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EVALUATION OF RADIOLOGICAL FEATURES AND TUMOUR CHARACTERISTICS AND THEIR SIGNIFICANCE IN OUTOME OF INTRACRANIAL MENINGIOMAS

Neurosurgery

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ABSTRACT

Meningioma is one of the most common intracranial tumours. Several advancements have been made for establishing the etiopathogenesis of meningiomas, including gene mutation and DNA methylation. Many factors have been found to be associated with tumour grade, time to recurrence, overall survival and prognosis. Today, with the availability of detailed radiological assessment and better micro neurosurgical techniques, the outcome has improved significantly. This study is aimed at evaluating detailed radiological features of meningiomas along with its characteristics like vascularity, adhesiveness and edema and to determine their significance in outcome.

SUMMARY: Meningioma is amongst the most common brain tumours. Several factors have been found to be associated with its origin, growth, grade, time to recurrence, outcome and overall prognosis. This prospective evaluation of 68 consecutive patients of intracranial meningioma was aimed at evaluating their detailed radiological features along with tumour characteristics like vascularity, adhesiveness and edema and to determine their significance in outcome.

Our study showed MRI was most useful tool for preoperative evaluation of tumour characteristics like edema, vascularity and adhesiveness which guide surgical outcome. Less vascular and adhesive tumours had good outcome as compared to highly vascular and strongly adhesive tumours. Size of tumour too was associated with outcome. In our study, all patients (100%) of grade 0 tumour removal had good outcome which was statistically highly significant ($p<0.01$). Most common histological variant was transitional type. We advocate aggressive surgical therapy as the primary and main mode of treatment in relation to the preoperative characteristics and features from imaging studies.

KEYWORDS

Meningioma, Computed Tomography (C T Scan), Magnetic Resonance Imaging (M R I Scan), Tumour characteristics

INTRODUCTION

The complexity and diversity of tumours of the nervous system is enormous, and, not surprisingly, some problematic questions of classification and grading remain unresolved.[1] Histological variants have been added, over time, if there is evidence of a different age distribution, location, genetic profile or clinical behavior.[2,3] Meningiomas so named by Harvey Cushing in 1922 "are the most common benign tumours of brain and constitute 13-18% of all primary brain tumours".[4] However higher-grade tumours with brain invasion as a criterion for atypia are aggressive.[5] Despite many advances these tumours can defy even the best attempts at surgical removal. They sometimes form one of the most formidable challenges in neurosurgery.[6] However nowadays with, development of skull base approaches and an understanding of biology and molecular genetics of these tumours, surgical results have improved considerably.

METHODOLOGY

This is a prospective evaluation of 68 consecutive patients of intracranial meningioma over a period of 05 (five) years with a minimum follow-up of 01 (one) year in the Department of Neurosurgery at Govind Ballabh Pant Institute of Post Graduate Medical Education and Research, New Delhi. Patients, before being admitted for operative procedure, were assessed clinically and radiologically. The institutional review board at our institution approved this study. Surgical approach varied depending upon the location of the tumour and removal was classified according to Modified Simpson grading.[7,8] Patients were followed up employing the Karnofsky scale, and MRI scanning. On the basis of this grading outcome was categorized into 4 groups:

Good: (Karnofsky grade 80-100) **Fair:**(Karnofsky grade 50-70) **Poor:**(Karnofsky grade 20-40) **Death:**(Karnofsky grade 10). These patients expired in post-operative period/ follow up and were excluded from evaluation for statistical significance)

STATISTICALANALYSIS:

All analyses were performed using JMP Pro (version 13; SAS Institute, Inc.). The results of the study were analyzed using appropriate statistical tests (Pearson's Chi Square Tests). Results are considered significant at p value <0.05 and highly significant at p value <0.01.

