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ORIGINAL ARTICLE - NEUROSURGERY GENERAL

The infratranstentorial subtemporal approach (ITSTA): a valuable skull base approach to deep-seated non-skull base pathology

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Abstract

Background Surgical access to space-occupying lesions such as tumors and vascular malformations located in the area of the tentorial notch, mediobasal temporal lobe, and para-midbrain is difficult. Lesions in this area are typically resected with supratentorial approaches demanding significant elevation of the temporal lobe or even partial lobectomy, or via a supracerebellar transtentorial approach. We introduce an alternative, the skull base infratranstentorial subtemporal approach (ITSTA), which provides excellent exposure of the incisural area while minimizing risk to the temporal lobe.

Methods We included consecutive patients with pathology involving the area of the tentorial incisura, para-midbrain, and mediobasal temporal area who underwent surgery via ITSTA from 2012 to 2018. The approach includes partial mastoidectomy, temporal craniotomy, and tentorial section. Space obtained by mastoidectomy provides a sharp high-rising angle-of-attack, significantly diminishing the need for temporal lobe retraction. Surgeries were performed using microsurgical techniques, neuronavigation, and electrophysiological monitoring. Clinical presentation, tumor characteristics, extent of resection, complications, and outcome were retrospectively reviewed under a waiver of informed consent.

Results Nine patients met inclusion criteria (five female, four male; mean age 44 years, range 7–72). They underwent surgery for removal of para-midbrain arteriovenous malformation (AVM, 3/9), medial tentorial meningioma (2/9), mediobasal epidermoid cyst (2/9), oculomotor schwannoma (1/9), or pleomorphic xanthoastrocytoma (PXA) of the fusiform gyrus (1/9). Three AVMs were removed completely; among six patients with tumors, gross total resection was achieved in three and subtotal resection in three. All surgeries were uneventful without complications. There were no new permanent neurological deficits. At late follow-up (mean 42.5 months), eight patients had a Glasgow Outcome Score (GOS) of 5. One 66-year-old female died 18 months after surgery for reasons not related to her disease or surgery.

Conclusions The ITSTA is a valuable skull base approach for removal of non-skull base pathologies located in the difficult tentorial-incisural parabrainstem area.

Keywords Arteriovenous malformation · Incisura · Skull base · Subtemporal · Tentorial notch · Transtentorial

Introduction

Tumors and AVMs located in the region of the tentorial notch, the mediobasal temporal lobe, and para-midbrain are difficult to access because of their depth and location in this complex anatomical area [1, 2, 4, 11]. These lesions are typically resected through a transsylvian approach [2, 6], subtemporally beneath or through an inferior temporal gyrus [2, 11], or via a supracerebellar transtentorial approach [1, 3, 9]. The strengths and limitations of these approaches vary. In general, limitations have revolved around three sets of factors with their attendant risks: the requirement to use a sitting position [3, 9, 10]; a longer working distance and/or a limited area of exposure, making

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the surgeries more technically demanding [1, 3, 9, 10]; and the need for temporal lobectomy [6] or prolonged temporal lobe retraction [11].

We sought to develop an approach to these lesions that would be performed in a supine position, provide a good working exposure, and require minimal temporal lobe retraction. We present our experience with the infratranstentorial subtemporal approach (ITSTA), which was modified from the posterior transpetrosal skull base approach and meets these criteria. The ITSTA includes partial superior mastoidectomy without violation of the labyrinth, and tentorial section, which, along with minimal temporal lobe retraction, provides a sharp high-rising angle-of-view beneath the temporal lobe and through the tentorium to expose the incisural content and mediobasal part of the temporal lobe adjacent to the tentorial notch.

Materials and methods

We identified consecutive patients with pathology involving the area of the tentorial incisura, para-midbrain, and mediobasal temporal area who underwent surgery from 2012 to 2018. Patients with non-skull base pathology involving this area via ITSTA were included in the study. Those who underwent other variations of subtemporal or tentorial approaches to this region were excluded. Cases of petrotentorial meningiomas growing below the tentorium with a neuroradiological or surgically documented origin from the petrous ridge were also excluded.

Data regarding patient demographics, clinical and imaging presentation, tumor pathology, surgical details, surgical complications, surgical morbidity and mortality, and long-term outcomes were extracted from medical, surgical, and imaging records. Our Institutional Review Board waived the requirement for informed consent for this retrospective review of patient data and the surgeon's notes for each procedure (SS-SM-005, 0223-19-HMO).

Resection was defined as gross total when no residual tumor or arteriovenous malformation (AVM), as relevant, was visualized during surgery or on postoperative imaging, or subtotal when a small remnant remained on the cranial nerves, brainstem, or vasculature. Patients were evaluated with pre- and postoperative CT and MRI before surgery and for long-term follow-up, with the addition of pre- and postoperative digital subtraction angiography (DSA) for patients with AVM.

