doi: 10.2176/nmc.oa.2021-0080
Neurol Med Chir (Tokyo) 61, 731–740, 2021
Online October 14, 2021

Dissection of the Sylvian Fissure in the Trans-sylvian Approach Based on the Morphological Classification of the Superficial Middle Cerebral Vein

Yasutaka Imada,[1] Chie Mihara,[1] Hitoshi Kawamoto,[1] and Kaoru Kurisu[2,3]

[1]Department of Neurosurgery, Yamada Memorial Hospital, Mihara, Hiroshima, Japan
[2]Department of Neurosurgery, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Hiroshima, Japan
[3]Department of Neurosurgery, Chugoku Rosai Hospital, Kure, Hiroshima, Japan

Abstract

The superficial middle cerebral vein (SMCV) is one of the main factors that can impede a wide opening of the sylvian fissure. To reveal the most efficient SMCV dissection for a wide operative field while preserving the veins in the trans-sylvian approach, we retrospectively investigated the SMCVs through intraoperative video images. We characterized the SMCV as composed of the frontosylvian trunk (FST; receiving frontosylvian veins [FSVs] or parietosylvian veins [PSVs]), the temporosylvian trunk (TST; receiving temporosylvian veins [TSVs]), and the superficial middle cerebral common trunk (SMCCT; receiving both FSV/PSV and TSV), and classified the SMCVs of the 116 patients into 5 types based on the morphological classification of the SMCV. Type A SMCV (60.4%) with the SMCCT anastomosed to the frontal side had few bridging veins (BVs) between the SMCCT and the temporal side during dissection. Type B (7.8%) had the SMCCT with no anastomoses to the frontal side. In Type C (17.2%) consisting of the FST and TST and Type D (12.9%) with a merging of the vein of Trolard and Labbé posteriorly and the SMCVs dividing into the FST and the TST again proximally, there were few BVs between the FST and the TST during dissection. Finally, in Type E (1.7%) showing an undeveloped SMCV, there were no BVs between the frontal and the temporal lobes. Postoperative venous infarction occurred in 2.6%. Morphological classification of the SMCV can inform appropriate dissection line to create a wide operative field while preserving the veins in the trans-sylvian approach.

Keywords: superficial middle cerebral vein, frontosylvian vein, temporosylvian vein, trans-sylvian approach

Introduction

In the trans-sylvian approach, opening the Sylvian fissure widely is crucial to the success of the operation.[1–6] Obtaining a wide operative field while preserving the venous structures in the trans-sylvian approach can be difficult because of various anastomoses of the superficial middle cerebral vein (SMCV).[7–22] Many neurosurgeons have conventionally dissected between the SMCV and the frontal lobe in the trans-sylvian approach.[22] However, this method of dissecting the SMCV can lead to sacrifice the bridging veins (BVs) with the frontal lobe in order to obtain a wide operative field, which may cause congestion and venous infarction.[9,12,15,16,23–25] Recently, dissection between multiple SMCVs or between the SMCV and the temporal lobe has been recommended.[17,18,26–29] However, the method of dissection is rarely discussed in detail in the clinical literature, and a consensus for a best approach has not been obtained,[8,17,18,22,27,28,30] likely due to the various patterns of SMCV anastomoses.

Although the morphological patterns of the SMCV has been clarified mainly on outflow in the past,[11,13,15,21,31–33] we have reported on the morphological classification of the SMCV from the number of stems, the course,

Received March 10, 2021; Accepted August 13, 2021

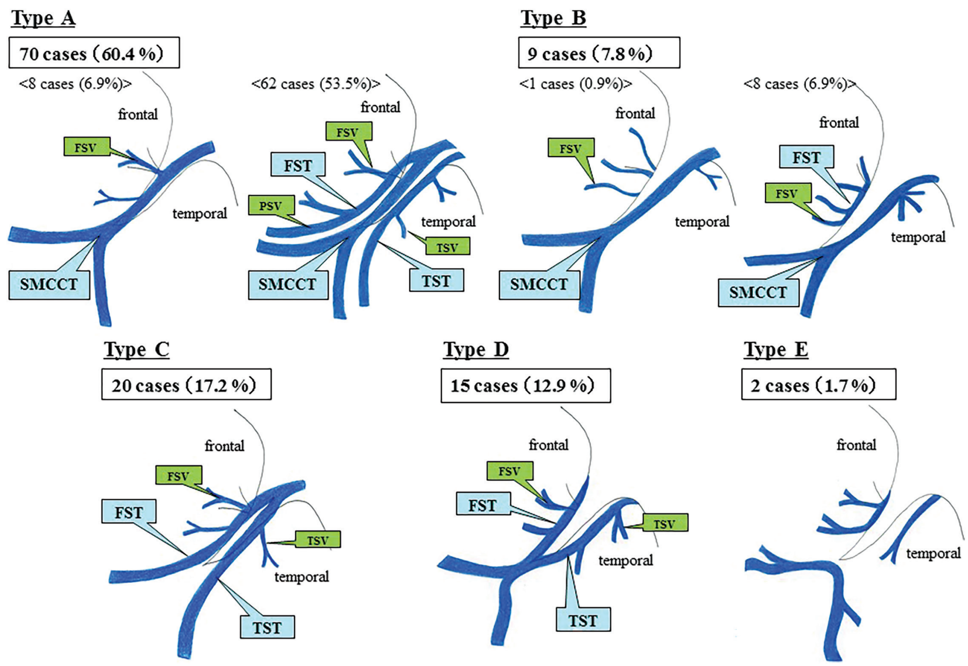

Fig. 1 FST is the SMCV that receives the FSV or the PSV. TST is the SMCV that receives the TSV. SMCCT is the SMCV that receives both the FSV (or PSV) and the TSV at the posterior end of the Sylvian fissure. FST: frontosylvian trunk, FSV: frontosylvian veins, PSV: parietosylvian veins, SMCCT: superficial middle cerebral common trunk, SMCV: superficial middle cerebral vein, TST: temporosylvian trunk, TSV: temporosylvian veins.

and anastomoses present at the distal portion in cadaveric cerebral hemispheres.[14] The purpose of the present study was to investigate the best approach to dissect the SMCV based on the above classification, in order to obtain a wide operative field while preserving the venous structures in the trans-sylvian approach.

