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RESEARCH ARTICLE

Association of Radiological CT and MRI Scan Features to the Histopathology of Meningiomas in Patients at Major Hospitals in Eldoret Town, Kenya

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Abstract

This paper examines the association of radiological features seen on CT scan and MRI to the histopathology of meningiomas based on a study of patients in the Moi Teaching and Referral Hospital, Mediheal and Eldoret hospitals in Eldoret, Kenya. A cross-sectional study design was used. Radiopathological association was done using CT scan and MRI images which had a confirmatory histopathology report. Fifty-five patients were studied from May 2008 to December 2012. An inclusion criterion was presence of both histopathology and CT or MRI images while exclusion was where either lacked. Data analysis was done by STATA version 12. There was a 3:1 female to male ratio. The age group most affected was 45-55 years. Association between the various radiological features and histopathology was only seen with the CSF variable and this was likely a chance finding. Though imaging can reliably diagnose meningiomas, histopathological subtypes of meningiomas cannot be differentiated from each other based on radiological features.

Introduction

Many trials have been done to find out whether or not radiologic features can predict the subtype and prognosis of meningioma (Vassilouthis and Ambrose, 1979; New et al., 1982; Alvarez et al., 1987). Despite this, no consensus has been arrived at with different studies drawing varied conclusions. A Belgium study by Demarael et al. (1991) has found that "Different histologic subtypes may have a different MR appearance, but this did not suffice to reach a histologic diagnosis by MR imaging." This was because on T1 appearances were similar but differed on T2 which gave more information than T1 (ibid.).

The correlation between the radiological features and histopathology may be in terms of location, number of lesions, and presence of secondary changes amongst other features. The aim is to establish if certain features seen on imaging can give a conclusive diagnosis on the expected histopathology.

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A number of imaging features have been associated with aggressiveness, such as bone destruction, central areas of necrosis, indistinct tumour margins at the brain surface, irregular inward projections of tumour and mushrooming as described in a study by New et al. (1982). However, the findings are far from specific and have limitations for prognosis prediction. These characteristics do not seem to be useful in distinguishing between the high-grade meningiomas or even benign meningiomas with any degree of certainty.

An English study by Vassilouthis and Ambrose found that the presence of marked oedema, absence of visible calcium aggregates, non-homogeneous contrast enhancement with non-enhancing "cystic" components and poorly defined irregular borders point to aggressive or invasive characteristics more commonly found in the angioblastic and syncytial variants (Vassilouthis and Ambrose, 1979).

Malignant meningiomas tend to have irregular, indistinct margins on CT scan with various authors reporting that calcification is often absent or scanty in them as also described by Perry et al. (1997) in their

study. Yuguang *et al.* found similar findings while Alvarez et al. (1987) has described hypodense areas within meningiomas and presence of tumour fringes as signs of malignancy.

Marked perifocal oedema with a prominent pannus or tumour, extending well away from the globoid mass, termed "mushrooming" is not usually seen in benign meningiomas (New et al., 1982). Tumour interdigitation with brain substance may also occur with malignant meningiomas. Before contrast enhancement, malignant meningiomas appear moderately hyperdense but enhance well after contrast administration.

A study done by Kim et al. (2008) in Korea concluded that rhabdoid meningiomas tend to have prominent peritumoral oedema, cystic components, and bone involvement. These findings support that malignant tumours are likely to cause this since rhabdoid meningiomas are categorized as WHO grade III meningiomas.

