

# Diagnostic Performance of Magnetic Resonance Imaging (MRI) in The Diagnosis of Intracranial Meningioma

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## Abstract:

**Background:** Meningiomas are the most common non-glial tumours of the central nervous system, arise from the arachnoid cap cells of the arachnoid villi compressing the brain. It is generally considered slowly growing lesions, often with an indolent clinical course depending on the location. Meningiomas are often clinically detected when already of large size or with increasing age. However, with increasing availability of cranial imaging, incidentally discovered meningiomas are becoming more frequent. They can arise from dura at any site, most commonly the skull vault, and base (planum sphenoidale, sphenoid wing, petrous ridge cavernous sinus, perisellar region and clivus) and at dural reflexions (falx cerebri, tentorium cerebelli and dura of adjacent venous sinuses), less commonly optic nerve sheath and choroid plexus. As meningiomas may display different growth dynamics over time, the initial tumor volume may have a significant impact on the risk of clinically relevant progression and outcome. Proper evaluation and detection is pivotal for further management.

**Purpose:** To assess the role of MRI in diagnosis of intracranial meningiomas.

**Materials & method:** This cross sectional study was conducted in Department of Radiology & Imaging, Dhaka Medical College Hospital, Dhaka during the period of July 2013 to June 2015. Patients with clinically suspected brain tumor referred to Department of Radiology & Imaging, DMCH for MRI imaging were enrolled for study. All these patients were evaluated by detailed history, physical examination and neurological evaluation. MRI was performed and diagnosis was suggested radiologically. Finally, MRI findings were correlated with histopathological diagnosis. All the information collected in data sheet. Data was processed and analyzed with the help of computer program SPSS and Microsoft excel. Quantitative data expressed as mean and standard deviation and qualitative data as frequency and percentage. Result was presented by tabulation and graphical presentation in the form of tables, pie chart, graphs, bar diagrams, histogram & charts etc.

**Result:** Among the 46 respondents, maximum 15(32.6%) patients were in the age group of 51-60 years. Mean age was 52.1±10.3 years. Out of 46 cases, 19(41.3%) were male and 27(58.7%) were female. Male – female ratio was 1:1.4. MRI diagnosis of meningioma revealed that among the 46 cases 40(87.0%) were meningioma, 4(8.7%) were acoustic schwannoma, 1(2.15%) was pituitary macroadenoma and 1(2.15%) was craniopharyngioma. Histopathological diagnosis of meningioma shows that among the 46 cases 38(82.6%) were meningioma, 5(10.9%) were acoustic schwannoma, 2(4.3%) was pituitary macroadenoma and 1(2.15%) was craniopharyngioma. Diagnostic validity of MRI revealed that sensitivity, specificity, accuracy, positive predictive value and negative predictive value was 97.4%, 62.5%, 91.3%, 92.5% and 83.3% respectively.

**Conclusion:** Meningiomas are the most common intracranial tumors and their incidence increases with age, with a median age at diagnosis of 52.1 years. Present study concludes that MRI (T1WI, T2WI, FLAIR & post contrast T1WI) is a useful diagnostic modality in evaluation of intracranial meningioma.

**Key words:** Intracranial Meningioma, Magnetic Resonance Imaging (MRI), Histopathology.

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**Introduction:**

Meningiomas are the most common intracranial tumors, making up more than a third of all primary central nervous system (CNS) tumors. They are a non-glial neoplasms that originates from the meningocytes or arachnoid cap cells of the meninges and are located anywhere that meninges are found and in some places where only rest cells are presumed to be located.<sup>1,2</sup> These tumors are classified into three grades, according to the World Health Organization (WHO). The majority of meningiomas are benign and considered grade.<sup>1,4,13</sup> About 1 to 3% of meningiomas can be transformed into malignant tumors with a 5-year survival rate of 32 to 64%.<sup>5</sup> Several predisposing factors increase the risk of occurrence, including genetic disorders such as neurofibromatosis type 2, exposure to radiation, hormonal therapy, and family history.