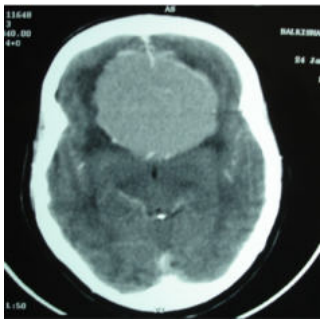
OBSERVATIONS

The patients were classified on the basis of age groups, gender, location, presenting symptoms, clinical findings and neurological status, radiological features as well as tumour characteristics. All the patients were investigated with CT scan brain (plain + contrast) and MRI brain (plain+ contrast). MR angiography and carotid angiography/DSA were done as per need.

Table 1: CT Scan features

Density	Hypo	Iso.	Hyper.
	11 (16.18%)	5 (7.35%)	52 (76.47%)
Enhancement	Homogenous	Heterogenous	
	58 (85.29%)	10 (14.71%)	
Calcification	Present	Absent	
	7 (10.29%)	61 (89.71%)	
Bone Involvement	Present	Absent	
	9 (13.23%)	59 (86.77%)	
Positivity	True Positive	False Positive	
	64 (94.12%)	4 (5.88%)	

Out of 68 patients, 64 were diagnosed as meningiomas on preoperative CT scan (94.12% true positive) while 4 patients, proved by histopathology after surgery, were not detected on pre-operative CT scan (5.88% false negative).



Picture 1: CECT head showing a large (62.4x61.6x65.4 mm) midline smooth walled contrast enhancing tumour in olfactory region. Final Diagnosis: Olfactory groove transitional meningioma

Table 2: MRI Scan features

Intensity	Hypo	Iso.	Hyper.
	6 (8.82%)	12(17.6%)	50(73.53%)
Enhancement	Homogenous	Heterogenous	
	58 (85.29%)	10 (14.71%)	
Rim	Present	Absent	
	59 (86.77%)	9 (13.23%)	
Edema	Absent	Mod	Severe
	15 (22.06%)	35(51.47%)	18(26.47%)
Mass effect	Mild	Mod	Severe
	9(13.23%)	12(17.65%)	47(69.12%)
Mean Dia.	5.75 cms.		

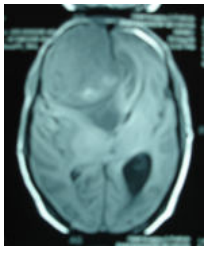
The maximal tumour diameter ranged from 3.2cm to 8.2cm (mean, 5.75cm). Based on signal intensity, they were divided into: Hypointense, isointense and hyperintense. Further based on degree of peritumoural edema[9] they were classified into three groups:

Edema (-): cases with no edema

Edema (+): which showed mild edema in the periphery of tumour.
Edema (++): which showed edema extending extensively into the white matter. On the basis of mass effect 10 these tumours were classified into three categories:

Mild (+): mild sulcus effacement
Moderate (++): causing buckling of underlying cortex.
Severe (+++): causing herniation of adjacent brain parenchyma.

Angiogram/DSA: It was performed in [10] cases, which were already diagnosed as meningiomas on CT/MRI, but were very vascular.



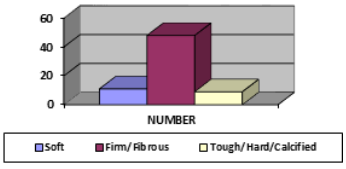
Picture 2: T1W MRI imaging of brain revealing a large (67.2x68.2x72.4mm) well marginated isointense, predominantly homogenous, extra-axial mass lesion in right high frontal parafalcine region with significant perilesional edema and mass effect with associated obstructive hydrocephalus. CSF cleft with gyral buckling evident. Final Diagnosis: Right Parafalcine Transitional Meningioma

Table 3: Pre-operative Grading (status of patients)

Pre-op KG	No. of Patients	(%)
100	-	-
90	4	5.88
80	8	11.77
70	6	8.82
60	12	17.64
50	4	5.88
40	18	26.47
30	12	17.64
20	3	4.42
10	1	1.47

Table 4: Intra-operative (Tumour Characteristics)

