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MRI PATTERNS OF INTRACRANIAL MENINGIOMAS CORRELATING WITH HISTOLOGICAL FINDINGS

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ABSTRACT

Background: Brain tumors are explored by radiology, which involves an MRI brain with and without contrast to reveal the nature, location, and size of the lesion. MRI is the preferred procedure for the initial evaluation of patients suspected of having intracranial lesions because of its wide availability, enhanced contrast activity, multiplanar capability without ionizing radiation, in any desired plane of section without requiring the patient to change position, and without bony artifact. **Objectives:** Is to evaluate the role of MRI in defining the characteristic patterns of intracranial meningiomas. And to correlate MRI with the histopathological findings in an attempt to predict the histological diagnosis prior to surgery. **Methods:** In this cross-sectional study fifty patients (17 males and 33 females) with an age ranging from 20-69 years which were studied at Ghazi Al Hariri Surgical Hospital on a period between October 2022 and September 2023. The questionnaire form was composed from two sections, section one for demographic information of the study participants. While section two for MRI findings. The study was performed on magnetic resonance imaging (MRI) of surgical and biopsy varied intracranial meningiomas in (50) patients (17 males) and (34 females) in an attempt to predict the MRI patterns of each histological types of meningioma. Pre-and post-contrast, sagittal and axial T1- weighted images with Gd-DTPA and a sagittal T2 weighted fast spin echo was done, the MRI were evaluated in regard to location, laterality of the tumor, signal intensity, contrast homogeneity, presence of meningiomas cleft sign, cystic changes, vascularity, mass effect and any other pathological observations (calcification , edema , bony or dural venous sinus invasion sign). **Results:** The study found that the most prevalent age groups were 40-49 and 50-59 years. histopathological examination confirmed the diagnosis of benign tumors among 44 (88%) patients, atypical tumors in in 4 (8%) patients, and malignant meningiomas in 2 (4%) patients only. In regards to the tumor location, cerebral convexity location was found in 17 (34%) patients, parasagittal in 11(22%) patients, Sphenoid ridge was seen in 6(12%) patients, olfactory groove 4 (8%) patients, suprasellar and cerebellar convexity each one of them having 3 (6%) patients, cerebellopontine angle (C.P.A) and intraventricular location in 2 (4%) patients for each, while the tentorium and cavernous sinus area locations shared 1 (2%) patient for each. Tumor sizes ranged roughly from (1.2 × 1.5 ×1 cm to 4.5 × 7.5 × 9.7 cm) in the anteroposterior, transverse and vertical dimensions. The sites of tumor encountered in both sides of brain, 27 (54%) patients having tumor in the right side, 16 (32%) patients having tumor in the left side and 7 (14%) patients having tumor at the central site. The two cases of intraventricular meningiomas were on in each lateral ventricle (4%). that most meningiomas showed isointense signal intensity on both T1 and T2 weighted images, in other word; 44 (88%) patients in T1 and 38 (76%) patients in T2 respectively. Moreover; most of the patients 41 (82%) had homogenous texture. 38 (76%) patients of tumors had positive meningioma cleft on MRI, while 16 (32%) patients had calcifications, just 5 (10%) patients had cystic changes and only 18 (36%) patients had avascular cellularity in MRI. eleven (22%) patients of meningiomas were not surrounded by edema, while, 25 (50%) patients had mild (+) degree, 8 (16%) patients had moderate (++) degree & 6 (12%) patients had marked (+++) degree of edema. Lastly; 41 (82%) patients had homogenous enhancement with contrast media while the heterogenous enhancement was occurred in 9 (18%) patients. Moreover; only 32 (64%) patients had dural tail enhancement. **Conclusion:** Overall, MRI is an effective non-invasive method for preoperative assessment of intracranial meningiomas, and it may accurately predict the aggressive behavior of more unusual and malignant meningiomas. This study found a lower rate of atypical and malignant meningiomas than other similar studies. Other findings are comparable to those reported in earlier studies on intracranial meningiomas.

KEYWORDS: Intracranial meningioma, Magnetic resonance imaging.

