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Histopathological Spectrum and Adverse Morphologic Features of Meningiomas in a Low-Volume Tertiary Centre: A Five-Year Retrospective Case Series

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ABSTRACT

Background: Meningiomas comprise a morphologically diverse group of primary central nervous system tumours. Although many exhibit indolent behaviour, individual lesions vary in proliferative activity and invasive potential. Histopathological assessment therefore remains important for characterising tumour morphology and identifying adverse microscopic features, particularly in settings where diagnosis is centred on routine histology.

Objective: To describe the histopathological spectrum and adverse morphologic features of meningiomas diagnosed over five years in a low-volume tertiary centre in southeastern Nigeria.

Methods: A retrospective descriptive case series was conducted at Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nigeria, covering January 2021 to December 2025. All histologically confirmed meningiomas diagnosed during the study period were included. Archived haematoxylin and eosin-stained slides were reviewed, and demographic and pathological variables were extracted from departmental records. Histological assessment focused on tumour subtype, mitotic activity, brain invasion and tumour necrosis. Data were analysed descriptively using frequencies, percentages, mean, standard deviation and range.

Results: Ten meningiomas were identified. Patients were aged 24 to 73 years, with a mean age of 51.6 ± 14.9 years, and eight of the ten patients were female. Meningothelial morphology was the most frequent subtype, occurring in six cases, while transitional and papillary patterns each occurred in two. The sphenoid wing was the most frequently recorded anatomical site, accounting for four cases. Mitotic activity was lower in meningothelial and transitional tumours and markedly higher in the papillary tumours. Brain invasion was present in both papillary tumours, while tumour necrosis was identified in one papillary case.

Conclusion: The series demonstrated a predominance of meningothelial morphology, with adverse histological features concentrated within the papillary tumours. The combination of increased mitotic activity, brain invasion and necrosis highlights the importance of systematic assessment of proliferative and invasive features alongside architectural subtype in routine meningioma histopathology. Larger multi-centre studies are needed to characterise these patterns more robustly across Nigerian and other sub-Saharan African settings.

Keywords: Meningioma; histopathology; meningothelial; papillary; brain invasion; mitotic activity; Nigeria.

INTRODUCTION

Meningiomas are the most common primary intracranial tumours in adults and account for a substantial proportion of tumours encountered in neurosurgical and neuropathology practice. Although many meningiomas follow an indolent course, their clinical behaviour is heterogeneous, and a subset is associated with local invasion, recurrence, treatment resistance and considerable neurological morbidity (Ogasawara et al., 2021; Soni et al., 2025). Histopathological assessment therefore remains central to diagnosis, particularly in settings where access to comprehensive molecular profiling is limited. Morphology

alone does not capture the full biological range of these tumours, but features such as mitotic activity, brain invasion, tumour necrosis, and other atypical changes remain important for diagnosis and prognosis (Louis et al., 2021; Sahm et al., 2025).

Contemporary classification has increasingly moved beyond the assumption that conventional histological subtype alone can explain meningioma behaviour. The fifth edition of the World Health Organization Classification of Tumours of the Central Nervous System recognises meningioma as a single tumour type with a range of morphologic patterns and incorporates molecular information into grading for the first time (Louis et al., 2021). TERT promoter mutation and homozygous deletion of CDKN2A/B are now recognised as molecular criteria associated with CNS WHO grade 3 disease, while histological features remain fundamental to routine specimen assessment. More recent cIMPACT-NOW recommendations have further refined the interpretation of mitotic activity, brain invasion and selected morphologies, emphasising the need for careful application of grading criteria rather than reliance on architectural pattern alone (Sahm et al., 2025). These developments reflect a broader shift towards integrated classification, although histology continues to provide the principal diagnostic foundation in many pathology services.

The biological heterogeneity of meningiomas has also become clearer through genomic and epigenomic research. Molecularly defined groups may differ in recurrence risk and clinical behaviour even among tumours that appear similar on routine microscopy, suggesting that conventional morphology and WHO grade do not explain all variation in outcome (Nasrallah & Aldape, 2023; Wang et al., 2023). This does not diminish the value of histopathology. Rather, it places greater importance on precise description of the morphologic features that are available in routine practice, especially where molecular testing cannot be performed routinely. A well-characterised histopathological series can therefore remain clinically informative when its claims are kept within the limits of the available material.

