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Meningiomas Involving the Anterior Visual Pathway: Neuroimaging Findings, Visual Prognosis, and Neurosurgical Decision-Making

Nicolás Camilo Rivera Calvo
Universidad de Santander UDES
Nicolasrivera1498.nr@gmail.com
https://orcid.org/0000-0003-2088-3931

Alejandra Cornejo Mayorga
Universidad Industrial de Santander
Alecm159@gmail.com
https://orcid.org/0009-0006-7982-9824

Victor Alfonso Melo Zambrano
Universidad Tecnológica de Pereira
victor.melo@utp.edu.co
https://orcid.org/0009-0000-7701-2622

Angie Valeria Hernandez Bernal
fundación universitaria en ciencias de la salud
avhernandez1@fucsalud.edu.co
https://orcid.org/0009-0009-7030-6412

Frida Desiree Lara Hernández
Universidad Anahuac Norte
fridadesy14@gmail.com
https://orcid.org/0009-0002-5768-6325

Jonathan Alexis Goyes Muñoz
Universidad de las Américas
respaldo.umss@gmail.com
https://orcid.org/0009-0005-2380-222X

Andrea Cristina Naranjo Calvachi
Hospital Gineco Obstetrico Pediátrico de Nueva Aurora Luz Elena Arismendi
naranjo.andreacristina@gmail.com
https://orcid.org/0009-0000-6981-8896

Pablo David Izquierdo Medina
Universidad Nacional de Loja
pizquierdomedina1995@gmail.com
https://orcid.org/0009-0009-3416-8630

Tatiana Isabel Panqueva Sánchez
Universidad de Santander - UDES
Tipshuem2023@gmail.com
https://orcid.org/0009-0009-9667-9970

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*** Corresponding Author:** Nicolasrivera1498.nr@gmail.com

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ABSTRACT

Optic pathway-related meningiomas represent a significant diagnostic and therapeutic challenge because of their proximity to critical neurovascular structures and their potential to cause

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progressive and irreversible visual impairment. This narrative review aimed to analyze the radiological characteristics, mechanisms of visual deterioration, and criteria guiding therapeutic selection in meningiomas involving the optic nerve sheath, tuberculum sellae, anterior clinoid process, and adjacent skull base structures. Twenty scientific publications, including international clinical studies, systematic reviews, meta-analyses, and Latin American contributions, were examined through a structured qualitative synthesis. The analysis focused on magnetic resonance imaging and computed tomography findings, optic canal involvement, preoperative visual function, surgical approaches, and postoperative outcomes. Published evidence demonstrated frequent optic canal involvement in tuberculum sellae meningiomas, highlighting the importance of anatomical localization beyond tumor dimensions. In a large international surgical cohort, postoperative visual improvement occurred in 73.0% of patients undergoing endoscopic endonasal surgery and 57.1% undergoing transcranial surgery among those with preoperative visual impairment and available follow-up assessments. However, endonasal procedures were associated with higher cerebrospinal fluid leakage rates (17.3% versus 2.2%). A separate meta-analysis reported an overall visual improvement estimate of 80.3% following optic canal unroofing. Differences in patient selection, tumor characteristics, and study methodologies limit direct comparisons between therapeutic strategies. The findings support individualized, multidisciplinary management integrating advanced neuroimaging, neuro-ophthalmological evaluation, and anatomical considerations. Preservation of visual function, neurological safety, and long-term quality of life should remain fundamental therapeutic priorities.

KEYWORDS

Optic pathway meningiomas, Optic nerve sheath meningioma, Tuberculum sellae, Anterior clinoid process, Magnetic resonance imaging, Visual impairment, Optic canal decompression, Skull base surgery, Endoscopic endonasal approach, Transcranial surgery, Visual outcomes

INTRODUCTION

Meningiomas involving the optic pathway represent a significant diagnostic and therapeutic challenge in contemporary neuro-oncology because of their close anatomical relationship with structures responsible for visual function. Although most meningiomas are histologically benign and exhibit relatively slow growth, lesions arising from the optic nerve sheath, tuberculum sellae, anterior clinoid process, and adjacent skull base regions may produce progressive visual impairment, optic nerve compression, and irreversible neurological deficits. Their clinical relevance therefore extends beyond tumor control, as preservation or restoration of vision constitutes a fundamental therapeutic objective. Early recognition and appropriate characterization are essential to establish individualized management strategies that balance oncological control with functional outcomes [1], [2].

Neuroimaging plays a central role in identifying these lesions, defining their anatomical relationships, and guiding treatment decisions. Magnetic resonance imaging (MRI), particularly contrast-enhanced sequences, provides detailed information regarding tumor extension, optic nerve involvement, chiasmatic compression, and relationships with adjacent neurovascular structures. Computed tomography (CT) complements MRI by identifying osseous changes, including hyperostosis and optic canal narrowing, which may influence surgical planning. Nevertheless, radiological findings do not always correlate directly with the severity of visual dysfunction, emphasizing the importance of integrating imaging characteristics with comprehensive neuro-ophthalmological assessment [3], [9].

Visual deterioration associated with optic pathway meningiomas may manifest as progressive reduction in visual acuity, visual field abnormalities, dyschromatopsia, and optic neuropathy. Previous investigations have demonstrated that postoperative visual recovery depends on multiple factors, including the duration and severity of preoperative impairment, tumor location, optic canal involvement, and the extent of neural decompression [8], [11]. Consequently, understanding the relationship between anatomical characteristics and functional deterioration remains essential for identifying patients who may benefit from early therapeutic intervention.

The selection of an appropriate neurosurgical approach remains controversial, particularly for meningiomas involving the tuberculum sellae and anterior clinoid region. Traditional transcranial approaches provide extensive surgical exposure and facilitate the management of complex neurovascular relationships, whereas endoscopic endonasal

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techniques offer direct access to selected midline lesions with potentially reduced manipulation of the optic apparatus. International investigations have reported favorable visual outcomes with both strategies, although differences in tumor extension, surgical accessibility, and patient selection complicate direct comparisons [10], [17]. Recent Latin American contributions, particularly studies conducted in Mexico and Brazil, have further emphasized the importance of individualized surgical planning and systematic assessment of postoperative visual function [18], [19]. For optic nerve sheath meningiomas, radiotherapy also represents an important therapeutic alternative, particularly when surgical intervention carries a substantial risk of visual deterioration [6], [7].

Despite advances in imaging and microsurgical techniques, uncertainty persists regarding which radiological findings most reliably predict visual prognosis and how these characteristics should influence therapeutic selection. This narrative review therefore examines the radiological features, mechanisms of visual deterioration, and criteria guiding treatment selection in meningiomas involving the optic pathway. Drawing upon international and Latin American literature, the review explores whether integrating detailed neuroimaging findings with preoperative visual assessment can improve clinical decision-making and help identify the most appropriate therapeutic approach. By synthesizing available evidence from imaging studies, clinical series, systematic reviews, and international guidelines, this article seeks to provide an interdisciplinary framework for understanding these tumors and supporting individualized, vision-preserving management strategies [1], [8], [16], [20].

DEVELOPMENT

Anatomical and Clinical Characteristics of Optic Pathway–Related Meningiomas

Optic pathway-related meningiomas constitute a heterogeneous group of tumors whose clinical behavior is strongly influenced by their anatomical origin and relationship with the anterior visual apparatus. Lesions involving the optic nerve sheath, tuberculum sellae, anterior clinoid process, and planum sphenoidale may produce different patterns of neural compression, vascular involvement, and visual deterioration. Although these tumors generally exhibit slow progression, their proximity to highly specialized neural structures means that even limited growth can produce considerable functional impairment. Consequently, anatomical localization is essential for understanding disease progression and determining the potential risks associated with therapeutic intervention [1], [2].

Optic nerve sheath meningiomas typically develop along the meningeal coverings of the optic nerve and may extend through the orbital, intracanalicular, and intracranial compartments. Their growth can compromise axonal conduction and the vascular supply of the nerve, progressively reducing visual function. In contrast, tuberculum sellae meningiomas frequently produce compression of the optic nerves or chiasm, whereas anterior clinoidal lesions may involve the optic canal, internal carotid artery, and adjacent neurovascular structures. These anatomical differences explain why tumor diameter alone is insufficient to predict clinical severity or determine surgical complexity [3], [8], [10].