Histologically, meningiomas arise from meningoepithelial cells, also known as arachnoid cap cells. As such, meningiomas most commonly occur where these cells are most numerous, such as where the arachnoid granulations are concentrated along the dural venous sinuses.<sup>6</sup> Of all intracranial meningiomas, approximately half are located along the skull base, 40% along the calvarial convexity, 10% along the falx and parasagittal region, and a small fraction within the ventricle or across multiple locations.<sup>7,8</sup> The clinical manifestation is dependent on the location and the size of the meningioma. Therefore, some patients can be asymptomatic, while others might experience neurological deficits. Brain magnetic resonance imaging (MRI) is the gold standard radiological investigation for diagnosing meningioma.<sup>9</sup>

The tumors are diverse in biological characteristics in terms of different pathological subtypes and grades. According to the WHO classification, meningiomas are of three types - benign (grade I – 80 to 90%), atypical (Grade II- 10 to 20%) and anaplastic (Grade III- 1 to 2%).<sup>10</sup> The classification is based on number of mitoses, cellularity, nuclear to cytoplasmic ratio, histologic pattern, growth pattern and risk of recurrence of the tumour.<sup>3,4</sup> WHO grade 1 meningiomas have a very low recurrence rate

after total resection, but there is a higher tendency for recurrence as the WHO meningioma grade increases.<sup>10</sup> The clinical presentations are nonspecific and depend on tumour location. Symptoms are produced due to compression of adjacent structures, direct invasion of or reactive changes in adjacent brain and obstruction of cerebrospinal fluid pathways, cortical veins or major venous sinuses. Common symptoms are headache with blurred vision, seizure disorder, and loss of consciousness, etc.<sup>2</sup>

MRI has excellent performance in diagnosing meningioma. Meningioma grading, based on the World Health Organization (WHO) classification, categorizes these tumors into three grades. Grade 1 (benign) is most common (~80%), grade 2 is atypical (intermediate), and grade 3 is malignant. MRI has high soft tissue resolution, and the sensitivity and specificity of MRI can reach 75.0% and 93.5%, respectively, for evaluating tissue conditions in and around the tumor.<sup>11</sup> The archetypal imaging characteristics of meningiomas are among the most stereotypic of all central nervous system (CNS) tumors. In the era of plain film and ventriculography, imaging was only performed if a mass was suspected, and their results were more suggestive than definitive. Asymptomatic meningiomas may be identified and their growth monitored over time; moreover, imaging routinely serves as an essential tool to survey tumor burden at various stages during the course of treatment, thereby providing guidance on their effectiveness or the need for further intervention.<sup>12</sup> Study concludes that conventional MRI (T1WI, T2WI, FLAIR & post contrast T1WI) is a useful diagnostic modality in evaluation of intracranial meningioma.<sup>13</sup> MRI evaluations can play an essential role in the differential diagnosis of tumor entities with similar presentations, facilitating the correct classification of patients and improving accuracy in the diagnosis and optimization of treatment.<sup>14</sup>

On MRI, meningiomas are usually hypo- to isointense relative to cerebral cortex on T1-weighted sequences and iso- to hyperintense on T2-weighted sequences.<sup>6</sup> On FLAIR, they

show hyperintensity. After intravenous contrast administration, the lesions enhance dense and homogeneous fashion and show 'dural tail' sign. As on CT, most meningiomas enhance avidly on MRI, and nearly all enhance at least in part, even if heavily calcified. The presence of intratumoral cysts, hemorrhage, or necrosis can produce a heterogeneous appearance and may be associated with more aggressive behavior of the tumor. A dural tail is seen on postcontrast imaging.<sup>12,13</sup> Intraoperatively, microscopic spread of tumor cells may also extend beyond the apparent dural tail on imaging. Yet despite the well-known association between dural tails and meningiomas, the sign is not specific, as other dural neoplasms can also demonstrate this finding.<sup>12,13</sup> Nevertheless, this feature is useful in confirming the extra-axial location of a large meningioma that is inseparable from brain and in distinguishing meningiomas from other extra-axial tumors such as schwannomas and pituitary adenomas that typically do not exhibit dural tails. Using these characteristic features MRI has sensitivity and specificity of 98% and 97% respectively. The accuracy of diagnosis of meningiomas on MRI was 95.2%.<sup>15</sup>