Subjects and Methods

This retrospective study included 116 patients (age range, 30–93 years; mean age, 69.4 years; 37 males, 79 females) who underwent the trans-sylvian approach at our institute from July 2006 to August 2019. We classified the SMCVs of these patients into 5 types as described in the following and investigated the most efficient methods of dissection of the SMCV to obtain a wide operative field while preserving the venous structure in the trans-sylvian approach based on this classification through intraoperative video images.

Anatomy and nomenclature

The anatomy of the Sylvian veins were defined as described in previous studies.[32,34,35] That is, the SMCV receives frontosylvian veins (FSV), parietosylvian veins (PSV), and temporosylvian veins (TSV), and usually arises at the posterior end of the Sylvian fissure and courses anteriorly and inferiorly along its edges. We tentatively defined the SMCV as follows: the frontosylvian trunk (FST) is the SMCV that receives the FSV or PSV; the temporosylvian trunk (TST) is the SMCV that receives the TSV; and the superficial middle cerebral common trunk (SMCCT) is the SMCV that receives the FSV and PSV, whose main component is the vein of Trolard, and the TSV, whose main component is the vein of Labbé, at the posterior end of the Sylvian fissure. We classified the SMCVs into 5 types (Fig. 1).

1 Type A SMCVs correspond to the SMCCT and have some anastomoses with the FST or the FSV on the Sylvian fissure.
2 Type B SMCVs correspond to the SMCCT and have no anastomoses with the FST or the FSV on the Sylvian fissure.
3 Type C SMCVs show no SMCCT, but the FST and the TST run in parallel along the Sylvian fissure and course toward the skull base.
4 Type D SMCVs are a merging of the vein of Trolard and the vein of Labbé at the posterior end of the Sylvian fissure, which divide into the FST and the TST again toward the proximal portion of the Sylvian fissure.
5 Type E SMCVs are underdeveloped on the Sylvian fissure.

Table 1 Characteristics of Type A and B SMCV

	Anastomosis between the SMCCT and the temporal side	Site of termination of the SMCCT			
		Dural sinus	Blind end	DMCV	unknown
Type A (n = 70)	11.4% (n = 8)	81.5% (n = 57)	15.7% (n = 11)	1.4% (n = 1)	1.4% (n = 1)
Type B (n = 9)	Unknown	100% (n = 5)	0% (n = 0)	0% (n = 0)	0% (n = 0)

Anastomosis between the SMCCT and the temporal side was unable to be evaluated by the intraoperative video images in 4 cases of Type A SMCV.
DMCV: deep middle cerebral vein, SMCCT: superficial middle cerebral common trunk, SMCV: superficial middle cerebral vein, unknown: unable to evaluate by the intraoperative video images.

Results

Type A SMCVs were observed in 70 of 116 cases (60.4%) and were the most frequent type, of which 8 cases (6.9%) had a single SMCV and 62 cases (53.5%) had multiple SMCVs (Fig. 1). The sites of aneurysm were 38 at the internal carotid artery (ICA), 17 at the middle cerebral artery (MCA) bifurcation, 2 at the M1 portion, and 6 at the anterior cerebral artery (ACA), and 7 cases were of putaminal hemorrhage.

In only 3 of the 70 Type A cases, the SMCVs were conventionally dissected only on the frontal side of the SMCCT. In 67 of the 70 Type A cases, the SMCVs were dissected at least on the temporal side of the SMCCT. In 30 of the 67 cases, additional dissection was not required. In the other 37 of the 67 cases, additional dissection was performed between the SMCCT or FST and the frontal lobe (34 cases), or between the TST and the temporal lobe (3 cases). Additional dissection was required in many cases of a large aneurysm or large orbital gyrus, which protrudes toward the adjacent temporal lobe.

The frequency of anastomoses between the SMCCT and the temporal side was low (8 cases: 11.4%). Most of these anastomoses were tiny BVs between the SMCCT and the temporal lobe or the TST, and these BVs were sacrificed during surgery. Only in 3 of the 70 Type A cases (4.3%), the SMCCT merged with the TST at the proximal portion, and these anastomoses were preserved during surgery. In other words, in most cases of Type A, the SMCCT and the TST drained into the skull base sinus separately. The other tiny BVs between the frontal lobe and the temporal lobe or between the frontal lobe and the TST were observed in 5 cases, all of which were sacrificed during surgery. The fronto-basal bridging vein (FBBV), which arose from the frontal base and drained into the FST or the skull base sinus, was sacrificed in only 2 cases. In 57 of the 70 Type A cases (81.5%), the proximal end of the SMCCT drained into either skull base sinus. In 12 of the 70 Type A cases (17.1%), the proximal end of the SMCCT did not drain into any skull base sinus and became a blind end at the base of the frontal lobe or connected to deep middle cerebral veins (DMCV) directly (Table 1). Thus, in many cases of Type A SMCV, starting to dissect the SMCV on the temporal side of the SMCCT to near the skull base and additional dissection mainly between the SMCCT/FST and the frontal lobe on the base side as much as needed were most efficient methods to obtain a wide operative field while preserving the venous structure (Fig. 2A).