Radiological Characterization and Diagnostic Assessment

Magnetic resonance imaging (MRI) is the principal imaging modality for evaluating optic pathway meningiomas because of its capacity to delineate tumor boundaries, dural attachment, neural compression, and relationships with adjacent structures. Contrast-enhanced T1-weighted sequences frequently demonstrate intense enhancement, while high-resolution T2-weighted imaging contributes to the identification of anatomical interfaces and surrounding cerebrospinal fluid spaces. In optic nerve sheath meningiomas, circumferential enhancement surrounding the optic nerve may produce the characteristic tram-track appearance, although this finding is not exclusive to meningiomas and must be interpreted within the broader clinical and radiological context [2], [3].

Computed tomography (CT) provides complementary information by identifying calcifications, hyperostosis, and alterations in skull base anatomy. These findings are particularly relevant when tumors involve the anterior clinoid process or extend into the optic canal, where osseous narrowing may contribute to neural compression. Furthermore, magnetic resonance angiography and computed tomography angiography can assist in evaluating arterial displacement, encasement, and vascular relationships that influence operative planning. The European Association of Neurosurgical Societies has emphasized the importance of combining advanced neuroimaging techniques when assessing complex anterior clinoidal meningiomas [9], [10].

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An important limitation of conventional radiological assessment is the imperfect relationship between tumor dimensions and visual dysfunction. Small lesions located within the optic canal may produce substantial compression because of restricted anatomical space, while larger tumors with predominantly extracanalicular extension may exhibit comparatively limited visual manifestations. Accordingly, radiological interpretation should consider not only tumor volume but also the direction of growth, degree of optic pathway displacement, canal involvement, and proximity to vascular structures [8], [13].

Visual Deterioration and Functional Prognosis

Visual impairment represents one of the principal manifestations of meningiomas involving the anterior visual pathway. Clinical abnormalities may include progressive reduction in visual acuity, visual field defects, impaired color perception, and optic disc changes. The pattern and severity of these manifestations depend on the structures affected, duration of compression, and extent of associated neural injury. Chronic mechanical compression may coexist with disturbances in microvascular perfusion, contributing to progressive optic neuropathy and limiting the possibility of complete recovery following treatment [4], [11].

Neuro-ophthalmological evaluation therefore constitutes an essential component of diagnostic assessment. Visual acuity testing, automated perimetry, fundoscopic examination, and optical coherence tomography (OCT) provide complementary information regarding functional impairment and structural integrity of the optic nerve. OCT can identify thinning of the retinal nerve fiber layer and ganglion cell complex, findings that may indicate established axonal damage. However, these measurements should be interpreted alongside visual testing and neuroimaging rather than as isolated predictors of postoperative recovery [10], [12].

Previous investigations have identified preoperative visual status, symptom duration, tumor location, and the extent of neural decompression as relevant factors associated with postoperative visual outcomes. Nevertheless, functional improvement is not guaranteed following complete tumor removal, particularly when longstanding compression has produced advanced optic neuropathy. These observations support the importance of timely diagnosis and individualized therapeutic planning aimed at preserving remaining visual function [11], [14], [15].

Neurosurgical Approach Selection and Therapeutic Outcomes

The selection of an appropriate surgical approach remains one of the most debated aspects of optic pathway-related meningioma management. Transcranial approaches provide direct access to complex lateral tumor extensions, facilitate vascular dissection, and allow decompression of the optic nerve through selected skull base corridors. Conversely, endoscopic endonasal approaches may offer anatomical advantages for appropriately selected midline lesions, particularly those arising from the tuberculum sellae with predominantly inferior or medial relationships to the optic apparatus [10], [17].

Evidence from the International Tuberculum Sellae Meningioma Study, which included 947 surgical cases across 40 centers, demonstrated that visual function remained stable or improved in 87.5% of patients. Among individuals with preoperative visual deficits, improvement was reported in 73.0% of those undergoing endoscopic endonasal surgery and 57.1% of those treated through transcranial approaches. Nevertheless, the endonasal group contained smaller tumors, and important differences in patient selection limited direct comparison. Additionally, cerebrospinal fluid leakage was more frequent following endonasal procedures, highlighting the need to balance functional benefits against approach-specific complications [17].

Optic canal decompression represents another relevant surgical consideration. A systematic review and meta-analysis involving 384 patients reported a pooled visual improvement rate of approximately 80.3% following optic canal unroofing in tuberculum sellae meningiomas. Although these findings support the potential benefits of targeted neural decompression, procedural outcomes remain dependent on tumor anatomy, surgical experience, and the extent of preexisting optic nerve injury [16].

Latin American evidence has contributed to this discussion. A Mexican retrospective study involving 29 patients with tuberculum sellae meningiomas compared transcranial and endoscopic endonasal approaches and found no statistically significant differences in visual outcomes between groups. The investigators emphasized individualized surgical

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selection according to tumor characteristics, neurovascular involvement, and preoperative visual status. Similarly, Brazilian surgical experience has reinforced the importance of anatomical assessment and careful manipulation of the optic apparatus [18], [19].

Radiotherapy and Integrated Therapeutic Decision-Making

Radiotherapy represents an important therapeutic option, particularly for optic nerve sheath meningiomas in which surgical resection may threaten functional vision. Fractionated radiation techniques can achieve tumor control while avoiding the direct neural manipulation associated with surgery. Nevertheless, treatment planning must consider the tolerance of the optic apparatus, preexisting visual impairment, and potential radiation-related complications [5], [6].

A Mexican clinical series examining 19 patients treated with radiation for optic nerve sheath meningiomas reported favorable local tumor control but variable visual outcomes, including deterioration in some individuals with preserved vision at diagnosis. These observations demonstrate that radiological disease control and visual preservation are distinct therapeutic outcomes and should be evaluated independently [7].

GENERAL OBJECTIVE AND SPECIFIC OBJECTIVES

General Objective

To critically analyze the radiological characteristics, mechanisms of visual deterioration, and therapeutic management of optic pathway-related meningiomas through a comprehensive review of international scientific literature, integrating neuroimaging findings, neuro-ophthalmological assessment, and neurosurgical considerations to establish evidence-based criteria for individualized treatment selection and visual function preservation.

Specific Objectives

The specific objectives were formulated according to Bloom's taxonomy, integrating cognitive, psychomotor, and affective learning domains to promote comprehensive understanding, practical interpretation, and clinically responsible decision-making.

Cognitive Domain: Knowledge, Analysis, and Evaluation

1. **Identify and classify** the principal anatomical locations of optic pathway-related meningiomas, distinguishing their radiological features, patterns of extension, and relationships with adjacent neurovascular structures.
2. **Analyze and correlate** MRI and CT findings with mechanisms of optic nerve compression, visual deterioration, and prognostic indicators, emphasizing their relevance to diagnostic accuracy and therapeutic planning.
3. **Compare and critically evaluate** transcranial, endoscopic endonasal, and radiotherapeutic strategies according to anatomical accessibility, visual outcomes, tumor control, and treatment-associated complications.

Psychomotor Domain: Interpretation and Applied Clinical Skills

4. **Develop a systematic approach** to interpreting neuroimaging findings and neuro-ophthalmological assessments, identifying anatomical characteristics that may influence the selection of surgical corridors and optic nerve decompression techniques.
5. **Integrate and apply** evidence-based criteria to representative clinical scenarios, constructing structured therapeutic decision pathways that prioritize preservation of visual function and minimization of neurological complications.

Affective Domain: Professional Judgment and Patient-Centered Care

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6. **Recognize and prioritize** the clinical, functional, and ethical importance of visual preservation, emphasizing multidisciplinary collaboration, individualized risk assessment, and respect for patient preferences when evaluating therapeutic alternatives.

7. **Promote critical reflection** on the balance between tumor removal, procedural safety, and long-term quality of life, recognizing the importance of avoiding unnecessary neurological morbidity and supporting informed clinical decisions.

