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Original article

Atypical Imaging Features of Meningioma in Correlation with Histopathologic Findings

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Abstract

Background: Imaging characteristics of meningiomas have been discussed previously in many studies; however complete imaging features involving general features, MRS-DWI of both typical and atypical meningiomas have been discussed in very few studies. This study was done to evaluate the role of imaging modalities feature in correlation with histopathological finding. **Patients and Methods:** 21 patients selected from Radiodiagnosis department at Benha University Hospital and Kasr Alaini Hospital, Cairo University and other radiological centers who having Brain CT and MRI from the **period of** January 2020toJanuary 2021. The study was conducted on 21 patients (11 females and 10 males) proved histopathological to have Atypical meningioma post-operative biopsy. All patients were subjected to MRI the brain was conducted with intravenous injection contrast media in rate of (4-4.5 ml/sec), imaging obtained at arterial (45sec) and venous phases (70sec). 21 patients did MRI examination and 5 of them have CT examination previously. **Results:** role of imaging modalities in diagnosis of atypical meningioma was (81.0% typical and 19.0% atypical meningioma) and we found the percentage in histopathological finding diagnosis was 100% (90.5% atypical and 9.5% typical meningioma).**Conclusion:** Imaging features of the modalities (MRI/CT) allow the radiologist to exam the detailed relations to the mass and surrounding brain parenchymal tissue, vessels and other structures. And it has role to approach a distinguish the atypical meningioma from others brain masses. The role of histopathological findings is recommended for diagnosis atypical meningioma at staging and grading.

Key words: Atypical Imaging Features, meningioma, histopathologic findings

Introduction

Since malignant meningioma was first recognized by Caushing and Eiswnhardt in 1938, there have been diverse criteria for histopathologically grading atypical and

anaplastic meningiomas, to improve this situation, the 2000 WHO classification recommends much more stringent and objective criteria. Clinical outcome and develop therapeutic strategies to improve outcome in patients with high grade meningioma **(1)**

Meningiomas are the most common nonglial primary tumors of the central nervous system and the most common extra-axial neoplasms. Meningiomas are arising from the leptomeningial covering of the brain and spinal cord according for 15%-20% of all central nervous system tumors. **(2),(3)**

Atypical meningiomal accounts for about 4.7% to 7.2% of all kinds of meningiomas which is invasive with a relatively high recurrence and mortality. Atypical or malignant characterizing by nuclear disorganization, necrosis prominent nucleoli and increase mitoses on histology. The typical course of atypical meningioma (6-10 months) is shorter than that of being meningioma (2-4years). **(2)(4)**

Imaging has a role in characterizing these lesions and helping in pre-surgical deferential diagnosis, which is essential for optimizing treatment strategies. **(4)**

Some meningioma have atypical imaging findings like cystic meningioma. osseous meningiomas. Assessment of these atypical findings are essential for diagnosis and for therapeutic plain. **(5)**

Magnetic resonance imaging (MRI) is the modality of choice for the investigation of meningiomas, providing superior contrast differentiation and usually the ability to differentiate between intra- and extra-axial lesions. In addition to MRI, Diffusion – weighted MRI, perfusion MRI and proton MR spectroscopy may be used in the diagnosis of meningiomas. **(5)**

CT/MRI play indispensable role in the localization and characteristic of this tumor, this help in surgical planning and to decide upon the need for –surgical radiotherapy these may sometime be overlapping features between lesions making the differentiation impossible. The histopathological remain a gold standard. **(2)(5)**

CT is more widely available is better suited for rapid screening in urgent setting, and can be used when patients have MRI exclusion (such as pacemakers). **(4)(5)**

The CT finding in aggressive or invasive meningioma's have been described by several authors, these signs include heterogeneous contrast enhancement with or without cystic components, Irregular tumor margins. and marked surrounding edema. The angiographic demonstration of deep draining veins in meningioma's implies underlying invasion of brain tissue and indicated tumor aggressiveness. **(6)**

The histopathological appearance of meningioma is an important predicator of

tumor behavior and is frequently factor in decisions concerning therapy. The relationship between histological features and prognosis is formalized in grading. [7]

Aim of the work

The aim of study is to highlight the characteristic features of atypical meningioma on imaging in correlation with histopathologic findings.

