Surgical Anatomy of the Sylvian Fissure

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1 Introduction

Cerebral fissures are tight clefts between two lobes or hemispheres that are limited by the arachnoid membrane [1]. Cisterns are enlarged pockets within the arachnoid layer that fill the spaces where the brain folds itself [2]. Arachnoid cisterns are also formed around neurovascular structures such as cranial nerves and the cerebral vasculature [3]. Cerebrospinal fluid (CSF) flows through these structures. Fissures and cisterns are anatomical pathways for the surgeon to reach deeper regions and a protective sheath for delicate structures [4]. The Sylvian fissure is continued medially with a wider space, the Sylvian cistern. These terms can sometimes be used indistinctly by some authors. To avoid confusion, we refer to both as the **Sylvian** corridor. The Sylvian corridor is a wide and versatile pathway that allows access to the basal cisterns and their contents, avoiding transgression of the parenchyma or minimizing brain retraction [5].

Furthermore, the insula, central core, and mesial temporal region can also be exposed [6]. Knowledge of anatomy is mandatory for the microsurgeon, and a sharp, clean, arachnoidal dissection is the way to open these spaces and gently "creep into" the depths of the brain to finally access a lesion that needs to be taken care of. This chapter will attend to the anatomical aspects of the Sylvian corridor and the microsurgical nuances relevant to this structure.

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2 History

The lateral cerebral fissure of the brain was originally described around the mid-1600s. However, it is uncertain if the first description is attributed to Sylvius or his disciple, Thomas Bartholin. Interestingly, Girolamo Fabrici d'Acquapendente illustrated the fissure 40 years before Sylvius's report, in *Tabulae Pictae* [7]. In the '60s, M.G. Yasargil led the transition from the lessons learned in H.G. Krayenbuhl's laboratory into the operating theater [8–12], introducing the operative microscope [13, 14], and thus permitting microsurgical exploration of structures such as the Sylvian fissure [15]. This allowed for revolutionary development in the surgical treatment of cerebral diseases such as aneurysms, tumors, and deep sitting lesions [9, 11, 12, 16].

3 Anatomy of the Sylvian Corridor

The Sylvian fissure is a deep sulcus that separates the frontoparietal and temporal opercula. It carries the middle cerebral artery M1, M2, and M3 branches within its depths. The M4 branches emerge on either side of the fissure to reach the lateral surface of the cerebral hemisphere. The disposition of the fissure is complex, starting at the orbitofrontal surface of the brain, lateral to the anterior clinoid process, and extends laterally in the convexity at the level of the supramarginal gyrus [17] (Fig. 1).

Concerning the cranial anatomical landmarks, the fissure runs at the level of the anterior squamous suture. The *anterior squamous point*, represented by the junction

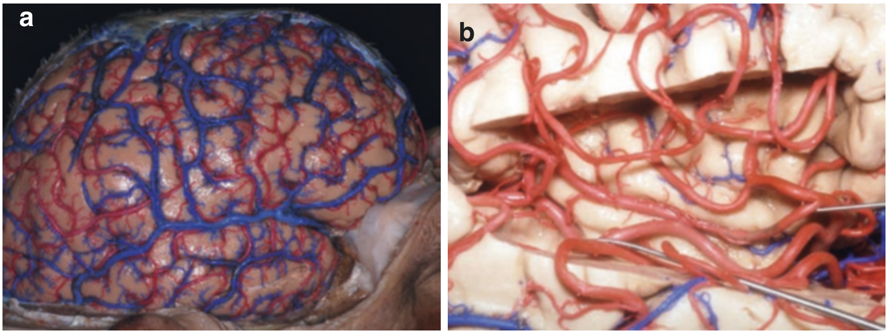

Fig. 1 The sylvian fissure. (**a**) In a lateral view of this right cerebral hemisphere. The disposition and extension of the sylvian fissure can be appreciated: commencing at the orbitofrontal surface of the brain, lateral to the anterior clinoid process and extending laterally in the convexity at the level of the supramarginal gyrus. The M4 branches of the middle cerebral artery (MCA), emerging from the fissure, and the superficial sylvian vein, with its tributaries, can be well appreciated. (**b**) The frontal and temporal opercula have been removed in this specimen and the insula is shown. The M2 and M3 branches of the MCA within the depths of the fissure and cistern