OBJECT OF STUDY

The object of study of this narrative review is the relationship between radiological characteristics, visual deterioration, and therapeutic decision-making in meningiomas involving the anterior visual pathway. Particular attention is directed toward tumors originating from or extending into the optic nerve sheath, tuberculum sellae, anterior clinoid process, and adjacent skull base structures, where anatomical relationships may influence optic nerve compression, functional prognosis, and the selection of treatment strategies [1], [2].

The population of interest comprises primarily adult patients with radiologically or histopathologically diagnosed optic pathway-related meningiomas, as represented in previously published clinical studies, surgical series, systematic reviews, and international guidelines. Rather than examining individual patients directly, the investigation focuses on aggregated clinical and radiological evidence reported in the scientific literature, incorporating findings from international institutions and Latin American neurosurgical centers [17]–[19].

The principal variables examined include tumor location, dimensions, intracanalicular extension, vascular involvement, optic nerve displacement, and radiological characteristics identified through magnetic resonance imaging and computed tomography. Functional variables encompass visual acuity, visual field alterations, optic neuropathy, and postoperative visual outcomes. Therapeutic variables include the selection of transcranial or endoscopic endonasal approaches, optic canal decompression, extent of tumor resection, radiotherapy, and treatment-associated complications [3], [10], [16].

The analysis is structured around three interconnected dimensions: anatomical and radiological characterization, clinical progression of visual impairment, and comparative evaluation of therapeutic strategies. These dimensions permit examination of the relationship between structural abnormalities and functional consequences while considering the clinical factors that influence surgical accessibility and treatment selection.

The study is limited to evidence concerning meningiomas with direct anatomical or functional relationships to the optic pathway. Other intracranial tumors and non-neoplastic optic neuropathies are considered only when relevant to differential diagnosis. Through this defined scope, the review seeks to establish an integrated understanding of the anatomical, radiological, and clinical factors supporting individualized therapeutic decisions and preservation of visual function.

METHODOLOGY

Study Design and Methodological Approach

This study was structured as a narrative review of scientific literature, applying the principles of the scientific method to examine relationships between radiological characteristics, visual deterioration, and therapeutic decision-making in optic pathway-related meningiomas. The methodological approach combined structured literature identification, critical evaluation of published evidence, and qualitative synthesis of clinical and radiological findings. Its purpose was to identify consistent patterns, relevant prognostic factors, and unresolved controversies without conducting direct patient interventions or generating primary clinical data.

The scientific method was selected because it permits systematic examination of a defined clinical problem through the formulation of research questions, evaluation of available evidence, and interpretation of findings within an established theoretical framework.

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Literature Search Strategy

The review was based on a selected collection of 20 scientific publications addressing optic nerve sheath, tuberculum sellae, anterior clinoidal, and related skull base meningiomas. PubMed/MEDLINE was used as the principal bibliographic reference source, with Scopus considered an additional resource for independent searches and citation verification.

A reproducible search strategy was defined using combinations of the following descriptors: *meningioma*, *optic pathway*, *optic nerve sheath meningioma*, *tuberculum sellae*, *anterior clinoid*, *magnetic resonance imaging*, *visual outcomes*, *optic canal decompression*, *endoscopic endonasal approach*, and *transcranial surgery*.

For independent replication, the principal Boolean search expression was established as:

("meningioma" OR "meningiomas") AND ("optic nerve sheath" OR "tuberculum sellae" OR "anterior clinoid" OR "optic canal") AND ("magnetic resonance imaging" OR "visual outcome" OR "surgical approach" OR "radiotherapy").

The proposed bibliographic window extended from January 1990 through October 2026 to incorporate foundational anatomical investigations and contemporary therapeutic evidence. Publications in English, Spanish, and Portuguese were considered relevant to support international coverage and Latin American participation.

Eligibility and Selection Criteria

Eligible publications included clinical observational studies, comparative surgical series, systematic reviews, meta-analyses, and internationally recognized clinical guidelines addressing radiological characterization, neuro-ophthalmological manifestations, therapeutic strategies, or visual outcomes in patients with optic pathway-related meningiomas.

Studies focused exclusively on unrelated intracranial neoplasms, publications without relevant clinical or radiological information, and duplicate reports were excluded from consideration. Greater interpretative weight was assigned to publications with clearly described patient populations, diagnostic methods, therapeutic procedures, and functional outcomes.

The selected literature included contributions from international research groups and Latin American institutions, particularly Mexico and Brazil, allowing comparison of clinical experiences across different healthcare settings [7], [17]–[19].

Data Extraction and Evidence Synthesis

The methodological framework established a standardized extraction process organized around five categories: anatomical localization, imaging characteristics, preoperative visual function, therapeutic intervention, and postoperative outcomes.

Radiological variables included tumor dimensions, optic canal involvement, hyperostosis, neural compression, and relationships with adjacent vascular structures. Clinical variables comprised visual acuity, visual field abnormalities, symptom progression, and functional recovery. Therapeutic information included surgical approach, extent of resection, optic nerve decompression, radiotherapy, and reported complications.

Evidence was synthesized qualitatively, comparing findings according to anatomical location and treatment modality. Particular attention was directed toward identifying factors consistently associated with visual prognosis and recognizing differences in patient selection that could affect comparisons between surgical techniques [10], [16], [17].

Because this investigation follows a narrative rather than a systematic review design, no pooled effect estimates or formal meta-analysis were performed. Numerical findings from individual studies were retained within their original clinical contexts to avoid misleading comparisons.

Methodological Reliability and Ethical Considerations

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Methodological consistency was supported through predefined thematic categories, explicit eligibility criteria, and interpretation of findings in relation to study design and reported limitations. Particular consideration was given to retrospective selection bias, variation in tumor characteristics, differences in surgical expertise, and heterogeneity in visual outcome measurements.

The review used previously published scientific information without direct patient recruitment, intervention, or access to identifiable clinical records. Its educational and scientific purpose was to integrate existing knowledge and establish a clinically relevant framework for understanding the radiological and therapeutic management of optic pathway-related meningiomas.

PHASES OF DEVELOPMENT

Phase 1. Identification and Definition of the Research Problem

The initial phase focused on identifying the clinical and radiological challenges associated with meningiomas involving the anterior visual pathway. Particular attention was directed toward the relationship between tumor location, optic nerve compression, progressive visual deterioration, and the complexity of therapeutic selection.

The central problem was defined as the difficulty of establishing consistent criteria for selecting the most appropriate treatment based on radiological findings and preoperative visual function. Although contemporary neuroimaging and surgical techniques have improved diagnostic precision and therapeutic possibilities, uncertainty persists regarding the anatomical and clinical factors that most strongly influence visual preservation [1], [8].

Phase 2. Formulation of Research Questions and Working Hypothesis

The second phase established the principal research question: How do radiological characteristics and preoperative visual impairment influence therapeutic selection and visual outcomes in patients with optic pathway-related meningiomas?

Three complementary questions guided the investigation: Which imaging characteristics are most relevant for evaluating optic nerve compromise? What clinical and anatomical factors are associated with postoperative visual recovery? Under which circumstances might transcranial surgery, endoscopic endonasal surgery, or radiotherapy provide the most appropriate therapeutic option?

The working hypothesis proposed that integrating detailed neuroimaging assessment with neuro-ophthalmological findings provides a more informative basis for individualized treatment selection than evaluating tumor dimensions or anatomical location independently. This proposition was treated as an interpretative framework for examining published evidence rather than as a hypothesis subjected to experimental testing [9], [11], [17].

Phase 3. Identification and Organization of Scientific Evidence

The third phase involved structuring the bibliographic evidence according to the research questions. The 20 selected publications formed the reference base for examining anatomical classification, radiological findings, visual prognosis, and therapeutic outcomes.

Scientific evidence was organized into thematic categories encompassing optic nerve sheath meningiomas, tuberculum sellae lesions, anterior clinoidal tumors, and surgical or radiotherapeutic interventions. International guidelines, systematic reviews, meta-analyses, and clinical series were considered according to their relevance and methodological characteristics.

Particular attention was given to incorporating Latin American publications, including Mexican and Brazilian contributions, to contextualize findings within different institutional and clinical environments [7], [18], [19].

Phase 4. Classification and Comparative Analysis of Findings

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The fourth phase established a comparative framework connecting anatomical, radiological, functional, and therapeutic variables.

