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Original Research Article

Cytomorphologic–Histopathologic Concordance In Meningiomas: A Prospective Analysis of Demographic Profile, Tumor Topography, and Histological Spectrum

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Abstract:

Background: Meningiomas are among the most common central nervous system tumors and exhibit variations in demographic profile, anatomical location, and histological subtype. Rapid intraoperative diagnosis is important for surgical planning, and the cytosmear technique offers a practical diagnostic approach.

Methods: This prospective study included 120 lesions evaluated for meningioma. Age, sex, site distribution, and histological patterns were analyzed. Intraoperative cytosmear diagnoses were compared with final histopathological examination, which served as the reference standard. Statistical analysis was performed using chi-square testing, and $p<0.05$ was considered significant.

Results: The age of the study subjects ranged from 13 to 71 years, with a mean age of 40 years. The highest proportion of cases was observed in the 40–49 years age group (38.3%) ($\chi^2=72.42$, $p<0.001$). Females constituted 57.5% of the cohort, with a female-to-male ratio of 1.35:1. Intracranial tumors predominated (81.7%) ($\chi^2=92.95$, $p<0.001$). WHO grade I meningiomas accounted for 91.7% of cases, with meningothelial meningioma as the most common subtype. Two lesions initially diagnosed as meningioma on cytosmear were schwannomas on histopathology. Overall cytosmear diagnostic accuracy was 98.3% ($\chi^2=88.17$, $p<0.001$).

Conclusion: Meningiomas in this series predominantly affected middle-aged females, were chiefly intracranial, and were mostly WHO grade I tumors. Cytosmear examination showed excellent concordance with histopathology.

Keywords: Meningioma, Cytosmear, Histopathology, Intraoperative diagnosis, Clinicopathological.

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Introduction

Meningiomas are the most common primary intracranial tumors in adults and exhibit considerable variation in demographic profile, anatomical distribution, histological subtype, and biological behavior [1]. Although most are WHO grade 1 tumors, a proportion show atypical or anaplastic features, and the histological pattern remains important because it correlates with tumor grade, recurrence risk, and clinical outcome. Recent studies have emphasized that clinicopathological evaluation of meningiomas should integrate age, sex, tumor site, and microscopic subtype to better characterize disease patterns and support prognostic assessment [2, 3]. In neurosurgical practice, intraoperative cytosmear examination is a rapid, simple, and tissue-conserving diagnostic method that can guide surgical decision-making, particularly when its findings are correlated with final histopathological diagnosis. Recent evidence has shown high concordance between squash smear cytology and permanent histopathology in central nervous system (CNS) tumors, including meningiomas [1, 2]. Therefore, the present study, conducted to analyze the age, sex, and site distribution of various histological patterns of meningioma and to evaluate the diagnostic accuracy of the cytosmear technique by comparison with histopathological examination.

Methods

This prospective observational study was conducted in the department of Pathology, Deccan Medical College, Hyderabad, from May 2025 to February 2026. All consecutive cases clinically and radiologically suspected to be meningioma and operated during the study period were included. Fresh tissue specimens obtained during craniotomy or burr-hole procedures were transported unfixed to the pathology laboratory in sterile normal saline containers immediately after excision. Relevant clinicodemographic and radiological details, including age, gender, tumor location, radiological diagnosis, extent of lesion, attachment to dura or cranial nerves, and prior therapeutic intervention, were recorded for each case.

Intraoperative cytological evaluation was performed using the squash smear technique. Small representative fragments of fresh tumor tissue, measuring approximately 1–2 mm, were selected and gently compressed between two clean glass slides to obtain thin, uniform smears. Care was taken to apply pressure according to tissue consistency in order to minimize crush artifact and preserve cytomorphological details. Whenever adequate material was available, at least four smears were prepared from each specimen. Two air-dried smears were stained with 1% aqueous toluidine blue for rapid preliminary assessment, and two wet smears were fixed in 95% alcohol and stained with rapid hematoxylin and eosin (HE). The toluidine blue smears were examined within minutes of receipt, while rapid HE staining enabled cytological interpretation within a short intraoperative interval. The remaining tissue, along with any subsequently received specimen, was fixed in 10% neutral buffered formalin, routinely processed, paraffin embedded, sectioned, and stained with hematoxylin and eosin for final histopathological examination. Special stains such as periodic acid–Schiff and immunohistochemistry markers including epithelial membrane antigen and glial fibrillary acidic protein were used whenever required to support the diagnosis and exclude histological mimics. Histological typing was performed according to the current WHO classification of CNS tumors [4].

