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The Common Radiological Features of Meningiomas on CT scan and MRI among Patients at Major Hospitals in Eldoret, Kenya

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ABSTRACT

Meningiomas are amongst the commonest primary brain tumours accounting for about 33% of all brain tumours. World Health Organization classifies Meningiomas into three grades based on histopathology; the subtype of which affects the prognosis. Imaging plays a key role in the diagnosis of Meningiomas and is often the first investigation aiding in its diagnosis. This paper examines the common radiological features of Meningiomas based on CT scan and MRI has seen among patients at the Moi Teaching and Referral, Mediheal and Eldoret hospitals in Kenya. The study was carried out in the Moi Teaching and Referral Hospital, Mediheal and Eldoret hospitals in Eldoret, Kenya. A cross-sectional study design was used. Radiopathological association has used CT scan and MRI images which had a confirmatory histopathology report. Fifty-five patients were studied from May 2008 to December 2012. The inclusion criterion was the presence of both histopathology and CT or MRI images while exclusion was where either lacked. Data analysis was done by use of STATA version 12. The common Meningiomas encountered were grade I (95%) with the meningothelial (53%), fibroblasts (22%) and transitional (20%) subtypes seen. Three grade II atypical Meningiomas were found but no malignant Meningiomas was encountered in the study population. The common CT scans features encountered were extra-axial, hyperdense (87%), mass lesions (98%) with mild (36%) to moderate edema (45%) that avidly enhanced with contrast either homogeneously (47%) or heterogeneously (53%). Common MRI features encountered were extra-axial mass lesions (97%) which were isointense (61%) on T1 weighted sequences, hyperintense (65 %) on T2 weighted images, hyperintense (65%) on FLAIR images and enhanced (100%) when gadolinium contrast was injected. Though imaging can reliably diagnose Meningiomas, histopathological subtypes of Meningiomas cannot be differentiated from each other based on radiological features.

Keywords: Common Radiological Features, Meningiomas, CT Scan, MRI, Patients, Major Hospitals, Eldoret, Kenya.

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INTRODUCTION

The purposes of imaging as assessed by Moseley are to confirm an intracranial lesion, determine its probable nature, attempt to predict the degree of aggressiveness, assess its location with respect to

adjacent (vital) structures and attempt to predict response to treatment.[1] Imaging therefore plays a key role in the management of Meningiomas patients.

On CT, the typical Meningiomas is a well-defined extra-axial mass that displaces the normal brain, is hyperdense on pre-contrast scans with underlying oedema and enhances homogeneously with contrast. Meningiomas are smooth in contour, adjacent to Durrell structures, and sometimes calcified or multilobulated. Calcification of Meningiomas, when present, occurs in a speckled, rim like, or nodular pattern. It occurs in 20-30% of patients.[2]

The typical Meningioma is isointense or hypointense to gray matter on T1 and isointense or hyperintense on proton density and T2 weighted images. Isointensity on MRI with normal surrounding brain may make diagnosis difficult in a non-contrasted scan, but intravenous contrast administration results in uniformly bright enhancement.[3, 4] There is usually minimal perilesional oedema.

In about 15 per cent of cases, there is an atypical pattern with necrosis, cyst formation, or hemorrhage. Cyst formation may be as a result of trapped CSF. Indistinct margins, marked oedema, mushroom-like projections from tumour, deep brain parenchymal infiltration, and heterogeneous enhancement all suggest, but do not prove, aggressive behavior as described by Shapir et al..[5]

CT scans well depicting bony hyperostosis[6], which may be difficult to appreciate on MRI. CT scanning may, however, fail to demonstrate a plaque and posterior fossa Meningiomas. CT scanning also has limitations in performing direct imaging in any other planes than axial. CT scanning is less helpful than MRI in differentiating types of soft tissue.

