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Intrasylvian Retraction Technique to Facilitate the Sylvian Fissure Dissection: A Clinical Study of 125 Cases

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Abstract

Although many authors have recommended the retractorless technique to avoid retractor-induced brain injury, others usually use brain retractors with a meticulous technique to facilitate the surgery, especially for sylvian fissure dissection. The intrasylvian retraction technique was described for sylvian fissure opening, but no clinical evidence was found. We evaluate the efficacy and safety of this technique for the distal transsylvian approach. We reviewed the video records of clinical cases where the distal transsylvian approach was performed using the intrasylvian retraction technique for aneurysm treatment and middle cerebral artery (MCA) bypass between September 2018 and August 2022. Operative techniques are described. The efficacy and safety of the technique were assessed by full exposure of the sylvian fissure and new postoperative perisylvian hematoma, respectively. One hundred twenty-five cases were included and had an average age of 53.5 (range 16–85) years. Women comprised 73.6%. Aneurysm surgery, pure MCA revascularization, and aneurysm surgery with MCA revascularization were 106 (84.8%), 12 (9.6%), and 7 cases (5.6%), respectively. The most common aneurysm location was the internal carotid artery-posterior communicating artery junction in 37 cases (34.9%), followed by the anterior communicating artery in 27 (25.5%). Full exposure of the Sylvian fissure was achieved in all cases. No perisylvian hematoma was detected by immediate postoperative computed tomography in any patient. Using an appropriate technique for brain retractor application, sylvian fissure dissection was safely performed. The intrasylvian retraction technique effectively facilitated sylvian fissure dissection and provided wide exposure for the distal transsylvian approach.

Keywords
- brain retractor
- distal transsylvian approach
- intrasylvian retraction
- sylvian fissure dissection
- sylvian fissure split

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Introduction

As described by Yasargil, sylvian fissure dissection for the transsylvian approach was a very important procedure for neurosurgeons, especially cerebrovascular surgeons. Via the transsylvian route, almost all anterior circulation aneurysms and supratentorial pathologies could be accessed. This approach used the sylvian fissure, a natural plane, to access the pathology without brain transgression.[1] Sylvian fissure dissection was generally performed with the retractor-assisted technique.[2–6] The proper application of the retractors was not well described, and generally, the retractor spatula was placed outside the sylvian fissure, especially on the frontal lobe[7–10] (►**Figs. 1–3**).

Some authors used brain retractors to retain space for clipping after dissecting the sylvian fissure, but otherwise, their use is avoided.[11,12] Although the retractorless technique (not the use of fixed retractors) was proposed by many authors to avoid retractor-induced brain injury,[7,13–16] Katsuno et al and Hafez et al proposed the distal transsylvian approach using a sharp dissection with a particular style of retractor application.[17,18] Hafez et al described the actions of the retractor but did not focus on the location of the retractor spatula placement. As they demonstrated in the pictures, a pair of retractor spatulas was placed inside the sylvian fissure on the frontal and temporal sides during the dissection (we called it the "intrasylvian retraction technique")[17] (►**Figs. 1**, **2C**, **3C**, and **3D**).

This study demonstrates the details of the intrasylvian retraction technique to facilitate the sylvian fissure dissection. It evaluates the efficacy and safety of this technique for the distal transsylvian approach.

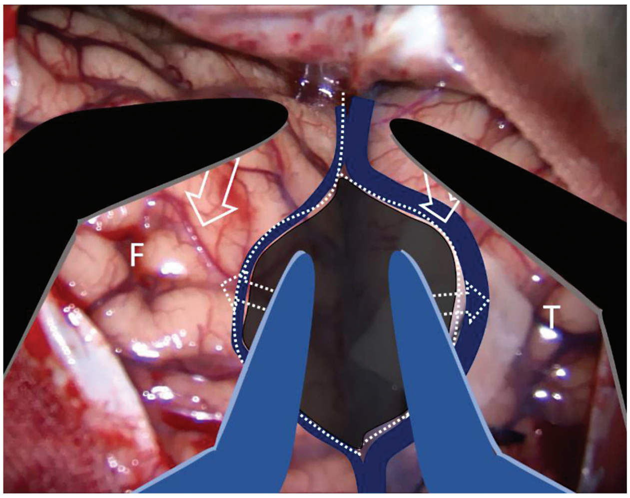

Fig. 1 Right frontotemporal craniotomy and right sylvian fissure. The superficial border of the sylvian fissure (*dotted line*) and superficial sylvian veins (*blue line*) were demonstrated. Extrasylvian retraction (*black retractors*) and direction of retraction force (*arrows*) were depicted. Intrasylvian retraction (*blue retractors*) and direction of retraction force (*dotted arrows*) were drawn. F: frontal lobe; T: temporal lobe.

Materials and Methods

We retrospectively reviewed the recorded video of patients who underwent a distal transsylvian approach using the intrasylvian retraction technique to treat aneurysms or M2 segment of middle cerebral artery (MCA) (M2) revascularization at the Faculty of Medicine Vajira Hospital, Navamindradhiraj University between September 2018 and August 2022. For aneurysm cases, we enrolled patients with ruptured and unruptured aneurysms. The exclusion criteria were (1) a distal MCA aneurysm (distal to the MCA bifurcation), (2) a case in which immediate postoperative computed tomography (CT) was not performed, and (3) an incomplete video record. Data regarding the location of the aneurysm, the side of the operative approach, and postoperative CT findings were collected and analyzed. In a case in which an MCA bypass was performed for aneurysm treatment, the case was classified as a revascularization case. Nonsubarachnoid hemorrhage (SAH) cases and World Federation of Neurosurgical Societies (WFNS) grades 1 to 3 of SAH were classified as good grades, and WFNS grades 4 and 5 were classified as poor.

