

## Original Article

## Microsurgical anatomy of the transsylvian translimen insula approach to the mediobasal temporal lobe: Technical considerations and case illustration

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### Abstract

**Background:** Various vascular, neoplastic, and epileptogenic pathologies occur in the mediobasal temporal region. A transsylvian translimen insula (TTI) approach can be used as an alternative to temporal transcortical approach to the mediobasal temporal region. The aim of this study was to demonstrate the surgical anatomy of the TTI approach, including the gyral, sulcal, and vascular anatomy in and around the limen insula. The use of this approach is illustrated in the resection of a complex arteriovenous malformation.

**Methods:** The TTI approach to the mediobasal temporal region was performed on three silicone-injected cadaveric heads. The gyral, sulcal, and arterial anatomy of the limen insula was studied in six formalin-fixed injected hemispheres.

**Results:** The TTI approach provided access to the anterior and middle segments of the mediobasal temporal lobe region as well as allowing access to temporal horn of the lateral ventricle. Using this approach we were able to successfully resect an arteriovenous malformation of the dominant medial temporal lobe.

**Conclusion:** The TTI approach provides a viable surgical route to the region of mediobasal temporal lobe region. This approach offers an advantage over the temporal transcortical route in that there is less risk of damage to optic radiations and speech area in the dominant hemisphere.

**Key Words:** Arteriovenous malformation, mesial temporal sclerosis, mesial temporal lobe, transinsular, translimen insula, transsylvian, uncus

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### INTRODUCTION

There are several approaches to lesions located in the medial temporal lobe region. Anatomic complexity, critical surrounding structures and deep location complicates surgical approach to pathology in this region of the brain.

De Oliveira<sup>[4]</sup> divided the mediobasal temporal lobe into three regions in an anterior-posterior plane: the anterior segment extending from the rhinal sulcus to the choroidal point; the middle segment extending from the choroidal point to the posterior aspect of the quadrigeminal plate; and the posterior segment consisting of the mediobasal

temporal lobe posterior to the quadrigeminal plate. Various surgical techniques have been described to access the anterior and middle regions of the mediobasal temporal lobe. Rhoton classified approaches to the mediobasal temporal lobe based on the cortical surface through which the approach is directed.<sup>[1]</sup> These include approaches through the lateral surface, through the basal surface, through the medial surface and through the superior surface of the temporal lobe. Superior approach to the mediobasal temporal lobe consists of the transsylvian-transinsular approach, first described by Yasargil for selective amygdalohippocampectomy.<sup>[38]</sup> Noted advantages of this approach include preservation of the basal and lateral temporal cortex; while drawbacks include a small operative window and entrance into the temporal horn through the roof of the ventricle, with associated risk of damage to Meyer's loop. Anterior-medial approach to the mediobasal temporal lobe is performed using a transsylvian-transcisternal exposure.<sup>[34]</sup> This approach preserves lateral and basal temporal cortex in addition to avoiding dissection through the ventricular roof and Meyer's loop. Disadvantages of the transsylvian-transcisternal approach include risk of injury to cisternal structures (internal carotid artery, optic and oculomotor nerves) and a limited operative window with constrained operative trajectories. In this study, we describe the technical considerations and surgical anatomy of an approach to lesions of the mediobasal temporal lobe through the limen insula. This approach combines components of both the transinsular and transcisternal approaches mentioned earlier. We provide an anatomic description, cadaveric dissection and a representative case illustration of this technique.