Surgical technique

The surgery is performed under general anesthesia utilizing an operating microscope, neuronavigation, high-speed drills, and microsurgical techniques. Intraoperative neurophysiological monitoring included motor-evoked potentials (MEP), somatosensory-evoked potentials (SSEP), and monitoring of cranial nerves (CN) VII and VIII. The main concept of the approach is to eliminate or reduce to a minimum temporal lobe retraction by taking advantage of a steep angle of attack directed from the space provided by upper mastoidectomy (Fig. 1).

Patient positioning

Patients are positioned in a manner similar to that used for a retrolabyrinthine approach. The patient is placed in a supine position with the head rotated to the contralateral shoulder and fixed in a three-pin Mayfield head holder. Equipment for neurophysiological monitoring is adjusted and neuronavigation registration is completed. During preparation of the sterile surgical field, an anterior abdominal wall is also prepped for fat harvesting.

A C-shaped skin incision is made beginning 2–3 cm above and curving behind the pinna to the posterior temporal/retroauricular area, and extending to the mastoid tip (Fig. 2). The soft tissue flap is elevated subperiosteally in a single layer and reflected anteriorly, exposing the posterior temporal bone and mastoid process.

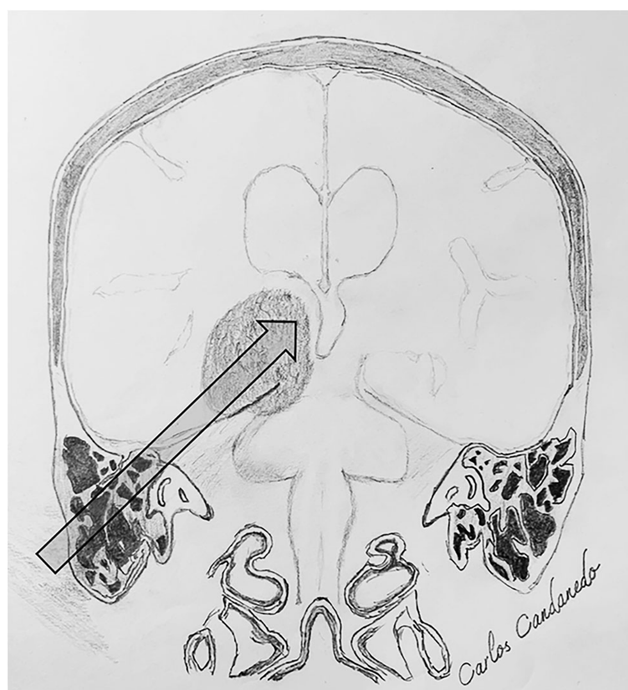

Fig. 1 A schematic diagram illustrating the concept of the infratranstentorial subtemporal approach (ITSTA). The high-riding angle of the approach provides good access to deep-seated lesions in the para-midbrain and incisural area, greatly reducing the need for temporal lobe retraction

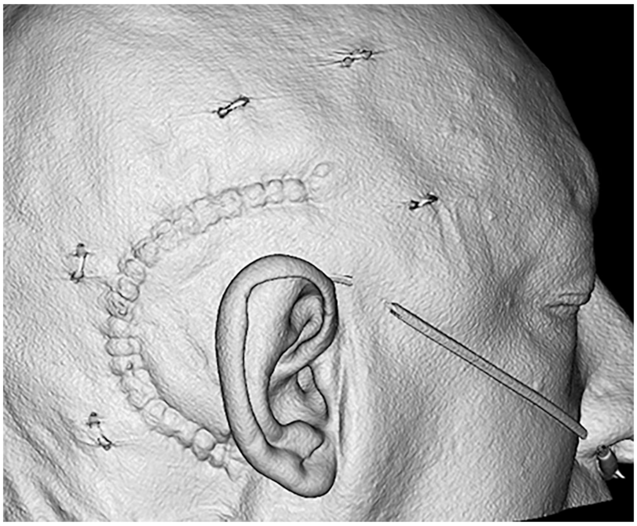

Fig. 2 Postoperative 3D head CT reconstruction showing the C-shaped skin incision curving above and behind the pinna and ending at the mastoid tip in a 65-year-old male who underwent gross total resection of a medial tentorial meningioma (patient 1)

Partial upper mastoidectomy

For the purpose of the approach, only a partial upper mastoidectomy, without violation of the labyrinth, is needed. The upper half of the mastoid process and tegmen tympani are drilled away using a high-speed drill with irrigation, to expose the sinodural angle as well as the basal temporal dura mater. The aditus ad antrum is opened to verify bulging of the lateral semicircular canal and the short process of the incus, indicating the anatomical position of the facial nerve between and beneath these structures, to ensure CN VII and hearing preservation. The inferior limit of bony drilling is determined by the angle required to reach the superior aspect of the lesion. Partial mastoidectomy enables tentorial section and provides a high-rising angle of attack to the incisural mediobasal area.

