Middle Cerebral Artery Aneurysm

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Approximately 30% of all ruptured cerebral aneurysms and 36% of all unruptured cerebral aneurysms originate along the middle cerebral artery (MCA) territory. They are usually located at the MCA bifurcation and often project laterally in the plane of the M1 segment.

MCA bifurcation aneurysms account for approximately 35% of all giant aneurysms. Because of their location, lateral projection, and attachment of the dome to the lobe, nearly 50% of ruptured MCA aneurysms present with intraparenchymal hematomas, and 80% of these are in the temporal lobe.

Any patient with a spontaneous hematoma adjacent to the Sylvian fissure, with or without associated subarachnoid hemorrhage, should undergo vascular imaging to rule out an underlying vascular anomaly. Complete vascular imaging is necessary; approximately 40% of patients with MCA aneurysms have multiple aneurysms, in contradistinction to approximately 20% of those with aneurysms in other locations. Moreover, mirror aneurysms can be seen in 13% of patients with MCA aneurysms.

Although MCA aneurysms are most commonly seen at the

MCA bifurcation, they may also be found proximally along the M1 segment, or distally along the M3 or M4 segments. Each location raises different surgical and management considerations; however, the anatomic and morphologic features of MCA aneurysms render them amenable to microsurgical clip ligation as the primary treatment of choice for most patients.

Indications for Surgery

Based on data from the International Study of Unruptured Intracranial Aneurysms (ISUIA,) MCA aneurysms have a relatively low rate of rupture when small, ranging from 0 to 1.5% over 5 years if smaller than 7 mm, and 2.6% over 5 years if between 7 and 12 mm. For aneurysms larger than 12 mm, the risk of hemorrhage jumps to 14.5% over 5 years, and to a staggering 40% over 5 years for giant aneurysms (≥25 mm).

Regardless of their size, aneurysms should be treated if they have an irregular morphology, have shown recent growth or change, or have an intraluminal thrombus. MCA aneurysms can grow to a large size, and a transient ischemic attack caused by intraluminal thrombus is an urgent indication for treatment.

Because of the distal location of MCA aneurysms and their wide-neck morphology, surgical clipping is more successful and carries a lower risk than endovascular therapy for most patients. The potential need for surgical decompression of a temporal lobe hematoma is another indication for microsurgery. Endovascular therapy may be superior for distal fusiform aneurysms.

Anterior temporal artery aneurysms almost always have a wide neck, and endovascular therapy can place the small-caliber anterior temporal artery at risk during embolization. Therefore, endovascular therapy may have a minimal role with this aneurysm subtype.

Preoperative Considerations

A careful analysis of the preoperative studies is warranted, including the length and morphology of the M1 and the direction of the aneurysm dome. The presence of an MCA trifurcation should be noted.

The exact location of the aneurysm along the vascular tree should be determined and a mental map of the M2 branches leading the surgeon to the neck is constructed. I pay special attention to identifying the location of the temporal trunk because this vessel is hidden underneath the sac and within the operative blind spot. The presence of calcium plaques across the neck or dome indicates the potential need for revascularization.