A study by Inskip et al. on the laterality of brain tumours found that Meningiomas nonsignificantly occurred more on the left side.[7]

Imaging enables the detection of multiple lesions. Multiple Meningiomas were previously described as uncommon but with the advent of the newer imaging modalities, the frequency of detection has increased. Sheehy and Crockard describe a rise in detection from 1.1% of cases to 8% with modern CT scanning.[8] An Israel study done at the Rambam medical center found the incidence of multiple Meningiomas to be 20% and on reassessment the incidence increased to 40%.[9]

Histology of Meningiomas

Histopathology enables distinguishing of the various Meningioma grades and subtypes. This is important as the various subtypes have different prognoses and different levels of recurrence. In a single series of 1799 Meningiomas from 1582 patients followed for an average of 13 years after

resection in Vienna, Austria, the nonrecurrence rate was 93% of WHO I tumours, 65% of WHO II, and 27.3% of WHO III.[10]

Histopathology is the basis on which WHO has classified Meningiomas. WHO grades Meningioma subtypes into one of three categories based primarily upon histopathology which affects the likelihood of recurrence and the rate of growth exhibited by each. The overall classifications are benign (Grade I), atypical (Grade II) and malignant (Grade III).[11] Generally, the higher the grade the higher the rate of growth and the more likely it is to recur.

A study by Mahmood et al. Henry Ford Hospital, Detroit Michigan found that 92% of the Meningiomas were benign, 6.26% atypical, and 1.7% malignant.[12] A local study done by Chumba in KNH (unpublished) found that the commonest histopathological subtypes were meningothelial and transitional representing 35% and 30% respectively. The Chumba's study found that Grade II and III subtypes accounted for 15.9% and 4% respectively.[13] A more recent study in KNH by Wanjeri (unpublished) found that grade I Meningiomas were the commonest at 94.7% and Grade II and grade III represented 4% and 1.3% respectively with fibroblasts, transitional and meningothelial accounting for 25.4%, 25.4% and 22.5% respectively.[14]

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 are 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 was patients presenting with meningoma at MTRH, Mediheal and Eldoret hospitals.

The 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 well 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 are a pituitary adenoma and a Meningioma or other brain pathology such as CVA. Second, patients who did not provide informed consent were not studied.

Sample size

The sample size was calculated using the following formula[15]

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

Where

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

The population proportion of 80% was obtained from the results of a study conducted in KNH.[13]

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).

$$N = 1.96^2 \text{x } 0.8 \text{ x } 0.2$$

$$0.1^2$$

= 62 which was then adjusted for finite population correct

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 the 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.[16] 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. The 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. The 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 year 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

Radiological features of Meningiomas

Most of the lesions, 16 (28%), we're located at the convexity. Some, 5 (9%), were located at the falx and another 5 (9%) in the posterior cranial fossa, 6 (10%) were located at the parasagittal and another 6 (10%) were located at the sphenoidal ridge, 6 (10%) were located in the olfactory groove, and 7 (12%) were located at suprasellar region. The other

locations included clival, petroclival, frontobasal, and petrous, and represented 11%. The side that was most affected by the Meningioma was the left representing 24 (57%). The right accounted for 17 (40%) proportion. One patient had both the right and the left side affected. There were 13 patients with midline lesions who were not included in computing the preceding proportions.

Almost all of the patients, 52 (95%), had one lesion and most patients, 53 (96%), had a lesion size >3.0 cm. Of those that had one lesion, 50 (96%) had the lesion size >3.0 cm while all those who had two lesions had their lesions >3.0cm. This gives a total of 53 (96%) patients with lesion size greater than 3 cm. Fisher's exact test of association between the number of lesions and the size was not statistically significant. The average length of the lesions was 5.30 (std: 1.72) cm. The median length was 5.35 (IQR: 4-6.6) cm with a minimum of 1.7 cm and a maximum of 9.3 cm

Of the 55 participants, 2 (4%) developed bone erosion while 7 (13%) had hyperostosis. Forty-six (84%) did not develop any bone affection. Oedema was extensive in one patient but mild and moderate in 21 (38%) and 18 (3%) respectively. Fifteen (27%) did not have oedema. None of the patients had brain invasion.