After finishing the upper mastoidectomy, a small temporal craniectomy or craniotomy is added.

The dural opening is the next important step. First, the dura is incised in the presigmoidal area and the arachnoid of the pontocerebellar cistern is opened, releasing the cerebrospinal fluid (CSF) and providing sufficient brain relaxation. Then the convexital temporal dura is opened and inverted basally with great care to prevent injury to the vein of Labbé. A temporal lobe retractor blade is then gently inserted in front of the vein of Labbé, and the tentorium is gradually coagulated and transected anterior to the point where the vein merges into the transverse/lateral sinus. The superior petrosal sinus is ligated with Weck clips (Teleflex, Wayne, PA, USA) and transected using the same technique as that routinely applied in posterior transpetrosal approaches [5]. The line of the tentorial and superior petrosal sinus section goes anterior to the entry point of the vein of Labbé and posterior to the point where the superior petrosal vein merges the superior petrosal sinus, thus preserving these two important venous draining complexes.

In the tentorial notch, CN IV is identified and preserved. After gaining full access with tentorial section, the temporal retractor is released and the retraction blade is placed beneath the transected tentorial edge to gently support the temporal lobe. There was no need for continuous temporal lobe retraction in our patients; intermittent support was sufficient. In patients undergoing removal of medial tentorial meningiomas, the tentorial section facilitates early tumor devascularization and detachment. As usual, lesion resection must be performed with care to ensure preservation of critical neurovascular structures, including CN III, IV, and V, and the posterior communicating, posterior cerebral and superior cerebellar arteries in the incisural area. Figure 3 illustrates the most important anatomical steps of the approach.

Lesion removal

Removal of tumors and AVMs is performed using regular microsurgical techniques, including high magnification, microdissection, bipolar coagulation, and cavitron ultrasonic surgical aspiration when appropriate.

Closure

After the lesion is removed and hemostasis is achieved, a dural substitute (Duragen, Integra Life Sciences, Plainsboro, NJ, USA) is placed to cover the dural defect. The entry into the aditus ad antrum is obliterated with a piece of muscle and fat graft harvested from the anterior abdominal wall. A second piece of harvested fat graft is placed above the Duragen with the addition of a small quantity of cryoprecipitate and thrombin mixture to fill the cavity after partial mastoidectomy. The temporal craniotomy flap is replaced and fixed with miniplates or Craniofix clamps (Aesculap, Center Valley, PA, USA). A piece of titanium mesh is placed over the fat graft for reinforcement and compression, and partially over the temporal bone flap. It is secured with miniscrews (Fig. 4). Closure is completed in a regular way. We do not routinely use spinal drainage or surgical wound drains.

Results

Nine patients were treated surgically with this approach during the study period, i.e., three patients with para-midbrain AVMs (Fig. 5), two with large medial tentorial meningiomas (Fig. 6a, b), one with an oculomotor schwannoma (Fig. 6c), two with mediobasal temporal epidermoid cysts (Fig. 7), and one patient with a pleomorphic xanthoastrocytoma (PXA) involving the fusiform gyrus (Fig. 7). Demographic data and

