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EXPANDED ENDONASAL TRANSSPHENOIDAL SURGERY FOR THE RESECTION OF TUBERCULUM SELLAE MENINGIOMA. DESCRIPTION OF SURGICAL TECHNIQUE AND REVIEW OF LITERATURE

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Abstract.
Meningiomas with originating from tuberculum sellae, sphenoid platform, and optic chiasmatic groove are collectively called as tuberculum sellae meningiomas (TSMs) and they are accounted for 5 to 10% of all intracranial meningiomas, which invade the optic canals and lead to visual impairment by displacing the optic nerves upward and laterally. Except presence of many transcranial microsurgical approaches, introduction of endoscopes with highest magnification and gaining much experience in this have made the endonasal route feasible for the resection of tuberculum sellae meningiomas. There are various case reports and mixed publication series discussing this approach. Despite pituitary adenomas, craniopharyngiomas, the literatures describing the surgical steps of endoscopic endonasal transsphenoidal surgery for the resection of tuberculum sellae meningiomas in detail are lacking

The objective of our research is to review recent literatures about endoscopic endonasal transsphenoidal surgery for the removal of tuberculum sellae meningiomas and describe surgical procedures step by step in a easy way for young neurosurgeons of developing countries.

Methods: In this study, we are going to review recent publications about endoscopic endonasal transsphenoidal surgery for the resection of TSMs by using Pubmed and Embase for the past ten years but, In this study, some older publications with significant importance were also included. The following key word for search in various combinations were used: tuberculum sellae, meningioma, endoscopy, tuberculum sellae meningioma, transsphenoidal surgery, transcranial surgery.

Results: A total of 27 publications including mixed case reports, original studies, systematic analyzes and review articles, video presentations were reviewed from the Pubmed and Embase database for the past ten years. Relevant anatomical knowledge and surgical procedure descriptions are collected. With the help of obtained information endoscopic endonasal transsphenoidal surgery explained step by step.

Conclusion: Except from traditional transcranial microsurgical approaches, recently introduced and being developed endoscopic techniques for the resection of tuberculum sellae meningiomas can be helpful by minimizing wide craniotomy approach related complications. Improvement in various skull base reconstruction methods decrease postoperative complications.

Key words. Meningioma, transsphenoidal surgery, tuberculum sellae, endonasal endoscopic transsphenoidal approach

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INTRODUCTION

Meningiomas with originating from tuberculum sellae, sphenoid platform, and optic chiasmatic groove are collectively called as tuberculum sellae meningiomas (TSMs) and they are accounted for 5 to 10% of all intracranial meningiomas, which invade the optic canals and lead to visual impairment by displacing the optic nerves upward and laterally [1]. People in fourth decade of their life mostly diagnosed with TSMs. And women are more suffered from this pathology. Despite small size of tumor, this lesion is deeply concerned due to development of visual disturbance in most cases [2]. The reasons are quite small diameter of optic canals and very sensible optic nerves. Due to complex anatomical relationship of this tumors with surrounding neurovascular structures, there is classic clinical presentation of chiasmal syndrome, a primary optic atrophy, with bitemtemporal field defects in adult patients with radiologically normal sellae. The main purpose of surgical treatment of TSMs are usually visual restoration and resection of the tumor. MRI evaluation and neuroophthalmological investigation are better tool to early diagnosis. There are two major surgical treatment methods. Transcranial approach (TC) is generally accepted standard surgical route of removing tuberculum sellae meningiomas and has resulted in good outcomes [3-5]. The most common transcranial approaches are pterional, unilateral or bilateral subfrontal craniotomies [16]. Recently, with introduction of endoscopic techniques and experiences, endonasal transsphenoidal approach has been aimed for the

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resection of TSMs because of its minimal invasiveness [6-10].

There are significant advantages in endoscopic endonasal transsphenoidal surgery (TSS) such as minimal brain retraction, early exposure and devascularization of the tumor base, clear visualization o perforators, o the optic apparatus, and pituitary stalk, little manipulation with optic nerves and optic chiasm, and direct removal of disturbed bone and dura. However, despite having abovementioned benefits, there are certain drawbacks of TSS such technically complex procedure, limited angle of view, problems with bleeding control and it is more often associated with high risk of postoperative cerebrospinal fluid (CSF) leakage resulting in high risk of infection and might require a secondary repair.

