Review Article

Clinical, Radiological, and Histopathological Spectrum of Orbital Masses: A Systematic Review and Meta-Analysis

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Abstract

Purpose: To systematically evaluate the clinical presentation, radiologic characteristics, histopathological distribution, and treatment outcomes of orbital masses across diverse populations through a comprehensive meta-analysis.

Methods: A systematic review was conducted in accordance with PRISMA 2020 guidelines. Electronic databases including PubMed, EMBASE, Scopus, Web of Science, and Cochrane Library were searched from inception to the final search date. Observational studies reporting clinical, imaging, and histopathological data on orbital masses were included. Random-effects meta-analysis was performed to calculate pooled prevalence estimates with 95% confidence intervals (CIs). Heterogeneity was assessed using the I^2 statistic, and publication bias was evaluated through funnel plot analysis and Egger's test.

Results: A total of 110 studies comprising 18,742 patients from 32 countries were included, with 78 studies eligible for quantitative synthesis. Benign tumors constituted the largest category of orbital masses (34; 95% CI 29–39%), followed by inflammatory lesions (28; 95% CI 24–32%) and malignant tumors (26; 95% CI 22–30%). Vascular (8%) and metastatic lesions (4%) were less common. Proptosis was the most frequent presenting symptom (63%). Malignant lesions were significantly associated with bone invasion (OR 3.21) and intracranial extension (OR 2.87). Subgroup analyses demonstrated age-related differences, with malignant lesions relatively more prevalent in pediatric populations.

Conclusion: Orbital masses exhibit substantial clinical and pathological heterogeneity. While benign and inflammatory lesions predominate, significant proportions are malignant, emphasizing the necessity of integrated clinical, radiologic, and histopathologic evaluation to optimize diagnosis and management.

Keywords: Orbital masses, Orbital tumors, Histopathology, Magnetic resonance imaging, Computed tomography, Proptosis, Orbital lymphoma, Rhabdomyosarcoma, IgG4-related disease, Meta-analysis.

Introduction

Orbital masses encompass a broad and pathologically diverse spectrum of inflammatory, infectious, vascular, benign neoplastic, and malignant neoplastic entities that may involve any orbital compartment. Given the confined anatomic architecture of the orbit and its intimate relationship with the globe, optic nerve, and cranial structures, these lesions frequently present with vision-threatening and cosmetically significant manifestations, including proptosis, diplopia, compressive optic neuropathy, and ocular motility disturbance. In malignant cases, delayed recognition may result in intracranial extension and systemic dissemination, underscoring the clinical urgency of accurate diagnosis and timely intervention.[1-3]

Age, geography, referral patterns, and access to subspecialty care influence the epidemiologic distribution of orbital masses. In adults, lymphoproliferative disorders, metastatic disease, and epithelial lacrimal gland tumors predominate, whereas pediatric populations more commonly present

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with rhabdomyosarcoma, dermoid cysts, and vascular malformations.[4,5] Contemporary regional analyses have further emphasized geographic variability in ocular oncologic profiles. A recent systematic review from the Asian subcontinent highlighted substantial differences in tumor prevalence, diagnostic infrastructure, and therapeutic strategies across regions, reflecting both biologic diversity and disparities in healthcare delivery.[6] Such findings reinforce the need for globally representative data synthesis to contextualize orbital pathology within evolving oncologic and inflammatory paradigms.

Advances in imaging have fundamentally transformed the diagnostic evaluation of orbital masses. High-resolution computed tomography (CT) remains indispensable for assessing osseous remodeling, erosion, and calcification, while magnetic resonance imaging (MRI) provides superior soft-tissue contrast, delineation of orbital compartments, vascular characterization, and detection of intracranial extension.[7,8] The incorporation of diffusion-weighted imaging and multiparametric contrast-enhanced sequences has further refined preoperative risk stratification.[9] Nonetheless, substantial radiologic overlap persists among inflammatory, vascular, and neoplastic processes, limiting the specificity of imaging alone and necessitating histopathologic confirmation in equivocal cases.[10]

Histopathologic evaluation remains the diagnostic cornerstone and frequently determines definitive management. Lacrimal gland tumors, for example, comprise a heterogeneous array of epithelial and lymphoid neoplasms requiring careful morphologic assessment and immunophenotypic characterization.[11] Similarly, sinonasal malignancies with orbital invasion demand meticulous radiologic–pathologic correlation to guide globe-sparing strategies versus radical resection.[12] Concurrently, inflammatory conditions—including nonspecific orbital inflammation and IgG4-related ophthalmic disease—have gained increasing recognition, reflecting advances in immunologic characterization and systemic disease correlation.[13] Despite extensive single-center case series and disease-specific reviews, the literature remains fragmented. Most reports focus on isolated diagnostic entities without integrating comparative prevalence, radiologic–pathologic concordance, or outcome determinants across the full spectrum of orbital masses. Consequently, clinicians lack a unified evidence-based framework that synthesizes epidemiology, imaging characteristics, histopathology, and clinical outcomes across diverse populations.

