Jurnal Kesehatan, Sains, dan Teknologi (JAKASAKTI)
Vol. 5, No. 1 April 2026
Available online at https://jurnal.undhirabali.ac.id/index.php/jakasakti/index

Research Article e-ISSN: 2963-0940

THE MOST COMMON ANATOMICAL SITE AND CLINICAL MANIFESTATIONS OF INTRACRANIAL MENINGIOMA: A SYSTEMATIC REVIEW

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Article info

Keywords:
Meningioma, Brain tumor, Systematic review

Abstract

Meningioma is the most common primary intracranial tumor, originating from the meninges surrounding the brain and spinal cord. Although its exact etiology remains unclear, exposure to ionizing radiation, hormonal factors, and genetic predisposition are considered important risk factors. This systematic review aimed to identify the most common anatomical location and clinical manifestations of brain meningioma worldwide. A literature search was conducted in PubMed, MedLine, and ProQuest for studies published between 2015 and May 2025. Eligible studies included original research focusing on intracranial meningioma, while studies involving other central nervous system tumors or non-journal publications were excluded. Of 95 identified articles, 10 studies involving more than 500 patients met the inclusion criteria. The findings consistently demonstrated that supratentorial meningiomas were the most frequent, particularly those located at the convexity (30%) and parasagittal region (24%). The most common clinical presentation was nonspecific headache, followed by vomiting, decreased level of consciousness, and other neurological deficits depending on tumor location. These findings highlight that supratentorial meningiomas represent the predominant anatomical site and that nonspecific headache remains the most frequent presenting symptom, emphasizing the importance of early clinical recognition and neuroimaging evaluation.

Kata kunci:
Meningioma, Tumor otak, Tinjauan sistematis

Abstrak

Meningioma merupakan tumor primer intrakranial yang paling sering ditemukan, berasal dari meninges yang menyelubungi otak dan medula spinalis. Meskipun etiologi pastinya hingga kini belum sepenuhnya diketahui, paparan radiasi pengion, faktor hormonal, serta predisposisi genetik dianggap sebagai faktor risiko utama yang berperan dalam perkembangan penyakit ini. Tinjauan sistematis ini bertujuan untuk mengidentifikasi lokasi anatomis yang paling sering ditemukan serta manifestasi klinis meningioma otak di berbagai negara di dunia. Penelusuran literatur dilakukan melalui basis data PubMed, MEDLINE, dan ProQuest terhadap artikel yang dipublikasikan antara tahun 2015 hingga Mei 2025. Studi yang memenuhi kriteria inklusi adalah penelitian asli yang berfokus pada meningioma intrakranial, sedangkan penelitian yang membahas tumor lain pada sistem saraf pusat maupun publikasi nonjurnal dikeluarkan dari analisis. Dari total 95 artikel yang berhasil diidentifikasi, sebanyak 10 penelitian yang melibatkan lebih dari 500 pasien memenuhi kriteria inklusi. Hasil kajian menunjukkan secara

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konsisten bahwa meningioma supratentorial merupakan tipe yang paling sering dijumpai, terutama yang berlokasi pada konveksitas serebri (30%) dan daerah parasagital (24%). Manifestasi klinis yang paling umum adalah sakit kepala nonspesifik, diikuti oleh muntah, penurunan tingkat kesadaran, serta berbagai defisit neurologis lain yang bervariasi sesuai dengan lokasi tumor. Temuan ini menegaskan bahwa meningioma supratentorial merupakan lokasi anatomis yang paling dominan, sementara sakit kepala nonspesifik tetap menjadi gejala klinis yang paling sering muncul. Oleh karena itu, pengenalan dini terhadap manifestasi klinis serta pelaksanaan evaluasi menggunakan pencitraan neuroimaging sangat penting untuk mendukung diagnosis yang lebih cepat dan penatalaksanaan yang lebih optimal.