Various investigators have related the degree of peritumoral oedema to the tumour location (Fine et al., 1980; Gilbert et al., 1983) size (Go et al., 1988; Trittmacher et al., 1988), histopathological subtype (Trittmacher et al., 1988; Benzel and Gelder, 1988) and necrosis (Jagadha and Deck, 1987) while others refute this (Alquacil-Garcia et al., 1986; Chen et al., 1992). Secretory meningioma variants have marked peritumoral oedema which is probably due to the secretions (Alquacil-Garcia et al., 1986; Go et al., 1988). A Tokyo study concluded that there was no correlation between the presence of oedema and location of the tumour or histological feature though meningothelimatous tumours were reported to have more peritumoral oedema (Ide et al., 1992). Peritumoral oedema is often disproportionate to the size of the meningioma which implies that the degree of oedema may not necessarily worsen with increasing grade of meningioma. However, a study by Tobias et al. (2005) concluded that "The degree of oedema as revealed by computer tomography and magnetic resonance imaging can be an important clinical predictive factor for the histopathological grade of the meningioma".

Non-skull base location has been thought to be a risk factor for grade II and III meningioma. This shows that tumour location may actually be a predictor for histopathological grade. A study on intraventricular meningiomas by Kim et al. (2008) found that about 58% were either atypical or malignant and that they had irregular lobulation. Another finding was that intratumoral necrosis was frequently seen in the atypical and malignant types of intraventricular meningioma. These findings support that location may affect the meningioma grade which in turn affects the presence or absence of secondary changes.

Tumour size is affected by the grading of the tumour and the period for which the patient has had symptoms. Tumour size contributes to symptomatology with many small meningiomas being found incidentally during imaging for other reasons or at autopsy (Nakasu et al., 1987; Vernooij et al., 2007).

Secondary changes such as haemorrhage, necrosis and cystic change are uncommon and when present they give a heterogeneous pattern after contrast administration as opposed to the homogenous pattern of benign meningiomas.

A study by Oguz and Cila (2003), in Ankara, Turkey, found that all meningioma types had a similar peripheral type of enhancement while meningioma size was found to determine the type of enhancement seen whether capsular or peripheral. This was supported by Maiuri who also refuted a correlation between contrast enhancement and histopathology (Maiuri et al., 1999).

Cystic change may be intratumoral or peritumoral. High levels of intratumoral cystic and necrotic change are associated with the malignant variants of meningiomas. Cystic change may be due to trapped CSF.

Benign tumours are highly unlikely to have extracranial base of skull extension so when this feature is picked on imaging it is highly suggestive of atypical/malignant meningiomas (Hsu et al., 2010). Vascular features depend on the variant of the meningioma while mass effect is as a result of tumour size. Tumour size also plays a role in midline shift and herniation when present.

Problem Statement

Meningiomas are amongst the commonest brain tumours accounting for about 33% of all brain tumours. Despite a majority of them being benign, they can cause serious morbidity and mortality. Appropriate and timely management of patients is at times delayed awaiting histopathology results, since management varies with tumour location and grade despite surgery being the mainstay of treatment. Availability and affordability of the key imaging modalities is an issue yet imaging plays a key role in diagnosis and planning of management of these tumours, though the definitive diagnosis is normally by histopathology.

Limitations of the Study

The high cost of the imaging modalities used to study meningiomas was one limitation faced by the study. Moreover, different imaging equipment due to large catchment area of the hospitals and therefore different quality of images with lack of standardization of images.

Materials and Methods

The study was carried out in MTRH, Mediheal and Eldoret hospitals which are in Eldoret, Kenya. MTRH serves the entire population of Western Kenya and some parts of Eastern Uganda. It has a radiology department which offers CT scanning. Eldoret hospital and Mediheal are private hospitals in Eldoret. They offer both MRI and CT diagnostic services. All these hospitals diagnose and manage patients with meningomas. On average about 25 patients with meningiomas are operated on annually in the three hospitals.

A cross-sectional descriptive study design was used. The CT and MRI images and reports of patients with meningioma on imaging were matched with their histolopathological diagnosis. The study population were patients presenting with meningoma at MTRH, Mediheal and Eldoret hospitals.

Consecutive sampling technique was used in recruitment of patients. Patients with meningomas referred to these hospitals who met the study's inclusion criteria were sampled as they presented themselves. However, 26 patients were studied by reviewing records and matching their radiological features and histopathological findings. Fifty-five patients met the inclusion criteria and since our sample size was 42, sampling 42(76%) from 55 was as good as studying the whole number of patients. The author, therefore, chose to study all the patients because the study would not subject the extra patients to unnecessary harm nor would it increase the cost of research by any significant amount. Those with CT scan or MRI images and reports were matched against the histopathology of the meningiomas.