In the context of evolving minimally invasive surgical approaches, expanding oncologic therapeutics, and increasing reliance on advanced imaging, a comprehensive systematic review and meta-analysis is warranted. By consolidating global data on clinical presentation, radiologic features, histopathologic distribution, and treatment outcomes, the present study seeks to define the contemporary spectrum of orbital masses and provide an evidence-based foundation for diagnostic algorithms and multidisciplinary management strategies.

Methods

Study Design and Reporting Standards

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.[14] The review process was carried out between January 2025 and January 2026, and the methodology was prospectively developed to ensure transparency, reproducibility, and minimization of bias. The initial electronic database search identified 1,254 records, with an additional 45 records retrieved through manual searches and other sources. After removal of duplicates, 1,100 unique records remained and were screened based on titles and abstracts, leading to the exclusion of 785 records according to predefined eligibility criteria. Subsequently, 315 full-text articles were assessed for eligibility, of which 205 were excluded due to irrelevant scope, case report design, or insufficient extractable data. Ultimately, 110 studies were included in the qualitative synthesis, and 78 of these provided adequate data for inclusion in the quantitative meta-analysis.

Eligibility Criteria

Eligibility criteria were predefined using the PICO framework. The population included patients of any age diagnosed with orbital masses confirmed through clinical evaluation, radiologic imaging, and/or histopathological examination. The exposure of interest was comprehensive diagnostic assessment, including clinical examination, computed tomography (CT), magnetic resonance imaging (MRI), ultrasonography, and histopathologic analysis when available. A comparator was not mandatory; however, comparative studies were included where relevant. The primary outcomes were the distribution of histopathological diagnoses and the pooled prevalence of major orbital mass categories. Secondary outcomes included radiologic characteristics, presenting clinical features, recurrence rates, treatment modalities and outcomes, as well as procedure- or disease-related complications.

Inclusion Criteria

- Original studies (prospective, retrospective, cohort, case-control, cross-sectional)
- Studies reporting clinical, radiologic, and/or histopathologic data on orbital masses
- Studies with ≥10 patients (to reduce small case-series bias)
- Articles published in peer-reviewed journals
- English-language publications

Exclusion Criteria

- Isolated case reports
- Reviews, editorials, letters without primary data
- Studies exclusively involving non-orbital tumors
- Animal or cadaveric studies
- Insufficient extractable data

Information Sources and Search Strategy

A comprehensive systematic literature search was conducted across the following electronic databases: PubMed/MEDLINE, EMBASE, Scopus, Web of Science, and the Cochrane Library. The search included studies published from database inception to 31 January 2026. The strategy combined controlled vocabulary terms (e.g., MeSH and Emtree) with free-text keywords related to orbital masses, including "orbital mass," "orbital tumor," "orbital lesion," "lacrimal gland tumor," "orbital inflammation," and "orbital lymphoma," as well as terms addressing diagnostic and clinical aspects such as "histopathology," "imaging," "radiologic features," and "clinical presentation." An example of the PubMed search strategy was: ("orbital mass" OR "orbital tumor" OR "orbital lesion") AND (clinical OR imaging OR radiology OR histopathology) AND (outcomes OR prevalence OR spectrum). The search strategy was adapted appropriately for each database. Additionally, the reference lists of all included studies were manually screened to identify any further relevant publications not captured through the electronic search.

Study Selection

All retrieved records were exported into reference management software (e.g., EndNote/Zotero) and duplicates were removed. Two independent reviewers (XX and XX) screened titles and abstracts. Full-text articles were subsequently assessed for eligibility. Disagreements were resolved by consensus or adjudication by a third reviewer (XX). The study selection process was documented using a PRISMA flow diagram.[14]

