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Research Article

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Diagnostic Accuracy and Clinical Impact of Stereotactic Biopsy in Intracranial Lesions: Correlation with MRI Findings

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ABSTRACT

Background: Magnetic resonance imaging (MRI) is widely used for the diagnosis of intracranial lesions. Radiological findings may not always correlate with histopathology. Stereotactic biopsy provides definitive tissue diagnosis after histopathology, which may alter treatment modalities.

Objectives: The aim of this study is to measure the diagnostic accuracy of MRI compared with histopathology and to assess the clinical impact of stereotactic biopsy on treatment decisions in patients with intracranial lesions.

Methodology: This is a cross-sectional type of study that includes about 25 patients with presumptive intracranial space-occupying lesions who underwent MRI followed by stereotactic biopsy. MRI diagnoses were compared with histopathological findings. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall accuracy, 95% confidence intervals (CI), and Cohen's kappa were calculated. Concordance rate, discordance rate, and treatment alteration rate following biopsy were assessed. 95% CI was measured using the Wilson formula.

Results: MRI showed a sensitivity of 85.7% (95% CI: 60%–96%) and specificity of 36.4% (95% CI: 15%–65%) in detecting neoplastic lesions. PPV and NPV were 63.2% and 66.7%, respectively. Overall diagnostic accuracy was 64% (95% CI: 45%–80%). Agreement between MRI and histopathology was fair (Cohen's $\kappa = 0.23$). Concordance rate was 60%, discordance rate was 40%, and treatment alteration rate was 40%.

Conclusion: MRI showed high sensitivity but limited specificity in diagnosing neoplastic intracranial lesions. Stereotactic biopsy significantly influenced treatment decisions. So, stereotactic biopsy has a significant role in the management of intracranial lesions.

Keywords: MRI, Stereotactic Biopsy.

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Introduction

Intracranial space-occupying lesions are a group of pathological conditions that include primary brain tumours, metastatic lesions, inflammatory processes, granulomatous diseases, and abscesses. Accurate diagnosis of these lesions is crucial because management strategies directly depend on diagnosis.

Magnetic resonance imaging (MRI) is the primary non-invasive modality used in the evaluation of intracranial lesions due to its high diagnostic accuracy [1]. MRI provides valuable information regarding lesion location, size, enhancement pattern, and surrounding oedema. However, radiological features of neoplastic and non-neoplastic lesions often overlap, which may lead to diagnostic uncertainty.

Although MRIs have experienced rapid development and found wide applications in

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recent years, radiological findings alone cannot always reliably distinguish between tumor and non-tumor conditions. Inaccurate diagnosis may result in inappropriate treatment, unnecessary surgery, or exposure to ineffective medical management [2].

Stereotactic biopsy offers a minimally invasive technique for obtaining tissue samples from intracranial lesions, particularly those located in deep regions of the brain. It allows histopathological confirmation, which remains the gold standard for definitive diagnosis [3]. Tissue diagnosis not only establishes the exact diagnosis but also helps in clinical decision-making. There are robotic methods of taking stereotactic biopsy, though the outcome is not that much different [4]. An alternative view holds that robotic stereotactic biopsies may improve diagnostic yield and targeting accuracy for intracranial lesions without increasing complication rates or operative time [5].

Despite widespread use of MRI, the degree of agreement between radiological diagnosis and histopathological findings varies in different settings. Furthermore, the extent to which stereotactic biopsy alters clinical management has not been adequately evaluated in many local institutions.
Therefore, this study was conducted to assess the diagnostic accuracy of MRI compared with histopathology and to evaluate the clinical impact of stereotactic biopsy on treatment decisions in patients with intracranial lesions.

Materials and Methods

A cross-sectional observational study was conducted at DMCH from January 19 to June 20. A total of 25 patients were included in this study.

