Orignal Article

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Extended Endoscopic Endonasal Approach for Tuberculum Sella Meningioms: Lessons Learned

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Abstract

Midline meningiomas arising from the anterior skull base, particularly the planum sphenoidale and tuberculum sellae (TSM), present unique challenges due to their proximity to vital structures such as the optic apparatus. Traditionally approached via transcranial routes, these lesions often lead to chronic compression of optic nerves, resulting in visual impairment. With advancements in endoscopic skull base surgery, extended endonasal endoscopic (EEE) approaches have emerged as a viable alternative. This study aims to analyze the technical nuances and outcomes of EEE approach for excision of anterior skull base meningiomas presenting with visual impairment.

Thirteen patients with TSM and visual impairment underwent EEE surgery at a single institute. Clinical, radiological, and ophthalmological evaluations were conducted pre- and post-operatively. Surgical techniques involved meticulous tumor excision, preservation of vital structures, and multi-layer skull base reconstruction. Visual outcomes, extent of resection, complications, and endocrine function were assessed.

The study demonstrated significant visual improvement in 76.9% of patients, with no cases of permanent visual deterioration. Complete tumor excision was achieved in the majority, with near-total excision in selected cases due to adhesions or tumor characteristics. Complications included CSF rhinorrhea, meningitis, and transient visual field defects, all managed effectively. Endocrine function remained largely unaffected postoperatively, except for one case of diabetes insipidus.

The EEE approach offers distinct advantages in accessing and excising anterior skull base meningiomas, particularly in achieving optic nerve decompression while preserving vision. Despite challenges associated with larger tumors and adhesions, careful surgical planning and techniques can optimize outcomes. This study contributes to the growing evidence supporting the efficacy and safety of EEE approaches in treating anterior skull base meningiomas, emphasizing the importance of surgical expertise and patient selection.

Keywords: Endoscopic excision, Tuberculum sellae meningioma,Visual Outcome

Introduction

Midline meningiomas arising from the anterior skull base form a distinct group of often histologically benign lesions1 that eventually cause impairment of the olfactory or optic nerves[2,3]. Meningiomas with dural base centered anywhere from the olfactory grooves anteriorly upto the diaphragma sellae posteriorly are grouped under this category of Anterior Skull Base Meningiomas (ASBM)[4]. This group of lesions includes Planum sphenoidale and Tuberculum sella (TSM) and clinoidal meningiomas. These lesions are known to be insidious and slowly progressive[1]. Nevertheless, those ASBMs arising and growing in the vicinity of the optic canals and the limbus chiasmaticus cause chronic displacement / compression of components of the optic apparatus even when relatively small in size, eventually leading to restriction of visual fields and decrease in visual acuity[5-10]. These tumors, commonly the tuberculum or planum sphenoidale meningiomas, have been traditionally approached via the transcranial route[2,3]. Approaching midline ASBMs transcranially (TC) from a frontal midline route or from a lateral (Pterional) route place the olfactory nerves and the optic nerves, respectively, in the surgical path to the lesion. As a result, these vital and usually primarily symptomatic structures stand at risk of retraction, handing and vascular compromise. Moreover, by approaching these lesions from above, their dural base, sellar extension and contralateral optic canal extensions (when present) become the last accessed and

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least accessible areas leading to incomplete clearance[3,11-14] With the advancement of visualization and instrumentation in skull base endoscopy[15-17] paired with improved methods for skull base repair[18-22], the logical direct approach for these lesions is now also a viable surgical option. This present study analyses the technical nuances Extended endonasal endoscopic (EEE)approach for excision of ASBMs presenting with visual impairment and the outcomes, particularly pertaining to vision in these cases

Materials & Methods

Inclusion criteria

All patients with TSM were with visual impairment at presentation who underwent tumor excision by Extended endoscopic endonasal surgery by a single surgeon at the authors' institute from January 2021 onwards were included in this study. Clinical, radiological and ophthalmological evaluation done. The tumors which were having a tumor base width of more than 3.5 to 4 cm with encasement of major vessels were excluded from the study.

Ophthalmological evaluation.

Assessments were done utilizing standardized methodologies for examining visual acuity, visual field, and fundus were conducted. These assessments were carried out both before the operation and during the postoperative follow-up period. The best corrected Snellen visual acuity was determined, with any change in visual acuity noted.