Consistency	Number	(%)
Soft	11	16.18
Firm/Fibrous	48	70.59
Tough/Hard/Calcified	9	13.23

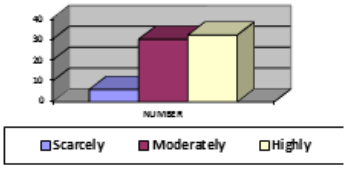


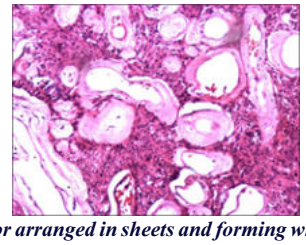
The visual analog scale (VAS), from zero to 10[11], was employed for evaluating tumor consistency. The tumours were divided into three groups:

Soft: VAS of 0-3.
Firm/ Fibrous: VAS of 4-6.
Tough/Hard/Calcified: VAS of 7-10.

Table 5: Tumour Vascularity

VASCULARITY	NUMBER	(%)
Scarcely	6	8.82
Moderately	30	44.12
Highly	32	47.06





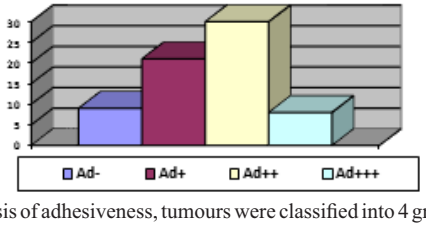
Picture 3: Tumor arranged in sheets and forming whorls with foamy cytoplasm in the stroma (xanthomatous change). Tumor cells are uniform with oval nuclei, delicate chromatin and moderate to abundant eosinophilic cytoplasm with ill-defined cell boundaries. Final Diagnosis: Angiomatous Meningioma

The visual analog scale (VAS), from zero to 10[11] was also used for evaluating vascularity based on intra operative bleeding and the tumours were divided into three groups:[12]

Scarcely vascular: VAS of 0-3.
Moderately vascular: VAS of 4-6.
Highly vascular: VAS of 7-10.

Table-7: Perilesional changes (Adhesiveness)

ADHESIVENESS	NUMBER	(%)
Adhesion (-)	9	13.23
Adhesion (+)	21	30.88
Adhesion (++)	30	44.12
Adhesion (+++)	8	11.77



On the basis of adhesiveness, tumours were classified into 4 groups:[11]
Adhesion (-): No adhesion to the intercalated arachnoids.

Adhesion (+): Weak adhesion. The arachnoids in contact with the tumour were conserved after tumour excision.

Adhesion (++): Strong adhesion. The arachnoids in contact with the tumour were stripped off in parts and the brain surface was exposed.

Adhesion (+++): Very strong adhesion. No intercalated arachnoids were present; separating the tumour from brain was difficult.

HISTOPATHOLOGY:

WHO GRADE	NO. OF PATIENTS
Grade I	60
Grade II	6
Grade III	2

Grade I: 60 cases (88.24%) with transitional type being the most common accounting for 35 patients (51.47%)
Grade II: 6 cases (8.82%) of which 5 patients (7.35%) were of atypical variety
Grade III: One case each of papillary and anaplastic meningioma (2.94%).

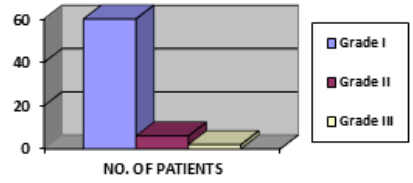
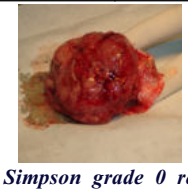


Table 7: Completeness of Excision (Modified Simpson Grading)

Excision	No. of cases	(%)
Grade 0	12	17.65
Grade 1	18	26.47
Grade 2	30	44.12
Grade 3	6	8.82
Grade 4	2	2.94
Grade 5	-	-
2nd surgery (earlier near total done)	2	2.94



Picture 4: Modified Simpson grade 0 removal of left frontal convexity tumour done. Final Diagnosis: Fibroblastic Meningioma

RESULTS:
The outcome was evaluated in relation to relation to extent of removal, vascularity, adhesiveness as well as post-operative Karnofsky grade.

