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TECHNICAL NOTE - NEUROSURGICAL ANATOMY

The endoscopic supraorbital translaminar approach: a technical note

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Abstract

Object Resection of lesions located within the third ventricle presents a surgical challenge. Several approaches have been developed in an attempt to obtain maximal resection, while minimizing brain retraction. In this work, we assess the surgical exposure and maneuverability of the endoscopic supraorbital translaminar approach (ESTA), a potential alternative to fenestrate the lamina terminalis and approach the third ventricle by using the endoscope through a keyhole supraorbital-eyebrow craniotomy.

Methods Five cadaveric heads were used to assess the corridor depth, area of exposure, and viewing angles offered by the ESTA. One additional utilized specimen provided a stepwise dissection of the approach.

Results The ESTA was successfully performed in all specimens. Depth of the surgical corridor from the craniotomy to the ipsilateral internal carotid artery (ICA), lamina terminalis, and contralateral carotid were 70.7 ± 2.9 mm, 73.2 ± 2.9 mm, and 78.9 ± 4.1 mm, respectively. Viewing angle referenced to the ipsilateral ICA was 6.5 ± 4.2°, while the viewing angle for the lamina terminalis was 25.8 ± 4.3°. The surgical exposure provided by the ESTA was 1655 ± 255 mm^2.

Conclusions The ESTA provides a wide surgical view of the lamina terminalis and may be potentially used to approach lesions located in the anterior third of the third ventricle. As a pure endoscopic approach, the ESTA requires minimal brain retraction, while affords good visualization of targeted lesions around the lamina terminalis. The ESTA uses an anterolateral approach and so provides a short and straightforward approach to these structures.

Keywords Aneurysm · Skull base · Hydrocephalus · Keyhole · Supraorbital · Anatomy · Eyebrow

Abbreviations

ICA Internal carotid artery
mFLT Microsurgical fenestration of the lamina terminalis
minLTBC Minimally invasive fenestration of the lamina terminalis and basal cisterns

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Introduction

Several approaches have been developed to approach lamina terminalis and the anterior third of the third ventricle. Due to the regional complexity of neurovascular structures surrounding this region, there is an increased risk of developing serious complications secondary to surgical treatment [5]. Therefore, in these cases, it is intended that maximal resection is achieved, while minimizing brain manipulation.

The microsurgical subfrontal translaminar route has been widely employed for tumors located in the anterior end of the third ventricle, as an alternative to transforaminal (foramen of Monro) approaches that require brain transection and a greater distance to access the lesion [1, 6, 7, 9]. There has been a growing interest in using the endoscopic view to approach the lamina terminalis as a substitute to the microsurgical

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technique, given its improvements in field illumination and the ability to reduce brain retraction [3, 14]. However, a dedicated quantitative analysis of the surgical exposure and maneuverability using keyhole endoscopic approaches has not yet been addressed.

Therefore, we proposed the endoscopic supraorbital translaminar approach (ESTA) to approach the lamina terminalis and the anterior third of third ventricle. The aim of the present study is to review the technical nuances of this approach and provide a quantitative anatomic analysis of the surgical corridor.

Methods

All anatomical dissections were performed at the Anatomical Laboratory for VisuoSpatial Innovations in Otolaryngology and Neurosurgery (ALT-VISION) at The Ohio State University, using standard institutionally approved practices for cadaveric specimens. Five embalmed human cadaveric heads of unidentified specimens were injected with red silicone through the common carotid and vertebral arteries and with blue silicone through the jugular veins.

Prior to dissection, specimens underwent high-resolution computed tomography imaging, which was uploaded to the iNtellect Cranial Navigation System (Stryker, Kalamazoo, Michigan). Cadavers were registered based on surface recognition with the BrainLab Curve (Feldkirchen, Germany) for the acquisition of landmark points for the operative exposure calculation. Surface matching refinement based on bone surface was performed during the dissection, ensuring a mean deviation less than 0.5 mm for all specimens.

