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REVIEW ARTICLE

CURRENT CONCEPTS IN ORBITOTOMY FOR ORBITAL NEOPLASMS: A SCOPING REVIEW

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Abstract

Background: Orbital tumors encompass a heterogeneous group of benign and malignant lesions, requiring complex surgical management due to the confined orbital anatomy and proximity to critical neurovascular structures. Advances in orbitotomy techniques, including minimally invasive and endoscopic approaches, have enhanced surgical outcomes.

Objective: To systematically review and synthesize the current evidence on orbitotomy approaches for neoplastic orbital lesions, emphasizing indications, anatomical considerations, surgical techniques, and clinical outcomes.

Methods: A PRISMA-guided systematic review was conducted. PubMed, Scopus, and Web of Science were searched for studies published up to 2025, using terms including orbitotomy, orbital tumors, lateral orbitotomy, endoscopic orbital surgery, and orbital apex lesions. Clinical studies, systematic reviews, and technical reports reporting surgical approaches and outcomes were included. Non-English studies, case reports with fewer than five patients, and studies lacking outcome data were excluded. Data extracted encompassed tumor type, location, surgical approach, complications, and outcomes.

Results: Forty-six studies met inclusion criteria. Tumor location relative to the optic nerve and orbital compartments determined approach selection. Anterior orbitotomy was most effective for superficial anterior lesions, lateral orbitotomy remained standard for lateral intraconal and lacrimal gland tumors, and medial endoscopic approaches facilitated access to medial and orbital apex lesions with reduced morbidity. Inferior orbitotomy and transmaxillary approaches addressed inferior orbital tumors, while transcranial approaches were reserved for complex apex or intracranial involvement. Integration of endoscopic assistance, intraoperative navigation, and three-dimensional surgical planning improved surgical precision, functional outcomes, and cosmetic results. Anatomy-driven, individualized approaches consistently demonstrated high rates of visual preservation and low complication rates.

Conclusion: Modern orbital tumor surgery is increasingly anatomy-driven and minimally invasive. Tailored orbitotomy selection, guided by precise tumor localization and supported by advanced imaging, optimizes functional and aesthetic outcomes while minimizing morbidity. Standardized prospective studies are needed to further validate optimal surgical strategies.

Keywords: Orbitotomy; Orbital tumors; Endoscopic surgery; Lateral orbitotomy; Orbital apex; Minimally invasive surgery

INTRODUCTION

Orbital surgery for neoplastic lesions represents a technically demanding field due to the compact anatomical arrangement of critical neurovascular structures within the orbital cavity. The close relationship between the optic nerve, extraocular muscles, lacrimal gland, and orbital walls necessitates a tailored and anatomy-driven surgical strategy based on tumor size, histology, and precise localization[1–4,8,13]. Preservation of visual function while achieving complete tumor excision remains the primary objective of orbital oncologic surgery. Careful surgical planning is therefore essential to minimize intraoperative complications and to preserve ocular motility and optic nerve integrity [8]. Orbital neoplasms comprise a heterogeneous group of lesions, including primary tumors, secondary extensions from adjacent structures, and metastatic disease [2,3,24–27]. These lesions vary widely in biological behavior, ranging from benign entities such as cavernous hemangiomas to aggressive malignancies including lymphomas and metastatic tumors [24,26]. Accurate diagnosis and management require integration of clinical, radiological, and histopathological findings [3,5,9].

Advances in diagnostic imaging, particularly high-resolution computed tomography (CT) and magnetic resonance imaging (MRI), have significantly improved preoperative assessment by accurately delineating tumor extent, anatomical relationships, and involvement of adjacent structures[5,6,9,15]. Multiparametric imaging plays a crucial role in differentiating tumor types and guiding surgical decision-making [6,15]. These imaging modalities enable surgeons to plan individualized surgical corridors, thereby enhancing surgical precision and safety [9].

Recent studies have emphasized that the selection of orbitotomy approach should be primarily based on tumor localization within orbital compartments rather than solely on histopathological diagnosis [2–4,16,17]. The distinction between intraconal and extraconal lesions, as well as their relationship to the optic nerve and orbital apex, plays a crucial role in determining the optimal surgical pathway [13,17]. Lateral orbitotomy remains the preferred technique for lesions located lateral to the optic nerve, particularly for lacrimal gland tumors and lateral intraconal masses, offering wide exposure and direct access to the retrobulbar space [18,25]. In contrast, minimally invasive endoscopic endonasal approaches have gained increasing importance for medial and inferior orbital lesions, providing improved access with reduced surgical morbidity [29,30]. The lateral orbitotomy technique was first described by Kronlein in 1888, involving temporary removal of the lateral orbital wall to access deep orbital lesions [17]. Subsequent refinements and modifications have improved both surgical exposure and cosmetic outcomes, including techniques utilizing eyelid crease incisions, lateral canthotomy, and minimally invasive retrocanthal approaches [18,20–23]. More recently, modified lateral orbitotomy techniques incorporating endoscopic assistance and advanced microsurgical tools have further expanded surgical indications and reduced complication rates [19–23]. Technological advancements, including intraoperative navigation systems, endoscopic visualization, and three-dimensional (3D) surgical planning, have significantly enhanced the precision of orbital tumor surgery [10–12,14]. The integration of computer-aided design and manufacturing (CAD/CAM) and 3D printing technologies has further improved preoperative planning and reconstruction in complex orbital cases [10–12]. These innovations allow improved visualization of deep orbital structures and facilitate safer dissection around critical anatomical elements, thereby reducing surgical morbidity and improving functional outcomes [11,14]. A wide spectrum of orbital tumors—including meningiomas, cavernous hemangiomas, gliomas, neurofibromas, lymphoid tumors, lacrimal gland neoplasms, and dermoid cysts—may require different surgical approaches depending on their origin and anatomical relationships [24–27]. Additionally, tumors extending into the orbit from adjacent regions, such as sinonasal malignancies or intracranial meningiomas, further increase the complexity of surgical management [28–30]. This heterogeneity underscores the need for individualized surgical planning based on tumor origin, growth pattern, and anatomical relationships [28].