Type B SMCVs was observed in 9 of 116 cases (7.8%), of which 1 case (0.9%) had a single SMCV and 8 cases (6.9%) had multiple SMCVs (Fig. 1). The sites of aneurysm were 6 at the ICA, 1 at the MCA bifurcation, and 2 at the ACA. The SMCVs were dissected on the frontal side of the SMCCT in all cases, and additional dissection was not required. Anastomoses between the SMCCT and TSV were unable to be confirmed through intraoperative video images. The proximal end of the SMCCT drained into either skull base sinus in all cases (Table 1). The FBBVs were excluded from the evaluation as a BV in this study, and all FBBVs were preserved during surgery. Thus, in many cases of Type B SMCV, dissection only on the frontal side of the SMCCT was sufficient to obtain a wide operative field while preserving the venous structure (Fig. 2B).

Type C SMCVs were observed in 20 of 116 cases (17.2%) (Fig. 1). The sites of aneurysm were 7 at the ICA, 5 at the MCA bifurcation, 1 at the M1 portion, and 1 at the ACA, and 6 cases were of putaminal hemorrhage. In 17 of the 20 Type C cases, the SMCVs were dissected between the FST and the TST until their proximal junction. In 3 of the 20 Type C cases, the SMCVs were dissected only on the temporal side of the TST. In 9 of the 17 cases, additional dissection was not necessary. In the other 8 of the 17 cases, additional dissection

