Original Article

Transpalpebral Approach for Microsurgical Removal of Tuberculum Sellae Meningiomas

Abstract

Background: The evolution of skull base approaches associated with individualization of surgical corridor and minimizing the collateral damage. Achieving the radical removal of tumor and preserving the neurological status of the patient is possible, both with the traditional approaches and keyhole approaches. Our work presents experience using the transpalpebral approach (TPA) for microsurgical removal of tuberculum sellae meningioma (TSM). **Materials and Methods:** A total of 15 patients with meningiomas underwent microsurgical removal of TSM through TPA. Ten patients were women and five were men. The standard preoperative diagnostic protocol includes magnetic resonance imaging with contrast enhancement, brain computed tomography for neuronavigation. We assess surgical complications, functional and cosmetic outcomes, and surgical parameters, including the time of surgery and intraoperative blood loss. **Results:** Visual impairment was finding in 100% patients, including slight decrease of vision (46,7%, seven patients), partial vision field loss (six patients, 40%), and serious visual impairment (two patients 13.3%). Visual improvement was noted in ten cases (66.7%), there was no improvement in four cases (26.7%), and one case (6.6%) had transient visual worsening for 4 days and slow improvement in 1 month. Headache disappeared in three patients (50%). There were no cases of cerebrospinal fluid leak. Transient frontal hypoesthesia was noted in all patients (100%) without permanent deficit. Transient palsy of the frontal muscle was noted in four patients for 4–6 months. Histological examination revealed WHO Grade I meningioma in 14 cases and in 1 case WHO Grade II meningioma. No deaths were identified in follow-up at 12 months. The average value of the Modified Rankin Scale was 1.4. The mean length of stay in hospital was 5. **Conclusion:** TPA is technically difficult and requires some experience to work in deep structures in a small surgical corridor. This technique can be good alternative to traditional fronto-lateral, supraorbital keyhole craniotomies, and endoscopic endonasal approaches.

Keywords: *Keyhole surgery, minimally invasive neurosurgery, transpalpebral approach, tuberculum sellae meningioma*

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Introduction

Tuberculum sellae meningiomas (TSMs) account for about 5%–10% of all intracranial meningiomas.[1]

It is well known that the surgical approach to the most TSMs was performed through a large visible frontotemporal skin incision with extended temporal muscle dissection and frontotemporal craniotomy with or without supraorbital bar removal. The evolution of skull base approaches is associated with individualization of surgical corridor and minimizing the collateral damage. For several decades, extended fronto-lateral approaches, such as bifrontal, pterional, and orbitozygomatic were the "working horses" for microsurgical removal of TSM.[2-8]

Surgical treatment of the TSMs is a complex problem. During this time, it became apparent that the unilateral approach gives the same outcome but with less damage in compared with bifrontal craniotomy.[9]

One of the main goals of surgery is the radical removal of the tumor with preserving the visual pathways and choosing the most optimal approach. Achievement of these goals is possible, both with the traditional approaches and keyhole approaches.

The endoscopic removal of TSM is another well-known alternative approach. There are certain disadvantages of the endonasal route: technically more complex, limited angle of view, problems with bleeding control, and a higher risk of postoperative cerebrospinal fluid (CSF) leak.[10,11]

How to cite this article: Dzhindzhikhadze RS, Dreval ON, Lazarev VA, Polyakov AV, Kambiev RL, Salyamova EI. Transpalpebral approach for microsurgical removal of tuberculum sellae meningiomas. Asian J Neurosurg 2020;15:98-106.

Submission: 22-06-2019 **Accepted:** 07-10-2019 **Published:** 25-02-2020

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Access this article online
Website: www.asianjns.org
DOI: 10.4103/ajns.AJNS_186_19
Quick Response Code:

One of the most important principles of keyhole surgery is not reducing the size of the craniotomy but minimizing the approach-related complications and unnecessary traumatization that is not related to the goal of the surgery. It should be noted that when we use mini approach, we see the same microscopic picture as with extended craniotomies. Adequate patient selection is critical for safe and effective removal of TSM.[12-15]

In this report, the authors present results of using the transpalpebral approach (TPA) with miniorbitofrontal craniotomy for microsurgical removal of TSM.