BACKGROUND

Meningioma is the most common primary central nervous system (CNS) tumour, accounting for approximately 37.6% of all primary CNS tumours and nearly 50% of all benign brain tumours (Ostrom et al., 2019). It originates from arachnoid cap cells within the meninges surrounding the brain and spinal cord and is classified into three histopathological grades according to the World Health Organization (WHO) Classification of Central Nervous System Tumours. Most meningiomas are WHO grade 1 and demonstrate a benign clinical course, whereas WHO grade 2 and grade 3 tumours exhibit higher recurrence rates, more aggressive biological behaviour, and poorer prognosis (Louis et al., 2021). Although uncommon, approximately 1–3% of meningiomas undergo malignant transformation, with reported 5-year survival rates for malignant meningiomas ranging from 32% to 64% (Buerki et al., 2018). Several risk factors have been associated with the development of meningioma, including neurofibromatosis type 2, prior exposure to ionizing radiation, hormonal influences, and family history (Buerki et al., 2018; Wiemels et al., 2010).

The clinical presentation of meningioma is highly heterogeneous and largely depends on tumour location, size, surrounding brain involvement, and the presence of peritumoral oedema. Consequently, many patients remain asymptomatic and are diagnosed incidentally, whereas others present with headaches, seizures, focal neurological deficits, cognitive impairment, or visual disturbances. Magnetic resonance imaging (MRI) remains the gold standard imaging modality for the diagnosis and preoperative evaluation of meningioma (Buerki et al., 2018; Gürçay et al., 2018). Current management strategies range from active surveillance for asymptomatic and slow-growing tumours to surgical resection, with or without radiotherapy, for symptomatic, enlarging, or high-grade lesions (Gürçay et al., 2018).

Because the clinical manifestations of intracranial meningiomas are strongly influenced by tumour location, understanding the anatomical distribution of these tumours is essential for accurate clinical assessment and timely diagnosis. Knowledge of the most frequent tumour sites can help clinicians better interpret neurological symptoms, formulate differential diagnoses, and optimize diagnostic imaging strategies.

Although numerous observational studies have described the anatomical distribution and clinical manifestations of intracranial meningiomas, their findings vary considerably across different populations and geographical regions. Furthermore, no recent systematic review has comprehensively synthesized the global evidence regarding the most common intracranial tumour locations and their associated clinical presentations. This lack of consolidated evidence makes it difficult for clinicians to obtain an overall understanding

of the epidemiological and clinical patterns of meningioma. Therefore, this systematic review was conducted to summarize the current evidence on the most common anatomical locations of intracranial meningiomas and their associated clinical manifestations. The findings are expected to improve clinicians' understanding of disease presentation and support earlier recognition and more accurate diagnosis of patients with intracranial meningioma.

METHODS

This systematic review was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 Statement. A comprehensive literature search was performed using three electronic databases, namely PubMed, MEDLINE, and ProQuest, to identify studies published between January 2015 and May 2025 that investigated the anatomical location and clinical manifestations of intracranial meningioma. The search strategy combined Medical Subject Headings (MeSH) and free-text terms related to meningioma, tumour location, and clinical presentation. The keywords included *"meningioma," "clinical manifestation," "symptom," "presentation," "location," "site,"* and *"intracranial location,"* combined using appropriate Boolean operators (AND/OR). To ensure that no relevant studies were missed, the reference lists of eligible articles were also manually screened.

Eligible studies included retrospective observational studies, retrospective case series, case reports, pictorial reviews, narrative reviews, and clinical reviews that provided descriptive information on the anatomical distribution and/or clinical manifestations of intracranial meningiomas. Only articles published in English with accessible full texts were considered. Because this review aimed to summarize the currently available evidence regarding tumour location and clinical presentation rather than treatment effectiveness, studies describing clinically relevant findings from descriptive research and review articles were included in the qualitative synthesis.

