ISSN: 2663-9491 e-ISSN: 2789-6897

# Prediction of the consistency of intracranial meningioma by MRI: Correlation with peroperative finding

**Muhammad Shahriar Kabir[1], Mohammed Hasnayen Faisal[2*], Tammana Zahan[3]**

**Received:** 2 June 2026
**Accepted:** 15 June 2026
**Published Online:** 18 June 2026

**Published by:**
Gopalganj Medical College, Gopalganj, Bangladesh

*Corresponding Author

**DOI:** 10.5281/zenodo.20741314



***ABSTRACT***

***Background:*** *Meningiomas constitute 13–26% of primary intracranial tumors and commonly occur in the fourth to sixth decades of life, with a female-to-male ratio of approximately 1.8:1. Preoperative prediction of tumor consistency aids neurosurgeons in planning the surgical approach and anticipating technical challenges. The aim of this study was to evaluate the correlation between T2-weighted MRI signal intensity and the peroperative consistency of intracranial meningiomas.* ***Methods & Materials:*** *This study involved 31 patients with MRI-confirmed intracranial meningiomas. T2-weighted MRI signal intensity was categorized as isointense, hypointense, or hyperintense compared to cortical gray matter, with hyperintense tumors predicted as soft and iso-/hypointense tumors as firm. Intraoperative tumor consistency was classified as soft or firm based on surgical handling. The study assessed correlation, agreement, and diagnostic performance of MRI in predicting tumor consistency.* ***Results:*** *T2-weighted MRI showed 18 isointense, 1 hypointense, and 12 hyperintense tumors. Peroperatively, 19 tumors were firm and 12 softs. Iso/hypointense tumors predicted as firm were confirmed in 17/19 cases, while 10/12 hyperintense tumors predicted as soft were confirmed. Correlation between MRI signal intensity and tumor consistency was significant ($p < 0.001$). Agreement analysis showed a Kappa value of 0.6 (fair agreement). For predicting firm tumors, MRI sensitivity was 90%, specificity 83.3%, positive predictive value 89.5%, negative predictive value 83.3%, and accuracy 87%. For soft tumors, sensitivity was 83.3%, specificity 89.5%, PPV 83.3%, NPV 89.5%, and accuracy 87%.* ***Conclusion:*** *T2-weighted MRI can reliably predict meningioma consistency, with hyperintense tumors likely soft and iso- or hypointense tumors likely firm, aiding preoperative surgical planning.*

***Keywords:*** *Intracranial meningioma, T2-weighted MRI, Tumor consistency, Preoperative assessment, Surgical planning.*

*(The Insight 2026; 9(2): 466-470)*

1. *Assistant Professor, Department of Neurosurgery, Dhaka Medical College, Dhaka, Bangladesh (ORCID: 0009-0003-4302-212X)*
2. *Classified Specialist, Department of Neurosurgery, Combined Military Hospital, Dhaka, Bangladesh (ORCID: 0009-0006-2327-3740)*
3. *Consultant, Department of Radiology, Holy Family Red Crescent Medical College, Dhaka, Bangladesh (ORCID: 0009-0008-9560-4208)*

## INTRODUCTION

Meningiomas, first described by Harvey Cushing in 1922, are the most common benign tumors of the meninges and account for approximately 13–26% of primary intracranial tumors, with an annual incidence of nearly 6 per 100,000 population [1,2]. They occur most frequently in the fourth to sixth decades of life, with a female-to-male ratio of about 1.8:1 [3]. In contrast, pediatric cases are rare, comprising only 1–4% of brain tumors, with no sex predilection [4].

The majority of meningiomas are benign (>90%), though 5% are atypical and 3–5% malignant [5]. Most lesions are supratentorial, while only 8–10% occur in the posterior fossa. Clinical manifestations vary depending on tumor size and location and include headache, seizures, focal neurological deficits, and cranial nerve dysfunction [5]. Meningiomas may develop at any site containing arachnoid cells, most commonly near arachnoid granulations, and are thought to arise due to hormonal, genetic, infectious, or traumatic influences [4].

Diagnosis is largely based on neuroimaging. MRI is superior to CT in detecting characteristic features such as morphology, dural attachment, and ancillary findings including calcification, hyperostosis, or vascular encasement [6]. Meningiomas may appear sessile, pedunculated, or en plaque, with their growth pattern influencing surgical difficulty. Histologically, the World Health Organization (WHO) classifies them as benign, atypical, or malignant, while earlier systems described transitional, fibroblastic, syncytial, and angioblastic subtypes [7].