Materials and Methods

A total of 15 patients with meningiomas underwent microsurgical removal of TSM in the Department of Neurosurgery, City Clinical Hospital named after F.I. Inozemtseva, Moscow, Russia, between 2016 and 2018. Ten patients were women, and five were men. All tumors were operated through the transpalpebral incision and keyhole orbitofrontal craniotomy. Summary of 15 cases of TSM is presented in Table 1.

The standard preoperative diagnostic protocol includes magnetic resonance imaging (MRI) with contrast enhancement, brain computed tomography (CT) for neuronavigation, examination by an ophthalmologist and an otolaryngologist, and a routine neurologic examination.

All patients were informed about the alternative extended craniotomies, supraorbital craniotomy with eyebrow skin incision and transsphenoidal endoscopic approach.

We used careful preoperative evaluation of the following parameters: facial and bone anatomy, frontal sinus topography and their relationship with the planning craniotomy, depth of the olfactory groove, and anterior clinoid pneumatization. The potential risk of frontal sinuses opening was evaluated by virtual craniotomy. We also used follow-up assessment of functional and cosmetic outcomes and assessment of disability in accordance with Modified Rankin scale (mRS). Extent of tumor resection was evaluated on a Simpson scale. All parameters were assessed over a period of 12 months.

Surgical parameters, including the time of surgery, intraoperative blood loss, and surgery-related complications, were also reviewed. Postoperatively, all patients underwent MRI with contrast enhancement on 4–5 days and 6–8 months after surgery.

Surgical technique

Before surgery, the incision is marked with the raised and lowered eyelid for better identification of the natural crease. The patient placed on the operating table with the head fixed in a 3-pin Mayfield head holder and elevated above the heart level, tipping the head downward, and turning in the opposite side from 15° to 30°. Three patients were approached from the left side and 12 from the right side. The side of craniotomy was determined by tumor side lateralization and preoperative dominant side of the visual deficit. The right side is preferable. Before the skin incision, we placed an ophthalmic gel subconjunctivally. Temporary tarsoraphia is performed with a 5-0 nylon suture. The area of the planned incision is infiltrated with an anesthetic solution and vasoconstrictor.

The skin incision is made through the natural fold of the upper eyelid. The incision of the orbicularis oculi muscle is like the projection of the skin incision and subcutaneous tissue [Figure 1]. The dissection of the orbicularis muscle was performed with preservation of the orbital septum and

Table 1: Summary of 15 cases of tuberculum sellae meningiomas

Case	Gender	Age	Max tumor size (mm)	Lateralization	Surgical time (min)	Blood loss (ml)	Extent of resection	Recurrence	Visual changes	Length of stay (days)	Follow-up period (months)
1	Male	54	21.4	Right	200	50	Simpson II	None	Improve	4	10
2	Female	52	32.2	None	240	100	Simpson II	None	Improve	5	17
3	Male	48	20.3	None	175	50	Simpson II	None	Improve	4	8
4	Female	62	30.8	None	210	100	Simpson II	None	None	5	16
5	Female	60	38.1	Right	245	150	Simpson II	None	None	6	21
6	Female	55	25.6	None	215	50	Simpson II	None	Improve	4	18
7	Female	48	30.2	None	245	150	Simpson IV	None	Improve	5	14
8	Male	48	24.2	None	245	50	Simpson II	None	Improve	4	12
9	Male	75	25.1	Right	220	100	Simpson II	None	Improve	5	14
10	Female	69	39.2	Right	275	300	Simpson IV	+	None	7	11
11	Female	60	37.7	Left	230	150	Simpson II	None	None	5	20
12	Female	52	29.9	None	225	150	Simpson II	None	Improve	6	22
13	Female	51	26.1	None	200	50	Simpson II	None	Improve	4	7
14	Male	59	38.7	Left	230	200	Simpson IV	None	Transient worsering	7	24
15	Female	64	30.7	Left	235	100	Simpson II	None	Improve	4	19

