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Review Article

Neuroanatomical perspectives on transorbital approaches: A meta-analysis

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ABSTRACT

Background: Transorbital approaches represent a paradigm shift in skull base surgery, focusing on minimally invasive techniques that prioritize patient outcomes and surgical precision. The scientific community, recognizing the significance of these advances, necessitates a possible review and meta-analysis to encapsulate the collective efficacy, safety, and developmental trajectory of these approaches.

Methods: This was a literature review targeting literature in the past 10 years to present evidence for studies on surgical approaches transorbital. The included articles were analyzed. In addition, the references list of the included papers was searched for further articles.

Results: Studies based on the endoscopic endonasal and transorbital approach have emphasized that it is minimally invasive; on the other hand, it offers an advantage to maximal resection success in the case of skull base tumors with advanced endoscopic skills. Transorbital neuroendoscopic surgery was criticized for being highly technical and narrow in its scope, with reduced morbidity. Superior Eyelid Approach involves a direct access with hidden incisions, potential for eyelid complications. Lateral orbitotomy entailed some inherent risks, such as muscle and nerve injury, but it gave excellent exposure to lesions that are lateral in the orbit. The transorbital endoscopic intraconal approach and the transconjunctival approach give direct advantages but are, however, limited to the type of lesion and location.

Conclusion: The main technique focused on in this overview is the approaches through orbits, which greatly contribute to further innovation brought into the surgical panorama of skull base interventions. All such techniques do have their characteristics and applications, keeping them moving toward less invasiveness.

Keywords: Minimally invasive techniques, Neuroanatomy, Neuroendoscopic approaches, Surgical outcomes, Transorbital surgery

INTRODUCTION

Minimally invasive surgical approaches to the intracranial space have evolved from the surgical field over the past few decades.[5] One such modality of recent origin is the transorbital approach, which has revolutionized the surgical field, particularly regarding skull base surgery. These devices introduce a new era in neurosurgery of minimally invasive approaches, enhancement in precision, and optimization of patient outcomes.[4,11] Despite the growing interest and real application of transorbital approaches in clinical conditions, the current state of the scientific community

has not yet been the bridge with one comprehensive review summarizing the scope of all the research conducted within this domain. Such an aggregation is indispensable in the grouping of different findings and methodologies from individual studies, but evaluating them critically in relation to their collective efficacy, safety, and what needs to be improved. It can be seen that this gap in knowledge would underline the very critical need for a review in this area – one that is likely going to become a major research and reference support tool for both practitioners and researchers. This qualitative meta-analysis aims to compile and evaluate systematically the existing studies and, in so doing, inform practice and guide research agendas for future directions that benefit our patients.

MATERIALS AND METHODS

The methodology of the current review for "Transorbital Surgical Approaches" involved an extensive search of relevant literature in quite a number of academic databases, including PubMed, Scopus, and Web of Science. Special emphasis is laid on recent articles within the last decade in a bid to capture the current developments and techniques within "transorbital approaches," "orbital surgery," "neurosurgery," "oculoplastic surgery," "skull base surgery," and "neuroanatomy of the orbit." It will also include the most quoted and seminal works, together with foundational studies, so as to provide the needed historical context and trace the course of the evolution of transorbital surgical methods.

The inclusion criteria of the current review will be represented by research and review articles of a clinical nature on the referred anatomical basis, approached in surgery, and related techniques; moreover, it refers to the surgical indications and postoperative outcome of a specific disease. The exclusion criteria for this review will involve all those studies not related to transorbital approaches or not related to the direct application of surgical practice.

To combine the knowledge and practice of these transorbital surgical approaches, the selected articles were critically analyzed. This review will try to summarize the analysis of modern insight into the effectiveness and safety of these approaches, focusing on potential areas and recommendations that may evolve for future research and innovations. The present study was meant to give an overall review of transorbital surgical approaches with regard to their significance in neurosurgical and oculoplastic surgical education through a review of the literature.