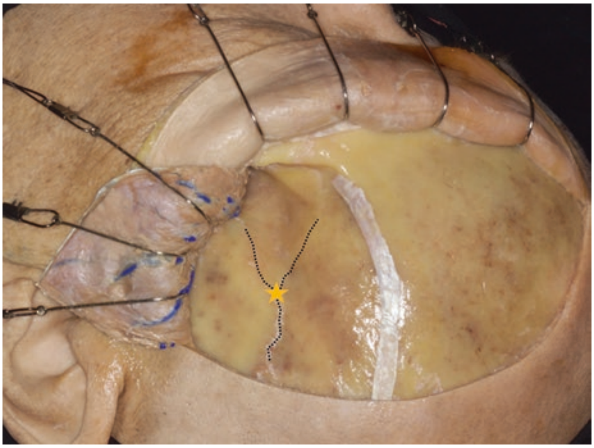

Fig. 2 The anterior squamous point is represented by the junction of the sphenoid wing, frontal and temporal bones, and is the topographical location of the anterior sylvian point, which divides the fissure in an anterior and a posterior rami

of the sphenoid wing, frontal and temporal bones, is the topographical location of the anterior Sylvian point, which in turn, is the most important surgical reference of the fissure [18] (Fig. 2). The anterior Sylvian point divides the fissure in anterior and posterior rami [17].

The stronger arachnoidal adhesions between the frontoparietal operculum and the temporal operculum give place to a broader space, deeper to the former, referred to as the **Sylvian cistern** (Fig. 3). This cistern is divided into two compartments: a proximal or **sphenoidal** compartment that harbors the M1 segment of the MCA and the distal or **operculoinsular** compartment containing the M2 and M3 branches [19]. The sphenoidal compartment separates the orbitofrontal cortex and anterior perforated substance from the temporal lobe. The operculoinsular compartment separates the frontal, parietal, and temporal operculum laterally and the insular surface medially. Both compartments are communicated at the level of the *limen insulae*. Thus, when the operculoinsular compartment is dissected in the laboratory or the OR, the insular surface represents "the floor" of this cavity.

The insula resembles a shallow three-sided pyramid with its base facing medially and the pyramid's tip being the insular apex. The short gyri are mostly located on the anterior facing side of the pyramid, while the long gyri represent the other two sides [20]. The shape of the insula is triangle-based anteriorly and with its tip pointing posteriorly. The anteroinferior angle of the insula is represented by the *limen insulae* [21]. The MCA's insular branches (M2) run in the Sylvian cistern and reach the edges of the insula (topographically, the limiting sulcus), and they loop, continuing as the M3 (opercular) branches, that run distally until reaching the Sylvian fissure more superficially, where they emerge as the M4 (cortical) branches [22] (Fig. 4).

The operculum covers the insula. The two upper thirds lay under the frontal and parietal lobes, represented by the inferior frontal gyrus (F3), while the lower third is covered by the superior temporal gyrus (T1) [23]. Therefore, a coronal cross-section of the Sylvian fissure and cistern will have an inverted "Y-" or "T-" shaped