Table 9: Surgical outcome in relation to completeness of excision

Compl;etene ss of Excision	Outcome			
	Good	Fair	Poor	Death
Grade 0	12(100%)	-	-	-
Grade I	13(72.22%)	4(22.22%)	1(5.56%)	-
Grade II	21(70%)	7(23.33%)	-	2(6.67%)
Grade III	2(33.34%)	3(50%)	1(16.66%)	-
Grade IV	-	-	-	2(100%)
Grade V	-	-	-	-

Tests	Value	df	7. Sig. (2-sided)
Pearson Chi-Square	47.429[a]	12	**.000**
Likelihood Ratio	29.863	12	.003
McNemar-Bowker Test	.	.	.[b]
N of Valid Cases	68		

Table 10: Surgical Outcome As Per Vascularity

Vascularity	Total	Outcome			
		Good	Fair	Poor	Death
Scarcely	6	5(83.33%)	-	-	1(16.67%)
Moderately	30	23(76.66%)	6(20%)	1(33.34%)	-
Highly	32	20(62.50%)	8(25%)	1(3.12%)	3(9.38%)

Tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.945[a]	6	**.429**
Likelihood Ratio	8.601	6	.197
McNemar-Bowker Test	.	.	.[b]
N of Valid Cases	68		

Table-11: Surgical outcome as per adhesiveness

Ashesiveness	Total	Outcome			
		Good	Fair	Poor	Death
Adh (-)	9	8(88.89%)	1(11.11%)	-	-
Adh (+)	21	15(71.43%)	5(23.81%)	1(4.72%)	-3(10.00%)
Adh(++)	30	20(66.67%)	7(23.33%)	-	
Adh (+++)	8	5(62.5%)	1(12.5%)	1(12.5%)	1(12.5%)

Tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.525[a]	9	**.482**
Likelihood Ratio	10.063	9	.345
McNemar-Bowker Test	.	.	.[b]
N of Valid Cases	68		

Table 12: Post-operative Grading (status of patients at 1 Year)

Pre-op Karnofsky Grade	NO. OF PATIENTS	(%)
100	22	32.35
90	19	27.94
80	7	10.29
70	9	13.23
60	3	4.41
50	2	2.94
40	2	2.94
30	-	-
20	-	-
10	4	5.88
Case Summaries	K G preop	K G at 1yr
N	68	64
Minimum	10	40
Maximum	90	100
Range	80	60
Mean	51.32	85.47
Std. Deviation	20.436	15.829
Median	45.00	90.00
Std. Error of Mean	2.478	1.979

Tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	71.558[a]	48	.015
Likelihood Ratio	52.206	48	.314
Linear-by-Linear Association	.224	1	.636
McNemar-Bowker Test	.	.	.[b]
N of Valid Cases	68		

There were 10 complications in 21 patients

DISCUSSION
Several grading systems have been proposed for classifying meningiomas.[7, 13] More recently specific DNA methylation has been found to be associated with tumour grade and survival.[14, 15] Gene mutations have been found to be associated with shorter time to recurrence, overall survival and poor prognosis.[16] If the meningioma can be totally removed by surgery, the recurrence is low.[17] Surgery is the primary and main mode of treatment, especially in large meningiomas, to relieve pressure manifestations.[18] Aggressive surgical therapy with wider dural removal should be considered in the presence of preoperative predictors of a recurrence.[8] The outcome for most patients with malignant meningiomas is poor.[19,20]

In our series 21(30.88%) of 68 tumours were seen in parasaggital/ parafalcine location and 20 (29.41%) were seen in convexity region and maximal tumour diameter ranged from 3.2cm to 8.2cm (mean 5.75cm). Other series have reported mean diameter of 4.16cm[9], 4.05cm.[21] Most of our patients reported for evaluation only when the size of tumour had increased significantly to hamper their daily activity of life.