Operative Technique

We used the distal transsylvian approach for almost all anterior circulation aneurysms, upper basilar artery aneurysms, and M2 revascularization. The patient was placed in

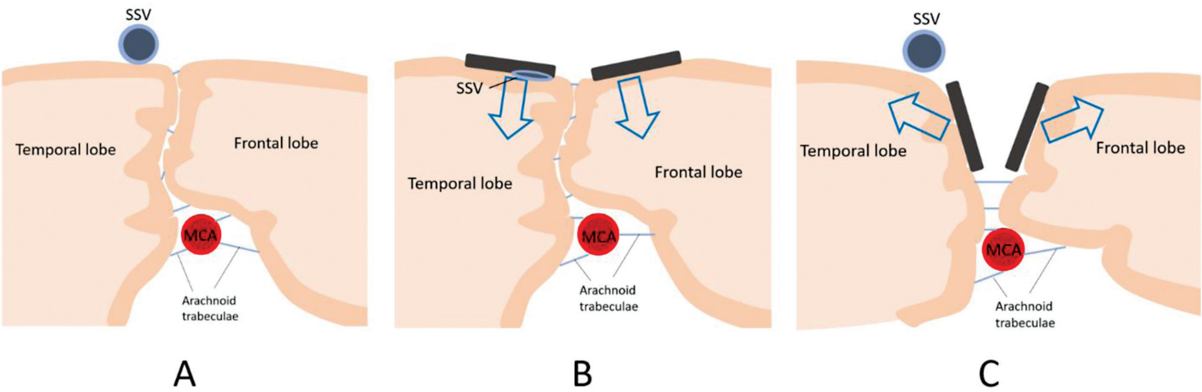

Fig. 2 Schema demonstrating the sylvian fissure dissection. (**A**) Anatomy of the sylvian fissure. (**B**) Retractor position for extrasylvian retraction (*black line*) and the direction of the retraction force (*arrows*). (**C**) Retractor position for intrasylvian retraction (*black line*) and the direction of the retraction force (*arrows*). The arachnoid trabeculae in the sylvian fissure were stretched by the retractor force to facilitate the dissection of the fissure. MCA: middle cerebral artery; SSV: superficial sylvian vein.

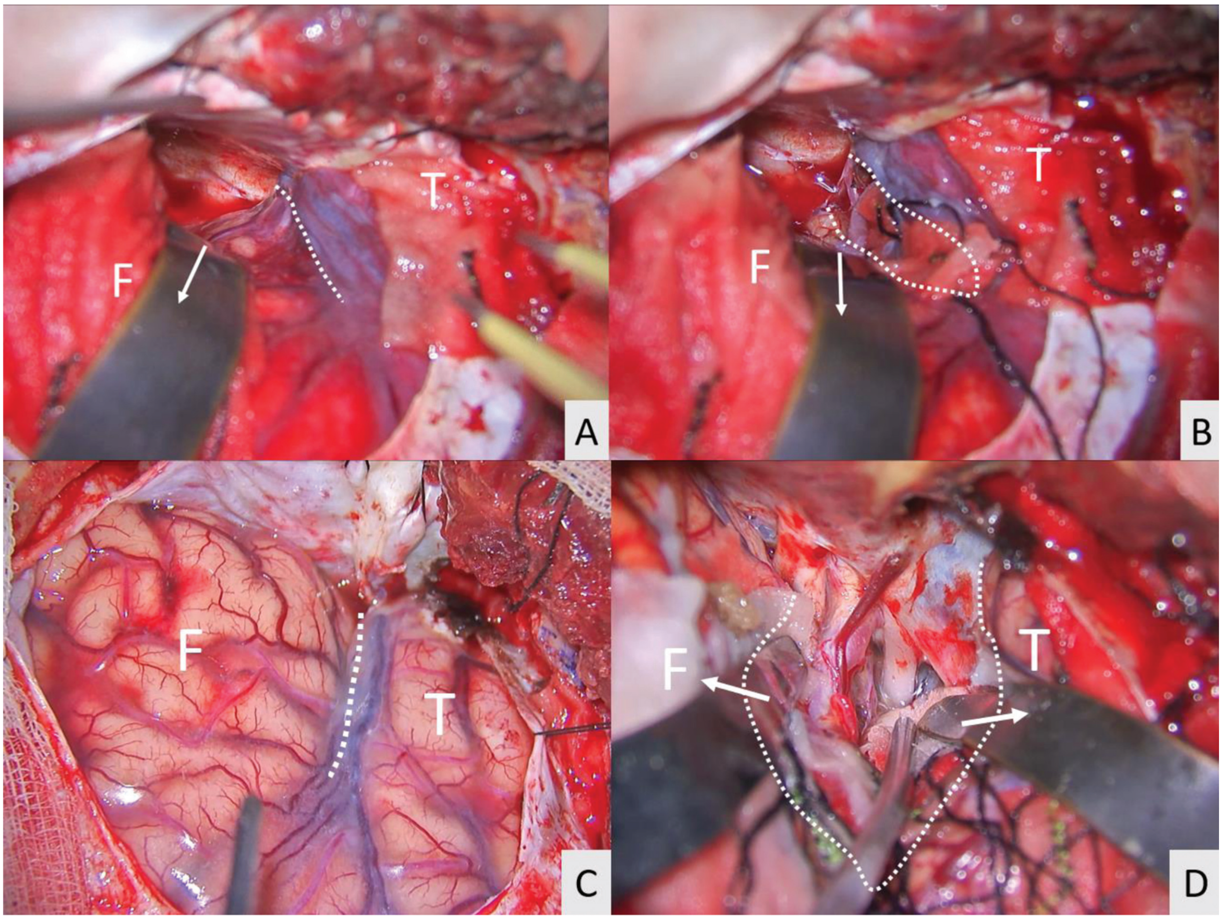

Fig. 3 Extrasylvian and intrasylvian retraction on the right sylvian fissure. (**A, B**) Extrasylvian retraction and (**C, D**) intrasylvian retraction. Superficial border of the sylvian fissure (*dotted line*). Arrow: direction of retraction force; F: frontal lobe; T: temporal lobe.

the supine position with the head of the bed approximately 30 degrees above the level of the heart. The patient's face was turned approximately 35 to 45 degrees away from the side of the operation with the vertex parallel to the floor and the neck extended in the sniffing position. Vertex down and turning the head more than 35 degrees made the temporal operculum drop to the sylvian fissure. Frontotemporal (pterional) craniotomy covering the entire length of the sylvian fissure and flattening of the sphenoid ridge was completed.

The sylvian fissure was dissected from the distal to the proximal part using sharp dissection. In cases with brain swelling from hydrocephalus, brain relaxation by cerebrospinal fluid released from the carotid cistern, lamina terminalis, or ventriculostomy was required before sylvian fissure dissection. The starting point of dissection was approximately 5 to 6 cm from the temporal tip.

For an anterior communicating artery (AcoA) aneurysm, the frontal side of the sylvian vein was usually dissected for the subfrontal transsylvian route. For posterior or lateral projecting internal carotid artery (ICA) aneurysm and upper basilar artery aneurysm, the temporal side of the sylvian vein was usually dissected for the anterior temporal approach. For the MCA aneurysm, either the frontal or temporal sides of the sylvian vein were dissected. For pure M2 revascularization, both M2 divisions and MCA bifurcation were fully exposed. The ICA was not necessary to identify this procedure.