+: Rec

lateral canthal ligament. A single musculocutaneous flap is formed. Subperiosteal dissection was performed in the supraorbital region from the lateral margin of the supraorbital notch to the frontal-zygomatic suture. The temporal muscle dissected with monopolar from the place of its attachment at the keyhole-point area and mobilized laterally to visualize the area of burr hole placement. At this step, an important nuance is a careful work with soft tissues to avoid the damage of the facial nerve branches that innervate the orbicularis oculi muscle. According to the work of Ouattara *et al*. in 63.3% of cases, the muscle is innervated by most of the temporal, upper zygomatic, and lower zygomatic branches and by the upper buccal branches.[16] Schmidt *et al*. reported that lateral border of the orbicularis oculi muscle, where the temporal and zygomatic nerves insert into the muscle, the mean distance between the temporal and zygomatic nerves was 1.72 ± 0.62 cm, and the average horizontal distance from the lateral canthus to the point where the nerve changes from a vertical course to a horizontal course was 4.70 ± 0.79 cm.[17]

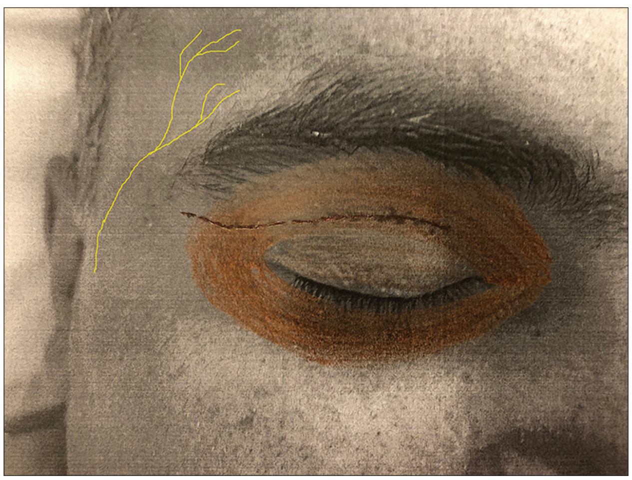


Figure 1: Projections of skin, subcutaneous tissue, and musculus orbicuaris oculi incision (Black line). Yellow line – projections of facial nerve branches

The one burr hole is placed in the keyhole point with the high-speed diamond drill. After that, a miniorbitofrontal craniotomy is performed, including the roof of the orbit and the portion of the frontal bone about 1–1.5 cm of the frontal process of the zygomatic bone. The diameter of the bone window was not exceeding 2.0–2.5 cm. The roof of the orbit was broken with a chisel [Figure 2a-f].

The dura mater (DM) is opened in a C-shaped fashion. The first important step is early brain relaxation. Basal cisterns are opened with sharp dissection. We use retractorless technique and dynamic retraction to protect the brain and minimizing traction damage. The next step is to identify ipsilateral optic nerve and the internal carotid artery. Small perforators on the inferior surface of the optic nerves and chiasm are preserved. In three cases, the optic canal was unroofed because of its invasion by the tumor. The tumor is devascularized in the early stages. The pituitary stalk is usually displaced posteriorly and easily dissected from the meningioma. In some cases, if the tumor is soft, we use ultrasonic aspirator to debulk the tumor. After removal of the tumor, we use endoscopic assistance to assess the residual volume. The matrix was coagulated, and the basal dura was resected. In eight cases (53.3%), extradural resection of the anterior clinoid process was performed. The DM is tightly closed. The bone flap is fixed with miniplates or CranioFix. Bone cement is optionally used for additional fixation. The wound is sutured layer by layer, an intradermal suture of absorbable 6-0 thread is applied to the skin. In the first 2 h after the operation, cubes of ice are placed on the area of the postoperative wound to reduce the periorbital edema.

Patients population

Of the 15 patients, there were 10 women (66.7%) and 5 men (33.7%). The female-to-male ratio was 2:1. The mean age was 57.1 years (range: 48–75 years). None of