All specimens underwent minFLTBC throughout a 2 × 2-cm craniotomy. The minFLTBC was performed using a 0 and 45° rigid endoscopes (4-mm diameter, 18-cm length; Karl Storz, Tuttlingen, Germany), endoscopic instruments (KLS Martin Group, Tuttlingen, Germany), and drills (Stryker-Leibinger Corp./Medtronic, Kalamazoo, MI, USA). The images were recorded and stored by the Karl Storz Aida system (Karl Storz, Tuttlingen, Germany).

Technique

The endoscopic supraorbital translaminar approach (Figs. 1 and 2)

The head is positioned in rigid three-point fixation simulating operating room positioning, with slight hyperextension of the vertex. A 3.5-cm skin incision is placed in the upper third of the eyebrow between the lateral epicanthus and the supraorbital notch. The skin incision for our dissections is somewhat longer than in a live patient, due to a lack of tissue elasticity in fixed cadaveric specimens. The periosteal layer is incised and retracted inferiorly. Thereafter, we fashion a quarter-dollar 2 × 2-cm supraorbital craniotomy lateral to the supraorbital notch, but always above the superior temporal line. The craniotomy is placed eccentric laterally when prominent pneumatization is observed via the neuronavigation, in an attempt to avoid any sinus violation. Before dural opening, the anterior skull base (orbital roof) is drilled flat to allow the endoscope to be inserted parallel to the anterior cranial base. The dura is opened in a curvilinear fashion and is retracted towards the orbital roof. The head extension and gravity retraction allow the frontal lobe to fall away from the anterior skull base, offering a broad corridor to the anterior aspect of both optic nerves and both ICAs.

The ipsilateral opticocarotid cistern is identified and the arachnoid carefully opened and dissected. Similar principles are carried out at the level of the suprasellar cisterns. These maneuvers enhance the anterolateral corridor and allow exposing the proximal segment of the ipsilateral middle cerebral artery. The ipsilateral sylvian cistern is opened at this time, and then, the endoscope was placed laterally, directed towards the contralateral side. In this position, the dissection is carried out towards the contralateral opticocarotid cistern. The proximal contralateral middle cerebral artery is exposed, along with both A1 segments of the anterior cerebral artery, centering the anterior communicating artery and the lamina terminalis. Using a 45° endoscope and rotating the camera allows a broad view from the ipsilateral to the contralateral sylvian cistern, and we advise to use the angled endoscope when exposing the most lateral points of the surgical field (e.g., ipsilateral and contralateral sylvian cisterns) (Fig. 3).

The lamina terminalis is then visualized behind the posterior chiasm directing posterior and superiorly, underneath both A1 and the anterior communicating artery. A combination of sharp and blunt dissection using microscissors and microdissectors are employed to open the avascular middle area of the lamina terminalis.

Measurements

After cadaver dissections, stereotactic measurements for each of the targets of interest consisting of the Cartesian X, Y, and Z coordinates were obtained with neuronavigation. All landmark coordinates were grouped and processed using dedicated software (Microsoft Office Excel 2013; Microsoft Corp., Redmond, Washington, USA) that calculated all the measurements from a spreadsheet of 3D coordinates. Depth of the surgical corridor was assessed calculating the distance from the center point of the keyhole supraorbital craniotomy to the following 3 points: (1) ipsilateral internal carotid artery (ICA); (2) lamina terminalis; (3) contralateral ICA (Fig. 4a). Area of exposure was calculated by means of the length and width of a quadrilateral-shaped region limited by four points (Fig. 4b): (1) medial limit of the craniotomy; (2) lateral limit of the