## MATERIALS AND METHODS

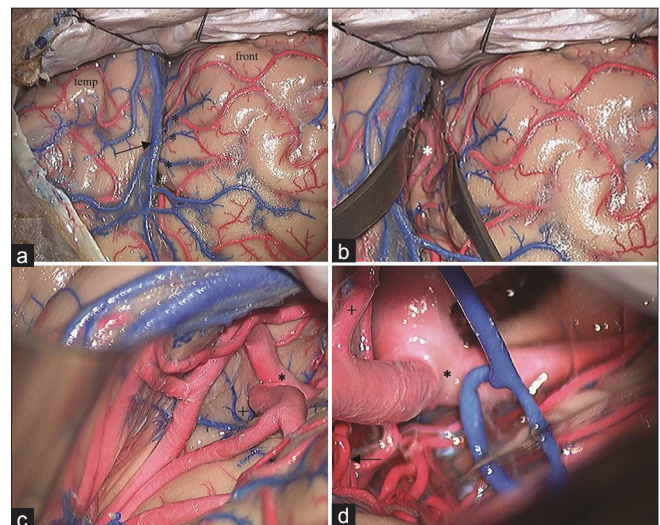
Three cadaveric heads were fixed with 4% formalin and subsequently infused with colored silicone via the common carotid and vertebral arteries (red silicone) and the jugular veins (blue silicone).<sup>[22]</sup> Cadaveric dissection through an orbitozygomatic exposure was used to provide anatomic illustration of the transsylvian translimen insula (TTI) approach. The feasibility of this approach to the mediobasal temporal region was examined. Furthermore, six formalin fixed cerebral hemispheres were used to study the gyral, sulcal, and arterial anatomy of the area in and around the limen insula. Application of this approach is demonstrated in the case of a patient with a mesial temporal lobe arteriovenous malformation (AVM) that was resected by the senior author (RM) using a TTI approach.

## RESULTS

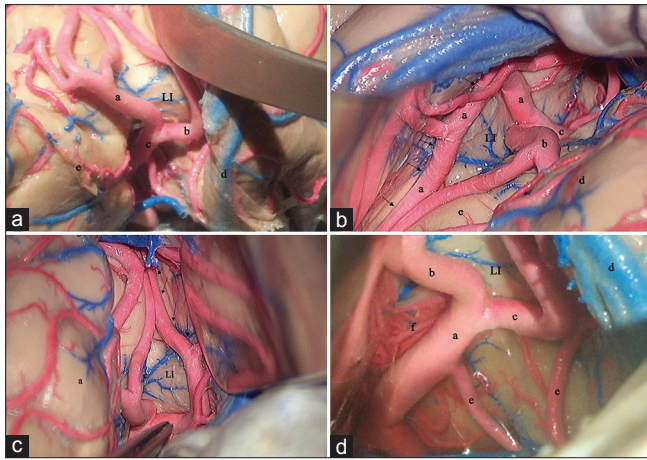
### Transsylvian translimen insula approach to the mediobasal temporal lobe region

A two piece orbitozygomatic craniotomy was performed in all three injected cadaveric heads.<sup>[24]</sup> Subsequently, the

sylvian fissure was widely opened under 40 × magnification of the operating microscope [Figure 1a and b]. The internal carotid in the paraclinoid region was indentified. The arachnoid of the frontal lobe over the ipsilateral optic nerve was released for better mobilization of the frontal lobe. The M1 segment of the middle cerebral artery (MCA) was identified in every specimen and followed to its bifurcation into the M2 segments. The limen insula was identified as the region of transitional cortex at the junction of the sylvian stem (sphenoidal compartment of sylvian fissure)<sup>[37]</sup> and the posterior limb (operculoinsular compartment) of the sylvian fissure [Figure 1c and d]. It is bordered posterolaterally by the posterior insular pole and anteromedially by the middle of the posterior orbital gyrus<sup>[35]</sup> [Figure 2a-d]. In all three injected heads, the temporal horn of the lateral ventricle was successfully entered through the posterior limen insula [Figure 3b-c]. In addition, the uncus (amygdala) and the parahippocampal region were accessible via a corticotomy and dissection through the limen insula [Figure 3d]. In some cases there are early temporal branch arteries from M1 crossing the limen insula, which need to be mobilized. Sacrifice of these arteries is not necessary and not recommended. In all cases the length of the anterior choroidal artery (AChA) could be identified in the temporal horn of the lateral ventricle at the choroidal point. After resection of uncus, parahippocampal gyrus, the crural cistern and the vascular structures in the crural cistern along with the oculomotor