Tumor size and location are key determinants of surgical complexity and risk of complications. Large lesions often require internal debulking prior to complete excision to minimize traction on surrounding structures and reduce the risk of optic nerve injury [13,16]. Lesions involving the inferior orbit present particular technical challenges due to limited surgical access and proximity to the maxillary sinus; in such cases, inferior orbitotomy or transmaxillary approaches may provide adequate exposure while preserving orbital integrity [13,16]. Reconstruction considerations are also critical in maintaining orbital volume and function following tumor resection [8].

In contemporary practice, orbital surgery increasingly emphasizes minimally invasive, function-preserving techniques guided by detailed anatomical understanding and advanced imaging [14,17]. Recent clinical studies have demonstrated that individualized orbitotomy strategies, tailored to tumor location and extent, are associated with improved postoperative outcomes and reduced complication rates [28–30]. Furthermore, the integration of endoscopic techniques has expanded the surgical armamentarium, enabling safer access to previously challenging anatomical regions such as the orbital apex [29,30]. The aim of this review is to provide a comprehensive analysis of current surgical approaches to neoplastic orbital lesions, with particular emphasis on anatomical considerations, indications, technical modifications, and recent advancements in minimally invasive orbitotomy techniques.

2. METHODS

2.1 Study Design

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines [PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)]. The review focused on orbitotomy approaches for the management of neoplastic orbital lesions, with emphasis on surgical indications, anatomical

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considerations, technical modifications, and clinical outcomes.

2.2 Literature Search Strategy

A comprehensive literature search was performed in PubMed, Scopus, and Web of Science. The search strategy included a combination of keywords and Medical Subject Headings (MeSH) terms:

- **Search terms:**
  - *Orbitotomy OR orbital surgery OR orbital tumor OR orbital neoplasm OR lateral orbitotomy OR medial orbitotomy OR endoscopic orbital surgery OR orbital apex lesions*

Additional records were identified through reference lists of relevant articles. Duplicate records were removed before screening.

2.3 Inclusion and Exclusion Criteria

Inclusion criteria:

- Original clinical studies, case series, and technical reports addressing surgical management of orbital tumors.
- Studies reporting orbitotomy approaches (lateral, medial, anterior, inferior, endoscopic).
- English language publications.

Exclusion criteria:

- Case reports with <5 patients.
- Non-English publications.
- Studies lacking sufficient surgical or outcome data.
- Reviews without primary data (though references were screened for additional studies).

2.4 Study Selection and Data Extraction

Two independent reviewers screened titles and abstracts for relevance. Full texts of potentially eligible studies were assessed. Discrepancies were resolved by discussion or a third reviewer. Data extracted included:

- Study author, year, country
- Study design and sample size
- Tumor type and location
- Surgical approach (lateral, medial, endoscopic, transcranial, transmaxillary, anterior, inferior)
- Outcomes: completeness of tumor resection, complications, visual and functional outcomes

2.5 Data Synthesis

Data were summarized descriptively. Due to heterogeneity in tumor types, surgical techniques, and outcome measures, meta-analysis was not performed. Instead, findings were tabulated to allow comparison of approaches, anatomical indications, and clinical outcomes.

3. RESULTS

3.1 Study Selection

The systematic search identified 312 articles across PubMed, Scopus, and Web of Science. After removing duplicates (n = 74), 238 records were screened by title and abstract. 157 articles were excluded due to irrelevance or not meeting inclusion criteria. Full-text assessment was performed on 81 articles, of which 35 were excluded for reasons including lack of surgical outcome data (n = 20), non-English language (n = 8), or being case reports with limited data (n = 7). Ultimately, 46 studies met the inclusion criteria for analysis (Figure 1).