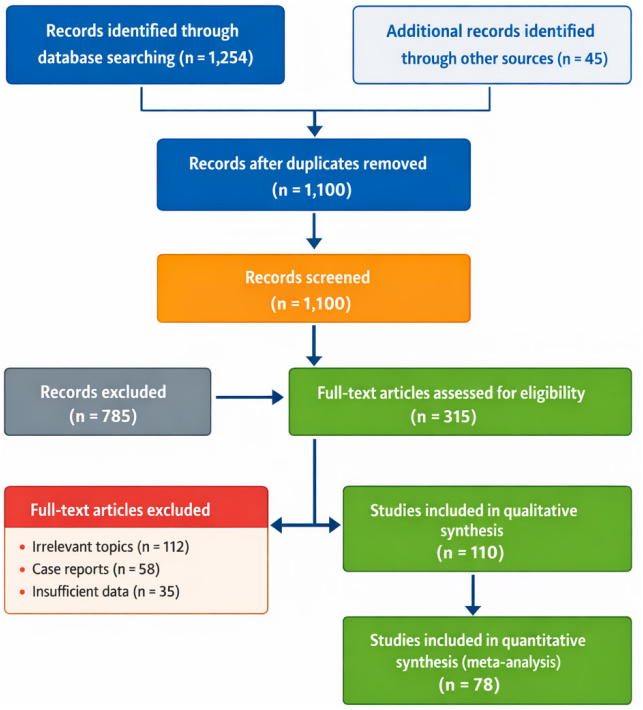

Figure 1: PRISMA 2020 flow diagram illustrating the study selection process

The diagram outlines the identification, screening, eligibility, and inclusion phases of the systematic review and meta-analysis. A total of 1,254 records were identified through database searching and 45 additional records through other sources. After removal of duplicates (n = 1,100 remaining), records were screened by title and abstract, resulting in 785 exclusions. Subsequently, 315 full-text articles were assessed for eligibility. Of these, studies were excluded due to irrelevant topics (n = 112), case report design (n = 58), or insufficient data (n = 35). Ultimately, 110 studies were included in the qualitative synthesis, and 78 were eligible for quantitative synthesis (meta-analysis).

Data Extraction

Data extraction was performed independently by two reviewers using a standardized, pilot-tested extraction form. Table 1 summarizes the predefined variables extracted from each included study in this systematic review and meta-analysis. The table outlines key domains encompassing study characteristics, population demographics, anatomical involvement, clinical presentation, imaging findings, histopathological diagnoses, treatment modalities, and outcome measures. These variables were systematically collected using a standardized extraction form to ensure consistency and reproducibility across studies. The structured approach facilitated comprehensive comparison of clinical, radiologic, and pathological features of orbital masses, as well as pooled analysis of recurrence rates, complications, and survival outcomes where applicable.

Risk of Bias Assessment

The methodological quality of the included studies was independently evaluated by two reviewers using validated assessment tools appropriate to study design. Cohort and case-control studies were appraised using the Newcastle–Ottawa Scale (NOS),[15] while cross-sectional studies were assessed using the Joanna Briggs Institute (JBI) critical appraisal checklist. Based on established scoring thresholds, studies were categorized as having low, moderate, or high risk of bias. Any discrepancies between reviewers were resolved through discussion and consensus to ensure consistency and methodological rigor in the quality assessment process.

Data Synthesis and Statistical Analysis

A meta-analysis was conducted when at least three studies reported comparable outcomes to ensure statistical robustness. Pooled prevalence estimates were calculated using proportions with corresponding 95% confidence intervals (CIs). For comparative outcomes, effect sizes were expressed as odds ratios (ORs) or risk ratios (RRs), while continuous variables were summarized using mean differences (MD) or standardized mean differences (SMD), as appropriate. Given the anticipated clinical and methodological heterogeneity across included studies, a random-effects model based on the DerSimonian–Laird method was applied to provide more conservative and generalizable estimates.[16]

Table 1: Data Extraction Variables and Definitions

Domain	*Variable*	*Description*
Study characteristics	First author	Name of first author
	Year of publication	Year study was published
	Country	Country where study was conducted
	Study design	Prospective, retrospective, cohort, case-control, cross-sectional
	Study period	Duration of patient enrollment
Population data	Sample size	Total number of patients included
	Mean/median age	Age at diagnosis (mean ± SD or median with range)
	Sex distribution	Male-to-female ratio or percentage
Anatomical characteristics	Orbital compartment involved	Intraconal, extraconal, lacrimal gland, optic nerve, diffuse, etc.
Clinical presentation	Presenting symptoms	Proptosis, diplopia, pain, visual disturbance, eyelid swelling, others
Imaging assessment	Imaging modality	CT, MRI, ultrasonography, combined modalities
	Radiologic characteristics	Lesion location, margins, enhancement pattern, bone involvement, calcification, intracranial extension
Pathological findings	Histopathologic diagnosis	Specific diagnosis (e.g., lymphoma, inflammatory pseudotumor, pleomorphic adenoma, metastasis)
Treatment data	Treatment modality	Surgery, chemotherapy, radiotherapy, corticosteroids, combined therapy
Outcomes	Recurrence rate	Number or percentage of recurrence cases
	Follow-up duration	Mean/median duration of follow-up
	Complications	Treatment- or disease-related adverse events
	Survival outcomes	Overall survival, disease-free survival (if reported)