Studies were excluded if they focused exclusively on spinal meningiomas without presenting separate data for intracranial tumours, investigated treatment outcomes, recurrence, molecular biology, or imaging techniques without reporting tumour location or clinical manifestations, included mixed central nervous system tumours without separate analyses for meningioma, or lacked sufficient information for data extraction. Conference abstracts, editorials, letters to the editor, and articles with unavailable full texts were also excluded.

Following the database search, duplicate records were removed before title and abstract screening. Full-text articles considered potentially eligible were subsequently assessed according to the predefined eligibility criteria. Because of the considerable heterogeneity among the included studies with respect to study design, sample size, patient characteristics, and reported outcomes, a quantitative meta-analysis was not performed. Instead, the extracted data were synthesized descriptively by grouping the findings into two major themes: the anatomical distribution of intracranial meningiomas and their associated clinical manifestations. The study selection process is illustrated in the PRISMA 2020 flow diagram (Figure 1).

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Research Article e-ISSN: 2963-0940

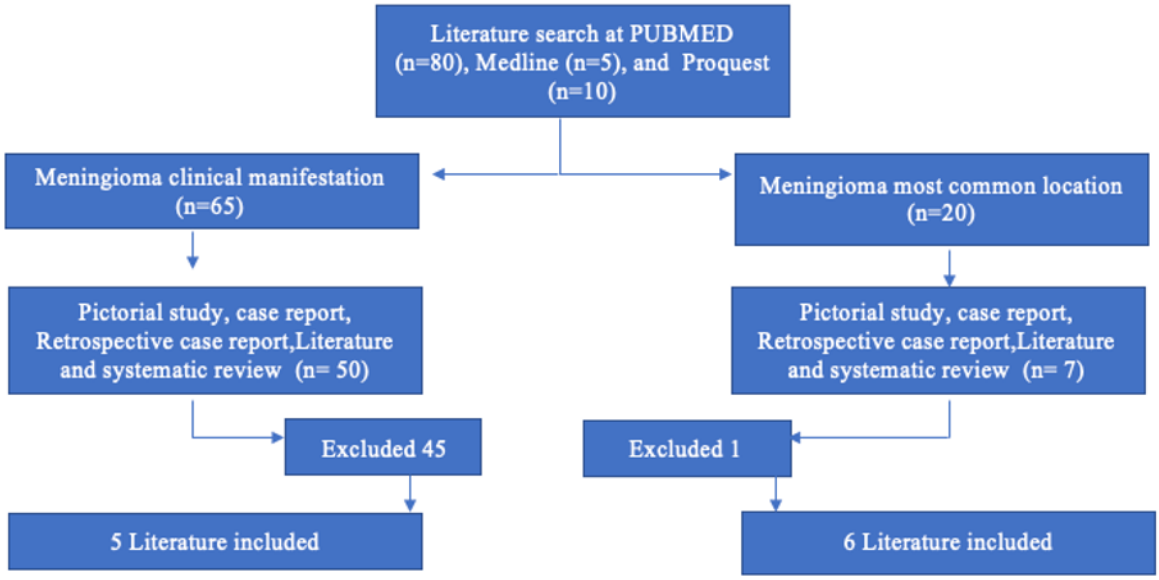

Figure 1. PRISMA 2020 flow diagram of the identification, screening, eligibility assessment, and inclusion of studies in this systematic review.

RESULT AND DISCUSSION

RESULT

A total of 95 records were identified through electronic database searching, comprising 85 records from PubMed, 5 from ProQuest, and 5 from MEDLINE. After removing duplicate records and screening titles and abstracts, studies that focused primarily on treatment strategies, surgical outcomes, molecular mechanisms, recurrence predictors, or imaging techniques without reporting tumour location or clinical manifestations were excluded. Following full-text eligibility assessment, studies that reported the anatomical location and/or clinical manifestations of intracranial meningiomas were included in the qualitative synthesis. The complete study selection process is illustrated in the PRISMA 2020 flow diagram (Figure 1).

