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MRI Imaging Features of Meningioma.

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ABSTRACT

Background: Meningiomas are the most common non glial extra axial primary brain tumors of the central nervous system (CNS), accounting for between 16 to 20% of all intracranial tumors. Aim: In this study we tried to describe typical and atypical locations and findings of intracranial meningiomas on MRI and also MRI features of meningiomas that differentiate from other extra axial lesions. **Methods:** Studied population was advised to undergo MRI investigations for confirmation of meningiomas and to differentiate from other extra axial tumors and CT suggested in few cases for confirmation of calcification and boney changes. All MR imaging were performed with 1.5T bravo MR imaging unit with standard protocol. In operated cases, MRI findings were correlated with intraoperative findings and histopathological diagnosis. **Results:** Majority of meningioma patients were observed in the age group of 51-70 years i.e., 24 (80%) out of 30 cases. The most common site of occurrence are the cerebral convexities, parasaggital location/falx, posterior fossa, sphenoid ridge, olfactory groove and others accounting for 33.3%, 20%. 20%, 10%, 6.7% and 10% respectively. 67% of meningiomas showed homogenous enhancement, 56% cases had dural tail sign, 40% meningioma cases observed with CSF cleft, 37% of cases showed mass effect on surrounding arteries, cranial nerves, ventricular system and brainstem noted in twelve cases. 33% of cases noticed with perilesional edema, 30% had calcifications, 20% hyperostosis, 13% sinus invasion and 10% were others such as haemorrhages, cystic or non enhancement areas. **Conclusions:** As Meningiomas are not an uncommon tumors, radiologists should be aware of different MRI characteristics and locations of meningiomal tumors, this will help to arrive at accurate diagnosis especially in atypical and misleading meningioma features.

Keywords: Meningioma, MRI features.

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INTRODUCTION

Meningiomas are the most common non glial extra axial primary brain tumors of the central nervous system (CNS), accounting for between 16 to 20% of all intracranial tumors.[1]

Meningiomas originate from arachnoid cap cells of the arachnoid villi which are usually located along dural venous sinuses.[2] The majority of meningiomas are spontaneous and of unknown aetiology, although recognised risk factors include previous exposure to radiation, trauma, genetic disorder such as Neurofibrmaatosis (NF) type 2, in which the tumors may be multiple.

Globally, the meningiomas are about 6 per 100,000.[3] Etiology of meningioma is not yet clearly understood. Suggested etiological factors discussed related to meningiomas are inherited genes, hormones, prior exposure to high dose ionizing radiation or other factors like obesity. Meningiomas occur in greater frequency in genetic conditions such as NF-2 & MEN-1.[4]

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They are more common in women,[5] mostly benign and usually have distinct appearance on histology and imaging but rarely, may be atypical or malignant. These atypical or malignant meningiomas comprise a small fraction of the total (~5%) and have a slight male predominance.

Meningiomas are characterized by slow but relentless growth resulting in compression of adjacent structures,[6] but they have tendency to recur. Because of intra cranial location often leads to serious and potentially lethal consequences.

For accurate diagnosis of meningiomas including size, location and extent of tumor, investigations such as high-resolution CT scanning, bone algorithms, MRI and selective digital substracion angiography.

In this study we tried to describe typical and atypical locations and findings of intracranial meningiomas on MRI and also MRI features of meningiomas that differentiate from other extraxial lesions.

MATERIALS & METHODS

This prospective study was conducted at Department of Radiology, Government General Hospital, Vijayawada from March 2018 to April 2019 over a period of 14 months. 30 patients with meningioma of both sexes aged 15-75 years age group were

included in this study. Informed consent has taken from all the patients before during this study.

Detailed history pertaining to age, sex, occupation, socioeconomic status, personal history, presenting complaints, relevant past history was taken. General and systemic examination of CNS was done to all the patients included in this study.

Studied population was advised to undergo MRI investigations for confirmation of meningiomas and to differentiate from other extraaxial tumors and CT suggested in few cases for confirmation of calcification and boney changes. All MR imaging were performed with 1.5T bravo MR imaging unit with standard protocol. In operated cases, MRI findings were correlated with intraoperative findings and histopathological diagnosis.

All the findings of each patient along with their details were entered into predesigned proforma. Results were tabulated based on these findings.

RESULTS

A total of 30 cases of meningioma were included. Out of 30 meningioma confirmed patients, 18(60%) were females and remaining 12 (40%) were males [Table 1].