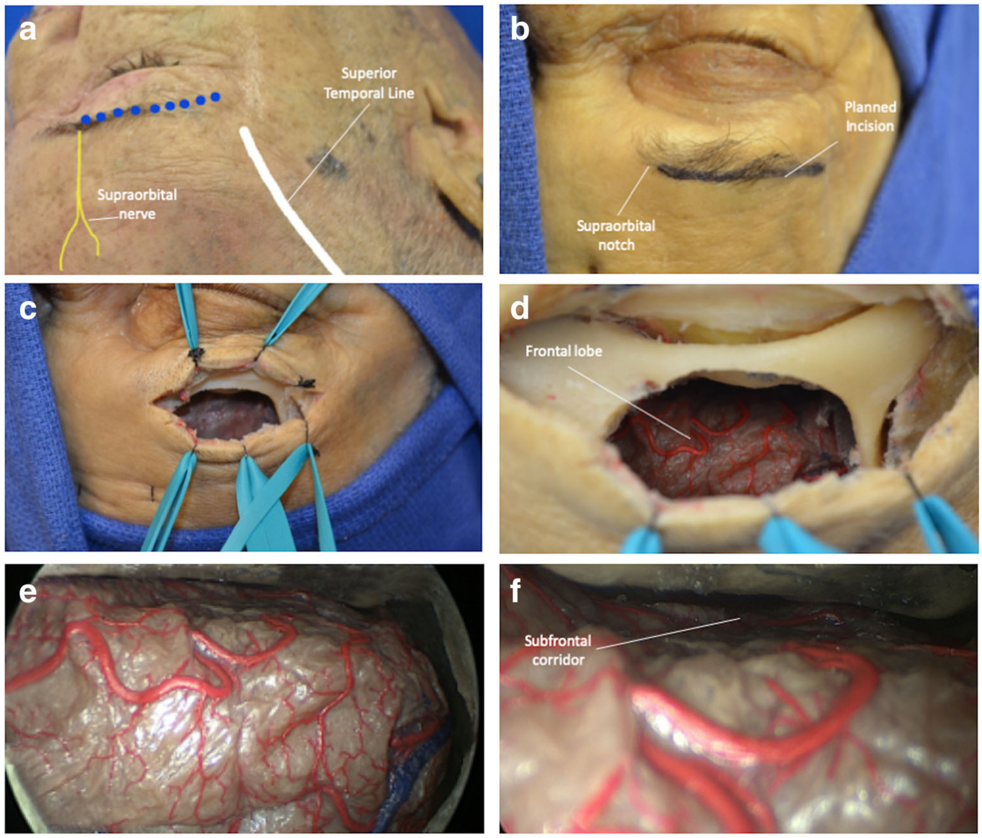

Fig. 1 Stepwise dissection (skin incision and craniotomy). **a** Before planning the incision and the keyhole craniotomy is important to mark important landmarks, such as the superior temporal line and the supraorbital notch, where the supraorbital nerve cross to inervate the forehead. **b** An arcuate incision over the superior third of the eyebrow, starting lateral to the supraorbital notch is planned. **c** A 2 × 2-cm craniotomy is performed beneath the skin incision lateral to the supraorbital notch and above the supratemporal line, so the temporalis muscle does not need to be dissected. **d** The dura is retracted inferiorly and the frontal lobe is exposed. **e** Given the head orientation and because of the gravity effect the frontal lobe tends to fall away from the anterior skull base. **f** The subfrontal corridor is used to get access to the anterior side of both optic nerves and internal carotid artery

craniotomy; (3) the ipsilateral bifurcation of the ICA; (4) the most distal point of the anterior cranial fossa that can be reached in the direction of the contralateral ICA. Horizontal angle of view was calculated in regard to 2 targets of interest: (1) the ipsilateral ICA; and (2) the lamina terminalis (Fig. 4c). Horizontal angle of exposure was calculated as the angle formed in between a sagittal plane that traverses these structures and the vertical plane that extends from the center of the craniotomy to these targets of interest.

Results

The minFLTBC was feasible to perform bilaterally in all five specimens (10 sides). In all specimens, both ICA, both anterior cerebral artery (A1 and A2 segments) and the anterior communicating artery formed an H-shaped ridge over both optic nerves and lamina terminalis. The anterior communicating artery was found in all specimens. This has a unique single lumen in 4 out of 5 specimens and was fenestrated in the other one.