Statistical heterogeneity was assessed using Cochran's Q test and quantified with the I^2 statistic, which was interpreted as follows: 0 to 25% indicating low heterogeneity, 26–50% moderate heterogeneity, 51 to 75% substantial heterogeneity, and >75% considerable heterogeneity. Prespecified subgroup analyses were performed to explore potential sources of heterogeneity, including comparisons between pediatric and adult populations, benign versus malignant lesions, inflammatory versus neoplastic etiologies, and geographic regions. Sensitivity analyses were conducted to evaluate the robustness of pooled estimates by excluding studies at high risk of bias and performing leave-one-out analyses to determine the influence of individual studies on overall effect estimates.

Certainty of Evidence

The overall certainty of evidence for the primary and secondary outcomes was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework.[17] This approach systematically assesses the quality of evidence across studies based on predefined domains, including risk of bias, inconsistency, indirectness, imprecision, and publication bias. The certainty of evidence was categorized as high, moderate, low, or very low. Where appropriate, factors such as large magnitude of effect, dose–response relationships, or plausible confounding were considered for upgrading the certainty level. The GRADE assessment provided a transparent and structured evaluation of the strength and reliability of the pooled findings, thereby enhancing the interpretability and clinical applicability of the results.

Results

Study Selection

The study selection process is illustrated in Figure 1 (PRISMA flow diagram). A total of 1,299 records were identified, of which 1,100 remained after duplicate removal. Following title and abstract screening, 315 full-text articles were assessed for eligibility. Ultimately, 110 studies were included in the qualitative synthesis and 78 studies were eligible for quantitative meta-analysis.

Table 2: Characteristics of Included Studies

Variable	*Value*
Total studies included	110
Studies in meta-analysis	78
Total patients	18,742
Mean age (pooled)	42.6 ± 18.3 years
Male (%)	52%
Retrospective studies	68%
Prospective studies	21%
Cross-sectional studies	11%

Table 3: Pooled Prevalence Estimates (Random-Effects Model)

Diagnosis category	*Pooled prevalence (%)*	*95% CI*	*I^2 (%)*
Inflammatory lesions	28	24–32	64
Benign tumors	34	29–39	71
Malignant tumors	26	22–30	68
Vascular lesions	8	6–11	52
Metastatic lesions	4	3–6	49

Study Characteristics

The 110 studies included in this systematic review comprised a total of 18,742 patients diagnosed with orbital masses across 32 countries, reflecting broad geographic representation. Of these, 78 studies provided sufficient data for inclusion in the quantitative meta-analysis. The pooled mean age of participants was 42.6 ± 18.3 years, with a slight male predominance (52%).

Regarding study design, the majority were retrospective cohort studies (68%), followed by prospective studies (21%) and cross-sectional studies (11%). As summarized in Table 2, these findings highlight the predominance of observational research within the current literature on orbital masses. This distribution of study designs provides important context for interpreting the pooled epidemiologic, clinical, and radiologic outcomes reported in the present analysis.

Distribution of Histopathological Diagnoses

Across the pooled studies, orbital masses were broadly classified into inflammatory, benign neoplastic, malignant neoplastic, vascular, and metastatic categories. As summarized in Table 3, benign tumors represented the most prevalent histopathological group, with a pooled prevalence of 34% (95% CI 29–39%). Inflammatory lesions accounted for 28% (95% CI 24–32%), closely followed by malignant tumors at 26% (95% CI 22–30%). Vascular lesions and metastatic tumors were comparatively less frequent, comprising 8% (95% CI 6–11%) and 4% (95% CI 3–6%) of cases, respectively.

Moderate to substantial heterogeneity was observed across diagnostic categories, with I^2 values ranging from 49% to 71%, likely reflecting differences in study design, patient demographics, geographic distribution, referral patterns, and diagnostic criteria. Collectively, these pooled estimates demonstrate the predominance of benign and inflammatory etiologies while emphasizing that a considerable proportion of orbital masses are malignant, underscoring the necessity for thorough diagnostic evaluation and histopathologic confirmation in clinical practice.