Patients and Methods

Patients

After taking an approval from the Department of Radiodiagnosis, Faculty of Medicine, Benha University, this retrospective study included 21 patients selected from the among patients attending Radiodiagnosis Department at Benha University, and Kasr Alaini Hospital, Cairo University during the period from January 2020 to January 2021for meningioma for different indications by CT or MRI, we included those patients with CT or MRI imaging features suspicious for atypical meningioma including 21 patients their final diagnoses based on histopathology were found to have showed 2 patients with typical meningioma the remaining 19 patients were finally proved to have atypical meningioma.

The study of 21 patients between age 23-71 years old(11female /10 male)from the period of January to October 2020.

Inclusion criteria:

This study was conducted on patients with atypical imaging features on CT or MRI.

Exclusion criteria:

This study was conducted on patients suspected to have atypical meningioma and were found to have other diagnosis.

Methodology:

Clinical examination and laboratory examination.

Imaging study:

CT or MRI, the imaging finding will be correlated with histo-pathological examination. Were analyzed for the summation of the present retrospective study.

This study was conducted on patients with atypical imaging features on CT or MRI. While patients suspected to have atypical meningioma and were found to have other diagnosis and were excluded.

Technician:

Each patient was subjected to complete history taken, thorough clinical examination, prior to the use of contrast media CT/MRI: routine laboratory investigations and appropriate creatinine clearance be measured and the patient preparation starts 24 hours prior to the scheduled time of procedure.

CT: Scan was carried out by GE-VCT 64Slice Scanner machine with stand CT protocol for head and neck. Nonionic contrast

media was routinely administered in all patients to look for the enhancement pattern and characteristics.

MRI: was contemplated using 1.5TeslaSIEMENS-MAGNETOM AVANTO with dedicated Radio Frequency receive only head coils using following sequences :

T1-weighted, T2-weighted, FLAIR, & Diffusion Weighted. After these sequences were obtained, intravenous contrast study was performed in all the patients to look for the

Degree and the pattern of enhancement and to assess the vascularity. The CT and MR scans were evaluated with respect to the following points: Location(supra/infratentorial)and site of the lesion, perifocal edema, intensity compared to grey matter, contrast enhancement and type of enhancement, Presence of extra axial signs , CSF cleft, displaced subarachnoid vessels, buckling of cortical gray matter between them and the white matter, displaced and expanded sub arachnoid space, broad dural base and bony reaction, presence of mass effect.

Presence of signal voids on T1WI and T2WI (calcification / fibrosis / vessels), Presence of hemorrhage, heterogeneity presence of necrosis / Cystic change, presence of calcifications, margins: Sharp & well defined or Ill-defined and Histology (wherever available).

The radiological findings was correlated with pathological results the medical ethics was considered. The patient was aware of examination, patient's approval was obtained and the patient had fit from examination.

Image interpretation:

The diagnoses atypical meningioma was considered in the presence of atypical location, atypical number, atypical imaging features (brain edema, cystic changes, evidence of invasive of adjacent structures).

The radiological diagnosis was correlation with the final diagnoses after pathological examination.

Statistical analysis:

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The confidence interval was set to 95% and the margin of error acceptedwassetto5%.So,thep-valuewasconsideredsignificantasP-value<0.05.

Results

Table (1): Distribution of meningioma cases according to their demographic data regarding gender (n=21).

Gender	No.	%
Female	11	52.4%
Male	10	47.6%
Total	21	100.0%

This table shows that the females (52.4%) and male (47.6%) of gender.