Meningiomas account for over a third of all primary CNS tumors and over half of nonmalignant CNS tumors, and predominate among extra-axial lesions. Despite this prevalence, broad differential diagnoses of meningioma exist, including dural-based metastasis (eg, from lung, breast, or prostate primaries), lymphoma and leukemia (ie, granulocytic sarcoma), solitary fibrous tumor, and hemangiopericytoma (now considered within the solitary fibrous tumor spectrum). Enhancing dural masses may be seen with sarcoidosis and tuberculosis but are often multiple. Imaging features which distinguish meningioma mimics from meningioma itself can include homogeneous T2 hypo- or hyperintensity in the tumor, adjacent osseous destruction, leptomeningeal or pial extension, and absence of a dural tail.<sup>12,16</sup>

Previous study among 82 meningioma cases reported that most tumors showed typical magnetic resonance signal intensities and homogeneous contrast enhancement. Atypical

features (22 cases) included heterogeneous signal, calcification, diverse contrast patterns, cysts, and necrosis. Dural tail signs and peritumoral edema occurred in over one-third of cases. Hyperostosis (24 cases) surpassed osteolysis. Six cases had intratumoral/peritumoral hemorrhage; one had spontaneous intracerebral hemorrhage, confirming an anaplastic subtype.<sup>17</sup> Considering histopathology as a gold standard test Sensitivity, Specificity, Positive predictive value, Negative predictive value and Accuracy of MRI scan in diagnosis of intracranial meningioma were 96.08%, 90%, 98%, 81.82% and 95.08% respectively.<sup>13</sup>

### Methodology:

This cross sectional study was conducted in Department of Radiology & Imaging, Dhaka Medical College Hospital, Dhaka in collaboration with Department of Neurosurgery, and Pathology, DMCH, during the period of July 2013 to June 2015. Patients with clinically suspected brain tumor referred to Department of Radiology & Imaging, DMCH for MRI imaging were enrolled for study. All these patients were evaluated by detailed history, physical examination and neurological evaluation. MRI was performed and diagnosis was suggested radiologically. The 0.3 Tesla Hitachi AIRIS II machine used for MRI with slice thickness 05 mm, with intersection gap 4 mm. Pre contrast T1W, T2W, FLAIR & post contrast T1W image with axial, sagittal and coronal scan were taken for evaluation of intracranial meningiomas. Finally, MRI findings were correlated with histopathological diagnosis. Diagnostic criteria of MRI of intracranial meningioma<sup>18</sup>: Meningiomas are well circumscribed globular or lobulated dural based mass lesion.

- Pre contrast MRI appearances of meningiomas are hypointense to isointense on T1-weighted image, iso to hyperintense on T2-weighted image and FLAIR sequences. A CSF cleft is often present around a meningioma, demarcating the brain-tumour interface. Other features are enlarged and displaced pial vessels and draining veins may be striking. Moderate to severe peritumoural oedema is present in two thirds of all cases.

- Post contrast MRI appearances of meningiomas are dural tail sign is present in 60% cases and strong homogeneous enhancement in 95% cases.

Atypical Meningiomas: Pre contrast MRI appearances of atypical meningiomas are heterogeneous signal intensity, irregular mushroom like surface, large amount of peritumoural oedema, absence of calcification and presence of necrosis. Post contrast MRI appearances of atypical meningioma is heterogeneous contrast enhancement.

Data was processed and analysed with the help of computer program SPSS and Microsoft excel. Continuous variables were expressed as mean, standard deviation and categorical variables as frequencies and percentages. The differences between groups were analyzed by unpaired t-test or chi-square ( $\chi^2$ ) test. To make out the relation between binary diagnostic test and the presence or absence of disease, a 2/2 contingency table constructed. A "P" value  $<0.05$  considered as significant. Result was presented by tabulation and graphical presentation in the form of tables, pie chart, graphs, bar diagrams, histogram & charts etc.