This issue is particularly relevant in low-resource settings, where access to advanced neuroimaging, molecular diagnostics and integrated multidisciplinary records may be uneven. Nigerian studies have shown that meningiomas constitute an important component of intracranial tumour practice, but institutional series vary in the histological patterns, anatomical distributions and level of accompanying clinical information reported. Salami et al. (2021), in a long-term Nigerian institutional series, documented substantial histological variation among meningiomas and reinforced the continued importance of systematic morphologic classification. In Enugu, Mezue et al. (2012) demonstrated the practical relationship between histological diagnosis, tumour location and surgical management, while more recent work from Enugu has examined the relationship between histological grade and immunohistochemical markers in an African population (Eluke et al., 2024). A separate histomorphological review from Benin City also highlighted the diagnostic diversity of meningeal lesions and the need for continued pathological audit in routine practice (Udoh, 2023). These studies provide valuable regional evidence, but much of the published Nigerian literature has been derived from larger referral centres or longer observation periods.

Low-volume tertiary centres occupy a different diagnostic position. Small case numbers limit population-level inference, yet such centres can still contribute useful evidence when the emphasis is placed on the pathological characteristics of the tumours actually encountered rather than on unstable estimates of frequency. This is especially relevant where uncommon morphologies coexist with adverse microscopic features. Careful documentation of mitotic activity, brain invasion and necrosis can identify biologically concerning patterns even when radiological, operative or molecular information is incomplete. The interpretive value of such series therefore lies less in estimating disease prevalence and more in demonstrating how histological variation presents within routine diagnostic practice.

This paper examines the histopathological spectrum of meningiomas diagnosed over five years in a low-volume tertiary centre in southeastern Nigeria. Particular attention is given to histological subtype, mitotic activity, brain invasion and tumour necrosis, with the aim of characterising the morphological patterns encountered in routine diagnostic practice. The study contributes institution-specific evidence from an under-represented setting and provides a focused account of the histopathological features observed within the series.

METHODS

Study design and setting

A retrospective descriptive case series was conducted at Nnamdi Azikiwe University Teaching Hospital, Nnewi, Anambra State, Nigeria. The hospital functions as a tertiary referral centre and provides histopathology services for surgical specimens, including intracranial tumours. The study covered the five-year period from January 2021 to December 2025. All histologically confirmed meningiomas diagnosed during this period were considered eligible for inclusion.

Case identification and eligibility

Cases were identified from the departmental histopathology register. Inclusion was restricted to specimens with a histological diagnosis of meningioma during the study period, without an age restriction. Specimens without histological confirmation of meningioma were excluded. Ten cases met the eligibility criteria and formed the study series.

Clinical and demographic information available in the histopathology records was extracted for each case. Variables included age, sex, tumour location and laterality. Information on whether the specimen represented a primary presentation was also recorded where available. The analysis was confined to

variables that could be established from the available records and histological material.

Histopathological evaluation

Archived haematoxylin and eosin-stained slides were retrieved and reviewed for all included cases. Histological assessment was based on the morphological criteria set out in the fifth edition of the World Health Organization Classification of Tumours of the Central Nervous System, which provides the current international framework for classifying central nervous system tumours (Louis et al., 2021; WHO Classification of Tumours Editorial Board, 2021). The review focused on the predominant histological pattern and the presence of adverse microscopic features that could be assessed on routine haematoxylin and eosin sections.

The histopathological variables examined were histological subtype, mitotic activity, brain invasion and tumour necrosis. Histological subtype was assigned according to the predominant recognised morphologic pattern. Mitotic activity was recorded from the available histological assessment, while brain invasion was defined on the basis of identifiable infiltration of tumour cells into adjacent brain parenchyma. Necrosis was recorded when present within viable tumour tissue. These features were analysed descriptively to characterise the range of morphologic appearances represented in the series.

The contemporary WHO framework was used principally to standardise tumour terminology and morphologic classification. Grade-specific inferential comparisons were not undertaken because the principal analytical focus was the histopathological spectrum and distribution of adverse morphologic features rather than prognostic modelling or between-group hypothesis testing.

Data management and statistical analysis

Data were entered and analysed using IBM SPSS Statistics version 25. Given the small number of cases and the descriptive purpose of the study, analysis was restricted to descriptive statistics. Categorical variables were summarised using frequencies and percentages, while age was described using the mean, standard deviation and range. Absolute numbers were retained alongside percentages to avoid overinterpretation of proportional differences within the small series.