Surgical resection is the treatment of choice, with complete removal reducing recurrence risk and improving patient outcomes. Preoperative assessment of tumor consistency is particularly important, as firm tumors are often associated with longer operative times, greater technical difficulty, and higher risk of complications. Therefore, this study aimed to assess the association between T2 weighted image inference of MRI and peroperative findings regarding consistency of intracranial meningiomas.

## METHODS & MATERIALS

### Study design and setting

This cross-sectional study was conducted in the Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, from June 2009 to November 2010.

### Sampling and participants

Purposive sampling was applied. Patients diagnosed with intracranial meningioma on MRI who subsequently underwent surgical resection were included. Patients whose histopathological findings were not consistent with meningioma were excluded.

### Sample size calculation

The sample size was determined considering the proportion of patients with meningiomas showing soft consistency on MRI

(66%) and the proportion found to have soft consistency intraoperatively (46%). Using a 5% level of significance ($Z\alpha$ = 1.96) and 80% statistical power ($Z\beta$ = 0.85), the required sample size was calculated to be approximately 90 patients [8]. However, due to study constraints and patient availability, data were ultimately collected from 31 participants.

**Study procedure**

Meningioma was diagnosed on MRI based on morphology, signal intensity, enhancement pattern, and ancillary features such as hyperostosis, calcification, or vascular encasement [6]. For the purpose of this study, only homogeneous parenchymal signal on T2-weighted images was evaluated, while areas of inhomogeneity due to calcification, necrosis, cystic changes, vascularity, or hemorrhage were excluded.

On T2-weighted MRI, tumor signal intensity was graded as hypointense, isointense, or hyperintense relative to cortical gray matter. It was hypothesized that hyperintense tumors were more likely to be soft, whereas hypo/isointense tumors were firm.

Intraoperative tumor consistency was classified as:

- **Soft**: easily excised with suction
- **Firm**: required sharp dissection for removal

**Data management and statistical analysis**

Data were checked manually for consistency and completeness. Statistical analyses included Chi-square test, agreement test, and diagnostic performance evaluation of MRI findings against intraoperative assessment. A p-value <0.05 was considered statistically significant.

**Ethical considerations**

Ethical clearance was obtained from the Department of Neurosurgery and the Institutional Review Board of BSMMU. Permissions were also secured from other hospitals from which patients were recruited. Written informed consent was obtained from all participants after explaining the study objectives, potential benefits, and risks. Confidentiality and the right to withdraw at any time were ensured.

## RESULTS

*Table I* summarizes the demographic characteristics and presenting complaints of the study subjects. The mean age was 40.8 years (range 23–65), with a female predominance (71%). The most common presenting symptom was headache (80.6%), followed by disturbance of vision (52.6%), weakness of limbs (45.1%), vomiting (38.7%), and convulsions (19.3%).

**Table I: Demographic characteristics and presenting complaints of study subjects (*n* = 31).**

| Characteristic / Complaint | Frequency | Percentage (%) |
|---|---|---|
| Age (years) | | |
| Mean (range) | 40.8 (23–65) | – |
| Sex | | |
| Male | 9 | 29 |
| Female | 22 | 71 |
| Presenting complaints | | |
| Headache | 25 | 80.6 |
| Vomiting | 12 | 38.7 |
| Convulsion | 6 | 19.3 |
| Disturbance of vision | 16 | 52.6 |
| Weakness of limbs | 14 | 45.1 |