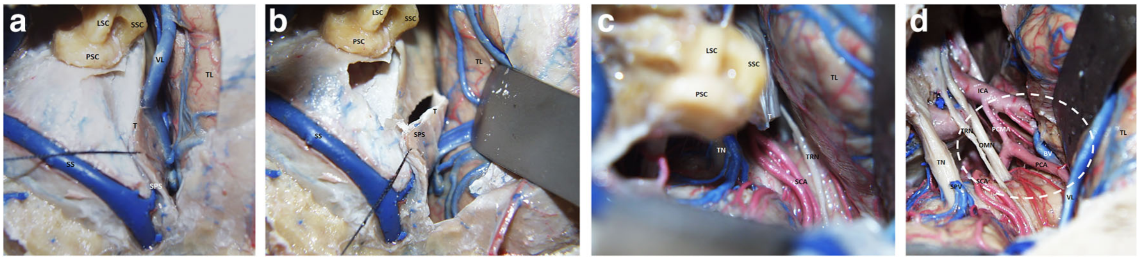

Fig. 3 **a** Anatomic studies illustrating the steps of the ITSTA. Left partial mastoidectomy has been performed. The dura of the temporal area is open, exposing the entry of the vein of Labbé into the tentorium. **b** The retractor blade has been placed beneath the temporal lobe, facilitating section of the tentorium anterior to the entry point of the vein of Labbé. **c** The tentorium has been transected completely, exposing the medial basal part of the temporal lobe, CN IV, midbrain, superior cerebellar artery, and superior petrosal vein. **d** For illustrative purposes only, this dissection depicts complete labyrinthectomy and transection of the superior petrosal vein to enable a better understanding and visualization of the content of the incisural area. The area which should be exposed by the ITSTA in a real surgical situation is delineated by the dashed line. BV, basal vein; ICA, internal cerebral artery; LSC, lateral semicircular canal; OMN, oculomotor nerve; PCA, posterior cerebral artery; PCMA, posterior communicating artery; PSC, posterior semicircular canal; SCA, superior cerebellar artery; SPS, superior petrosal sinus; SPV, superior petrosal vein; SS, sigmoid sinus; SSC, superior semicircular canal; T, tentorium; TL, temporal lobe; TN, trigeminal nerve; TRN, trochlear nerve; VL, vein of Labbé

surgical details are presented in Table 1. Mean volume of the tumors was 35.6 cc (range 2.4–65.8 cc) and of the AVMs was 3.3 cc (range 3.0–4.0 cc). In all cases, the approach provided adequate exposure, enabling surgical removal of the pathology.

There were no surgical complications or mortality and no new permanent neurological deficits. We did not encounter any difficulties or complications regarding the arteries or venous draining system during the surgical approach or lesion resection. No patient presented with a venous lake within the tentorium or a superior petrosal sinus drainage anomaly. The superior petrosal sinus was transected without complications. The vein of Labbé was preserved in all cases. The arteries involved in the tentorial hiatus/incisura area—the posterior communicating, posterior cerebral, and superior cerebellar arteries—were all preserved in all patients, including those with AVMs. No patient developed a CSF leak. All patients returned to a normal life. No one had a record of epileptic events after the surgery. Mean follow-up was 42.5 months (range 15–75 months).

Two patients developed transient neurological deficits after surgery. Patient 2 developed transient diplopia secondary to a trochlear nerve palsy after removal of a tentorial notch meningioma, and patient 6 had transient partial oculomotor nerve palsy after removal of the schwannoma originating from this nerve. Both were fully recovered at late follow-up.

Postoperative MRI confirmed ipsilateral temporal lobe, cerebellar, and brainstem preservation in all patients. In three patients who underwent resection of AVMs (patients 3–5), postoperative DSA confirmed complete removal. Gross total tumor resection was achieved in patients 1, 6, and 7. A small residual tumor was left in patients 2, 8, and 9.

In patient 2, a small residual adhering to the deep venous system on the posterior third of the tentorial hiatus was left to avoid venous injury during resection of a large tentorial meningioma. On histopathology, this was a WHO I meningioma; thus, the patient did not receive adjuvant stereotactic radiosurgery (SRS). At 23-month follow-up, this small residual was stable.

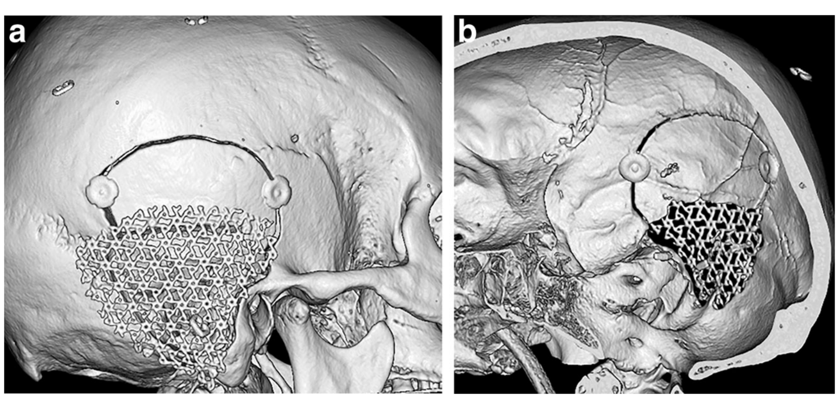

Fig. 4 Postoperative 3D head CT reconstruction, (**a**) outside and (**b**) inside views following temporal craniotomy with partial mastoidectomy. Titanium mesh has been placed over the temporal flap, fat graft, and bone defect. This 72-year-old female underwent subtotal resection of a large medial tentorial meningioma (patient 2)