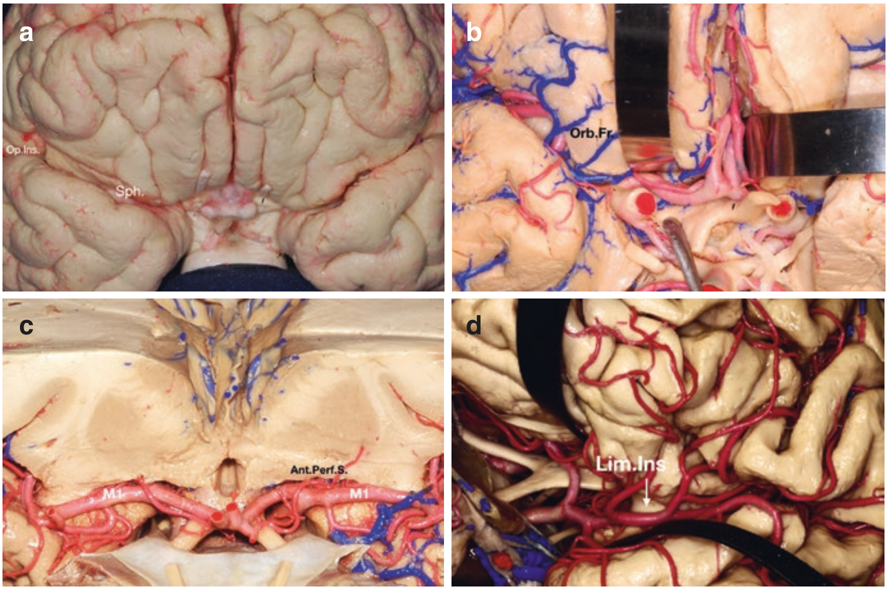

Fig. 3 Strong arachnoidal adhesions between the frontoparietal and the temporal opercula give place to the sylvian cistern. (**a**) This cistern is divided into two compartments: a proximal or sphenoidal compartment (Sph.), and a distal or operculoinsular compartment (Op.Ins.). (**b, c**) The sphenoidal compartment separates the orbitofrontal cortex (Orb.Fr.) and anterior perforated substance (Ant.Perf.S.) from the temporal lobe and contains the M1 segment of the MCA. (**d**) The operculoinsular compartment, which contains the M2 and M3 branches, separates the frontal, parietal, and temporal operculum laterally and the insular surface medially; the insular surface represents the floor of this cavity. Both compartments are communicated at the level of the limen insulae (Lim.Ins)

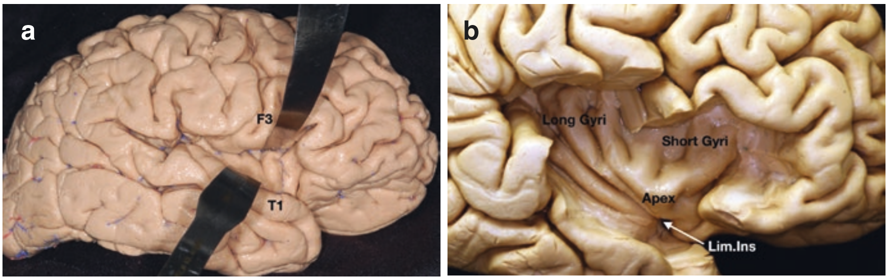

Fig. 4 Anatomy of the insula: In order to fully appreciate the anatomy of the insula, dissection and retraction of both, the frontoparietal and temporal operculum, is needed. (**a**) The insula is covered by the operculum. The two upper thirds lay under the frontal and parietal lobes, represented by the inferior frontal gyrus (F3), while the lower third is covered by the superior temporal gyrus (T1). (**b**) The insula resembles a shallow three-sided pyramid with its base facing medially and the tip of the pyramid being the insular apex, pointing laterally. The short gyri are mostly located in the anterior facing side of the pyramid while the long gyri represent the other two sides. The anteroinferior angle of the insula is represented by the limen insulae

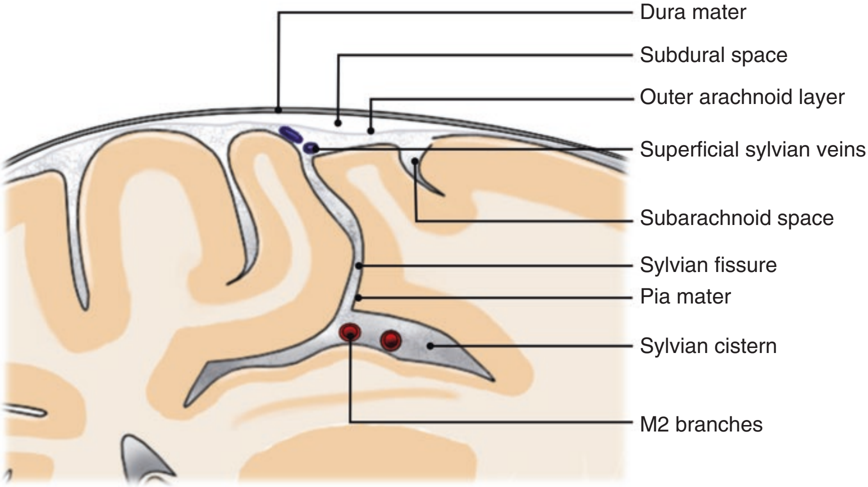

Fig. 5 Illustration of the disposition of the meninges and their relation to the sylvan fissure and cistern. Note the inverted "Y" or "T" shape of the cross section

disposition separating the three internal surfaces (Fig. 5). The Sylvian cistern entirely covers the superior surface of the temporal lobe. It is divided into two areas: anteriorly, the *planum polare*, posteriorly the *planum temporale,* and between both of them, the long oblique-running Heschl's gyrus [24].