Radiological findings were classified according to tumor location, optic canal involvement, osseous changes, neural displacement, and relationships with adjacent vascular structures. Functional characteristics included visual acuity, visual field alterations, evidence of optic neuropathy, and reported postoperative evolution.

Therapeutic outcomes were considered separately for transcranial approaches, endoscopic endonasal techniques, optic canal decompression, and radiotherapy. Comparisons emphasized differences in patient selection, tumor morphology, treatment-related complications, and visual outcomes.

The analysis also considered the limitations of retrospective studies and differences in reported outcome measures, recognizing that favorable results associated with one approach cannot necessarily be generalized to anatomically dissimilar tumors [10], [16], [17], [20].

Phase 5. Interpretation and Integration of Evidence

The fifth phase focused on integrating the findings into an interdisciplinary model of clinical interpretation. Radiological characteristics were examined in relation to functional impairment, while treatment strategies were evaluated according to their potential to preserve vision and achieve adequate tumor control.

This integration considered three principal decision-making dimensions: anatomical accessibility, preoperative visual status, and procedural risk. Tumors with extensive lateral extension or complex vascular relationships were differentiated from predominantly midline lesions, while optic nerve sheath meningiomas were considered separately because of their distinct therapeutic considerations.

The resulting framework emphasized that treatment selection should not depend on a single radiological measurement. Instead, it should reflect the combined assessment of anatomical complexity, functional prognosis, and the potential consequences of surgical or nonsurgical intervention [4], [6], [12], [18].

Phase 6. Synthesis and Development of Clinical Interpretation Criteria

The final phase consisted of organizing the evidence into practical criteria for interpreting optic pathway-related meningiomas and their therapeutic implications.

The synthesis prioritized accurate anatomical characterization, systematic evaluation of visual dysfunction, recognition of optic canal involvement, and identification of factors influencing surgical accessibility and risk. It also emphasized the distinction between radiological tumor control and functional visual recovery, since these outcomes may not evolve in parallel.

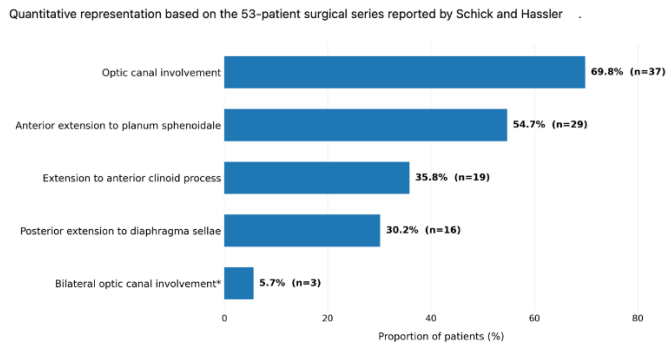
The resulting interpretative criteria support multidisciplinary evaluation involving neurosurgery, neuroradiology, neuro-ophthalmology, and radiation oncology. Rather than establishing a universally superior therapeutic technique, the review emphasizes individualized management informed by available evidence and the clinical characteristics of each anatomical presentation [1], [7], [17].

These phases provide a coherent progression from clinical problem identification to critical evidence interpretation. Their application within a narrative review framework supports transparent scientific reasoning while acknowledging that observational evidence and heterogeneous clinical series cannot establish definitive causal relationships between treatment selection and visual recovery.

RESULTS AND DISCUSSION

Figure 1.
Anatomical Extension Patterns and Optic Canal Involvement in Tuberculum Sellae Meningiomas

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The anatomical distribution illustrated in Figure 1 demonstrates considerable variability in the extension patterns of tuberculum sellae meningiomas, with optic canal involvement representing the most frequently documented characteristic. In the retrospective series of 53 surgically treated patients reported by Schick and Hassler, 37 tumors (69.8%) involved the optic canal, establishing this region as the predominant anatomical structure affected among the extension categories examined. The remaining findings showed substantial involvement of neighboring skull base structures, reflecting the diversity of anatomical relationships encountered in meningiomas arising from the tuberculum sellae [13].

Extension toward the planum sphenoidale was documented in 29 patients (54.7%), representing the second most frequently reported anatomical pattern. Involvement of the anterior clinoid process was identified in 19 cases (35.8%), whereas posterior extension toward the diaphragma sellae was observed in 16 patients (30.2%). The difference between the most and least frequent principal anatomical categories was approximately 39.6 percentage points. These findings describe a heterogeneous distribution of tumor extension within the anterior skull base, with anatomical involvement extending beyond the original dural attachment in a substantial proportion of the reported cases [13].

A particularly relevant observation was the identification of bilateral optic canal involvement in three patients (5.7% of the total cohort). These cases constituted a subset of the 37 patients with optic canal involvement rather than an independent anatomical category. Accordingly, the figure distinguishes overall canal involvement from its bilateral presentation without treating the corresponding percentages as additive. The coexistence of different anatomical extensions also means that the reported percentages cannot be interpreted as mutually exclusive categories. A single tumor may involve the optic canal while simultaneously extending toward the planum sphenoidale or anterior clinoid process [13].

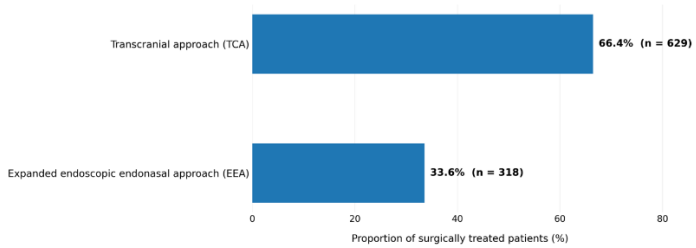
The anatomical patterns presented in the figure correspond to structures that require detailed evaluation during radiological characterization. Previous investigations have described the contribution of contrast-enhanced magnetic resonance imaging to the identification of tumor extension, relationships with the optic nerves, and involvement of adjacent neurovascular structures. Computed tomography provides complementary characterization of the osseous anatomy, particularly in lesions extending toward the anterior clinoid process or involving the optic canal. Studies examining anterior clinoidal meningiomas have additionally documented the importance of identifying hyperostosis, calcification, vascular encasement, and cavernous sinus extension as separate radiological findings [9], [10].

Although the quantitative distribution presented in Figure 1 corresponds specifically to tuberculum sellae meningiomas, the broader literature describes different anatomical configurations in tumors originating from the optic nerve sheath. These lesions may demonstrate tubular, fusiform, or globular configurations, with contrast-enhanced magnetic resonance imaging providing characteristic evidence of perineural tumor extension. Consequently, the frequencies displayed in Figure 1 should not be extrapolated to optic nerve sheath or primary anterior clinoidal meningiomas, which represent anatomically distinct clinical populations [2], [3].

The original series also documented a median tumor diameter of 2.6 cm and reported that tumor size was not associated with visual acuity in the examined population. This finding was reported alongside the anatomical distribution but was not incorporated into the graphical percentages because it represents a different measurement dimension. Similarly, the study documented variation in preoperative and postoperative visual function, which will be examined separately in subsequent figures addressing therapeutic and functional outcomes [13].

Figure 2.
Distribution of Neurosurgical Approaches in Tuberculum Sellae Meningiomas

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The distribution presented in Figure 2 demonstrates a marked predominance of transcranial approaches in the surgical management of tuberculum sellae meningiomas within the International Tuberculum Sellae Meningioma Study. This retrospective multicenter investigation included 947 patients treated across 40 neurosurgical institutions, representing one of the largest published cohorts evaluating surgical management strategies for these tumors. Among the included patients, 629 (66.4%) underwent transcranial surgery, while 318 (33.6%) were treated through an expanded endoscopic endonasal approach. The absolute difference of 311 patients corresponded to 32.8 percentage points, with transcranial procedures performed approximately 1.98 times as frequently as endoscopic endonasal interventions [17].

The reported distribution was obtained after the evaluation of 1,003 submitted patient records. Fifty records were excluded because of incomplete information, while six additional patients undergoing planned two-stage procedures involving both surgical approaches were excluded from the final analysis. Consequently, the comparative cohort comprised patients classified according to either a transcranial or an expanded endoscopic endonasal approach, permitting a descriptive comparison of the two principal surgical categories without incorporating combined procedures [17].