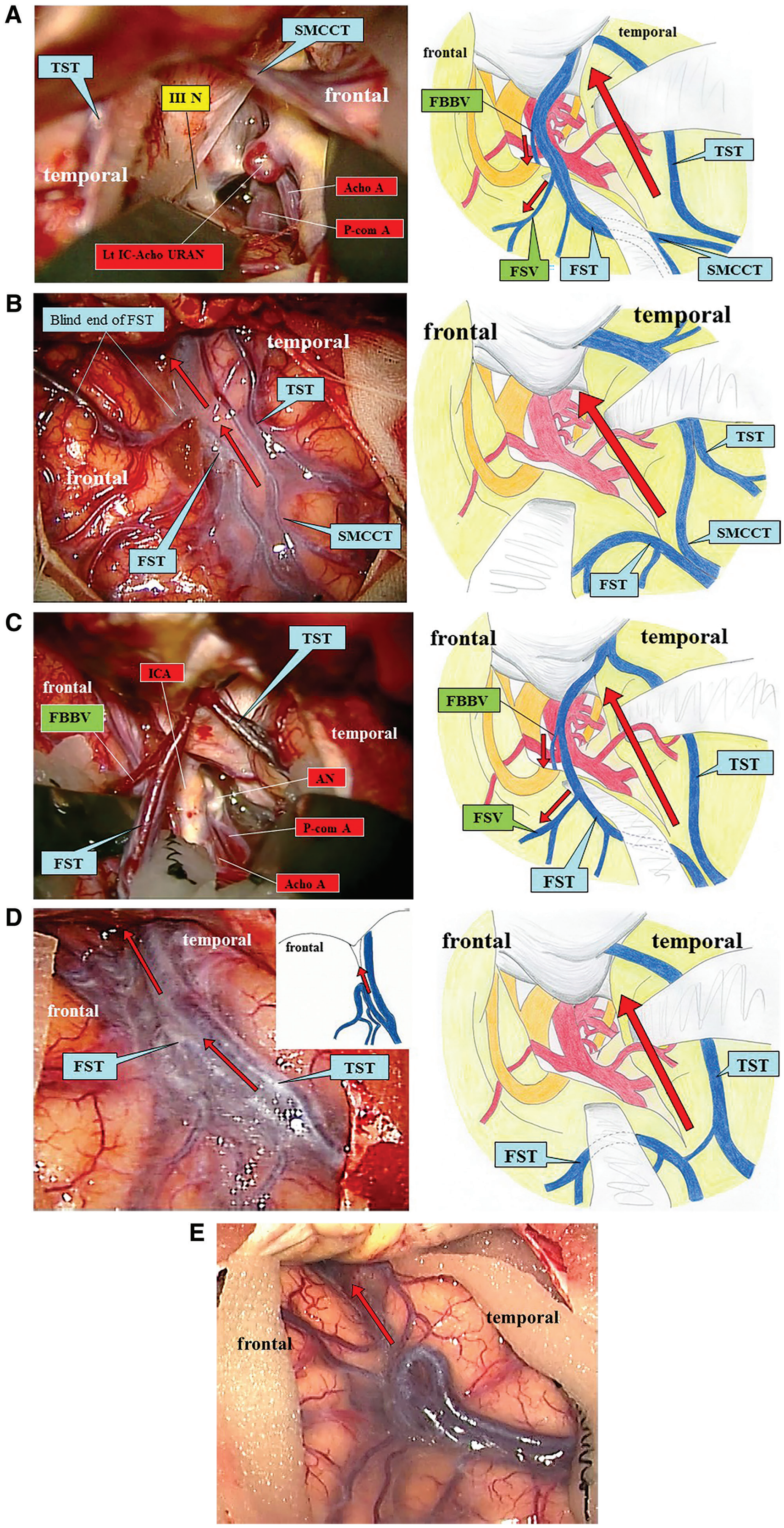

Fig. 2 (A) Intraoperative view of a case of Type A SMCVs (left IC–Acho A unruptured aneurysm; 71 year-old woman) and the schema of dissection of Type A SMCVs based on our classification of the SMCV. Red arrows show the dissecting line. (B) Intraoperative view of Type B SMCVs (right side) and the schema of dissection of Type B SMCVs based on our classification of the SMCV. Red arrows show the dissecting line. (C) Intraoperative view of a case of Type C SMCVs (right IC–P com A URAN; 56 year-old man) and the schema of dissection of Type C SMCVs based on our classification of the SMCV. This case seemed to have no SMCCT, and the FST and TST were recognized in parallel along the Sylvian fissure and coursed toward the skull base. Red arrows show the dissecting line. (D) Intraoperative view of a case of Type D SMCVs and the schema of dissection of Type D SMCVs based on our classification of the SMCV. Type D SMCVs can show a complex morphology at the first glance. Red arrows show the dissecting line. (E) Intraoperative view of Type E SMCVs (right side). Red arrow shows the dissecting line of the SMCV to provide mobility to the frontal and temporal lobes while preserving venous structures as much as possible. III N: oculomotor nerve, Acho A: anterior choroidal artery, AN: aneurysm, FBBV: fronto-basal bridging vein, FST: frontosylvian trunk, FSV: frontosylvian veins, IC: internal carotid, ICA: internal carotid artery, P-com A: posterior communicating artery, SMCCT: superficial middle cerebral common trunk, SMCV: superficial middle cerebral vein, TST: temporosylvian trunk, URAN: unruptured aneurysm.

Table 2 Characteristics of Type C and D SMCV

	Anastomosis between the FST and the FSV	Anastomosis between the TST and the TSV	BV between the FST and the TST	Merger of the FST and the TST at the proximal portion	Site of termination of the FST			
					Dural sinus	Blind end	DMCV	unknown
Type C (n = 20)	100% (n = 20)	50% (n = 10)	10% (n = 2)	60% (n = 12)	100% (n = 20)	0% (n = 0)	0% (n = 0)	0% (n = 0)
Type D (n = 15)	100% (n = 15)	86.7% (n = 13)	20% (n = 3)	0% (n = 0)	46.7% (n = 7)	40% (n = 6)	0% (n = 0)	13.3% (n = 2)

Merger of the FST and the TST at the proximal portion was unable to be confirmed by the operative video in the other 8 cases of Type C SMCV.
Site of termination of the FST was unable to be confirmed by the intraoperative video images in 2 cases of Type D SMCV.
BV: bridging vein, DMCV: deep middle cerebral vein, FST: frontosylvian trunk, FSV: frontosylvian vein, SMCV: superficial middle cerebral vein, TST: temporosylvian trunk, TSV: temporosylvian vein, unknown: unable to evaluate by the intraoperative video images.

Table 3 Characteristics of Type E SMCV

	BV between the frontal lobe and the temporal lobe
Type E (n = 2)	0% (n = 0)

BV: bridging vein, SMCV: superficial middle cerebral vein.

was performed between the FST and the frontal lobe on the base side (5 cases), between the TST and the temporal lobe (2 cases), or both (1 case).

The frequency of anastomoses between the FST and the FSV was very high (100%), and that between the TST and the TSV was moderate (50%), all of which were preserved during surgery. In 12 cases (60%), merger of the FST and the TST at the proximal portion was confirmed, but, in the other 8 cases, we were unable to identify a merger accurately through the intraoperative video images. The frequency of anastomoses between the FST and the TST was low (10%), and these anastomoses were tiny BVs that were sacrificed during surgery. The proximal end of the FST drained into either skull base sinus in all cases (Table 2). Thus, in many cases of Type C SMCV, starting to dissect between the FST and the TST until their proximal junction and additional dissection mainly between the FST and the frontal lobe on the base side as much as needed were most efficient methods to obtain a wide operative field while preserving the venous structure (Fig. 2C).

Type D SMCVs was observed in 15 of 116 cases (12.9%) (Fig. 1). The sites of aneurysm were 5 at the ICA, 7 at the MCA bifurcation, and 3 at the ACA. In all cases, the SMCVs were dissected between the FST and the TST. Additional dissection between the FST and the frontal lobe was performed in a few cases. The frequency of anastomoses between the FST and the FSV was very high (100%), and that between the TST and the TSV was also very high (86.7%), all of which were preserved during surgery. The frequency of anastomoses between the FST and the TST was low (20%), and these anastomoses were tiny BVs that were sacrificed during surgery. In 6 cases of Type D (40%), the proximal end of the FST did not drain into any skull base sinus and became a blind end at the base of the frontal lobe (Table 2). Thus, in many cases of Type D SMCV, dissection between the FST and the TST was sufficient to obtain a wide operative field while preserving the venous structure (Fig. 2D).

Type E SMCVs was observed in 2 cases with MCA bifurcation aneurysm of the 116 cases (1.7%) (Fig. 1). In these cases, SMCVs were dissected between the frontal and temporal lobes. Merger of the vein of Trolard and the vein of Labbé was observed at the posterior end of the Sylvian fissure, and no BVs were observed between the frontal and the temporal lobes (Table 3). In Type E SMCV, there was no choice but to dissect between the frontal and temporal lobes (Fig. 2E).

Our investigation revealed that in 17 of 116 cases (14.7%), the proximal end of the SMCCT or FST did not drain into any skull base sinus and became a blind end at the base of the frontal lobe (Tables 1 and 2). In these cases, all SMCVs (SMCCT/FST) and FSV were preserved. Overall, postoperative frontal lobe damage occurred in 7 of 116 cases (6.0 %), of which 4 (3.4%) was due to excessive retraction and 3 (2.6%) was due to venous sacrifice or kinking. In 4 cases due to excessive retraction, the orbital gyrus was large and cerebral edema was severe. In 1 case due to excessive retraction and FSV sacrifice, SMCVs were dissected only on the frontal side of the SMCCT in Type A SMCV (Table 4).