The inferior frontal gyrus at this level has multiple foldings, and three distinct segments can be recognized. Anteriorly: the *pars orbitalis*, which is continuous medially with the orbitofrontal cortex. The pars orbitalis is separated by the horizontal rami of the Sylvian fissure from the *pars triangularis* (named for its triangular shape, with its tip facing inferiorly). The pars triangularis marks the anterior limiting sulcus of the insula in the fissure depth and coincides with the anterior limit of the basal ganglia and frontal horn of the lateral ventricle. Posteriorly: the anterior ascending rami separates the latter from the *pars opercularis*. This is a "U-" shaped segment that contains the most inferior aspect of the precentral sulcus. These structures are easily recognizable and are useful surgical landmarks [25] (Fig. 6). Broca's area usually resides in the superior half of the pars opercularis and the anterior half of the pars triangularis on the dominant hemisphere.

Across the fissure, and opposed to these structures, the superior temporal gyrus is mostly non-eloquent on its anterior part, but the posterior aspect of this convolution harbors Wernicke's area close to the supramarginal gyrus. As mentioned before, the superior temporal gyrus is continuous medially with the cisternal or superior surface of the temporal lobe. The inferior frontal gyrus correlates with the planum polare anteriorly. The precentral gyrus, which is frequently continuous with the posterior half of the pars opercularis, is a good landmark to identify the most external aspect of Heschel's gyrus. The postcentral gyrus and supramarginal gyrus are

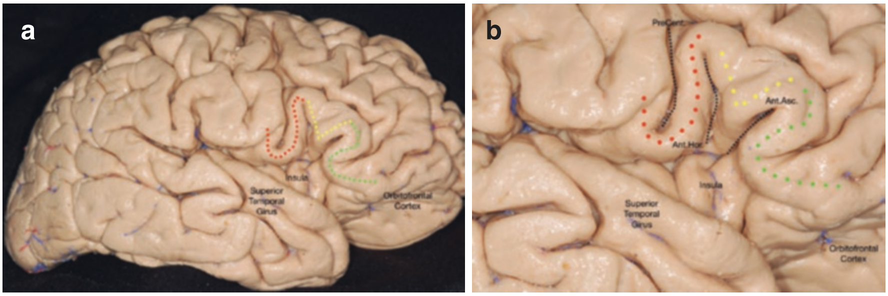

Fig. 6 (**a** and **b**) The inferior frontal gyrus at this level has multiple foldings and three distinct segments can be recognized. Anteriorly: the pars orbitalis (green), which is continuous medially with the orbitofrontal cortex. The pars orbitalis is separated by the anterior horizontal rami (Ant. Hor.) of the sylvian fissure from the pars triangularis (in yellow, named for its triangular shape, with its tip facing inferiorly). The pars triangularis marks the anterior limiting sulcus of the insula in the depth of the fissure and also coincides with the anterior limit of the basal ganglia and frontal horn of the lateral ventricle. Posteriorly: the anterior ascending rami (Ant.Asc) separates the latter from the pars opercularis. This is a "U" shaped segment which contains the most inferior aspect of the precentral sulcus (PreCent.)

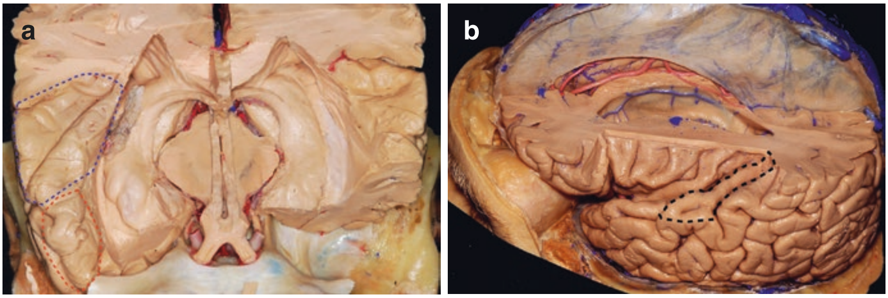

Fig. 7 The cisternal or superior surface of the temporal lobe: (**a**) the superior surface is continued laterally with the superior temporal gyrus. The inferior frontal gyrus correlates with the planum polare (red), anteriorly. The precentral gyrus, which is frequently continuous with the posterior half of the pars opercularis (ParsOp.), is a useful landmark to identify the most external aspect of Heschel's gyrus (**b**). The postcentral gyrus (PostC.) and supramarginal gyrus (SM) are coincidental with the planum temporale (**a**, blue)

coincidental with the planum temporale [26] (Fig. 7). Wernicke's area is usually seated at the level of the central lobule [27].