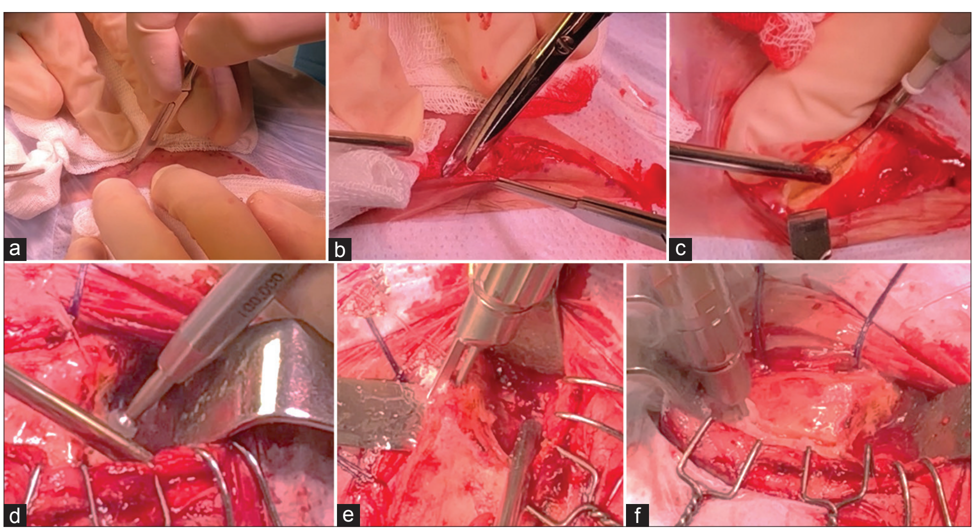


Figure 2: Steps of performing transpalpebral approach. (a) Skin incision. (b and c) Soft-tissue dissection. (d) Burr hole forming with a high-speed drill. (e and f) Mini-orbitofrontal craniotomy

the patients underwent prior surgery and did not undergo radiation courses.

Clinical features

Visual impairment – the most frequent symptoms that find in 100% patients, including slight decrease of vision (seven patients, 46.7%), partial vision loss (six patients, 40%), and serious visual impairment (two patients, 13.3%).

The other symptoms include headache (six patients, 40%), anosmia (three patients, 20%), and diplopia (one patient, 6.7%). None of the patients had pre- and post-operative endocrinological deficit.

Radiological features

Pre- and post-operative MRI with contrast enhancement was used and combined with CT for craniotomy planning.

The mean tumor diameter and volume were 30.0 mm (range: 20.3–43.2 mm) and 15.2 cm^3 (range: 11.3–27.1 cm^3). There are four R-lateralization cases and three L-lateralization cases. Tumor calcification was found in two patients (13.3%).

Results

In three patients, resection had to be subtotal, a residual tumor was observed on follow-up MRI as expected. In three patients, the tumor was attached to the artery of Heubner.

There were no serious approach-related complications (CSF leakage, epidural and subdural hematoma, wound infection, and keloid scar). In four cases, the frontal sinus was opened. In one case, the mucous membrane was damaged, and cranialization was performed with abdominal fat packing with vancomycin and additional fibrin glue sealing. In other three cases, a small frontal sinus defect was waxed.

We used rigid endoscopes (Karl Storz, Germany) with 0°- and 30°-angled lenses for microsurgery assistance. Simpson II resection achieved in 80% cases. Invasion in the optic canal was in three patients. The mean surgical time was 226 min and the mean blood loss was 110 ml.

All patients were in the intensive care unit for 1 day. An early postoperative CT was performed within 24 h to exclude complications.

Visual improve was noted in ten cases (66.7%), there was no improvement in four cases (26.7%), and one case (6.6%) had transient visual worsening for 4 days and slow improvement in 1 month. Our results in part of the visual deficit are comparable with the results of other authors. Obviously, the degree of changes in visual impairments depends on many factors that not directly related to the surgical approach (duration of the symptoms, tumor size and its adherence to the optic nerves, and tumor location).

There were no motor or sensory limb dysfunctions in the postoperative period. All parameters are shown in Table 2. Headache disappeared in three patients (50%). There were no cases of CSF leak.

Two major cosmetic outcomes of TPA were also evaluated. Transient frontal hypoesthesia for 3–5 months was reported in all patients (100%), permanent deficit was not reported. Transient palsy of the frontal muscle for 6–8 months was reported for four patients, permanent palsy was not reported.

Histological examination revealed WHO Grade I meningioma in 14 cases and in 1 case WHO Grade II meningioma. Almost 80% of patients have Simpson II resection. No deaths occurred in follow-up at 12 months. The average value of mRS was 1.4. The mean length of stay in hospital was 5. The mean follow-up period was 15.5 months. No patients had endocrinological disturbances. The list of complications is presented in Table 3. Satisfaction with the postoperative cosmetic outcome after TPA is shown in Table 4.