Microscissors were used for sharp dissection throughout the sylvian fissure. After the distal part of the sylvian fissure was partially opened, two tapered-shape retractor spatulas (Leyla retractors)[3,4,19] were applied inside the sylvian fissure on both the frontal and temporal sides (intrasylvian retraction) to separate the frontal and temporal lobes and stretch the arachnoid trabeculae. The direction of the retractor force was perpendicular to the fissure to elevate, not compress, the brain (►**Fig. 4A**). To prevent brain injury from accidental compression of the retractor spatula into the brain and to stabilize the retractor spatula, a part of the spatula should be placed on the skull edge[20] (►**Fig. 4A–D**). By using the suction tube as another dynamic retractor to create more tension on the arachnoid trabeculae, microscissors were used to cut the arachnoid trabeculae in a one-by-one fashion. The suction tube was also used as another dissector to facilitate dissection. Microforceps with the nondominant hand could be applied to manipulate the arachnoid membrane and vascular structures. Therefore, the sylvian fissure dissection could be performed with two hands (bimanual dissection). The outside-in and inside-out or paper-knife cut techniques were used for dissection. Retractors were dynamically placed inside the sylvian fissure according to the shape of the sylvian fissure to stretch the arachnoid trabeculae until the fissure was completely opened (►**Figs. 5** and **6**). Brain retractors and suction tubes were used to create tension on the arachnoid trabeculae to cut them with microscissors so the dissection could be performed precisely and

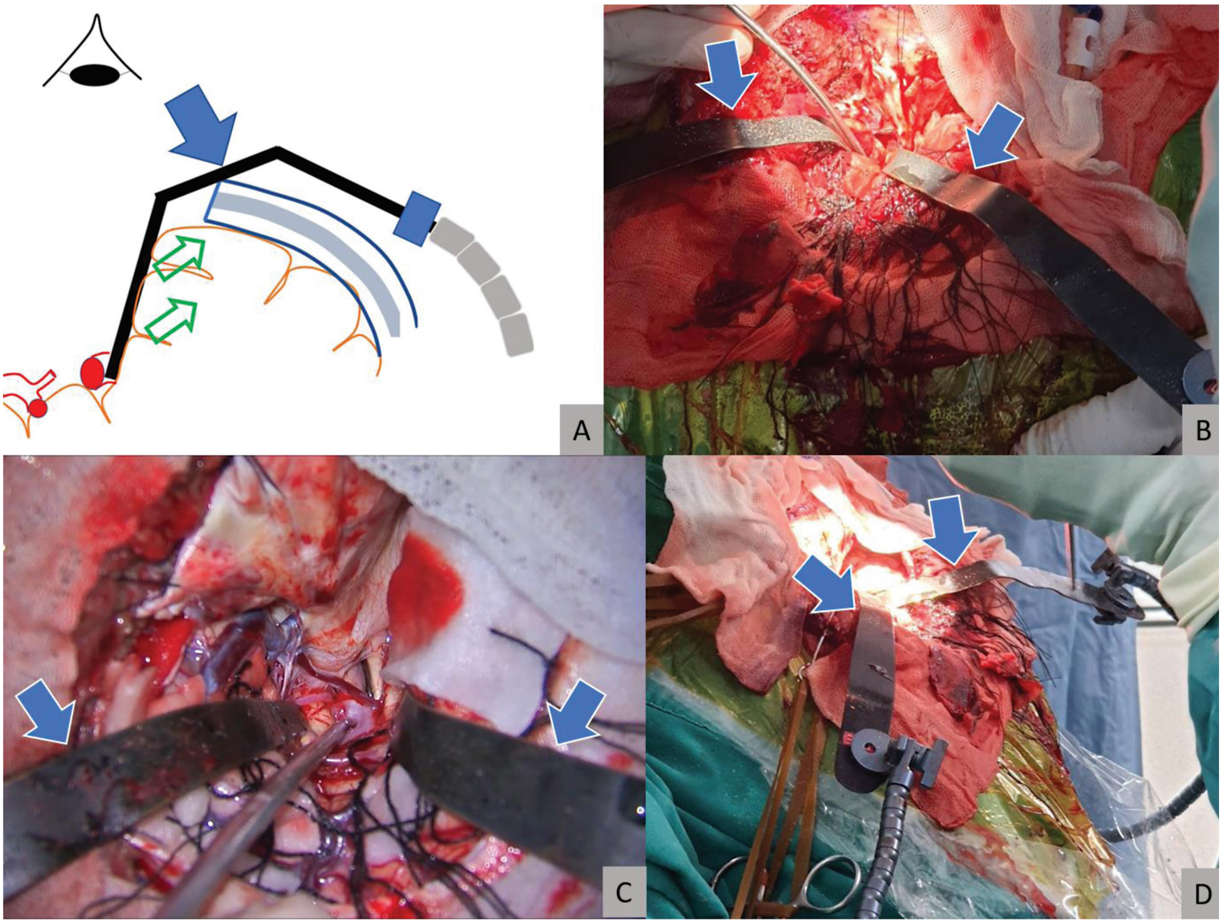

Fig. 4 (**A**) The direction of the retractor force was to elevate (*green arrow*), not compress the brain. A part of the retractor spatula was placed on the skull edge (*blue arrow*). (**B, C,** and **D**) Intraoperative pictures demonstrating the proximal part of the retractor spatulas resting on the skull edge (*blue arrow*).

quickly (►**Fig. 7**). Bridging veins of the sylvian vein were preserved as much as possible. The second (M2) and first (M1) segments of the MCA, anterior temporal artery, carotid terminus, and anterior choroidal artery were exposed, respectively. After the Sylvian fissure was completely opened, the retractor spatulas were used as the brain holder or elevator to provide a sufficient corridor for clear visualization of the lesion and surgical instruments[17,18] (►**Fig. 5F**). Because the surgical corridor was maintained with the retractor spatulas, the lesion could be comfortably handled with two hands.

Outcome Assessment

The efficacy of the technique was assessed by the degree of sylvian fissure exposure. Full exposure sylvian fissure was defined as the exposure of M2, M1 segment of MCA, and ICA for aneurysm surgery cases, and the sufficient exposure of M2 and M1 for pure M2 revascularization cases. The safety of the technique was evaluated by new perisylvian hematoma formation from an immediate postoperative CT scan (within 24 hours), routinely performed at our institute.

Results

One hundred twenty-five cases were enrolled. The average age was 53.5 (range 16–85) years. Women and men were 92 (73.6%) and 33 cases (26.4%), respectively. The SAH as an initial presentation was 98 cases (78.4%), and poor grade SAH (WFNS grade 4 and 5) was 42 cases (33.6%). Operations for aneurysm surgery, pure M2 revascularization, and aneurysm surgery with MCA revascularization were 106 (84.8%), 7 cases (5.6%), and 12 cases (9.6%), respectively. The most common aneurysm location was the ICA-posterior communicating artery junction in 37 cases (34.9%) (►**Table 1**). The most common aneurysm needed for M2 revascularization was the unclippable ICA aneurysm. Severe stenosis of the ICA was the most common indication for pure M2 revascularization. Full exposure of the sylvian fissure was achieved in all cases. No perisylvian hematoma was detected by immediate postoperative CT (►**Table 2**).

