The role of MRI in defining the characteristic patterns of intracranial meningioma. Prospective study

Osamah Ayad Abdulsattar
Babylon medical university
ausmarealmadrid@yahoo.com

Abstract

objective:

the purpose of this study is to evaluate the role of mri in defining the characteristic pattern of intracranial meningiomas and to correlate mri with the histopathological findings in an attempt to predict the histological diagnosis (subtype) prior to surgery.

patients and methods

between january 2011 to october 2013. pre- and post-contrast sagittal and axial t1-weighted images with gd-dtpa and sagittal t2-weighted fast spin echo were obtained in 62 symptomatic patients aged 20-69 years. the mr images were evaluated in regard to location and laterality of the tumors, signal intensity, contrast homogeneity, presence of meningioma cleft sign, cystic changes, vascularity, mass effect and any other pathological observations (calcification, edema, bony or dural venous sinus invasion).

results:

on mri appearance, atypical and malignant meningiomas in contrast with the more benign histology had more heterogeneous signal intensity and enhancement in (80%) and (100%) respectively, less obviously showed meningioma cleft sign, more cystic appearance in (60%) and (100%) respectively, surrounded by marked edema (+++) degree, exert more mass effect and invade the dural venous sinus in almost all the cases .

conclusion:

overall, mri is an excellent non-invasive tool for the preoperative evaluation of intracranial meningiomas and can predict with certainty the aggressive behavior of the more atypical and malignant meningiomas.

Key words: Meningioma ,CT of brain tumor, MRI of meningioma, brain tumor .

الخلاصة

اجريت دراسة مقطعيه لاثنان وستون مريضا مصابين بورم الاغشيه الدماغيه ,تم فحصهم باللرنين المغناطيسي لتشخيص كون الورم حميد او خبيث او الحالب تم اجراء الرنين المغنطيسي لهم الرنين العادي والرنين الملون تم احتساب العملات المميزه بالرنين لتشخيص الورم خبث او حميد اثبتت هذه الدراسه عدم امكانيه الرنين في تشخيص الورم حميد او خبيث .

الكلمات المفتاحية: ورم الاغشيه الماغيه, مفراس ورم الدماغ, رنين ورم الاغشيه الدماغيه, ورم الدماغ

Introduction

The meninges are three membranouslayers that surround the structures of the central nervous system. They include the dura mater, the arachnoid mater, and the pia mater. Together they cushion the brain and spinal cord with cerebrospinal fluid and support the associated vascular structures. (Sinnatamby 2006;Waugh & Grant, 2010). A meningioma is a type of tumor that develops from the meninges, the membrane that surrounds the brain and spinal cord. There are three layers of meninges, called the dura mater, arachnoid, and pia mater. Most meningiomas (90%) are categorized as benign tumors, with the remaining 10% being atypical or malignant. However, the word "benign" can be misleading in this case, as when benign tumors grow and constrict and affect the brain, they can cause disability and even be life threatening. (Colledge *et al.*, 2010).

Meningioma account for 30% of all primary brain tumor diagnoses in adults in the United States.9The overall age-adjusted incidence rate is (CBTRUS, 2005). 52 per100,000 (Colledge *et al.*, 2010). Although age-adjusted incidence rates are reportedly similar across racial groups, the incidence in women is approximately twice that in men

(Colledge *et al.*, 2010). The incidence increases with increasing age, peaking in the seventh and eighth decades of life; these tumors are very rare in children (Colledge *et al.*, 2010). It is currently estimated that 83% of all meningiomas are microscopically confirmed (CBTRU, 2005). The incidence of both diagnostically and non diagnostically confired meningiomas increased between 1985 and 1999 (CBTRUS, 2005) on average the incidence of non diagnostically confirmed meningiomas increased significantly at 4.1% per year (95% CI2.5–5.6) potentially reflecting both the increased use of improved imaging techniques such as MR imaging and increased numbers of meningiomas treated with observationor primary radiotherapy rather than through surgical intervention.A similar statistically significant difference in the average annual percent change was not seen for diagnostically confirmed meningiomas. (CBTRUS, 2005). The vast majority of meningiomas are considered histologically benign (92.8%); only 2.2% are defined as uncertainor atypical, and 5% as malignant. (Colledge *et al.*, 2010). Five-year survivalrates are high for this tumor type (reported to be any where from 70 to 95%)(6,7.8) and therefore the estimated population prevalence (number of individuals living with this tumor) is relatively high, 50.4 per 100,000 (Rajaraman *et al.*, 2006; Sadetzki *et al,* 2005). Long survival times coupled with potentially significant neurocognitiveand physical deficits could lead to significant medical costs over time. The estimated average years of potential life lost in persons with meningiomas is 13 years, providing further evidence of the long-term burden of this disease (Thuppal *et al.*, 2006).