Discussion

The SMCV is one of the main factors that can impede a wide opening of the Sylvian fissure in

Table 4 Summary of postoperative frontal lobe damage

No	Sex	Age	Site	Type of SMCV	Venous sacrifice	Cause
1	F	67	Ruptured MCA bif AN	A	No	Excessive retraction to the frontal lobe
2	F	56	Unruptured M1 AN	A	FSV	Excessive retraction and venous sacrifice
3	F	46	Ruptured ICPC AN	A	No	Excessive retraction to the frontal lobe
4	F	68	Ruptured A-com AN	B	No	Excessive retraction to the frontal lobe
5	M	39	Ruptured ICPC AN	D	No	Excessive retraction to the frontal lobe
6	F	71	Ruptured ICPC AN	D	No	Stretching of the DMCV by retraction
7	F	53	Unruptured MCA bif AN	E	No	Kinking of the branch of the DMCV by clipping

A-com: anterior communicating artery, AN: aneurysm, DMCV: deep middle cerebral vein, F: female, FSV: frontosylvian vein, ICPC: internal carotid artery–posterior communicating artery, M: male, M1: horizontal segment of middle cerebral artery, MCA bif: bifurcation of middle cerebral artery, SMCV: superficial middle cerebral vein.

the trans-sylvian approach.[7–22] Many neurosurgeons have conventionally made the trans-sylvian approach starting with dissection between the SMCV and the frontal lobe according to Yasargil.[22] Neurological deficits caused by sacrificing the BVs from the frontal base or temporal tip to the SMCV has been considered to be rare.[22,35,36] However, postoperative brain damage caused by excessive retraction or venous sacrifice occurred in 14–47% in the trans-sylvian approach for aneurysms.[15,23,24] Most of such postoperative brain damage, which was contusion, venous infarction, or hemorrhage, occurred in the inferior frontal lobe. Reduced regional cerebral blood flow (rCBF) in the retracted area is a major cause of postoperative brain damage. The brain retraction itself impairs the rCBF in the retracted area. Moreover, venous congestion in the retracted area drastically reduces the rCBF.[37,38] Thus, venous sacrifice leads to more venous congestion and promotes postoperative brain damage. According to Saito et al.,[24] FBBVs were sacrificed in about half of 300 cases and postoperative brain damage occurred in 14%, of which 11% was due to excessive retraction and only 3% was due to venous sacrifice. Although FBBVs were sacrificed in only 2 of our 116 cases, postoperative brain damage due to venous injury occurred in 3 of 116 cases (2.6%), of which one was due to FSV sacrifice and the other 2 were due to kinking of the DMCV. Thus, FBBVs sacrifice may not cause venous infarction frequently. However, according to Suzuki et al.,[25] postoperative venous infarction might be caused by sacrifice of an FBBV in cases in which the second segment of the basal vein of Rosenthal was partially hypoplastic. According to Kageyama et al.,[15] the venous perfusion patterns in the inferior frontal lobe were classified into 3 types (Sylvian type, which drains mainly into the SMCVs; frontal type, which drains into the frontal BVs, and intermediate type, which drains evenly into both sets of veins), and postoperative brain damage was most likely to occur in the Sylvian type. Our 1 case of postoperative brain damage due to FSV sacrifice might be the Sylvian type. Moreover, our investigation revealed that, in 17 of 116 cases (14.7%), the proximal end of the SMCCT or FST did not drain into any skull base sinus and became a blind end at the base of the frontal lobe (Tables 1 and 2). In such cases, postoperative brain damage may easily occur due to excessive retraction or venous sacrifice, because the SMCCT or the FST may drain the inferior frontal lobe mainly from the proximal portion to the distal portion. Therefore, not only avoidance of excessive brain retraction but also preservation of intracranial venous structures is very important to prevent postoperative venous complications in the trans-sylvian approach. However, the conventional method to dissect only between the SMCV and the frontal lobe has 3 major problems. First, it is often necessary to cut the BVs with the frontal lobe in order to obtain a wide operative field. Second, the retraction to the frontal lobe tends to be excessive, especially in cases of large orbital gyrus, which protrudes toward the adjacent temporal lobe. Third, it is impossible to provide sufficient mobility to the temporal lobe by just cutting the BVs with the frontal lobe, since mobility of the temporal lobe is limited by adhesion with the main stems of the SMCV, which usually run on the temporal lobe and the draining point of the SMCV to the skull base sinus.[26,30,39–41] The mobility of the temporal lobe is very important to obtain not only a wide working space but also an operative view from the lateral side. This lateral view makes it possible to confirm the perforators behind the aneurysm and also to reduce the retraction to the frontal lobe in the trans-sylvian approach.[26,30,39–41] Thus, the method to dissect the SMCV that provides sufficient mobility to the frontal and temporal lobes while preserving the venous structures is considered ideal. Some reports recommend dissection between multiple SMCVs or between the SMCV and the temporal lobe in the trans-sylvian approach for such ideal dissection of the SMCV.[17,18,26–30,39–41]

In our 116 cases, almost FSVs and FBBVs, and all SMCVs (FST, SMCCT, TST) and TSVs were preserved. The mobility of the frontal and temporal lobes was sufficient to obtain the wide operative field in almost cases. Postoperative brain damage occurred in 7 cases (6.0 %), which was lower than previously reported (Table 4). Therefore, we recommend the method to dissect the SMCV based on our morphological classification of the SMCV in the trans-sylvian approach as follows.