Illustrative Cases

Illustrative Case 1

A 58-year-old woman was diagnosed with an unruptured aneurysm of the left distal ICA (►**Fig. 8**). She underwent surgery for a ruptured vertebral artery aneurysm several months ago. No neurological deficit was detected during this admission. The left distal transsylvian anterior temporal approach using the intrasylvian retraction technique was performed for aneurysm clipping. The sylvian fissure was

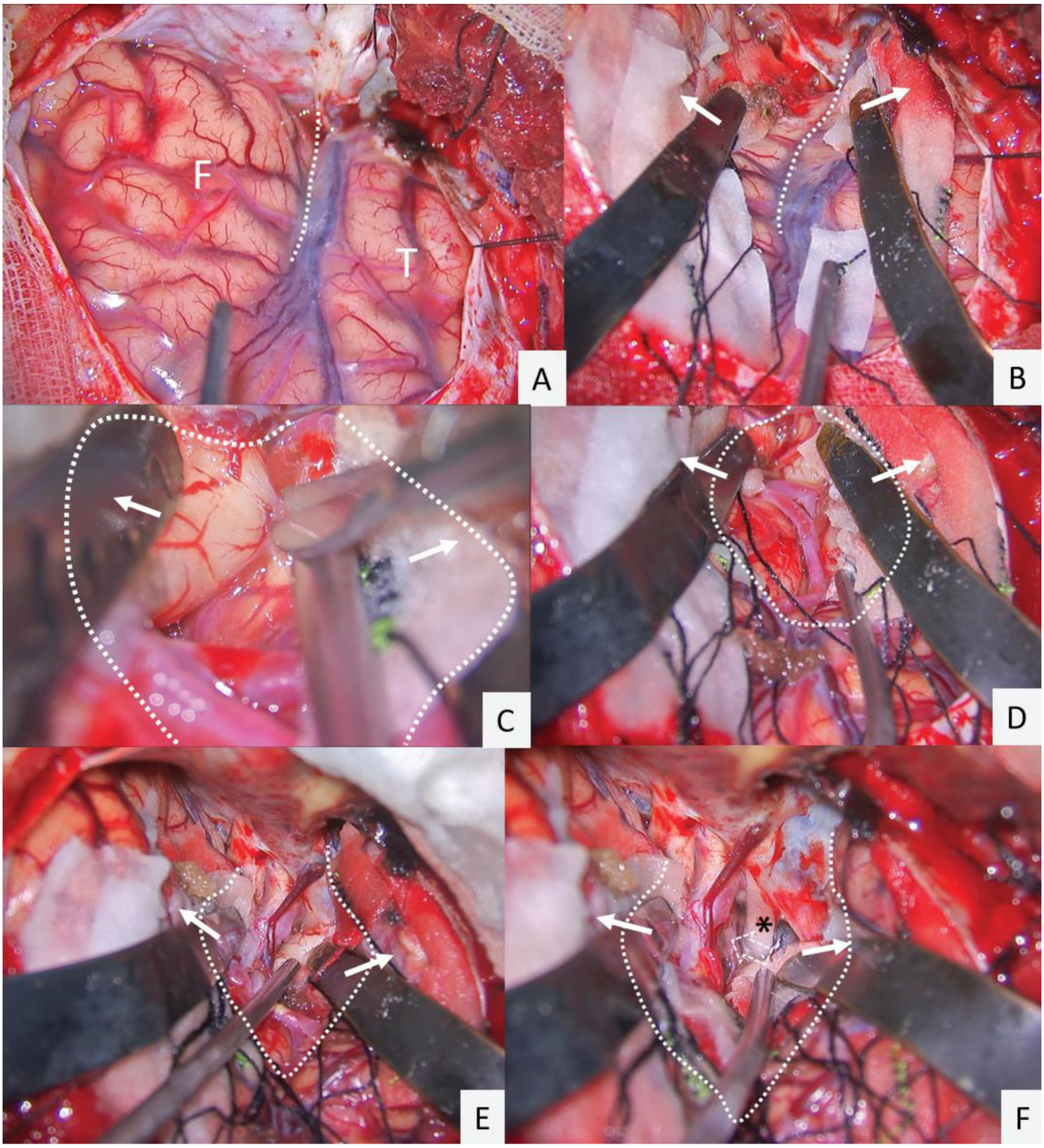

Fig. 5 Steps of the intrasylvian retraction technique for right sylvian fissure dissection. (**A**) Right sylvian fissure and superficial border of the sylvian fissure (*dotted line*). (**B**) Before dissection, two retractors were applied parallel to the sylvian fissure axis (*dotted line*) to stretch the outer arachnoid membrane above the sylvian fissure. (**C**) After the distal part of the superficial sylvian fissure was partially opened, retractors were placed inside the sylvian fissure (*inside the dotted line*) to stretch the arachnoid membrane in the fissure. The direction of the retraction force (*arrow*) was perpendicular to the fissure. (**D**) After the fissure was further opened, the retractors were applied inside the fissure to the proximal part of the fissure. (**E**) While further dissection was performed, the retractors were deeply placed into the fissure. (**F**) After a full dissection of the sylvian fissure for the retrocarotid space, the anterior choroidal artery (*dashed arrow*) and the oculomotor nerve (*asterisk*) were identified. The directions of the retractor force were away from the sylvian fissure in all steps. Arrow: direction of retraction force; F: frontal lobe; T: temporal lobe.

dissected widely with intrasylvian retraction. M2 and M1 segments of the MCA and ICA were fully exposed, and a small saccular aneurysm of the proximal M1 was also detected intraoperatively (not shown in the figure). The aneurysm of the distal ICA was found as the origin of the anterior temporal artery (►**Fig. 9**). Both aneurysms were occluded with an aneurysm clip while preserving all branches. Computed tomography angiography (CTA) performed immediately postoperatively showed complete aneurysm obliteration without perisylvian hematoma (►**Fig. 10**). The patient