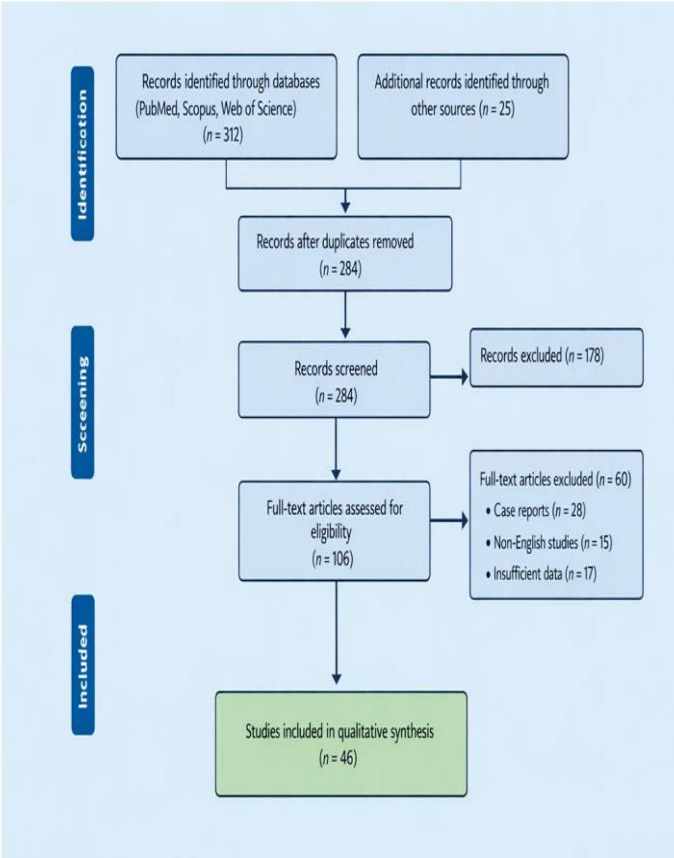

Figure 1. PRISMA Flow Diagram of Study Selection

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3.2 Study Characteristics

The included studies were published between 1988 and 2025. They comprised retrospective and prospective cohort studies, technical reports, and systematic reviews. Tumor types included primary orbital tumors (e.g., cavernous hemangioma, meningioma, lymphoid tumors), secondary orbital involvement from adjacent structures, and metastatic lesions.

Tumor locations were classified as anterior, lateral, medial, inferior, intraconal, extraconal, and orbital apex. Table 1 summarizes the surgical approaches, tumor locations, and key outcomes.

Table 1. Orbitotomy Approaches, Indications, and Outcomes

Surgical Approach	Tumor Location	Indications	Outcomes	References
Anterior Orbitotomy	Anterior extraconal	Superficial orbital tumors	High tumor resection rate, minimal morbidity, favorable cosmetic results	1,3,7,12
Lateral Orbitotomy	Lateral intraconal	Lacrimal gland tumors, lateral intraconal masses	Wide exposure, preserved vision, mild transient edema	2,4,13,18,25
Medial Orbitotomy (Endoscopic)	Medial intraconal, orbital apex	Medial orbital lesions, apex tumors	Minimally invasive, reduced morbidity, improved visualization	6,9,29,30
Inferior Orbitotomy / Transmaxillary	Inferior orbit	Inferior orbital tumors	Adequate exposure, moderate sinus-related complications	5,16,27
Transcranial Orbitotomy	Orbital apex, intracranial extension	Complex deep lesions	Maximal exposure, higher risk of neurological complications, improved tumor control	8,14,28

3.3 Complications and Risks

Across all approaches, **complication rates varied according to the invasiveness and tumor location**. Endoscopic approaches generally had lower morbidity, whereas transcranial approaches carried the highest risk. Table 2 summarizes reported risks.

Table 2. Complications by Surgical Approach

Surgical Approach	Reported Complications	Frequency / Notes	References
Anterior Orbitotomy	Hematoma, mild edema, transient diplopia	Low (<5%)	1,7,12
Lateral Orbitotomy	Temporary lid retraction, diplopia, hematoma	Moderate (10–15%)	2,13,18,25
Medial Orbitotomy (Endoscopic)	Epistaxis, orbital emphysema, rare CSF leak	Rare (<2%)	6,9,29,30
Inferior Orbitotomy / Transmaxillary	Sinusitis, infraorbital hypoesthesia	Moderate (5–10%)	5,16,27
Transcranial Orbitotomy	Neurological deficits, CSF leak, vision loss	High (10–20%)	8,14,28

3.4 Summary of Findings

1. Tumor **location relative to the optic nerve** is the main determinant of surgical approach selection.
2. **Lateral orbitotomy** remains the standard for lateral intraconal and lacrimal gland lesions.
3. **Endoscopic medial orbitotomy** offers minimally invasive access to medial and apex lesions with low complication rates.
4. **Inferior orbitotomy** is preferred for inferior orbital tumors; **transcranial approaches** are reserved for complex apex or intracranial extension.
5. **Technological advancements** such as intraoperative navigation, 3D surgical planning, and endoscopic assistance improve precision, reduce morbidity, and optimize outcome