Visualization of both ICA bifurcations (ipsilateral and contralateral) was possible in all specimens. Dissection of suprasellar and opticocarotid cisterns was successfully achieved in all dissections. Visualization of the proximal middle cerebral artery and dissection of the proximal sylvian cistern was achieved in all but one specimen (successful in 8 out of 10 sides). Gravity and further manual retraction of the frontal lobe in this head was not enough to provide access to these structures using endoscopic instruments and dissection only achieved exposure of both ICA bifurcations.

Measurements

Surgical corridor depth Average distances and standard deviation from the supraorbital craniotomy to the ipsilateral ICA, lamina terminalis, and contralateral were 70.7 ± 2.9 mm, 73.2 ± 2.9 mm, and 78.9 ± 4.1 mm, respectively.

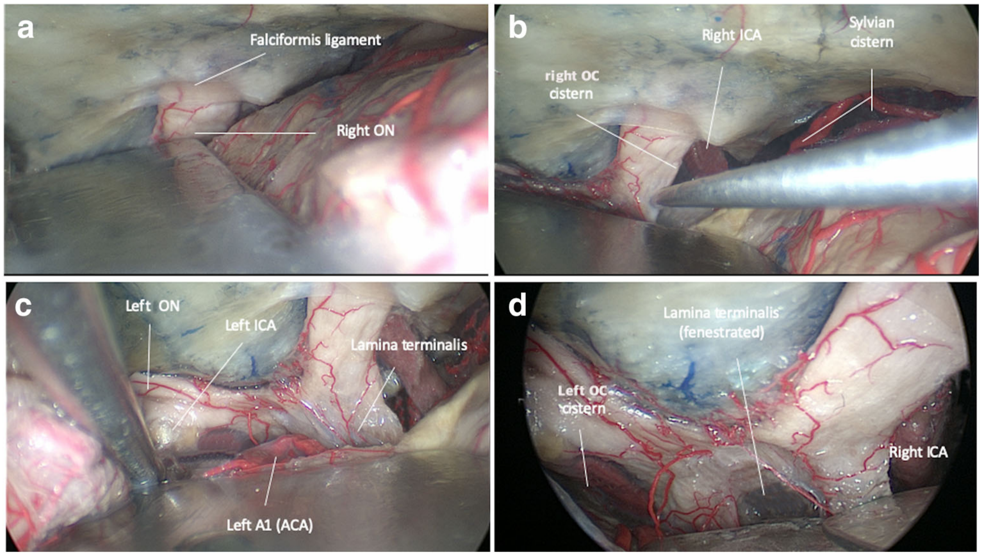

Fig. 2 Stepwise dissection (cont'd intradural dissection). **a** Initially, ipsilateral optic nerve and the falciform ligament are visualized, medial to the prominence that is formed by the anterior clinoid process. **b** Ipsilateral carotid cistern is broadly opened, and some CSF is released in order to induce brain relaxation and facilitates the exposure of the ipsilateral sylvian fissure and contralateral structures. **c** The 45° endoscope is rotated and placed in the lateral side of the craniotomy, allowing the visualization and opening of the contralateral optic carotid cistern and proximal part of the sylvian fissure. **d** Opening of suprasellar and contralateral cisterns allows to further expose the lamina terminalis and open it using a combination of sharp and blunt dissection

Area of exposure The average area of skull base exposure provided by the minFLTBC was 1655 ± 255 mm^2.

Horizontal viewing angle Viewing angle for the ipsilateral bifurcation of the ICA was $6.5 \pm 4.2°$, while the viewing angle for the lamina terminalis was $25.8 \pm 4.3°$.