There was one patient who had coarse calcification and another one with fine calcification. Four (7%) of them had moderate calcification. Forty-nine (89%) did not develop any form of calcification. Other secondary changes were not seen in 29 (53%) patients but necrosis were seen in 21 (38%) patients and cyst formation was seen in 5 (9%). Mass effect was absent in 9 (16%) patients but mild in 20 (36%), moderate in 25 (45%) and severe in one of the patients. The tumour margins were distinct in all the patients.

The CSF pathway was also investigated in these patients and it was found that 12 (22%) had a compressed CSF pathway, 20 (36%) had displaced CSF pathway and 7 (13%) had obstruction of the CSF pathway. One person had both compressed and obstructed CSF pathway and another one with displaced as well as an obstructed CSF pathway. Fourteen (25%) patients did not have their CSF pathway affected. The shape was a mass in 54 (98%) of the patients. One patient with atypical histopathology had an en plaque Meningioma.

Of the 38 patients with density data available, there were 33 (87%) of them with hyperdense density. Mixed density, isodense and hypodense densities were present in 2(5%), 2(5%) and 1(3%) patients, respectively. Irregular enhancement was present in 29 (53%) of the patients while uniform enhancement was present in the remaining. There was no herniation in 45 (82%) of the patients. Three (5%), 6 (11%) and 1 (2%) had subfalcine, tonsillar and transtentorial herniation.

Vascular features such as arterial encasement, displacement of adjacent vessels, displacement of adjacent vessels and increased vascularity of tumour, identifiable tumour vessels and increased vascularity of tumour was present in 4 (7%), 7 (13%), 1 (2%), 39 (71%) and 4 (7%) respectively.

Histopathology of Meningiomas among Participants

Grade I Meningiomas were seen in 52 (95%) of the patients. This included 12 (22%) fibroblasts Meningiomas, 29 (53%) meningothelial and 11 (20%) transitional Meningiomas. There were 3 (5%) grade II atypical Meningiomas. Details are as shown in Figure 1.