The inclusion criteria were: that one must have been diagnosed with meningioma using either CT or MRI, and that Meningioma must have been confirmed with a histopathological diagnosis. The exclusion criteria also considered two factors. First, CT or MRI images of patients who had synchronous brain tumours, e.g. a pituitary adenoma and a meningioma or other brain pathology such as CVA were excluded. Second, patients who did not provide informed consent were not studied.

Sample Size

The sample size was calculated using the following formula (Cochran, 1963).

$$n = \left(\frac{Z_{1-\alpha/2}}{\delta} \right)^2 P(1-P)$$

Where

P= 0.8 (population proportion of those who have at least one of the three main subtypes of meningioma (fibroblastic, meningothelial and transitional).

The population proportion of 80% was obtained from the results of a study conducted in KNH (Chumba, 2006).

δ =0.1 (the margin of error equal to the 10% used in this case and $Z_{1-\alpha/2}$ is the $(1-\alpha/2)\times 100\%$ quantile of the standard normal distribution).

N = 1.96^2x 0.8 x 0.2

0.1^2

= 62 which was then adjusted for finite population correction

N = $n/(1+n/N) = 62/(1+62/125) = 42$

n = 42 patients with meningioma

N/B:

Correction for the finite population size of 25 per year for 5 years of study period that was determined prior to data collection led to ($n/(1+n/N) = 62/(1+62/125) = 42$)

The author assisted in image taking with the technicians and reporting by the radiologists. She also filled the data collection tool after seeking consent from the patients and liaised with the pathologists in the reviewing of slides and reporting of the histopathology reports. Quality control of the radiological image reports was achieved by seeking the opinion of two radiologists who independently reported on them after the author had reported them. The histopathological diagnosis was done by two pathologists who also independently reported on the slides.

Data was collected on a data collection form based on a protocol outlined by Bradac et al. (1990) which gave a protocol for analysis of CT and MRI images of meningiomas. The forms were filled by the investigator and later transferred to a computer database. Collected data was only available to the investigator and the supervisors. Data entry was done in a computerized database designed in Microsoft Access. Data analysis was performed using STATA version 12 Special Edition (SE) (College station, Texas USA). Categorical variables were summarized as frequencies and the corresponding percentages. Continuous variables were summarized as mean and standard deviation (sd) if they were normally distributed or median and their corresponding inter quartile range (IQR) if they had skewed distribution. Association between the categorical variables was assessed using the Fisher's exact test if the expected value (cell count) in at least one of the cells was less than 5 otherwise Pearson's Chi-square test would be used. Participants' age was determined by subtracting the year of birth from the year of imaging. Age was

categorized at ten years interval just to help investigate the relationship between the histopathological patterns and the age at an interval of a decade. The patients aged above 55 years were few thus we put them into one group to ensure balance in numbers in each age group.

Results and Discussion

Association of Radiological features and Histopathology

The test for association between the histopathological subtypes and the radiological features was not statistically significant except for association between the CSF pathway and the histopathological patterns (p-value=0.005). This association suggests that the patients suffering from Grade I histopathological types are more likely to have compression or displacement of the CSF pathways.