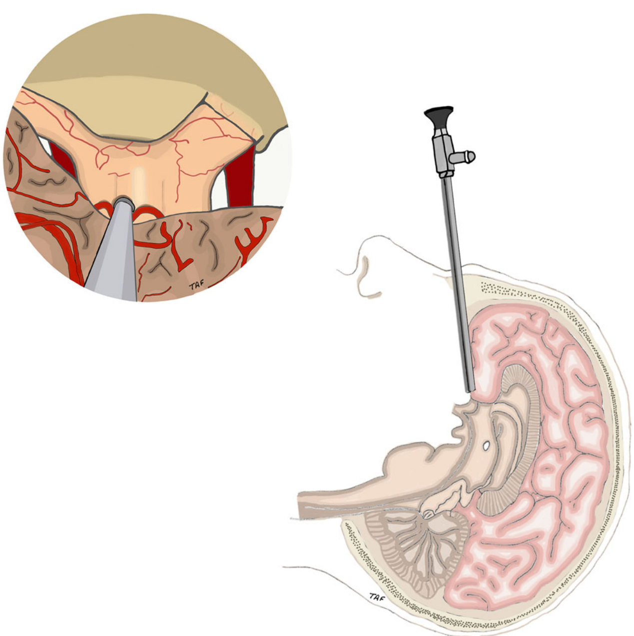

Fig. 3 Drawing showing regional endoscopic anatomy and position of the endoscope. A1, A1 segment of the anterior cerebral artery; A2, A2 segment of the anterior cerebral artery; AComm, anterior communicating artery

Discussion

The ESTA performed through a keyhole supraorbital-eyebrow craniotomy is a minimally invasive alternative to the microsurgical fenestration of the lamina terminalis and basal cisterns. Depth of the surgical corridor to the three selected targets of interest (ipsilateral ICA, lamina terminalis, and contralateral ICA) is less than 8 cm in all cases, while the angle of exposure to the ipsilateral ICA and lamina terminalis is 6 and 25°, respectively. The ESTA is a straightforward approach, as demonstrated by both the short distance and the orthogonal trajectory from the craniotomy to main surgical targets in basal cisterns and lamina terminalis. The ESTA, as described in the present work, uses the subfrontal corridor, to provide a wide exposure of the third ventricle and lamina terminalis, through a small 2 × 2-cm craniotomy. Other benefits of the ESTA include minimization frontal lobe retraction, reduced risk of intraparenchymal bleeding, avoidance of blind dissection, short distance to target, and anterior visualization of the lamina terminalis.

Only a few studies addressing endoscopic fenestration of the lamina terminalis through a transcranial nontransventricular approach exist in the literature [3, 14]. The ESTA is a modification to the approach described by Spena et al. [14], who suggested performing a small minicraniotomy over the supraciliary region to access the lamina terminalis. We do not agree, however, that the simple visualization of the surgical field using an endoscopic view is enough to justify the use of a technique. The new proposal

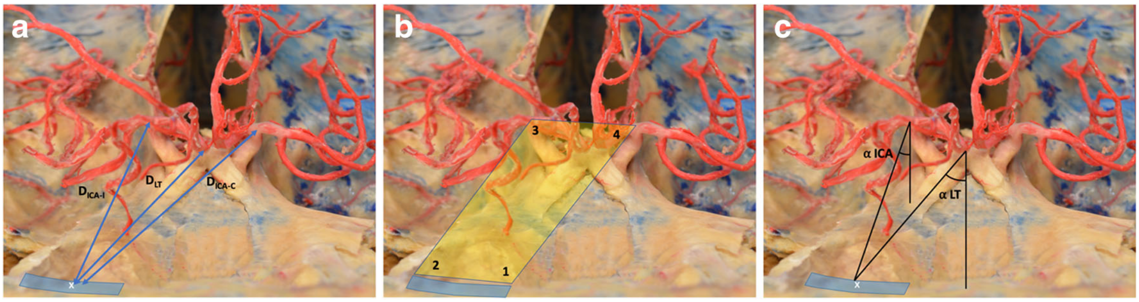

Fig. 4 Anatomical dissection showing the vascular relationships in anterior and middle cranial fossa and measurements that were taken in the design of the current study. **a** Depth of the surgical corridor was assessed calculating the distance from the center point of the keyhole supraorbital craniotomy to three targets of interest: ipsilateral internal carotid artery (D_{ICA-I}), lamina terminalis (D_{LT}), and contralateral internal carotid artery (D_{ICA-C}). **b** Area of exposure was calculated by means of the length and width of a quadrilateral-shaped region limited by four points: medial limit of the craniotomy (1), lateral limit of the craniotomy (2), ipsilateral bifurcation of the internal carotid artery (3), and most posterior point of the anterior cranial fossa that can be reached in the direction of the contralateral ICA (4). **c** Horizontal viewing angle was calculated in regard to 2 targets of interest: the ipsilateral internal carotid artery (α ICA) and the lamina terminalis (α LT)

