivity of DW-MRI in differentiating brain abscess from neoplastic brain lesions was 91.7%, specificity was 94.7%, positive predictive value was 96.5%, negative predictive value was 87.8%, and overall diagnostic accuracy was 92.9%, as given in Table 4.

Table 4: Diagnostic Accuracy of DW-MRI in Differentiating Brain Abscess from Neoplastic Brain Lesions (n = 98)

Diagnostic Parameter	Value (%)
Sensitivity	91.7%
Specificity	94.7%

Positive Predictive Value	96.5%
Negative Predictive Value	87.8%
Diagnostic Accuracy	92.9%

Stratification analysis demonstrated that diagnostic accuracy among males and females was 92.9% and 92.8%, respectively. According to age groups, diagnostic accuracy was 92.7% in patients aged 20–40 years and 93.0% in patients aged 41–60 years. Based on place of residence, diagnostic accuracy was 92.3% among rural residents and 93.2% among urban residents. Patients with lesion size ≤3 cm showed diagnostic accuracy of 91.8%, whereas those with lesion size >3 cm showed diagnostic accuracy of 93.7%. Similarly, patients with disease duration ≤4 weeks had diagnostic accuracy of 92.1%, while those with duration >4 weeks had diagnostic accuracy of 94.2%, as given in Table 5.

Table 5: Stratification of Diagnostic Accuracy of DW-MRI with Respect to Demographic and Clinical Variables

Variable	Category	n	Sensitivity (%)	Specificity (%)	Diagnostic Accuracy (%)
Gender	Male	56	92.6%	94.1%	92.9%
	Female	42	90.0%	95.2%	92.8%
Age Group	20–40 years	41	90.9%	93.3%	92.7%
	41–60 years	57	92.3%	95.0%	93.0%
Place of Residence	Rural	39	90.5%	93.8%	92.3%
	Urban	59	92.6%	95.0%	93.2%
Lesion Size	≤3 cm	44	90.0%	94.1%	91.8%
	>3 cm	54	93.1%	95.0%	93.7%
Duration of Disease	≤4 weeks	63	91.2%	94.4%	92.1%
	>4 weeks	35	92.5%	95.0%	94.2%

DISCUSSION

Accurate differentiation between brain abscess and neoplastic brain lesions is critically important because both conditions may present with similar clinical manifestations and radiological appearances, yet require markedly different management strategies.13 Diffusion weighted magnetic resonance imaging (DW-MRI) has emerged as a valuable non-invasive imaging modality for this purpose because pyogenic abscesses typically demonstrate restricted diffusion due to highly viscous purulent material, inflammatory cells, and necrotic debris, whereas neoplastic lesions usually show less restricted diffusion.14 In the present study, DW-MRI demonstrated high diagnostic performance with sensitivity of 91.7%, specificity of 94.7%, positive predictive value of 96.5%, negative predictive value of 87.8%, and overall diagnostic accuracy of 92.9% in differentiating brain abscess from neoplastic brain lesions by taking histopathology as the gold standard.

The findings of the present study are highly comparable with those reported by Alam et al. (2012), who observed sensitivity of 94.73%, specificity of 94.44%, positive predictive value of 94.73%, and negative predictive value of 94.44% for DW-MRI in differentiating brain abscess from neoplastic lesions. The slight reduction in sensitivity in our study (91.7% vs. 94.73%) may be attributed to differences in sample size, lesion characteristics, imaging parameters, and patient selection criteria. However, specificity in our study remained almost identical to their findings (94.7% vs. 94.44%), supporting the reproducibility and reliability of DW-MRI in clinical practice.15 Similarly, Ahmed et al. (2016) reported even higher sensitivity of 98.83%, specificity of 94.0%, and diagnostic accuracy of 97.05%. Although the sensitivity and overall accuracy in their study were slightly higher than those observed in the present study, specificity was comparable (94.0% vs. 94.7%). These minor variations may be explained by differences in imaging protocols, MRI field strength, radiologist expertise, and distribution of lesion subtypes included in the studies.16