Differences in preoperative tumor dimensions were also documented between the surgical groups. The median maximum tumor diameter was 2.5 cm among patients undergoing transcranial surgery, compared with 2.1 cm among those treated through an expanded endoscopic endonasal approach. This difference of 0.4 cm was statistically significant ($p < 0.0001$). The observed findings indicate that the endonasal group contained tumors with smaller median dimensions, demonstrating that the anatomical characteristics of the two surgical populations were not entirely equivalent at baseline [17].

Additional differences were observed in the radiological characteristics of the study population. Peritumoral edema was documented in 114 patients (18.1%) undergoing transcranial surgery and 33 patients (10.4%) treated endonasally, with a statistically significant difference between groups ($p = 0.0019$). By contrast, the distribution of World Health Organization tumor grades did not differ significantly according to surgical approach ($p = 0.3708$). These findings describe variation in selected preoperative characteristics while identifying other variables with comparable distributions between treatment groups [17].

The duration of postoperative observation also differed between approaches. The median follow-up period was 28 months in the transcranial group and 22 months in the endoscopic endonasal group, with a statistically significant difference ($p < 0.0001$). The median follow-up for the complete cohort was 26 months. Therefore, the study populations differed not only in the frequency of surgical approach selection but also in baseline tumor dimensions and the duration of postoperative evaluation [17].

An important characteristic of these findings is that the percentage distribution reflects the frequency with which each surgical approach was employed within the participating institutions. The proportions do not directly represent differences in therapeutic effectiveness, visual recovery, or complication rates, which require separate outcome analyses. Similarly, the predominance of transcranial surgery should be interpreted within the specific multicenter population rather than as a universal distribution applicable to all healthcare systems or neurosurgical institutions [17].

In summary, Figure 2 identifies transcranial surgery as the most frequently employed approach in the evaluated cohort, accounting for approximately two-thirds of the interventions. Expanded endoscopic endonasal surgery represented approximately one-third of procedures. The accompanying descriptive findings demonstrate significant differences in tumor dimensions, peritumoral edema, and follow-up duration between groups, establishing the principal demographic and radiological context for the subsequent comparison of postoperative visual outcomes [17].

Figure 3.

Postoperative Visual Outcomes According to Neurosurgical Approach in Patients with Preoperative Visual Deficits

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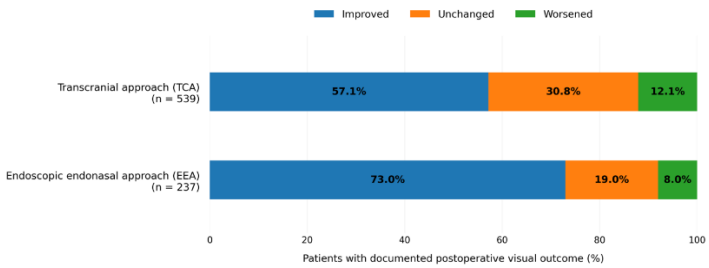


Figure 3 presents the distribution of postoperative visual outcomes according to neurosurgical approach among patients with documented preoperative visual impairment. The analyzed subgroup comprised 776 individuals from the International Tuberculum Sellae Meningioma Study, including 539 patients who underwent transcranial surgery and 237 treated through an expanded endoscopic endonasal approach. Visual outcomes were classified into three categories: improvement, stability, and deterioration. These categories were based on postoperative functional assessments reported by participating centers and permitted comparison of visual changes between the two surgical populations [17].

The most prominent finding was the difference in the proportion of patients experiencing postoperative visual improvement. Among individuals treated through the endoscopic endonasal approach, 173 of 237 patients (73.0%) demonstrated improved visual function, compared with 308 of 539 patients (57.1%) undergoing transcranial surgery. This represented an absolute difference of 15.9 percentage points between groups, with a statistically significant association between surgical approach and visual improvement ($p < 0.0001$). The reported unadjusted odds ratio for improvement following endoscopic endonasal surgery compared with transcranial intervention was 2.02 (95% confidence interval: 1.45–2.83) [17].

Differences were also identified in the proportion of patients maintaining unchanged visual function after surgery. Stable postoperative vision was documented in 166 patients (30.8%) undergoing transcranial surgery and 45 patients (19.0%) treated endonasally. This represented an absolute difference of 11.8 percentage points, with a statistically significant difference between groups ($p = 0.0007$). Thus, the distribution of favorable postoperative outcomes differed between approaches, with the endoscopic endonasal group demonstrating a higher proportion of improvement and the transcranial group presenting a higher proportion of visual stability [17].

Postoperative visual deterioration occurred less frequently than improvement or stability in both surgical groups. Worsening was documented in 65 patients (12.1%) following transcranial surgery and 19 patients (8.0%) following endoscopic endonasal intervention. Although the observed difference was 4.1 percentage points, the comparison did not reach statistical significance ($p = 0.0950$). Accordingly, the reported data demonstrated a statistically significant difference in visual improvement but not in the frequency of visual deterioration among patients with preoperative impairment [17].

When both surgical groups were considered together, 481 of the 776 patients (62.0%) demonstrated visual improvement, while 211 (27.2%) maintained stable postoperative visual function. The remaining 84 patients (10.8%) experienced deterioration. Therefore, visual function was preserved or improved in approximately 89.2% of the subgroup with preoperative impairment and documented outcomes. This subgroup-specific percentage differs from the 87.5% reported for the overall study cohort, which also included individuals without preoperative visual deficits [17].

The broader investigation additionally evaluated postoperative visual worsening through multivariate analysis. Transcranial surgery was associated with increased odds of visual deterioration (odds ratio: 1.78; 95% confidence interval: 1.05–3.01; $p = 0.0258$), while gross total tumor resection was associated with reduced odds of worsening (odds ratio: 0.37; 95% confidence interval: 0.24–0.59; $p < 0.0001$). These findings originated from the overall analytical population and were therefore considered separately from the descriptive percentages illustrated in Figure 3 [17].

Several baseline characteristics differed between the surgical populations. The median maximum tumor diameter was 2.5 cm in patients undergoing transcranial surgery and 2.1 cm in those treated endonasally ($p < 0.0001$). Preoperative visual deficits were also more frequent in the complete transcranial cohort, affecting 88.0% of patients compared with 77.4% in the endoscopic endonasal group. Furthermore, median postoperative follow-up was longer following transcranial intervention (28 months) than after endonasal surgery (22 months). These differences establish relevant characteristics of the populations from which the postoperative visual findings were obtained [17].

The original investigation also reported limitations in the standardization of visual assessment. Formal visual field examinations were available for approximately 57% of patients, and detailed quantitative measurements of preoperative and postoperative visual function were not consistently recorded across participating institutions.

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Consequently, visual outcomes were primarily classified according to whether postoperative function improved, remained unchanged, or deteriorated, rather than through standardized changes in visual acuity or automated perimetry measurements [17].

Figure 4.
Postoperative Visual Improvement Following Optic Canal Unroofing in Tuberculum Sellae Meningiomas

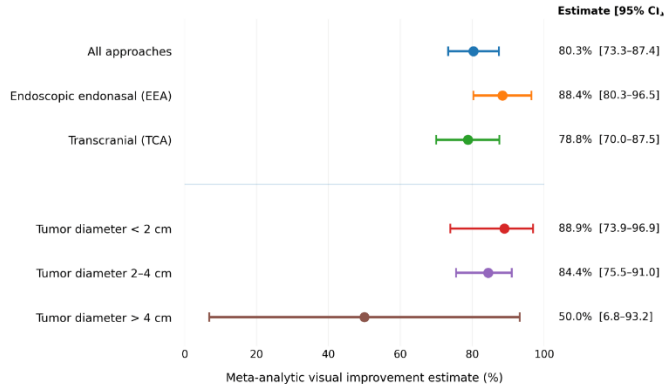


Figure 4 presents the postoperative visual improvement rates associated with optic canal unroofing in patients undergoing surgical treatment for tuberculum sellae meningiomas. The findings were derived from the systematic review and meta-analysis conducted by Lin et al., which incorporated 15 retrospective clinical studies published between 2003 and 2023. The combined study population included 384 patients who underwent optic canal decompression through either a transcranial or an endoscopic endonasal approach. Among these patients, 341 presented with preoperative visual impairment, and 266 were reported to have experienced postoperative visual recovery. The pooled meta-analytic estimate of visual improvement was 80.3%, with a 95% confidence interval ranging from 73.3% to 87.4% [16].