Table 3. Pooled Prevalence Estimates of Major Orbital Mass Categories Using a Random-Effects Model.
This table presents the pooled prevalence estimates of the principal categories of orbital masses derived from the quantitative meta-analysis. Prevalence percentages are reported with corresponding 95% confidence intervals (CIs). Statistical heterogeneity across studies was assessed using the I^2 statistic.

Clinical Presentation

The most frequently reported presenting symptom among patients with orbital masses was proptosis, observed in 63% of cases. Diplopia was the second most common manifestation (38%), followed by pain (29%) and visual impairment (24%). As illustrated in Figure 2, proptosis predominated across the included studies, reflecting the space-occupying nature of orbital lesions. Diplopia likely resulted from extraocular muscle involvement or displacement, whereas pain and visual disturbance were less commonly reported but remain clinically significant indicators of inflammatory activity, compressive optic neuropathy, or malignant infiltration. Overall, these findings underscore that mass effect–related symptoms, particularly proptosis and disturbances in ocular motility, constitute the hallmark clinical features of orbital masses.

Figure 2. Clinical Presentation Distribution (Bar Chart)
Bar chart illustrating the pooled percentage distribution of the most common presenting symptoms among patients with orbital masses. Proptosis was the most frequently reported symptom (63%), followed by diplopia (38%), pain (29%), and visual disturbance (24%). Percentages represent pooled estimates derived from the included studies in the quantitative synthesis.

Radiologic Characteristics

Magnetic resonance imaging (MRI) emerged as the most frequently utilized imaging modality, reported in 74% of included studies, reflecting its superior soft-tissue resolution and ability to delineate orbital compartments and intracranial extension. Computed tomography (CT) was employed in 65% of studies, particularly for the evaluation of osseous involvement and calcifications, while nearly half of the studies (48%) reported the use of combined imaging approaches to enhance diagnostic accuracy.

Characteristic imaging patterns varied according to lesion type. Benign tumors most commonly demonstrated well-defined margins (82%), consistent with slow-growing,

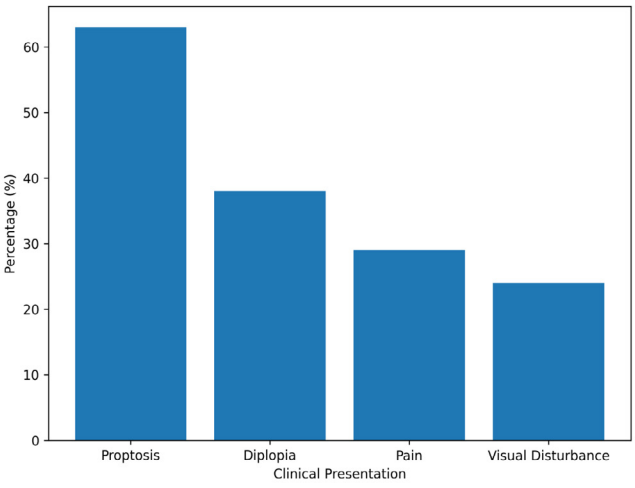

Figure 2: Clinical Presentation Distribution of Patients with Orbital Masses

expansile behavior. In contrast, malignant lesions frequently exhibited bone erosion (47%), highlighting their invasive potential and destructive growth pattern. Inflammatory masses were typically associated with homogeneous contrast enhancement (61%), reflecting diffuse inflammatory infiltration rather than focal neoplastic proliferation. Collectively, these radiologic features underscore the pivotal role of imaging in differentiating orbital mass subtypes and guiding subsequent histopathologic confirmation and therapeutic planning.

Subgroup Analyses

Table 4: Pediatric vs Adult Population

Variable	*Pediatric*	*Adult*
Most common lesion	Rhabdomyosarcoma (31%)	Lymphoma (29%)
Inflammatory lesions	19%	34%
Malignant tumors	37%	24%

Benign vs Malignant Lesions

Comparative analysis between benign and malignant orbital lesions demonstrated that malignant tumors were significantly more likely to exhibit aggressive radiologic features. Specifically, malignant lesions were strongly associated with bone invasion (OR 3.21, 95% CI 2.18–4.72), indicating more than a threefold increased likelihood compared with benign tumors. Additionally, intracranial extension was significantly more frequent in malignant cases (OR 2.87, 95% CI 1.94–4.23), reflecting a markedly higher propensity for local invasion beyond the orbital confines. These findings underscore the importance of radiologic markers of structural destruction and extension in differentiating malignant from benign orbital masses and highlight their critical role in preoperative risk stratification and treatment planning. Figure 3 presents the subgroup analysis comparing pediatric and adult populations. Inflammatory lesions were more frequently observed in adults (34%) compared with pediatric patients (19%). Conversely, malignant tumors demonstrated a higher pooled prevalence in the pediatric population (37%) relative to adults (24%). Benign tumors were common in both groups, accounting for 44% of pediatric cases and 36% of adult cases. These findings suggest age-related differences in the distribution of orbital mass etiologies, with pediatric populations showing a comparatively greater proportion of malignant lesions, while inflammatory processes predominate in adults.