Nonetheless, with incredible advances in skull base reconstruction, TS is contemplated as an essential option for the removal of TSMs [8, 10-12, 17, 21].

Hence, there is a gap about the approach selection for TSMs [13-15]. Salek et. al. in their report excluded tumor extending beyond midpupillary line. Indication for endoscopic approaches were tumors situated in midline with or without extending the optic canal, and vessel encasement.

According to them, tuberculum sellae meningiomas were considered if tumor located on the small surface between the chiasmatic sulcus and diaphragma sellae. [17].

Muskens et al, conducted meta analyzes by comparing microscopic transcranial approaches to endoscopic endonasal approach in tuberculum sellae meningiomas and olfactory groove meningiomas and had obtained result that visual improvement was considerably higher in TSMs resected by TSS. While intraoperative arterial injury was also higher in endonasal approach compared to microscopic transcranial approaches [20].

Despite pituitary adenomas, craniopharyngiomas, the literatures describing the surgical steps of endoscopic endonasal transsphenoidal surgery for the resection of tuberculum sellae meningiomas in detail are lacking

The objective of the study.

In this article we evaluated recent literatures about choice of surgical approach focusing on key indications for endoscopic transsphenoidal surgery

METHODS

We carried out review of literatures using Pubmed and Embase for the past ten years but, some older publications with significant importance were also included.

The following key word for search in various combinations were used: tuberculum sellae, meningioma, endoscopy, tuberculum sellae meningioma, transsphenoidal surgery, transcranial surgery.

Surgical anatomy and treatment.
Indication for surgery.

Typically, primary indications for surgical treatment is visual dysfunction due to posteriorly and superiorly oriented tumor growth leading to compression and displacement of optic nerves [19]. Tumor factors such as large size and vascular encasement decrease chance of gross total resection (GTR) [20].

Surgical anatomy. Tuberculum sellae is laterally bounded by the tubercular crest, represented by the medial optico-carotid recess (mOCR) as seen from the EEA. The course of the optic nerves runs in the cisternal, preforaminal, intracanalicular, and intraorbital segments. The lateral optico-carotid recess corresponds to the optic strut and is a landmark for the intracanalicular segment. The dural fold of the limbus sphenoidale forms the falciform ligament as it extends laterally [1]. Small perforators and the superior hypophyseal artery (SHA) arise from the medial wall of the internal carotid artery (ICA) supplying the optic apparatus and the pituitary gland (Figure 1).

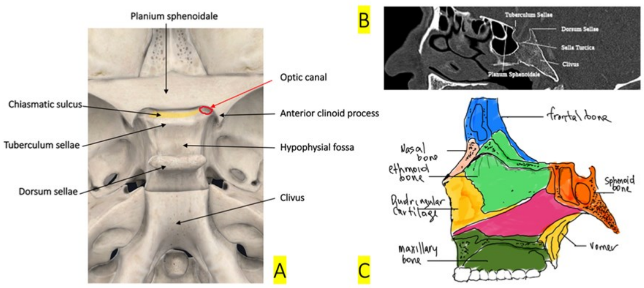

Figure 1. illustration of nasal bone and sellar region. A – bone anatomy of sellar region, B – CT, sagittal view of sellar region and sphenoid sinus [24]. C – painted image of bone anatomy involving throughout nasal stage of procedure.

Surgical technique. Well-equipped, high-tech operation theatre makes challenging surgical procedures more accessible, and improvement of

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surgical treatment has been achieved on the experienced hands. For the schematic illustration of surgery and extend of bone resection pay attention to the illustration drawn on sagittal CT scan below (figure 4) where TSM is marked with blue color and possible bone are which must be exposed is marked with pink and other surrounding structures including planum sphenoidale (red), sellar floor (green) dorsum sellae (black) and clivus (yellow) are also marked.