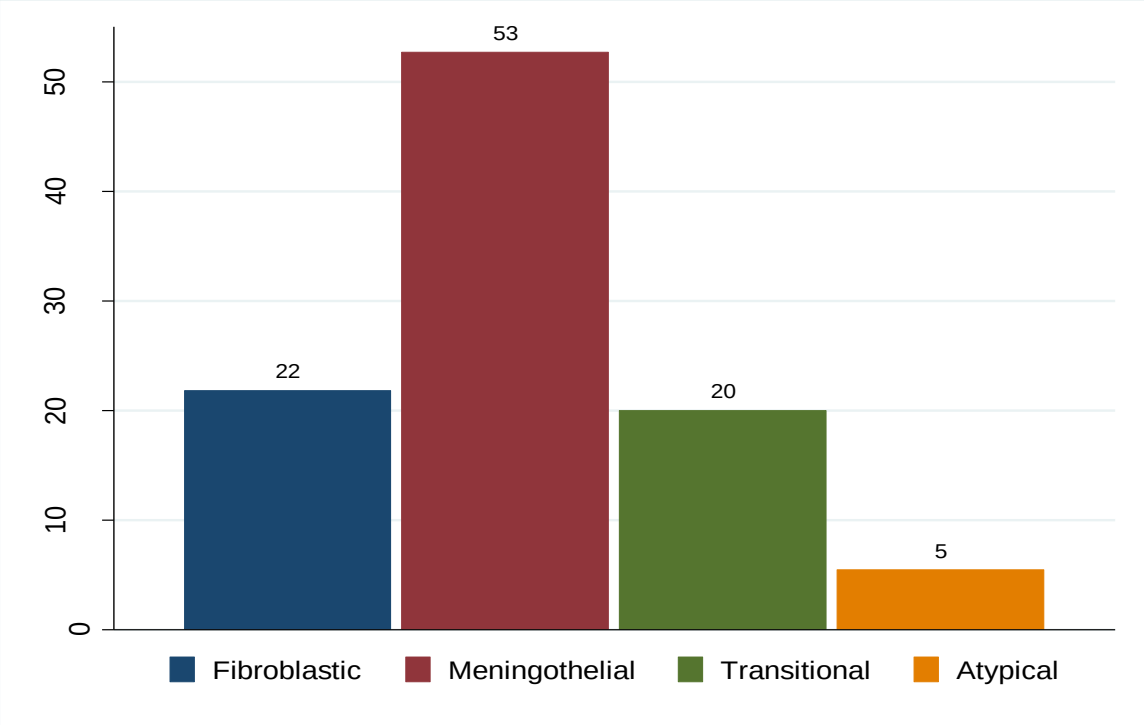

Figure 1: Distribution of the Histopathological subtypes

DISCUSSION

In the study, 47% of the patients were studied by reviewing records while the rest were from data collected by the principal investigator with the largest number of patients accounting for 73% of the studied patients being from MTRH.

The common Meningioma subtypes in Eldoret were meningothelial, transitional and fibroblasts.

These are all grade I Meningiomas and accounted for 95% of all Meningiomas. The remaining 5% were grade II atypical Meningiomas with no malignant (grade III) Meningiomas being encountered in the study population. A study by Chumba in 2005 in KNH found that grade I tumours were the commonest accounting for 80.1% of the Meningiomas. Grade II and III tumours accounted for 15.9% and 4% respectively.[13] A more recent study in KNH by Wanjeri in 2011 found that like in our study, grade I Meningiomas were the commonest at 94.7% and Grade II and grade III represented 4% and 1.3% respectively.[14] A study by Mahmood et al. in Henry Ford Hospital, Detroit Michigan had similar findings in this study with 92% of the Meningiomas being benign, 6.26% atypical, and 1.7% malignant.[12]

The commonest subtypes in KNH were meningothelial and transitional accounting for 35% and 30% respectively as per Chumba while Wanjeri found that fibroblasts, transitional and meningothelial accounted for 25.4%, 25.4% and 22.5% respectively. In Eldoret, however, meningothelial Meningiomas were accounting for 53% followed by fibroblasts at 22% then transitional at 20%.

Of the encountered grade II Meningiomas, 67% were in men. This is similar to findings in other parts of the world in which grade II and III Meningiomas are found to be more common in men than women as described by a study done by Alvarez et al. In which male predominance was seen in the non-benign group of Meningiomas.[17] This may be due to hormonal factors which play a role in benign Meningioma development not playing a role in atypical and malignant Meningiomas.

The common radiological features of the meningitis seen in Eldoret on CT were hyperdense (87%), mass lesions (100%) with mild (36%) to moderate edema (45%) that avidly enhanced with contrast either homogeneously (47%) or heterogeneously (53%) while the common MRI features seen were mass lesions (97%) which were isointense (61%) on T1 weighted sequences, hyperintense (65%) on T2 weighted images, hyperintense (65%) on FLAIR images and enhanced (100%) when gadolinium contrast was injected. Studies with findings similar to or different from this are discussed under the specific variables.

The female to male ratio in our study was 2.7:1. This is almost equivalent to a study by Thomas et al who reported a ratio of 3.1.[18] Benign Meningiomas have been reported more in women with a male predominance seen in the atypical and malignant Meningiomas. This may be attributed to hormonal factors being a risk factor for Meningioma development.

The incidence of Meningiomas generally increases with age though in this study there was a slight

decrease in the age groups 35-45 and >55 years. This was probably due to reduced surgical intervention in older patients who present with co-existing comorbidities and associated general poor health in our setup.

The commonest location of Meningiomas was found to be in the convexity accounting for 28%. Of these 56% were of the meningothelial subtype. This convexity location finding is similar to a study done in South Africa by Vivier et al. in which convexity Meningiomas were the greatest and accounted for 25%.[19] In the South African study the next commonest location was the parasagittal region which accounted for 21% unlike this study in which suprasellar was the next commonest location accounting for 12%. The meningothelial subtype was the commonest in all locations apart from the posterior cranial fossa and suprasellar region where fibroblasts were the commonest. No association between the location and histopathological pattern was established.