1- INTRODUCTION

The term "intracranial tumor" refers to both benign and malignant tumors that arise in intracranial tissues and meninges.[1] Brain tumors have been divided into infratentorial and supratentorial brain tumors according to their location.[2] Clinical manifestations of supratentorial tumors include elevated intracranial pressure (ICP) (headache and vomiting), seizures, progressive neurological deficits (limb weakness, dysphasia, etc.), changes in mental status, and, in the case of pituitary tumors, symptoms resulting from endocrine disruptions, visual field defects, CSF leak, etc.[3-4] Infratentorial tumors exhibit signs and symptoms of a high ICP caused by hydrocephalus, such as difficulty walking, dizziness, double vision, palsies of the lower cranial nerves, etc.[3-6] The majority of pediatric brain tumors are infratentorial, and they are divided equally between medulloblastomas, cerebellar astrocytomas, and brainstem gliomas.[7] The most prevalent benign posterior fossa tumors in children are pilocytic astrocytomas.[8] Patients with infratentorial tumors may also have altered level of consciousness as a result of compression, direct brainstem involvement, or hydrocephalus.[7-9]

Typically, brain tumors are explored by radiology, which involves an MRI brain with and without contrast to reveal the nature, location, and size of the lesion.[10] A CT scan of the brain with 3D reconstruction is conducted to examine normal sinus structure, bone hyperostosis and erosions.[11] Depending on the results of these radiological studies, more workup is performed. Following thorough preoperative testing, these tumors are either surgically or radiotherapy-treated.[12] If surgery is chosen for a specific tumor, the tumor is either partially or completely excised, depending on the involvement of surrounding structures.[13] Patients are then treated further based on histopathology. Preoperative radiological examinations are used to assist surgical planning, which is then linked with histology to inform the patient's prognosis and subsequent therapy.[15]

MRI has quickly advanced from a technique with a lot of promise to one that is now the main, and sometimes the only, diagnostic technique needed for many medical problems.[16] MRI is the preferred procedure for the initial evaluation of patients suspected of having intracranial lesions because of its wide availability, enhanced contrast activity, multiplanar capability without ionizing radiation, in any desired plane of section without requiring the patient to change position, and without bony artifact.[17] Since high-field-strength imaging has been developed, it has been clear that MRI is generally more informative than other imaging techniques when it comes to the visualization and thorough characterization of extra-axial masses.[18]

The purpose of this study was to assess the role of MRI in identifying the distinctive patterns of intracranial meningiomas. And to compare MRI results with histopathology findings in order to anticipate the histology diagnosis before surgery.

2-PATIENTS AND METHODS

In this cross-sectional study, fifty patients (17 males and 33 females) aged 20 to 69 years were studied at Ghazi Al Hariri Surgical Hospital between October 2022 and September 2023. Each patient provided a comprehensive medical history. The preoperative presumptive diagnosis of intracranial extra-axial meningiomas was performed utilizing an available MRI scanner, the SIEMENS-MAGNETOM Avanto. Superconducting magnet 1.5 Tesla with a head coil. When scheduling an MRI exam. The contrast medium was gadolinium DTPA at a dosage of (0.1) millimol/kg of body weight. The dosage is administered by slow I.V. while the patient remains within the MR tunnel.

Every sequence measured five millimeters. To get a suitable resolution and a decent signal to noise ratio, slice thickness should be separated by 1 mm.

Statistical analysis was done using SPSS computer software (Statistical Package of social sciences) using version 29.0. Chi square test was used. P value < 0.05 level of significance was considered statistically significant.

3. RESULTS

In this study, fifty patients (48 newly diagnosed and 2 recurrent) with intracranial meningiomas were evaluated. The meningiomas were detected by MRI using precise tissue type criteria, surgically validated, and the final diagnosis was confirmed by tissue biopsy. Among the fifty patients, 17 (34%) were males and 33 (66%) were females. Furthermore, the most common age groups were 40–49 and 50–59 years. A histological study confirmed the diagnosis of benign tumors in 44 (88%) patients, atypical tumors in four (8%) patients, and malignant meningiomas in just two (4%) individuals. These 44 cases of benign meningiomas were further subdivided histopathologically into.