**Figure 1:** (a) Sylvian fissure exposed after dural incision. The arachnoid layer on the frontal (front) side of the superficial sylvian vein (→) is opened to initiate the dissection. Bridging frontal veins (\*) may be sacrificed to retract the sylvian vein with the temporal lobe (temp). Triangular cistern (#). (b) Dissection of the arachnoid layers is continued until the M2 branches (\*) coursing along the insular surface are identified. (c) Dissection follows the distal M2 segments back to the MCA bifurcation (\*) near the limen insula (+). (d) M1 is followed proximally through the sphenoidal compartment of the sylvian fissure back to the ICA bifurcation (\*). Note the lateral lenticulostriate arteries (←) emanating from the M1 and the early temporal branch also emerging from the M1 (+)

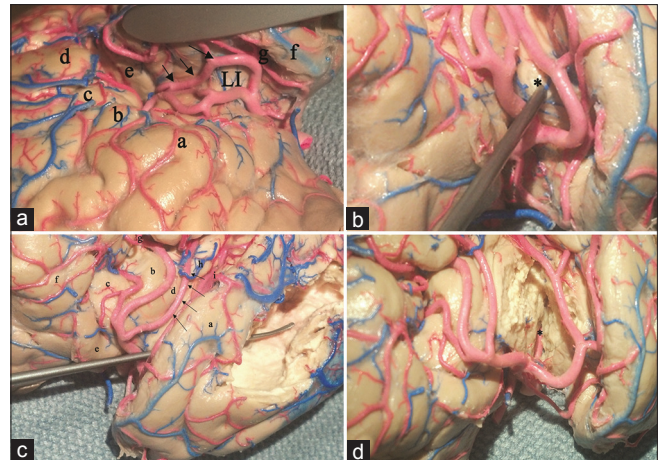


**Figure 2:** (a) Limen insula (LI), a - superior division of MCA, b - inferior division of MCA, c - M1 emerging from sphenoidal compartment of sylvian fissure, d - temporal tip, e - posteromedial orbital lobule (inferior frontal gyrus, pars orbitalis). (b) Limen insula (LI), a - inferior division of MCA, b - superior division of MCA, c - M1 emerging from sphenoidal compartment of sylvian fissure, d - pars orbitalis, e - anterior short insular gyrus, f - transverse insular gyrus. (→) outline inferior circular sulcus, the inferior division of the MCA consistently follows this sulcus through the opercular compartment of the sylvian fissure. (c) LI limen insula, a - pars orbitalis, b - anterior portion of parstriangularis, c - deep sylvian vein → inferior circular sulcus. (d) LI limen insula, a - M1, b - superior division of MCA, c - inferior division of MCA, d - superficial temporal vein, e - anterior temporal branch, emerging from M1 prior to bifurcation, f - lateral lenticulostrates emerging from M1 entering into the anterior perforated substance

nerve was identified in all cases [Figure 3d]. The average depth of visualization was 3 cm and the average length of limen insula corticotomy was 2 cm.

### Gyral, sulcal, and vascular anatomy of the limen insula

The “threshold” of the insula (limen insula) exists in the genu of the sylvian fissure. It represents a segment of transitional cortex extending between the archicortex of the anterior perforated substance and the neocortex of the temporal pole.<sup>[11]</sup> The limen insula is bounded by the posterior insular pole posterolaterally; by the middle of the posterior orbital gyrus anteriorly; by the transverse insular gyrus and the limen recess medially (a hiatus between the most lateral lenticulostrates from the M1 and the limen insula, ~1.5 cm in width); and by the MCA and sylvian fissure anteriorly. The bifurcation of the M1 into its M2 branches typically occurs at this point in the sylvian fissure. The majority of the arterial supply to the limen insula derives from the inferior branch of the M2 (in ~83% of specimens) and to a lesser extent from the middle temporal artery (a branch from off of an early temporal artery). Venous drainage from the limen insula region is through the central and posterior insular veins and their confluence as the deep middle cerebral vein and ultimately to the basal vein of Rosenthal (seen in Figure 2b as the confluence of veins coursing toward