The overall improvement estimate differed slightly from the crude proportion calculated directly from the reported patient counts, which corresponded to 78.0% (266 of 341 patients). This distinction reflects the use of study-level meta-analytic estimates rather than simple aggregation of individual patient outcomes. The reported overall heterogeneity was moderate to substantial, with an I^2 value of 64.81%, indicating variation in visual improvement estimates across the included investigations. Accordingly, the graphical representation preserves the published pooled estimates and their confidence intervals rather than replacing them with unweighted proportions [16].

Subgroup analysis according to surgical approach demonstrated differences in the reported visual improvement estimates. The endoscopic endonasal subgroup comprised five studies, including 56 patients with preoperative visual deficits, of whom 47 experienced postoperative improvement. The pooled improvement estimate was 88.4% (95% CI: 80.3–96.5%). In comparison, the transcranial subgroup included 10 studies involving 285 patients with preoperative visual impairment, among whom 210 experienced postoperative recovery. The corresponding pooled estimate was 78.8% (95% CI: 70.0–87.5%). The absolute difference between the two pooled estimates was 9.6 percentage points [16].

The variability of the visual improvement estimates differed between surgical subgroups. The endoscopic endonasal studies demonstrated an I^2 value of 0%, whereas the transcranial studies presented substantial heterogeneity, with an I^2 value of 72.21%. The confidence intervals of the two subgroups overlapped, and the reported subgroup estimates did not constitute a randomized or otherwise equivalent comparison between surgical techniques. These findings describe the distribution and variability of postoperative visual recovery within the analyzed studies without establishing the independent effect of the surgical corridor on visual outcomes [16].

An additional analysis examined visual improvement according to maximum tumor diameter. This assessment included a smaller subset of 136 patients for whom sufficient information was available to classify tumors into three anatomical size categories. The highest pooled improvement estimate was observed among patients with tumors smaller than 2 cm, reaching 88.9% (95% CI: 73.9–96.9%). Patients with tumors measuring between 2 and 4 cm demonstrated an improvement estimate of 84.4% (95% CI: 75.5–91.0%), representing a difference of 4.5 percentage points compared with the smaller-tumor group [16].

In contrast, patients with tumors larger than 4 cm presented a pooled visual improvement estimate of 50.0%, with a notably wide 95% confidence interval extending from 6.8% to 93.2%. This estimate was 38.9 percentage points lower than that observed in the subgroup with tumors smaller than 2 cm and 34.4 percentage points lower than the estimate for tumors measuring 2–4 cm. However, the considerable width of the confidence interval demonstrates substantial

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statistical uncertainty surrounding the estimate for larger tumors. The combined heterogeneity for the tumor-size subgroup analysis was relatively low, with an I^2 value of 20.80%, although the precision of individual subgroup estimates varied considerably [16].

The original meta-analysis also evaluated the extent of tumor resection in patients undergoing optic canal unroofing. Twelve studies contributed to this assessment, and the reported pooled gross total resection rate was 91.1% (95% CI: 84.8–96.1%). Further stratification by tumor dimensions yielded pooled gross total resection estimates of 93.3% for tumors smaller than 2 cm, 88.0% for tumors measuring 2–4 cm, and 60.0% for tumors larger than 4 cm. These findings were analyzed separately from visual improvement because the two outcomes represented different clinical measurements and were not necessarily assessed in identical patient subsets [16].

Regarding postoperative complications, visual deterioration was evaluated in nine studies, producing a pooled incidence estimate of 7.7%. Olfactory nerve injury was analyzed in six studies, with a corresponding pooled estimate of 5.4%. The published report presented slightly different upper confidence limits for visual deterioration in its abstract and full-text results; therefore, the point estimate is reported here without assigning a single confidence interval. These complication outcomes were not incorporated into Figure 4 because the graphical analysis was specifically focused on postoperative visual improvement [16].

The studies included in the meta-analysis demonstrated variations in surgical approach, tumor dimensions, preoperative visual status, and the methods used to assess postoperative functional recovery. Furthermore, all 15 included investigations employed retrospective observational designs. These characteristics limited the extent to which the reported pooled estimates could account for differences in patient selection and clinical assessment across institutions. The visual improvement estimates therefore represent outcomes documented in previously published surgical populations rather than standardized predictions for individual patients [16].

Figure 5.

Postoperative Complications According to Neurosurgical Approach in Tuberculum Sellae Meningiomas

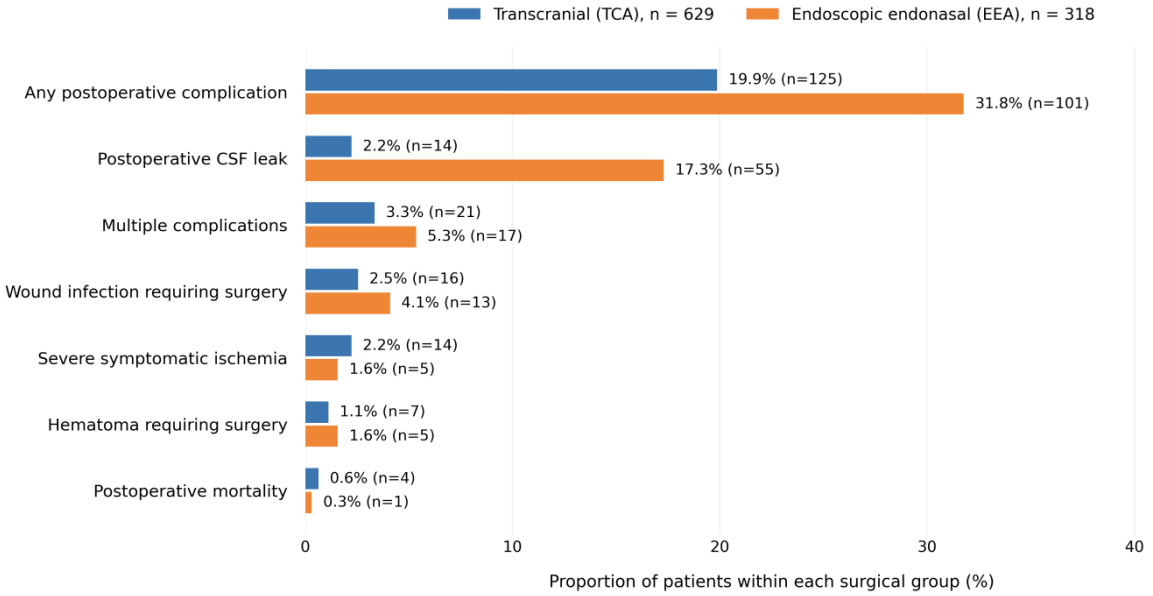


Figure 5 illustrates the distribution of postoperative complications following transcranial and expanded endoscopic endonasal surgery for tuberculum sellae meningiomas. The analysis was derived from the International Tuberculum Sellae Meningioma Study, which included 947 surgically treated patients from 40 participating institutions. Of these, 629 underwent transcranial surgery, while 318 were treated through an expanded endoscopic endonasal approach. The original investigation documented postoperative complications in 226 patients (23.9%), including 38 individuals (4.0%) who experienced more than one complication [17].

The overall frequency of postoperative complications differed between surgical groups. Among patients undergoing transcranial surgery, 125 of 629 (19.9%) experienced at least one complication, compared with 101 of 318 (31.8%) in the endoscopic endonasal group. This represented an absolute difference of 11.9 percentage points. The original study reported significantly greater odds of complications following endoscopic endonasal surgery (odds ratio: 1.88; 95% confidence interval: 1.38–2.55; $p < 0.0001$). The difference in overall postoperative morbidity was primarily associated with the frequency of cerebrospinal fluid leakage [17].

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Cerebrospinal fluid leakage demonstrated the largest difference among the individual complications examined. Postoperative leakage was documented in 14 patients (2.2%) undergoing transcranial surgery and 55 patients (17.3%) treated through the endoscopic endonasal approach. The absolute difference between surgical groups was 15.1 percentage points, corresponding to an approximately 7.9-fold difference in the observed proportions. The reported odds ratio was 9.1 (95% confidence interval: 5.02–16.81; $p < 0.0001$), establishing cerebrospinal fluid leakage as the complication with the most pronounced between-group difference in the analyzed cohort [17].