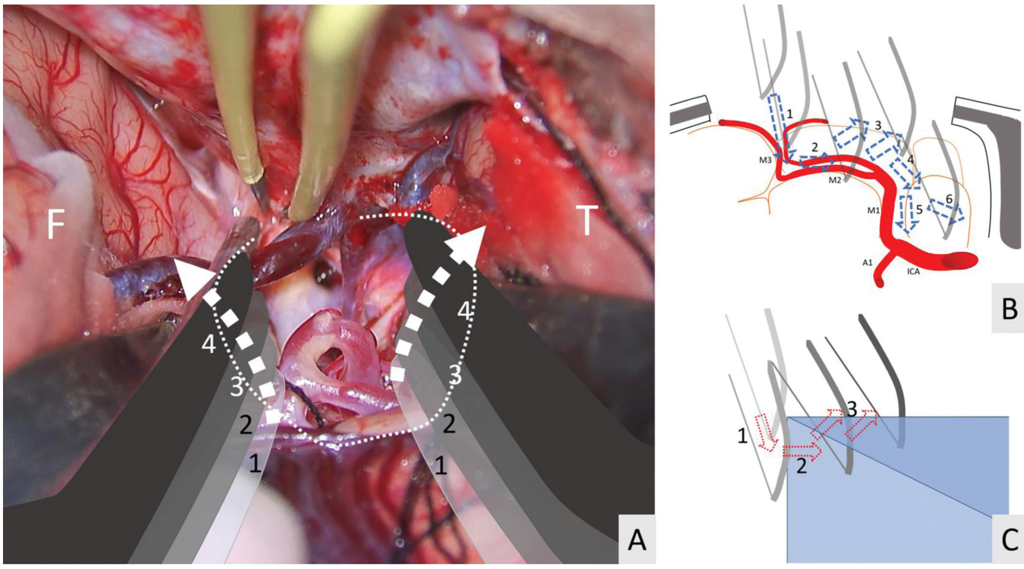

Fig. 6 Intrasylvian retraction steps. (**A**) The retractor positions were changed during sylvian fissure dissection (*arrow and serial number*). (**B**) The sequence of the sylvian dissection from the distal to proximal part (*arrow and serial number*) is a paper-knife cut (**C**). A1: first segment of the anterior cerebral artery; F: frontal lobe; M1 to M3: first to third segment of the middle cerebral artery; T: temporal lobe.

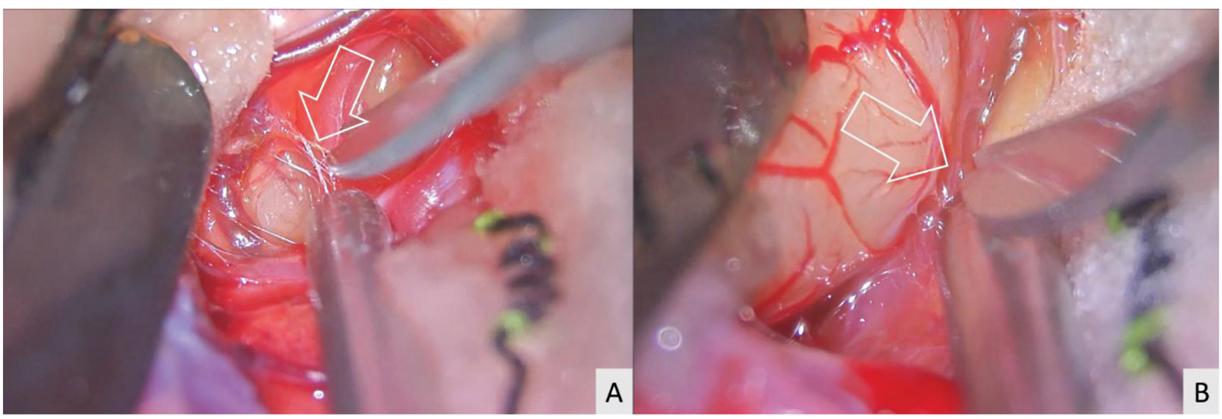

Fig. 7 (**A** and **B**) Stretched arachnoid trabeculae (*arrow*), caused by the intrasylvian retraction technique, facilitate sharp dissection of the fissure.

Table 1 Patients' characteristics

Data	Total ($N = 125$)
Women: Men	92:33
Mean age (years)	53.5 (range 16–85)
Subarachnoid hemorrhage	
• Yes	98 (78.4%)
• No	27 (21.6%)
Grading at presentation	
• Good grade (U + WFNS 1, 2, and 3)	83 (66.4%)
• Poor grade (WFNS 4 and 5)	42 (33.6%)

(*Continued*)

Table 1 (*Continued*)

Data	Total ($N = 125$)
Aneurysm clipping	106 (84.8%)
• AcoA	27 (25.5%)
• PcoA	37 (34.9%)
• MCA	20
• Basilar bifurcation	8
• BA–SCA	5
• Others	9
Aneurysms with MCA revascularization	7 (5.6%)
Pure M2 revascularization	12 (9.6%)

Abbreviations: AcoA, anterior communicating artery; BA, basilar artery; M2, second segment of middle cerebral artery; MCA, middle cerebral artery; SCA, superior cerebellar artery; U, unruptured case; WFNS, World Federation of Neurological Surgeons.

Table 2 Outcomes of the sylvian fissure dissection using the intrasylvian retraction technique

	Full exposure of the sylvian fissure		New perisylvian hematoma after surgery	
	Yes	No	Yes	No
Aneurysm clipping	106	0	0	106
Aneurysm with M2 bypass	7	0	0	7
Pure M2 bypass	12	0	0	12
Total	125	0	0	125

Abbreviation: M2, the second segment of the middle cerebral artery.

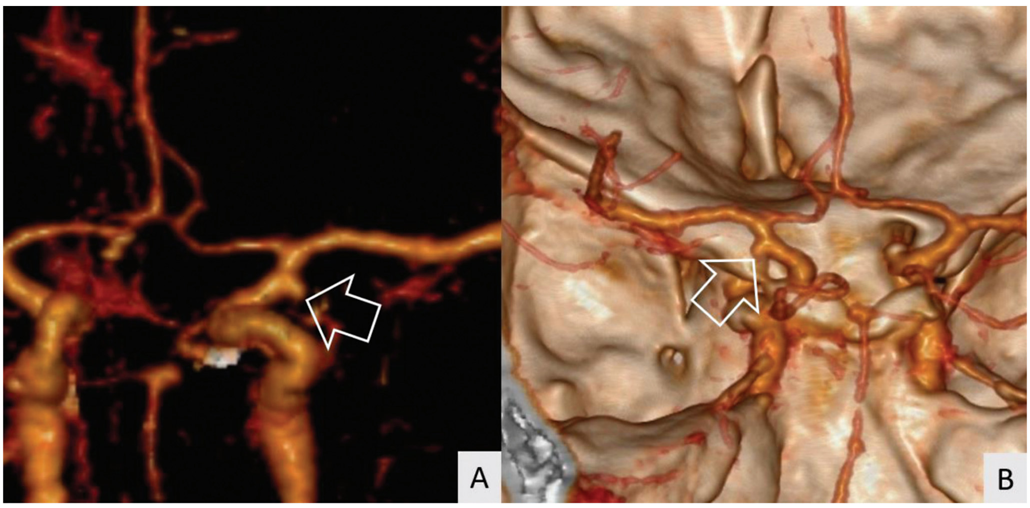

Fig. 8 Illustrative case 1. (**A, B**) Computed tomography angiography (CTA) demonstrated a lateral projecting left distal internal carotid artery aneurysm (*arrow*).

showed no neurological deficits during the postoperative period and achieved a Glasgow outcome score (GOS) of 5 3 months after the operation.