Table (2): Distribution of meningioma cases according to their age (years)(n=21).

Age (years)	Total(n=21)
Range	23-71
Mean±SD	46.19±12.60
Median(IQR)	43(18)

This table shows that the ranged 23-71with mean±SD 46.19±12.60 of age (years).

Table (3): Distribution of meningioma cases according to their location (n=21).

Location	No.	%
Olfactorygroove	5	23.8%
Parasagital	4	19.0%
Parietal	4	19.0%
Frontal	3	14.3%
Foramen maginum	2	9.5%
Sphenoid wing	2	9.5%
Supra-sellar	1	4.8%
Total	21	100.0%

This table shows that the Olfactory groove23.8%, Parasagital19.0%, Parietal19.0%,Frontal14.3%, Foramenmaginum9.5%, Sphenoidwing 9.5% and Suprasellar 4.8% of Location.

Table(4): Distribution of meningioma cases according to their MRI(n=21).

MRI	No.	%
T1WISI		
Intermediate	5	23.8%
Intermediate to Low	2	9.5%
Low	14	66.7%
T2WISI		
Bright	1	4.8%
Intermediate to High	10	47.6%
Intermediate	2	9.5%
Intermediate to Low	6	28.6%
Strong	2	9.5%
Flair SI		
Bright	17	81.0%
Intermediate to Low	2	9.5%
Strong	2	9.5%
Strong Enhancement		
Heterogeneous	1	4.8%
Homogenous	7	33.3%
Strong	13	61.9%
DWI restricted	13	61.9%
Dural Tail		
No	15	71.4%
Seen	6	28.6%
Cystic changes		
No	17	81.0%
Yes	4	19.0%
Brain infiltration		
No	18	85.7%
Yes	3	14.3%
Area of broken down		
No	19	90.5%
Yes	2	9.5%

This table shows that the intermediate 23.8%, intermediate to Low 9.5%, Low 66.7% of **T1WISI;** regarding **T2WISI** Bright 4.8%, intermediate to High 47.6%, intermediate 9.5%, intermediate to Low 28.6% and Strong 9.5% of **Flair SI;** regarding Bright 81.0%, Intermediate to Low 9.5% and Strong 9.5%; **Strong Enhancement** Heterogeneous 4.8%, Homogenous 33.3% and Strong 61.9%; **DWI restricted** 61.9%; **Dural Tail** 28.6%; **Cystic changes** 19.0%; **Brain infiltration** 14.3% and **Area of broken down** 9.5% of **MRI**.

Table (5): Distribution of meningioma cases according to their CT by sclerotic changes (n=21).

CT by Sclerotic Changes	No.	%
No	14	66.7%
Yes	7	33.3%
Total	21	100.0%

This table shows that the no (66.7%) and yes (33.3%) of CT by sclerotic changes.

Table (6): Distributionofmeningiomacasesaccordingtotheirhistopathology(n=21).

Histopathology	No.	%
Type of diagnosis		
Typical meningioma,WHO Grade I	2	9.5%
Atypical meningioma WHO Grade II	19	90.5%
Psammoma body		
No	12	57.1%
Yes	9	42.9%
Brain invasive		
No	12	57.1%
Yes	9	42.9%
Necrotic		
No	16	76.2%
Yes	5	23.8%
Neoplastic cell		
No	13	61.9%
Yes	8	38.1%

This table shows that the **Type of diagnosis** of Typical meningioma,WHO Grade I 9.5% and Atypical meningioma WHO Grade II 90.5%; **Psammoma body** 42.9%; **Brain invasive** 42.9%; **Necrotic** 23.8% and **Neoplastic cell** 38.1% of **histopathology**.

Table(7): DistributionofmeningiomacasesaccordingtotheirMRI/CTimaging(AtypicalMeningioma)(n=21).