Dissection of a Type A SMCV

In Type A SMCV, it is recommended to start to dissect the SMCV on the temporal side of the SMCCT to near the skull base, and then, dissect between the SMCCT or the FST and the frontal lobe on the base side as much as needed (Fig. 2A). Indeed, it is difficult, especially for inexperienced surgeons, to peel off the SMCCT from the temporal lobe. This is because the SMCVs usually run on the temporal lobe with tight adhesion, and very delicate dissection is necessary to avoid damage of the pia matter of the temporal lobe and the tiny TSVs that cross under the SMCCT without merging. However, this procedure, which requires patience, not only provides a wide operative field but also improves the skill of surgeons using micro scissors. If more mobility of the temporal lobe is necessary, additional dissection between the TSV/TST should be performed. It may be sufficient to dissect only the temporal side of the SMCCT in the distal trans-sylvian approach for a small to medium ICA aneurysm with a small orbital gyrus that does not protrude toward the adjacent temporal lobe or a similar-sized MCA bifurcation aneurysm. On the other hand, the conventional method to dissect only between the SMCV and the frontal lobe is not suitable for cases of large aneurysm or aneurysm on the posterior wall of the ICA.

Dissection of a Type B SMCV

In many cases of Type B SMCV, it is probably sufficient to dissect only on the frontal side of the SMCCT (Fig. 2B). However, if more mobility of the temporal lobe is necessary, additional dissection on the temporal side of the SMCCT or the TST should be performed.

Dissection of a Type C SMCV

In Type C SMCV, it is recommended to start dissecting between the FST and the TST until their proximal junction and then between the FST and the frontal lobe on the base side as much as needed (Fig. 2C). If the mobility of the temporal lobe is not sufficient, additional dissection between the TST and the temporal lobe should be performed. Likely, it is sufficient to dissect only between the FST and the TST until their proximal junction for cases of small or medium MCA bifurcation aneurysm in the distal trans-sylvian approach.

Dissection of a Type D SMCV

Careful observation may be required to identify the Type D SMCV because this type can show a complex morphology at the first glance. In Type D SMCV, it is recommended to start dissecting between the FST and the TST (Fig. 2D). In cases that the proximal end of the FST does not drain into any skull base sinus and is blind ended at the base of the frontal lobe, additional dissection is not necessary. In cases that the FST drains into either skull base sinus, additional dissection between the FST and the frontal lobe may be necessary. However, in cases of a small to medium MCA bifurcation aneurysm, such additional dissection may not be necessary.

Dissection of a Type E SMCV

In Type E SMCV, there is no choice but to dissect between the frontal and the temporal lobes (Fig. 2E).

In cases with multiple SMCVs, it may be difficult to distinguish between Type A SMCV and Type C SMCV because the open range of the dura is limited. In such cases, it may be better to estimate the SMCCT from the proximal anastomotic pattern of the SMCVs because the SMCCT and the TST are separated at the proximal portion in many cases (Fig. 3a and 3b). It may be difficult to identify the type of SMCV in cases of the subarachnoid hemorrhage; however, sufficient irrigation of the subarachnoid space is useful for improving the visibility of the SMCV. Recently, the utility of indocyanine green video angiography for the SMCV dissection was reported.[27,42,43]

Although the patterns of DMCVs were not investigated in detail in this study, opening the Sylvian fissure widely was sometimes obstructed by the DMCV. In such cases, the DMCVs or its branches should be dissected from the surrounding tissue as much as possible, and additional dissection of the SMCV, such as between the TST/TSV and the temporal lobe, may be required (Fig. 3c).

Many experienced neurosurgeons can obtain a wide operative field while preserving venous