must ensure that delicate microsurgical maneuvers can be comfortably performed to not jeopardy the procedure safety [10]. In their report [14], authors use an inflated balloon as a method to retract the frontal lobe. Blinded retraction of the frontal lobe may cause inadvertent venous bleeding that can be difficult to control considering such a narrow corridor. Despite the similarities and that the size of the craniotomy is not reported in their original work, we consider that a too small craniotomy prevents from performing an adequate dissection and that may be the reason behind that additional retraction was needed. In our technique, if an adequate dissection is performed across the surgical field provided by a 2-cm craniotomy, no additional retraction rather than the simple gravity force is needed. Along with the access to the lamina terminalis, the ESTA proposed in this work allows expanding the dissection to a more lateral orientation, which is confirmed by the wide viewing angle in the horizontal view ($25.8 \pm 4.3°$). Indeed, along with the lamina terminalis fenestration we propose to systematically open the anterior circulation basal cisterns (including suprasellar, opticocarotid, crural, and sylvian cisterns) in an attempt to improve CSF dynamics and facilitate brain relaxation.

Beer-Furlan and colleagues [3] described an interhemispheric endoscopic fenestration of the lamina terminalis through a simple paramedian burr hole. In their technique, the corridor provided by the burr hole was not wide enough to allow two-surgeon four-handed work and microsurgical dissection. Hence, the interhemispheric dissection was aided by a 12F Foley catheter, which was eventually used as a retractor. Such maneuvers, in the absence of sharp dissection, may cause venous tearing from the anterior parasagittal veins. The limited surgical maneuverability, along with the use of the interhemispheric corridor, reduces visibility of the lateral aspect of the third ventricle and basal cisterns. Additionally, while we acknowledge the interhemispheric lamina terminalis is also a direct and a straightforward approach to the lamina terminalis, the midline skin incision carries more esthetic concerns than that derived from an eyebrow incision [13].

In comparison with the microsurgical subfrontal translaminar approach, the ESTA provides wider viewing angle and field illumination [4]. These properties allow working through narrow corridors as demonstrated. In this paper, we employed a craniotomy of 2×2 cm that, as demonstrated by the enlarged viewing angles, is enough to not only expose the lamina terminalis, but also to expand the arachnoid dissection to the suprasellar, opticocarotid, and sylvian cisterns. Such exposure can be achieved with minimal brain retraction and the gravity retraction alone is normally enough to introduce the tip of the endoscope to expose these structures anteriorly. Further dissection of basal cisterns and CSF relief induce brain relaxation facilitating the visualization and surgical manipulability around the lamina terminalis. The endoscopic view allows the manipulation of deep lesions under direct vision with minimal disruption of normal brain structures, which translates, for instance, in a reduced risk of venous injury during the dissection of arachnoid membranes in the subfrontal corridor. Likewise, the use of a smaller craniotomy and the minimization of frontal retraction can potentially improve the associated postoperative discomfort, short functional recovery times, and reduce operative times.

Approaching tumoral lesions located in the third ventricle is a potential indication for using the ESTA. The frontal transcortical-transforaminal approach using endoscopic vision has also demonstrated its feasibility for approaching lesions located within the third ventricle, but unlike in the present technique, the exposure is limited to lesions entirely located within the third ventricle [1]. The area of exposure provided by the minFLTBC was 1655 ± 255 mm^2, exposing the entire area between both ICA from an anterior perspective in all cases. The broad exposure of the lamina terminalis makes this approach a potential tool to be employed for lesions exceeding the anterior limits of the third ventricle, such as some craniopharyngiomas, or tuberculum sellar meningiomas that secondarily invades the third ventricle. The ESTA would afford approaching lesions that also extends into the anterior cranial fossa and subarachnoid space. Tumors entirely located within the anterior third ventricle can represent another potential indication of this approach, such as purely intraventricular craniopharyngiomas, hypothalamic gliomas, or colloid cysts. Improvements in endoscopic visualization and in illumination field allow performing a safer tumor resection, while the maneuverability seems to be sufficient despite the small craniotomy size. Finally, the ESTA avoids entering the parenchyma to reach the anterior margin of the third ventricle, which would theoretically reduce the risk of developing potential complications associated to bleeding and edema.