The superficial Sylvian veins are found in variable numbers, ranging from being absent in some cases to being a large venous complex with multiple veins of various sizes [28] (Fig. 8). However, the most common is to find 2–5 veins that typically drain anteriorly in the sphenoparietal sinus [29]. These veins are most frequently attached to the arachnoid over the fissure and run parallel to it, although they can be displaced inferiorly in some cases.

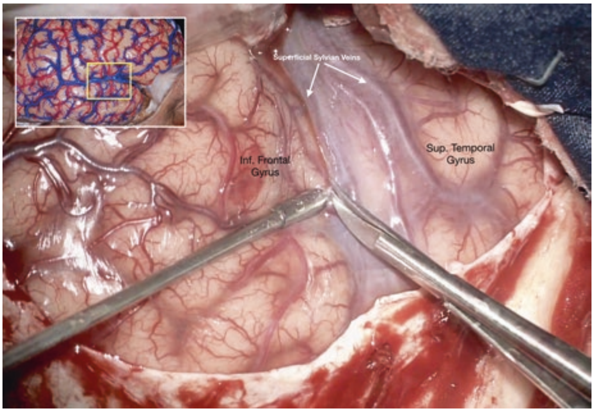

Fig. 8 The arachnoid membrane is incised by microscissors on the frontal side of the superficial sylvian veins at the level of the pars triangularis

4 Indications

The Sylvian corridor might be the most versatile approach in the microsurgeon's armamentarium (Fig. 9). When combined with the classic pterional craniotomy or extended variations of it [30, 31], this corridor can grant access to the sellar and parasellar regions [32], the anterior floor of the third ventricle via the *lamina terminalis* [33], the internal carotid artery and the carotid collar [34], the anterior clinoid process [35], the cavernous sinus [36], the interpeduncular cistern [37], the whole length of the middle cerebral artery [19], the A1 segment of the anterior cerebral artery and anterior communicating artery complex, the anterior perforated substance, the mesial temporal regions [26], the frontal and temporal horns of the lateral ventricle [38], the central core and basal ganglia [39], and the anterolateral surface of posterior fossa [40]. In addition, the sphenoidal compartment of the contralateral Sylvian cistern can be accessed as well from this corridor [41].

5 Surgical Technique

The "splitting" of the Sylvian fissure (Fig. 10) usually begins at the apex of the pars triangularis of the inferior frontal gyrus, the site where the brain parenchyma is most retracted and the arachnoid membrane can be incised safely [42, 43]. This landmark is known as the *anterior Sylvian point* [18]. The incision is carried out with a sharp instrument, either an arachnoid knife, micro scissors, or a number 11 blade, on the frontal side of the superficial temporal veins. These structures will be left attached to the temporal lobe to avoid damage by traction or the need to sacrifice them [19].