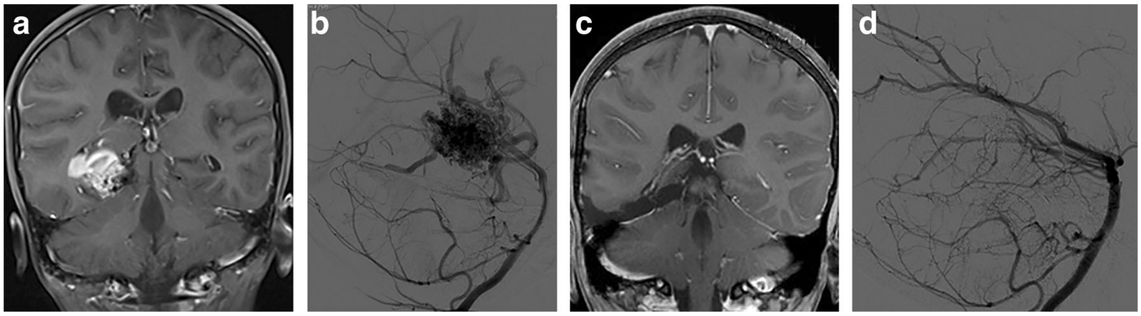

Fig. 5 **a** Preoperative coronal T1-weighted gadolinium-enhanced MRI showing a right deep-seated AVM in a 7-year-old girl (patient 5). **b** Preoperative lateral angiogram showing the right AVM originating from the posterior cerebral artery. (**c**) Postoperative coronal T1-weighted gadolinium-enhanced MRI, and (**d**) postoperative lateral angiogram showing complete removal of the AVM

A small remnant adherent to the brainstem was left in patient 8, who had a large incisural epidermoid cyst. She had an uneventful recovery, without neurological deficit. She died 18 months later for reasons unrelated to the surgery or residual epidermoid, which was unchanged.

PXA invaded the brainstem in patient 9 and intraoperative decline in the MEP precluded total removal. The patient received adjuvant BRAF inhibitor (dabrafenib) and at 39-month follow-up had achieved GOS 5 with no evidence of tumor progression.