Ninety-eight percent of the patients had globular (mass) tumours. Only one patient had an en plaque tumour and it was associated with adjacent bone hyperostosis. En plaque tumours are reported to be uncommon with no clear prevalence or incidence information being quoted. This study found this to be the case as only one en plaque tumour was encountered.

When the midline lesions were not considered, the left represented 57% as compared to 40% on the right. Nonsignificant left side affection is similar to a study done by Inskip et al. on the laterality of brain tumours in which Meningiomas were found to nonsignificantly occur more on the left than on the right.[7] No association was found to histopathology as regards to the affected side.

Ninety-five percent of all patients seen had only one lesion with all the atypical Meningiomas having one lesion only. Of those with two lesions, 67% were meningothelial and 33% were fibroblasts. The study's figure of 5% for multiple lesions is in keeping with Sheehy and Crockard who described a rise in detection from 1.1% of cases to 8% with modern CT scanning.[8] This however is much lower than a study by Borovich et al. done at Rambam medical centre in Israel which reported 20% multiple Meningiomas at first assessment that increased to 40% on reassessment.[9] This difference could be due to failure to detect very small Meningiomas initially on imaging. Statistically no association was found between the number of lesions and histopathology.

Large lesions, that is lesions greater than 3 centimeters represented 96% of the study population with the average length of encountering lesions being 5.30 centimeters. Of these, meningothelial accounted for 53%. The remaining 4% was due to medium sized lesions with no small

lesions being encountered. These findings differ from those of a study done in Westmead Hospital, Australia by Kizana et al. in which 8% of the lesions were small, 46% medium and 46% large.[20] These differences could be as a result of delayed diagnosis in our setup due to a low index of suspicion as time is lost managing the wrong disease and meanwhile the tumours are increasing in size. It may also be due to a smaller percentage of calcified Meningiomas (11%) than the 20 to 30% described by Greenberg et al.[2] Calcified Meningiomas are thought to grow at a slower rate. There was no association found between the size of the tumour and histopathology in either study.

Bone involvement, which is best appreciated on CT but can be detected on MRI was absent in 84% of the study patients. Thirteen percent of the study patients had hyperostosis. Of those with hyperostosis, the commonest location affected was the sphenoidal ridge accounting for 43% followed by the convexity at 29%. In Westmead hospital, Australia, 27% of the patients had hyperostosis with 48% being in the convexity region and 24% in the sphenoidal region.[20] The findings are similar in regards to which two locations are most affected but differ in that while sphenoidal ridge was most affected in this study, the convexity was most affected in Westmead hospital.

Bone erosion was encountered in 4% of the study patients compared with a study at Westmead hospital which had 3%.[20] It was only seen in patients with meningothelial Meningiomas. No significant association was found between bone involvement and histopathological patterns.

Oedema was extensive in one patient but mild and moderate in 38% and 33% respectively while 27% of patients did not have oedema in this study. In the Westmead study 28% did not have edema, while it was mild, moderate and extensive in 33%, 25% and 14% respectively. Similarity was seen in the patients without edema and those with mild edema. Extensive edema has been thought to be due to atypical or malignant Meningiomas or patients with larger lesions. However, in this study, extensive edema was seen with a meningothelial Meningioma whose size was smaller than the average tumour length in the study of 5.3 cm. Histopathological subtype has been thought to affect the extent of edema but does not always correlate with the extensiveness as described by Jagadha and Deck All the atypical Meningiomas had edema associated with them with 67% having moderate edema. No association was found between edema and histopthological pattern in this study or the one at Westmead Hospital, Australia unlike the study in Brazil by Tobias et al that reported an association with histopthological grade.

None of the patients had brain invasion and tumour margins appeared distinct in all patients comparable to the Westmead study in which 85%

had distinct margins on CT and 90% on MRI. This could be due to the majority of the Meningiomas being benign and not invading surrounding brain tissue.