MRI/CT imaging (Atypical Meningioma)	No.	%
No	17	81.0%
Yes	4	19.0%
Total	21	100.0%

This table shows that the no (81%) and (19%) of **MRI/CT imaging (Atypical Meningioma),** also it turns out that there are two cases out of our cases of **typical meningioma**.

Table (8): Distribution of meningioma cases according to their Histopathology (Atypical Meningioma) (n=21).

Histopathology(Atypical Meningioma)	No.	%
No	2	9.5%
Yes	19	90.5%
Total	21	100.0%

This table shows that the no (9.5%) and (90.5%) of **Histopathology (Atypical Meningioma)**.

Table (9): Distribution of meningioma cases according to their Histopathology (Atypical Meningioma) (n=21).

Recurrence	No.	%
No	18	85.7%
Yes	3	14.3%
Total	21	100.0%

This table shows that the no recurrence (85.7%) and recurrence (14.3) of recurrence.

Table (10): Sensitivity, PPV, FN, FP and over all accuracy of MRI/CT in characterization of Atypical Meningioma compared with histopathology.

	Histopathology(Atypical Meningioma)			Sen.	PPV	FN	FP	Accuracy
MRI/CT imaging (Atypical Meningioma)	**TP=2**	**FP=2**	**4**	10.5%	50%	89.5%	100%	9.5%
	FN=17	**TN=0**	**17**					
Total	**19**	**2**	**21**					

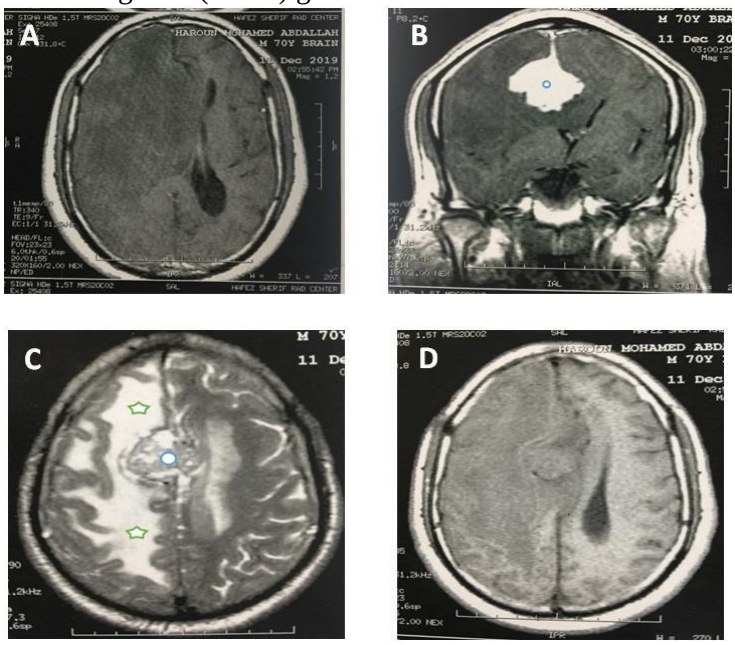
Evaluation of Diagnostic Performance: with sensitivity of 10.5%, positive predictive value of 50%, false negative 89.5%, false positive 100% with diagnostic accuracy of 9.5%.

Case (1)

70 years old male patients come with presented of chronic headache loss of sensation in left extremities.

MRI: A large well defined extra axial dural based SOL is seen at frontal parasagittal region (arrow).