Histopathological examination was considered the reference standard for final diagnosis [5]. Cytosmear findings were compared with permanent histopathology to assess diagnostic concordance and accuracy. The age, gender, site distribution, and frequency of various histological patterns of meningioma were analyzed. Data were entered into Microsoft Excel and analyzed using SPSS version 21.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were summarized as mean ± standard deviation. Associations between histological patterns and clinicodemographic variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. $P<0.05$ was considered statistically significant.

Results

Total 120 lesions were evaluated in the present study. The age of the study subjects ranged from 13 to 71 years, with a mean age of 40 years. The highest proportion of cases was observed in the 40–49 years age group (38.3%), followed by 30–39 years (19.2%) and 50–59 years (16.7%), statistically significant ($\chi^2 = 72.42$, $P <0.001$; Table 1). Female subjects constituted 57.5% of the study cohort, whereas males accounted for 42.5%, yielding a female-to-male ratio of 1.35:1 (Table 2). With regard to anatomical distribution, intracranial tumors formed the overwhelming majority (81.7%), followed by intraspinal (15.8%) and extracranial lesions (2.5%), and this difference was highly significant ($\chi^2 = 92.95$, $P< 0.001$; Table 3). Histopathological examination showed that WHO grade I meningiomas comprised the largest category (91.7%), with meningothelial meningioma being the most frequent subtype, followed by fibroblastic, transitional, and psammomatous variants. WHO grade II and grade III lesions were uncommon, each accounting for 3.3% of cases. Two lesions initially interpreted as meningioma on cytosmear were diagnosed as schwannoma on final histopathology, resulting in an overall cytosmear diagnostic accuracy of 98.3% ($\chi^2 = 88.17$, $P < 0.001$; Table 4).

Table 1: Gender wise distribution of study members

Age group	Number	%
10–19	3	2.5
20–29	18	15
30–39	23	19.2
40–49	46	38.3
50–59	20	16.7
60–69	9	7.5
70–79	1	0.8
Total	120	100

Table 2: Gender wise distribution of study members		
Gender	**Number**	**%**
Female	69	57.5
Male	51	42.5
Total	120	100

Table 3: Distribution of study members according to tumor site		
Site	**Number**	**%**
Intracranial	98	81.7
Intraspinal	19	15.8
Extracranial	3	2.5
Total	120	100

Table 4: Distribution of study subjects according to histopathological subtype and cytosmear–histopathology concordance		
Diagnosis	**Number**	**%**
WHO grade I meningiomas	110	91.7
Meningothelial	35	29.2
Fibroblastic	24	20
Transitional	22	18.3
Psammomatous	21	17.5
Angiomatous	5	4.2
Microcystic	2	1.7
Secretory	1	0.8
WHO grade II meningioma	4	3.3
Atypical	4	3.3
WHO grade III meningiomas	4	3.3
Rhabdoid	1	0.8
Anaplastic	3	2.5
Schwannoma on final histology	2	1.7

Discussion

The present study showed that meningiomas over a wide age range, 13–71 years, with a mean age of 40 years and a clear clustering in the fourth and fifth decades. This overall pattern is consistent with the established epidemiology of meningioma, which identifies adulthood and middle age as the most common period of presentation, although large contemporary surgical series from Europe have reported a somewhat higher mean age at surgery, often around the late fifth decade [1, 6]. The relatively younger mean age in the present series may reflect differences in referral pathways, case selection, healthcare access, and the inclusion of surgically treated patients from a tertiary public hospital setting rather than a population-based registry [1, 6]. The female predominance observed in this study, with a female-to-male ratio of 1.35:1, also agrees with the well-recognized sex distribution of meningioma. Recent studies continue to demonstrate that women constitute the majority of patients with benign meningiomas, while biological differences between men and women may influence genomic alterations, progression risk, and clinicopathological behavior [6, 7]. Berghaus et al. reported that females accounted for nearly three-fourths of benign tumors in their cohort, reinforcing the view that sex-linked hormonal and molecular factors likely contribute to meningioma susceptibility [7]. Thus, the demographic profile in the present study is broadly in agreement with current literature, although the lower mean age and more modest female predominance suggest local population and institutional influences on the case mix [1, 6, 7].