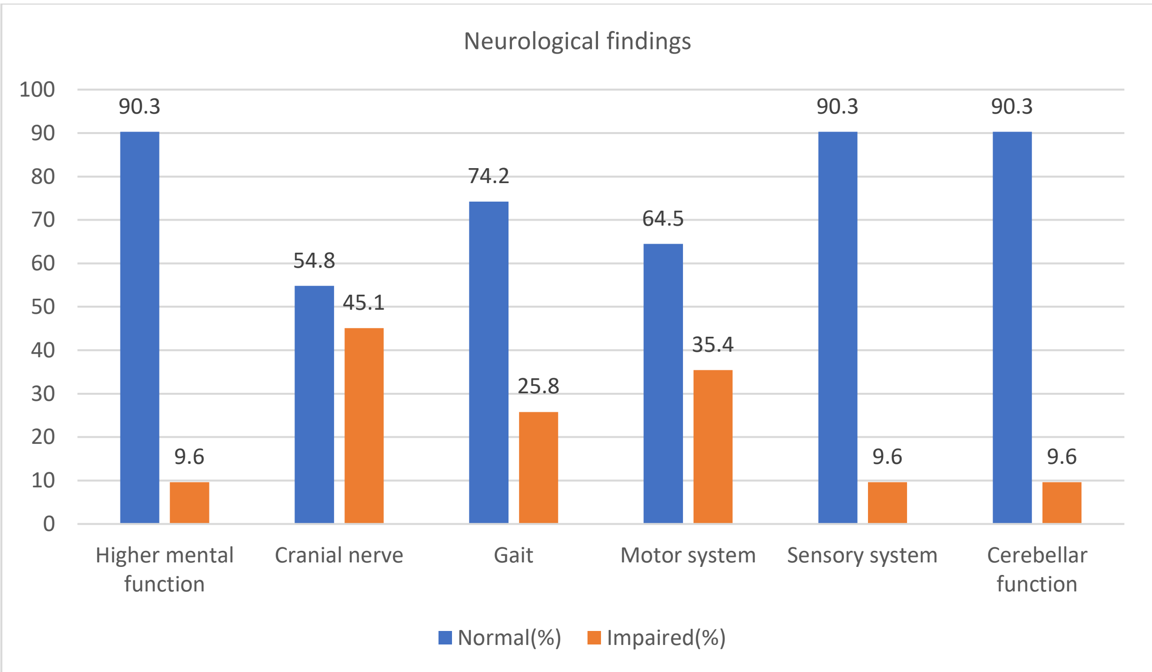


**Figure 1: Neurological findings of study subjects.**

*Figure 1* show the neurological findings, higher mental function impaired in 3(9.6%), cranial nerve abnormalities in 17(54.8%), motor system that is weak in 20(64.5 %), gait disturbance in 23(74.2%), impaired cerebellar function in 3(9.6%) patients.

*Table II* shows the location of meningiomas, convexity meningiomas shows frequency of 10(32.2%), falcine shows 6(19.3%), parasagittal shows 2(6.4) and cerebellopontine angle shows 4(12.9%) out of 31 study subjects.

**Table II: Location of meningioma of study subjects.**

| Location | Frequency | Percentage (%) |
|---|---|---|
| Convexity (frontal, parietal, temporal, occipital) | 10 | 32.2 |
| Falcine | 6 | 19.3 |
| Parasagittal | 2 | 6.4 |
| Cerebellopontine angle | 4 | 12.9 |
| Spheno-orbital | 2 | 6.4 |
| Sphenoid wing | 2 | 6.4 |
| Suprasellar | 2 | 6.4 |
| Foramen magnum | 1 | 3.2 |
| Olfactory groove | 1 | 3.2 |
| Tentorial | 1 | 3.2 |

*Table III* shows the distribution of meningioma signal intensity on T2-weighted MRI and the corresponding intraoperative tumor consistency. On MRI, 58% of tumors were isointense and 3.2% hypointense (both considered firm), while 38.7% were hyperintense (considered soft). When grouped into a 2×2 classification, 61.3% were iso/hypointense (firm) and 38.7% hyperintense (soft). Peroperative assessment showed 61.3% of tumors were firm and 38.7% soft, consistent with MRI predictions.

**Table III: Distribution of meningioma signal intensity on T2-weighted MRI and peroperative consistency (*n* = 31).**

| MRI Intensity / Consistency | Frequency | Percentage (%) |
|---|---|---|
| T2-weighted MRI intensity | | |
| Isointense (firm) | 18 | 58 |
| Hypointense (firm) | 1 | 3.2 |
| Hyperintense (soft) | 12 | 38.7 |
| Combined MRI classification | | |
| Iso/Hypointense (firm) | 19 | 61.3 |
| Hyperintense (soft) | 12 | 38.7 |
| Peroperative consistency | | |
| Firm | 19 | 61.3 |
| Soft | 12 | 38.7 |

*Table IV* shows the correlation between T2-weighted MRI signal intensity and the peroperative consistency of meningiomas. Among tumors that appeared isointense on T2-weighted images, 16 out of 18 (88.8%) were found to be firm intraoperatively, while only 2 (11.1%) were soft. The single hypointense tumor was firm (100%). In contrast, among hyperintense tumors, the majority (10 out of 12, 83.3%) were soft, and only 2 (16.7%) were firm during surgery. The overall distribution demonstrates a statistically significant correlation between T2-weighted MRI intensity and tumor consistency (p < 0.01, Chi-square test), indicating that hyperintense tumors on T2-weighted MRI are more likely to be soft, whereas iso/hypointense tumors are more likely to be firm.