In our study, 4 patients who had meningiomas (proved by histopathology after surgery) were not detected on pre-operative CT scan (5.88% false negative). New et al found that CT scans were positive in 96% and diagnostic in 90% of cases.[22] "Dural lucent line" is a characteristic feature of hyperostosing meningioma en plaque.[23] This zone may be related to widening of the subarachnoid space, cerebral edema, tissue necrosis or demyelination.

Lee et al found male sex, hyperintensity in T2WI and pial blood supply to be associated with peritumoural edema in meningioma that influence the clinical prognosis of patients.[24]

On unenhanced MRI, extra axial mass effect suggested by white matter buckling, a rim of CSF around the mass, a pial vascular rim and a shorter T2 of the mass are described as characteristics of meningioma.[9, 10] Stewens et al found that edema occurred most frequently in the centrum semiovale and deep white matter around the ventricular trigones and frontal horns, the distribution reflecting mainly the size of interstitial spaces adjacent to the tumours.[25] In most cases, the mass

effect is secondary to a combination of both the tumour mass and the surrounding edema.[10]

Meningiomas hyperintense to the cortex on T2 are usually soft, more vascular and more frequently of syncytial or angioblastic subtype; tumors hypointense or hypo-isointense on T2 tend to have a harder consistency and are more often of fibroblastic or transitional subtype.[26] Invasive pattern of brain–tumor interface and hyperintensity on T2WI were indicative factors of meningiomas producing brain edema.[24,27]

Surgical management of paediatric meningiomas is challenging because of atypical locations.[28] The site of origin, clinical presentation and size of the tumour determines the operative approach and success of surgery. Radical tumor removal can usually be achieved without further morbidity and with postoperative improvement of the preexisting symptoms.[29] In our study, all patients (100%) of grade 0 tumour removal had good outcome which was statistically highly significant ($p<0.01$).

It was evident that scarcely and moderately vascular tumours had good outcome in a higher proportion of patients as compared to highly vascular tumours. Good outcome was seen in 5(83.33%) out of 6 scarcely vascular tumours. It was seen in 23(76.66%) of 30 moderately vascular lesions and in 20(62.50%) out of 32 highly vascular ones. There were 3 deaths among highly vascular tumours and 1 death among scarcely vascular tumours. Good outcome was seen in 88.89% adhesion (-), 71.43% of adhesion (+), 66.67% of adhesion (++) and 62.5% of adhesion (+++) type of tumours. Mortality was seen in 3 patients (95.88%) with adhesion (++) and 1 patient (12.5%) of adhesion (+++) type. Intra-operative findings with regard to consistency, vascularity and adhesiveness were similar with the figures quoted by Yasargil.[31]

There were 4 deaths in our series making it 5.88%. In Robert G. Ojemann's series, mortality was 1% (2 out of 200 cases).[32] In Yasargil's series it was 0.9% (5 out of 548 patients).[31] In Mayo clinic series of 682 patients, mortality was 5.1%. In our series, a higher mortality was seen due to poor pre-operative condition, very large tumours and other co-morbidities. Various large series have attributed large size of meningiomas along with high vascularity, extent of surgical removal to affect recurrence rate, postoperative outcome, operative morbidity and mortality rates, and survival time.[21,33,34]

CONCLUSIONS

Based on this study we conclude that most tumours in our study were very large at presentation with a mean diameter of 5.75cm. MRI was most useful tool for preoperative evaluation of tumour characteristics like edema, vascularity and adhesiveness which guide surgical outcome. Highly vascular and adherent tumours were difficult to excise completely. Most common histological variant was transitional type. Surgical outcome was good in majority of patients with morbidity and mortality comparable to other large series. Most of our findings were similar to other reported series with variations resulting due to late presentation of patients, large size of tumour and poor preoperative status.

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