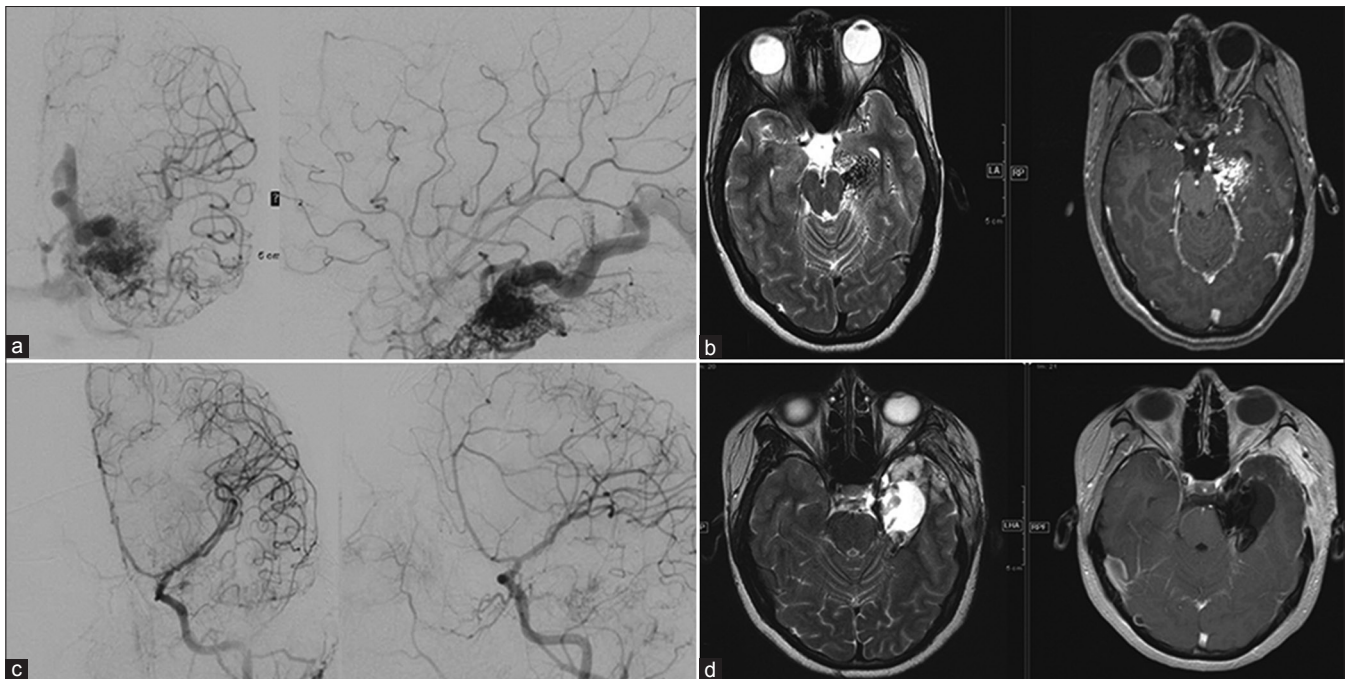


**Figure 3:** (a) LI limen insula, a - pars orbitalis, b - pars trigangularis, c - pars opercularis, d - pli-de-passage inferior, e - Heschel's gyrus, f - temporal tip, g - planum polare, → inferior circular sulcus. (b) Entry point (\*) and angle of approach for accessing the temporal horn of through the limen insula. (c) Explanted hemisphere with middle temporal gyrus removed demonstrating access to the temporal horn (+) via an entry point at the posterior limen insula. a - superior temporal gyrus, b - middle short insular gyrus, c - anterior short insular gyrus, d - posterior short insular gyrus, e - transverse insular gyrus, f - pars orbitalis, g - triangular cistern, h - anterior long insular gyrus, i - posterior long insular gyrus, → central insular sulcus and artery. (d) Corticotomy and dissection through the limen insula to reach the mesial temporal lobe and the crural cistern. The PComm artery (\*) is seen in the depth of the dissection