Table 1: Age and sex distribution among meningioma patients

Age in years	Male	%	Female	%	Total	%
0-30	0	0	0	0	0	0
31-40	1	3.3	0	0	1	3.3
41-50	2	6.6	1	3.3	3	10
51-60	4	13.3	3	10	7	23.3
61-70	5	16.6	12	40	17	56.6
>71	0	0	2	6.6	2	6.6
Total	12	40	18	60	30	100

The earliest age observed with meningioma was 33 years young male. After 71 years of age, only 4 (13.3%) cases were observed. Majority of meningioma patients were observed in the age group of 51-70 years i.e., 24 (80%) out of 30 cases.

Most of the meningioma lesions were solitary except one case where multiple (two) meningiomal noted in a neurofibromatosis patient. All the meningioma lesions presented were intracranial lesions.

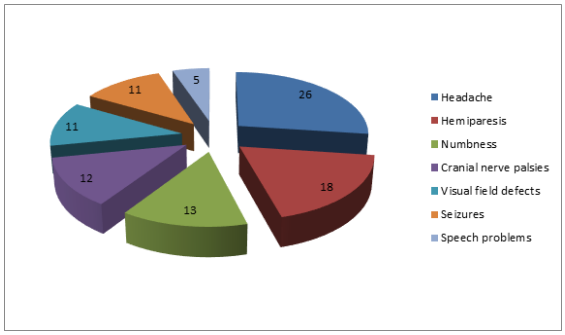

Figure 1: Clinical features of meningioma patients

Most common presenting symptom was headache followed by symptoms related to brain compression like hemiparesis, cranial nerve palsies, visual field defects, seizures, numbness and speech problems. 86.6% meningioma patients presented with headache, 60% of patients' hemiparesis, 43.3% had numbness, 40% cranial nerve palsies, 36.6% visual field defects and seizures each and 16.6% had speech problems [Figure 1].

The most common site of occurrence are the cerebral convexities, parasaggital location/falx, posterior fossa, sphenoid ridge, olfactory groove and others accounting for 33.3%, 20%. 20%, 10%, 6.7% and 10% respectively [Figure 2].

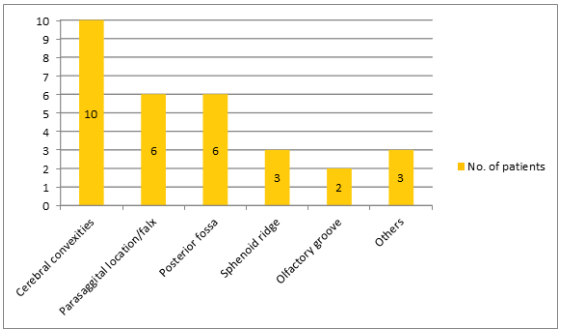

Figure 2: Location of meningiomas according to MRI features

Majority were typical (WHO grade 1) in 96.6%, only 3.4% were atypical (WHO grade 2) and no WHO grade III cases were detected.

Meningiomas are well circumscribed globular or lobulated dural-based tumours clearly demarcated from the brain.

The typical MRI signal intensity characteristics consist of iso to slight hypointensity relative to grey matter on the T1-weighted sequence and iso to slight hyperintensity relative to grey matter on the T2 sequence. After contrast administration, meningiomas typically show avid, homogeneous enhancement found in 67% cases. Rest of the 33% of cases showed peripheral, heterogenous enhancement due to calcifications, non enhancing cystic and necrotic areas.

Adjacent boney changes, Hyperostosis noted in 20% of cases, as though better demonstrated in CT than MRI.

Typical Imaging features [Figure 3]:

The typical radiological signs of extraaxial location are better identified on MRI, although not specific, more frequently observed in meningiomas than in other extra-axial lesions. These signs are the following.

White matter buckling of the underlying brain parenchyma.

Dural tail sign - enhancement of the dura infiltrating away from the lesion. It is highly suggestive but not specific for meningioma.

Cerebrospinal fluid cleft sign around meningioma confirm its extraaxial location representing brain

tumor interface– T1 low signal intensity (SI), T2 high SI

Pial vascular structures interposed between the tumour and the brain surface.

Perilesional edema, both moderate and severe edema noted in ten cases (33.3%) and is often associated with pial vascular supply.

Calcifications noted in 30% of cases, it may be peripheral or central, small punctate or large conglomerate.

Cystic or non enhancing areas were noted in two cases.

Areas of hemorrhage noted in one case.

Diffusion restriction noted in one case.