The original investigation also examined whether institutional surgical volume was associated with differences in postoperative cerebrospinal fluid leakage following endoscopic endonasal procedures. Centers performing more than 20 endonasal operations were classified as higher-volume institutions, encompassing 166 patients across five centers, whereas 152 patients were treated at 35 lower-volume centers. The reported leakage rates were 15.6% and 19.1%, respectively, without a statistically significant difference ($p = 0.4598$). These findings described variation in the observed complication rates across institutional groups but did not demonstrate a statistically significant association between the specified surgical volume categories and postoperative leakage [17].

The frequency of multiple postoperative complications was comparatively low in both surgical populations. Among patients undergoing transcranial surgery, 21 individuals (3.3%) experienced more than one complication, compared with 17 patients (5.3%) undergoing endoscopic endonasal surgery. Although the observed percentage was numerically higher in the endonasal group, both approaches demonstrated substantially lower frequencies of multiple complications than of overall postoperative morbidity [17].

Wound infection requiring surgical intervention represented another documented postoperative event. This complication occurred in 16 patients (2.5%) following transcranial surgery and 13 patients (4.1%) following endoscopic endonasal intervention, corresponding to an absolute difference of 1.6 percentage points. Unlike cerebrospinal fluid leakage, wound infection was observed at relatively low frequencies in both surgical populations. The reported figures describe infections requiring additional surgical management rather than all postoperative infectious events, which may have included conditions managed without reoperation [17].

Severe symptomatic ischemia demonstrated a different distribution between surgical approaches. Fourteen patients (2.2%) in the transcranial group experienced this complication, compared with five patients (1.6%) in the endoscopic endonasal group. The absolute difference was 0.6 percentage points, with a numerically higher frequency following transcranial surgery. Hematoma requiring additional surgical intervention was reported in seven patients (1.1%) undergoing transcranial surgery and five patients (1.6%) treated endonasally. Both complications occurred substantially less frequently than cerebrospinal fluid leakage or overall postoperative morbidity [17].

Postoperative mortality was uncommon in the complete study population. Five deaths were documented, corresponding to an overall mortality rate of approximately 0.5%. Four deaths occurred among the 629 patients undergoing transcranial surgery (0.6%), while one occurred among the 318 patients treated through the expanded endoscopic endonasal approach (0.3%). The absolute difference between groups was approximately 0.3 percentage points. Given the small number of events, these descriptive proportions provide limited information for comparative assessment of mortality between surgical techniques [17].

Visual deterioration constituted an additional functional outcome reported separately from the general complication categories represented in Figure 5. Within the subgroup of patients presenting with preoperative visual deficits and available postoperative assessments, visual worsening occurred in 65 of 539 patients (12.1%) following transcranial surgery and 19 of 237 patients (8.0%) following endoscopic endonasal intervention. This difference did not reach statistical significance ($p = 0.0950$). Across the broader surgical cohort, newly developed unilateral and bilateral blindness were reported in 3.3% and 0.4% of patients, respectively. These visual outcomes were analyzed separately because their denominators and assessment criteria differed from those used for the general postoperative complications [17].

The complications included in Figure 5 represent distinct clinical categories that may overlap within individual patients. Consequently, the sum of individual complication frequencies exceeds neither a required nor a meaningful total of affected patients, since some individuals experienced multiple adverse events. Additionally, differences in tumor dimensions, anatomical characteristics, and postoperative follow-up between surgical groups were documented in the original investigation. Median tumor diameter was 2.5 cm in the transcranial group and 2.1 cm in the endoscopic endonasal group, while median follow-up was 28 and 22 months, respectively [17].

DISCUSSION

The findings of this narrative review demonstrate that the management of optic pathway-related meningiomas requires a comprehensive interpretation of anatomical characteristics, radiological findings, preoperative visual function, and treatment-associated risks. Although advances in neuroimaging and skull base surgery have improved the characterization and treatment of these lesions, determining the most appropriate therapeutic strategy remains

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challenging because visual outcomes are influenced by multiple interacting factors. The evidence examined throughout this review supports the importance of individualized decision-making rather than selecting treatment exclusively according to tumor size, anatomical location, or the possibility of achieving complete resection [1], [8], [10].

Anatomical Characteristics and Radiological Correlation

One of the principal findings concerns the high frequency of optic canal involvement among tuberculum sellae meningiomas. The surgical series reported by Schick and Hassler demonstrated optic canal extension in 69.8% of patients, illustrating the close anatomical relationship between these tumors and the anterior visual apparatus. Importantly, the investigators found that tumor size was not significantly associated with visual acuity, whereas longer symptom duration, increasing age, and intraconal extension were associated with less favorable visual findings [13]. These observations suggest that the clinical relevance of radiological abnormalities cannot be adequately determined through tumor dimensions alone.

This relationship is consistent with the recommendations of the European Association of Neurosurgical Societies, which emphasize detailed anatomical assessment using MRI, CT, and selected vascular imaging techniques. High-resolution imaging is particularly relevant for characterizing optic canal extension, hyperostosis, vascular encasement, and relationships with the cavernous sinus [10]. Nevertheless, conventional neuroimaging cannot reliably establish the degree of microscopic neural injury or distinguish reversible compression from advanced optic neuropathy. Consequently, the integration of radiological findings with functional neuro-ophthalmological evaluation remains essential.

The anatomical heterogeneity identified in this review also reinforces the importance of distinguishing optic nerve sheath meningiomas from tumors originating in the tuberculum sellae or anterior clinoid process. Although these lesions may produce similar manifestations of optic neuropathy, their growth patterns, relationships with the optic nerve, and therapeutic considerations differ substantially. Therefore, their outcomes should not be combined indiscriminately when interpreting surgical or radiotherapeutic evidence [2], [3], [9].

Visual Recovery and Selection of Surgical Approach

The comparison of neurosurgical techniques revealed differences in postoperative visual recovery between transcranial and expanded endoscopic endonasal approaches. In the international multicenter investigation by Magill et al., visual improvement among patients with preoperative impairment was observed in 73.0% of those treated through the endoscopic endonasal approach, compared with 57.1% undergoing transcranial surgery [17]. These findings suggest a potential functional advantage of endonasal surgery in appropriately selected patients. However, the interpretation of this difference requires consideration of the unequal baseline characteristics of the two populations.

Patients selected for endoscopic endonasal surgery had smaller tumors on average and shorter postoperative follow-up periods. Furthermore, the selection of surgical approach was not randomized, and each participating institution employed techniques according to anatomical characteristics and surgical expertise. Therefore, the observed differences cannot be attributed exclusively to the surgical corridor. This distinction is particularly important because observational comparisons may favor a technique used more frequently in patients with less complex anatomical presentations [17].

Evidence from Latin America contributes to this discussion. Marian-Magaña et al. evaluated 29 patients treated at a Mexican referral center and found no statistically significant differences in visual outcomes between transcranial and endoscopic endonasal approaches. Although certain functional measurements numerically favored one technique, the limited sample size and retrospective design restricted definitive comparisons [18]. These findings differ from the larger international cohort in their statistical results but remain compatible with the broader observation that surgical outcomes depend on patient selection, anatomical characteristics, and institutional experience.

The central question is therefore not whether one surgical technique is universally superior, but under which anatomical and functional circumstances each approach provides the most appropriate balance between tumor removal and visual preservation. Predominantly midline lesions may be accessible through an endoscopic endonasal corridor, whereas

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tumors with extensive lateral extension, complex vascular involvement, or substantial anterior clinoid relationships may require transcranial exposure [10], [17], [18].

CONCLUSION

The management of optic pathway-related meningiomas represents a complex clinical challenge in which anatomical characteristics, radiological findings, and visual function must be evaluated as interconnected determinants of therapeutic decision-making. This narrative review highlights the importance of integrating high-resolution neuroimaging with comprehensive neuro-ophthalmological assessment to characterize tumor extension, identify optic nerve compromise, and establish individualized treatment strategies. Tumor dimensions alone are insufficient to determine clinical severity, particularly when lesions involve anatomically restricted regions such as the optic canal or establish close relationships with critical neurovascular structures [1], [10], [13].