the sphenoidal compartment of the sylvian fissure, underneath the MCA bifurcation). The association fibers of the uncinata fasciculus, connecting the temporal lobe to the frontal lobe, course beneath the superficial cortical layer in the limen insula.<sup>[7]</sup> The inferior occipitofrontal fasciculus (IFOF) runs posterior to the limen insula and the uncinata fasciculus, coursing beneath inferior circular (inferior limiting) sulcus ~1 cm posterior to the limen insula.<sup>[6,18]</sup> Meyer's loop also runs along the roof of the temporal horn, beginning ~5 mm behind the limen insula<sup>[2]</sup> and extends to the posterior inferior insular point (where Heschl's gyrus intercepts the inferior circular sulcus, marking the anterior-posterior location of the lateral geniculate nucleus of the thalamus).<sup>[3]</sup> The anterior insular pole and the insular apex are situated superiorly and slightly posterior to the limen insula.<sup>[28]</sup>

### Case presentation

A 19-year-old female presented with new onset of grand mal seizures. Cerebral angiogram [Figure 4a] and magnetic resonance imaging (MRI) of the brain [Figure 4b] demonstrated a Spetzler–Martin grade 4 arteriovenous malformation (AVM) situated in her dominant left mediobasal temporal lobe. The AVM extended from the uncus, involved the parahippocampal gyrus and extended posteriorly to the level of the ambient cistern. The AVM had feeding vessels off the AChA, the posterior communicating artery (Pcomm) and the MCA. Venous drainage of the AVM was through the basal vein



**Figure 4: (a) Preoperative AP and lateral angiogram. (b) Preoperative T2 and T1 + contrast MRI. (c) Postoperative AP and lateral angiogram. (d) Postoperative T2 and T1 + contrast MRI**

of Rosenthal. The options of stereotactic radiosurgery and microsurgical resection were discussed with the patient. It was thought that embolization of the AVM would not be safe due to feeders from AChA and Pcomm perforators. The patient and her family chose to proceed with microsurgical resection.

The patient was placed in Mayfield headholder and head was turned to the right with the head slightly extended with the malar eminence the highest point. A left frontotemporal craniotomy along with a two piece orbitozygomatic approach was performed. The sylvian fissure was split widely under the microscope. The M1, ICA, Pcomm, and AChA were identified. Next the limen insula was identified as the area adjacent to the bifurcation of the MCA on the temporal side. Next, the temporal horn of the lateral ventricle was entered at a 45° angle. The AVM was identified in the ventricle. Next, the uncus was resected through the limen insula. Then, using the ventricle as a landmark, through the limen insula corridor the lateral margin of the AVM was dissected. Since the major blood supply of the AVM was supplied by the anterior choroidal at the choroidal point, these feeders were disconnected. Subsequently, the perforators from the posterior cerebral artery and Pcomm were disconnected. We sequentially circumferentially dissected the AVM using a combination of corridor through the limen insula and the ICA oculomotor triangle. Access to the lateral and posterior margins of the AVM was achieved through the translimen insula approach, as described earlier, and these margins were disconnected

from their vascular pedicles. At the end there were several draining veins that merged into the basal vein of Rosenthal. These draining veins were eliminated at the very end. An immediate postoperative cerebral angiogram and MRI confirmed complete resection of the AVM [Figure 4c and d] and patency of the AChA, the Pcomm, and PCA.