Meningiomas associated with complications such as dural sinus invasion noted in four cases, significant mass effect on surrounding arteries, cranial nerves, ventricular system and brainstem noted in twelve cases.

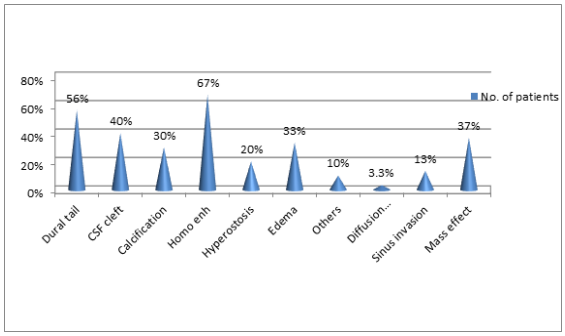

Figure 3: Prevalence of Various imaging features of meningiomas

DISCUSSION

Most of the meningiomas are chronic and asymptomatic, until tumor compress or squeeze the adjacent brain, nerves and vessels. Once it is symptomatic and requires treatment might involve surgery or radiation.

Complete surgical resection has been the standard treatment for meningioma. Other treatments for meningiomas are radiotherapy including single session stereotactic radiosurgery, hypofractionated stereotactic radiotherapy (FSRT) and conventionally fractional EBRT. For WHO grade II (high grade) meningiomas and recurrent meningiomas, treatment options are either STR or GTR and RT as an adjuvant to surgery.

CT plays a role in special cases of meningiomas when there is calcification and adjacent boney hyperostosis. For meningiomas, MRI is the ultimate investigation to provide superior contrast differentiation and aids to differentiate between intra and extra axial lesions. For diagnosis of malignant meningiomas, spectroscopy and diffusion tensor imaging are useful.[7]

Histological grading of meningiomas and based on the current WHO classification. WHO grade I, lesions compromise about 90% of cases, it subtypes based on histology include meningothelial, psammomatous, secretory, fibroblastic, angiomatous, lymphoplasmacyte – rich, transitional, metaplastic and microcystic. WHO grade II lesions compromise about 5-7% atypical and WHO grade III are anaplastic, about 1-3% of cases.[3]

Out of 30 meningioma confirmed patients, 18 (60%) were females and remaining 12 (40%) were males. Most of the scientific literature documented as female preponderance in meningiomas. In the similar way, even in this study male to female ratio is 1:1.5, in all the age groups female predominance observed.

In the present study, earliest age observed with meningioma was 33 years young male. After 71 years of age, only 4 (13.3%) cases were observed. Majority of meningioma patients were observed in the age group of 51-70 years i.e., 24 (80%) out of 30 cases. All 30 cases of meningiomas are intracranial type.

Pratik B Desai et al,[8] from Gujarat did a study on 50 cases of meningiomas, out of them 28 (56%) cases were observed in the age group of 31-50 years, followed by 11(22%) cases in 51-60 years age group, 1 case in 0-20 years group, they didn't notice any patient in childhood. They also documented 88% cases were intracranial type and 12% cases intraspinal type. Among 50 cases, 16 (32%) patients were male and 34 (68%) female subjects. So, male to female ratio is 1:2.12.

Majority were typical (WHO grade 1) in 96.6%, only 3.4% were atypical (WHO grade 2) and no WHO grade III cases were detected. Varun R kshettry et al,[9] did a study from 2004 to 2010, the overall proportions of WHO I, II, and III intracranial meningiomas were 94.6%, 4.2%, and 1.2%, respectively.

In this study 86.6% meningioma patients presented with headache, 60% of patients' hemiparesis, 43.3% had numbness, 40% cranial nerve palsies, 36.6% visual field defects and seizures each and 16.6% had speech problems. In similar to this study, Pratik B Desai et al,[8] documented that out of 50 cases of meningioma, 29 (58%) patients were with headache, followed by seizures in 20 (40%) cases, vomiting in 12 (24%) cases, visual disturbance in 9 (18%) cases, and altered level of consciousness in 7 (14%) cases.

The most common site of occurrence are the cerebral convexities, parasaggital location/falx, posterior fossa, sphenoid ridge, olfactory groove and others accounting for 33.3%, 20%. 20%, 10%, 6.7% and 10% respectively, as per this study.

Rohringer et al,[10] and Hwong Khan et al,[11] reported convexity of the skull as the most common location, prevalence was 34.7% and 42.2%, and both studies also documented parasaggital location as the second most common location, it was 22.2% and 15.7% respectively.