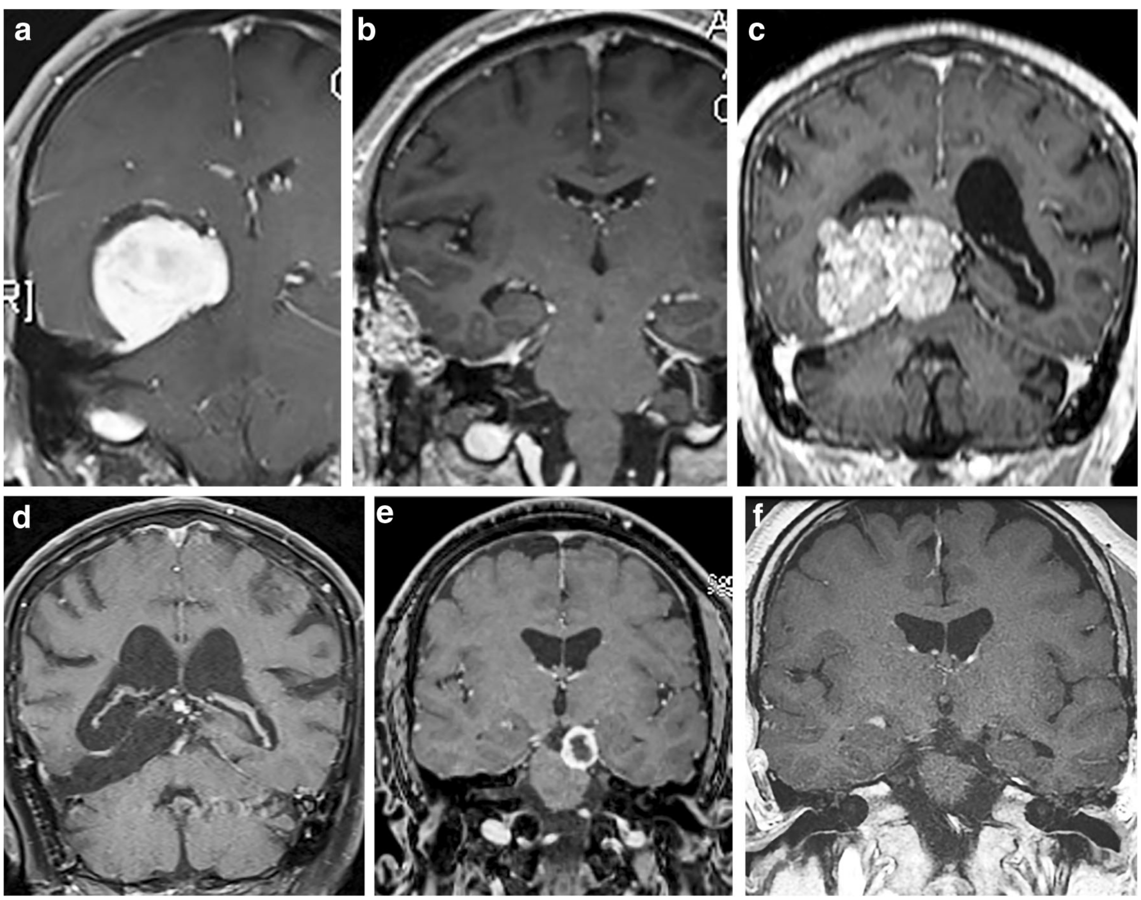

Fig. 6 (**a**) Preoperative coronal T1-weighted gadolinium-enhanced MRI showing a large medial tentorial meningioma, and (**b**) coronal T1-weighted gadolinium-enhanced postoperative MRI without signs of tumor residual. Note the intact temporal lobe without contusion or signs of temporal encephalomalacia, since minimal or no temporal lobe retraction is needed to approach the tumor (patient 1). **c** Preoperative coronal T1-weighted gadolinium-enhanced MRI showing a large tentorial notch meningioma (patient 2), and (**d**) postoperative coronal T1-weighted gadolinium-enhanced MRI showing no signs of gross tumor residual. Note the high-riding angle provided by the approach. **e** Preoperative coronal T1-weighted gadolinium-enhanced MRI demonstrating a left parabrainstem tumor in a 42-year-old male (patient 6), and (**f**) Postoperative coronal T1-weighted gadolinium-enhanced MRI showing complete removal of the tumor, found at surgery to be a schwannoma originating from cranial nerve (CN) III