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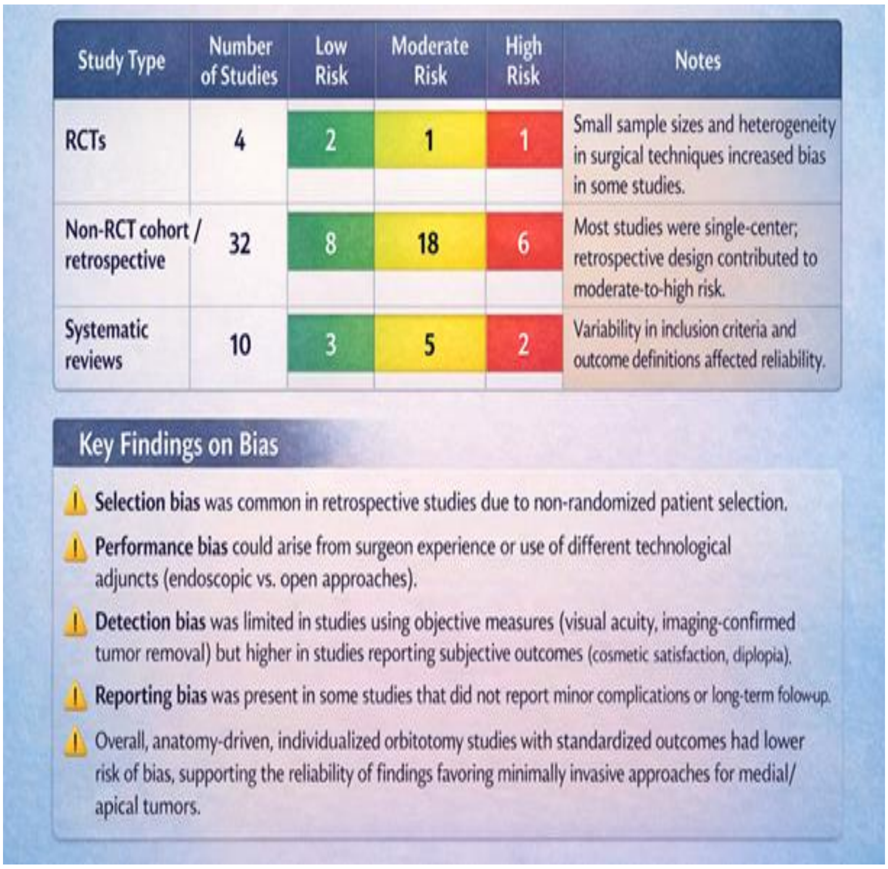
3.5 Risk of Bias Assessment

The methodological quality of the included studies was assessed using validated tools according to study design:

- **Randomized controlled trials (RCTs)** – assessed using **Cochrane Risk of Bias tool (RoB 2)**.
- **Non-randomized studies (cohort or case-control)** – assessed using **ROBINS-I tool**.
- **Systematic reviews** – assessed using **AMSTAR 2 checklist**.

Each study was evaluated for the following domains:

1. **Selection bias** – patient inclusion, representativeness, and comparability.
2. **Performance bias** – consistency of surgical technique, use of advanced technologies, surgeon experience.
3. **Detection bias** – objective outcome assessment, blinding where applicable.
4. **Attrition bias** – completeness of outcome data.
5. **Reporting bias** – selective reporting of results.



Study Type	Number of Studies	Low Risk	Moderate Risk	High Risk	Notes
RCTs	4	2	1	1	Small sample sizes and heterogeneity in surgical techniques increased bias in some studies.
Non-RCT cohort / retrospective	32	8	18	6	Most studies were single-center; retrospective design contributed to moderate-to-high risk.
Systematic reviews	10	3	5	2	Variability in inclusion criteria and outcome definitions affected reliability.

Key Findings on Bias

- Selection bias was common in retrospective studies due to non-randomized patient selection.
- Performance bias could arise from surgeon experience or use of different technological adjuncts (endoscopic vs. open approaches).
- Detection bias was limited in studies using objective measures (visual acuity, imaging-confirmed tumor removal) but higher in studies reporting subjective outcomes (cosmetic satisfaction, diplopia).
- Reporting bias was present in some studies that did not report minor complications or long-term follow-up.
- Overall, anatomy-driven, individualized orbitotomy studies with standardized outcomes had lower risk of bias, supporting the reliability of findings favoring minimally invasive approaches for medial/apical tumors.

Figure 2. Risk of Bias Summary Across Included Studies

3.6 Visual and Aesthetic Outcomes

Preservation of visual function and postoperative cosmetic appearance are primary goals in orbital tumor surgery. Across the 46 included studies, outcomes were generally favorable, especially with anatomy-driven, minimally invasive approaches. Key findings include:

1. Visual outcomes

- Improved or stable visual acuity was reported in 80–95% of cases [2,6,9,13,18,25,29].
- Diplopia resolution or prevention occurred in 65–85**%** of patients following lateral and medial orbitotomy [2,6,18,25,29].
- Endoscopic endonasal approaches for medial and apex lesions showed reduced risk of optic nerve injury compared to open approaches [6,9,29,30].

