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Intracranial Meningioma: Diagnostic Performance of Conventional Magnetic Resonance Imaging

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Abstract:
Background: *Meningiomas are the most common intracranial tumors, making up more than a third of all primary central nervous system tumors. Its incidence is increasing overtime, particularly in elderly and related to wider indications for cranial imaging, better imaging facilities in increasing ageing population.* ***Objective:*** *The study aimed to evaluate diagnostic performance of conventional magnetic resonance imaging in diagnosis of intracranial meningioma.* ***Methods:*** *This cross sectional observational study was conducted in the Departments of Radiology and Imaging of Sir Salimullah Medical College & Mitford hospital (SSMC & MH) and National Institute of Neurosciences & Hospital (NINS & H), Dhaka during the period of January 2017 to December 2018. A purposive sampling technique was used. Patients with suspected extra-axial tumors on MRI who underwent surgical intervention and histopathological examinations were included. A total 61 patients were included in the study.* ***Results:*** *MR diagnosis was compared with histopathological finding and it was found that among 61 cases 49 cases were true positive for meningioma, 09 cases were extra-axial lesions other than meningioma, 01 case was false positive and 02 cases were false negative. Considering histopathology as a gold standard for diagnosis of intracranial meningioma, the validity of conventional MRI showed a sensitivity of 96.08%, specificity of 90%, positive predictive value of 98%, negative predictive value of 81.82% and accuracy of 95.08%.* ***Conclusion:*** *This study concludes that conventional MRI (T1WI, T2WI, FLAIR & post-contrast T1WI) is a useful diagnostic modality in evaluation of intracranial meningioma.*

Key words: Meningioma, Magnetic resonance imaging.

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Introduction:

Meningiomas are the most common non-glial tumours of the central nervous system,[1] representing 36.6% of all primary intra-cranial neoplasms in adults[2] and accounting for approximately 20% of all intra-cranial tumours in male and 38% in female.[3] Tumours arise from the arachnoid cap cells of the arachnoid villi[4] compressing the brain.[5] Although the majority of meningiomas are benign, a small subset exhibits aggressive behaviour.[2]

Intracranial meningiomas are most common in adults from 4^{th} to 6^{th} decades of life and rare in children.[6] In adults they are more common in female (female: male- 3:2 to 2:1)[7] but atypical and anaplastic subtypes are more common in male.[8] In children and adolescent, there is no sex predominance with a tendency for more aggressive subtypes and commonly associated with neurofibromatosis type 2 (NF-2).[9,10]

They can arise from dura at any site, most commonly the skull vault, and base (planum sphenoidale, sphenoid wing, petrous ridge

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cavernous sinus, perisellar region and clivus) and at dural reflexions (falx cerebri, tentorium cerebella and dura of adjacent venous sinuses), less commonly optic nerve sheath and choroid plexus. 10% of meningiomas arise outside the craniospinal axis.[11,12]

According to the WHO classification, meningiomas are of three types - benign (grade I - 90%), atypical (Grade II- 7%) and anaplastic (Grade III- 2%).[13] The classification is based on number of mitosis, cellurarity, nuclear to cytoplasmic ratio, histologic pattern, growth pattern and risk of reference of the tumour.[14]

The clinical presentations are nonspecific[15] and depend on tumour location.[16] 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.[17] Common symptoms are headache with blurred vision, seizure disorder, and loss of consciousness, etc.[15]

Imaging techniques play an integral role in management of intracranial lesions.[18] In conjunction with contrast media (gadolinium diethylene triamine penta- acetic acid), MRI may be a sensitive modality for detection and characterization of meningiomas.[1] Although not a substitute for angiography, MRI does allow assessment of venous patency as well as tumour encasement or occlusion of vascular structures[1] and superior soft tissue resolution[19] offer a clear advantage over CT scanning. In MR imaging, intracranial meningiomas appear as sharply circumscribed spherical or lobulated or en plaque lesions showing slightly hypointensity on T1WI and T2WI with a minority of lesions slightly hyperintensity on T2WI. On FLAIR, they show hyperintensity. After intravenous contrast administration, the lesions enhance dense and homogeneous fashion and show 'dural tail' sign.[20] The characteristic MRI findings involve cortical buckling, CSF cleft and broad base contact against the dural surface, pseudo capsule of displaced vessels of subarachnoid space, secondary intra-axial vasogenic edema and dural tail sign.[21] Using these characteristic features MRI has sensitivity and specificity of 98% and 97% respectively.[22] The accuracy of diagnosis of meningiomas on MRI was 95.2%.[23]

Objective:
To evaluate the diagnostic performance of Conventional Magnetic Resonance Imaging (MRI) in the diagnosis of intracranial meningioma in terms of sensitivity, specificity, positive predictive value, negative predictive value and accuracy.