Anatomic dissection for endoscopic endonasal transsphenoidal surgery consists of three consecutive stages: nasal, sphenoid and sellar stages. And each stages requires excellent fund of knowledge about surrounding anatomy and its possible clinical variations in this situation (figure 3 and 4), preoperative CT helps us to identify types of sphenoid sinus variations. In adult, sphenoid sinus have one of three variations depending on the extent which the sphenoid bone is pneumatized: sellar, presellar and conchal (figure 2)

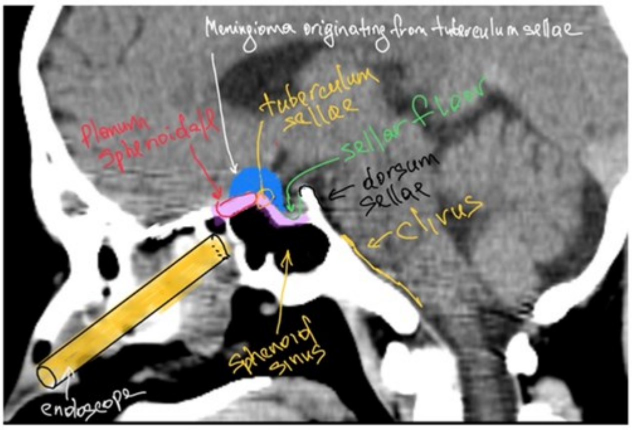
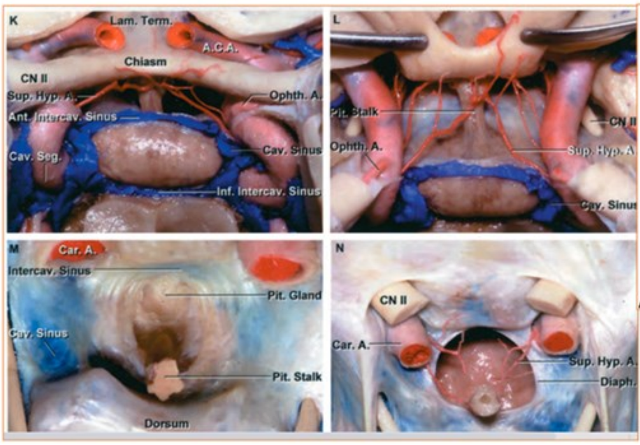


Figure 2. possible visualization of endoscopic expanded endonasal transsphenoidal transplanum transtuburculum approach for the resection of tuberculum sellae meningioma (TMS)



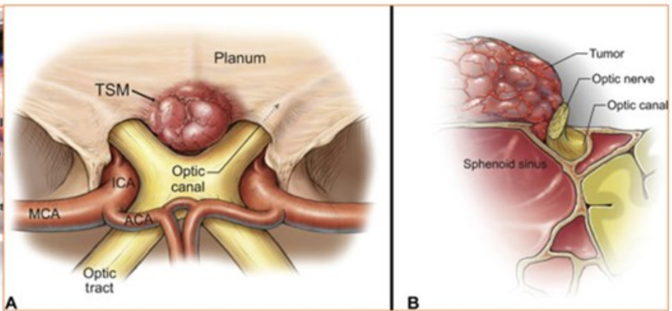


Figure 3. Normal anatomical view of sellar region (upper four images)[25] and painted illustration tuberculum sellae meningioma that compress optic chiasm[26]

Under general anesthesia, the patient positioned at 150, the head fixed to the dead holder or placed on horseshoe shape head holder, then patient head rotated toward surgeon side 100. Depending on suprasellar extension of tumor head flexed or extended. 5% Chlorhexidine is used for face and nasal cavity asepsis. Cotton pledges soaked in 50% poly-vidone-iodine are placed along the floor of nasal cavites and in the spaces between the nasal septum and the turbinate and left within 5 minutes to get effect. Surgical drapes are then put to exposed nasal nostril. 1:100 000 Adrenaline [27] or Epinephrine solution is enough for intranasal mucosal dissection.

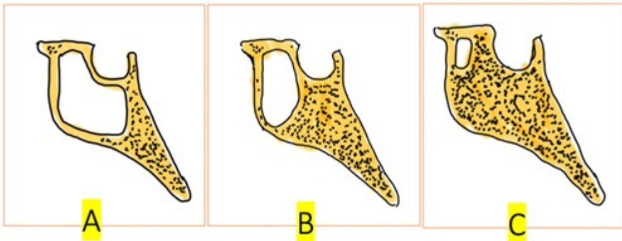


Figure 4. sphenoid sinus possible variations in adults. A-sellar type, B- presellar type and C-conchal type.