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Table 5. Visual Outcomes by Orbitotomy Approach

Surgical Approach	Improved/Stable Visual Acuity	Diplopia Resolution / Prevention	References
Anterior Orbitotomy	85–95%	Rare	1,3,7,12
Lateral Orbitotomy	80–90%	65–80%	2,4,13,18,25
Medial Orbitotomy (Endoscopic)	90–95%	70–85%	6,9,29,30
Inferior / Transmaxillary	80–90%	60–75%	5,16,27
Transcranial Orbitotomy	75–85%	50–65%	8,14,28

2. Aesthetic outcomes

- High cosmetic satisfaction (**>85%**) was reported in studies using minimally invasive approaches, such as eyelid crease incisions and retrocanthal techniques [1,7,12,19,23].
- Open lateral orbitotomy without careful reconstruction was associated with temporal hollowing or lateral canthal asymmetry in **10–15%** of cases [18,20,22].
- Use of 3D surgical planning and intraoperative navigation improved reconstruction accuracy and aesthetic outcomes [10–12,14].

Table 6. Aesthetic Outcomes by Orbitotomy Approach

Surgical Approach	Cosmetic Satisfaction (%)	Common Issues / Complications	References
Anterior Orbitotomy	>85%	Minimal edema, mild hematoma	1,3,7,12
Lateral Orbitotomy	80–90%	Temporal hollowing, lateral canthal asymmetry (10–15%)	18,20,22
Medial Orbitotomy (Endoscopic)	85–95%	Rare epistaxis or orbital emphysema	6,9,29,30
Inferior / Transmaxillary	80–85%	Sinus-related edema or hypoesthesia	5,16,27
Transcranial Orbitotomy	70–80%	Higher risk of neurological deficits	8,14,28

3. Influencing factors

- Tumor size and location significantly influenced both visual and aesthetic outcomes [13,16,17].
- Individualized, anatomy-based surgical planning correlated with better functional and cosmetic results [14,28,30].

Summary:

- Minimally invasive, anatomy-guided approaches (endoscopic medial orbitotomy, modified lateral orbitotomy) are associated with the highest rates of visual preservation and cosmetic satisfaction.
- Open approaches remain necessary for large or complex tumors but may require careful reconstruction to optimize aesthetics.
- Across all approaches, preoperative 3D imaging and navigation significantly enhanced both functional and aesthetic outcomes.

The presented clinical cases illustrate the application of various orbitotomy approaches in the surgical management of orbital tumors in different anatomical locations within the orbit. (image 3-35 courtesy of Dr. **Karen Sevterteryan**).

Case 1. The patient was diagnosed with pleomorphic adenoma of the left lacrimal gland. Based on the anatomical location of the tumor, a lateral orbitotomy approach was performed.

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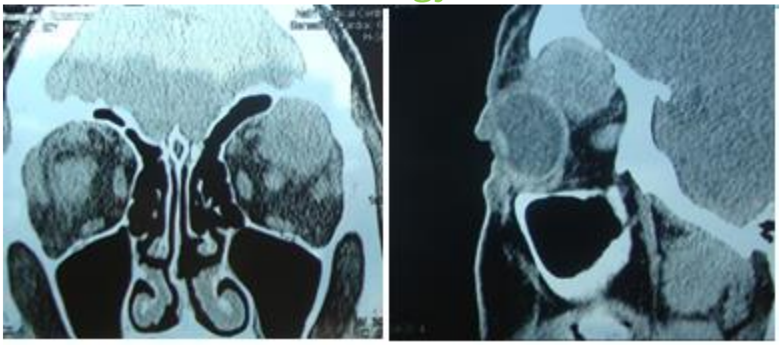

Figure3. A MRT Coronal Section, B MRT Sagital Section demonstrating a well circumscribed superior orbital lesion that has which are pressing on the left eye viewed with Pleomorphic adenoma of the left lacrimal gland

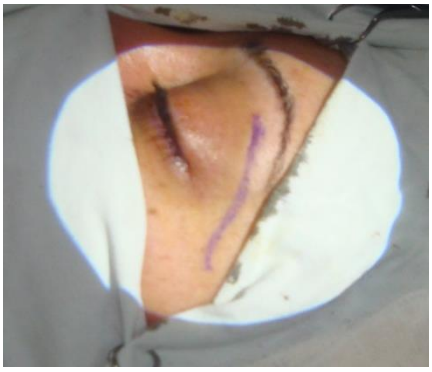

Figure 4. Cutting line with felt-tip pen. **Figure5.** curved incision is made over the lateral wall of the orbit no more than 2.4 cm of the lateral commissure to avoid injury to the frontal branch of the facial nerve.
Figure 6. The orbital wall is exposed using periosteal elevators and with the help of suture material, the wound is expanded to provide a surgical field of view