Characteristics of the Included Studies

The included literature consisted of retrospective observational studies, case reports with literature reviews, pictorial reviews, narrative reviews, and epidemiological studies published between 2016 and 2025. Sample sizes ranged from single-patient case reports to retrospective cohorts involving more than one hundred patients. The studies evaluated the clinical manifestations, anatomical distribution, clinicopathological characteristics, diagnostic challenges, and imaging findings of intracranial meningiomas. The characteristics of the included studies are summarized in Table 1.

Table 1. Characteristics of the included studies

Author (Year)	Study design	Sample	Main objective	Main findings
Zhao et al. (2017)	Case report and literature review	1 patient	Malignant rhabdoid meningioma	Headache, limb numbness, memory disturbance, right frontal tumour with pulmonary and cerebellar metastases

Buerki et al. (2018)	Narrative review	87 references	Overview of meningioma	Headache, seizures, focal neurological deficits; convexity commonly involved
Nowosielski et al. (2017)	Narrative review	Literature review	Diagnostic challenges	Most tumours located supratentorially
Kong et al. (2018)	Retrospective study	126 patients	Clinical presentation of parafalcine meningiomas	Headache was the most frequent presenting symptom
Nigim et al. (2018)	Narrative review	165 references	Molecular characteristics	Convexity, parasagittal region and falx were common locations
Starr & Cha (2017)	Pictorial review	Imaging review	Imaging characteristics	Typical dural attachment sites described
Gitto et al. (2018)	Retrospective forensic review	6 patients	Sudden death due to meningioma	Multiple uncommon tumour locations reported
Chakravarthy et al. (2018)	Case report	1 patient	Pregnancy-associated meningioma	Convexity common; headache and neurological deficits
Gallagher et al. (2016)	Retrospective cohort	145 patients	Recurrence predictors	Skull base predominated in surgical cohort
Alruwaili & De Jesus (2023)	Clinical review	—	Clinical features	Location-dependent manifestations
Felistia et al. (2025)	Retrospective cohort	Hospital cohort	Clinicopathological characteristics	Convexity was the most common location

Clinical Manifestations of Brain Meningioma

Across the included studies, the clinical presentation of intracranial meningiomas was strongly influenced by tumour location, tumour size, and compression of adjacent neural structures. Headache was the most consistently reported presenting symptom across both retrospective studies and literature reviews. Other frequently reported manifestations included seizures, focal neurological deficits, contralateral limb weakness, sensory disturbances, visual impairment, cranial nerve dysfunction, memory impairment, cognitive decline, behavioural changes, and gait instability.

Kong et al. reported that among 126 patients with parafalcine meningiomas, headache was the initial symptom in 71 patients, followed by contralateral muscle weakness (25 patients), seizures (17 patients), and paresthesia (13 patients). Visual dysfunction, pyramidal signs, and ataxia were also observed during neurological examination.

Similarly, Buerki et al. described headache secondary to increased intracranial pressure, focal neurological deficits, cranial nerve dysfunction, and generalized or focal seizures as the most common clinical manifestations of intracranial meningiomas. Most tumours exhibited an insidious onset and were frequently detected incidentally during neuroimaging.

Rare but aggressive clinical presentations were reported by Zhao et al., who described a patient with a WHO grade III rhabdoid meningioma presenting with headache, sudden limb numbness, and memory disturbance. Following surgical resection, pulmonary

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metastasis was detected within two weeks and cerebellar metastasis developed six months later, demonstrating the highly aggressive behaviour of malignant rhabdoid meningioma.

Clinical manifestations also varied according to tumour location. Tumours involving the convexity and parasagittal regions frequently presented with headache, seizures, and focal neurological deficits. Sphenoid and suprasellar meningiomas commonly caused visual impairment due to optic pathway compression, whereas posterior fossa tumours were associated with hearing loss, cranial nerve dysfunction, gait disturbance, and cerebellar signs. Intraventricular meningiomas frequently presented with obstructive hydrocephalus and altered mental status.