No inferential statistical testing was performed. Histological findings were interpreted at the level of the observed series, with emphasis on subtype distribution and the occurrence of mitotic activity, brain invasion and necrosis. This analytical approach was considered appropriate for a low-volume case series in which the primary objective was morphological characterisation rather than estimation of population-level associations.

Ethical considerations

Ethical approval was obtained from the Ethics Committee of Nnamdi Azikiwe University Teaching Hospital (NAUTH/CS/66/Vol19/ver.5/231/2026/055). Patient confidentiality was maintained throughout data extraction and analysis, and no personally identifying information was included in the analytical dataset or manuscript.

RESULTS

Cohort characteristics

Ten histologically confirmed meningiomas were identified during the five-year study period. Patients were aged 24 to 73 years, with a mean age of 51.6 years (SD 14.9). Eight cases (80.0%) occurred in women and two (20.0%) in men. Anatomical distribution and laterality are summarised in Table 1. The sphenoid wing was the most frequently recorded site, accounting for four cases (40.0%), followed by the parasagittal region with two cases (20.0%). Convexity, skull base, and other sites each accounted for one case (10.0%), while the site was not stated for one case (10.0%). Laterality was recorded as left-sided in three cases (30.0%), right-sided in three (30.0%) and midline in two (20.0%); laterality was not stated in two cases (20.0%).

Table 1: Demographic and anatomical characteristics of the meningioma series (N = 10)

Characteristic	Category	Value	%
Age, years	Mean (SD)	51.6 (14.9)	
Age, years	Range	24-73	
Sex	Female	8	80.0
Sex	Male	2	20.0
Tumour site	Sphenoid wing	4	40.0

Characteristic	Category	Value	%
Tumour site	Parasagittal	2	20.0
Tumour site	Convexity	1	10.0
Tumour site	Skull base	1	10.0
Tumour site	Other	1	10.0
Tumour site	Not stated	1	10.0
Laterality	Left	3	30.0
Laterality	Right	3	30.0
Laterality	Midline	2	20.0
Laterality	Not stated	2	20.0

Note: SD = standard deviation. Percentages are based on N = 10. Blank percentage cells indicate continuous age summaries rather than categorical frequencies.

The distribution of tumour sites is shown in Figure 1. The site profile was concentrated most strongly at the sphenoid wing, while the remaining recorded locations were represented by one or two cases each.

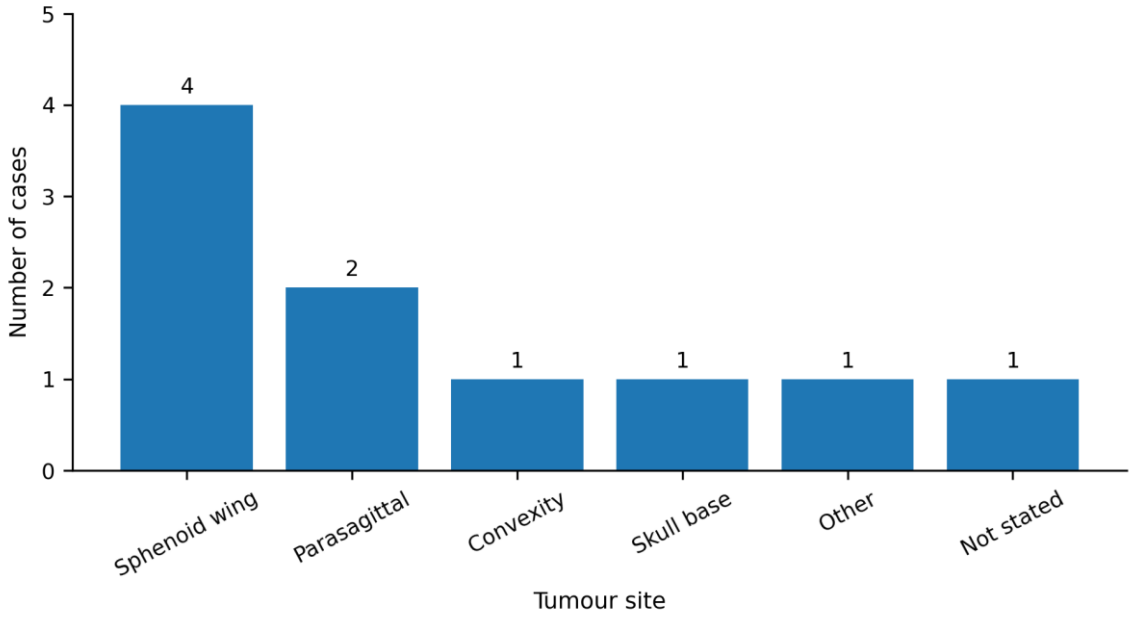


Figure 1: Distribution of meningioma cases by anatomical site (N = 10).