Clinical case of using TPA for microsurgical removing of TSM is shown in Figures 3 and 4.

Cosmetic outcomes are shown in Figure 5. The patients have consented to the submission of this article for submission to the journal.

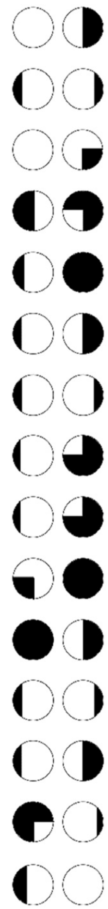
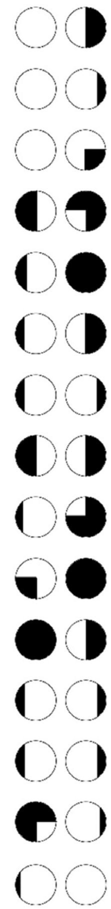
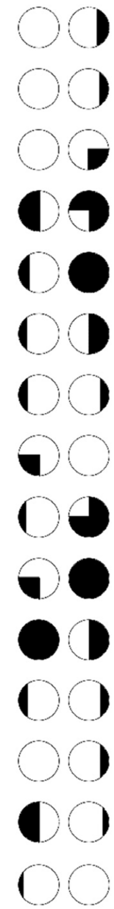
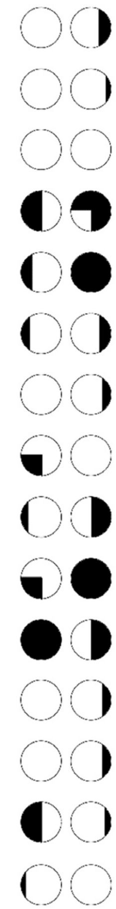
Discussion

One of the first article, devoted to the description of suprasellar meningiomas, was the report of Cushing and Eisenhardt in 1929.[3] Various approaches were used in the surgical treatment of this pathology, using the bifrontal and unilateral approaches with different series of patients.[18-23]

Despite the advantages of traditional approaches, there still exist some risks of approach-related complications that is not related with the surgical target: atrophy of the temporal muscle, asymmetry of the face, risk of dysfunction of the temporomandibular joint, pain and numbness in the orofacial region, pain during chewing, discomfort in wearing glasses, injury of the frontal branch of the facial nerve, alopecia in the postoperative scar, risk of epidural hematoma, and retraction-induced damage.[24-29]

Over time, it became obvious, that the microsurgical removal of TSM possible through keyhole approaches with minimum risks of approach-related complications. Minimally invasive neurosurgery allows us to adapt and individualize the surgical view and reduces the associated surgical trauma. The concept of keyhole surgery was popularized by Perneczky and Reisch. Many authors presented effective and safety outcomes of mini approaches (minisupraorbital craniotomy) for the parasellar and anterior cranial fossa lesions with adequate patient selection.[12,13,30-37]