Inclusion Criteria

- Patients with a presumptive diagnosis of intracranial space-occupying lesions
- Patients who underwent MRI followed by stereotactic biopsy
- Invasive lesions without significant mass effect
- Supratentorial lesion

Exclusion Criteria

- Age below 15 years
- Terminally ill patients requiring ICU or HDU support
- Coagulopathies, septicemia
- Large lesion producing mass effect
- Infratentorial lesion

All patients underwent preoperative MRI of the brain. MRI findings were classified as neoplastic and non-neoplastic. A biopsy was performed in a procedure room under local anesthesia. After fixing a "KOMAI" stereotactic frame to the head, a contrast-enhanced computed tomography (CT) head scan was done. The lesion was identified, and the target point for biopsy was chosen. In the supine position, through a burr hole, a biopsy was done with a side-cutting biopsy forceps. Statistical analysis was done using SPSS. A 2×2 contingency table was constructed by comparing MRI diagnosis (neoplastic vs non-neoplastic) with histopathological findings. From the table, Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), concordance rate, discordance rate, treatment alteration rate, and Overall accuracy were measured. Ninety-five percent confidence intervals (95% CI) for proportions were calculated using the Wilson score method due to the small sample size. Agreement between MRI and histopathology was assessed using Cohen's kappa (κ) coefficient.

Results

A total of 25 patients were included in the study. Among them, 64% male and 36% female. Their age is described in Table 1. Table 2 shows the correlation between MRI findings and histopathological findings from which true positive, true negative, false positive, and false negative are found. Tables 3 and 4 show MRI-based and histopathology-based diagnoses, respectively. Table 5 shows the number of concordant cases and discordant cases. Table 6 shows the diagnostic performance of MRI, where high sensitivity and low specificity are observed. Fair agreement is seen between MRI and histopathology.

Table 1: Patient demographic

Age (years)	Sex with frequency		Total
	Male (n= 16)	*Female (n= 9)*	
20-30	2(12.5%)	1(11.1%)	3(12.0%)
31-40	6(37.5%)	4(44.5%)	10(40.0%)
41-50	5(31.2%)	2(22.2%)	7(28.0%)
51-60	3(18.7%)	2(22.2%)	5(20.0%)
Mean ± SD	43.6 ± 7.52	44.2 ± 7.21	

Table 2: 2X2 Contingency table showing Correlation between MRI findings and Histopathological findings

Histological diagnoses by stereotactic biopsy	MRI findings	
	Neoplastic lesion (n=14)	*Non-neoplastic lesion (n=11)*
Primary & secondary brain tumour (n=19)	12(63.15%)	7(36.84%)
Non-neoplastic lesion (n=6)	2(33.33%)	4(66.67%)

So, True positive (TP) =12(a)
False positive (FP) =7(b)
False negative (FN) =2(c)
True negative (TN) =4(d)

Table 3: MRI-Based Provisional Diagnosis with Percentage

MRI finding	Number of patients	Frequency
Glioblastoma multiforme	5	20%
metastasis	5	20%
TB	6	24%
Low-grade glioma	2	8%
Pilocytic astrocytoma	2	8%
abscess	3	12%
Choroid plexus papilloma	0	0

Malignant round cell tumour	0	0
Non hodgkins lymphoma	0	0
neurocycticercosis	2	8%
hematoma	0	0
gliosis	0	0

Table 4: Histopathological Diagnosis with Percentage

Histopathological finding	Number of patients	Frequency
Glioblastoma multiforme	3	12%
metastasis	3	12%
TB	2	8%
Low-grade glioma	2	8%
Pilocytic astrocytoma	3	12%
abscess	2	8%
Choroid plexus papilloma	1	4%
Malignant round cell tumour	1	4%
Non hodgkins lymphoma	1	4%
neurocycticercosis	1	4%
hematoma	1	4%
gliosis	5	20%

Table 5:

Patient (N)	MRI findings	histopathology	matching
1	Glioblastoma multiforme	Glioblastoma multiforme	yes
2	Glioblastoma multiforme	Glioblastoma multiforme	yes
3	Glioblastoma multiforme	Glioblastoma multiforme	yes
4	Glioblastoma multiforme	Low-grade glioma	no
5	Glioblastoma multiforme	metastasis	no
6	metastasis	metastasis	yes
7	metastasis	metastasis	yes
8	metastasis	Glioblastoma multiforme	no
9	metastasis	Glioblastoma multiforme	no
10	metastasis	Low-grade glioma	no
11	TB	TB	yes
12	TB	TB	yes
13	TB	Neurocycticercosis	no
14	TB	metastasis	no
15	TB	metastasis	no
16	TB	Glioblastoma multiforme	no
17	Low-grade glioma	Low-grade glioma	yes
18	Low-grade glioma	Low-grade glioma	yes
19	Pilocytic astrocytoma	Pilocytic astrocytoma	yes
20	Pilocytic astrocytoma	Pilocytic astrocytoma	yes
21	abscess	abscess	yes
22	abscess	abscess	yes
23	abscess	Glioblastoma multiforme	no
24	neurocycticercosis	neurocycticercosis	yes
25	neurocycticercosis	metastasis	no