Aim of the study

1- To evaluate the role of MRI in defining the characteristic patterns of intracranial meningiomas.
2- To correlate MRI with the histopathological findings in an attempt to predict the histological diagnosis prior to surgery.

Patients and methods

In this cross-sectional study a sixty-two patients (21 males and 41 females) with an age ranging from 20-69 years (mean 58 years) were studied at the surgical wards of Al-hilla teaching Hospital between October 2009 and June 2012.

A complete history was taken from each patient. Preoperative presumptive diagnosis of intracranial extra-axial meningiomas was made using Philips Gyroscan (N.T. 3000 super-conducting, 1.5 Tesla), and when making an appointment for an MR examination, a brief explanation of the examination to the patient was done, mentioning the contraindications, advising how long it takes and how to dress for it, inform about the gradient noise will be heard while being immobilized in a narrow space and about the communication via the intercom, or video camera.

Head coil was used which is quadrature detector coil suitable for head imaging. All patients subsequently underwent surgery for their intracranial tumors and tissue sections from each case were viewed by pathologist and a detailed histopathological report was obtained.

MRI examination technique:

The patient is placed in the head support. If the patient has a short neck, it is advisable to place some padding over the lower part of the support under the shoulders.

A small wedge should be used to immobilize the head by placing them firmly between the head and the sides of the support. The head fixation strap can be used for extra- immobilization. Once the patient is positioned the head rests, pull the sliding part gently over the head and face, this is most easily performed by pulling gently on both sides of the coil. Close the base, move the table up and towards the magnet. Switch the light visor on and center to the marks on the coil to have a good quality images. Once

correctly centered, travel-to-scan can be performed. Observe the patient and place a reassuring hand on the patient's leg whilst the table is in motion.

Types of the images

Standard brain MRI examination include the following:

1-Sagittal and axial TI-weighted imaging (TR/TE=400-600 msec./20-30 msec.).
2-Sagittal and axial T2-weighted imaging (TR/TE=2200-3000 msec./80100 msec.).
3-T2-FLAIR coronal.
4-Post-contrast TI-weighted images in axial, sagittal and coronal sections to demonstrate the enhancement pattern of the lesions.

Contrast medium

Gadolinium DTPA: The dose is (0.1) m.mol/Kg body weight. Omniscan is a paramagnetic contrast media, each ml. Containing (0.5) m.mol of Gadiamide. It is manufactured by Nycomed, Ireland and supplied readily for use as a sterile solution.
The dose is given through slow I.V. route while the patient is still inside the MR tunnel. Patients were examined immediately after C.M. injection.
All sequences were of 5 mm. Slice thickness with 1 mm. gap in between to get an appropriate resolution with a good signal to noise. The imaging matrix was 256 x 256.

Results

In this study, sixty-two patients (59 newly diagnosed and 3 recurrent) with intracranial extra-axial meningiomas, suggested by MRI according to specific criteria for tissue typing, surgically verified and the final diagnosis proved by tissue biopsy were studied.

These sixty-two patients (table 1 and 2), were 21(34%) males, 41(66%) females, aged between 20-69 years with mean age of 58 years and the histopathological diagnoses we found benign tumors in 55 cases (88.7%) with no MRI specificity could be found to each tissue type, atypical tumors in 5 cases (8%), and malignant meningiomas in 2 cases (3.3%) only (in this series hemangiopericytomas were excluded). These 55 cases of benign meningiomas were further subdivided histopathologically into: Meningothelial variety which represents 18 cases (33% of the benign type) [8 (44%) males and 10 (56%) females], fibroblastic meningiomas which represents 6 cases (11%) of the benign type [4 (67%) males and 2 (23%) females], transitional variety was found in 28 cases (51 %) of the, benign tumors [6 (21 %) males and 22 (79%) females], angioblastic type that represents 2 cases (3%) all were females and other varieties of benign meningiomas in one male case (2%) which proved to be psammomatus meningioma.