Illustrative Case 2

A 64-year-old woman presented with sudden changes in consciousness. The WFNS grade was 1 at the presentation. CT showed a diffuse SAH. An anterosuperior projecting basilar bifurcation aneurysm was detected with CTA (►**Fig. 11**). A right anterior temporal approach using the intrasylvian retraction technique was performed for aneurysm clipping. Complete obliteration of the aneurysm without perisylvian hematoma was confirmed with CTA immediately postoperatively (►**Fig. 12**). No further neurological deficits were detected. The patient achieved a GOS of 5 at 3 months after the operation.

Discussion

Sylvian Fissure Dissection

Traditionally, the brain retractors were used to maintain the surgical corridor and during the sylvian fissure dissection.[2,4–6,9,19] The position of the retractors was traditionally placed outside the sylvian fissure, especially on the frontal lobe.[8–10]

The blunt dissection technique by bipolar tip spreading was frequently used by most neurosurgeons. Although this technique was quickly applied, cortical microbleeds might occur with improper use. Some authors performed the highly focused opening of the sylvian fissure to avoid unnecessary cortical injury from the wide splitting of the sylvian fissure.[7] However, the operative field gained by the focused arachnoid dissection was narrow, and the retraction force to the brain parenchyma by the retractor spatulas or retracting the instrument was usually greater than the case when the sylvian fissure was completely opened. Thus, the well-known retractorless technique was proposed by Spetzler and Sanai to avoid retractor-induced brain injury.[14]

Retractor-Induced Brain Injury

Many studies have reported brain injury induced by a fixed retractor.[2,6,16,21–24] Andrews and Bringas found that brain retraction injury is estimated to occur in 10% of skull-base surgery and 5% of aneurysm surgery.[2] Yu et al reported a randomized controlled trial regarding brain retraction injury. They found that the percentages of intraoperative brain ischemia and brain retraction injury were higher in the fixed retractor group (23.1 and 34.6%) than in the retractorless group (0 and 5.3%). Brain retraction injury is a local delayed (within 7 days) intracerebral hematoma, brain contusion,

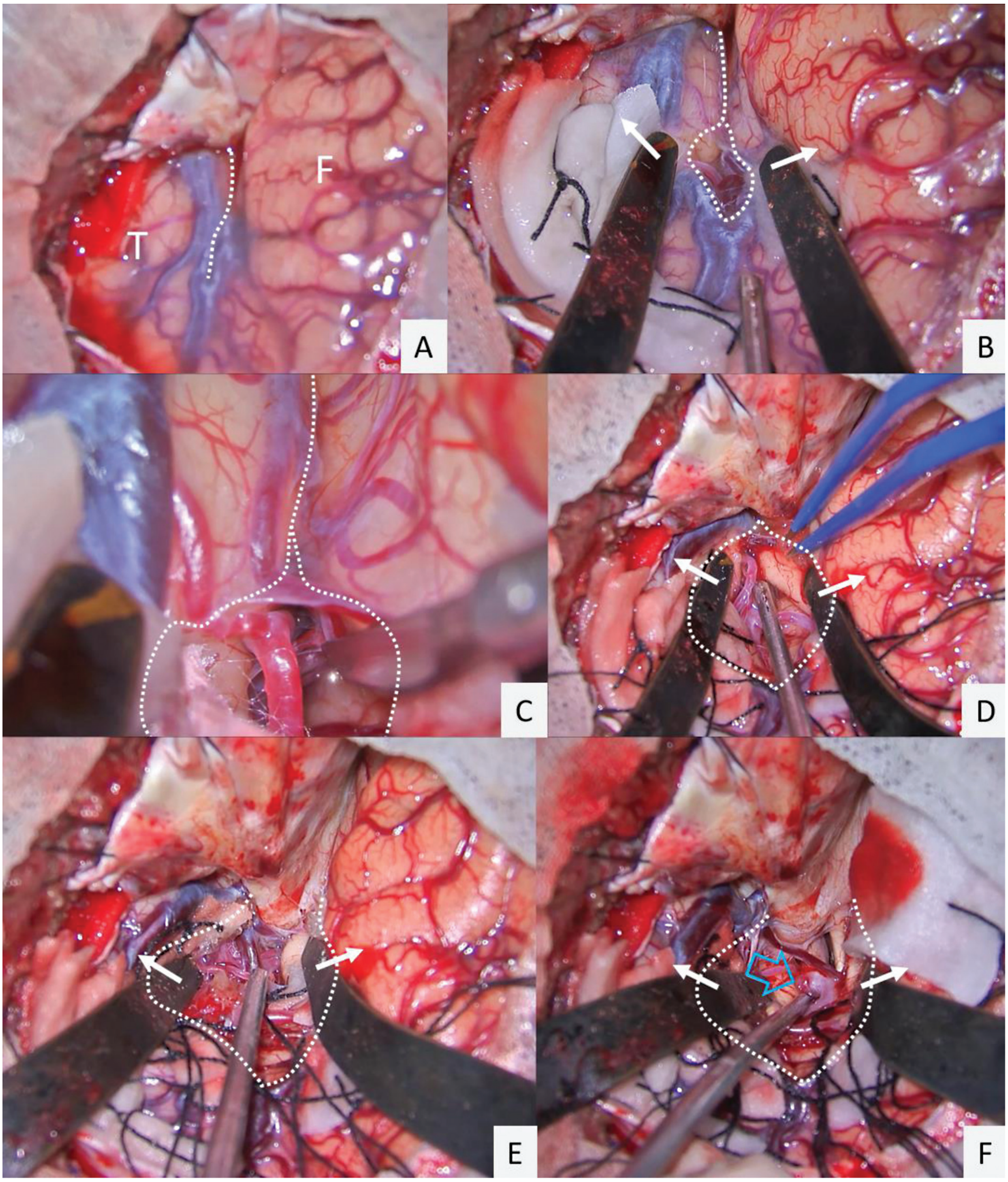

Fig. 9 Illustrative case 1. Left sylvian fissure dissection using the intrasylvian retraction technique. (**A**) After the dural opening, the frontal (F), temporal lobe (T), and sylvian fissure (*dotted line*) were exposed. (**B**) The distal part of the sylvian fissure was opened. (**C**) The sylvian fissure was dissected sharply with microscissors in an outside-in fashion. (**D**) Retractor spatulas were placed inside the opened sylvian fissure. (**E**) The proximal part of the sylvian fissure was opened in an inside-out fashion. (**F**) After dissecting the sylvian fissure completely, the distal internal carotid artery aneurysm (blue arrow) was fully exposed. Dashed line: superficial border of the sylvian fissure; F: frontal lobe; T: temporal lobe; white arrow: direction of brain elevation by retractor spatula.