Sphenoid-wing tumours comprised four of the ten cases, twice the number recorded at the parasagittal site. No other individual site accounted for more than one case.

Histological spectrum and mitotic activity

Histological findings are presented in Table 2. Meningothelial meningioma was the predominant morphologic

subtype, identified in six cases (60.0%). Papillary and transitional morphologies were each identified in two cases (20.0%). The subtype distribution is displayed in Figure 2.

Table 2: Histological characteristics and adverse morphologic features (N = 10)

Characteristic	Category	n	%
Histological subtype	Meningothelial	6	60.0
Histological subtype	Papillary	2	20.0
Histological subtype	Transitional	2	20.0
Mitotic count per 10 HPF	2	1	10.0
Mitotic count per 10 HPF	3	4	40.0
Mitotic count per 10 HPF	4	3	30.0
Mitotic count per 10 HPF	14	1	10.0
Mitotic count per 10 HPF	15	1	10.0
Brain invasion	Present	2	20.0
Brain invasion	Absent	8	80.0
Tumour necrosis	Present	1	10.0
Tumour necrosis	Absent	9	90.0

Note: HPF = high-power field. Both cases with brain invasion had papillary morphology. The single case with tumour necrosis also had papillary morphology.

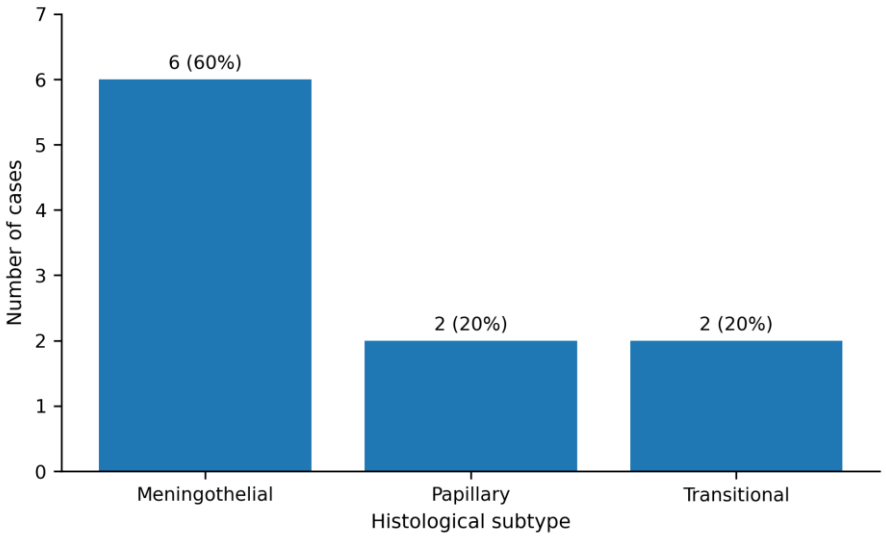


Figure 2: Histological subtype distribution of meningiomas in the series (N = 10).

Meningothelial morphology accounted for six cases, whereas papillary and transitional morphologies each accounted for two. Mitotic counts ranged from 2 to 15 per 10 HPF. Eight cases had counts between 2 and 4 per 10 HPF, while two cases had counts of 14 and 15 per 10 HPF. The two higher mitotic counts occurred in the papillary tumours; meningothelial and transitional tumours showed counts within the lower range of 2 to 4 per 10 HPF.

Adverse histological features

The distribution of brain invasion and tumour necrosis by histological subtype is shown in Figure 3. Brain invasion was identified in two cases (20.0%), both of which had papillary morphology. Tumour necrosis was identified in one case (10.0%), also within the papillary subgroup. Neither feature was recorded in the meningothelial or transitional tumours.