Postoperatively the patient was kept intubated and completely sedated with systolic blood pressure range of 90-110 mmHg for 24 hours. Patient's postoperative examination after extubation showed that she was neurologically normal with the exception of a profound left frontalis palsy most likely from extended retraction on the nerve during surgery. At her 6 month follow-up the patient's frontalis nerve palsy is improving. She has had one seizure since surgery and thus still taking her antiepileptic. After the postoperative seizure, a second agent was added and the patient has been seizure free.

## DISCUSSION

Both the Frontotemporal Orbitozygomatic (FTOZ) craniotomy and a standard pterional craniotomy may be used to achieve adequate access to lesions in the mediobasal temporal lobe via the transsylvian, translimen insula approach described earlier. The FTOZ approach confers a shorter working distance, as well as greater vertical and horizontal working angles<sup>[10,12,14,23]</sup> as compared with the pterional craniotomy and may enable a reduction in brain retraction. We chose to use

this approach in the case of a mesial temporal lobe AVM (presented earlier) to provide generous access to the cisternal arterial feeders from the Circle of Willis, enable proximal vascular control, minimize stress on draining veins and have ample working space in the event of intraoperative hemorrhage or swelling. For less tenuous lesions—such as, cavernomas, tumors and mesial temporal sclerosis—a pterional craniotomy would be adequate.

The original transsylvian transinsular approach to the mediobasal temporal lobe was described by Yasargil in 1985 for the application of selective amygdalohippocampectomy.<sup>[38]</sup> Yasargil's approach continues to be used today and involves a wide splitting of the lateral sylvian fissure and cortical incision in the inferior circular sulcus of the insula, entry into the temporal horn and transventricular access to the mediobasal temporal lobe. Vajkoczy *et al.* described a transsylvian-transcisternal approach to the mediobasal temporal lobe in 1998,<sup>[34]</sup> which provided access to the mediobasal lobe while avoiding damage to the insular cortex and white matter inherent to Yasargil's approach.

The TTI approach, which is described in this paper, was first reported by Nagata *et al.* in 2005<sup>[19]</sup> in a case series of seven patients where it was used to access the crural, ambient, and interpeduncular cisterns. It draws its foundations from both Yasargil's transylvian transinsular approach and Vajkoczy's transsylvian transcisternal approach and provides access to the anterior and middle segments of the mediobasal temporal lobe. In lesions such as AVMs, the cisternal access allows for early control of feeding arteries from the PComm and AChA. This "tangential"<sup>[26]</sup> approach and its advantages have been documented by Du *et al.*,<sup>[5]</sup> and primarily depends on the lack of cortical disruption required for alternative approaches (lateral, superior or basal). However, this approach also results in reduced visualization and access to the posterior and lateral margins of the lesion.<sup>[5]</sup> This problem is not encountered with transinsular approaches, which provide ample exposure to the posterior and lateral margins. However, Meyer's loop covers the roof and lateral aspect of the anterior temporal horn<sup>[2,25,29]</sup> and both transinsular and lateral (e.g., transmiddle temporal gyrus as described by Niemeyer in 1958) approaches are associated with damage to Meyer's loop. Transsylvian transinsular approaches through the inferior circular sulcus are associated with significant visual field deficits in up to 28% of patients.<sup>[8]</sup> In the transcisternal approach the visual field deficits were noted in only 3% of patients, however, up to 9% had temporary oculomotor nerve palsies postoperatively.<sup>[34]</sup> Moreover, in the transsylvian transinsular approach, access to feeding vessels in the cisternal space may be less controlled when the cisterns are blindly accessed through the choroidal fissure with these approaches. Combining the transcisternal approach with a limited corticotomy through the limen insula