ischemia, or edema after retraction.[16] Konya et al found that brain retraction injury was identified postoperatively in 42 of the 94 patients (44.7%) who underwent surgical clipping of an unruptured aneurysm. The postoperative cortical hypodensity in the surgical area was defined as brain retraction injury.[22] Previous research revealed 5 to 10% of brain retraction injuries after neurosurgical procedures, but the definition of brain retraction injury was unclear.[22]

Retractorless Technique

The retractorless technique was proposed by Spetzler and Sanai and many subsequent neurosurgeons.[7,13–15] This well-

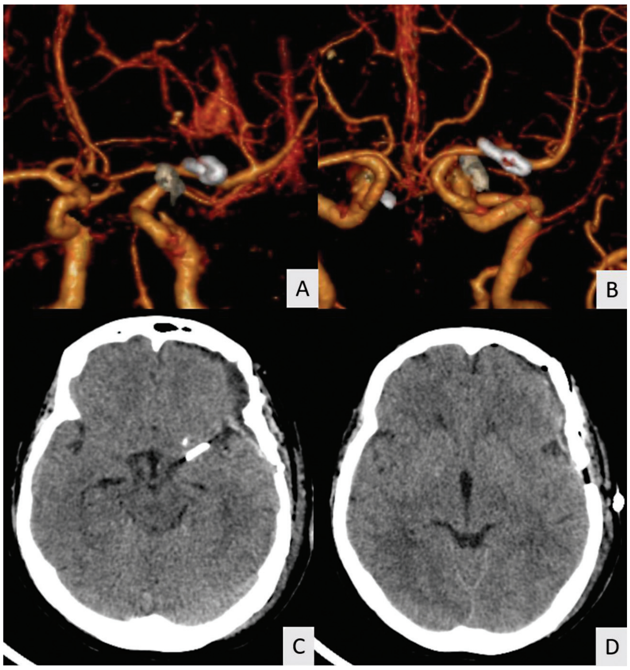

Fig. 10 Illustrative case 1. (**A, B**) Postoperative CTA showed complete aneurysm obliteration. (**C, D**) No perisylvian hematoma was detected on postoperative CT.

known technique was developed because of reports of brain damage caused by brain retractors during brain surgery.[2,6,9] Instead of using the brain retractors, a suction tube was applied as a dynamic retractor.

Although three of four of the third-generation cerebrovascular neurosurgeons (America and Europe) did not use the retractors during sylvian fissure dissection,[7] the retractors are routinely used by Japanese cerebrovascular surgeons to facilitate the sharp dissection of arachnoid trabeculae during sylvian fissure dissection.[17] When performing the retractorless technique, the neurosurgeon uses one hand with a suction tube as the brain retractor and holder to create the surgical corridor. Therefore, bimanual dissection might be limited, and suction tube-induced brain injury might occur when neurosurgeons have insufficient experience.[21] In addition, the narrow surgical corridor is a poor space that blocks the light beam of the operating microscope and decreases the visualization quality of the pathology.

Intrasylvian Retraction Technique

The intrasylvian retraction technique was technically the same as the interhemispheric fissure dissection for the basal interhemispheric approach to AcoA aneurysm. Two retractor spatulas were dynamically placed within the interhemispheric fissure to create tension on the arachnoid trabeculae, facilitating the precise cut of the arachnoid trabeculae without pial injury.[25–27] The step outside-in and inside-out or paper-knife cut technique was used to dissect the interhemispheric and sylvian fissures.[28] Hafes et al proposed an integrated multimaneuver dissecting technique for the sylvian fissure opening contributed by professor Kamiyama and Tanikawa. The retractor spatulas were used for brain holding, elevating, and initiating arachnoid tension, not for brain compression. A pair of retractor spatulas was gently applied to the frontal and temporal sides of the sylvian fissure dynamically according to the shape of the sylvian fissure like a fan stairs fashion. This technique facilitated the meticulously sharp dissection of arachnoid trabeculae under proper visualization with high magnification.[17] However, the positions of the retractor spatula related to the sylvian fissure were not focused and detailed. This study focused on the proper position of the retractor spatula to facilitate the sylvian fissure split.

For the transsylvian anterior temporal approach to the distal basilar artery[18] and posterior projecting ICA aneurysms,[29] the retractor spatulas were used to facilitate the sylvian fissure dissection. They could be safely placed on the medial surface of the temporal lobe after complete sylvian fissure dissection.[17]

Appropriate Applications of a Brain Retractor

During sylvian fissure opening, we routinely used a pair of tapered-shape brain retractors to facilitate this procedure. The advantages of using the brain retractors were (1) facilitating the bimanual dissection of the arachnoid trabeculae, vascular structures, and pathology, (2) clear visualization of pathology and surrounding important structures in a panoramic view via a bright operative field without using a suction tube as a retractor, and (3) avoiding the instrument-induced brain injury.

Brain retraction injury could be avoided with appropriate and meticulous techniques for brain retractor application. Hongo et al suggested that the use of multiple retractors can

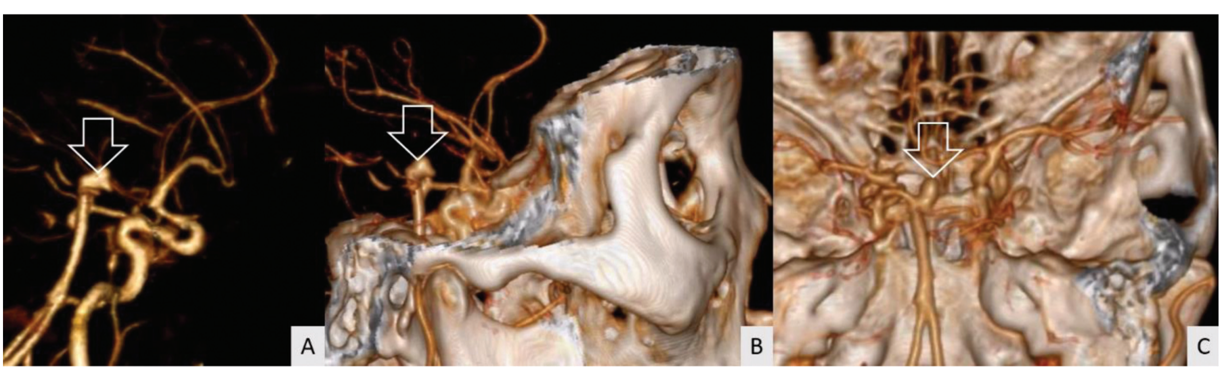

Fig. 11 Illustrative case 2. (**A, B, C**) An anterosuperior projecting basilar bifurcation aneurysm (*arrow*) was demonstrated by CTA.