### Result & Observation:

Total of 46 patients fulfilling inclusion/exclusion criteria were studied. Results and observations are given below:

**Table I**  
*Demographic profile of the study subjects (n=46)*

| Variables     | Frequency       | Percentage (%) |
|---------------|-----------------|----------------|
| Age (years)   |                 |                |
| 31-40         | 7               | 15.0           |
| 41-50         | 13              | 28.3           |
| 51-60         | 15              | 32.6           |
| 61-70         | 11              | 23.9           |
| Mean $\pm$ SD | 52.1 $\pm$ 10.3 |                |
| Gender        |                 |                |
| Male          | 19              | 41.3           |
| Female        | 27              | 58.7           |

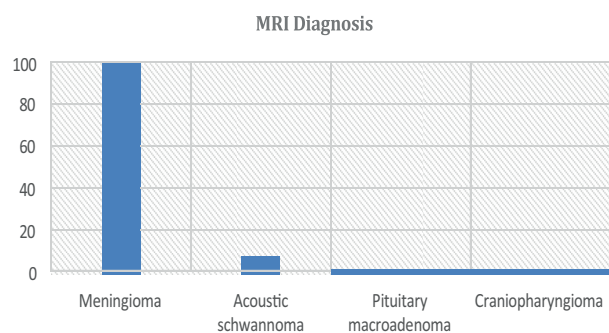
Table I shows demographic profile of patients. Among the 46 respondents, maximum 15(32.6%) patients were in the age group of 51-60 years. Mean age was 52.1 $\pm$ 10.3 years. Out of 46 cases, 19(41.3%) were male and 27(58.7%) were female. Male – female ratio was 1:1.4.

**Table II**

*Distribution of study subjects according to MRI findings (n=120) MRI features*

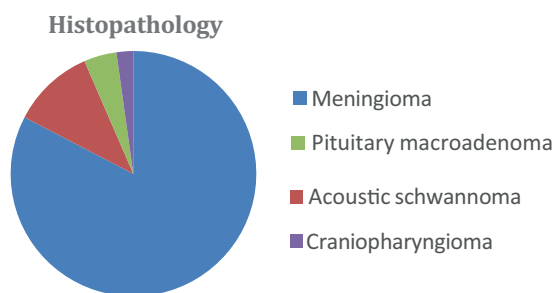
|                       | Frequency | Percentage |
|-----------------------|-----------|------------|
| Shape of lesion       |           |            |
| Round                 | 30        | 65.2       |
| Oval                  | 13        | 28.3       |
| Lobulated             | 3         | 6.5        |
| Signal                |           |            |
| T1W1 (hypointense)    | 30        | 65.2       |
| T1W1 (isointense)     | 16        | 34.8       |
| T2W1 (hyperintense)   | 43        | 93.5       |
| T2W1 (isointense)     | 3         | 6.5        |
| FLAIR (hyperintense)  | 43        | 93.5       |
| FLAIR (isointense)    |           |            |
| Nature of enhancement | 3         | 6.5        |
| Homogenous            | 38        | 82.6       |
| Heterogenous          |           |            |
| Degree of enhancement | 8         | 17.4       |
| Moderate              | 14        | 30.4       |
| Intense               |           |            |
| Area of necrosis      | 32        | 69.6       |
| Present               | 4         | 8.7        |
| Absent                |           |            |
| Calcification         | 42        | 91.3       |
| Present               | 7         | 15.2       |
| Absent                |           |            |
| Cystic change         | 39        | 84.8       |
| Present               | 4         | 8.7        |
| Absent                |           |            |
| Perilesional oedema   | 42        | 91.3       |
| Present               | 24        | 52.2       |
| Absent                |           |            |
| Mass effect           | 22        | 47.8       |
| Present               | 28        | 60.9       |
| Absent                |           |            |
| Dural tail            | 18        | 39.1       |
| Present               | 16        | 34.8       |
| Absent                |           |            |
| CSF cleft             | 30        | 65.2       |
| Well defined          | 35        | 76.1       |
| Ill defined           | 11        | 23.9       |

Table II shows the MRI findings of the respondents. Almost two thirds (65.2%) was round shape of the lesion. Majority (82.6%) had homogeneous nature of enhancement. More than two third (69.6%) had intense degree of enhancement. Four (8.7%) was area of necrosis, 7(15.2%) was calcification and 4(8.7%) was cystic change. More than half (52.2%) had peritumoral oedema, 28(60.9%) had mass effect, 16(34.8%) had Dural tail and 35(76.1%) had CSF cleft.