Goldmann perimetry was employed to assess any visual field defects using Carl Zeiss Humphrey field analyzer. The visual status of patients was evaluated using comparing the pre and post op visual acuity and fields in immediate post operative period and during follow up.

The visual outcome were evaluated using a Visual Impairment Score (VIS) following guidelines set by the German Ophthalmological Society[23]. The VIS is calculated by aggregating reference table scores for both visual acuity and visual field defect. Normal vision is graded as 0, while the maximum score of 100 indicates blindness. Patients were categorized as completely improved, partial improved , stabilized or no improvement and worsened.

Radiological evaluation included pre and post op MRI brain (plain and contrast). The radiological features noted in MRI are the size, location, extent of the tumor into the optic canal, encasement of the vessels, edema, pial invasion and completeness of excision post operatively. CT scan brain with bone windows and Para Nasal Sinuses to assess the degree of hyperostosis of the tuberculum sella and ossification of the tumor.

Blood work included endocrinological investigations and other routine work-up were collected. Post-operative clinical, endocrinological and ophthalmological parameters we well as post-operative imaging were documented.

Surgical technique:

Patient administered general anesthesia and positioned supine with slight head laterally to opposite side on Mayfield head clamps. Prophylactic broad spectrum antibiotics were given. Neuronavigation(easyNav,HRS Navigation, Bangalore,India) planning and registration was done. Nose and abdomen or lateral thigh are prepped and draped. A rigid endoscope with an outer diameter of 4 mm and a length of 18 cm with 0° and 45°optics (Karl Storz Endoscope, Karl Storz; Tuttlingen, Germany) was used with moderate light intesnsity under a Xenon light source. The decongestion of the nasal mucosa and turbinates were done with the adrenaline soaked nasal packs (1:10000) and lateralization of the turbinates were done.None of our cases had any turbinectomy. Vascularized naso septal flap (Hadad-Baasagestguy flap) raised from the right side of the nasal septum and packed in the nasopharynx . Reverse septal flap raised and sutured with absorbable suture onto the exposed septum. Bony septum including the keel of Vomer removed and anterior face of sphenoid sinus beginning from ostia removed and sphenoid sinus exposed. Wide anterior Sphenoidotomy upto the medial side of lamina papyracea was performed using high speed 3mm diamond drill and 2mm Kerrison rongeurs.

Planum sphenoid , bilateral medial and lateral optico carotid recess(OCR), optic canal and upper sella were exposed.

From here on binasal and four hand approach was followed with assistant holding the scope with intermittent luke warm saline irrigation for cleaning the scope .

Medial Optico carotid recess,Tuberculum sella and proximal part of the optic canal are drilled as the as the posterior limit of the anterior cranial fossa craniotomy. The extent of anterior limit of was decided taking pre operative imaging , extent of spread into consideration and confirmed using navigation.

Drilling was done using low profile curved minimal access attachment of the high speed drill (Anspach Emax2plus With Ma 15c 15 Cm Straight Driver With Curved Sleeve)using 3mm spherical diamond drill bit. For better visualization of the anterior cranial fossa , 45 degree angled lens attachment is used. Venous ooze from lateral part of dura near Medial OCR was controlled If necessary using injectable gelatin and thrombin based hemostatic matrix (Floseal,Baxter,USA).Following the bone drilling tumor is thoroughly devascularized with using elctrocoagulation.Dural opening is done by midline incisions with the horizontal cuts of the dura extending onto the exposed proximal part of the dura covering the optic nerve and bleeding from the anterior intercavernous sinus was controlled by electrocoagulation .

The dura and posterior ethmoid artery are coagulated for tumor devascularization. It gives access to the core of the tumor, prechiasmatic and supra sellar cisterns. Initial internal decompression of the tumor was done with suction ,curettes and ultrasonic aspirator with gentle mobilization from the surrounding arachnoid. Utmost care was taken to preserve the arachnoid plane with careful dissection from the perforators of the superior hypophyseal artery. Tumor and arachnoid bands from the anterior cerebral and anterior communicating artery were divided using sharp and blunt dissection. Tumor was excised in piece meal fashion along with the tumor extending into optic canal. Following tumor removal, Hemostasis was secured using surgicel. Thorough irrigation was done with saline and inj. Papaverine instilled during dissection of the tumor from ACA complex. In case of the dense adhesions to the ACA complex, superior hypophyseal perforators, optic apparatus, tiny bits of the tumor was left rather than pursuing aggressive dissection.