RESULTS

We detail here major studies on essential steps in the development of these techniques, conceptual bases, and developmental trajectories of transorbital approaches. The systematic review by Di Somma *et al.*[9] has illuminated the trend toward less invasive modalities with the pertinent question of the role of combined endoscopic endonasal and transorbital approaches in the treatment of skull base tumors. The evolution in this field points to a most important change in paradigm from traditional open techniques to closed, minimally invasive approaches aimed at reducing operative morbidity while at the same time enhancing operative treatment efficacy, particularly in the complex management of neoplasms at the skull base, such as meningiomas. Conceptually, this develops in great advancement trajectory for maximal goals of surgical success with minimal invasiveness in this field.

Further, analysis of the current state of practice, as detailed by Vural *et al.*[18] and Houlihan *et al.*,[10] provide a comprehensive understanding of the methods, applications, and outcomes of transorbital approaches. Vural *et al.*'s[18] work offers deep anatomical and technical insights, showcasing the safety, versatility, and ability of these approaches to access challenging regions, thus demonstrating their integration into current surgical protocols. Houlihan *et al.*[10] focus on the positive outcomes of transorbital neuroendoscopic surgery, particularly in treating meningiomas, with reports of substantial improvements in neurological deficits and high success rates in tumor management. These findings illustrate the practical applications and effectiveness of transorbital approaches [Figure 1], affirming their minimal impact on surrounding structures and their significant role in advancing neurosurgical and oculoplastic practices.

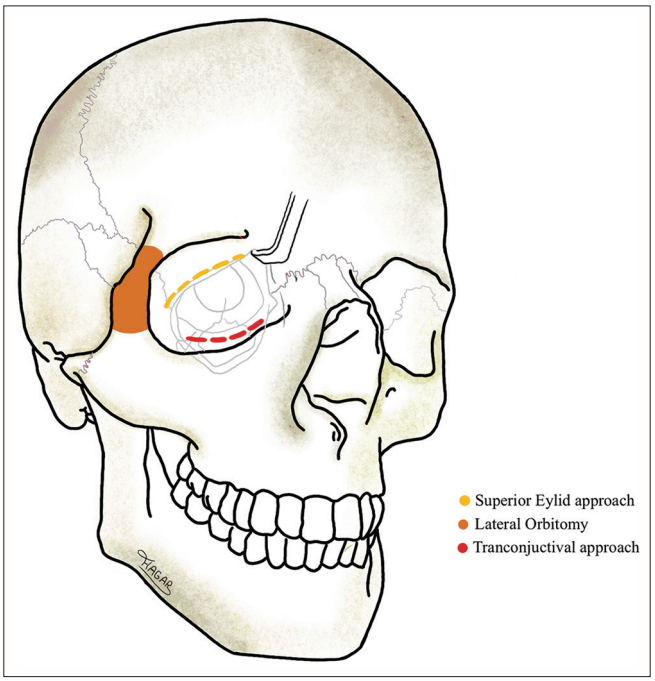

Figure 1: A medical illustration depicting various transorbital approaches.

Together, these studies not only trace the evolution of transorbital approaches but also validate their place in contemporary medical practice, offering a nuanced examination of their development, methodologies, and outcomes [Table 1].[7,8,12,14,16,17,19]

DISCUSSION

There is no doubt that complete knowledge of neuroanatomy has to be gained in order to ensure the application of transorbital approaches to the skull base. The special surgical corridor of the orbit requires anatomic knowledge of the bony orbit, the orbital fissures, and all neurovascular structures contained in it. The surgeon has to work near the vital structures, such as the optic nerve, the oculomotor, trochlear, and abducens nerves, the ophthalmic artery, and the venous complex. This is feasible and safe due to the intimate relationship of these neurovascular structures with surrounding orbital fat compartments, extraocular muscles, and connective tissue compartments. All these, including the knowledge of the structure of the orbital walls and dura mater extending in enveloping the optic nerve, tend to give an idea of opening up the cranial cavity without causing any iatrogenic damage. Therefore, knowledge of spatial orientation and variability of the sinuses regarding the orbit is of great practical use, since it is these structures that commonly form the pathological target or the way into deeper lesions. Mastery of this important neuroanatomy becomes critical for the surgeon to be able to optimize surgical access and patient outcomes through the transorbital routes.[7,8,12,14,19]