Meningothelial variety was present among 20 (45.4%) patients of benign type, of them 7 (35%) males and 13 (65%) female, fibroblastic meningiomas was present among 9 (20.4%) patients of the benign type, of them 3 (33.3%) males and 6 (66.6 %) females, transitional variety was found in 13 (29.5%) patients of the benign tumors, of them 4 (30.7%) males and 9 (69.3%) females, angioblastic type was present among 1 (2%) patient (female). The other varieties of benign meningiomas which present among 1 (2%) patient (male), was proved to be psammomatus meningioma. While of the 4 cases that proved to be atypical meningiomas they were 1(25%) male and 3(75%) females and the two cases of malignant entity were females (100%). As shown in table 3.1.

Table 3.1: Age and gender distribution of intracranial meningiomas.

Age in years	BENIGN												Atypical		Malignant		TOTAL			
	M.		F.		T		A.		O.		Total									
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	%	F	%
20 - 29	1								1		2						2	4		
30 - 39	1	2		1	1			1			2	4					2	4	4	8
40 - 49	2	4	1	2	2	3					5	9		1		1	5	10	11	22
50 - 59	2	5	1	1	1	4					4	10	1	2	1		6	12	12	24
60 - 69	1	2	1	2		2					2	6					2	4	6	12
TOTAL	7	13	3	6	4	9		1	1		15	29	1	3	1	1	17	34	33	66

Meningothelial (M), Fibroblastic (F), Transitional (T), Angioblastic (A.), Others (O.).

In regards to the tumor location (table 3.2), cerebral convexity location was found in 17 (34%) patients, parasagittal in 11(22%) patients, Sphenoid ridge was seen in 6(12%) patients, olfactory groove 4 (8%) patients, suprasellar and cerebellar convexity each one of them having 3 (6%) patients, cerebellopontine angle (C.P.A) and intraventricular location in 2 (4%) patients for each, while the tentorium and cavernous sinus area locations shared 1 (2%) patient for each.

Table 3.2: Correlation between location of intracranial meningiomas and their histopathology.

Location Side	Benign							Atypical		Malignant		Total	
	M.	F.	T.	A.	O.	Total							
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%
Rt. Side	11	4	6	1	1	23	46	3	75			26	54
Lt. side	5	4	3			12	24	1	25	2	100	15	28
Central	3	1	3			7	14					7	14
Intraventricular													
Rt. L. V.			1			1	2					1	2
Lt. L. V.	1					1	2					1	2
TOTAL	20	9	13	1	1	44	100	4	100	2	100	50	100

Tumor sizes ranged roughly from (1.2 × 1.5 ×1 cm to 4.5 × 7.5 × 9.7 cm) in the anteroposterior, transverse and vertical dimensions. The sites of tumor encountered in both sides of brain (table 3.3), 27 (54%) patients having tumor in the right side, 16 (32%) patients having tumor in the left side and 7 (14%) patients having tumor at the central site. The two cases of intraventricular meningiomas were on in each lateral ventricle (4%).

Table 3.3: Correlation between laterality in location of intracranial meningiomas and their histopathology.

Location	Benign							Atypical		Malignant		Total	
	M.	**F.**	**T.**	**A.**	**O.**	**Total**							
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%
Cerebral convexity	7	3	4			14	28	3	75			17	34
Parasagittal	3	1	2	1	1	8	16	1	25	2	100	11	22
Sphenoid ridge	3	2	1			6	12					6	12
Olfactory groove	1	1	2			4	8					4	8
Suprasellar	1		2			3	6					3	6
Cerebellar convexity	2	1				3	6					3	6
C.P.A	1		1			2	4					2	4
Intraventricular	1	1				2	4					2	4
Tentorium			1			1	2					1	2
Cavernous sinus	1					1	2					1	2
Total	20	9	13	1	1	44	88	4		2		50	100

- Meningothelial (M), Fibroblastic (F), Transitional (T), Angioblastic (A.), Others (O.), lateral ventricle (L.V.)
- Statistically the excess right side affected observed here do not depart significantly from the hypothesis of equal proportion between right and left side (P value > 0.5).

Table 3.4 shows that most meningiomas showed isointense signal intensity on both T1 and T2 weighted images, in other word; 44 (88%) patients in T1 and 38

(76%) patients in T2 respectively. Moreover; most of the patients 41 (82%) had homogenous texture.

Table 3.4: Correlation between MRI signal intensity on T1-WI &T2-WI and histopathological subtypes of intracranial meningiomas.