Skull base reconstruction done in 3 to 4 layers, using abdominal muscle fascia with or without artificial dural graft as inlay, naso septal flap and fat graft as outlay subsequent layers. The reconstructi, buttressed with the Merocel packing in both nostril. Post operatively a lumbar drain placed for 48 hours and nasal packs removed after 72 hours.Extent of resection was noted by intra operative impression and post op contrast MRI scan.

Results

A total of 13 patients were included, 12 of whom were female and 1 was a male patient. The age group ranged from 23 to 76 years (mean age: 47 years).11 patients had tuberculum sella meningioma and one patient had clinoidal meningioma. Vision diminution was the predominant symptom followed by headache.

Size of the tumor average is was ranging from 0.8X1.1X1 to 6x3.3x.3.2 cm with an average approximate tumor volume of 18.01cm3.One patient had a 6 cm tumor growing vertically encasing the entire ACA complex ,carotid arteries and adherent to the optic apparatus.

The follow up ranged from 1 month to 36 months and with a mean of 11 months. Patients' clinical characteristics are summarized in Table 1.

TABLE1: PATIENTS CLINICAL CHARACTERISTICS

TOTAL NO OF PATIENTS	13
MEAN AGE	47 YEARS
MALE :FEMALE RATIO	1:11
TUMOR LOCATION	
Tuberculum Sella	12
Clinoidal	1
RADIOLOGICAL FEATURES	
Encasement Of ICA	1
Encasement Of ACA	3
Bilateral Optic Canal Extension	2
Unilateal Optic Canal Extension	1
TUMOR SIZE	
Range (CM)	0.8X1.1X1 - 6x3.3x.3.2
Average tumor volume CM3	18.5
SURGICAL APPROACH	
EEE	12
EEE Followed by Transcranial	1
EXTENT OF RESECTION	
Gross Total	10
Near Total	2
Sub Total	1
AVERAGE DURATION OF FOLLOW UP (MONTHS)	11
HISTOPATHOLOGY	
Transitional	9
Meningotheliomatous	3
Secretory	1
COMPLICATIONS	
CSFRhinorrhoea	1
Meningitis	1
Temporary Visual Field Defect	1
Diabetes Insipidus	1
Hyposmia	1

ACA: Anterior Cerebral Artery , ICA: Internal Cerebral Artery

Gross Total Excision (GTE) of tumor was achieved in 10 patients with excision of involved dura, dural tail and (over)underlying bone. Near Total Excision (NTE) was done in two cases with small bit of residual tumor that were densely adherent to the optic apparatus or vascular structures like Anterior Cerebral Artery (ACA) complex or internal carotids were left behind. One patient underwent both endonasal and transcranial surgery and had only subtotal excision.

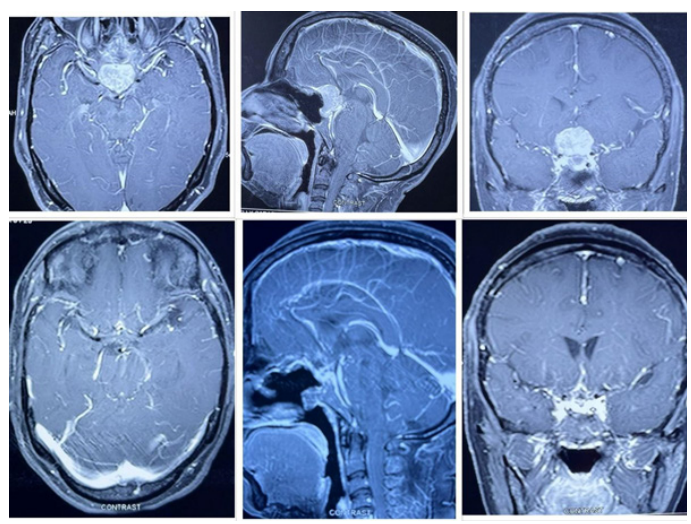

Figure 1: pre and post op contrast MRI showing the tuberculum sella meningioma which is excised in toto.