Calcification was seen in only 11% of the study patients which is much lower than the 20-30% described by Greenberg et al. All calcified Meningiomas were grade one with 50% being meningothelial. No association was found between histopathology and calcification.

Fifty-three percent of the patients did not have any secondary changes. Of those with secondary changes necrosis was seen more frequently than cyst formation. Secondary changes were encountered more frequently than is described for Meningiomas. An English study found that secondary changes pointed towards a non-benignity of Meningiomas. This finding may be as a result of the large tumour sizes seen in this study. Larger tumours may outgrow their supply and undergo necrotic change. No association was found between histology and the presence of secondary changes.

Mass effect was absent in 16% of patients encountered. Of those with mass effect, moderate effect was the most encountered seen in 45% of patients. One patient had a severe mass effect and his Meningioma subtype was meningothelial. This patient also had the largest tumour encountered and it also caused bone erosion. Mass effect has been associated with tumour size rather than histopathological grade or subtype. No association was found between histopathology and mass effect.

Seventy-five percent of the patients had their CSF pathway affected. Of those in whom it was affected, compression was the commonest finding followed by displacement. All the patients with atypical Meningiomas developed compression. A significant relationship between histopathology and CSF pathway affection was found though this is likely to have been a chance finding as no specific pattern was appreciated in the data.

The density was hyperdense in 87% of the patients who had CT scans. This is in keeping with literature as the typical appearance of a Meningioma is a hyperdense lesion on CT scanning pre-contrast that avidly enhances homogeneously post contrast. The hyperdense appearance was the most frequently encountered in all the grades one Meningioma. None of the patients with an atypical Meningioma had a CT scan done. No significant association existed with histopathological patterns.

In this study, on T1 sentence Meningiomas were the commonest (61%) unlike Westmead Hospital, Australia where hypointense (53%) were the commonest.[20] On T2 imaging; most Meningiomas (65%) were hyperintense. In Westmead majority (45%) were also hyperintense on T2. Our study used FLAIR sequence while the Westmead one used Proton Density sequence. No association was found between the MRI intensities and

histopathology in either study. This differed from a study done at University Hospital, Belgium concluded that different histologic subtypes may have a different MR appearance, but that did not suffice to reach a histologic diagnosis by MR imaging.[21]

Irregular enhancement occurred in 53% of the Meningiomas encountered. This irregular enhancement was as a result of secondary changes such as necrosis. This heterogeneous pattern was observed in 67% of the atypical Meningiomas. Except for the fibroblasts variant, irregular enhancement was more frequent than a uniform enhancement. No association was found between enhancement and histopathology. This is similar to a study in Ankara, Turkey that found that different Meningioma variants have a similar enhancement pattern.[22] Meningiomas generally enhance homogeneously but the heterogeneous enhancement in this study could have been due to most of the lesions (96%) being large as tumour size has been associated with secondary changes especially necrosis which in turn causes heterogeneous enhancement.

Eighty-three percent of the studied patients had no herniation. Herniation was seen in 70%, 20% and 10% of meningothelial, fibroblasts and atypical Meningiomas respectively. In those in whom there was herniation, tonsillar herniation was the commonest. This finding differs from that seen in the Weastmead hospital in which herniation was mostly subfalcine [20]. No radiopathological association was seen. Herniation is more likely to be affected by tumour size and location as opposed to tumour subtype.

Of the vascular features, identifiable tumour vessels were most encountered both in our study and the one at Westmead hospital. No association to histopathology was seen.

CONCLUSION AND RECOMMENDATIONS

From the study, the common CT scans features encountered were extra-axial, hyperdense, mass lesions with mild to moderate edema that avidly enhanced with contrast either homogeneously or heterogeneously while the common MRI features encountered were extra-axial mass lesions which were isointense on T1 weighted sequences, hyperintense on T2 weighted images, hyperintense on FLAIR images and enhanced when gadolinium contrast was injected. Histopathological diagnosis of meaningless in terms of grade and subtype should be continued and improved in terms of immunohistochemistry.

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