**Figure 1:** Diagnosis of meningioma according to MRI findings (n=46)

Figure 1 shows the MRI diagnosis of meningioma. Among the 46 cases 40(87.0%) were meningioma, 4(8.7%) were acoustic schwannoma, 1(2.15%) was pituitary macroadenoma and 1(2.15%) was cranio-pharyngioma.



**Figure 2:** Histopathological diagnosis of meningioma (n=46)

Figure 2 shows the histopathological diagnosis of meningioma. Among the 46 cases 38(82.6%) were meningioma, 5(10.9%) were acoustic schwannoma, 2(4.3%) was pituitary macroadenoma and 1(2.15%) was craniopharyngioma.

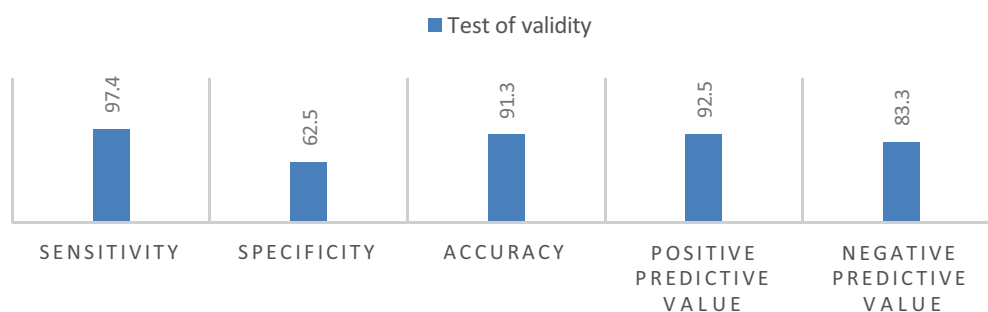
**Table III**

*Comparison between MRI diagnoses and histopathological diagnoses of meningioma (n=46)*

| MRI diagnoses         | Histopathology |                       | Total |
|-----------------------|----------------|-----------------------|-------|
|                       | Meningioma     | Other than meningioma |       |
| Meningioma            | 37 (TP)        | 3 (FP)                | 40    |
| Other than meningioma | 1 (FN)         | 5 (TN)                | 6     |
| Total                 | 38             | 8                     | 46    |

Table III shows the comparison between MRI diagnoses and histopathological diagnoses of meningioma. Out of all cases, 40 were diagnosed as meningioma by MRI and among them 37 were confirmed by histopathological evaluation or true positive (TP). Remaining 3 cases were false positive (FP). Out of 6 cases of other than meningioma which was diagnosed by MRI, histopathology confirmed 5 cases result similar or other than meningioma (TN), but single case confirmed as meningioma (FN).

Figure 3 shows the diagnostic validity of MRI in the diagnosis of Intracranial Meningioma. Sensitivity, specificity, accuracy, positive predictive value and negative predictive value of the MRI was 97.4%, 62.5%, 91.3%, 92.5% and 83.3% respectively.



**Figure-3:** Diagnostic validity of MRI in the diagnosis of Intracranial Meningioma (n=46)

**Discussion:**

Meningiomas are the most common extra-axial broad-based non-glial tumors of the central nervous system (CNS). They are frequently observed in individuals over 50 years, with a prevalence of 2–3% among the elderly population. In this study maximum 15(32.6%) patients were in the age group of 51–60 years. Mean age was  $52.1 \pm 10.3$  years. Out of 46 cases, 19(41.3%) were male and 27(58.7%) were female. Male to female ratio was 1:1.4. Similar study reported that mean age was  $53.05 \pm 9.58$  years, with female to male ratio 2.39:1<sup>13</sup>. In the study of Yan et al. the mean age was  $52.89 \pm 9$  years and female to male ratio was 2.36.<sup>19</sup>