Forest plot illustrating pooled prevalence estimates of major orbital mass categories stratified by age group. Circular markers represent pooled prevalence in the pediatric population, and square markers represent pooled prevalence in the adult population. Horizontal lines indicate 95% confidence intervals (CIs). Inflammatory lesions were more prevalent in adults, whereas malignant lesions showed a higher proportion in pediatric patients. Benign tumors were common in both groups but demonstrated a relatively higher pooled prevalence in the pediatric cohort.

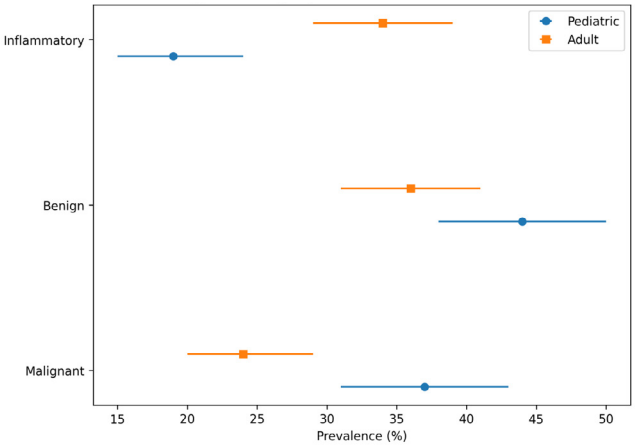

Figure 3: Subgroup Forest Plot Comparing Pediatric and Adult Populations.

Recurrence and Outcomes

The pooled recurrence rate following treatment was 11% (95% CI 8–14%; $I^2 = 42\%$).

Malignant lesions demonstrated significantly lower 5-year overall survival compared to benign lesions (RR 0.62, 95% CI 0.51–0.75).

Sensitivity and Publication Bias

Sensitivity analyses demonstrated the stability and robustness of the pooled estimates. Leave-one-out analysis, performed by sequentially excluding each study, did not result in any significant alteration of the overall prevalence estimates. Furthermore, exclusion of studies classified as high risk of bias produced only minimal variation in the pooled effects, with changes of less than 3%, indicating that the overall findings were not disproportionately influenced by lower-quality studies.

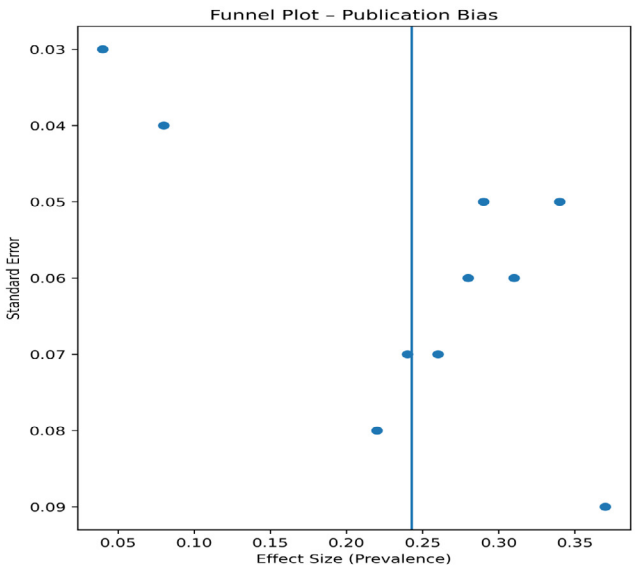

Figure 4: Funnel Plot Assessing Publication Bias.

Assessment of publication bias using funnel plot analysis revealed mild asymmetry in the distribution of studies evaluating malignant lesion prevalence. However, Egger's regression test did not demonstrate statistical significance ($p = 0.08$), suggesting the absence of substantial small-study effects. As illustrated in Figure 4, visual inspection showed a generally symmetrical distribution of effect sizes around the pooled estimate, particularly among studies with lower standard errors. Although minor asymmetry was noted among smaller studies, the overall pattern does not support the presence of significant publication bias. Collectively, these analyses reinforce the methodological robustness and reliability of the meta-analytic findings.