While of the 5 cases that proved to be atypical meningiomas they were 2 (40%) males and 3 (60%) females and the two cases of malignant entity were females (100%).

In regard to the tumor location (table 3), cerebral convexity location was found in 25 cases (40.4%), parasagittal in 20 cases (32.2%), olfactory groove and cerebellar convexity each with 4 cases (6.5%), sphenoid ridge location was seen in 3 cases (5%), the tubercullum sellae and intraventricular location in 2 cases for each (3.2%), while the tentorium and the cerebellopontine angle (C.P.A.) locations shared the same number of cases (one for each) that represent (1.5%) of total cases of meningiomas. Sizes ranged approximately from (1 x 1.4 x 1.8 cm. to 10 x 8.4 x 6 cm.) in the vertical, transverse, and anteroposterior dimensions. The site of the tumor encountered in both sides of the brain (table 4), by 33 cases (53.3%) in the right side, 18 cases (29%) in the left side while 9 cases (14.5%) were central. The two cases of intraventricular meningiomas were one in each lateral ventricle (1.6 %).

Most meningiomas showed isointense signal intensity on both T 1-WI and T2-WI, [56 cases (90.3%)] and [47 cases (76%)] respectively, and homogenous texture in 45 cases (73%) (table 5).

Forty-seven (76%) of the tumors showed positive meningioma cleft on MRI, while 21 cases (34%) showed calcification; just 8 cases (13%) had cystic changes and only 25cases (40%) were avascular on MRI (table 6).

Regarding peritumoral edema, twelve cases (19.5%) of meningiomas were not surrounded by edema, 31 cases (50%) had mild (+) degree, 10 cases (16%) had moderate (++) degree and 9 (14.5%) cases had marked (+++) degree (table 7).

All of these meningiomas showed enhancement with intravenous contrast media to different extent, two cases (3.2%) had mild (+) degree, 26 (42%) had moderate (++) degree and 34 cases (54.8%) had marked (+++) degree (table 8). 49 (79%) of the cases had homogenous enhancement with contrast media and 38 cases (61 %) show dural tail enhancement (table 9).

Mass effect was seen fluctuating between mild sulcus effacement (+) degree and severe one degree with subfalxial herniation with or without hydrocephalus (table 10).

Six cases (11%) of the benign tumors, 2 cases (40%) of the atypical and one case (50%) of the malignant tumors had positive bone involvement, while the ratios for dural venous sinus invasion on MRI were (16.4%), (60%) and (100%) for the benign, atypical and the malignant tumors respectively (table 11).

Table (1): Age distribution by intracranial meningioma histopathological subtypes.

Age in years	Benign							Atypical		Malign		Total	
	M.	F.	T.	A.	O.	In Total							
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%
20-29	2				1	3	5.5					3	4.8
30-39	2	1	3	2		8	14.5					8	13
40-49	6	1	8			15	27.2	1	20	1	50	17	27.4
50-59	4	2	11			17	31	4	80	1	50	22	35.5
60-69	4	2	6			12	21.8					12	19.3
Total	18	6	28	2	1	55	88.7	5	8	2	3.3	62	100

*Meningothelial (M.), Fibroblastic (F.), Transitional (T.), Angioblastic (A.), Others (O.)
** Spearman's Rank Correlation Coefficient between meningioma histopathological subtype and age in years (r=0.05) (P=0.71$^{(NS)}$)

Table (2): Age and gender distribution by intracranial meningiomas histopathological subtypes

AGE IN YEARS	BENIGN												ATYP.		MALIG		TOTAL			
	M.		F.		T.		A.		O.		IN TOTAL									
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	%	F	%
20-29	2								1		3						3	14		
30-39	1	1	1		2	2		1			4	4					4	19	4	10
40-49	2	4		1	3	5		1			5	11		1		1	5	24	13	32
50-59	2	2	2			13					5	15		1			5	24	16	39
60-69	1	3	1	1		2					2	6	2	1		1	4	19	8	19
TOTAL	8	10	4	2	6	22		2	1		19	36	2	3		2	21	34	41	66

*Meningothelial (M.), fibroblastic (F.), Transitional (T.), Angioblastic (A.), Others (O.), Atypical (ATYP.), Malignant (MALIG.)