Table 2: Summary of motor and sensory limbs function, visual outcomes

Parameter	Motor function		Sensory function		Visual changes												mRs		
Cases/ Months					Preoperative			3			6			12					
	3	6	3	6	Acuity		Visual fields	Acuity		Visual fields	Acuity		Visual fields	Acuity		Visual fields	3	6	12
					Left	Right	Left|right	Left	Right	Left|right	Left	Right	Left|right	Left	Right	Left|right			
1	NW	NW	NP	NP	1.0	0.5		1.0	0.5		1.0	0.6		1.0	0.7		1	1	1
2	NW	NW	NP	NP	0.5	0.6		0.5	0.6		0.5	0.7		0.6	0.7		1	1	1
3	NW	NW	NP	NP	1.0	0.7		1.0	0.7		1.0	0.7		1.0	0.8		1	1	1
4	NW	NW	NP	NP	0.4	0.3		0.4	0.3		0.4	0.3		0.4	0.3		2	2	2
5	NW	NW	NP	NP	0.6	0		0.6	0		0.6	0		0.6	0		2	2	2
6	NW	NW	NP	NP	0.5	0.5		0.6	0.5		0.6	0.6		0.6	0.7		1	1	1
7	NW	NW	NP	NP	0.6	0.7		0.6	0.7		0.6	0.7		0.7	0.8		1	1	1
8	NW	NW	NP	NP	0.6	0.4		0.6	0.5		0.6	0.5		0.6	0.6		1	1	1
09	NW	NW	NP	NP	0.3	0.1		0.3	0.3		0.3	0.3		0.4	0.3		1	1	1
10	NW	NW	NP	NP	0.2	0		0.2	0		0.2	0		0.2	0		2	2	2
11	NW	NW	NP	NP	0	0.1		0	0.1		0	0.1		0	0.1		2	2	2
12	NW	NW	NP	NP	0.6	0.6		0.6	0.6		0.6	0.6		0.7	0.7		1	1	1
13	NW	NW	NP	NP	0.7	0.8		0.8	0.8		0.8	0.9		0.8	0.9		1	1	1
14*	NW	NW	NP	NP	0.02	0.8		0	0		0	0.6		0	0.7		3	3	2
15	NW	NW	NP	NP	0.2	1.0		0.3	1.0		0.3	1.0		0.4	1.0		1	1	1

Case 14* had transient visual worsening for 4 days with slow improvement in 1 month. NW – No limbs weakness. NP – No limbs paresthesia, mRs – modified Rankin Scale

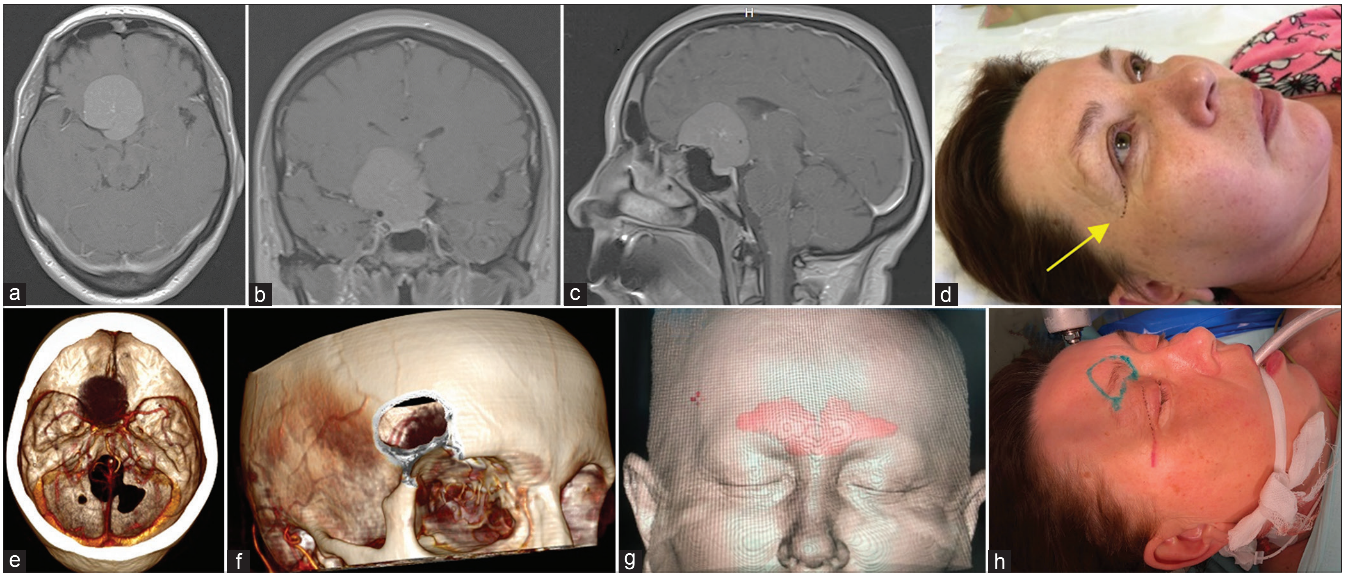


Figure 3: Preoperative planning transpalpebral approach. (a-c). Preoperative magnetic resonance imaging with cerebrospinal fluid, tuberculum sellae meningioma. (d) Projection line of skin incision (arrow). (e and f) Virtual craniotomy, planning of transpalpebral approach in computer model. (g and h) Using the neuronavigation to mark the frontal sinus