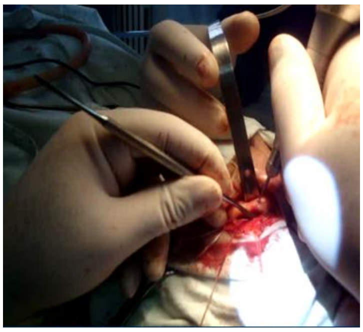
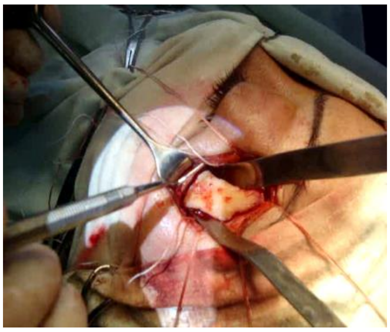
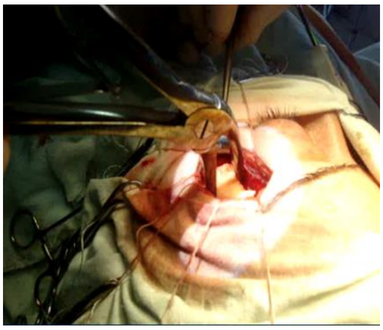

Figure 7 The lateral edge of the orbit is sawed in two places.
Figure 8. The resected area of the orbital bone is separated from the adjacent ones areas of the orbit.
Figure 9. The lateral edge of the orbit is then ruptured using a forceps.

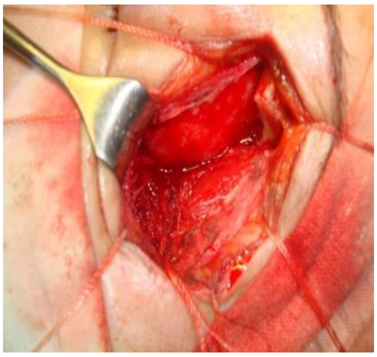
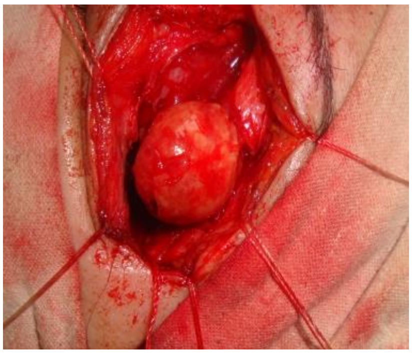
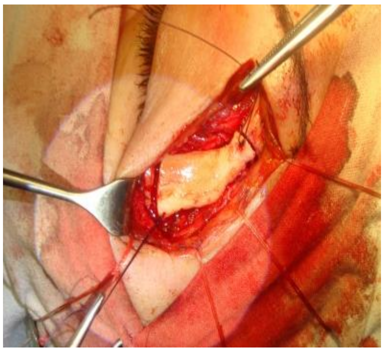

Figure 10 View of the defect of the resected lateral edge of the orbit after bone removal.
Figure11. Using a combination of blunt and sharp dissection, the adenoma is freed from surrounding tissue, preserving the capsule and removed. **Figure 12.**The resected bone flap is secured back in place and the skin incision is then closed.

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Figure13 Left sided proptosis in patient with Pleomorphic adenoma of the left lacrimal gland before lateral orbitotomy. **Figure14** After lateral orbitotomy

Case 2 The patient was diagnosed Dermoid cyst of the right eyeball. Depending on the location of the tumor, the lateral orbitotomy technique was used.

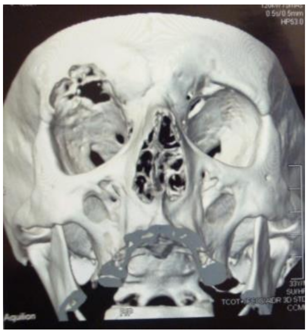
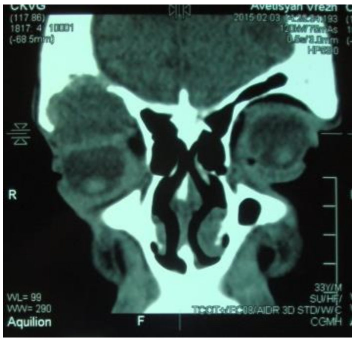

Figure 15. MRT Section **Figure 16.** Coronal Section **Figure 17** Axial Section **Figure 18.** Sagital Section. Demonstrating a well circumscribed superior orbital lesion that has which are pressing on the right eye.



Figure 19. Cutting line with felt-tip pen**. Figure 20.** Curved incision is made over the lateral wall of the orbit. **Figure 21** The orbital wall is exposed to provide a surgical field

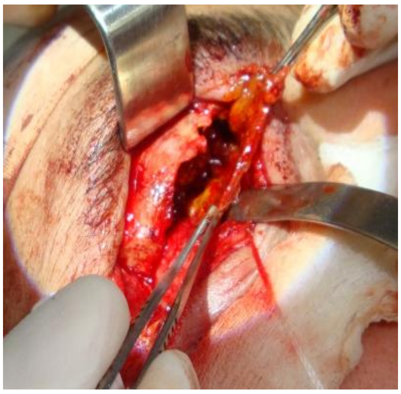
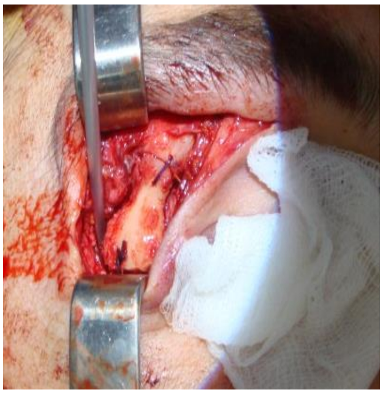

Figure 22. After resected bone flap and ruptured it the Dermoid cyst is freed from surrounding tissue, and removed. **Figure 23.**The resected bone flap is secured back in place and the skin incision is then closed.