MRI signal intensity	Benign							Atypical		Malignant		Total		P-Value
	M.	F.	T.	A.	O.	Total								
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%	
T1- hypointense	2	3				5	10	1	25			6	12	<0.005
T1- Isointense	18	6	13	1	1	39	78	3	75	2	100	44	88	
T2- Isointense	15	8	10		1	34	65	3	75	1	50	38	76	<0.005
T2- hyperintense	5	1	3	1		10	20	1	25	1	50	12	24	
Homogenous	18	9	12	1		40	80	1	25			41	82	<0.005
Heterogeneous	2		1		1	4	8	3	75	2	100	9	18	

Table 3.5 shows that 38 (76%) patients of tumors had positive meningioma cleft on MRI, while 16 (32%) patients had calcifications, just 5 (10%) patients had cystic changes and only 18 (36%) patients had avascular cellularity in MRI.

Table 3.5: Correlation between other MRI findings and histopathological diagnosis of intracranial meningiomas.

MRI Finding	Benign							Atypical		Malignant		Total		P-Value
	M.	F.	T.	A.	O.	Total								
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%	
Meningioma cleft														
Positive	17	8	10	1	1	37	74	1	25			38	76	<0.005
Negative	3	1	3			7	14	3	75	2	100	12	24	
Calcification														
Present	7	2	5		1	15	28	1	25			16	32	<0.005
Absent	13	7	8	1		29	78	3	75	2	100	34	68	
Cystic changes														
Positive	1					1	2	2	50	2	100	5	10	<0.005
Negative	19	9	13	1	1	43	68	2	50			45	90	
Vascularity														
Avascular	5	6	5		1	17	34	1	25			18	36	<0.005
Vascular	15	3	8	1		27	54	3	75	2	100	32	64	
Total	20	9	13	1	1	44	88	4	100	2	100	50	100	

Regarding peritumoral edema. Table 3.6 shows that eleven (22%) patients of meningiomas were not surrounded by edema, while, 25 (50%) patients had mild (+) degree, 8 (16%) patients had moderate (++) degree & 6 (12%) patients had marked (+++) degree of edema.

Table 3.6: Correlation between degree of perifocal edema and intracranial meningiomas histopathological subtypes.

Perifocal edema	Benign							Atypical		Malign.		Total	
	M.	F.	T.	A.	O.	Total							
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%
Absent	5	2	4			11	22					11	22
(+)	11	5	7		1	24	48	1	25			25	50
(+ +)	3	1	2	1		7	14	1	25			8	16
(+ + +)	1	1				2	4	2	50	2	100	6	12
Total	20	9	13	1	1	44	100	5	100	2	100	50	100
Median	+	+	+	+ +	+	+		+ + +		+ + +		+	

- Meningiothelial (M), Fibroiblastic (F), Transitional (T), Angioblastic (A.) Others (O.).
- (+) mild = extend up to 2 cm around the lesion.
(++) moderate = 2 - 4 cm.
(+++) marked > 4 cm.
- There is strong relationship between meningioma histopathological subtype and Perifocal edema (P< 0.001).

Table 3.7 shows that 41 (82%) patients had homogenous enhancement with contrast media while the heterogenous enhancement was occurred in 9 (18%) patients. Moreover; only 32 (64%) patients had dural tail enhancement.

Table 3.7: Enhancement pattern by intracranial meningiomas histopathological subtypes.

Enhancement	Benign							Atypical		Malign.		Total	
	M.	F.	T.	A.	O.	Total							
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%
Mode of Enhancement:													
Homogenous	18	9	12		1	40	80	1	25			41	82
Heterogeneous	2		1	1		4	8	3	75	2	100	9	18
Dural tail sign:													
Absent	8	2	6	1		17		1	25			18	36
Present	12	7	7		1	27		3	75	2	100	32	64
Total	20	9	13	1	1	44	100	4	100	2	100	50	100

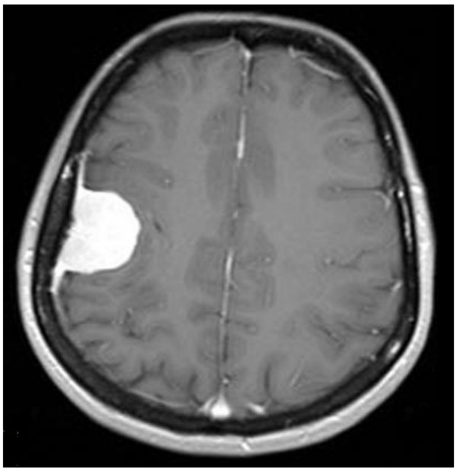

Figure 3.1: Axial T1 post contrast Rt cerebral convexity avidly enhancing meningioma (white arrow) with dural tail sign (black arrows).