The ESTA has potential drawbacks that deserve mention. Intraventricular tumors are often complex. Large tumors invading multiple compartments can distort the anatomy, increasing the risk of causing inadvertent injury to eloquent structures, such as the optical apparatus. Similarly, complex intraventricular tumors, such as some hypothalamic-third ventricle floor gliomas and craniopharyngiomas can growth inferiorly behind the optic chiasm, which would obscure its visualization and safe removal. Development of angled dissectors and endoscope lens (e.g., 45 and 75°) permits increase the expectances in terms of visualization and attempts more complete resection, but still, in those scenarios, we discourage the use of the ESTA until further clinical experience is demonstrated. Likewise, use of the subfrontal trajectory can cause personality changes and memory impairment [2, 11, 12]; in the case of mLTF such phenomenon, however, this is related to frontal lobe contusion and edema provoked by excessive brain retraction. Frontal lobe retraction is minimal when using our proposed endoscope-assisted minFLTBC procedure, and the gravity effect is regularly enough to get access to both optic nerves and supraclinoid ICA. Subsequently, psychological and memory disturbances are at least anatomically less likely than when using an open approach [8].

Moreover, the present study possesses limitations inherent to its design. This is a preclinical laboratory cadaver-based study. Formalin fixation hardens tissues and certain properties cannot be assessed as in the operating room with regard to brain swelling, CSF egress, and bleeding. Furthermore, the clinical efficacy of the minFLTBC versus traditional open fenestration during aneurysm surgery has not yet been determined; our potential clinical applications are predicated on minFLTBC also leading to decreased shunt dependence and/or vasospasm as prior open lamina terminalis fenestrations have suggested. Despite the encouraging lab-based results, we certainly note that further prospective studies in the clinical setting are needed to determine the effectiveness and safety of the proposed technique.

Conclusions

This preclinical laboratory study suggests that the ESTA is a valid alternative to the microsurgical supraorbital translaminar approach for approaching the anterior compartment of the third ventricle. As per the results obtained, the surgical view and maneuverability are wide enough to consider its use for the treatment of tumoral lesions located in this region. The straight trajectory through a keyhole supraorbital craniotomy along with the wide viewing angle disposed by the subfrontal corridor and the optometric properties of the endoscope allows to easily access the lamina terminalis and anterior segment of the third ventricle with minimal brain manipulation or retraction.

Authorship contributions Conception and design of study, Rafael Martinez-Perez and Thiago Albonette-Felicio; acquisition of data, Rafael Martinez-Perez, Thiago Albonette-Felicio, and Mostafa Shahein; analysis and/or interpretation of data, Douglas A. Hardesty and Mostafa Shahein. Drafting the manuscript, Rafael Martinez-Perez and Thiago Albonette-Felicio; revising the manuscript critically for important intellectual content, Ricardo L. Carrau and Daniel M. Prevedello; approval of the version of the manuscript to be published, Rafael Martinez-Perez, Thiago Albonette-Felicio, Douglas A. Hardesty, Mostafa Shahein, Ricardo L. Carrau, and Daniel M. Prevedello.

Compliance with ethical standards

Conflict of interest Daniel M. Prevedello is a consultant for Stryker Corporation and Medtronic Corp. Daniel Prevedello has equity on 3 rivers LLC, eLUM Technologies, LLC and Soliton LLC. Daniel Prevedello receives royalties from KLS-Martin and Mizuho. Ricardo L. Carrau is a consultant for Medtronic Corp.