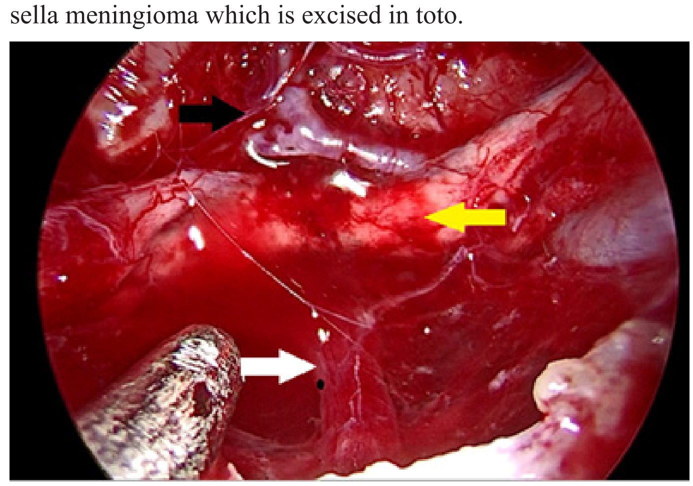

Figure 2. tumor bed after gross total excision showing the pituitary stalk (white arrow), ACA Complex(black arrow) and optic chaism (yellow arrow)

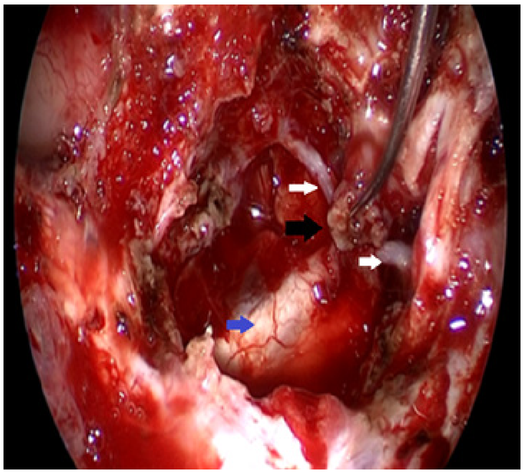

Figure 3: small residual attached to the ACA complex (Black arrow), note bilateral A1 Segments of ACA (white arrow) and Chiasm(Blue arrow)

Visual outcomes:

Among 13 patients, encompassing a total of 26 eyes, 23 eyes exhibited involvement with varying degrees of diminished visual acuity and field deficits, while 3 eyes retained complete preservation. The majority of patients observed significant visual recovery, with the peak improvement occurring at the 4-month mark. Notably, 19 eyes displayed either partial or complete restoration in fields, whereas 7 eyes exhibited stabilization in vision without no deterioration in any patient. . Fig:4 shows the pre and post operative visual fields in a case of clinoidal meningioma who showed a complete recovery.

The VIS scores exhibited improvement, with the pre-operative mean score of 58 decreasing to a post-operative mean score of 22 and 10 out of the 13 patient (76.92%) showed various degrees of improvement in vision. The visual outcomes are summarized in Tables 2&3.

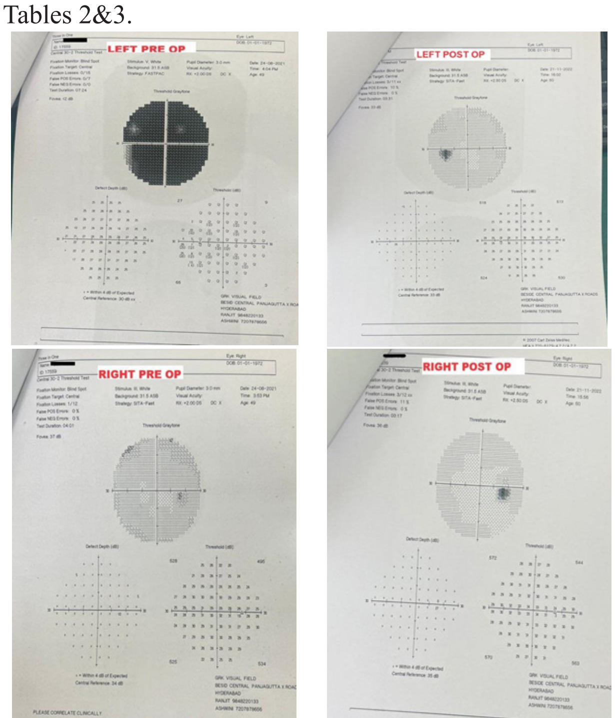

Figure:4 Pre and post operative Visual fields perimetry comparison in a case of clinoidal meningioma