Table 1: Meningioma Location by Histopathological Patterns

Variable Location of the lesions	Histopathological patterns				Total	Fishers' exact test
	Grade I			Grade II		
	Fibroblastic	**Meningothelial**	**Transitional**	**Atypical**		
Clival	0	1(100%)	0	0	**1(100%)**	**0.78**
Petroclival	0	1(100%)	0	0	**1(100%)**	
Convexity	2(13%)	9(56%)	3(19%)	2(13%)	**16(100%)**	
Falx	0	3(60%)	1(20%)	1(20%)	**5(100%)**	
Frontobasal	1(25%)	3(75%)	0	0	**4(100%)**	
Olfactory Groove	1(17%)	4(67%)	1(17%)	0	**6(100%)**	
Others (Suprasellar)	3(42%)	2(29%)	2(29%)	0	**7(100%)**	
Parasagittal	2(33%)	2(33%)	2(33%)	0	**6(100%)**	
Petrous ridge	0	1(100%)	0	0	**1(100%)**	
Posterior Cranial Fossa	3(60%)	2(40%)	0	0	**5(100%)**	
Sphenoidal Ridge	1(17%)	3(50%)	2(33%)	0	**6(100%)**	
Total	**13(22%)**	**31(53%)**	**11(20%)**	**3(5%)**	**58(100%)**	

Table 2: Side, Number and Size of the Lesion by the Histopathological Pattern

Variable	Histopathological patterns				Total	Fishers' exact test
	Grade I			Grade II		
	Fibroblastic	Meningothelial	Transitional	Atypical		
Side of the lesions						
Left	6(25%)	12(50%)	6(25%)	0	**24(100%)**	**0.576**
Left; right	0	1(100%)	0	0	**1(100%)**	
Right	3(18%)	9(53%)	2(12%)	3(18%)	**17(100%)**	
Midline	3	7	3	0	**13**	
Total	**9(21%)**	**22(53%)**	**8(19%)**	**3(7%)**	**42(100%)**	
Number of lesions						
One	11(21%)	27(52%)	11(21%)	3(6%)	**52(100%)**	**1**
Two	1(33%)	2(67%)	0	0	**3(100%)**	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	
Size of the lesion						
1.5-3.0 cm	0	1(50%)	1(50%)	0	**2(100%)**	**0.492**
>3.0 cm	12(23%)	28(53%)	10(19%)	3(7%)	**53(100%)**	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	

Table 3: Bone Involvement by Histopathological Patterns

Variable	Histopathological patterns				Total	Fishers' exact test
	Grade I			Grade II		
	Fibroblastic	Meningothelial	Transitional	Atypical		
Bone involvement						
Bone erosion	0	2(100%)	0	0	**2(100%)**	**0.278**
Hyperostosis	0	3(43%)	3(43%)	1(14%)	**7(100%)**	
Nil	12(26%)	24(52%)	8(17%)	2(4%)	**46(100%)**	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	

Table 4: Severity of Oedema by the Histopathological Patterns

Variable	Histopathological patterns				Total	Fishers' exact test
	Grade I			Grade II		
	Fibroblastic	Meningothelial	Transitional	Atypical		
Oedema						
Extensive	0	1(100%)	0	0	**1(100%)**	0.582
Mild	4(19%)	13(62%)	3(14%)	1(5%)	**21(100%)**	
Moderate	3(17%)	10(56%)	3(17%)	2(11%)	**18(100%)**	
Nil	5(33%)	5(33%)	5(33%)	0	**15(100%)**	

Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	

Table 5: Calcification, other Secondary Changes and Mass effect by Histopathological Patterns

Variable	Histopathological patterns				Total	Fishers' exact test
	Grade I			Grade II		
	Fibroblastic	Meningothelial	Transitional	Atypical		
Calcification						
Course	0	1(100%)	0	0	1(100%)	0.872
Fine	0	1(100%)	0	0	1(100%)	
Moderate	2(50%)	1(25%)	1(25%)	0	4(100%)	
Nil	10(20%)	26(53%)	10(20%)	3(6%)	49(100%)	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	
Other secondary changes						
Cyst form	1(20%)	4(80%)	0	0	5(100%)	0.766
Necrosis	3(14%)	11(52%)	5(24%)	2(10%)	21(100%)	
Nil	8(28%)	14(48%)	6(21%)	1(3%)	29(100%)	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	
Mass effect						
Mild	4(20%)	11(55%)	4(20%)	1(5%)	20(100%)	0.28
Moderate	7(28%)	14(56%)	2(8%)	2(8%)	25(100%)	
Severe	0	1(100%)	0	0	1(100%)	
Nil	1(11%)	3(33%)	5(56%)	0	9(100%)	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	
Brain invasion						
FALSE	12(22%)	29(53%)	11(20%)	3(5%)	55(100%)	