Table (3): Correlation between location of intracranial meningiomas and their histopathology

Location	Benign							Atypical		Malign		Total	
	M	F.	T.	A.	O.	In Total							
	No	No	No.	No	No	No	%	No	%	No	%	No.	%
Cerebral Convexity	5	2	14			21	38	4	80			25	40.4
Parasagittal	7	1	6	2	1	17	31	1	20	2	100	20	32.2
Olfactory groove	1	2	1			4	7.4					4	6.5
Cerebellar Convexity	2	1	1			4	7.4					4	6.5
Sphenoid ridge			3			3	5.5					3	5
Tuberculm sellae	2					2	3.6					2	3.2
Intraventricular	1		1			2	3.6					2	3.2
Tentorium			1			1	1.8					1	1.5
C. P. A.			1	-		1	1.8					1	1.5
Total	18	6	28	2	1	55		5				62	100

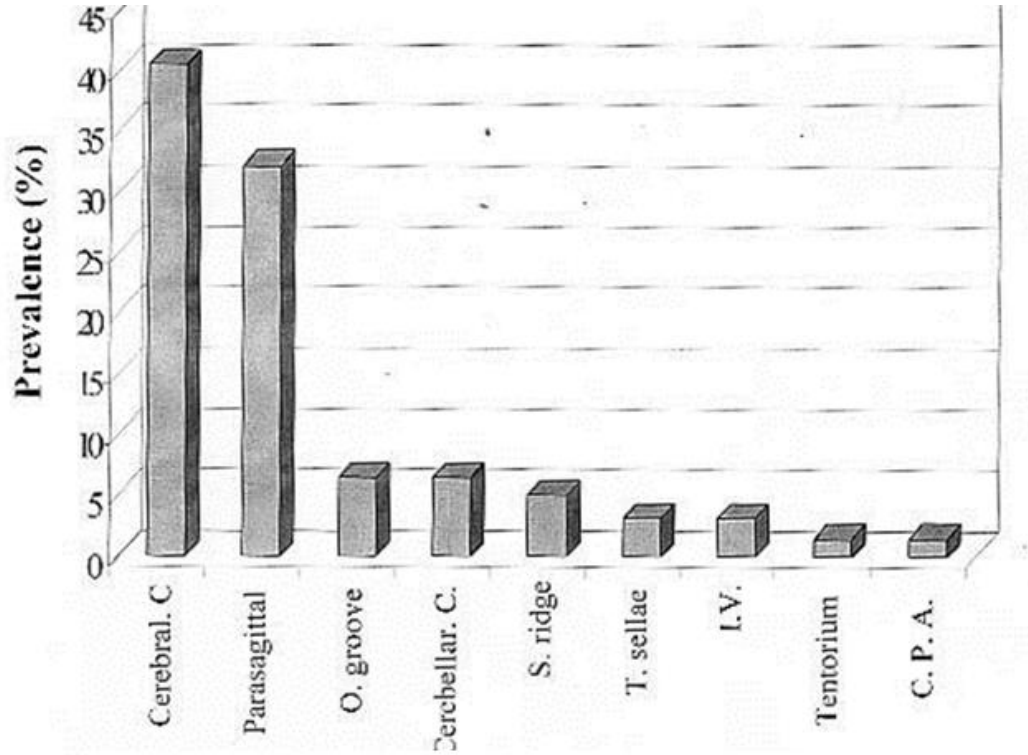

Table (4): Correlation between laterality in location of intracranial meniniomas and their histopathology.

Location Side	Benign							Atypical		Malignant		Total	
	M	F.	T.	A	O	In total							
	No	No	No	No	No	No	%	No.	%	No.	%	No.	%
Rt. Side	9	3	15	2	1	30	54.5	3	60			33	53.3
Lt. Side	2	1	11			14	25.5	2	40	2	100	18	29
Central	6	2	1			9	16.4					9	14.5
Intravent:													
Rt. L. V.			1			1	1.8					1	1.6
Lt. L. V.	1					1	1.8					1	1.6
Total	18	6	28	2	1	55	100	5	100	2	100	62	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 ($p = 0.13^{[NS]}$).

Table (5): correlation between MRI signal intensity on T1-WI &T2-WI and histopathological subtypes of intracranial meningiomas.