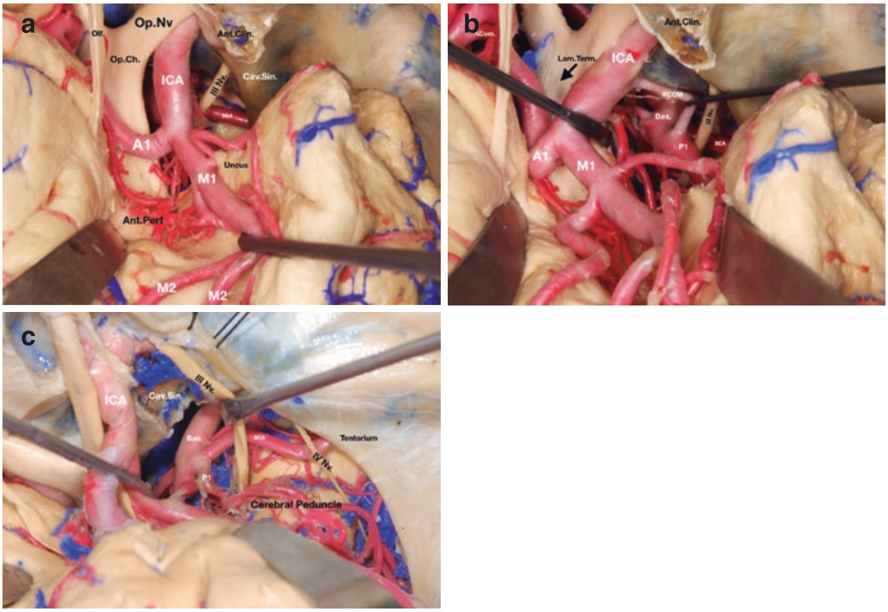

Fig. 9 The proximal sylvian fissure is dissected in this specimen. This corridor can grant access to the sellar and parasellar regions, the anterior floor of the third ventricle via the lamina terminalis (Lam.Term.), the internal carotid artery (ICA) and the anterior clinoid process (Ant.Clin), the cavernous sinus (Cav.Sin), the interpeduncular cistern, the whole length of the middle cerebral artery (M1–M2), the A1 segment of the anterior cerebral artery and anterior communicating artery complex (ACom), the anterior perforated substance (Ant.Perf), the mesial temporal regions, the frontal and temporal horns of the lateral ventricle, the central core and basal ganglia, and the anterolateral surface of posterior fossa. (**a, b**) Classic sylvian corridor. (**c**) The pretemporal corridor is an interesting way of complementing the sylvian corridor. It allows the surgeon to access the cavernous sinus and to perform an anterior petrosectomy in order to expose the anterolateral aspect of the brainstem

The arachnoid incision is wide enough to gently allow the bipolar forceps to spread the space between the temporal and frontal lobes. We recommend using small (0.5 mm) short non-stick bipolar forceps for the Sylvian fissure. The suction cannula can be used as a retractor as the arachnoid membranes are dissected. Using microscissors, the arachnoidal bands are cut, avoiding the vessels. Gentle counter traction with the suction cannula is useful to identify the avascular plane better to cut. It is advisable first to dissect in-depth, transitioning from the tight cleft of the fissure to the wider space of the Sylvian cistern. The dissection progresses gently until the M2 branches are identified. The "splitting" then continues proximally from "the inside to the outside," which usually makes the job of separating both lobes easier, especially in tighter fissures [19].

There are small superficial veins that cross as a bridge from one lip of the operculum to the other. These can be coagulated and divided. Arteries should be preserved and dissected carefully and only then displaced to the corresponding lobe. Unlike veins, M3–M4 branches don't cross over the fissure. They remain on their