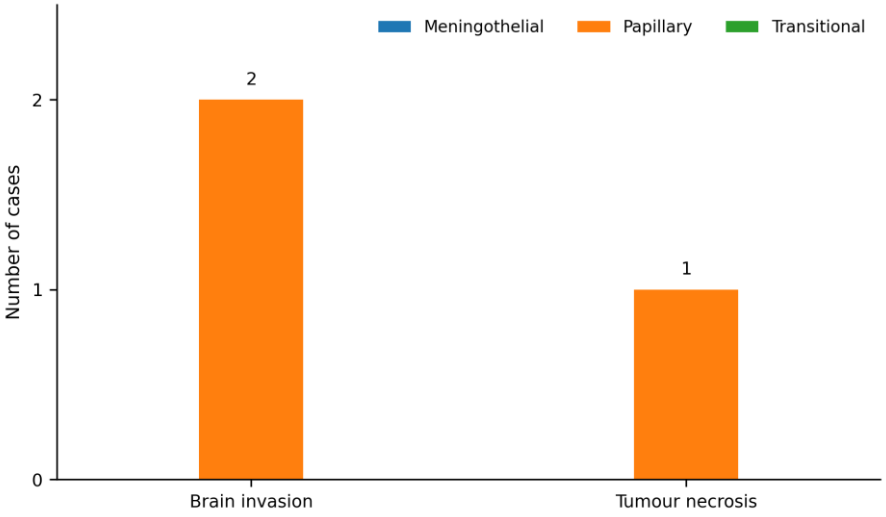


Figure 3: Distribution of adverse histological features by meningioma subtype (N = 10).

Among the two papillary tumours, brain invasion was present in both cases, while necrosis was present in one. No brain invasion or necrosis was identified among the eight non-papillary tumours. All ten tumours represented primary presentations. The available series was analysed descriptively; no inferential statistical tests were performed.

DISCUSSION

The present series provides a focused account of the histopathological spectrum of meningiomas encountered in a low-volume tertiary centre over a five-year period. Meningothelial morphology predominated, accounting for six of the ten tumours, while transitional and papillary patterns each occurred in two cases. The demographic profile was characterised by a mean age of 51.6 years and a marked female predominance, with eight of the ten cases occurring in women. Sphenoid wing tumours were the most frequent anatomical category. The most distinctive pathological finding was the concentration of adverse microscopic features within the papillary tumours, which demonstrated substantially greater mitotic activity than the meningothelial and transitional tumours. Brain invasion was

identified in both papillary lesions, while necrosis was present in one. Meningioma manuscript Meningioma manuscript

The age and sex distribution broadly accords with the established epidemiology of meningioma. Large registry studies consistently show a pronounced female excess, although the magnitude of the difference varies with age, population and mode of case ascertainment. Ho et al. (2023), drawing on more than 23,000 cases in the Dutch Brain Tumour Registry, confirmed the substantial population burden of meningioma and the strong contribution of adult and older-age disease. The 80% female proportion in the present series is also directionally consistent with Nigerian data. Ogunsanya (2023) reported 68 women among 99 meningioma cases in a 15-year Ibadan series, while Salami et al. (2021) similarly observed a female predominance in their larger single-institution cohort. These comparisons are useful as contextual anchors rather than estimates of equivalence, since the present series is too small to support population-level inference.

The predominance of meningothelial morphology is also consistent with part of the Nigerian evidence base, although institutional differences in subtype distribution are apparent. Ogunsanya (2023) found meningothelial meningioma to be the most frequent subtype in Ibadan, followed by transitional morphology. In contrast, transitional meningioma was the most frequently encountered pattern in the larger series reported by Salami et al. (2021). Such variation is not unexpected. Histological subtype frequencies can differ between institutional series because of referral pathways, case volume and the composition of surgically sampled tumours. The current findings are therefore most appropriately interpreted as an institutional morphologic profile rather than evidence that one subtype predominates consistently across Nigerian populations.

Anatomical distribution showed a notable concentration at the sphenoid wing, where four of the ten tumours were located. Although the number is small, the finding is compatible with the broader observation that meningiomas are not distributed uniformly throughout the intracranial compartment. Hosainey et al. (2022), using a population-based anatomical atlas of 602 intracranial meningiomas, demonstrated clear predilection for anterior intracranial locations, including the frontal region, parasagittal compartment and skull base of the anterior and middle cranial fossae. Sphenoid wing and clinoidal tumours accounted for an appreciable proportion of that population. The prominence of the sphenoid wing in the present series should therefore be regarded as anatomically plausible, although four cases are insufficient to establish a centre-specific predilection.