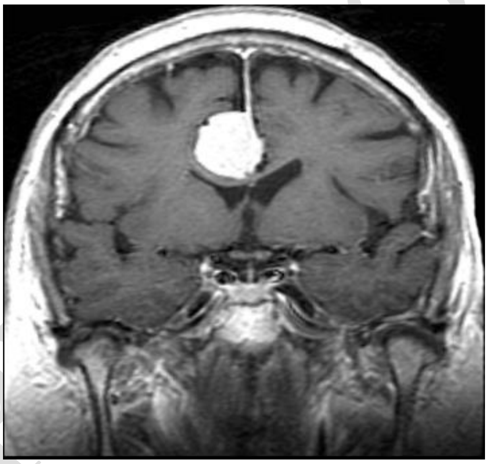

Figure 3.2: Coronal T1 post contrast MRI showing right sided Falcie meningioma

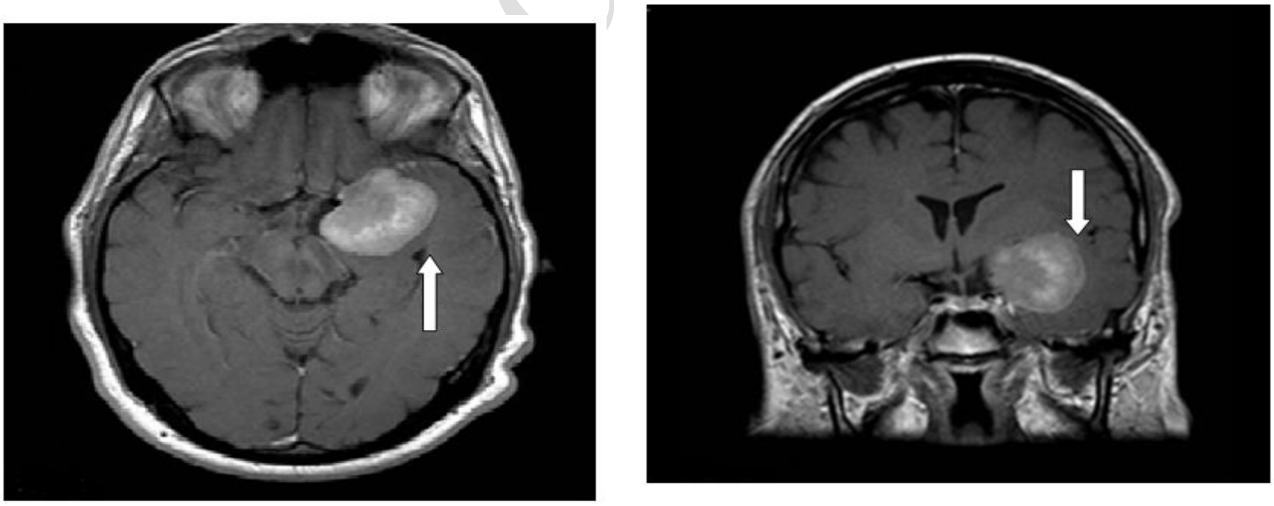

Figure 3.3: Lt sided sphenoid wing meningioma visualized in axial and coronal T_1 post contrast. MRI.