Table 2. Clinical manifestations according to tumour location

Tumour location	Clinical manifestations	Supporting studies
Convexity	Headache, seizures, focal neurological deficits	Buerki et al.; Alruwaili & De Jesus; Felistia et al.
Falx and parafalcine	Headache, contralateral weakness, paresthesia, seizures	Kong et al.
Parasagittal	Leg weakness, cognitive impairment, seizures	Alruwaili & De Jesus
Sphenoid	Visual disturbance, facial numbness, seizures	Alruwaili & De Jesus
Olfactory groove	Anosmia, visual impairment	Alruwaili & De Jesus
Suprasellar	Visual impairment	Gitto et al.; Alruwaili & De Jesus
Posterior fossa	Hearing loss, cranial nerve palsy, gait disturbance, ataxia	Gitto et al.; Alruwaili & De Jesus
Intraventricular	Hydrocephalus, headache, altered mental status	Gitto et al.; Alruwaili & De Jesus
Intraorbital	Proptosis and visual loss	Alruwaili & De Jesus

Anatomical Distribution of Brain Meningioma

Most studies consistently reported that intracranial meningiomas predominantly occur in supratentorial locations, particularly the cerebral convexity, parasagittal region, falx cerebri, and skull base. However, the frequency of each anatomical site varied according to study population and study design.

Felistia et al. reported that the cerebral convexity was the most common tumour location (26.8%), followed by the parasellar region (11.7%) and the falx cerebri (10.4%). Likewise, Alruwaili and De Jesus summarized that convexity meningiomas account for approximately 20–34% of intracranial meningiomas, followed by parasagittal/falcine tumours (18–22%) and sphenoid or middle cranial fossa lesions (17–25%).

In contrast, Gallagher et al. found that skull-base meningiomas represented 53% of surgically treated WHO grade I tumours, whereas parasagittal and convexity meningiomas accounted for 24% and 23%, respectively. This discrepancy likely reflects differences in patient selection and surgical referral patterns.

Rare tumour locations included the cerebellopontine angle, optic nerve sheath, posterior cranial fossa, intraventricular region, and orbital cavity. These locations were generally associated with distinctive neurological symptoms related to local compression of cranial nerves or cerebrospinal fluid pathways.

Table 3. Anatomical distribution of intracranial meningiomas

Study	Most common location
Felistia et al. (2025)	Convexity (26.8%)
Alruwaili & De Jesus (2023)	Convexity (20–34%)

Gallagher et al. (2016)	Skull base (53%)
Kong et al. (2018)	Middle third of the falx
Nowosielski et al. (2017)	Supratentorial (calvaria and skull base)
Nigim et al. (2018)	Convexity, parasagittal, falx
Starr & Cha (2017)	Falcine, parafalcine, planum sphenoidale
Gitto et al. (2018)	Cerebellopontine angle, suprasellar region, posterior fossa, intraventricular region
Chakravarthy et al. (2018)	Cerebral convexity
Zhao et al. (2017)	Right frontal lobe (case report)

DISCUSSION

This systematic review found that intracranial meningiomas most frequently arise in supratentorial locations, particularly along the cerebral convexity, parasagittal region, and falx cerebri. This general pattern was observed across several of the included studies, although the reported proportions varied considerably. Alruwaili and De Jesus reported that convexity meningiomas accounted for approximately 20–34% of cases, followed by parasagittal and falcine tumours at 18–22%, whereas Felistia et al. identified the cerebral convexity as the most common location at 26.8%, followed by the parasellar region and falx cerebri. In contrast, Gallagher et al. reported a predominance of skull-base meningiomas in their surgically treated cohort. These differences indicate that the anatomical distribution of meningiomas is not uniform across all populations and may be influenced by study setting, referral patterns, case selection, tumour grade, and the characteristics of the population being investigated.