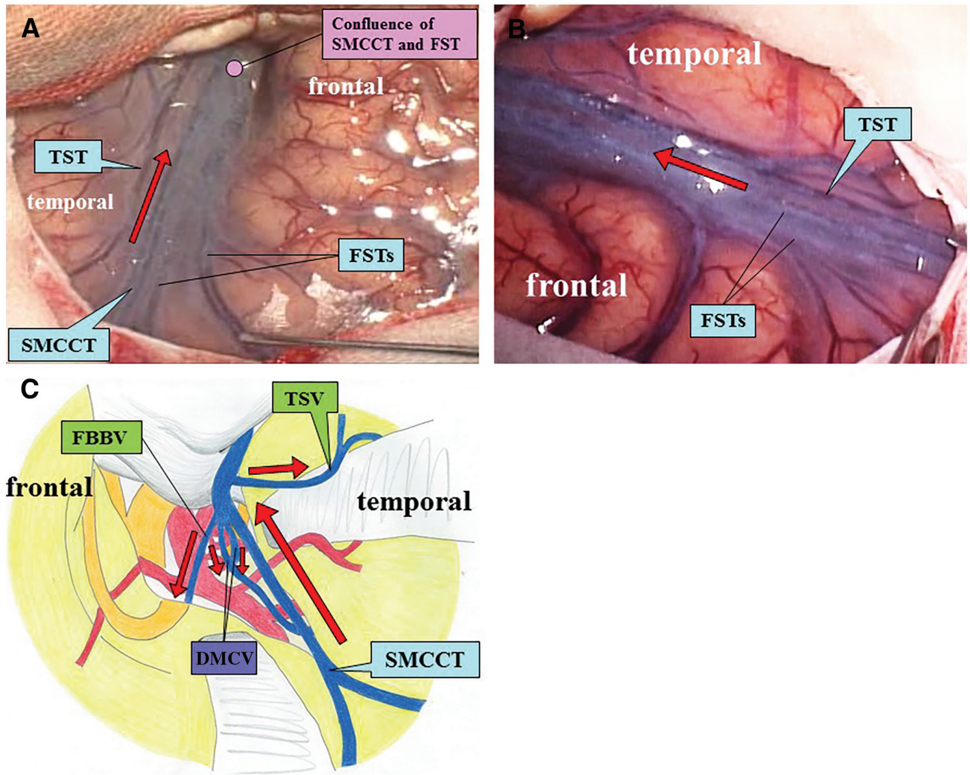

Fig. 3 (A) Photograph of Type A with multiple SMCVs. (B) Photograph of Type C with multiple SMCVs. (C) The schema of dissection of the sylvian veins in cases in which the DMCV impede a wide opening of the Sylvian fissure. DMCV: deep middle cerebral vein, FBBV: fronto-basal bridging vein, FST: frontosylvian trunk, SMCCT: superficial middle cerebral common trunk, SMCV: superficial middle cerebral vein, TST: temporosylvian trunk, TSV: temporosylvian veins.

structures without abiding by our concept of the patterns of dissection of the SMCV. They can accomplish this because they easily skeletonize the SMCV as much as possible to provide mobility to both the frontal and the temporal lobes. However, opportunities for young neurosurgeons to perform direct surgery are decreasing because of increased use of endovascular technique. Therefore, the method to dissect the SMCV based on our morphological classification of the SMCV is not only useful for obtaining a wide operative field while preserving venous structures but also especially useful as opportunity for young neurosurgeons to efficiently master the trans-sylvian approach.

Conclusions

The SMCVs show various patterns in courses and anastomoses. We have classified it into 5 types in order to obtain a simple and safe opening of the Sylvian fissure. By using the surgical technique according to each type, it was possible to obtain a wide surgical field while preserving the venous structure.

Conflicts of Interest Disclosure

The authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

References

1) de Oliveira E, Tedeschi H, Siqueira MG, Peace DA: The pretemporal approach to the interpeduncular and petroclival regions. *Acta Neurochir (Wien)* 136: 204–211, 1995
2) Heros RC, Lee SH: The combined pterional/anterior temporal approach for aneurysms of the upper basilar complex: technical report. *Neurosurgery* 33: 244–250; discussion 250-251, 1993
3) Ito Z: Microsurgery of Cerebral Aneurysm. Tokyo, Nishimura/Elsevier, 1985, pp 95–201
4) Sugita K, Kobayashi S, Shintani A, Mutsuga N: Microneurosurgery for aneurysms of the basilar artery. *J Neurosurg* 51: 615–620, 1979
5) Sano K: Temporo-polar approach to aneurysms of the basilar artery at and around the distal bifurcation: technical note. *Neurol Res* 2: 361–367, 1980