Most commonly, meningiomas are asymptomatic, although clinical signs may vary and arise from the compression of brain structures or obstruction of the ventricular system. This study revealed meningiomas significantly located in parasagittal (39.1%), convexity (28.3%), cerebellopontine (CP) angle (17.4%) and sellar region (15.2%). Previous study noted that meningiomas predominantly occur along the lateral hemisphere convexity (20–34%), parasagittal (18–22%), sphenoid wing, middle cranial fossa (17–25%), and olfactory groove. Less common sites include cerebellopontine (CP) angle (2–4%), intraventricular (2–5%), orbital (<1–2%), clivus (<1%), and ectopic areas such as optic nerve sheath (0.4–1.3%) and choroid plexus (0.5–3%).<sup>17</sup> This finding is supported by another study as meningiomas significantly occupied supratentorial localization in 86.89% cases compared to infratentorial localization in 13.11%.<sup>13</sup>

MRI findings of the present study shows that almost two third (65.2%) was round shape of the lesion. Majority (82.6%) had a homogeneous nature of enhancement. More than two third (69.6%) had intense degree of enhancement. Four (8.7%) was area of necrosis, 7(15.2%) was calcification and 4(8.7%) was cystic change. More than half (52.2%) had peritumoral oedema, 28(60.9%) had mass effect, 16(34.8%) had Dural tail and 35(76.1%) had CSF cleft.

These observations were consistent with observations of Rahman et al<sup>13</sup>, reported that meningiomas showed isointensity in 80% and

hypointensity in 20% on T1WI, isointensity in 80% & hyperintensity in 20% cases on T2WI and FLAIR. Study also showed intense enhancement in 85.25% of tumours, homogeneous enhancement in 77.05% of tumours, dural tail was present in 77.05% of cases, white matter buckling in 72.13% and CSF cleft in 62.3% cases & 86.89% cases displayed broad dural base and peritumoural edema was found in about one third (31.15%) of meningiomas.<sup>13</sup>

Comparison between MRI diagnoses and histopathological diagnoses of meningioma revealed that out of all cases, 40 were diagnosed as meningioma by MRI and among them 37 were confirmed by histopathological evaluation or true positive (TP). Remaining 3 cases were false positive (FP). Out of 6 cases of other than meningioma which was diagnosed by MRI, histopathology confirmed 5 cases result similar or other than meningioma (TN), but single case confirmed as meningioma (FN). Sensitivity, specificity, accuracy, positive predictive value and negative predictive value of the MRI was 97.4%, 62.5%, 91.3%, 92.5% and 83.3% respectively.

Result is in agreement with the results of Rahman et al.<sup>13</sup> They reported out of 61 cases 50 (87.36%) were diagnosed as intracranial meningiomas in MRI study. Histopathology confirmed 49 cases (true positive), 01 case was not compatible with histopathological report (false positive). Histopathology revealed 02 cases of meningioma which were diagnosed as brain tumors other than meningioma by MRI features (false negative). According to the observation of present study of sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MRI in diagnosis of intracranial meningioma were 96.08%, 90%, 98%, 81.82% and 95.08% respectively<sup>13</sup> which is comparable to study done by Pouratian et al<sup>20</sup>. They found sensitivity and specificity of MRI to be 98% and 97% respectively.

Previous study reported that the tumor-brain interface had the highest efficacy in evaluating WHO grade and brain invasion, with AUCs of 0.779 and 0.860, respectively. Combined, the variables had AUCs of 0.834 and 0.935 for

determining WHO grade and brain invasion, respectively. MRI has excellent performance in diagnosing meningioma WHO grade and brain invasion, while the tumor- brain interface serves as a key factor.<sup>10</sup> Preoperative MR imaging is increasingly appreciated to provide information regarding differential diagnosis, extent of tumor, and histologic grade of meningioma. Quantitative analytical methods are further augmenting the interpretation of imaging data and helping to correlate imaging features with clinical outcome<sup>12</sup>. Considering histopathology as a gold standard test Sensitivity, Specificity, Positive predictive value, Negative predictive value and Accuracy of MRI scan in diagnosis of intracranial meningioma were 96.08%, 90%, 98%, 81.82% and 95.08% respectively.<sup>13</sup>

### Conclusions:

Present study concluded that MRI is an useful diagnostic modality for evaluation of meningioma with high sensitivity, specificity. Meningiomas are the most common non-gliar tumours of the central nervous system. Therefore, proper evaluation and early management is pivotal for reduction of burden. Based on these findings, it can be inferred that MRI is a good tool in evaluation of intra-cranial extra- axial meningiomas.

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