Final diagnoses: Atypical meningioma (WHO) grade II

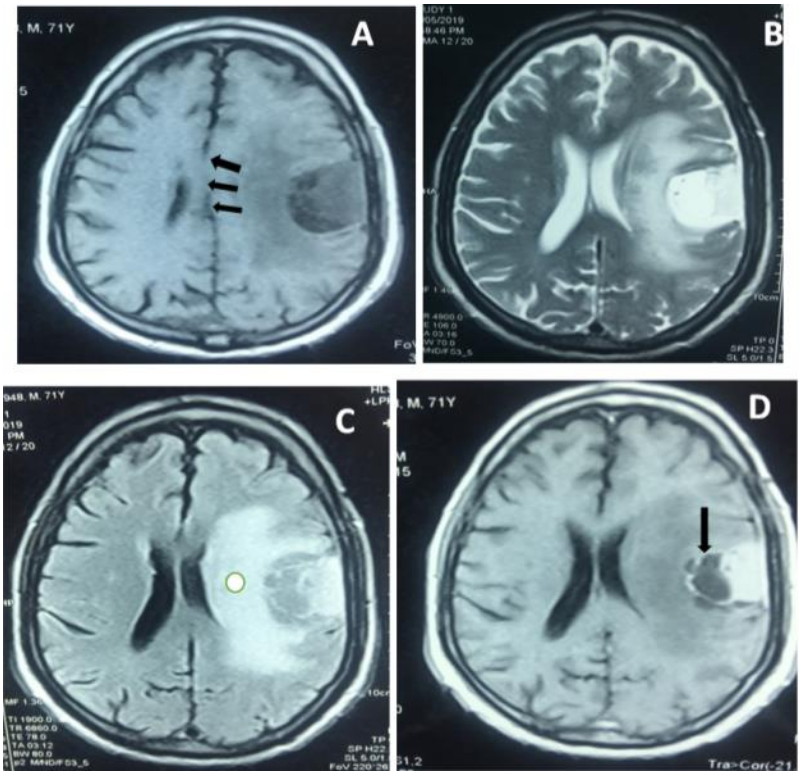


(a)-axial viewT1WI isointense SI.**(b):**coronal view TIWI intense homogenous post contrast enhancement(blue circle) **(C)**axial view T2WI moderate to high heterogeneous SI perifocal and vasogenic edema(green stars) and mass effect.**(d):**FLAIR showing intermediate SI.

30 years old female patients with history of repeated attack of coma and severe headache since 8 months ago.

MRI: axial view showing pattern of complex cystic lesion with peripheral devoid of flow voids.

Final diagnoses: Atypical meningioma (WHO) grade II



(a): T1WI appear low signal intensity.

(d): Gadolinium-enhancement axial T1WI show homogenously vasogenic nodule with subtle dural and associated cyst (black arrow)

(b,c): Axial T2WI /FLAIR showing moderate to high SI and mild perifocal asogenic edema(green circle) and mass effect. And shifting midline with compressed on left lateral ventricle (black arrows)

Discussion

Meningiomas are the most common nonglial primary tumors of the central nervous system and the most common extraaxial neoplasms. Meningioma are arising from the leptomeningial covering of the brain and spinal cord, accounting for 15%-20% of all central nervous system tumors. [(2), (3)]

Majority of the patients having atypical Meningioma were female (52.17%), while 47.82% were males. The age distribution of Meningioma revealed maximum incidence in the fourth decade (30.43%) followed by sixth decade (17.89%) and seventh decade (15.22%).Majority of the cases having atypical Meningioma involved parasaggital, CP angle , and sphenoid and petrous regions (15.27% each), followed by involvement of fronto-parietal (10.87%). Less common sites were parietal, tempero-parietal and occipital regions. Majority of the cases (73.91%) showed supra-tentorial location, rest were infratentorial (26.08%) **[(8)]**.

On our study shows that the majority of the patients having meningioma were female (52.4%) and male (47.6%) of gender. The age distribution of atypical Meningioma revealed

maximum incidence in the third and fourth decade (35%-40.3%)followed by fifth decade (25%)and sixth and seventh decade (15, 5%)majority of the cases atypical location was in the Olfactory groove 23.8%, Parasagital 19.0%, followed by Parietal 19.0%, Frontal 14.3%, Foramen magnum 9.5%, Sphenoid wing 9.5% and Suprasellar 4.8% of atypical Location.