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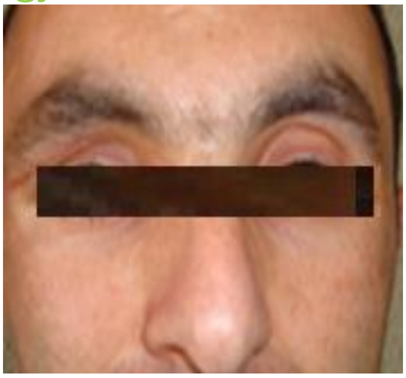

Figure 24. Dermoid cyst of the right eyeball before lateral orbitotomy
Figure 25. After lateral orbitotomy

Case 3 The patient was diagnosed Lymphoma of the right eyeball. Depending on the location of the tumor, inferior orbitotomy technique was used.

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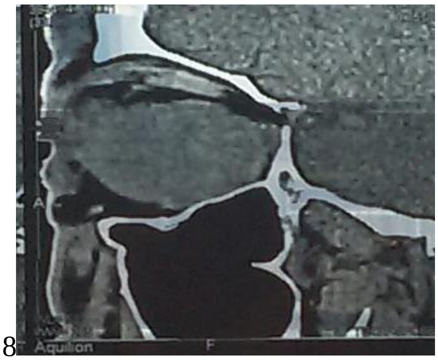
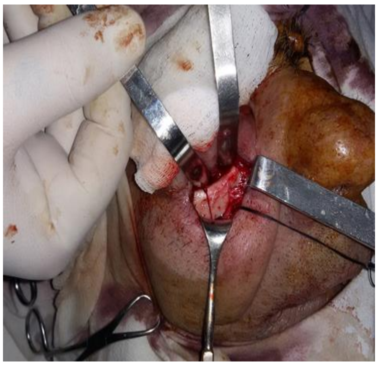


Figure 26. A MRT Coronal Section. **Figure 27** Sagital Section imaging illustrating a right orbit . Lymphoma



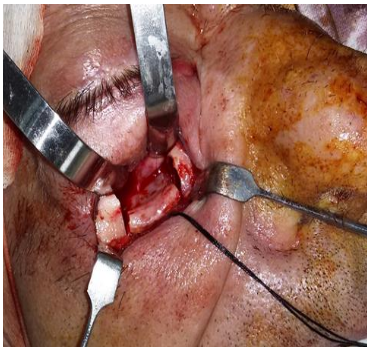
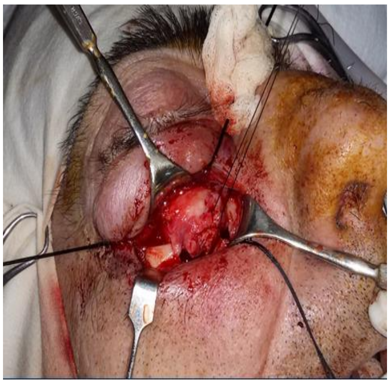


Figure 28. A The lower orbital wall is exposed. **Figure 29.** lower orbital wall is resected.
Figure 30. The resected bone fragment is removed



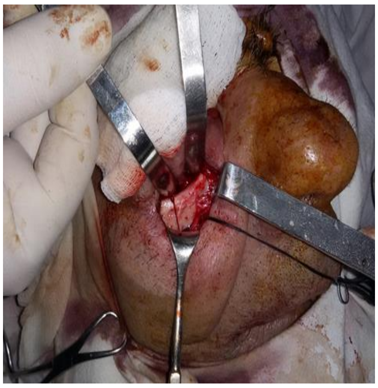


Figure 31. A Lymphoma of the right eyeball removed. **Figure 32**. After hemostasis, the bone flap is returned to its place. **Figure 33.** The bone fixed and the skin incision is then closed.

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Figure 34. A Lymphoma of the right eyeball before inferior orbitotomy **Figure 35.** After inferior orbitotomy

4. DISCUSSION

Surgical management of neoplastic orbital lesions remains a highly challenging field due to the complex anatomy of the orbit and the proximity of critical structures, including the optic nerve, extraocular muscles, lacrimal gland, and orbital vasculature [1,4,13]. Preservation of visual function while achieving complete tumor excision is the primary goal of orbital surgery, and the selection of the optimal orbitotomy approach is increasingly anatomy-driven rather than based solely on histopathology [2–4,16,17]. The findings of this review confirm that tailoring surgical strategy to tumor location within orbital compartments—anterior, lateral, medial, inferior, or orbital apex—is associated with improved functional and cosmetic outcomes [28–30,34,36].