Nasal stage. There are two possible variants that can be performed alone or in combination: through either one nostril or both nostrils. This stage starts by introducing 0-degree endoscope though one nostril. First thing must be done is that two structures; laterally located inferior turbinate and medially located nasal septum are identified (figure 5.1) and endoscope continues to move forward superior anteriorly until middle turbinate appears in the field (figure 5.2.). Middle nasal turbinates are closest to nasal septum, and it is mobilized laterally and sometimes removed to make surgical corridor wider.

A special attention should be paid to the

Preparation of nasoseptal flap. It begins with making a superior incision just below the sphenoid ostium, continuing anteriorly toward the nasal septum,

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preserving approximately 1.5 cm of the superior portion of the septal mucosa to prevent olfactory injury, and extending to the columella region. The inferior incision is made just above the choana arch, creating a pedicle around 1.5 cm wide, where this must be preserved because it contains branches of the sphenopalatine artery which irrigates the septal mucosa. To achieve a large pedicled flap, in all cases, the incision was extended anteriorly along the nasal fossa floor below the inferior concha. Nasoseptal flap is ready. After producing the nasoseptal flap, the vomer and perpendicular plate of the ethmoid were removed, preserving 1.5 cm superiorly at the bone-cartilage transition point (posterior chondrotomy), creating a single posterior cavity to access both nostrils concomitantly. Sometimes nasoseptal flap might not be prepared in advance and in general. After identification of middle turbinate , at the margin of middle turbinate vertical incision of septal mucosa is performed so that endoscope introduced transeptally (figure 5. 3.)

Alternatively, when approach is performed though one nostril (unilateral approach), septal mucosa on one side is cut vertically in front of the beginning of middle turbinate and dissected subperiosteally until vomer bone becomes visible. As the endoscope continues to forward direction along the floor of nasal nostril, we reach choana. Boundaries of choana are important landmarks for further surgical step. It is bounded superiorly by the sphenoidal sinus, while inferior border of choana is the soft palate, medial and lateral boundaries are vomer and inferior nasal turbinates respectively. Then identification of sphenoid ostium plays key role to perform anterior sphenoidotomy as it is the entry towards the sphenoid sinus. In sellar type sphenoid sinus, it is easy to locate sphenoid ostium as it is more laterally behind the upper nasal turbinate and be thus difficult to identify. In such case, removal of upper nasal turbinates is essential for a proper visualization of the ostium. However, care should be taken not to damage cribiform plate, to minimize the risk of CSF fistula [23]. Another alternative approach to localize the sphenoid ostium if abovementioned option is not possible is that the access to sphenoid sinus cavity may be achieved at a point placed at approximately 15 mm from the Choana`s upper boundary, over the sphenoethmoidal recess

Sphenoidal stage. This stage focuses on opening anterior wall of sphenoid sinus and removing mucosa within sphenoid sinus cavity. First, mucosa in the sphenoidal recess around the sphenoid ostium or point 1,5 sm above from the top superior boundaries of choana is coagulated so that bleeding from the septal branches of the sphenopalatine artery does not occur. Following this, mucosa is resected until the bone appears. The nasal bone septum composing of the vomer and perpendicular plate of the ethmoid bone is drilled apart from the anterior aspects of the sphenoid bone with a 4 mm drill, thereby exposing the complete rostrum of the sphenoid bone (Figure 5.5-d) and its typical keel-like shape submucosally and bilaterally. Removal of the sphenoid rostrum is done by either drilling or with rongeurs. After removal of anterior wall of the sphenoid sinus along with the rostrum, mucosa of the sphenoid sinus cavity is partially removed to avoid endoscopic view impairment. As the endoscope descends deeply into the sphenoid sinus, there should be confirmation of relevant anatomical landmarks based on experience and fund of knowledge as well as data received from preoperative CT and MRI. Keep endoscope centrally toward sellar floor and planum sphenoidale above and clivus inferior to sellar floor, then, carotid artery and optic nerve protuberances, the optic-carotid recess between them must be recognized on each side of the sellar floor (figure 5.10-12.). However, these anatomic recesses are not clear in poor