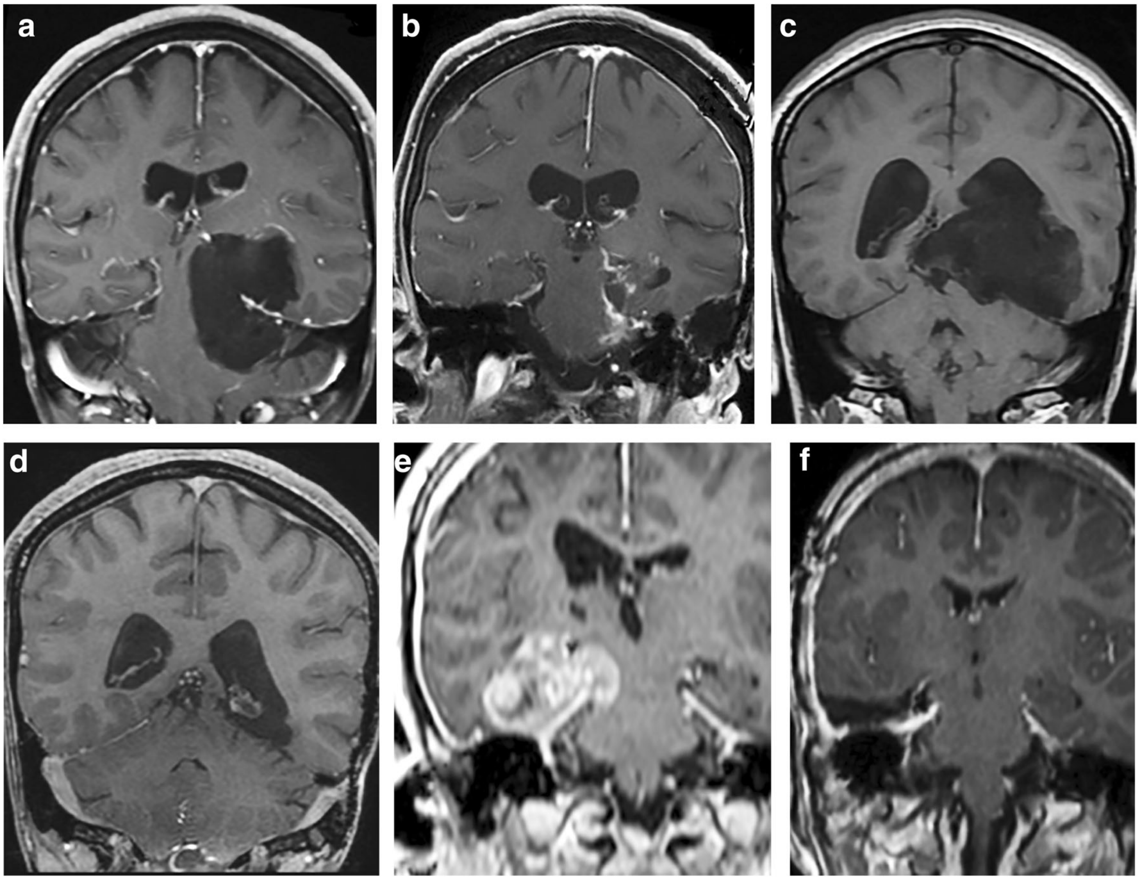

Fig. 7 (**a**) Preoperative T1-weighted gadolinium-enhanced MRI showing a large incisural mediobasal epidermoid cyst in a 28-year-old female (patient 7), and (**b**) postoperative T1-weighted gadolinium-enhanced MRI. (**c**) Preoperative T1-weighted gadolinium-enhanced MRI showing a large incisural mediobasal epidermoid cyst in a 66-year-old female (patient 8), and (**d**) postoperative T1-weighted gadolinium-enhanced MRI. (**e**) Preoperative T1-weighted gadolinium-enhanced MRI showing a fusiform gyrus pleomorphic xanthoastrocytoma (PXA) in a 10-year-old girl (patient 9), and (**f**) T1-weighted gadolinium-enhanced MRI 19 months after surgery and adjuvant systemic chemotherapy

Discussion

We have modified the posterior transpetrosal approach, a classic approach to the skull base, for the removal of non-skull base lesions located in the para-midbrain/incisural area. We have simplified it by diminishing the amount of bone work (partial mastoidectomy) and have found it to be straightforward, efficient, and effective. The ITSTA has a number of important advantages. It provides a high-rising angle of view to these deeply located lesions and significantly diminishes or eliminates the need of temporal lobe retraction. It is extracerebral and can be tailored to the target lesion with the help of neuronavigation, adjusting the extent of bone drilling. In the nine patients described here, we achieved good resection, with no surgical complications or mortality and no new permanent neurological deficits. We had no epileptic events and no case of temporal lobe contusion after these surgeries. The temporal lobe appeared well-preserved on long-term MRI in all of our patients.

Historically, these lesions have been approached in several ways. The supracerebellar transtentorial approach [10], with resection of the tentorium [3, 9], is performed in a sitting position. It provides a good window to the mediobasal surface of the temporal lobe and avoids the need its retraction; however, there is a long working corridor and it is contraindicated when there is a patent foramen ovale (PFO) or when the vein of Rosenthal drains into the tentorium [3] since it may compromise venous drainage from critical diencephalic structures. Although this approach has been modified to accommodate a park bench position [1], the area of exposure remains limited, there is a longer working distance, and the approach is more technically demanding [1]. A transzygomatic approach with anteriorly limited inferior temporal gyrectomy has also been described [6]; however, it requires a partial temporal lobectomy for resection of completely extra-axial tumors and extensive retraction of the temporal lobe since the surgeon must "look up" the upward slope of the tentorium from the petrous bone towards its apex to visualize the superior pole of the tumor [6]. The subtemporal transtentorial petrosalapex

Table 1 Lesion characteristics and surgical outcomes in nine patients operated via infratranstentorial subtemporal approach

Pt. no.	Gender, age (years)	Pathology	Characteristics	Extent of resection	Neurological outcome	Duration follow-up (months)
1	M, 65 (Figs. 2 and 6a, b)	Medial tentorial Meningioma	Volume 53.8 cc	GTR	No deficit	23
2	F, 72 (Figs. 4 and 6c, d)	Medial tentorial Meningioma	Volume 40.7 cc	STR	Transient hemiparesis and diplopia (CN IV)	15
3	M, 65	Parabrainstem AVM	Origin SCA, SM-III, volume 3 cc	Complete	No deficit	42
4	M, 42	Parabrainstem AVM	Origin SCA, SM-III, volume 4 cc	Complete	No deficit	75
5	F, 7 (Fig. 5a–d)	Parabrainstem AVM	Origin PCA, SM-III, volume 3 cc	Complete	No deficit	74
6	M, 42 (Fig. 6e, f)	Oculomotor schwannoma	Volume 2.4 cc	GTR	Transient partial CN III	24
7	F, 28 (Fig. 7a, b)	Incisural mediobasal epidermoid cyst	Volume 35 cc	GTR	No deficit	73
8	F, 66 (Fig. 7c, d)	Incisural mediobasal epidermoid cyst	Volume 65.8 cc	STR	No deficit[1]	17
9	F, 10 (Fig. 7e, f)	Fusiform gyrus PXA	Volume 16.2 cc	STR	No new deficit[2]	39

AVM, arteriovenous malformation; *CN*, cranial nerve; *GTR*, gross total resection; *PCA*, posterior cerebral artery; *PXA*, pleomorphic xanthoastrocytoma; *SCA*, superior cerebellar artery; *SM*, Spetzler-Martin classification [8]; *STR*, subtotal resection

[1] Patient died 18 months after surgery from unrelated reasons

[2] Patient had hemiparesis following hemorrhagic manifestation of her tumor. She was stable at postoperative and late follow-up

approach [11] requires substantial retraction of the temporal lobe, often with significant complications.