With respect to anatomical distribution, the marked predominance of intracranial tumors in the present study is expected and aligns with the established biology of meningiomas, which arise from arachnoid cap cells and therefore occur predominantly along intracranial dural reflections and skull-base surfaces [2, 8]. Contemporary clinicopathological studies have consistently shown that most meningiomas are intracranial, whereas spinal and extracranial lesions form smaller subsets [1, 2, 6]. In the present series, intracranial lesions accounted for 81.7% of cases, followed by intraspinal lesions in 15.8%, indicating that although spinal meningiomas were much less frequent, they still formed a clinically meaningful subgroup. This is important because spinal meningiomas are not only anatomically distinct but may also show differences in histological pattern, molecular profile, and sex distribution [8]. The raw data in the present

study further showed that frontal, cerebellopontine angle, sphenoid, suprasellar, and spinal locations were prominent sites. Such a distribution is comparable with recent reports in which convexity and skull-base tumors dominate the intracranial group, while spinal lesions remain a recognized but smaller component of the meningioma spectrum [1, 6]. Notably, recent work on psammomatous meningiomas has emphasized their relative enrichment in spinal locations and their association with female and NF2-related alterations, which may help explain why some histological subtypes show site predilection rather than a random anatomical spread [8]. Therefore, the strong intracranial predominance and the meaningful spinal representation in the present study are both biologically plausible and supported by recent evidence [1, 6, 8].

Histopathologically, the overwhelming predominance of WHO grade I meningiomas in the present study is in keeping with modern classification-based and epidemiological data. Recent large series have consistently shown that grade I tumors comprise the great majority of meningiomas, whereas grade II and grade III tumors remain distinctly less common [2, 6, 9]. In the French nationwide study of over 30,000 histopathologically confirmed meningiomas, grade I tumors accounted for 83.9% of cases, while grade II and III lesions formed much smaller fractions, a pattern that closely parallels the current findings despite some variation in exact proportions [6]. Similarly, the present study identified meningothelial meningioma as the most common subtype, followed by fibroblastic, transitional, and psammomatous variants, which is again concordant with the current literature showing that meningothelial architecture remains the dominant histological phenotype among benign tumors [2, 6]. Recent reviews of meningioma classification also emphasize that although histomorphology remains central to diagnosis, the field has evolved to incorporate molecular risk markers, especially for tumors with atypical or clinically discordant behavior [2, 9, 10]. This is especially relevant to the smaller subset of atypical, rhabdoid, and anaplastic tumors identified in the present study, because higher-grade lesions carry a substantially greater risk of recurrence and aggressive clinical course than grade I tumors [9 – 11]. Trivedi et al. demonstrated significant associations between adverse clinicopathological features and high-grade disease, while Zanconato et al. highlighted the prognostic importance of brain invasion and chromosome 1p deletion in atypical meningiomas [10, 11]. Accordingly, the histological profile observed here confirms the expected predominance of low-grade tumors while also underscoring the importance of careful recognition of the smaller high-grade subset [6, 10, 11].

A notable strength of the present study is the very high overall cytosmear diagnostic accuracy of 98.3%, with only two discrepant lesions that were initially interpreted as meningioma on squash cytology but were confirmed as schwannoma on final histopathology. This finding strongly supports the usefulness of intraoperative smear techniques in meningioma diagnosis. Recent studies on intraoperative squash smear cytology have reported high levels of diagnostic agreement with permanent histopathology, particularly for relatively cohesive and morphologically distinctive lesions such as meningioma [12 – 14]. Philip et al. reported that diagnostic accuracy was especially high for meningioma among central nervous system tumors, and Ramchandani et al. also confirmed that squash smear cytology is a rapid, cost-effective, and reliable method for intraoperative decision-making in resource-limited settings [12, 13]. Kumar et al. likewise showed that squash smear interpretation retains substantial value when correlated with histopathology and radiology, reinforcing its role as a practical alternative where frozen section is unavailable or limited [14]. The two discordant cases in the present study are also understandable from a neuropathological perspective, because spindle-cell or fascicular lesions at sites such as the cerebellopontine angle or spine may overlap cytologically with schwannoma, particularly when tissue is scant or when architecture is partially lost during smear preparation [12, 14]. Thus, the present results support the continued use of cytosmear examination as an effective intraoperative tool, while also highlighting the need for cautious interpretation in anatomically and morphologically overlapping lesions [13, 14].