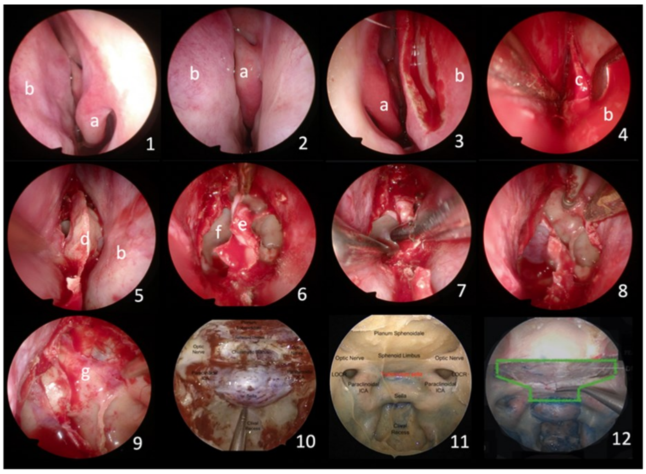

Figure 5. Case from institutional experience. 1. Introduction of endoscope into the left nostril; a- inferior nasal turbinate, b- nasal septum. 2. Visualization of middle turbinates -a, and nasal septum -b. 3. Vertical septal incision at the margin of middle turbinate a, b-nasal septum. 4. Removal pf posterior perpendicular ethmoidal bone-c. 5. Identification of rostrum sphenoidale. 6. Sphenoid sinus septum-e. and sphenoid sinus cavity-f. 7. Removal of septum of sphenoid sinus by rongeur. 8. Expanding bone expose of sphenoid sinus with 4 mm drill. 9. Visualization of cellar mucosa-g. 10-11. Anatomical landmarks. 12. Possible bone removal are for transplanum transtuburculum approach.

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pneumatized sphenoid sinus, and in such case, establishment of sellar floor position are achieved by identification of carotid protuberances, clivus and planum sphenoidale. Use of the navigation system is very helpful. Sometimes, when surgeon does not have much experience and navigation system is not available, ultrasound navigation is used to identify carotid protuberances.

Sellar stage. As the sellar floor has been identified, the endoscope can be mobilized by means of a mechanic fitting with endoscope holder so that surgeon could work with both hands. But in four hand techniques, it is better that assistant keep holding the endoscope so that he could change position and direction of endoscope with surgeon`s action simultaneously. The sellar floor is drilled open or cut open with rongeurs. Then widening of the cranial base defect by removing the bone upward from the sellar floor and laterally and very close to carotid artery. This wide exposure is enough to remove tuberculum sellae and planum sphenoidale meningiomas.

The reconstruction. Recent advances in the reconstruction techniques have improved surgical outcomes by leading to significant decrease in postoperative complication in the form of CSF leakage. In Uzbekistan, we usually perform reconstruction with autologous fat, fascia lata, hemostatic and nasoseptal flap. Use of “Bio glue” or “Dura seal” is mandatory for our neurosurgeons, however, it is not sometimes afforded by patients and their relatives. It is believed that use of combined autologous fascia lata inlay and well vascularized nasoseptal flap onlay is effective reconstruction technique [27]. However, Takeuchi et.al consider dural suturing is more effective in skull base reconstruction (figure 6 a).

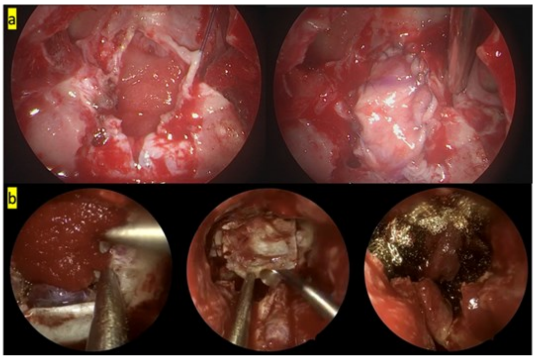

Figure 6. possible reconstruction techniques. a- Dura Gen inlay and Dural suturing. Duragen or hemostatic inlay and fascia and hemostatic outlay.

How to avoid complication.