MRI Signal Intensity	Benign							Atypical		Malign		Total		P VALUE
	M.	F.	T.	A.	O.	In Total								
	No.	No.	No.	No.	No.	No.	%	No	%	No.	%	No.	%	No.
T1-hypointense	2	2	1			5	9	1	20			6	9.7	> 0.5
T1- Isointense	16	4	27	2	1	50	91	4	80	2	100	56	90.3	
T2-isointense	13	5	21	2	1	42	76.3	4	80	1	50	47	76	> 0.5
T2- hyperintense	5	1	7			13	23.7	1	20	1	50	15	24	
Homogeneous	12	6	25	1		44	80	1	20			45	73	< 0.005
Heterogeneous	6		3	1	1	11	20	4	80	2	100	17	27	

Table (5) :Correlation between bony and dural venous sinus invasion by meningioma detected by MRI and histopathology

MRI Findings	Benign							atypical		Malignant		Total		P value
	M	F	T	A	O	IN TOTAL								
	N	N	N	N	N	No.	%	No.	%	No.	%	No.	%	
Bony involvement														
Positive:	1		5			6	11	2	40	1	50	9	14.5	>0.05
Negative:	17	6	23	2	1	49	89	3	60	1	50	53	85.5	
Dural venous sinus invasion:														
Positive:	2		6	1		9	16.4	3	60	2	100	14	22.5	<0.005
Negative:	16	6	22	1	1	46	83.6	2	40			48	77.5	
Total	18	6	28	2	1	55	100	5	100	2	100	62	100	

Table (6): Correlation between other MRI findings and histopathological diagnosis of intracranial meningiomas.

MRI findings	Benign							Atypical		Malignant		Total		P value
	M	F	T	A	O	IN TOTAL								
	N	N	N	N	N	No.	%	No.	%	No	%	No	%	
Meningioma cleft:														
Positive	14	6	23	1	1	45	82	2	40			47	76	< 0.005
Negative	4		5	1		10	18	3	60	2	100	15	24	
Calcification														
Flecks of:	7		11		1	19	34.5	2	40			21	34	> 0.5
Absent:	11	6	17	2		36	65.5	3	60	2	100	41	66	
Cystic changes:														
Positive:	1		2			3	5.5	3	60	2	100	8	13	< 0.005
Negative;	17	6	26	2	1	52	94.5	2	40			54	87	
Vascularity														
Avascular:	7	4	12		1	24	43.6	1	20			25	40	> 0.5
Vascular:	11	2	16	2		31	56.4	4	80	2	100	37	60	
TOTAL	18	6	28	2	1	55	100	5	100	2	100	62	100	

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

Table (7): Correlation between degree of perifocal edema and intracranial meningioma histopathological subtypes.

Perifocal edema	Benign							Atypical		Malign.		Total	
	M.	F.	T.	A.	O.	In Total							
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%
Absent	5	2	5			12	22					12	19.5
(+)	7	3	19		1	30	54.5	1	20			31	50
(++)	4	1	2	2		9	16.3	1	20			10	16
(+++)	2		2			4	7.2	3	60	2	100	9	14.5
Total	**18**	**6**	**28**	**2**	**1**	**55**	**100**	**5**	**100**	**2**	**100**	**62**	**100**
Median	+	+	+	++	+	+		+++		+++		+	

*Meningothelial (M.), Fibroblastic (F.), Transitional (T.), Angioblastic (A.), Others (O.)
**(+) mild=extend up to 2 cm around the lesion, (++) moderate=2-4 cm, (+++) marked > 4 cm
***Spearman's Rank Correlation Coefficient between meningioma histopathological subtypes and perifocl edema (r=0.45) (P<0.001)

Table(8):correlation between degree of mass effect and intracranial meningioma histopatholgy subtype.

Mass effect	Benign							Atypical		Malign.		Total	
	M.	F.	T.	A.	O.	In Total							
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%
With H.C.													
(+)	3		2			5	9					5	8
(++)	1		2	1		4	7.3	1	20			5	8
(+++)			1			1	1.8			1	50	2	3.5
Without H.C.													
(+)	8	5	16			29	52.7	2	40			31	50
(++)	5	1	6	1	1	14	25.6	1	20			15	24
(+++)						2	3.6		20	1	50	4	6.5
Total	**18**	**6**	**28**	**2**	**1**	**55**	**100**	**5**	**100**	**2**	**100**	**62**	**100**

* Hydrocephalus (H.C.)