Overall, the present study demonstrates a clinicopathological pattern that is both internally coherent and externally comparable with contemporary literature: meningiomas occurred predominantly in middle-aged adults, showed female preponderance, arose mainly in intracranial locations, and were chiefly represented by WHO grade I histology. These observations reinforce the view that conventional demographic and histomorphological parameters continue to provide meaningful biological information even in the era of molecularly refined classification [2, 9]. At the same time, current meningioma literature increasingly stresses that morphology alone may not fully capture recurrence risk, especially in atypical tumors and in lesions with molecular abnormalities such as TERT promoter alteration, CDKN2A/B loss, or chromosome 1p deletion [9, 11, 15]. Therefore, the value of the present work lies not only in documenting local epidemiological and histological trends but also in showing that a carefully performed cytology–histopathology correlation study remains highly relevant in routine practice. In many institutions, especially in resource-constrained

settings, intraoperative squash cytology continues to provide rapid guidance to neurosurgeons, helps optimize tissue handling, and supports timely surgical decisions without compromising final histopathological confirmation [12, 14]. Taken together, the findings of this study support the continued diagnostic relevance of traditional pathological evaluation while also aligning with current evidence that meningioma assessment should increasingly integrate histology, anatomical context, and selected molecular risk parameters for more precise prognostication.

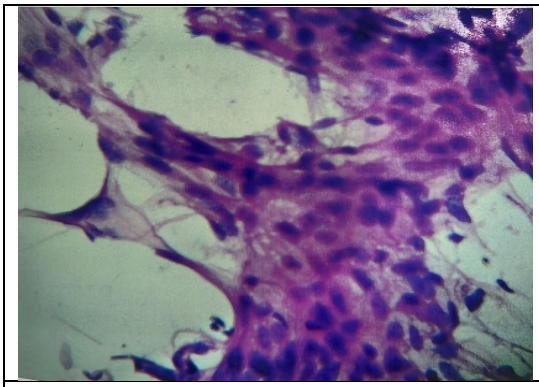

Fig 1: Meningothelial cells arranged in three dimensional clusters under H & E stain

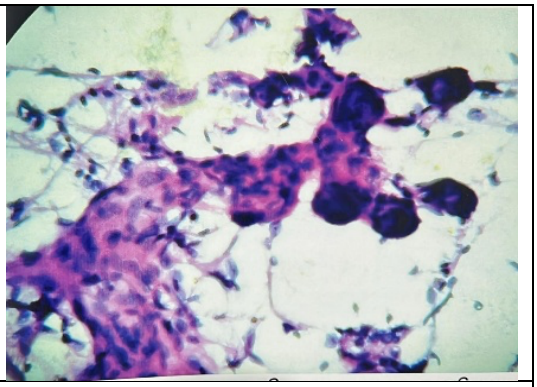

Fig 2: Psammomatous meningioma - Psammoma bodies under H & E stain

Conclusion

The present study demonstrated that meningiomas occurred predominantly in middle-aged individuals, with a female preponderance and a marked intracranial predominance. WHO grade I tumors constituted the overwhelming majority, with meningothelial meningioma emerging as the most frequent histological subtype. Higher-grade meningiomas were distinctly uncommon. The cytosmear technique showed excellent diagnostic performance, with a high concordance with final histopathology and an overall accuracy of 98.3%. These findings confirm that intraoperative cytosmear examination is a rapid, reliable, and tissue-conserving diagnostic adjunct in meningioma evaluation and remains highly valuable for immediate surgical decision-making in routine neurosurgical pathology practice.

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