The most informative finding concerned the distribution of adverse histological features. Mitotic activity in the meningothelial and transitional tumours remained within a relatively narrow lower range, whereas the two papillary tumours demonstrated markedly greater mitotic activity. Brain invasion was also confined to these two lesions, and necrosis was identified in one. These observations indicate that the morphologically distinctive papillary cases carried the most conspicuous adverse microscopic features in the series. The importance of separating architectural pattern from biological behaviour is increasingly recognised in contemporary meningioma pathology. Morphology remains central to diagnosis, but proliferative activity, invasion and other adverse features carry information that cannot be inferred reliably from subtype designation alone.

Brain invasion deserves particular attention because its pathological interpretation has evolved alongside meningioma classification. Go and Kim (2023) describe invasion as a complex biological process involving extracellular matrix degradation, tumour-cell migration, adhesion and neovascular support. Their review also highlights the continuing uncertainty surrounding the prognostic weight of invasion when considered in isolation. Gousias et al. (2023), in a systematic review of meningiomas with central nervous system invasion, similarly found that the prognostic effect of brain invasion is influenced by the accompanying histological context and by methodological variation in how invasion is identified and sampled. These considerations support careful description of invasion as an observed morphological feature rather than treating it as a self-contained surrogate for clinical outcome.

The coexistence of increased mitotic activity, invasion and necrosis within the papillary subset is also relevant to the contemporary view of meningioma heterogeneity. Current research increasingly demonstrates that apparently similar meningiomas may differ substantially in their biological programmes. Choudhury et al. (2022), integrating DNA methylation, genomic, transcriptomic, proteomic and single-cell data from 565 tumours, identified molecular groups with markedly different biological behaviour, including a hypermitotic group characterised by cell-cycle activation and less favourable outcomes. Nassiri et al. (2021) likewise showed that integrative molecular classification can provide clinically meaningful stratification beyond conventional morphological categories. These studies do not permit molecular conclusions to be drawn from the present material, but they reinforce the broader principle that mitotic activity and other adverse histological findings may reflect biological diversity that extends beyond architectural appearance.

This distinction is particularly important for papillary morphology. Contemporary classification no longer supports treating architectural appearance as sufficient evidence of biological behaviour in isolation. Recent cIMPACT-NOW guidance emphasises integrated interpretation of morphology, mitotic activity, invasion and, where available, molecular risk parameters when evaluating meningiomas with potentially aggressive features (Sahm et al., 2025). The present series should therefore be read at the level that its evidence supports: the two papillary tumours displayed a cluster of adverse histological characteristics, including substantially increased mitotic activity and brain invasion, with necrosis additionally present in one lesion. No further biological or prognostic inference is required to establish the pathological importance of that pattern.

The findings also illustrate why routine histomorphology retains considerable value despite rapid progress in molecular classification. Molecular approaches have improved risk stratification and clarified biological heterogeneity, but morphology remains the starting point for meningioma diagnosis and continues to determine which tumours warrant closer pathological scrutiny. Maas et al. (2021) demonstrated that combining molecular and morphologic information improves prognostic classification, while contemporary international guidance continues to position pathological assessment as a core component of meningioma evaluation. The practical implication is not that routine morphology is obsolete, but that features such as increased mitotic activity, invasion and necrosis should be recorded carefully and interpreted in combination rather than reduced to subtype labels alone.

Several limitations should temper interpretation. The series contains only ten cases from a single tertiary centre, which restricts statistical precision and prevents reliable estimation of institutional or population prevalence. Each case represents 10% of the cohort, so apparently large percentage differences may be produced by very small absolute changes. For this reason, the findings are best considered as a descriptive histopathological series rather than an epidemiological estimate. The retrospective design also limits the analysis to variables recorded consistently across the study period. These constraints do not invalidate the observed morphology, but they preclude broader claims regarding determinants, prognosis or population distribution.

Despite the small sample, the series contributes institution-specific evidence from a part of sub-Saharan Africa where detailed histopathological descriptions remain comparatively limited. The principal value lies in the coexistence of conventional meningothelial and transitional patterns with a smaller papillary subset carrying the most prominent adverse histological features. Larger multi-centre studies incorporating standardised histological assessment would be valuable for determining whether similar patterns are reproduced across Nigerian and wider African pathology services. Where feasible, future work could also examine how routine morphologic findings correspond with contemporary molecular risk categories, without displacing the central diagnostic role of careful histopathological evaluation.

CONCLUSION

Meningiomas encountered in this five-year series displayed a varied histopathological spectrum, with meningothelial morphology predominating and transitional and papillary patterns occurring less frequently. The most prominent adverse microscopic features were concentrated within the papillary tumours, which showed substantially greater mitotic activity than the meningothelial and transitional lesions. Brain invasion was identified in both papillary tumours, while tumour necrosis was present in one case. These findings reinforce the importance of assessing meningiomas beyond architectural subtype alone and of documenting proliferative and invasive features systematically during routine histopathological evaluation.