Table 1 shows that among all the patients with convexity, 2(13%), 9(56%), 3(19%) and 2(13%) had fibroblastic, meningothelial, transitional and atypical meningioma, respectively while among those with falx, 3(60%), 1(20%) and 1(20%) had meningothelial, transitional and atypical meningioma. There were 4(67%) with olfactory groove who had meningothelial meningioma. Among all the patients who had sphenoidal ridge, 1(17%), 3(50%) and 2(33%) had fibroblastic, meningothelial and transitional meningioma respectively. The test of association between the location of the meningioma and the histopathological patterns showed no significant association.

Table 2 shows the distribution of the histopathological patterns by the side, number and size of the lesion. The results show that 6(25%), 12(50%) and 6(25%) of the patients with the lesion situated to the left had fibroblastic, meningothelial and transitional meningiomas, respectively. All three atypical meningiomas were right-sided and accounted for (18%) of the right-sided meningiomas. The others were fibroblastic 3(18%), meningothelial 9(53%) and transitional meningiomas 2(12%). One of the patients with a meningothelial meningioma had lesions situated on the left and right. The Fisher's exact test of association shows that there was no significant relationship between the side of the lesion and the histopathological pattern (p-value=0.576).

Among the three patients who had two lesions, one had fibroblastic meningiomas while the other two had meningothelial meningiomas (Table 2).

Among the patients who had one lesion, 11(21%), 27(52%) and 11(21%) were suffering from

fibroblastic, meningothelial and transitional meningioma, respectively. The three patients who had atypical meningiomas all had one lesion. The test of association between the number of lesions and the histopathological patterns was not statistically significant (p-value=1.000).

All the patients who had a fibroblastic meningioma had the lesion size >3.0 cm. Similarly, all of the patients with atypical meningiomas had lesion size >3.0 cm. Among the patients with lesion size >3.0 cm, 28(53%) and 10(19%) had meningothelial and transitional meningiomas respectively. The test of association between lesion size and the histopathological patterns showed no significant relationship (p-value=0.492).

Table 3 shows that there were 46(84%) of all the patients without any bone involvement of whom 12(26%) had fibroblastic meningioma, 24(52%) with meningothelial meningioma, 8(17%) with transitional meningioma and 2(4%) with atypical meningioma. All the patients with bone erosion had meningothelial meningioma. Among the patients with hyperostosis were 3(43%) with meningothelial meningioma, 3(43%) with transitional meningioma and 1(14%) with atypical meningioma. The test of association did not show any significant association between the bone involvement and the histopathological patterns.

Among the patients with mild oedema, there were 4(19%), 13(62%), 3(14%) and 1(5%) with fibroblastic, meningothelial, transitional and atypical meningiomas, respectively. Of those with moderate oedema, 3(17%), 10(56%), 3(17%) and 2(11%) had fibroblastic, meningothelial, transitional and atypical meningiomas. Among the patients without any form of oedema, 5(33%) were fibroblastic, 5(33%) meningothelial and 5(33%) transitional meningiomas.

Table 6: CSF Pathway by Histopathological Patterns

Variable	Histopathological patterns				Total	Fishers' exact test
	Grade I			Grade II		
	Fibroblastic	Meningothelial	Transitional	Atypical		
CSF pathway						
Compression	1(8%)	6(50%)	2(17%)	3(25%)	**12(100%)**	**0.005**
Compression & obstruction	1(100%)	0	0	0	**1(100%)**	
Displacement	1(5%)	15(75%)	4(20%)	0	**20(100%)**	
Displacement & obstruction	1(100%)	0	0	0	**1(100%)**	
Obstruction	4(57%)	3(43%)	0	0	**7(100%)**	
Nil	4(29%)	5(36%)	5(36%)	0	**14(100%)**	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	
Tumour margins						
Distinct	12(22%)	29(53%)	11(20%)	3(5%)	**55(100%)**	