TABLE2: VISUAL OUTCOMES – ACUITY

VISUAL ACUITY	No of eyes	
COMPLICATIONS	PRE-OPERATIVE	POST-OPERATIVE
6/6	8	14
6/6 to 6/60	13	8
CF,HM,PL	5	4

CF: Counting fingers, HM:Hand movements ,PL: Perception of Light

TABLE3: VISUAL OUTCOMES – FIELDS

PRE OPERATIVE VISUAL FIELD DEFECTS	No of eyes
Temporal hemianopia	19
Quadrantanopia	1
Could not be assessed	3
Uninvolved	3
POST OPERATIVE RECOVERY	
Complete recovery	5
Partial recovery	14
Stabilized	7

ENDOCRINE OUTCOME:

All patients had normal pre operative hormone profile except for one patient with hypothyroidism.

Following the surgery. One patient had Diabetes insipidus (DI) immediate after the surgery, he continues to have DI at 5 months follow up requiring oral desmopression. Rest of the patients had no hormonal imbalances.

COMPLICATIONS:

One patient had post operative CSF rhinorrhea early in the series on post op day 4 and 5 who required re- exploration to repair the skull base defect. Nasoseptal flap necrosis was the reason for CSF leak. Small Fat globules as in lay in addition to the fascial graft and over lay fat graft and 72 hours of lumbar drain helped in sealing the skull base defect.

One patient had post operative meningitis and was given intravenous antibiotics based on culture and sensitivity.

We adopted using minimal saline irrigation into nasal cavity after dural and cisternal opening to prevent entry of nasal organisms into CSF spaces.

One patient had hyposmia post operatively and it persisted at a follow up of one and half months.

One patient had transient temporal visual field defect due to tight packing of the defect using artificial dural graft and fascia as inlay. The visual deterioration occurred on first postoperative day probably due to the swelling of the artificial dural graft. Reexploration of the skull base reconstruction and repacking was done. Vision restoration occurred immediately after the reexploration. Authors in their experience have observed any visual deterioration on postoperative day 1 or subsequently are because of tight inlay packing and over draining of CSF. Such deterioration should be investigated on emergency basis with either CT Or MRI to rule out hematoma followed by reexploration without losing time.

FOLLOW UP:

All patients were followed up for an average period of 11 months. No instances of recurrence were observed in patients who underwent complete excision. In contrast, in two cases of near total excision and one case of subtotal excision, the size of the residual tumor remained unchanged compared to the post-operative scan during the follow up MRI.

Discussion

Evolution of EEE approaches

Planum Meningiomas are traditionally approached through frontal or frontolateral approaches. The efforts to lessen the neural structure manipulation by getting direct access to skull base lead to the development of EEE approaches.
However EEE approaches only could lessen it but could not eliminate it completely.

Jho and colleagues first described the purely endoscopic endonasal approach for removing sellar, suprasellar, and anterior skull base lesions, including Tuberculum Sella Meningiomas[24,25]. This technique further popularization by Kassam, Snyderman, Cavallo, Cappabianca, and Miranda, Gardener et al. led to wider acceptance of the purely endoscopic approach[26,27]

Visual recovery

Research comparing the endoscopic endonasal (EEE) approach with craniotomy for treating tuberculum sellae meningiomas (TSM) consistently demonstrates superior visual outcomes with EEE. These studies not only indicate greater improvement but also lesser postoperative deterioration[12,27-29]. Our study aligns with these findings, showcasing vision improvement in 76.9% of TSM patients with the EEE approach. All the patients had either improvement or preservation of the vision. No patient had permanent deterioration of the vision. The following table (Table:3) is a comparison of visual outcomes of in various studies of TSMs operated via EEE approaches in management of TSM.

Table :4 Comparison of visual outcomes across multiple studies that utilized the endonasal endoscopic approach for excising tuberculum sella meningiomas.