Materials and Methods:
This cross sectional study was carried out in the Department of Radiology and Imaging of Sir Salimullah Medical College & Mitford hospital (SSMC & MH) and National Institute of Neurosciences Hospital (NINS & H), Dhaka during the period of January 2017 to December 2018 among patients of clinically suspected intracranial space occupying lesions referred from respective departments of neurosurgery for MRI. Patients with suspected intracranial space occupying lesion (ICSOL) and had the MRI done were selected irrespective of age and gender. Patients with extra-axial tumours who underwent surgery & had the histopathology reports available were ultimately included in the study. Finally, 61 patients were available for analysis. Purposive sampling method was used.

MRI scanning technique:
MRI was done with 1.5 Tesla MRI machine. Slice thickness of 05 mm was taken with an intersection gap 04 mm. In the scanning protocol T1W axial, T2W axial, T2W coronal and T2W sagittal, FLAIR axial and Post contrast T1W images using Gd-DPTA as the IV contrast were taken.

Diagnostic criteria of MRI of intracranial meningioma:[24]

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.
- 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.
- 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.
- Presence of necrosis.

Post contrast MRI appearances of atypical meningioma is-
- Heterogeneous contrast enhancement.

Data Collection and Statistical Analysis of Data: After taking permission from relevant authority and written consent of the patients and their attendants data were collected and recorded and statistical analyses were performed by using the Statistical package for Social Science (SPSS) version 16.0 for Windows.

Results:
A total 61 patients with extra-axial brain tumour in MRI were studied from January 2017 to December 2018.

Their age ranged between 31 to 68 years with mean age of 53.05 years and SD of 9.58. The male to female ratio was 2.39:01.

In this study the commonest presenting symptom was headache 55(90.16%) followed by vertigo 37 (60.66%), paresthesia 34 (55.74%), vomiting 25 (40.98%), seizure (focal/generalized) 12 (19.67%), visual impairment 11 (18.03%), altered level of consciousness 07 (11.46%), hearing impairment 04 (6.56%) while the least was loss of smell 02 (3.28%).

Among 61 patients the supratentorial localization of tumours was reported in 53 (86.89%) and infratentorial was in 08 (13.11%) patients. Sites of tumours were parasagittal in 23 (37.71%), convexity region in 15 (24.59%), sella and suprasella region in 08 (13.11%), sphenoid wing 05 (8.2%), olfactory groove in 02 (3.28%), cerebellopontine angle in 06 (9.83%), posterior fossa tentorial region in 02 (3.28%) subjects in the present study.

Table I
Distribution of study subjects according to the margin of the lesions (n=61)

Tumour margin	Frequency (n)	Percentage (%)
Well defined	58	95.08
Ill defined	03	4.92
Total	61	100

Table II
Distribution of study subjects according to MRI signal intensity of the lesions (n=61)

Signal intensity	Frequency* (n)	Percentage* (%)
T1WI		
Iso	46	75.41
Hypo	15	24.59
T2WI		
Hyper	42	68.85
Iso	15	24.59
Hypo	04	6.56
FLAIR		
Hyper	55	90.16
Iso	06	9.84

* Multiple response

Table III
Distribution of study subjects according to the characters of contrast enhancement by the lesions (n=61)

Characters of contrast enhancement	Frequency* (n)	Percentage* (%)
Nature of enhancement		
Homogeneous	47	77.05
Heterogeneous	14	22.95
Degree of enhancement		
Intense	52	85.25
Moderate	09	14.75
Dural tail sign	47	77.05

* Multiple response

Table IV

Distribution of study subjects according to the extra-axial signs displayed by the lesions on MRI study (n=61)

Features	Frequency* (n)	Percentage* (%)
Broad dural base	53	86.89
White matter buckling	44	72.13
CSF cleft	38	62.30

* Multiple response

Table V

Distribution of study subjects according to the perilesional oedema (n=61)