The small number of cases limits broader epidemiological interpretation, but the series provides institution-specific evidence from a low-volume tertiary centre in southeastern Nigeria. Careful morphological assessment remains particularly important in settings where diagnostic practice is centred on conventional histopathology. Larger multi-centre studies using standardised histological criteria would allow more robust characterisation of meningioma patterns across Nigerian and other sub-Saharan African populations and would provide a stronger basis for examining how adverse morphologic features relate to contemporary risk classification.

AUTHOR CONTRIBUTION

All authors played a substantive role in shaping this study and developing the manuscript. K.G.I. conceptualised the study and designed the overall research framework. The authors collaboratively analysed, interpreted, and validated the findings, with each author contributing to the discussions that informed the final results. K.G.I. and K.O.O. prepared the initial manuscript draft, covering the introduction, methods, results and discussion. Co-authors strengthened the analysis, provided detailed revisions, and enhanced the clarity and coherence of the final manuscript. All authors reviewed and approved the final manuscript and accept responsibility for the accuracy and integrity of the work.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

1. Choudhury, A., Magill, S. T., Eaton, C. D., Prager, B. C., Chen, W. C., Cady, M. A., Seo, K., Lucas, C.-H. G., Casey-Clyde, T. J., Vasudevan, H. N., Liu, S. J., Villanueva-Meyer, J. E., Lam, T.-C., Pu, J. K.-S., Li, L.-F., Leung, G. K.-K., Swaney, D. L., Zhang, M. Y., Chan, J. W., . . . Raleigh, D. R. (2022). Meningioma DNA methylation groups identify biological drivers and therapeutic

vulnerabilities. Nature Genetics, 54(5), 649-659. https://doi.org/10.1038/s41588-022-01061-8