Majority of cases showed well defined margins (84.78%) with homogenous lesions(73.91%). Foci of necrosis were noted in 32.60% of cases and 15.22% of cases showed calcification foci. Sinus invasion noticed in 15.22% of cases, whereas adjacent bony reaction noticed in 30.43% of cases. Most of cases demonstrated homogenous enhancement of the mass (82.61%), whereas 13.04% of cases showed heterogeneous enhancement and 4.35%showed ring enhancement. Two third of cases showed intense enhancement (63.04%), where as 30.43% showed moderate enhancement. Two third of the cases showed peritumoral edema in adjacent brain parenchyma (65.1%). **(9)** .

On T1 weighted MRI, majority of the lesions appeared as isointense to adjacent grey matter and on T2 weighted majority appeared as mildly hyperintense lesions, adjacent white matter buckling (71.74%) and surrounding CSF cleft (52.17%). Displaced subarachnoid vessels were demonstrated in30.43%, whereas the pathognomonic dural tail was present in only 23.91% of the cases. All the cases of Meningioma demonstrated restriction on diffusion weighted sequences suggestive of high cellularity of the lesions. On angiography, neovascularity was noticed in 85.71% and tumor blush was noticed in 71.42% incidence (Table 4). On MRS, all demonstrated choline peak (100%) and in 33.33% of cases alanine peak was discernible among atypical features demonstrated by Meningiomas, cystic changes were present in 13.04% of the cases. Hyper calcification and intraventricular location were noted in 8.69% of cases **(10)**.

This study shows that the Intermediate 23.8%, Intermediate to Low 9.5%, Low 66.7% of T1WI SI; regarding T2WI SI Bright 4.8%, Intermediate to High 47.6%, Intermediate 9.5%, Intermediate to Low 28.6% and Strong 9.5% of Flair SI; regarding Bright 81.0%, Intermediate to Low 9.5% and Strong 9.5%; Strong Enhancement Heterogeneous 4.8%, Homogenous 33.3% and Strong 61.9%; DWI restricted 61.9%; Dural Tail 28.6%; Cystic changes 19.0%; Brain infiltration 14.3% and Area of breaken down 9.5% of MRI.

On CT, majority appeared as isodense or hyperdense to adjacent brain. This table shows that the no (66.7%) and yes (33.3%) of CT by sclerotic changes.

After GTR without postoperative radiation, AMs have a high recurrence rate. Most recurrences occurred within 5 years after resection. Recurrences caused numerous reoperations per patient and shortened

survival. Our finding suggesting lower recurrence rates in patients undergoing immediate postoperative radiation should be investigated in larger, prospective series.

Men with mitoses and prominent nucleoli, with 70% recurrence . [(11)] shows that the no recurrence (85.7%) and recurrence (14.3) of recurrence

Atypical meningiomas are diagnosed in the presence of: (1) three or more of the following minor atypical criteria: increased cellularity, small cells with a high nuclear/cytoplasmic ratio, prominent nucleoli, sheeting, and foci of spontaneous or geographic necrosis; (2) mitotic count≥4 mitoses per 10 HPF (high mitotic index); (3) brain invasion. Our results suggest reconsideration of classification of meningiomas as atypical based only on minor atypical criteria. The presence of brain invasion and the co-occurrence of sheeting and high mitotic count may be useful to identify high risk cases, which may benefit from adjuvant treatments [(12)].

In this study shows that the atypical meningioma WHO Grade II Psammoma body 42.9%; Brain invasive 42.9%; Necrotic 23.8% and Neoplastic cell 38.1% of histopathology.

Conclusion:

In this study Imaging features of the modalities (MRI/CT) allow the radiologist to exam for cases for atypical meningioma .the presence Intratumoral cystic changes, Hyperosteosis of the adjacent skull, Bony destruction, Extra axial tumor extension through the skull base, Arterial encasement and, Peritumoral brain edema, may suggest atypical meningioma. And such diagnosis is essential for preparation management.

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