The complication can be classified as follows; a) Surgery-related complications, b) Sodium and fluid balance disorders, c) Hormonal dysfunction. Complication rate also varies from surgeon to surgeon depending on techniques they use for the reresection of the TSMs and reconstruction of bone defect (table 1).

Authors	n	approach	Reconstruction techniques	Timing (min)	Complications			
					CSF leakage	Diabetes insipidus	Worsening of vision	other
Salek MA et al.[17]	8	Expanded endoscopic transnasal trasphenoidal transplanum transtubercular	with fat, fascia lata, nasoseptal flap, and reinforced with plateletrich fibrin.	-	25 %	12,5% transient	no	
Dzhindzhikhadze, *et al.*[18]	15	Transpalpebral (keyhole orbitofrontal craniotomy) with endoscope assistance	-	226	No		-	
Gardner PA et al.[23]	13 (35)*	Endoscopic endonasal transsphenoidal surgery			40 %		-	
Dolci RL et.al.[27]	10	Endoscopic endonasal	autologous grafts, fascia lata inlay, and nasoseptal flap onlay		no	no	no	Brain abscess

*13 out of 35 anterior skull base meningiomas were tuberculum sellae meningiomas among olfactory groove meningiomas, and petroclival meningiomas. All treated by TSS. There was 95% near total ad 92% gross total resection of TSMs.

First group complications can be minimized in the hand of experienced surgeons. And this accounts for <1% of the cases and are usually attributed to anatomical manipulation during surgery. They might occur early or later. Early complications include worsening of visual symptoms due to compression of the optic nerve during surgery or hematoma in

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postoperative period. Vascular injury, Intracranial hematoma, brain ischemia, SCF fistula. Last group of complications are CSF fistula and Postoperative meningitis. Regarding CSF fistula, it is diagnosed when tamponades are removed. Confirmation is achieved by providing blood glucose-measuring test strips of nasal secretion. CSF fistula usually closed within 48-72 hours. If not, continuous lumbar drainage for 48-72 hours can placed CSF.

DISCUSSION

Despite having many achievements in both Endoscopic transsphenoidal surgery and microscopic transcranial surgery to the resection of tuberculum sellae meningiomas and other suprasellar lesion, there is still huge gap between some authors regarding superiority of one from another approach. Mahmoud et al. [21] for example, believe that supraorbital craniotomy remains the favored approach for removal of tumors invading with optic canal extension since it allows unroofing of both optic canals, wide excision of the dura, and drilling of the affected bone. They also discussed advantages of the supraorbital approach and the limitation of endoscopic transsphenoidal surgery. By contrast, opponents [22] claim that they are not agree with their conclusion regarding limitation of ETSS. Therefore, some detailed arguments against conclusions of former authors are given by latter authors. First, the endonasal corridor is anatomically more favorable to access the suprasellar lesions. It is ventral and caudocranial approach that provides direct access to the base of the tumors and offers unique visualization of the complex neurovascular anatomy of the perichiasmatic regions. The endonasal approach progresses from the core of the tumor (ideal for debulking) to the periphery, whereas the transcranial approach has to deal with the neurovascular periphery of the tumor first to allow later access to the core and attachment of the tumor. Second, when dealing with tuberculum sellae meningiomas, the associated hyperostotic or invaded bone, dural attachment, and meningeal vascular supply are systematically removed as an inherent part of the approach. This results in early tumor devascularization in the dissection and facilitates visualization. Third, the endonasal route is inherently the preferred approach for medial optic nerve decompression. In the setting of a tuberculum sellae meningioma with optic canal invasion, authors systematically perform a 270° decompression of the optic nerve by removing the medial wall, floor, and roof of the optic canal. The falciform ligament and intracanalicular dura are sectioned from medial to lateral, allowing removal of the tumor within the canal without any manipulation of the optic nerve.

CONCLUSION

Except from traditional transcranial microsurgical approaches, recently introduced and being developed endoscopic techniques for the resection of tuberculum sellae meningiomas can be helpful by minimizing wide craniotomy approach related complications. Improvement in various skull base reconstruction methods such as dural suturing and well vascularized nasoseptal flap can decrease postoperative complications.

CONFLICT OF INTEREST.

There is no conflict of interest.

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