The reviewed evidence demonstrates that both transcranial and endoscopic endonasal approaches can achieve favorable visual outcomes in appropriately selected patients. Although several investigations reported higher proportions of postoperative visual improvement following endoscopic endonasal surgery, differences in tumor characteristics, baseline visual impairment, and institutional experience limit the possibility of establishing the superiority of a single surgical technique. Furthermore, optic canal decompression was associated with substantial rates of visual improvement, whereas postoperative complications, particularly cerebrospinal fluid leakage, remained important considerations when comparing surgical strategies [16], [17].

The incorporation of Latin American investigations provides additional perspectives on clinical management and reinforces the relevance of adapting therapeutic decisions to anatomical characteristics and available institutional resources. Radiotherapy also constitutes an important treatment option, particularly for optic nerve sheath meningiomas in which surgical manipulation may threaten preserved visual function [7], [18], [19].

Despite advances in diagnostic and therapeutic techniques, the available evidence remains limited by the predominance of retrospective studies, heterogeneous patient populations, and differences in visual outcome assessment. Future prospective multicenter investigations should prioritize standardized neuro-ophthalmological measurements, detailed radiological classifications, and long-term functional follow-up to improve prognostic accuracy and facilitate more reliable comparisons between therapeutic approaches.

Ultimately, successful management of optic pathway-related meningiomas should not be defined exclusively by the extent of tumor resection or radiological disease control. Preservation of visual function, prevention of neurological complications, and maintenance of long-term quality of life must remain central objectives. An individualized, multidisciplinary approach supported by contemporary scientific evidence constitutes the most appropriate framework for balancing therapeutic effectiveness with functional safety.

REFERENCES

[1] R. Goldbrunner *et al*., “EANO guideline on the diagnosis and management of meningiomas,” *Neuro-Oncology*, vol. 23, no. 11, pp. 1821–1834, 2021, doi: 10.1093/neuonc/noab150.
[2] R. T. Parker, C. A. Ovens, C. L. Fraser, and C. Samarawickrama, “Optic nerve sheath meningiomas: prevalence, impact, and management strategies,” *Eye Brain*, vol. 10, pp. 85–99, 2018, doi: 10.2147/EB.S144345.
[3] B. Lindblom, C. L. Truwit, and W. F. Hoyt, “Optic nerve sheath meningioma: Definition of intraorbital, intracanalicular, and intracranial components with magnetic resonance imaging,” *Ophthalmology*, vol. 99, no. 4, pp. 560–566, 1992, doi: 10.1016/S0161-6420(92)31932-3.
[4] R. E. Turbin, C. R. Thompson, J. S. Kennerdell, K. P. Cockerham, and M. J. Kupersmith, “A long-term visual outcome comparison in patients with optic nerve sheath meningioma managed with observation, surgery, radiotherapy, or surgery and radiotherapy,” *Ophthalmology*, vol. 109, no. 5, pp. 890–899, 2002, doi: 10.1016/S0161-6420(02)01017-5.
[5] P. Saeed *et al*., “Primary radiotherapy in progressive optic nerve sheath meningiomas: A long-term follow-up study,” *Br. J. Ophthalmol.*, vol. 94, no. 5, pp. 564–568, 2010, doi: 10.1136/bjo.2009.166793.
[6] Y. J. Vaishnav *et al*., “Radiotherapy and radiosurgery in the management of optic nerve sheath meningiomas: An international systematic review and meta-analysis of twenty studies,” *World Neurosurg.*, vol. 164, pp. e929–e944, 2022, doi: 10.1016/j.wneu.2022.05.064.

[7] J. A. Torres-Ríos *et al*., "Radiation therapy for optic nerve sheath meningiomas: Local control and treatment related visual changes," *World Neurosurg. X*, vol. 23, Art. no. 100291, 2024, doi: 10.1016/j.wnsx.2024.100291.
[8] P.-L. Hénaux, M. Bretonnier, P.-J. Le Reste, and X. Morandi, "Modern management of meningiomas compressing the optic nerve: A systematic review," *World Neurosurg.*, vol. 118, pp. e677–e686, 2018, doi: 10.1016/j.wneu.2018.07.020.
[9] W. R. Copeland, J. J. Van Gompel, C. Giannini, L. J. Eckel, K. K. Koeller, and M. J. Link, "Can preoperative imaging predict tumor involvement of the anterior clinoid in clinoid region meningiomas?," *Neurosurgery*, vol. 77, no. 4, pp. 525–530, 2015, doi: 10.1227/NEU.0000000000000873.
[10] D. Starnoni *et al*., "Surgical management of anterior clinoidal meningiomas: Consensus statement on behalf of the EANS skull base section," *Acta Neurochir. (Wien)*, vol. 163, no. 12, pp. 3387–3400, 2021, doi: 10.1007/s00701-021-04964-3.
[11] A. Leclerc, T. Gaberel, M.-A. Laville, S. Derrey, J.-C. Quintyn, and E. Emery, "Factors associated with favorable visual outcome after surgery of clinoidal meningiomas," *Clin. Neurol. Neurosurg.*, vol. 223, Art. no. 107508, 2022, doi: 10.1016/j.clineuro.2022.107508.
[12] S. Cohen-Cohen *et al*., "Anterior clinoid meningiomas: Surgical results and proposed scoring system to predict visual outcomes," *J. Neurosurg.*, vol. 140, no. 5, pp. 1295–1304, 2024, doi: 10.3171/2023.8.JNS23894.
[13] U. Schick and W. Hassler, "Surgical management of tuberculum sellae meningiomas: Involvement of the optic canal and visual outcome," *J. Neurol. Neurosurg. Psychiatry*, vol. 76, no. 7, pp. 977–983, 2005, doi: 10.1136/jnnp.2004.039974.
[14] T. Mathiesen and L. Kihlström, "Visual outcome of tuberculum sellae meningiomas after extradural optic nerve decompression," *Neurosurgery*, vol. 59, no. 3, pp. 570–576, 2006, doi: 10.1227/01.NEU.0000228683.79123.F9.
[15] N. Margalit *et al*., "Tuberculum sellae meningiomas: Surgical technique, visual outcome, and prognostic factors in 51 cases," *J. Neurol. Surg. B Skull Base*, vol. 74, no. 4, pp. 247–258, 2013, doi: 10.1055/s-0033-1342920.
[16] P.-W. Lin, W. You, A.-S. Guo, Z.-R. Lin, and Y.-Z. Wang, "Efficiency and safety of optic canal unroofing in tuberculum sellae meningiomas: A meta-analysis and systematic review," *Neurosurg. Rev.*, vol. 46, no. 1, Art. no. 240, 2023, doi: 10.1007/s10143-023-02151-9.
[17] S. T. Magill *et al*., "International Tuberculum Sellae Meningioma Study: Surgical outcomes and management trends," *Neurosurgery*, vol. 93, no. 6, pp. 1259–1270, 2023, doi: 10.1227/neu.0000000000002569.
[18] R. Marian-Magaña *et al*., "Visual outcomes in tuberculum sellae meningiomas comparing transcranial and endoscopic endonasal approaches," *World Neurosurg. X*, vol. 23, Art. no. 100319, 2024, doi: 10.1016/j.wnsx.2024.100319.
[19] J. A. Landeiro, M. B. Gonçalves, R. D. Guimarães, J. Klescoski, J. L. A. Correa, M. A. Lapenta, and O. Maia, "Tuberculum sellae meningiomas: Surgical considerations," *Arq. Neuropsiquiatr.*, vol. 68, no. 3, pp. 424–429, 2010, doi: 10.1590/S0004-282X2010000300019.
[20] C.-C. Lee, T.-W. Chang, Y.-C. Wang, Y.-J. Lin, Y.-C. Huang, P.-W. Hsu, A. P.-H. Huang, and C.-C. Chuang, "Visual outcomes following endoscopic endonasal approach for tuberculum sellae meningiomas: A systematic review and meta-analysis," *Int. J. Surg.*, vol. 112, no. 4, pp. 10560–10571, 2026, doi: 10.1097/JS9.0000000000004737.

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