Ethical approval and informed consent (to participate and for publication) Informed consent and ethical approval were not deemed necessary by the local ethics in view of the design of the study (anatomy laboratory study). All anatomical dissections were performed at the Anatomical Laboratory for VisuoSpatial Innovations in Otolaryngology and Neurosurgery (ALT-VISION) at The Ohio State University, using standard institutionally approved practices for cadaveric specimens.

Code availability Not applicable.

References

1. Abdou MS, Cohen AR (1998) Endoscopic treatment of colloid cysts of the third ventricle. Technical note and review of the literature. J Neurosurg 89(6):1062–1068
2. Barrash J, Abel TJ, Okerstrom-Jezewski KL, Zanaty M, Bruss JE, Manzel K, Howard M, Tranel D (2019) Acquired personality disturbances after meningioma resection are strongly associated with impaired quality of life. Neurosurgery. https://doi.org/10.1093/neuros/nyz440

3. Beer-Furlan A, Pinto FG, Evins AI, Rigante L, Anichini G, Stieg PE, Bernardo A (2014) Interhemispheric endoscopic fenestration of the lamina terminalis through a single frontal burr hole. J Neurol Surg B Skull Base 75(4):268–272
4. Bossi Todeschini A, Montaser AS, Hardesty DA, Carrau RL, Prevedello DM (2018) The limits of the endoscopic endonasal transclival approach for posterior fossa tumors. J Neurosurg Sci 62(3):322–331
5. Cikla U, Swanson KI, Tumturk A, Keser N, Uluc K, Cohen-Gadol A, Baskaya MK (2016) Microsurgical resection of tumors of the lateral and third ventricles: operative corridors for difficult-to-reach lesions. J Neuro-Oncol 130(2):331–340
6. Du C, Feng C-Y, Yuan X-R, Liu Q, Peng Z-F, Jiang X-J, Li X-J, Xiao G-L, Li Y-F, Xiong T (2016) Microsurgical management of craniopharyngiomas via a unilateral subfrontal approach: a retrospective study of 177 continuous cases. World Neurosurg 90:454–468
7. Erturk M, Kayalioglu G, Ozer MA (2003) Morphometry of the anterior third ventricle region as a guide for the subfrontal (translaminaterminalis) approach. Neurosurg Rev 26(4):249–252
8. Fountas KN, Hadjigeorgiou GF, Kapsalaki EZ, Paschalis T, Rizea R, Ciurea AV (2018) Surgical and functional outcome of olfactory groove meningiomas: lessons from the past experience and strategy development. Clin Neurol Neurosurg 171:46–52
9. Krishna V, Blaker B, Kosnik L, Patel S, Vandergrift W (2011) Trans-lamina terminalis approach to third ventricle using supraorbital craniotomy: technique description and literature review for outcome comparison with anterior, lateral and trans-sphenoidal corridors. Minim Invasive Neurosurg 54(5–6):236–242
10. Martinez-Perez R, Mura JM (2019) The Extradural Minipterional Approach: “Think Small, Play Wider.”. World Neurosurg 125: 534–535
11. Mavaddat N, Kirkpatrick PJ, Rogers RD, Sahakian BJ (2000) Deficits in decision-making in patients with aneurysms of the anterior communicating artery. Brain 123(Pt 10):2109–2117
12. Molino I, Cavaliere C, Salvatore E, Quarantelli M, Colucci L, Fasanaro AM (2014) Is anterior communicating artery syndrome related to fornix lesions? J Alzheimers Dis 42(Suppl 3):S199–S204
13. Park HH, Sung KS, Moon JH, Kim EH, Kim SH, Lee K-S, Hong C-K, Chang JH (2019) Lateral supraorbital versus pterional approach for parachiasmal meningiomas: surgical indications and esthetic benefits. Neurosurg Rev. https://doi.org/10.1007/s10143-019-01147-8
14. Spena G, Fasel J, de Tribolet N, Radovanovic I (2008) Subfrontal endoscopic fenestration of lamina terminalis: an anatomical study. Minim Invasive Neurosurg 51(6):319–323