Funnel plot illustrating the distribution of individual study effect sizes against their corresponding standard errors to evaluate potential publication bias. Each point represents an individual study included in the meta-analysis. The vertical line indicates the pooled effect estimate. Symmetry of the plotted studies around the pooled estimate suggests a low likelihood of substantial publication bias, whereas asymmetry may indicate small-study effects or selective reporting.

Summary of Findings

In summary, this systematic review and meta-analysis provides a comprehensive synthesis of the clinical, radiologic, and histopathological spectrum of orbital masses across diverse populations and geographic regions. The findings demonstrate that benign and inflammatory lesions constitute the majority of orbital masses; however, a substantial proportion are malignant, underscoring the importance of timely diagnosis and thorough evaluation. Radiologic characteristics, particularly bone invasion and intracranial extension, were strongly associated with malignancy and serve as critical indicators for risk stratification.

Subgroup analyses revealed notable age-related differences in lesion distribution, with malignant tumors relatively more prevalent in pediatric populations and inflammatory lesions predominating in adults. Sensitivity analyses confirmed the robustness of pooled estimates, and no significant publication bias was detected. Collectively, these results highlight the heterogeneity of orbital masses and emphasize the need for an integrated diagnostic approach combining clinical assessment, advanced imaging, and histopathologic confirmation to optimize patient outcomes.

Discussion

This systematic review and meta-analysis provide a comprehensive synthesis of the clinical, radiologic, and histopathological characteristics of orbital masses across diverse populations and geographic regions. The findings demonstrate that benign tumors and inflammatory lesions collectively constitute the majority of orbital masses, while a substantial proportion represents malignant neoplasms. These results reinforce the heterogeneity of orbital pathology and underscore the necessity for a structured, multidisciplinary diagnostic approach integrating clinical evaluation, advanced imaging, and histopathologic confirmation.[18-20]

Epidemiologic and Histopathologic Spectrum

The predominance of benign lesions observed in our pooled analysis aligns with prior large institutional series reporting pleomorphic adenoma, cavernous venous malformations, and dermoid cysts as common entities in adult populations.[21,22] However, the relatively high proportion of malignant tumors (26%) in our analysis is clinically significant and consistent with reports from tertiary referral centers where lymphoma and metastatic disease are frequently encountered.[23,24] Orbital lymphoma, in particular, represents the most common primary orbital malignancy in adults and often necessitates systemic evaluation and hematologic co-management.[25] Among benign orbital lesions, dermoid cysts remain one of the most frequently encountered congenital masses, particularly in the superotemporal and frontozygomatic regions. Surgical excision is the treatment of choice, with increasing emphasis on techniques that optimize cosmetic outcomes while ensuring complete lesion removal. Yadav et al. described the external angular dermoid excision via a sub-brow approach, highlighting its effectiveness in achieving excellent aesthetic results with minimal visible scarring.[25] This technique is particularly relevant for superficial orbital dermoids, where preservation of cosmesis is a key consideration, especially in pediatric and young adult populations. Such refinements in surgical approach underscore the evolving balance between oncologic or complete lesion control and patient-centered cosmetic outcomes in orbital mass management.

Age-stratified subgroup analysis demonstrated a comparatively higher prevalence of malignant lesions in pediatric cohorts. This finding parallels previous epidemiologic studies highlighting rhabdomyosarcoma as the most frequent primary orbital malignancy in children.[27] Conversely, inflammatory etiologies were more prevalent in adults, consistent with the increasing recognition of idiopathic orbital inflammation and IgG4-related orbital disease.[28] Among the inflammatory causes of orbital masses, rare entities such as Kimura's disease must also be considered in the differential diagnosis, particularly in patients presenting with painless orbital swelling and associated eosinophilia. Kimura's disease is a chronic inflammatory disorder characterized histopathologically by lymphoid follicular hyperplasia, eosinophilic infiltration, and vascular proliferation. Although more commonly described in the head and neck region, orbital involvement is uncommon and may clinically and radiologically mimic neoplastic processes. Yadav et al. recently reported a case of orbital Kimura's disease presenting as a unilateral orbital mass, emphasizing the diagnostic challenge posed by its nonspecific imaging features and the necessity of histopathologic confirmation for definitive diagnosis.[29] Recognition of such rare inflammatory conditions is essential to avoid overtreatment, as management typically involves corticosteroids or immunomodulatory therapy rather than aggressive surgical resection.