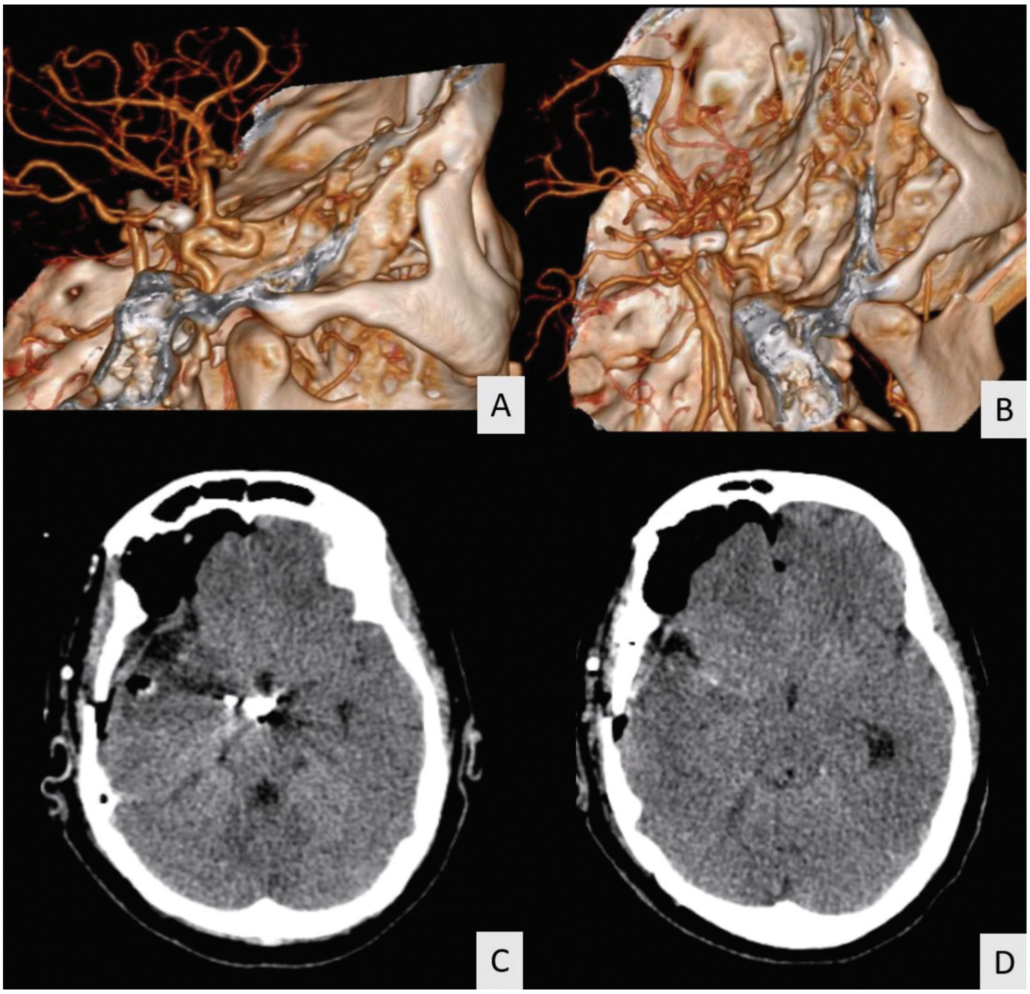

Fig. 12 Illustrative case 2. (**A, B**) Postoperative computed tomography angiography showed complete aneurysm obliteration. (**C, D**) No perisylvian hematoma was detected on postoperative CT.

reduce the pressure applied by each retractor, and brain relaxation prior to brain manipulation could also decrease the retraction pressure.[21] They supported the use of two retractors for the sylvian fissure split. Yokoh et al and Kaido et al found that intermittent (dynamic) brain retraction produces less brain damage than continuous retraction.[30,31] These studies support the use of the dynamic brain retraction technique.

This study defined brain retraction injury as the new perisylvian hematoma formation on the postoperative CT. We omitted the cortical hypodensity as in the study by Konya et al.[22] The hypodensity lesion might be resulted from vasospasm, especially in SAH cases, which is the majority in this study.

The perisylvian hematoma formation was not found in all cases after the operation with the operative technique we used. Although the retractors were used in all cases, the position of the two retractor spatulas was not fixed in the same position for a long time and dynamically changed according to the shape of the sylvian fissure. In addition, we did not use the retractor spatula to compress the brain to gain the surgical corridor. However, the retractors were used only for tensing the arachnoid trabeculae, facilitating the sharp dissection, and then for holding the brain after completely separating the sylvian fissure.

Limitations of this Study

This study has several limitations. The first was its retrospective descriptive study design without a comparative group. The second limitation was the lack of available intraoperative monitoring to detect intraoperative brain ischemia. The last limitation was the assessment of perisylvian hematoma on the immediate postoperative CT scan (within 24 hours). Delayed perisylvian contusion and focal brain ischemia might not be detected without routine delayed postoperative CT and magnetic resonance imaging (diffusion-weighted images and T2 fluid-attenuated inversion recovery).

To our best knowledge, this study was the clinical evaluation of sylvian fissure dissection using brain retractors in the highest percentage (78.4%) of SAH cases.

Conclusion

Sylvian fissure dissection was safely performed using the appropriate technique for brain retractor application. The intrasylvian retraction technique effectively facilitated sylvian fissure dissection and provided wide exposure for the distal transsylvian approach.

Author's Contributions

K.S. and C.A. conceived and designed the study, acquired the data, and performed the analysis and interpretation. K.S. drafted and critically revised the article, reviewed the submitted version, and supervised the study.

Ethical Approval

The study was approved by the Institutional Review Board of the Faculty of Medicine Vajira Hospital, COA no. was 076/2566.

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None.

Conflict of Interest

None declared.

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