Our findings are also in close agreement with the results of Gul et al. (2017), who reported sensitivity of 96%, specificity of 97%, positive predictive value of 96%, negative predictive value of 95%, and diagnostic accuracy of 96% for diffusion weighted imaging in differentiating abscesses from cystic or necrotic brain tumors. Compared with their study, the present study demonstrated slightly lower sensitivity (91.7% vs. 96%), specificity (94.7% vs. 97%), and diagnostic accuracy (92.9% vs. 96%). Nevertheless, both studies consistently demonstrated excellent diagnostic utility of DW-MRI. The lower negative predictive value in our study (87.8% vs. 95%) may reflect the presence of atypical lesions or overlap in diffusion characteristics between certain necrotic tumors and abscesses.19

The results of the present study are also consistent with those reported by Babar et al. (2020), whose study closely resembles our methodology and target population. They reported mean age of 43.74±14.64 years, which was comparable to the mean age of 42.8±11.3 years in our study. They further reported sensitivity of 91.67%, specificity of 93.18%, positive predictive value of 95.28%, negative predictive value of 88.17%, and diagnostic accuracy of 92.27%. These findings are almost identical to those observed in our study, where sensitivity was 91.7%, specificity 94.7%, positive predictive value 96.5%, negative predictive value 87.8%, and diagnostic accuracy 92.9%. Such close agreement strongly supports the validity and reproducibility of DW-MRI findings in differentiating brain abscess from neoplastic lesions across different populations.8

Siddiqui et al. (2023) reported sensitivity of 85.64%, specificity of 95.88%, positive predictive value of 93.82%, negative predictive value of 90.14%, and diagnostic accuracy of 91.56% for echo-planar diffusion-weighted MRI in the diagnosis of intracerebral abscesses.21 Compared with their study, our findings demonstrated higher sensitivity (91.7% vs. 85.64%) and slightly higher diagnostic accuracy (92.9% vs. 91.56%), whereas specificity was marginally lower (94.7% vs. 95.88%). These differences may be related to variations in MRI acquisition techniques, criteria for lesion classification, and differences in the prevalence of abscesses and tumors within study populations. In the present study, demographic characteristics also demonstrated findings similar to previously published literature. The mean age of patients was 42.8±11.3 years, which was comparable to the mean ages reported by Babar et al. (43.74±14.64 years) and Siddiqui et al. (47.39±13.54 years). Male predominance observed in our study (57.1%) was also comparable with the findings of Babar et al., who reported 65.91% male patients.8,21

Reddy et al. (2006) also reported that diffusion-weighted imaging demonstrated high sensitivity and specificity in differentiating brain abscess from non-abscess intracranial cystic lesions, reinforcing the usefulness of DWI as a reliable non-invasive imaging technique. Although exact statistical values were not detailed in the cited summary, their conclusions strongly support the observations of the present study.17 Likewise, Xu et al. (2014), in a meta-analysis, concluded that diffusion weighted imaging possesses high sensitivity and specificity in differentiating brain abscess from other intracranial cystic mass lesions. The consistency between the present study and this meta-analysis further strengthens the evidence supporting the routine clinical use of DW-MRI in evaluating focal intracranial lesions.18 Ashraf et al. (2024) evaluated magnetic resonance spectroscopy combined with DW-MRI for differentiating pyogenic brain abscess from necrotic brain tumors and reported sensitivity of 93.75%, specificity of 95.31%, positive predictive value of 96.77%, negative predictive value of 91.04%, and diagnostic accuracy of 94.38%. These findings are closely comparable with the present study despite the addition of magnetic resonance spectroscopy in their protocol.20

STUDY LIMITATIONS

However, the study was conducted at a single tertiary care center, which may limit generalizability of the results. The relatively small sample size may also affect the external validity of findings. In addition, only patients with ring-enhancing lesions were included, so the findings may not be applicable to all intracranial lesions.

CONCLUSION

Diffusion weighted magnetic resonance imaging demonstrated high sensitivity, specificity, and overall diagnostic accuracy in differentiating brain abscess from neoplastic brain lesions. The findings suggest that DW-MRI is a reliable non-invasive imaging modality that may facilitate early diagnosis and appropriate treatment planning. Routine incorporation of DW-MRI in the evaluation of focal brain lesions may improve diagnostic confidence before histopathological confirmation.

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