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

*** Spearman's Rank Correlation Coefficient between meningioma histopathological subtype and degree of mass effect (r=0.3) (P=0.02)

Table (9): Enhancement pattern by intracranial meningioma histopathological subtypes.

Enhancement	Benign							Atypical		Malign		Total	
	M.	F.	T.	A.	O.	In Total							
	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	%
**Mode of: ** **													
Homogenous	16	6	25		1	48	87	1	20			49	79
Heterogeneous	2		3	2		7	13	4	80	2	100	13	21
Dural tail: * **													
Absent	8	3	10	1	1	23	42	1	20			24	39
Present	10	3	18	1		32	58	4	80	2	100	38	61
Total	**18**	**6**	**28**	**2**	**1**	**55**	**100**	**5**	**100**	**2**	**100**	**62**	**100**

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

**Spearman's rank correlation coefficient between meningioma histopathological subtypes and mode of enhancement (r=0.6)($P<0.001$)

*** Spearman's rank correlation coefficient between meningioma histopathological subtypes and the presence of the dural tail (r=0.18)(P=1.6 [NS])

Discussion

In our thesis we found female predominant, 66% female, 34% male, which is go with study of intra cranial meningioma by Isabelle (Isabelle *et al.*, 2000) as 60 – 80% of patients are female in adults, however in younger age group no female predominance.

As we show: the benign/typical meningioma about 88.7%, malignant/atypical meningioma about 11.3%, however in (Herz *et al.*,1999), the benign/typical meningioma about 71% , malignant/ atypical meningioma about 29% this difference could be related to histopathological efficiency examination difference, or by using different histopathological staging methods.The meningiothelial type of meningioma is most common histopathological type in our study which is similar to result of Jelana in 2011, (Jelena *et al.,* 2011). As we seen in our study the most common location of intra cranial extra axial meningioma is in cerebral convexity and next common location is para sagital/ para falcine, which is similar to results of Sutton and Calvaria in 2000, (Jelena *et al.*,, 2011; Rohringer, *et al.,* 2011). We see that 1.6% of patient diagnosed as intra ventricular meningioma, however in (Rohringer 2001; Rohringer *et al,* 2011), the percent of intra ventricular meningioma about 5% this could be, that some patient come late and come with completely calcified meningioma and not undergone surgery, some initially misdiagnosed as choroid plexus papilloma and their surgery postponed or not done. Most meningiomas in our study seen isointense in T1 and T2 , this goes with our histopathologic result (packed cell/ meningiothelial type), and goes with result of (German , 2013) the most of meningioma give no signal intensity, i.e. isointense in T1 and T2 in brain magnetic resonance imaging. Hadidy *et al* reported that the majority of meningiomas presented with isointense signal on T1WI and T2WI, hyperintense signal on FLAIR and intense staining (Hadidy *et al.,* 2013).

We see about 76% patient CSF cleft sign which is in near proximity to result of Drelevelegas, (Drevelegas, 2005), in which about 60%, however some difference could be may be or due to over estimation of dural enhancement or could be co existence of infection as in some young age group.

Bone hyperostosis seen in our thesis in about 34% , which is reach about result of Bigner in 1998 which is about 15 – 20%. (Bigner *et al.,* 1998).

Our result approved about 13% of cases are cystic in nature, as compared to be 10% in result of (Zee, 2003), in which we see that cystic component of meningioma is much smaller than its solid component and it is not necessary to be attach to the cortex of brain.

In most cases about 50% in our study we discover that meningioma mostly come with mild degree of surrounding edema , and that go with study of German C Castillo in which about 70%, however this difference may due to personal variation in assessment degree of edema or due to different in immunity of patient giving impression of wide zone of edema. (Hadidy *et al.,* 2013).

We show that 54.8% of our patients have marked enhancement which give similarity to results of Neenu Philip about 60% in which show homogenous intense contrast enhancement. (Neenu *et al.,* 2012).

Conclusion

1-overall, MRI is an excellent non-invasive tool for the preoperative evaluation of intracranial meningiomas and can predict with certainty the aggressive behavior of the more atypical and malignant meningiomas.

2- Thus, imaging findings may contribute incremental value to clinical parameters in providing prognostic information, consequently improving the quality of the data used in therapeutic planning.

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