Perilesional oedema	Frequency (n)	Percentage (%)
Present	19	31.15
Absent	42	68.85
Total	61	100

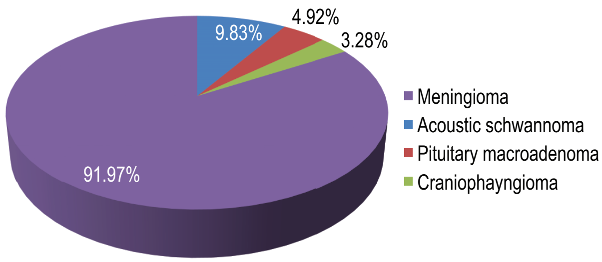

Fig 1: *Showing percentages of Intra cranial extra axial tumors distribution by our MRI study.*

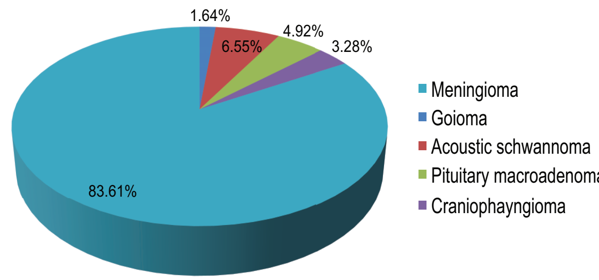

Fig 2: *Showing percentages of Histopathological diagnosis of Intra cranial extra axial tumors in study.*

Table VI

Comparison of MRI diagnosis with histopathological diagnosis of the lesions in patients under the present study

MRI diagnosis	Histopathological diagnosis		Total
	Meningioma	Other than meningioma	
Meningioma	49 (TP)	01 (FP)	50
Other than meningioma	02 (FN)	09 (TN)	11
Total	51	10	61

TP- True Positive, TN- True Negative, FP- False Positive, FN- False Negative

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.

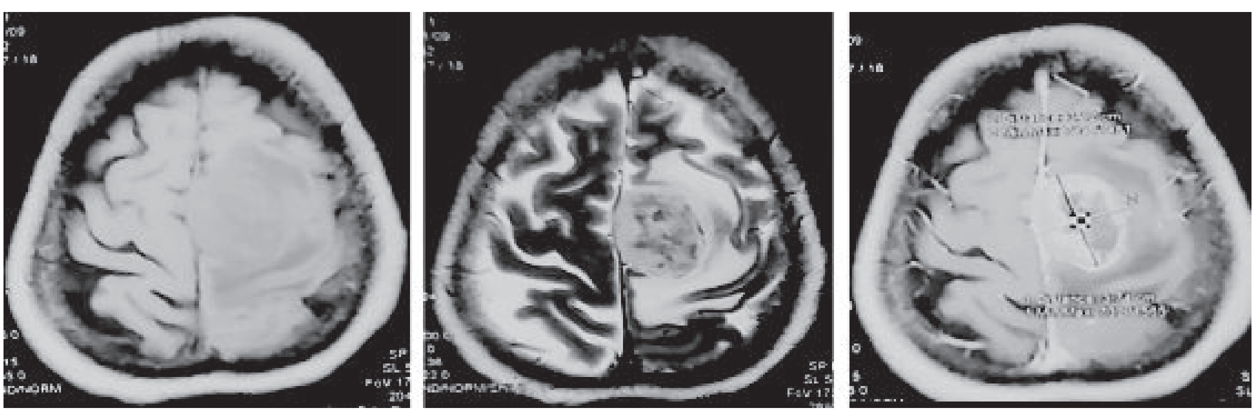

Fig 3a(Left image): *showing Hypo intense lesion on T1W pre contrast axial MR image of left para sagittal meningioma and* **3b(middle image):** *showing the lesion as hyper intense on T2W image and* **Fig 3c(Right image):** *Showing strong heterogeneous enhancement of the lesion.*