The predominance of convexity, parasagittal, and falcine meningiomas may be explained by the biological origin of these tumours. Meningiomas arise from meningothelial or arachnoid cap cells, which are concentrated within arachnoid villi and granulations, particularly around the dural venous sinuses. This anatomical distribution may partly explain the frequent occurrence of meningiomas adjacent to the superior sagittal sinus, falx cerebri, and cerebral convexities. In addition, supratentorial tumours may be detected more frequently because they can produce clinically apparent cortical symptoms, including seizures, focal motor deficits, sensory abnormalities, and cognitive changes. Nevertheless, the finding that skull-base meningiomas predominated in some institutional cohorts suggests that anatomical frequency may also reflect patterns of referral and surgical selection rather than only the natural biological distribution of the disease.

The most frequently reported clinical manifestation was headache, although this symptom was nonspecific and varied in intensity and character. Headache may result from increased intracranial pressure, dural irritation, peritumoral oedema, or compression of pain-sensitive intracranial structures. However, because many meningiomas are slow-growing, the brain may gradually accommodate the expanding mass, allowing tumours to become relatively large before producing obvious symptoms. This may explain why some patients are diagnosed incidentally, whereas others present with headache, seizures, focal neurological deficits, or cognitive changes only after substantial tumour growth. Buerki et al. similarly described meningiomas as generally slow-growing lesions with an insidious onset of symptoms, while Zhao et al. reported headache, limb numbness, and memory disturbance in a patient with a right frontal rhabdoid meningioma.

The clinical presentation was strongly influenced by anatomical location. Convexity, falcine, and parasagittal meningiomas were commonly associated with headache, seizures, contralateral limb weakness, sensory disturbances, and pyramidal signs because of their proximity to the motor and sensory cortices. In the study by Kong

et al., headache was the most frequent initial symptom among patients with parafalcine meningiomas, followed by decreased contralateral limb strength, seizures, and paresthesia. Tumours involving the frontal region may also produce subtle cognitive, behavioural, or personality changes, which can delay diagnosis because these manifestations may initially be attributed to psychiatric, age-related, or nonspecific neurological conditions.

By contrast, skull-base, parasellar, suprasellar, sphenoid, and orbital meningiomas tend to produce cranial nerve dysfunction and visual disturbances because of their close relationship with the optic nerves, optic chiasm, cavernous sinus, and other cranial nerves. Posterior fossa and cerebellopontine-angle meningiomas may present with hearing impairment, facial symptoms, ataxia, gait disturbance, or impaired coordination. Intraventricular meningiomas may remain asymptomatic until they obstruct cerebrospinal fluid pathways, resulting in hydrocephalus, headache, vomiting, or altered mental status. These location-specific patterns support the clinical importance of correlating neurological symptoms with the anatomical distribution of the tumour rather than relying on headache alone as a diagnostic indicator.

The included studies also demonstrated that clinical presentation is influenced not only by location but also by tumour size, histological grade, surrounding oedema, growth rate, and involvement of adjacent neurovascular structures. High-grade or biologically aggressive meningiomas may progress more rapidly and produce more severe neurological manifestations. Zhao et al., for example, described a WHO grade III rhabdoid meningioma with intracranial and pulmonary involvement, followed by cerebellar metastasis. Other reported cases also described extracranial spread to the lungs, liver, or bone. However, such metastatic behaviour should be interpreted cautiously because it represents an uncommon clinical course and cannot be generalized to the majority of meningiomas, which are histologically benign and remain confined to the central nervous system.