So, concordant case=15
And, discordant case=10
From the above tables,
Sensitivity= [(a/(a+c)] =85.7%
Specificity= [d/(d+b)] =36.4%
PPV (positive predictive value) = [a/(a+b)] = 63.2%
NPV (negative predictive value) = [d/(d+c)] =66.7%
Accuracy= [(a+d)/N] = 64%
Cohen's Kappa($\hat{k}$)= $(P_o-P_e)/(1-P_e)$ = 0.23
Here, P_o observed agreement) = (16/25) = 0.64
P_e(expected agreement) = [{(19/25)X(14/25)}+{(11/25)X(6/25)}]= 0.531
Concordance rate= [concordant case/total case]X100
= [15/25]X100=60%
Discordance rate= [discordant case/total case]X100
= [10/25]X100=40%
Treatment alteration rate= [10/25]X100=40%

95% CI measured using the Wilson formula,
For sensitivity, specificity, and accuracy, the values are 60%-90%, 15%-65%, 45%-80%, respectively

Table 6: Diagnostic Performance of MRI

Parameter	Value	95% CI
Sensitivity	85.7%	60%–90%
Specificity	36.4%	15%–65%
PPV	63.2%	—
NPV	66.7%	—
Binary accuracy	64%	45%–80%
Cohen's κ	0.23	Fair agreement

Discussion

This study evaluated the diagnostic accuracy of MRI in comparison with histopathological findings and assessed the clinical impact of stereotactic biopsy in patients with intracranial lesions. The results demonstrated that MRI had high sensitivity (85.7%) but relatively low specificity (36.4%) in differentiating neoplastic from non-neoplastic lesions. Binary accuracy was 64%, and agreement between MRI and histopathology was fair (κ = 0.23). At the same time, another study reveals that the Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of MRI were 92%, 25%, 93%, 2%, and 87%, respectively [6].

The high sensitivity found in this study indicates that MRI is effective in diagnosing most neoplastic lesions. However, the relatively low specificity indicates that MRI may overestimate neoplastic pathology, particularly in cases where inflammatory, infectious, or granulomatous lesions mimic tumor characteristics radiologically.

The fair level of agreement between MRI and histopathology highlights the limitations of relying solely on imaging findings for definitive diagnosis. This finding is in favour of histopathological confirmation before treatment decision-making, especially in cases where imaging findings are vague.

Importantly, stereotactic biopsy altered the treatment plan in 36% of patients in this study. It proves that one-third of patients would have received potentially inappropriate management if treatment decisions were based solely on MRI findings [7]. So, it has significant clinical significance.

The safety profile of stereotactic biopsy in this study was acceptable, with minimal procedure-related complications [8]. This supports the role of stereotactic biopsy as a minimally invasive and safe method for obtaining a definitive diagnosis, particularly for deep-seated or surgically inaccessible lesions.

This study has several limitations. The sample size was small (n = 25), which may limit the generalizability of the findings. Additionally, the study was conducted at a single center, and subgroup analyses based on lesion type or location were not performed. Besides, frameless biopsy is widely used nowadays, but the study was conducted with frame-based biopsy.

Conclusion

Stereotactic biopsy remains an essential tool for accurate diagnosis and appropriate therapeutic decision-making in patients with intracranial lesions. Magnetic resonance imaging demonstrated high sensitivity but limited specificity in differentiating neoplastic from non-neoplastic intracranial lesions. The fair level of agreement between MRI and histopathology proves the limitations of imaging alone in establishing a definitive diagnosis.

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