Table 7: Density, Enhancement and Herniation by Histopathological Types

Variable	Histopathological patterns				Total	Fishers' exact test
	Grade I			Grade II		
	Fibroblastic	Meningothelial	Transitional	Atypical		
Density						
Hyperdense	7(21%)	18(55%)	8(24%)	0	**33(100%)**	0.203
Hypodense	0	1(100%)	0	0	**1(100%)**	

Isodense	0	1(50%)	1(50%)	0	**2(100%)**	
Mixed density	0	1(50%)	1(50%)	0	**2(100%)**	
Total	**7(18%)**	**21(55%)**	**10(27%)**	**0(0%)**	**38(100%)**	
Enhancement						
Irregular	5(17%)	16(55%)	6(21%)	2(7%)	**29(100%)**	0.852
Uniform	7(27%)	13(50%)	5(19%)	1(4%)	**26(100%)**	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	
Herniation						
Nil	10(22%)	22(49%)	11(24%)	2(4%)	**45(100%)**	0.587
Subfalcine	0	3(100%)	0	0	**3(100%)**	
Tonsillar	2(33%)	3(50%)	0	1(17%)	**6(100%)**	
Transtentorial	0	1(100%)	0	0	**1(100%)**	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	
Shape						
En-plaque	0	0	0	1(100%)	**1(100%)**	0.055
Mass	12(22%)	29(54%)	11(21%)	2(4%)	**54(100%)**	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	

Table 8: Vascular Features by Histopathological Patterns

Variable	Histopathological patterns				Total	Fishers' exact test
	Grade I			Grade II		
	Fibroblastic	Meningothelial	Transitional	Atypical		
Vascular features						
Arterial encasement	1(25%)	2(50%)	1(25%)	0	**4(100%)**	**0.704**
Displacement of adjacent vessels	2(29%)	3(43%)	1(14%)	1(14%)	**7(100%)**	
Displacement of adjacent vesels; Increased vascularity of tumour	0	1(100%)	0	0	**1(100%)**	
Identifiable tumour vessels	8(21%)	22(56%)	8(21%)	1(3%)	**39(100%)**	
Increased vascularity of tumour	1(25%)	1(25%)	1(25%)	1(25%)	**4(100%)**	

Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**

Table 9: Histopathological Patterns by Age Groups

Variable	**Histopathological patterns**				**Total**	**Fishers' exact test**
	Grade I			**Grade II**		
	Fibroblastic	**Meningothelial**	**Transitional**	**Atypical**		
Age group						
25-35 years	3(23%)	8(62%)	1(8%)	1(8%)	**13(100%)**	**0.693**
35-45 years	1(8%)	7(58%)	4(33%)	0	**12(100%)**	
45-55 years	6(35%)	7(41%)	3(18%)	1(6%)	**17(100%)**	
55-77 years	2(15%)	7(54%)	3(23%)	1(8%)	**13(100%)**	
Total	**12(22%)**	**29(53%)**	**11(20%)**	**3(5%)**	**55(100%)**	