S NO	STUDY	NO OF PATIENTS	GROSS TOTAL RESECTION PERCENTAGE	IMPROVED	STABILIZED	WORSENED	MORTALITY
1	Peng[30] et al	40	95	97	2.6	0	0
2	Wang[10] et al	12	91.7	92	8	0	0
3	Divitiis et al[12]	7	85.7	71.4	28.6	0	0
4	Koutourousiou [27] et al						
	75	81.4	85.7	10.7	3.6	1.3	
5	Kong[28] et al	84	83.3	85	10	5	1.2
6	Salek[31]	6	80	50	37	13	0
7	Current study	13	75	76.9	23.1	0	0

These tumors push the chiasm upwards and posteriorly. So the tumor removal was without manipulation of the optic apparatus. The other advantage is the visualization of the superior hypophyseal perforators on the inferolateral aspect of the chiasm supplying the optic nerves early on enabling their dissection without damage where as in transcranial approach the perforators come in the opticocarotid corridor making them prone surgical manipulation , traction, coagulation etc. In endoscopy the arachnoid layer remains intact throughout the procedure making the microvasculature less exposed to the bleeding, preventing them from going to vasospasm, avoiding thermal and mechanical injury from the electrocautery and ultrasonic aspiration.

SIZE OF THE TUMOR AND EXTENT OF RESECTION

In our practice, the majority of tumors treated are less than 4 cm in vertical extension, often medial to the carotid but not fully encasing the artery, and with a width of the tumor less than 3.5 cm. However, we encountered difficulty in a case with larger vertical extensions of 6 cm and a fibrous tumor. Despite attempting optic canal decompression and partial tumor decompression via the endonasal route, the procedure had to be abandoned due to the fibrous nature of the tumor and encasement of the anterior cerebral artery complex. Subsequent craniotomy and decompression were attempted but were not successful in adequately decompressing the tumor due to its fibrous nature and encasement of blood vessels. In this instance, the endoscopic endonasal approach (EEEA) proved beneficial in achieving optic nerve decompression, which would have otherwise been challenging.

Larger tumors with a base wider than 3-4 cm, with extension lateral to the internal carotid arteries (ICAs) or encasement of major vessels, are generally considered for a transcranial approach1[2,32,33]. However, with increasing expertise and in selected cases, they are being considered for EEEA[30,34.] Recent literature suggests that certain selected cases of vascular encasement can still be operated upon if there is only wrapping around the nerve with no adhesions[30].

Additionally, the endonasal approach provides direct access to extensions of the tumor into the optic canal, primarily to the medial and inferior aspects of the optic nerve. This is advantageous as approaching these extensions by craniotomy often requires retraction of the optic nerve, even after anterior clinoid drilling, whereas the medial optic canal with part of the optic canal is readily accessible via endoscopic approaches.

Regarding the extent of resection, complete tumor excision was performed in all cases included in the study except in three patients, where residual tumor was left behind due to adhesions to the chiasm, major vessels (ICA & ACA), and the fibrous nature of the tumor. It's noted that dissecting tumor adherences from the chiasm poses a high risk of visual deterioration, thus it's recommended to shave off and leave a thin layer of tumor to prevent such complications. The distinct advantage of this approach is the ability to remove the bone and dura involved, achieving Simpson's Grade I excisions in the majority of cases chosen for this approach. In cases with dense adherences to the chiasm and ICA, shaving off a thin layer is considered more pragmatic than excising them at the risk of serious consequences.

Skull base reconstruction technique

A four layer technique of reconstruction where two layers of inlay involving collagen dural substitute and fascia as inlay followed by nasoseptal flap and fat as outlay was very effective in preventing the CSF leak. Collagen dural substitute was used in large size tumors when the post resection tumor cavity is big enough to accommodate two layers. In cases of partial resections and small tumors only fascial inlay was used. The collagen dural substitutes can swell and cause the visual deteriorations , so it is important to be careful not to use oversized grafts.

Endocrine functions

The endocrine function is not affected in most of the patients before surgery. DI post surgery in one patient could be as a result of superior hypophyseal perforator injury during dissection.

Conclusions

The current case series adds to the growing experience of treating tuberculum sella and clinoidal meningioma by extended endonasal endoscopic approaches. For meningiomas of the tuberculum sella with base less than 3.5 to 4 cm and , selected clinoidal meningiomas EEE approaches offers distinct advantages. It could as well be part of the strategy in decompressing and achieving visual stabilization or improvement in larger tumors with optic canal extension. However it has learning curve associated with it and can be attempted once the surgical team has gained adequate experience performing skull base endoscopy.
Conflicts of Interest: none

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