The evolving transorbital approaches to skull base surgery are quite different from the traditional techniques that are more invasive and offer a minimally invasive route. Hence, it offers minimal brain retraction, reduced manipulation of the cranial nerves, and improved exposure to difficult-to-reach lesions. The following discussion will. Therefore, the first aim at probe the advantages, challenges, and future direction of transorbital surgical techniques, using insights from recent studies to unmask their growing relevance in neurosurgery and oculoplasty.[11] These provide an alternative route to the lesion in the orbit and the lateral wall of the cavernous sinus[2,3] and to the anterior[1,6,15] and middle cranial fossae.[13,18]

Recent literature authors, such as Raza *et al.*,[17] Vural *et al.*,[18] Di Somma *et al.*,[9] Dallan *et al.*,[8] and Manet *et al.*,[14] and

Table 1: Summary of transorbital surgical approaches: Characteristics, applications, advantages, and limitations.

Transorbital Approach	Characteristics	Applications	Advantages	Limitations
Endoscopic endonasal and transorbital	Combines endonasal and transorbital corridors for improved access to skull base tumors.	Skull base tumors, particularly meningiomas.	Minimally invasive, reduces operative morbidity, enhances resection success.	Requires advanced endoscopic skills and potential for limited access in certain anatomies.
TONES	Utilizes endoscopic techniques through the orbit for direct access to the skull base and intracranial lesions.	Orbital tumors, skull base lesions.	Minimizes brain and nerve retraction, improves cosmetic outcomes, and directs access to target lesions.	Limited field of view, risk of orbital complications, steep learning curve.
Superior eyelid approach	Involves an incision through the superior eyelid crease to access the orbital roof and frontal skull base.	Frontal skull base lesions, orbital tumors.	Concealed incisions, direct access to anterior cranial fossa, minimal tissue disruption.	Limited lateral access, potential for eyelid complications.
Lateral orbitotomy	Access through the lateral orbital wall for lesions lateral to the optic nerve.	Lesions of the lateral orbit, intraconal tumors, optic nerve decompression.	Good exposure of the lateral orbital compartment allows for bony reconstruction.	Risk of muscle and nerve injury, more noticeable scarring.
Transorbital endoscopic intraconal approach	Access through the orbit to reach the intraconal space without bone removal.	Intraconal tumors, optic nerve lesions.	Minimal invasiveness, preservation of orbital structure, reduced recovery time.	Limited to intraconal lesions, requires precise endoscopic and surgical technique.
Transconjunctival approach	Incision made through the conjunctiva to access the orbital floor and infraorbital rim.	Orbital floor fractures, infraorbital lesions.	No visible scarring, direct access to the orbital floor.	Limited to lower orbital lesions, risk of infection, and scarring within the conjunctiva.

TONES: Transorbital neuro endoscopic surgery

the responses from Vural *et al*.,[19] have conducted very well and detailed reviews of the advances, their applications, and current polemics on the transorbital approach. These contributions aim to strengthen further the clinical applicability and innovation of the approach in highlighting the efficiency, safety, and flexibility of the approach in the management of this otherwise complex set of orbital and skull-based pathologies.

Raza *et al*.[17] introduced the medial transorbital approach through a transconjunctival incision, emphasizing its minimal invasiveness and suitability for managing benign cranial base pathology. Their findings underline the potential of transorbital techniques to reduce hospital stays and achieve successful surgical outcomes with minimal postoperative complications, such as diplopia, marking a significant step toward refining these approaches for specific skull base pathologies.