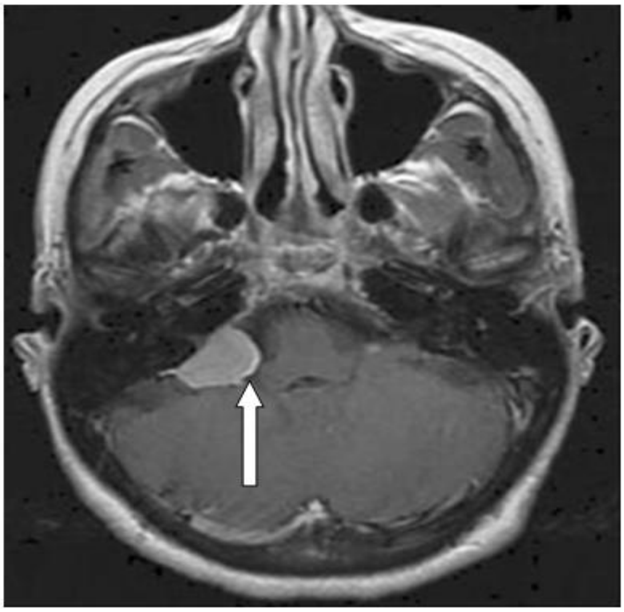

Figure 3.4: Axial post contrast MRI of brain with Rt crebellopontine angle meningioma.

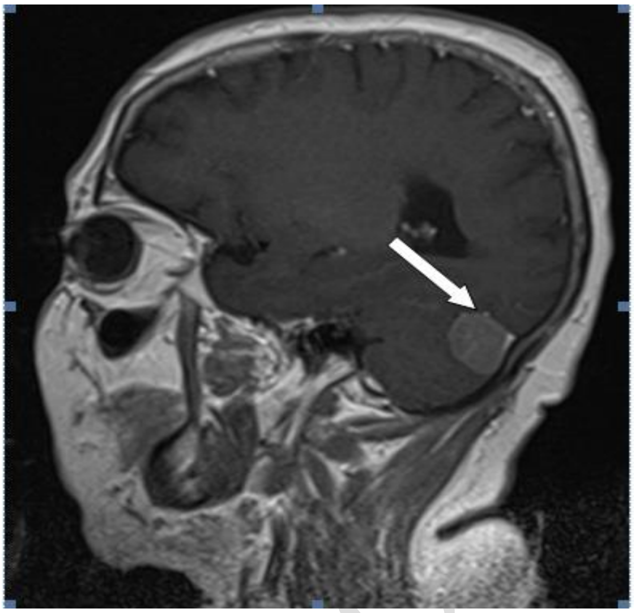

Figure 3.5: post Gad administration coronal MRI showing left tentorium cerebelli meningioma with infratentorial extension.