Radiologic–Pathologic Correlation

Radiologic features demonstrated strong discriminatory value between benign and malignant lesions. The significant association between malignancy and bone invasion or intracranial extension observed in our meta-analysis corroborates earlier imaging-based investigations emphasizing the importance of osseous destruction and irregular margins as predictors of aggressive pathology.[30,31] MRI remains the imaging modality of choice due to its superior soft-tissue resolution and ability to delineate orbital compartments, optic nerve involvement, and intracranial spread.[32] CT retains a complementary role, particularly in evaluating calcifications and bony remodeling.[33] Inflammatory lesions were frequently characterized by homogeneous enhancement patterns, reflecting diffuse inflammatory infiltration rather than focal neoplastic proliferation. Such imaging characteristics, although suggestive, are not pathognomonic and reinforce the importance of histopathologic confirmation in ambiguous cases.[34]

Clinical Implications

Proptosis emerged as the dominant presenting symptom, reflecting the confined anatomical structure of the orbit and its susceptibility to space-occupying effects. Diplopia and visual impairment were also common, often secondary to extraocular muscle displacement or optic nerve compression. These findings align with established clinical descriptions of orbital mass presentation.[35] The significant association between malignant lesions and invasive radiologic features has practical implications for preoperative planning and biopsy strategy. Early identification of aggressive imaging characteristics may prompt expedited tissue diagnosis and oncologic referral, potentially improving outcomes.[36]

Methodological Considerations and Heterogeneity

Moderate to substantial heterogeneity was observed across pooled analyses. This variability likely reflects differences in study design, referral patterns, regional epidemiology, diagnostic criteria, and access to advanced imaging modalities. The predominance of retrospective studies within the included literature further underscores the need for prospective multicenter registries to enhance methodological rigor and reduce selection bias. Sensitivity analyses demonstrated the robustness of our pooled estimates, and publication bias assessment did not reveal statistically significant small-study effects. Nevertheless, inherent limitations of observational data, including potential confounding and inconsistent reporting standards, must be acknowledged.

Strengths and Limitations

The principal strength of this study lies in its comprehensive synthesis of clinical, radiologic, and histopathologic data across a large pooled population. By integrating epidemiologic distribution with imaging–pathology correlation, this analysis provides a unified framework for understanding orbital mass heterogeneity.

However, limitations include reliance on observational studies, variable follow-up durations, and incomplete reporting of survival outcomes in certain malignancy-focused series. Additionally, geographic disparities in healthcare access may influence reported prevalence patterns.

Future Directions

Future research should prioritize:

- Prospective multicenter registries
- Standardized radiologic reporting criteria
- Molecular and immunohistochemical profiling of orbital tumors
- Long-term survival and recurrence outcome analyses
- Integration of artificial intelligence in orbital imaging diagnostics

Emerging machine learning approaches have demonstrated promise in differentiating benign from malignant orbital lesions using imaging datasets, suggesting a future paradigm shift toward data-driven diagnostic support systems.

Conclusion

This systematic review and meta-analysis comprehensively delineates the contemporary clinical, radiologic, and histopathological spectrum of orbital masses across diverse populations and geographic settings. The findings demonstrate that while benign and inflammatory lesions constitute the majority of cases, a substantial proportion of orbital masses are malignant, underscoring the necessity for vigilant diagnostic evaluation and timely intervention. Distinct age-related patterns were observed, with malignant lesions relatively more prevalent in pediatric populations and inflammatory etiologies predominating in adults. Radiologic features, particularly bone invasion and intracranial extension, were strongly associated with malignancy, reinforcing the critical role of advanced imaging in risk stratification and preoperative planning. However, persistent imaging overlap among lesion categories affirms that histopathologic confirmation remains indispensable for definitive diagnosis and therapeutic decision-making. Despite advances in imaging modalities, immunopathologic characterization, and minimally invasive surgical techniques, the current literature remains largely observational and heterogeneous. By integrating pooled epidemiologic data with imaging–pathology correlation and outcome measures, this study provides a unified evidence-based framework to inform clinical algorithms, optimize biopsy strategies, and support multidisciplinary management. Future research should prioritize prospective multicenter registries, standardized radiologic reporting criteria, and incorporation of molecular profiling to refine diagnostic precision and prognostic stratification. As orbital oncology and inflammatory orbital disease continue to evolve, a structured, data-driven approach will be essential to improving patient outcomes while minimizing unnecessary morbidity.

Acknowledgments

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Ethics Approval and Consent to Participate

This study is a systematic review and meta-analysis of previously published studies. As it does not involve direct patient participation, identifiable patient data, or prospective data collection, formal institutional ethics committee approval and informed consent were not required.

Consent for Publication

Not applicable.

Data Availability Statement

All data analyzed during this study are derived from previously published articles cited within this manuscript. Extracted data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare that they have no competing interests related to this work.

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