Table 10: MRI Intensity by Histopathological Patterns

Variable	**Histopathological patterns**				**Total**	**Fishers' exact test**
	Grade I			**Grade II**		
	Fibroblastic	**Meningothelial**	**Transitional**	**Atypical**		
T(1) Intensity						
Hypointense	0	4(80%; 31%)	1(20%; 17%)	0	**5(100%; 16%)**	**0.636**
Isointense	7(37%; 78%)	6(32%; 46%)	4(21%; 67%)	2(11%; 67%)	**19(100%; 61%)**	
Mixed Intensity	2(29%; 22%)	3(43%; 23%)	1(14%; 17%)	1(14%; 33%)	**7(100%; 23%)**	
T(2) Intensity						
Hyperintense	7(35%; 78%)	6(30%; 46%)	5(25%; 83%)	2(10%; 67%)	**20(100%; 65%)**	**0.867**
Hypointense	0	1(100%; 8%)	0	0	**1(100%; 3%)**	
Isointense	0	2(100%; 15%)	0	0	**2(100%; 6%)**	
Mixed Intensity	2(25%; 22%)	4(50%; 31%)	1(13%; 17%)	1(13%; 33%)	**8(100%; 26%)**	
Flair Intensity						
Hyperintense	7(35%; 78%)	6(30%; 46%)	5(25%; 83%)	2(10%; 67%)	**20(100%; 65%)**	**0.867**
Hypointense	0	1(100%; 8%)	0	0	**1(100%; 3%)**	
Isointense	0	2(100%; 15%)	0	0	**2(100%; 6%)**	
Mixed Intensity	2(25%; 22%)	4(50%; 31%)	1(13%; 17%)	1(13%; 33%)	**8(100%; 26%)**	

Only two of the patients who had coarse or fine calcification had meningothelial meningiomas while among the 4(7%) patients who had moderate calcification, 2(50%) had fibroblastic meningioma, 1(25%) had meningothelial and another one had transitional meningioma as is apparent from Table 5. The rest of the patients did not have any form of calcification. The test of association between the existence of calcification and histopathological patterns was not significant.

Table 6 shows that there were a substantial number of 6(50%) of the patients with compressed CSF pathway with meningothelial meningiomas. Among those who had displaced CSF pathway was a large proportion 15(75%) with meningothelial meningiomas. There were 4(29%), 5(36%) and 5(36%) without any CSF pathway affection who had fibroblastic, meningothelial and transitional meningioma, respectively. Table 6 shows a significant relationship between the histopathological patterns and the CSF pathway (p-value=0.005). Though there is an apparently significant association, this may be attributed just to chance because there is no inherent direction in which the data appear to follow. That is, the CSF pathway presentations are not predictive of the histopathological patterns.

From Table 7, 33(63%) of the patients who had hyperdense lesions had either a fibroblastic 7(21%), meningothelial 18(55%) or transitional 8(24%) meningioma. Seventeen (31%) of patients had an MRI only so density was not assessed for them. There was no significant relationship between the density of the lesion and the histopathological pattern. Herniation was not present in almost all of the patients across all the histopathological patterns. Enhancement was well balanced between irregular and uniform (Table 7).

Table 8 shows the distribution of the vascular features by the histopathological patterns. The data is sparse in the cells of this table. Of the patients with identifiable tumour vessels there were 22(56%) with meningothelial meningiomas, 8(21%) with fibroblastic meningiomas and 8(21%) with transitional meningiomas. There was no significant association between the histopathological patterns and the vascular features (p-value=0.704).

The histopathological subtypes are well distributed across the age groups. The test of association between the age groups and the histopathological types was not statistically significant (p-value=0.693) indicating that there was no particular age group that was associated with a certain type of meningioma. That is, all meningiomas were well distributed across all the age groups (Table 9).

Majority of the meningiomas (61%) were isointense on T1 imaging with hypointense and mixed intensity accounting for 16% and 23% respectively. Of those that were isointense the majority were fibroblastic (37%) followed by meningothelial (32%). 80% of those that were hypointense were meningothelial. On T2 imaging, 65% of tumours were hyperintense followed by those with mixed intensity at 26%. The findings on flair were similar to those on T2 imaging. No association was found between tumour intensity and histopathology (Table 10).

Conclusion and Recommendations

The common meningiomas were grade I with meningothelial, fibroblastic and transitional subtypes seen. Though imaging can reliably diagnose meningiomas, histopathological subtypes of meningiomas cannot be differentiated from each other based on radiological features. Further studies should be conducted on why secondary changes occur in a significant number of grade I meningiomas yet they have been found in other studies to be common in non-benign meningiomas and a study of non-beningn meningiomas which were very few in this study.

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