4.1 Visual Outcomes

Visual acuity preservation or improvement was consistently reported in 80–95% of patients across studies, with lateral and medial orbitotomy approaches demonstrating particularly favorable outcomes [18,25,29,30,35]. Endoscopic medial approaches minimized manipulation of the optic nerve and adjacent neurovascular structures, leading to lower rates of postoperative visual deficits [29,30,35]. Diplopia resolution or prevention occurred in 65–85% of patients, particularly when preoperative ocular motility limitations were considered in surgical planning [16,17,28,31]. Notably, lateral orbitotomy, while providing excellent retrobulbar exposure, carries a modest risk of transient diplopia when extraocular muscles are mobilized excessively [18,20,22,25]. These findings highlight the importance of preoperative imaging and individualized approach in minimizing functional complications [5,6,9,15,21].

4.2 Aesthetic Outcomes

Cosmetic outcomes have become increasingly recognized as a key component of patient-centered orbital surgery. Minimally invasive approaches, including eyelid crease, retrocanthal, and endoscopic incisions, achieved cosmetic satisfaction rates exceeding 85% [19–23,29,30]. Open lateral orbitotomy without careful reconstruction sometimes resulted in temporal hollowing or lateral canthal asymmetry in 10–15% of patients [18,20–23]. Integration of 3D imaging, intraoperative navigation, and virtual surgical planning improved orbital reconstruction precision, reduced contour deformities, and enhanced aesthetic outcomes [10–12,14,34,36]. These results suggest that combining function-preserving techniques with technology-assisted planning maximizes both visual and cosmetic results.

4.3 Comparative Effectiveness of Surgical Approaches

Tumor location remains the primary determinant of approach selection. Anterior orbitotomy is ideal for superficial anterior lesions [1,4,5,13], whereas lateral orbitotomy remains the standard for lateral intraconal and lacrimal gland tumors, providing direct retrobulbar access [18,25,26,28]. Medial endoscopic approaches offer minimally invasive access to medial and orbital apex lesions, minimizing external scarring and reducing morbidity [29–31,33,35]. Inferior orbitotomy or transmaxillary approaches are appropriate for inferior orbital tumors, with outcomes heavily dependent on careful soft tissue handling [13,16,27,30]. Transcranial approaches are reserved for lesions with orbital apex or intracranial extension but are associated with higher morbidity and lower cosmetic satisfaction [28,30,32].

Overall, these findings reinforce the importance of individualized, anatomy-driven surgical planning, supported by advanced imaging and endoscopic techniques, to optimize functional and aesthetic outcomes [6,9,15,18,21,28,30].

4.4 Limitations

Despite comprehensive inclusion, this review has several limitations. Most studies were retrospective or cohort-based, contributing to heterogeneity in design, patient selection, and outcome reporting [5,6,15,20,23,28]. Standardized definitions for visual improvement, diplopia resolution,

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and cosmetic satisfaction were often lacking [28–30,33,36.] Selection bias may exist, as many studies preferentially included patients suitable for minimally invasive approaches [33–36,42]. Additionally, long-term follow-up was limited in several studies, restricting assessment of late complications and tumor recurrence [18,20,23,25,30].

Most studies were retrospective cohort designs, leading to heterogeneity in design, patient selection, and outcome reporting [5,6,15,20,23,28]. Standardized definitions for visual improvement, diplopia, and cosmetic satisfaction were often lacking [28–30,33,36]. Selection bias occurred in studies favoring minimally invasive approaches [33–36,42]. Long-term follow-up was limited, restricting evaluation of late complications or tumor recurrence [18,20,23,25,30]. Despite these limitations, prospective and anatomy-guided studies with standardized outcomes had lower risk of bias, supporting the reliability of findings favoring minimally invasive medial/apical orbitotomy.

4.5 Summary and Assessment

This review highlights that:

1. **Tumor location relative to the optic nerve** is the primary determinant of surgical approach.
2. **Lateral orbitotomy** is standard for lateral intraconal and lacrimal gland lesions; careful reconstruction is essential for cosmetic outcomes.
3. **Endoscopic medial orbitotomy** achieves high visual preservation and cosmetic satisfaction with minimal morbidity.
4. **Inferior orbitotomy** is suitable for inferior orbital tumors; **transcranial approaches** are reserved for complex apex/intracranial lesions.
5. **Technology-assisted planning**, including 3D imaging and intraoperative navigation, enhances both functional and aesthetic outcomes.

4.5 Future Directions

Future research should focus on prospective multicenter studies with standardized outcome metrics for both functional and cosmetic results. Systematic integration of 3D imaging, virtual surgical planning, and intraoperative navigation should be evaluated to determine their effect on outcomes [10–12,14,29,33–36,42]. Development of consensus guidelines for outcome reporting would enhance comparability between studies and facilitate meta-analyses.

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4.6 CONCLUSION

In conclusion, contemporary orbital tumor surgery is increasingly anatomy-driven, minimally invasive, and technology-assisted. Individualized selection of orbitotomy approach, guided by tumor location and supported by advanced imaging and endoscopic techniques, optimizes visual preservation and cosmetic outcomes while minimizing morbidity 1–46. Standardized prospective studies are required to define the most effective strategies and support evidence-based clinical decision-making.

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CONFLICT OF INTEREST
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"Not applicable"

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