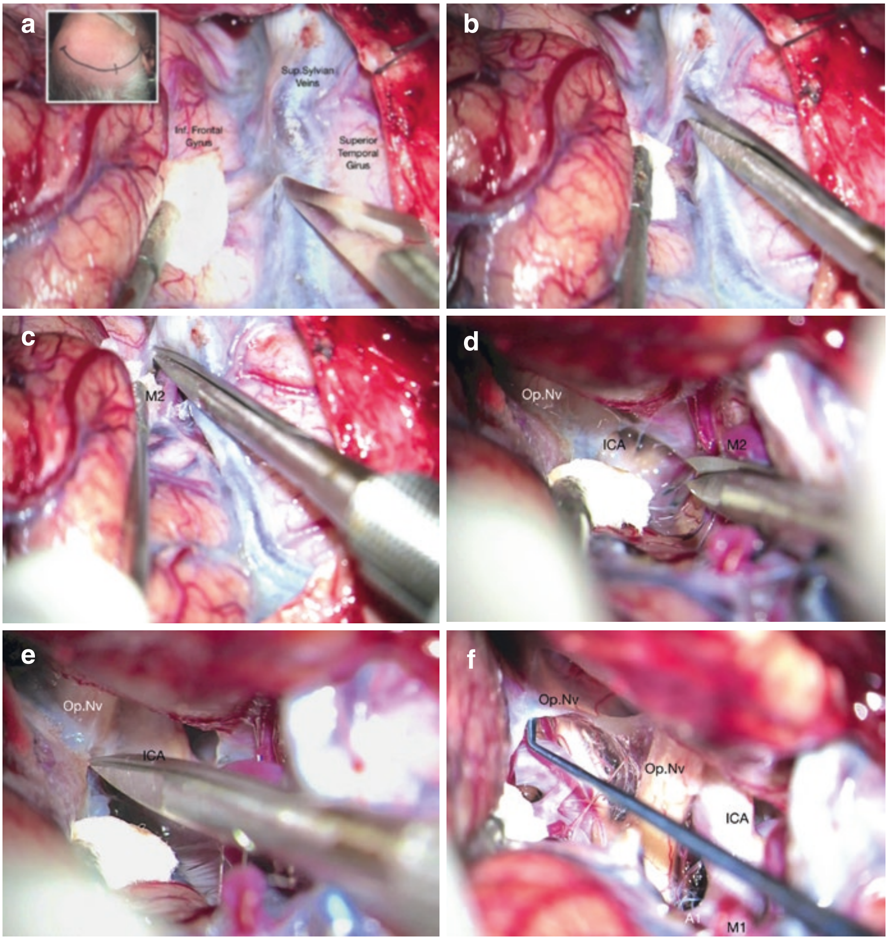

Fig. 10 Illustrative case. (**a**) The opening of the sylvian fissure usually begins at the anterior sylvian point where the brain parenchyma is most retracted and a safer incision can be made. (**b**) Using microscissors, the arachnoidal bands are cut avoiding any vessels. Gentle counter traction with the suction cannula is useful to better identify the avascular plane where to cut. (**c**) The dissection progresses gently until the M2 branches are identified. (**d**) The "splitting" then continues proximally following M1 to the carotid bifurcation. (**e, f**) In the final steps of the dissection, the complete opening of the sylvian corridor will allow the surgeon a full exposure of the neurovascular elements of the basal cisterns, which is, as already seen, a vast pathway to treat a grand variety of pathologies, both humoral and vascular. This will require the dissection of other arachnoidal membranes such as the suprasellar cistern (chiasmatic cistern), the carotid cistern and, if further depth is required, Liliequist membrane

corresponding lobe. Any bleeding from small veins or pial vessels should be meticulously coagulated, and the field must be kept clean at all times. Gentle compression with cottonoids will usually stop any minor venous oozing without the need for bipolar coagulation. In the case of ruptured aneurysms, keeping a clean surgical field, and identifying the structures under the microscope, can be difficult. Copious irrigation with saline can help clean some of the clots in the arachnoid. Certain authors have mentioned the benefits of using fibrinolytic agents such as urokinase in irrigation [44]. These can be dangerous in the presence of ruptured aneurysms; therefore, the surgeon should use these agents with caution and preferably away from the rupture site. Again, identifying the M2 branches and dissecting the perivascular spaces will lead the way to the basal cisterns [45].

As the opening of the corridor progresses, the frontal and temporal lobes will begin to separate. The surgeon can help with the placement of a brain retractor. However, if the brain is relaxed and the head positioning has been achieved correctly, this might not be necessary. When the genu of the MCA has been reached at the level of the limen insulae, the surgeon might need to switch to longer instruments as the dissection now will become deeper following the horizontal trajectory of M1.

A deep venous branch draining the orbital surface of the frontal lobe can be encountered in the depth of the sphenoidal compartment of the cistern. This vein or veins will drain in the sphenoparietal sinus, and its preservation is recommended, especially if they are large. Full exposure is rarely needed for vascular lesions within the basal cisterns. However, distal MCA aneurysms or insular tumors will likely need a wider opening, extending from the pars triangularis proximally and distally, to reach the *posterior Sylvian point* [46]. This landmark is coincidental with the posterior tip of the insula. For full exposure of the insula, the dissection will need to reach the anterior, superior, and inferior limiting sulcus [39].

Working within the depth of the silvan fissure usually requires retraction of the operculum. However, this can damage the eloquent structures [47]. Therefore, soft, transient retraction, often changing pressure points and sparing it whenever possible, is recommended.

6 Conclusion

The Sylvian corridor is a versatile avenue used by microdissection of the Sylvian fissure and cistern. It will grant access to a wide range of subdural, subarachnoid, and intraparenchymal lesions. Careful dissection and deep knowledge of anatomy are of capital importance for safer and more successful surgeries.

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