**Table IV: Correlation between $T_2$ weighted image and peroperative finding consistency.**

| | Peroperative finding | | | |
|---|---|---|---|---|
| T2 weighted MRI | Firm No. (%) | Soft No. (%) | Total No. (%) | p value |
| Isointense (firm) | 16 (88.8) | 2 (11.1) | 18 (58) | < 0.01 |
| Hypointense (firm) | 1 (100) | | 1 (3.2) | |
| Hyperintense (soft) | 2 (16.7) | 10 (83.3) | 12 (38.7) | |
| Total | 19 | 12 | 31 | |

*Chi-square test was done as the test of significance.*

*Table V* shows the Kappa value of 0.6 indicates fair agreement between T2-weighted MRI signal intensity and intraoperative tumor consistency, suggesting MRI can moderately predict meningioma firmness or softness.

ISSN: 2663-9491 e-ISSN: 2789-6897

**Table V: Agreement between T2-weighted MRI and peroperative tumor consistency.**

| MRI Intensity | Peroperative Findings | Total | Kappa Value | Comment |
|---|---|---|---|---|
| | Firm | Soft | | |
| Iso/Hypointense (firm) | 17 | 2 | 19 | 0.6 |
| Hyperintense (soft) | 2 | 10 | 12 | |
| Total | 19 | 12 | 31 | |

*Table VI* shows Iso/hypointense tumors on T2-weighted MRI accurately predicted firm consistency in 90% of cases, with high specificity and overall diagnostic accuracy of 87%.

**Table VI: Diagnostic performance of MRI for prediction of firm consistency.**

| MRI Intensity | Peroperative Finding | Total |
|---|---|---|
| | Firm | Soft |
| Iso/Hypointense (firm) | 17 | 2 |
| Hyperintense (soft) | 2 | 10 |
| Total | 19 | 12 |

**Performance metrics for firm consistency:**

- Sensitivity: 90%
- Specificity: 83.3%
- Positive Predictive Value (PPV): 89.5%
- Negative Predictive Value (NPV): 83.3%
- Accuracy: 87%

*Table VII* presents hyperintense tumors on T2-weighted MRI predicted soft consistency with 83.3% sensitivity and 89.5% specificity, showing that MRI is a reliable tool for preoperative assessment of tumor consistency.

**Table VII: Diagnostic performance of MRI for prediction of soft consistency.**

| MRI Intensity | Peroperative Finding | Total |
|---|---|---|
| | Soft | Firm |
| Hyperintense (soft) | 10 | 2 |
| Iso/Hypointense (firm) | 2 | 17 |
| Total | 12 | 19 |

**Performance metrics for soft consistency:**

- Sensitivity: 83.3%
- Specificity: 89.5%
- Positive Predictive Value (PPV): 83.3%
- Negative Predictive Value (NPV): 89.5%
- Accuracy: 87%

## DISCUSSION

Meningiomas are primary tumors that are thought to arise from the arachnoid cap cell of the meninges [5]. Demaerel et al. [9] states that meningioma is the most common benign intracranial tumor. In this study, mean age of the study subjects was 40.8 yrs, age range was 23 to 65 yrs. Carpeggiani et al. [10] found age range 23 to 74 yrs, mean age 55.2 yrs. Average age observed by Alvarez et al. [11] was 50yrs. Moradi et al. [5] study shows the mean age of the patients with meningiomas as 49.11 ± 12.99 yrs. The peak incidence of age in this subcontinent is in 4th decade that varies from western literature [12].

The present study showed presenting complaints of study subjects as headache 80.6%, disturbance of vision 52.6%, weakness of limbs 45.1%, vomiting 38.7% and convulsion 19.3%. The occurrence of seizures as a presenting symptom may be consequent in the predilection of meningiomas for the cerebral convexity [13].

Moradi et al. [5] shows the presenting complaints as headache 66.7%, epilepsy 28.5%, motor sensory deficit 30% and cranial nerve involvement19%. The MRI appearances of intracranial meningiomas have been extensively investigated and attempts to correlate signal intensity with consistency have given differing results. The correlation of signal intensity on MR Imaging brain and meningioma consistency remains controversial. Suzuki et al. [14] shows a significant correlation between T2weighted image and meningioma consistency, which corresponded with my results however others have reported no significant correlation.

Suzuki et al. [14] states that the lower the intensity on T2 weighted images, the harder the consistency of the tumor. The hard character of these tumors probably derives from a high proportion of fibrous or calcified tissues.