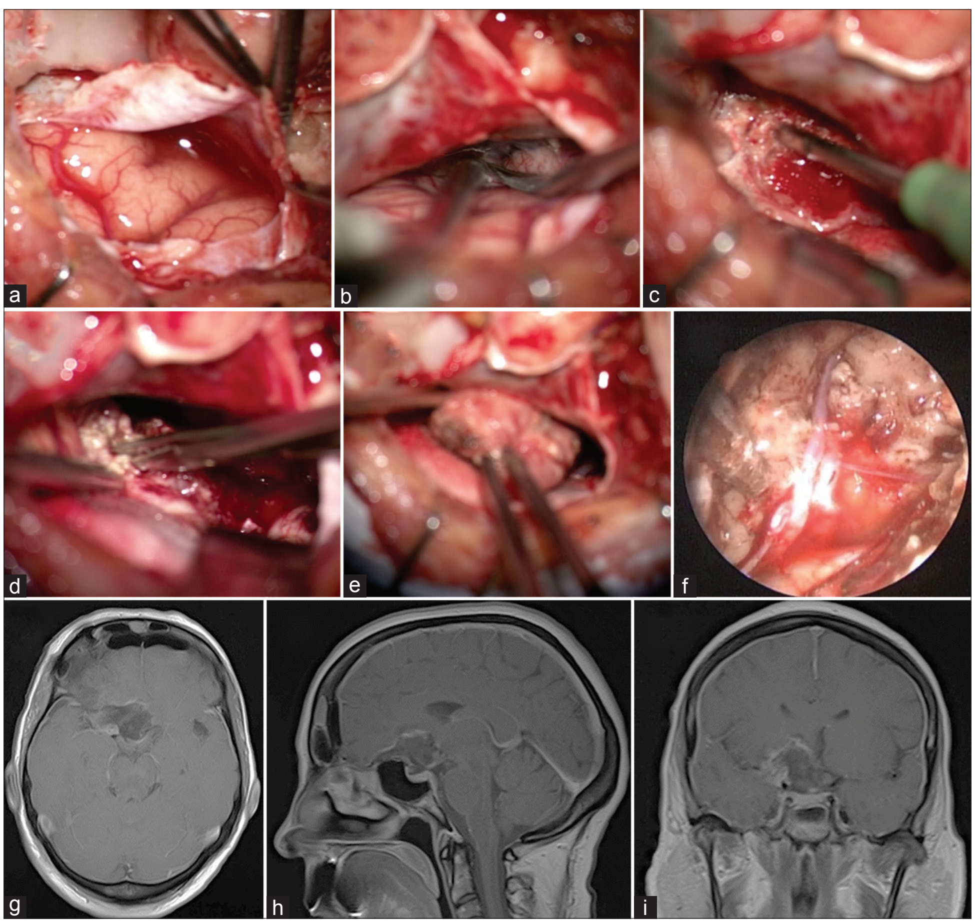


Figure 4: Intraoperative pictures, microsurgical removal of tuberculum sellae meningioma through transpalpebral approach. (a) Dural opening. (b) Basal cistern opening, brain relaxation. (c) Tumor debulking with ultrasonic aspirator. (d) Tumor resecting partially with microscissors. (e) Part of meningioma removing through small craniotomy. (f) Endoscope assistance. (g-i) 1-month postoperative magnetic resonance imaging with cerebrospinal fluid

We have an experience of using TPA in the skull base surgery. Our cases include performing TPA for anterior circulation aneurysms, microsurgical removal tumors of the anterior cranial fossa, and orbital cavernomas.

Figure 5: (a-d) Cosmetic outcomes after transpalpebral approach

Table 3: Postoperative complications after transpalpebral approach

Complication	Number of complications, *n* (%)
Wound infection	0
CSF leakage	0
Epidural, subdural hematoma	0
Traction damage	2 (13.3)
Endocrinologic complications	0
Postoperative seizure	0
Cognitive worsening	3 (20)
Keloid scar	0
Lethal cases in 12 months follow-up	0

CSF – Cerebrospinal fluid

Table 4: Satisfaction with the postoperative cosmetic outcome after transpalpebral approach in 15 patients

Scale of satisfaction	Number of cases, *n* (%)
Unsatisfactory	0
Good	2 (13.3)
Excellent	13 (86.7)

We assessed the functional and cosmetic outcomes, surgical complications and concluded that TPA could be successfully performed as an alternative method to traditional extended approaches and endoscopic routes in the skull base surgery.[38-40]

In this report, we presented outcomes in 15 patients diagnosed with TSM. A surgical approach was selected with critical assessment of facial and bone anatomy, sizes of the tumor.