2. Eluke, C. C., Aniume, O. I., Olusina, B. D., Okafor, O. C., & Olasode, B. J. (2024). Correlation of progesterone receptors and P63 to the histological grade of meningiomas: Review and significance in an African population. Journal of Neurosciences in Rural Practice, 15(1), 69-73. https://doi.org/10.25259/JNRP_332_2023
3. Go, K.-O., & Kim, Y. Z. (2023). Brain invasion and trends in molecular research on meningioma. Brain Tumor Research and Treatment, 11(1), 47-58. https://doi.org/10.14791/btrt.2022.0044
4. Gousias, K., Trakolis, L., & Simon, M. (2023). Meningiomas with CNS invasion. Frontiers in Neuroscience, 17, 1189606. https://doi.org/10.3389/fnins.2023.1189606
5. Ho, V. K. Y., Anten, M. M., Garst, A., Bos, E. M., Snijders, T. J., Eekers, D. B. P., Seute, T., Dutch Brain Tumour Registry, & Dutch Society for Neuro-Oncology. (2023). Epidemiology of adult meningioma: Report from the Dutch Brain Tumour Registry (2000-2019). European Journal of Neurology, 30(10), 3244-3255. https://doi.org/10.1111/ene.15979
6. Hosainey, S. A. M., Bouget, D., Reinertsen, I., Sagberg, L. M., Torp, S. H., Jakola, A. S., & Solheim, O. (2022). Are there predilection sites for intracranial meningioma? A population-based atlas. Neurosurgical Review, 45(2), 1543-1552. https://doi.org/10.1007/s10143-021-01652-9
7. Louis, D. N., Perry, A., Wesseling, P., Brat, D. J., Cree, I. A., Figarella-Branger, D., Hawkins, C., Ng, H. K., Pfister, S. M., Reifenberger, G., Soffietti, R., von Deimling, A., & Ellison, D. W. (2021). The 2021 WHO Classification of Tumors of the Central Nervous System: A summary. Neuro-Oncology, 23(8), 1231-1251. https://doi.org/10.1093/neuonc/noab106
8. Louis, D. N., Perry, A., Wesseling, P., Brat, D. J., Cree, I. A., Figarella-Branger, D., Hawkins, C., Ng, H. K., Pfister, S. M., Reifenberger, G., Soffietti, R., von Deimling, A., & Ellison, D. W. (2021). The 2021 WHO Classification of Tumors of the Central Nervous System: A summary. Neuro-Oncology, 23(8), 1231-1251. https://doi.org/10.1093/neuonc/noab106 OUP Academic
9. Maas, S. L. N., Stichel, D., Hielscher, T., Sievers, P., Berghoff, A. S., Schrimpf, D., Sill, M., Euskirchen, P., Blume, C., Patel, A., Dogan, H., Reuss, D., Dohmen, H., Stein, M., Reinhardt, A., Suwala, A. K., Wefers, A. K., Baumgarten, P., Ricklefs, F., . . . Sahm, F. (2021). Integrated molecular-morphologic meningioma classification: A multicenter retrospective analysis, retrospectively and prospectively validated. Journal of Clinical Oncology, 39(34), 3839-3852. https://doi.org/10.1200/JCO.21.00784
10. Mezue, W. C., Ohaegbulam, S. C., Ndubuisi, C. A., Chikani, M. C., & Achebe, D. S. (2012). Management of intracranial meningiomas in Enugu, Nigeria. Surgical Neurology International, 3, 110. https://doi.org/10.4103/2152-7806.101788
11. Nasrallah, M. P., & Aldape, K. D. (2023). Molecular classification and grading of meningioma. Journal of Neuro-Oncology, 161(2), 373-381. https://doi.org/10.1007/s11060-022-04228-9
12. Nassiri, F., Liu, J., Patil, V., Mamatjan, Y., Wang, J. Z., Hugh-White, R., Macklin, A. M., Khan, S., Singh, O., Karimi, S., Corona, R. I., Liu, L. Y., Chen, C. Y., Chakravarthy, A., Wei, Q., Mehani, B., Suppiah, S., Gao, A., Workewych, A. M., . . . Zadeh, G. (2021). A clinically applicable integrative molecular classification of meningiomas. Nature, 597(7874), 119-125. https://doi.org/10.1038/s41586-021-03850-3
13. Ogasawara, C., Philbrick, B. D., & Adamson, D. C. (2021). Meningioma: A review of epidemiology, pathology, diagnosis, treatment, and future directions. Biomedicines, 9(3), 319. https://doi.org/10.3390/biomedicines9030319
14. Ogunsanya, T. O. (2023). Meningioma-01 histopathological pattern of meningioma in Ibadan, Southwest Nigeria: A 15-year retrospective study. Neuro-Oncology Advances, 5(Supplement_4), iv4. https://doi.org/10.1093/noajnl/vdad121.014
15. Sahm, F., Aldape, K. D., Brastianos, P. K., Brat, D. J., Dahiya, S., von Deimling, A., Giannini, C., Gilbert, M. R., Louis, D. N., Raleigh, D. R., Reifenberger, G., Santagata, S., Sarkar, C., Zadeh, G., Wesseling, P., & Perry, A. (2025). cIMPACT-NOW update 8: Clarifications on molecular risk parameters and recommendations for WHO grading of meningiomas. Neuro-Oncology, 27(2), 319-330. https://doi.org/10.1093/neuonc/noae170
16. Salami, A. A., Okunlola, A. I., Ajani, M. A., & Onakpoma, F. (2021). WHO classification of meningiomas: A single institutional experience. Neurochirurgie, 67(2), 119-124. https://doi.org/10.1016/j.neuchi.2020.10.005
17. Soni, N., Ora, M., Bathla, G., Szekeres, D., Desai, A., Pillai, J. J., & Agarwal, A. (2025). Meningioma: Molecular updates from the 2021 World Health Organization Classification of CNS Tumors and imaging correlates. American Journal of Neuroradiology, 46(2), 240-250. https://doi.org/10.3174/ajnr.A8368
18. Udoh, M. O. (2023). A retrospective histomorphologic study of meningeal masses in Benin City, Nigeria. Ibom Medical Journal, 16(2), 139-147. https://doi.org/10.61386/imj.v16i2.310
19. Wang, J. Z., Nassiri, F., Landry, A. P., Patil, V., Liu, J., Aldape, K., Gao, A., & Zadeh, G. (2023). The multiomic landscape of meningiomas: A review and update. Journal of Neuro-Oncology, 161(2), 405-414. https://doi.org/10.1007/s11060-023-04253-2
20. WHO Classification of Tumours Editorial Board. (2021). Central nervous system tumours (WHO Classification of Tumours, 5th ed., Vol. 6). International Agency for Research on Cancer. Available at: https://publications.iarc.who.int/601 [Accessed: 21/04/2026]