Our ITSTA has certain advantages. In comparison with the transzygomatic approach [6], there is no need of partial temporal lobectomy. We needed only transient and minimal retraction of the temporal lobe in our patients. We believe our approach is somewhat less technically demanding and more straightforward, and it provides a wider and more superficial exposure as compared with the various modifications of the supracerebellar transtentorial approach [1, 3, 9]. Of course, special attention should be paid to prevent injury to the facial nerve and hearing loss due to partial mastoidectomy, to CN IV during transection of the tentorial notch, the trigeminal nerve in the caudal border, and the oculomotor nerve in the rostral border of the surgical field, as well as vascular structures such as the venous draining system, which may vary between patients. Although we did not encounter venous anomalies in our patients, anatomical variations and the importance of venous preservation was stressed in seminal papers [5, 7]. During tentorial transection, it is important to preserve two structures that are found in the great majority of individuals: the vein of Labbé, which provides supratentorial venous drainage, and the superior petrosal vein, which provides infratentorial drainage. We were able to preserve all critical neurovascular structures in our patients, with only transient deficits in CN III and IV in two different patients.

Some deep cerebral non-skull base pathologies are very difficult to access, including those in the parabrainstem, mediobasal, incisural area. These lesions may be most successfully resected by skull base surgeons, or neurosurgeons who are familiar with skull base techniques and have experience gaining access to remote regions with complex neuroanatomy, as the current series suggests.

Conclusion

The infratranstentorial subtemporal approach (ITSTA) is a valuable skull base approach to difficult and deep-seated non-skull base pathologies located in the para-midbrain/incisural area. It should be included in the armamentarium of skull base and non-skull base surgeons operating this region.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval For this type of study, formal consent was not required.

References

1. Ansari SF, Young RL, Bohnstedt BN, Cohen-Gadol AA (2014) The extended supracerebellar transtentorial approach for resection of medial tentorial meningiomas. Surg Neurol Int 5:35
2. Campero A, Troccoli G, Martins C, Fernandez-Miranda JC, Yasuda A, Rhoton AL Jr (2006) Microsurgical approaches to the medial temporal region: an anatomical study. Neurosurgery 59:ONS279–ONS307; discussion ONS307-278
3. de Oliveira JG, Parraga RG, Chaddad-Neto F, Ribas GC, de Oliveira EP (2012) Supracerebellar transtentorial approach-resection of the tentorium instead of an opening-to provide broad exposure of the mediobasal temporal lobe: anatomical aspects and surgical applications: clinical article. J Neurosurg 116:764–772
4. Goel A, Muzumdar D (2004) Conventional posterior fossa approach for surgery on petroclival meningiomas: a report on an experience with 28 cases. Surg Neurol 62:332–338 discussion 338-340
5. Guppy KH, Origitano TC, Reichman OH, Segal S (1997) Venous drainage of the inferolateral temporal lobe in relationship to transtemporal/transtentorial approaches to the cranial base. Neurosurgery 41:615–619; discussion 619-620
6. Lee EJ, Park ES, Cho YH, Hong SH, Kim JH, Kim CJ (2015) Transzygomatic approach with anteriorly limited inferior temporal gyrectomy for large medial tentorial meningiomas. Acta Neurochir 157:1747–1755 discussion 1756
7. Matsushima T, Rhoton AL Jr, de Oliveira E, Peace D (1983) Microsurgical anatomy of the veins of the posterior fossa. J Neurosurg 59:63–105
8. Spetzler RF, Martin NA (1986) A proposed grading system for arteriovenous malformations. J Neurosurg 65:476–483
9. Türe U, Harput MV, Kaya AH, Baimedi P, Firat Z, Türe H, Bingöl CA (2012) The paramedian supracerebellar-transtentorial approach to the entire length of the mediobasal temporal region: an anatomical and clinical study. Laboratory investigation. J Neurosurg 116: 773–791
10. Voigt K, Yaşargil MG (1976) Cerebral cavernous haemangiomas or cavernomas. Incidence, pathology, localization, diagnosis, clinical features and treatment. Review of the literature and report of an unusual case. Neurochirurgia (Stuttg) 19:59–68
11. Yang J, Liu YH, Ma SC, Wei L, Lin RS, Qi JF, Hu YS, Yu CJ (2012) Subtemporal transtentorial petrosalapex approach for giant petroclival meningiomas: analyzation and evaluation of the clinical application. J Neurol Surg B Skull Base 73:54–63