6) Yasargil MG, Antic J, Laciga R, Jain KK, Hodosh RM, Smith RD: Microsurgical pterional approach to aneurysms of the basilar bifurcation. *Surg Neurol* 6: 83–91, 1976
7) Andrews RJ, Bringas JR: A review of brain retraction and recommendations for minimizing intraoperative brain injury. *Neurosurgery* 33: 1052–1063, discussion 1063-1064, 1993
8) Aydin IH, Kadioğlu HH, Tüzün Y, Kayaoğlu CR, Takçi E: The variations of Sylvian veins and cisterns in anterior circulation aneurysms. An operative study. *Acta Neurochir (Wien)* 138: 1380–1385, 1996
9) Baily P: Peculiarities of the intracranial venous system and their clinical significance. *Arch Neurol Psychiatry* 32: 1105, 1934
10) Bendok BR, Getch CC, Parkinson R, O'Shaughnessy BA, Batjer HH: Extended lateral transsylvian approach for basilar bifurcation aneurysms. *Neurosurgery* 55: 174–178; discussion 178, 2004
11) Bisaria KK: The superficial sylvian vein in humans: with special reference to its termination. *Anat Rec* 212: 319–325, 1985
12) Browder J, Krieger AJ, Kaplan HA: Cerebral veins in the surgical exposure of the middle cerebral artery. *Surg Neurol* 2: 359–363, 1974
13) Hacker H: [Outflow pathways of the sylvian vein group]. *Radiologe* 8: 383–387, 1968 (Japanese)
14) Imada Y, Kurisu K, Takumi T, et al.: Morphological pattern and classification of the superficial middle cerebral vein by cadaver dissections: an embryological viewpoint. *Neurol Med Chir (Tokyo)* 59: 264–270, 2019
15) Kageyama Y, Fukuda K, Kobayashi S, et al.: Cerebral vein disorders and postoperative brain damage associated with the pterional approach in aneurysm surgery. *Neurol Med Chir (Tokyo)* 32: 733–738, 1992
16) Kaplan HA: Results of obliteration of specific cerebral veins and dural venous systems, in Kapp JP, Schmidek HH (eds): The Cerebral Venous System and Its Disorders. New York, Grune & Stratton, 1984, pp 275–282
17) Kazumata K, Kamiyama H, Ishikawa T, et al.: Operative anatomy and classification of the sylvian veins for the distal transsylvian approach. *Neurol Med Chir (Tokyo)* 43: 427–433; discussion 434, 2003
18) Sakata Y, Hadeishi H, Tanaka M, et al.: Strategy of superficial sylvian vein dissection on distal sylvian approach. Inspection of microsurgical anatomy. *Surgery for Cerebral Stroke* 38: 387–390, 2010 (Japanese)
19) Sugita K, Kobayashi S, Yokoo A: Preservation of large bridging veins during brain retraction. Technical note. *J Neurosurg* 57: 856–858, 1982
20) Suzuki Y, Matsumoto K: Variations of the superficial middle cerebral vein: classification using three-dimensional CT angiography. *AJNR Am J Neuroradiol* 21: 932–938, 2000
21) Wolf BS, Huang YP, Newman CM: The superficial sylvian venous drainage system. *Am J Roentgenol Radium Ther Nucl Med* 89: 398–410, 1963
22) Yasargil MG: Microneurosurgery, vol 1. Stuttgart, New York, Georg Thieme Verlag, 1984, pp 5–168, 215–233
23) Dean BL, Wallace RC, Zabramski JM, Pitt AM, Bird CR, Spetzler RF: Incidence of superficial sylvian vein compromise and postoperative effects on CT imaging after surgical clipping of middle cerebral artery aneurysms. *AJNR Am J Neuroradiol* 26: 2019–2026, 2005
24) Saito F, Haraoka J, Ito H, Nishioka H, Inaba I, Yamada Y: Venous complications in pterional approach: about fronto-temporal bridging veins. *Surgery for Cerebral Stroke* 26: 237–241, 1998 (Japanese)
25) Suzuki Y, Endo T, Ikeda H, Ikeda Y, Matsumoto K: Venous infarction resulting from sacrifice of a bridging vein during clipping of a cerebral aneurysm: preoperative evaluation using three-dimensional computed tomography angiography--case report. *Neurol Med Chir (Tokyo)* 43: 550–554, 2003
26) Takahashi A, Kamiyama H, Houkin K, Abe H, Nomura M: Anterior temporal approach as a modification of extended trans-sylvian approach. *Surgery for Cerebral Stroke* 22: 307–310, 1994 (Japanese)
27) Joo SP, Jung SH, Kim SH, Kim TS: Correct plane of the sylvian vein dissection for middle cerebral artery aneurysm using indocyanine green videoangiography. *World Neurosurg* 97: 453–458, 2017
28) Maekawa H, Hadeishi H: Venous-preserving sylvian dissection. *World Neurosurg* 84: 2043–2052, 2015
29) Nakase H: [Neurosurgical phlebology: prevention of postoperative venous infarction]. *No Shinkei Geka* 43: 97–107, 2015 (Japanese)
30) Kazumata K, Yokoyama Y, Sugiyama T, et al.: Anatomic consideration for trans-sylvian approach. *Jpn J Neurosurg* 21: 680–687, 2012 (Japanese)
31) Chung JI, Weon YC: Anatomic variations of the superficial middle cerebral vein: embryologic aspects of the regressed embryonic tentorial sinus. *Interv Neuroradiol* 11: 115–122, 2005
32) Oka K, Rhoton AL, Barry M, Rodriguez R: Microsurgical anatomy of the superficial veins of the cerebrum. *Neurosurgery* 17: 711–748, 1985
33) Suzuki Y, Matsumoto K: Variations of the superficial middle cerebral vein: classification using three-dimensional CT angiography. *AJNR Am J Neuroradiol* 21: 932–938, 2000
34) Gibo H, Carver CC, Rhoton AL, Lenkey C, Mitchell RJ: Microsurgical anatomy of the middle cerebral artery. *J Neurosurg* 54: 151–169, 1981
35) Rhoton AL Jr: Rhoton. Cranial Anatomy and Surgical Approaches. Philadelphia, Lippincott Williams & Wilkins, 2003, pp 187–234
36) Yasargil MG: *Microneurosurgery*, vol 2. Stuttgart, New York, Georg Thieme Verlag, 1984, pp 331–339
37) Rosenørn J: The risk of ischaemic brain damage during the use of self-retaining brain retractors. *Acta Neurol Scand Suppl* 120: 1–30, 1989
38) Fujimoto S, Kuyama H, Nishimoto K, Akioka T, Nagao S, Nishimoto A: [Effect of local brain retraction on local cerebral blood flow and neural function Experimental study]. *Neurol Med Chir (Tokyo)* 22: 893–900, 1982 (Japanese)

39) Kazumata K, Kamiyama H, Ishikawa T, et al.: Anterior temporal approach for the treatment of the posterior wall aneurysms of the internal carotid artery. *Surgery for Cerebral Stroke* 31: 431–435, 2003 (Japanese)
40) Tanikawa R, Sugimura T, Hokari M, et al.: Surgery of internal carotid aneurysms in distal transsylvian approach: differences and advantages of distal transsylvian approach. *Surgery for Cerebral Stroke* 32: 19–24, 2004 (Japanese)
41) Tanikawa R, Wada H, Ishizaki T, et al.: Anterior temporal approach for basilar bifurcation aneurysms as a modified distal transsylvian approach. *Surgery for Cerebral Stroke* 26: 259–264, 1998 (Japanese)
42) Motoyama Y, Gurung P, Takeshima Y, Nakagawa I, Park YS, Nakase H: Indocyanine green (ICG) videoangiography-guided dissection of the sylvian fissure on the transsylvian approach: technical note. *World Neurosurg* 87: 45–47, 2016
43) Toi H, Matsushita N, Ogawa Y, et al.: Utility of indocyanine green video angiography for sylvian fissure dissection in subarachnoid hemorrhage patients - sylvian ICG technique. *Neurol Med Chir (Tokyo)* 58: 85–90, 2018

Corresponding author: Yasutaka Imada, MD, PhD
Department of Neurosurgery, Yamada Memorial Hospital, 6-2-1 Miyaura, Mihara, Hiroshima 723-0051, Japan.
e-mail: yasutaka5682@yahoo.co.jp