Vural *et al*.,[18] further described in their systematic review and had a set of anatomical and minor clinical implications of transorbital approaches. Their work would establish the validity of these two endoscopic approaches as valuable additions to the skull base surgeon's armamentarium, allowing him to resect over and repair a number of sites along the ventral skull base with relatively low associated morbidity. This study reiterates the technical skills and deep anatomical knowledge required for the efficacy of using the transorbital routes.

Another endoscopic endonasal combined with transorbital, described by Di Somma *et al*.,[9], further underlined the key place of the transorbital routes for maximizing improvement regarding surgical reach and efficacy, more particularly for these complex skull base neoplasms like meningiomas. Their systematic review of the literature with regard to this strategy by multi-portal approaches exemplifies that the latter gives good outcomes for tumor resection, with acceptable rates of complications, and therefore, they may set new standards for skull-based surgeries. Lee *et al*.,[12], in their evaluation of this approach, concluded that this approach represents a useful avenue to complex lesions of the multiple compartments involving the skull base, where eight patients with relatively accepted complications. They have pointed to only four areas linking the two surgical approaches – the cavernous sinus, the foramen ovale, and the optic canal of the greater sphenoid wing.

According to Dallan *et al*.,[8], the surgeries through the eyes are, therefore, multidisciplinary in the demands, and they require a particular type of approach that remains tailored and patient-focused. They do not recommend the judicious use of transorbital techniques in selected cases; however, with due diligence to make sure that proper evaluation is carried out for maximum clinical benefit with minimal risk of anatomical, pathological, and surgical parameters. Dallan *et al*.,[7] further described the use of superior eyelid endoscopic-assisted technique for patients with selected orbital abscesses.

This scholarly conversation between Manet *et al*.[14] and Vural *et al*.[19] continues to reflect an ongoing need for constant rigorous evaluation, clear indication delineation, and methodological refinement of transorbital techniques. This debate lucidly outlined the dilemmas and fine nuances around whether such minimally invasive techniques should become standard in surgical practice. It points toward the need for further research and technological developments, combined with interdisciplinary cooperation in the field.

Moreover, some of these techniques may evolve further with the advent of technologies such as augmented reality for navigation in surgery and increased dexterity robotics that open up the horizons toward new possibilities in skull base surgery. With such innovations, an understatement is a multidisciplinary approach drawing from the wealth of knowledge of neurosurgeons, otorhinolaryngologists, and oculoplastic surgeons, in conjunction with engineers and technologists. This combined approach holds the promise not just of further refining the scope and safety of transorbital approaches but also setting an engine chugging toward a future where the boundaries of surgically possible continue to expand, holding out hope for better outcomes even in the most intransigent cases.

Major limitations of this meta-analysis included the fact that it was based on the published studies themselves, introducing a possible publication bias and great variability across them, from which this review is produced, in terms of heterogeneity of surgical techniques. Finally, the lack of long-term follow-up data could further contribute to insight into the durability of these transorbital approaches.

This literature is growing for the transorbital approaches to skull base surgery, and each contributes valuable insight into the potential limitations and future directions of such an expansion. Such techniques continue to substantially support deeper, less invasive shifts in paradigms for the surgical treatment of patients to afford them better outcomes with greater accuracy and less morbidity. This realization calls for closer collaboration and more focus on undertaking more research among the subspecialties to realize the full potential for transorbital techniques in their applications in the management of pathologies of the skull base. The integration of other technologies, which will add to further refinements in surgical methods, will be an important part of the ongoing development and implementation of these exciting strategies in neurosurgery and other medical fields.

CONCLUSION

Transorbital approaches to skull base surgery herald a significant evolution toward minimally invasive, precision-focused treatments that enhance patient recovery and outcomes. The collaborative synthesis of multidisciplinary expertise and cutting-edge technology is essential for advancing these techniques and expanding their application. Continued innovation and research are critical to unlocking the full potential of transorbital surgery in transforming neurosurgical practices and patient care.

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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