Buetow MP et al,[12] documented as meningioma are most commonly located at parasaggital aspect of the cerebral convexity, the lateral hemisphere convexity, the sphenoid wing, middle cranial fossa and olfactory groove.

At cerebellopontine angle, after acoustic schwannoma, meningiomas are commonest mass lesion.[12] About 10% of meningiomas arise in the spine. 0.4-1.3% cases of meningiomas cases observed in optic nerve sheath and 0.5-3% cases in the choroid plexus.[13]

Most of the typical meningiomas are lobular, extra axial masses with well – circumscribed margins, in homogenous iso intense with cortex on all sequences; usually have a broad-based attachment. If it is infiltrate growth pattern over the dura, termed meningioma en plaque. T1 weighted sequence is usually isointense to grey matter in 60-90%, hypotense to grey matter in 10-40%. T1C+ (Gd), usually intense and homogneous enhancement and virtually all meingiomas, including densely calcified "brian rocks" and intra ossesous tumors. T2 weighted sequence usually isotense to grey matter (50%) and hypertense to grey matter (35-40%).[14,15] DWI/ADC shows atypical and malignant subtypes may be greater than expected restricted diffusion although recent work suggests that this is not useful in prospectively predicting histological grade.[16,17]

MRI imaging features observed in the present study were 67% of meningiomas showed homogenous enhancement, 56% cases had dural tail sign, 40% meningioma cases observed with CSF cleft, 37% of cases showed mass effect on surrounding arteries, cranial nerves, ventricular system and brainstem noted in twelve cases. 33% of cases noticed with perilesional edema, 30% had calcifications, 20% hyperostosis, 13% sinus invasion and 10% were others such as haemorrhages, cystic or non enhancement areas.

Dural "tail" sign is in majority of meningiomas and varies from a relatively focal area adjacent to the tumor to extensive dural thickening and enhancement extending far beyond the site of tumor attachment. Most of the enhancing dural tail represents benign, reactive dural thickening. CSF cleft appears between the tumor and the underlying brain cortex, which is suggestive of an extra axial location. The cleft may contain CSF or cortical vessels entrapped between the tumour and the underlying cortex.

Paek et al,[18] described dense, homogeneous enhancement in 11, heterogeneous enhancement in 3 and 2 cases of scanty, peripheral enhancement.

Bitzer M et al,[19] did a study on angiogenesis and brain oedema in intracranial meningiomas, noticed 60% of all cases were associated with brain oedema. They documented hypothesis related to brain oedema and meningiomas by supporting vasogenic theory; ischemia occurs due to chronic pressure by tumor or secondary to venous obstruction, in turn leads to osmotic dispersion by the pressure gradient between the extracellular space of the tumor and the interstitium of the brain; hypothesis suggests that tumour cells secrete an oedema-inducing substance into the adjacent brain parenchyma. Another concept is the expression of vascular endothelial growth factor (VEGF) which is an important factor in meningioma-related vasogenic oedema, with a correlation between VEGF expression and pial blood supply.

About 2 to 4% of intracranial meningiomas are cystic meningiomas. They were divided to four subtypes by Nauta et al and fifth subtype by Worthington et al. Type I - intratumoural cysts completely surrounded by tumour, Type II - intratumoural cysts at the periphery of the tumour surrounded by a histologically detectable row of neoplastic cells, Type III - peritumoural cysts whose walls partly consist of tumour, Type IV - peritumoural cysts whose walls are formed by arachnoid and are separated from tumour by a capsule, Type V - peritumoural subtype comprises entrapped CSF.[20]

Bosnjak et al,[21] did a study on 145 intracranial bleeding cases of meningiomas, found haemorrhage was predominantly noticed in two age groups, under 30 and over 70 years and the patterns of haemorrhage include subarachnoid, subdural, intracerebral and intratumoural. The proposed mechanism of spontaneous haemorrhage in meningiomas are vast and include weakening of feeding and draining vessels, intra tumoural angiomatous areas with friable vascular walls, meningeal invasion of vessel walls, blood dyscrasias, concurrent anticoagulation and head trauma.

CONCLUSION

While diagnosing typical or malignant meningiomas, should think about higher imaging modalities other than routine MRI including Diffuse tensor imaging, Magnetic resonance spectroscopy; these plays a vital role in evaluation of malignant potential and useful for surgical planning and prognostication. As Meningiomas are not an uncommon tumors, radiologists should be aware of different MRI characteristics and locations of meningiomal tumors, this will help to arrive at accurate diagnosis especially in atypical and misleading meningioma features.

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