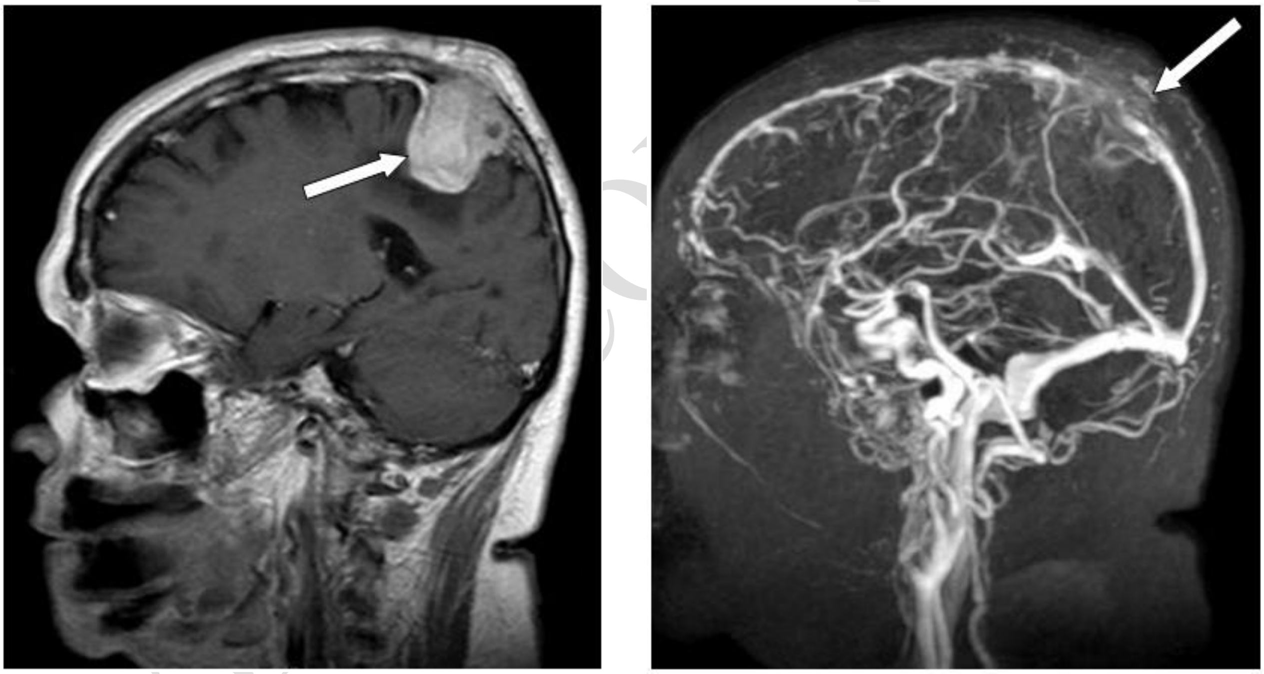

Figure 3.6: Sagittal T1 postcontrast MRI shows high parietal parasagittal enhancing meningioma. MRV shows invasion into the superior sagittal sinus.

4. DISCUSSION

In this study, meningiomas were benign in 88% of cases, atypical in 8%, and only 4 % were found to be malignant, which is slightly different from the what was found by previous studies.[19-20] Additionally; the size of tumor ranged roughly from (1×1.2×1.5 cm to 9.7×4.5×7.5cm) in the vertical, transverse and anteroposterior dimensions with no statistical correlation was found between this factor and meningiomas subtypes, which is consistent with Nazir et al.[21] In this study; meningioma was found in female as thrice as male (3:1) with peak incidence occurred among patients aged 40-59 years. Which suggest a potential link between female hormones and meningioma development, as meningiomas have been found to express estrogen and progesterone receptors.[22]

The primary advantage of multiplanar imaging is improved tumor localization, rather than increased lesion detection. Meningiomas have a preference for certain intracranial regions, while they can form anywhere where meninges exit if there are cell remains of meningeal origin. The position of the arachnoid granulation is closely related to the most common site of genesis for meningiomas; approximately 45% of convexity meningiomas are parasagittal or linked to the sagittal sinus. Which is similar to Michael Schmutzer et al study's findings.[23] Furthermore; in this study, there was total right laterality in 27 (54%) patients, total Left laterality in 16 (32%) patients, and 7 (14%) patients were central in location. Comparable results were obtained from Joonas Laajava et al.[24]

This study discovered that, in T1 weighted images, meningiomas were typically isointense or mildly hypointense to normal gray matter, whereas, T2 weighted were reported to be isointense to mildly hyperintense in comparison to gray matter. The tumor's aggressive behavior is responsible for the heterogeneous signal intensity pattern that is associated with tumor vascularity, calcification, and cystic foci. This is parallel to Juan Yu et al[25] and Jörg Christian Tonn studies' findings.[26] Regarding the heterogeneity; the current study found that meningioma are relatively homogeneous lesions, with heterogeneity of internal structure of meningioma depends on several factors like tumor blood supply, the presence of macro- and microcysts, hemorrhages, calcifications, and sites of stroma with different density.[27] In addition to that; with regards to perifocal edema the study found eleven (22%) patients of meningiomas were not surrounded by edema, while, 25 (50%) patients had mild (+) degree, 8 (16%) patients had moderate (++) degree & 6 (12%) patients had marked (+++) degree of edema. This means that the majority of the patients in the study (78%) did exhibit some degree of perifocal edema surrounding their meningiomas, which is in agreement with Nico Teske et al study findings.[28]

When using contrast-enhanced MR imaging for meningiomas, it's common to see a "dural tail," which is a narrow line of enhancement that extends down the dural surface at varying distances from the tumor mass. Dural tail seen in 64% of the study participants which was comparable to Vitor Nagai Yamaki et al study results.[29]

5-CONCLUSION

MRI is a non-ionizing, non-invasive modality, with direct multiplanar imaging, high soft tissue contrast resolution without bone and metal artifacts, beside the advent of I.V. contrast agent, all these make it the initial examination of choice in the detection, localization and characterization of intracranial meningioma. MRI can predict with a good degree of certainty the aggressive behavior of the potentially more atypical or malignant meningiomas. So if there is no contraindication for MRI, it is recommended as the examination of choice in every patients with features of intracranial lesions even for patients whose investigated by other methods.

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Conflict of intertest

About this study, the authors disclose no conflicts of interest.

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