The variation in location percentages among studies also deserves attention. Felistia et al. reported convexity as the leading site, whereas Gallagher et al. found a greater proportion of skull-base tumours. This discrepancy may reflect differences in the denominator and inclusion criteria. A hospital-based surgical cohort may overrepresent symptomatic, technically challenging, or surgically selected tumours, whereas epidemiological or general clinical reviews may include incidental and conservatively managed lesions. Differences in imaging availability, referral systems, age distribution, sex distribution, histological grade, and institutional expertise may also contribute to variation. Therefore, the conclusion that convexity or parasagittal meningiomas are the most common should be understood as a general pattern rather than an absolute finding applicable to every clinical population.

The results have several clinical implications. First, clinicians should consider meningioma in patients presenting with persistent headache accompanied by seizures, focal neurological deficits, visual impairment, cranial nerve abnormalities, or progressive cognitive changes. Second, the location of the suspected tumour should guide neurological examination and imaging interpretation. Third, the nonspecific nature of many symptoms reinforces the importance of magnetic resonance imaging in patients with persistent or progressive neurological manifestations. Earlier recognition of location-specific symptom patterns may facilitate timely diagnosis and reduce the risk of delayed treatment, particularly in slow-growing tumours.

This review has several limitations. The included studies were heterogeneous in design, sample size, population, tumour grade, and outcome reporting. The review also included case reports, narrative reviews, pictorial reviews, and retrospective studies, which differ substantially in methodological quality and evidentiary strength. Some studies focused primarily on treatment, recurrence, imaging, or rare clinical presentations rather

than directly estimating the frequency of tumour locations or symptoms. Consequently, the reported findings could not be pooled quantitatively, and the conclusions were based on descriptive synthesis. The use of only English-language publications and a limited number of databases may also have resulted in language and publication bias. In addition, rare or unusual manifestations may have been overrepresented because they are more likely to be published as case reports.

Future research should prioritize large, multicentre observational studies using standardized definitions of anatomical location and clinical manifestations. Studies should report tumour grade, size, oedema, demographic characteristics, and symptom duration in a consistent manner to permit meaningful comparison and meta-analysis. Further research is also needed to determine how tumour location interacts with biological factors, including histological subtype and molecular alterations, in shaping clinical presentation and prognosis. Such data would provide a stronger basis for predicting symptom patterns, improving early diagnosis, and developing location-specific clinical management strategies.

CONCLUSION

This systematic review indicates that intracranial meningiomas most commonly arise in supratentorial regions, particularly the cerebral convexity, parasagittal area, falx cerebri, and parafalcine region, although the predominant location varied across study populations. The clinical manifestations were heterogeneous and strongly influenced by tumour location, size, surrounding oedema, and compression of adjacent neurological structures. Headache was the most frequently reported symptom, followed by seizures, focal motor or sensory deficits, visual disturbances, cranial nerve dysfunction, cognitive or behavioural changes, vomiting, and decreased consciousness in patients with larger or more advanced tumours.

These findings highlight the importance of considering meningioma in patients presenting with persistent headache or unexplained focal neurological symptoms, particularly when the pattern of symptoms corresponds to a specific intracranial location. Knowledge of the relationship between tumour location and clinical presentation may support earlier clinical suspicion, more targeted neurological assessment, and timely neuroimaging.

However, the findings should be interpreted cautiously because the included studies differed in design, sample size, study population, tumour classification, and outcome reporting. The inclusion of case reports, narrative reviews, and pictorial reviews also limited direct comparison and prevented quantitative meta-analysis. In addition, some studies focused on selected clinical groups, such as surgically treated, pregnancy-associated, metastatic, or high-grade meningiomas, which may not represent the general population of patients with intracranial meningioma.

Future studies should use prospective, multicenter designs with standardized definitions of anatomical location and clinical manifestations. Larger population-based studies and meta-analyses are also required to determine whether patterns of tumour location and presentation differ according to geographical region, age, sex, histopathological grade, molecular subtype, and other patient characteristics. Such evidence may improve diagnostic accuracy, risk stratification, and individualized clinical management of intracranial meningioma.

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