In this study, nineteen intracranial meningiomas predicted by T2 weighted MR Image to be firm, showed seventeen firm and two softs in consistency peroperatively. Twelve meningiomas predicted by T2 weighted MRI to be soft, showed ten soft and two firm peroperatively. This represented sensitivity 90%, specificity 89.5%, positive predictive value 83.3% and accuracy 87% for prediction of firm consistency by T2 weighted MRI.

Twelve intracranial meningiomas predicted to be soft showed ten soft and two firm in consistency peroperatively. Nineteen intracranial meningiomas predicted to be firm showed two soft and seventeen firm peroperatively. This represents sensitivity 83.3%, specificity 89.5%, positive predictive value 83.3%, negative predictive value 89.5%, accuracy 87% for the prediction of soft consistency by T2 weighted MRI. These findings suggest that T2-weighted MRI can reliably predict the consistency of intracranial meningiomas, providing valuable preoperative information to guide surgical planning and anticipate technical challenges.

## CONCLUSION

Consistency of meningiomas can be predicted from T2 weighted MRI of brain. Hypo and isointense tumors are firm and hyperintense tumors are soft in consistency. Prediction of consistency of intracranial meningiomas by T2 weighted MRI is very useful for the neurosurgeons in providing optimal surgical

ISSN: 2663-9491 e-ISSN: 2789-6897

care. More precise quantification of tumor consistency helps in preoperative planning of meningioma surgery. Therefore, all patients with intracranial meningioma should have a MRI of brain done for optimal surgical outcome.

## REFERENCES


1. *Al-Rodhan RF, Laws ER. The history of intracranial meningiomas. Meningiomas. New York: Raven Press, Ltd. 1991:1-6.*
2. *Kleihues P, Cavenee WK, editors. Pathology and genetics of tumours of the nervous system. International Agency for Research on Cancer; 1997.*
3. *Claus EB, Bondy ML, Schildkraut JM, Wiemels JL, Wrensch M, Black PM. Epidemiology of intracranial meningioma. Neurosurgery. 2005 Dec 1;57(6):1088-95.*
4. *D'Ambrosio AL, Bruce JN. Treatment of meningioma: an update. Current Neurology and Neuroscience Reports. 2003 Jun;3(3):206-14.*
5. *Moradi A, Semnani V, Djam H, Tajodini A, Zali AR, Ghaemi K, Nikzad N, Madani-Civi M. Pathodiagnostic parameters for meningioma grading. Journal of Clinical Neuroscience. 2008 Dec 1;15(12):1370-5.*
6. *Zimmerman RD. MRI of intracranial meningiomas. Meningiomas. 1991:209-23.*
7. *Maiuri F, İaconetta G, De Divitiis O, Cirillo S, Di Salle F, De Caro ML. Intracranial meningiomas: correlations between MR imaging and histology. European journal of radiology. 1999 Jul 1;31(1):69-75.*
8. *Yamaguchi N, Kawase T, Sagoh M, Ohira T, Shiga H, Toya S. Prediction of consistency of meningiomas with preoperative magnetic resonance imaging. Surgical neurology. 1997 Dec 1;48(6):579-83.*
9. *Demaerel P, Wilms G, Lammens M, Marchal G, Plets C, Goffin J, Baert AL. Intracranial meningiomas: correlation between MR imaging and histology in fifty patients. Journal of computer assisted tomography. 1991 Jan 1;15(1):45-51.*
10. *Carpeggiani P, Crisi G, Trevisan C. MRI of intracranial meningiomas: correlations with histology and physical consistency. Neuroradiology. 1993 Aug;35(7):532-6.*
11. *Alvarez F, Roda JM, Romero MP, Morales C, Sarmiento MA, Blázquez MG. Malignant and atypical meningiomas: a reappraisal of clinical, histological, and computed tomographic features. Neurosurgery. 1987 May 1;20(5):688-94.*
12. *Misra BK. Intracranial meningioma. In: Ramamurthi B, editor. Textbook of Neurosurgery. 2nd ed. New Delhi: Churchill Livingstone; 1996. Vol. 2. p. 1077–1087.*
13. *Rohringer M, Sutherland GR, Louw DF, Sima AA. Incidence and clinicopathological features of meningioma. Journal of neurosurgery. 1989 Nov 1;71(5):665-72.*
14. *Suzuki Y, Sugimoto T, Shibuya M, Sugita K, Patel SJ. Meningiomas: correlation between MRI characteristics and operative findings including consistency. Acta neurochirurgica. 1994 Mar;129(1):39-46.*