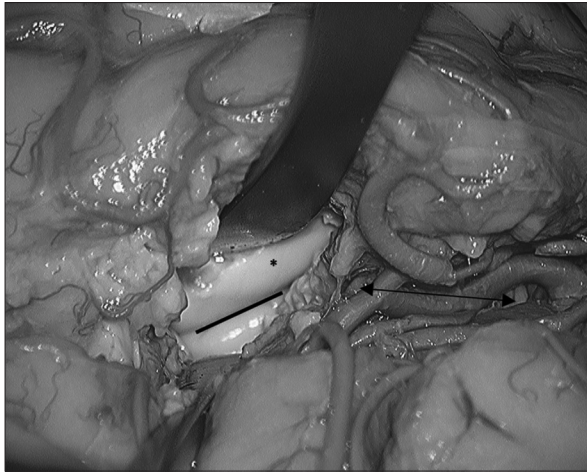
maximizes the ability to control feeding vessels in the basal cisterns and enables the lateral and posterior margins of the lesion to be readily accessed, while minimizing the risk of damage to visual fibers in Meyer's loop.<sup>[2]</sup> As compared with basal approaches (subtemporal approaches through the various basal temporal sulci or gyri), the TTI approach minimizes retraction on the temporal lobe and avoids potential injury to the vein of Labbé. The primary risks associated with the TTI approach to lesions of the mediobasal temporal lobe are related to the exposure of structures in the sylvian fissure and cisternal spaces and to the transection of functional neural tissue in performing the translumen approach. The major neural structures disrupted in the translumen approach include the amygdala and the uncinate fasciculus: unilateral damage of these structures is unlikely to cause significant morbidity,<sup>[7,19,36]</sup> though neuropsychological effects are possible and should be considered.<sup>[16]</sup> Risks to cisternal structures include injury to the optic nerve, oculomotor nerve (as seen in our patient) and vascular injuries to the ICA and its branches (PComm, AChA, and associated perforators) and the MCA and injury to the lateral lenticulostriate perforators or early temporal branches of the MCA.

The TTI approach is most applicable to cases where circumferential exposure and early vascular control is required for the treatment of a lesion located in the anterior or middle segments of the mediobasal temporal lobe. These include vascular lesions such as aneurysms, AVMs and cavernous malformations in addition to tumors including gliomas, meningiomas, and metastatic lesions. In the case series by Nagata, the TTI approach was applied to two basilar artery aneurysms, one AChA aneurysm, one AVM, one craniopharyngioma, and two cases of hydrocephalus treated with ventriculo-cisternal communication.<sup>[19]</sup> In this paper, we describe its application to an AVM.

Surgical access to the ambient cistern using the translumen approach may be enhanced by extension of the corticotomy at the limen insula into the inferior circular sulcus, as has been previously described in transsylvian transinsular and transsylvian transchoroidal approaches<sup>[19,33,36,38]</sup> [Figure 5]. This posterior extension, however, requires entry into the temporal horn via the roof of the ventricle, risking damage to Meyer's loop and resultant superior quadrantanopsia. It does, however, enable significant lateral mobilization of the temporal lobe. Based on anatomical reasoning, the morbidity with this exposure is not expected to be significantly greater than that of transinsular approaches alone.

## CONCLUSION

Surgical access to lesions in the mediobasal temporal lobe is a difficult task. Many surgical options have been



**Figure 5: Corticotomy into the inferior circular sulcus of insula, extending ~2 cm posterior to limen insula, provides access to inferior horn of lateral ventricle (~5 mm deep at 45 degree trajectory). Connection of this incision with the translimen insula incision (↔) provides expanded access to the ventricular space and will permit access to the crural and ambient cistern through a transchoroidal incision (→). Hippocampus (\*)**

developed to achieve such adequate and safe exposure of this region for the treatment of a variety of vascular, neoplastic, and epileptogenic lesions. We present an anatomical description and case presentation of the TTI approach that provides exposure to the anterior and middle segments of the mediobasal temporal lobe utilizing. Such an approach enhances access to the mediobasal region when compared with transcisternal approaches and minimizes the risk of morbidity associated with traninsular approaches.

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