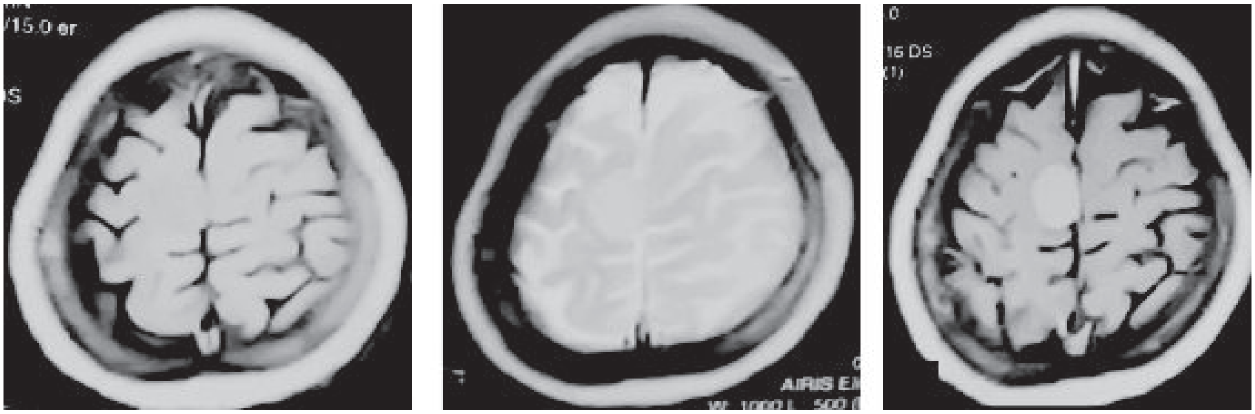

Fig 4a (Left image): *Showing a right para sagittal meningioma as Iso to hypointense lesion on T1W pre contrast axial image and* **4b (Middle image):** *showing same lesion as hyperintense in T2WI.* **Fig 4c (Right image):** *Showing intense homogeneous enhancement in axial section.*

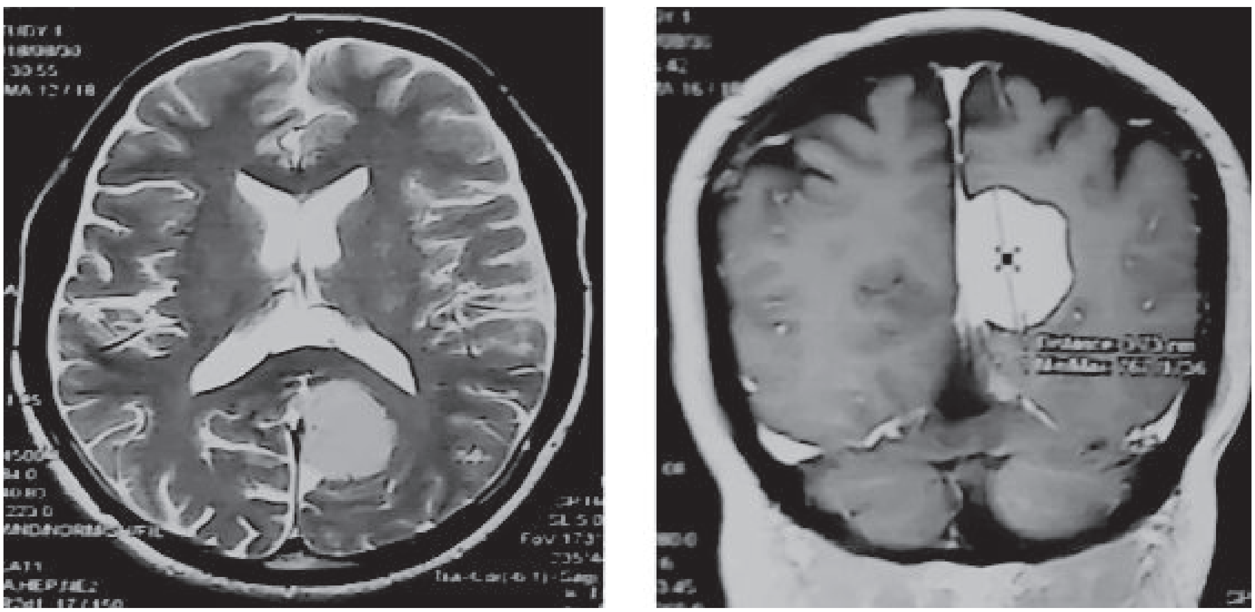

Fig 5a: *Showing a left para sagittal meningioma which was hyper intense in T2W axial image &* **5b:** *The same lesion showing intense enhancement on T1W post contrast coronal image.*