Visual disturbances are the main symptom of TSMs. It is agreed that the visual outcome depends on the duration of the disease and the visual deficit before surgery.[41] One of the most important goals is to decrease additional damage to the already impaired visual pathways. Some reports showing improvement of visual function in a wide range from 25% to 80%.[42-49] Mathiesen and Kihlström hypothesizing that early optic canal decompression and optic nerve release can improve visual outcomes.[50] Al-Mefty and Smith report that direct compression of the tumor on the vascular support to the optic chiasm and optic nerve is the main cause of visual impairment.[43] Some studies compared the endoscopic transsphenoidal versus supraorbital keyhole approach for the resection of TSM.[51,52] However, adequate minimization of approach allows us to achieve similar results on the visual pathways, without increasing the risk of developing approach-related complications.

It is known that the mortality rate for microsurgical removing of TSM varies from 0 to 8.7%.[41,45,48,49] According to the report by Nakamura *et al.*, there is a definite dependence of mortality on the approach performed (9.5% bifrontal craniotomy vs. 0% pterional/fronto-lateral craniotomy).[9] The outcome of the TSM surgery is dependent more on the clinical state of the patient. Individualization and minimization of the approach allow as to reduce the damage of normal structures that are not related to the pathology.

Subtotal resection has ranged from 8% to 33%.[9,22,41,49] The degree of tumor resection depends primarily on the experience of the neurosurgeon. In the report of Nakamura *et al.*, there were no significant differences in the degree of tumor resection and the chosen approach.[9] It is always necessary to assess the relationship of the tumor with the vessels and optic nerves. If necessary, the residual part is left in critical structures to avoid the neurological deficit and it is not associated with transcranial approach (extended or keyhole craniotomy).

CSF leakage complications range from 4% to 33%.[9,23,45,53,54] Linsler *et al*. reported that CSF leakage was manifested after supraorbital keyhole approach (6%), in another article by Fatemi *et al*. CSF leak occurred after transnasal endoscopic removal of the tumor (29%).[51,52]

There are few reports of the development of endocrinological complications-diabetes insipidus with a frequency of 5%–33%.[19,23,43,47] There are some reports on the development of endocrinological complications in single cases, both after endonasal approach and supraorbital keyhole craniotomy.[51,52]

TPA planning should be carried out in advance with using virtual craniotomy. When we choose TPA, it is important to assess the individual surgical route to the lesion and adequately minimize craniotomy. This approach gives a surgical view such as pterional, lateral supraorbital, and orbitozygomatic craniotomy. As we have a predefined subfrontal route to the lesion, it is not necessary for the large exposure of the cerebral cortex.[55] Some modifications of the TPA: resection of the orbital roof, extradural resection of the anterior clinoid, and partially sphenoidal wing resection could be successfully applied to increase the microsurgical corridors. Creating a comfortable work through small craniotomy by opening basal cisterns can significantly increase the space for manipulating with microsurgical instruments and removing large volume tumors. Using of neuronavigation helps to determine the lateral border of the frontal sinus. We individualize and determine the surgical corridor because any damaging of the frontal sinus increases the risk of infectious complications and CSF leakage.[56,57]

Conclusion

We conclude that the TPA can be used for removing TSM with good cosmetic and functional outcomes.

Over the entire microsurgical era, many approaches have been used to the TSM. Over time, they underwent a certain evolution from extended approaches to mini-approaches and endonasal routes. Each craniotomy has specific advantages and disadvantages. It is important that TPA is technically more difficult and requires some experience to work in a deep structure through a small surgical corridor. This technique can be good alternative to traditional fronto-lateral craniotomies, eyebrow supraorbital and endonasal approaches.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given their consent for their images and other clinical information to be reported in the journal. The patient understands that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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