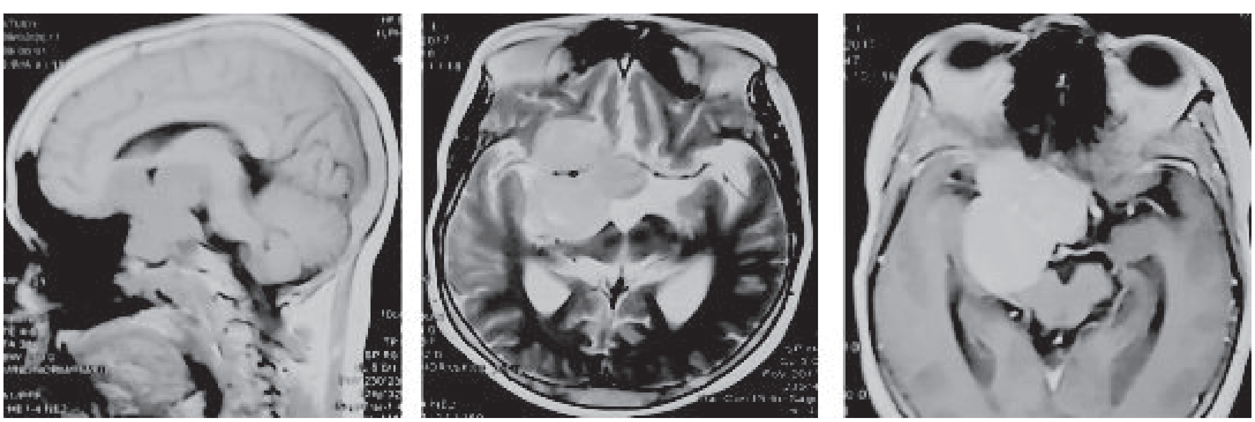

Fig 6a (Left image): *Showing a subfrontal meningioma which presented as a lobulated hypo intense lesion in T1W pre contrast sagittal image &* **6b (middle image):** *which was hyper intense on T2W axial Image.* **Fig 6c (Right image):** *Showing intense enhancement of the same lobulated subfrontal meningioma.*

Discussion:

The aim of the present study was to establish efficacy of conventional MRI in detection of intracranial meningioma.

The mean age was 53.05 ± 9.58 years, with female to male ratio 2.39:1. In the study of Yan et al. the mean age was 52.89 ± 9 years and female to male ratio was 2.36.[2]

The most common complaint was headache 90.16% followed by vertigo 60.66%. Similar observations were made by Moussa and Naggar. They found the commonest clinical manifestation was headache (75%).[4]

This study revealed meningiomas significantly occupied supratentorial localization in 86.89% cases compared to infratentorial localization in 13.11%. This finding is supported by Gangadhar et al.[25]

In this study meningiomas were common in parasagittal (37.71%) and convexity (24.59%) regions which was also supported by studies done by Hadidy et al.[21] and Stefanoviæ et al[5].

Considering tumour margin, we observed that 95.08% tumours had well defined margin. Gangadhar el al[25] reported well defined margin in 85% of cases.which is close to present study.

In current study meningiomas showed isointensity in 80% and hypointensity in 20% on T1WI, isointensity in 80% & hyperintensity in 20% cases on T2WI and FLAIR. These observations were consistent with observations of Stefanoviæ et al.[5]

The present study showed intense enhancement in 85.25% of tumours which goes with findings of Stefanoviæ et al.[5] Our study showed homogeneous enhancement in 77.05% of tumours which is in agreement with the results of Gangadhar et al.[25]

In this study dural tail was present in 77.05% of cases. A study done by O'Leary et al. revealed dural tail in 72%.[19] This finding was in agreement with present study.

Regarding the extra-axial signs displayed by meningiomas on MRI study, current study revealed white matter buckling in 72.13% and CSF cleft in 62.3% cases & 86.89% cases displayed broad dural base which were supported by Gangadhar et al[25]. In the present series peritumoural edema was found in about one third (31.15%) of meningiomas which defer from findings of Gangadhar et al.[25] They reported peritumoural edema in two third (65.1%) cases.

In the current work, 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 which is comparable to study done by Pouratian et al.[22] They found sensitivity and specificity of MRI to be 98% and 97% respectively. Huang et al.[23] reported that the correct rate of diagnosis was 95.2% which goes with present study.

Conclusion:

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 in our study. 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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