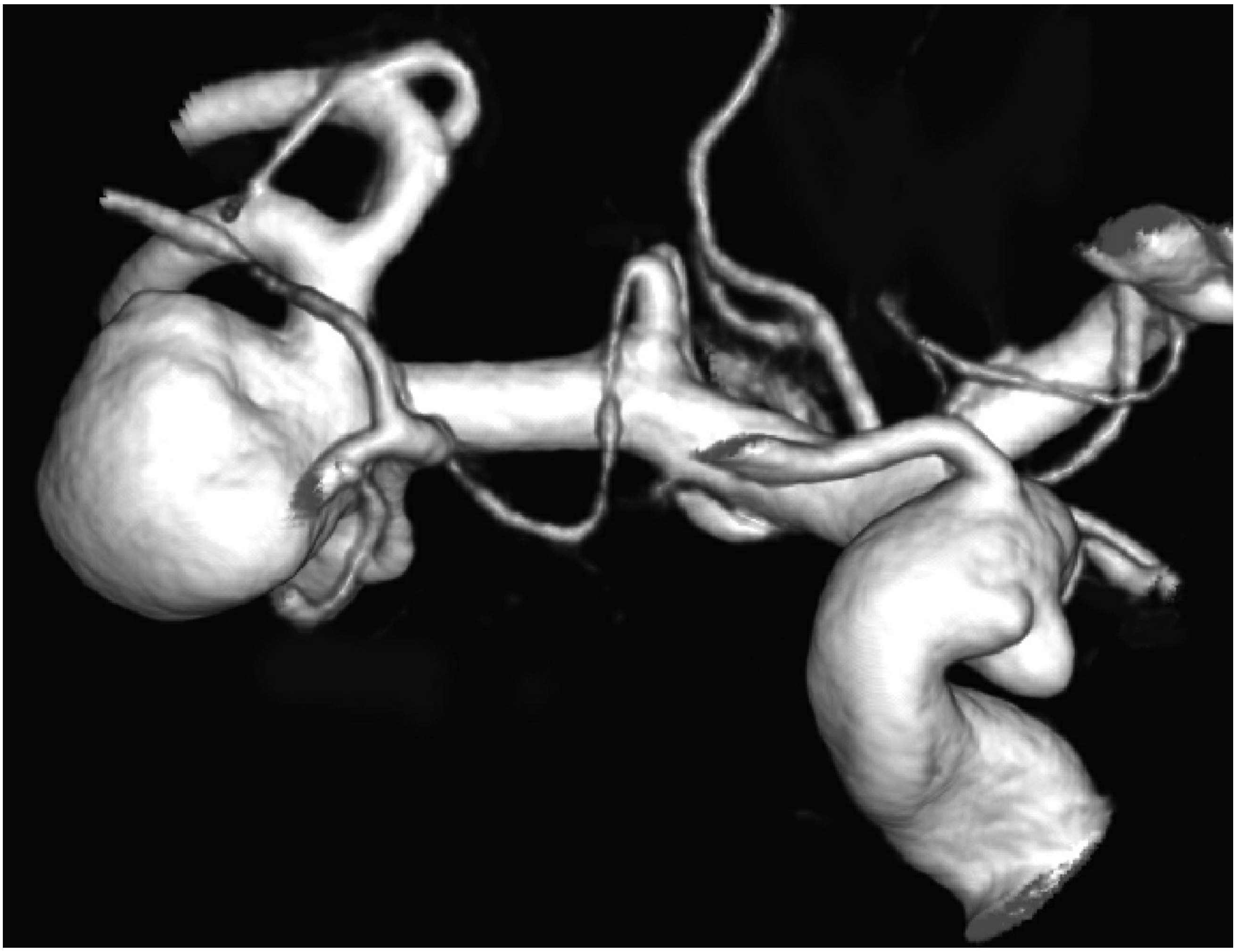
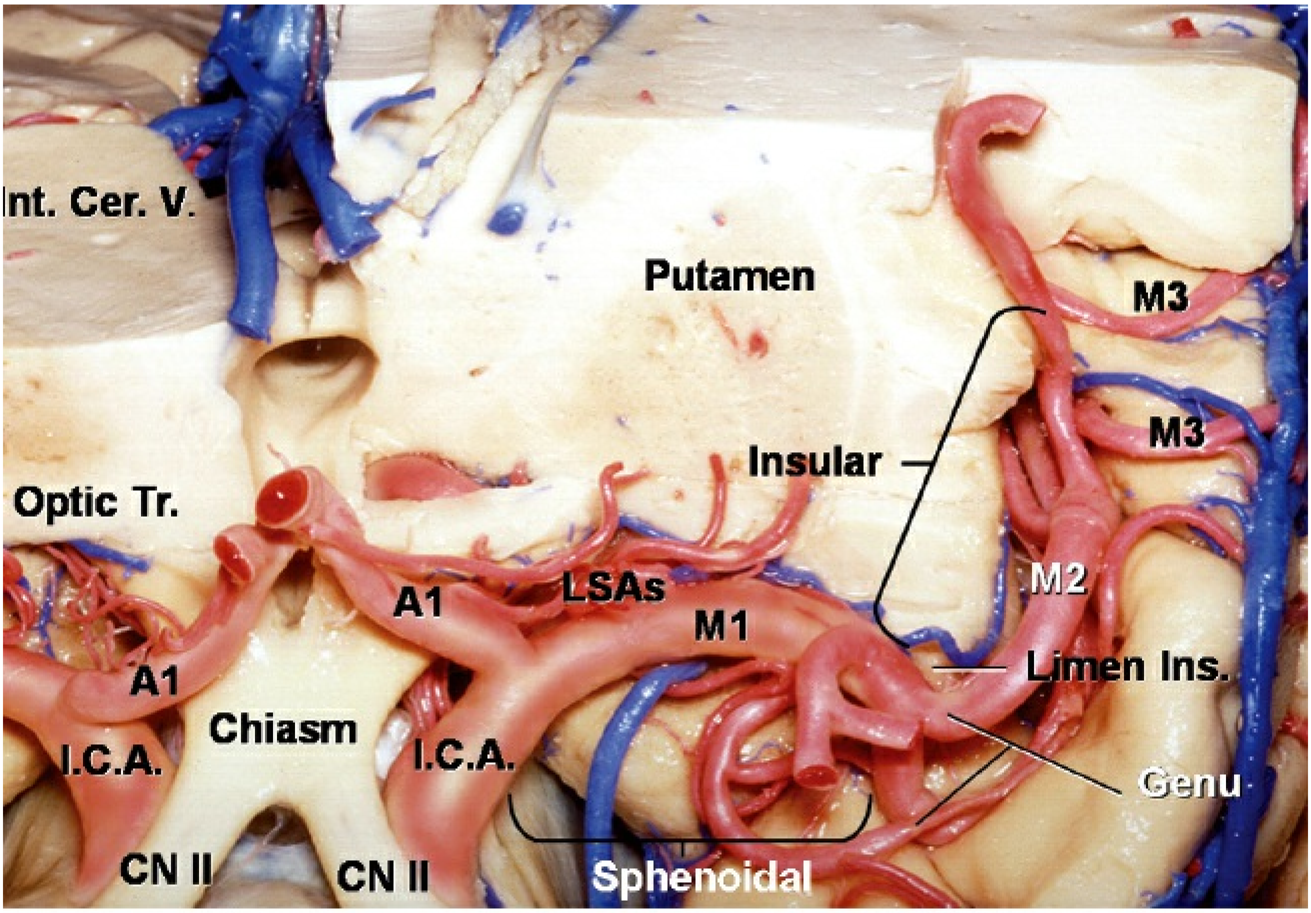


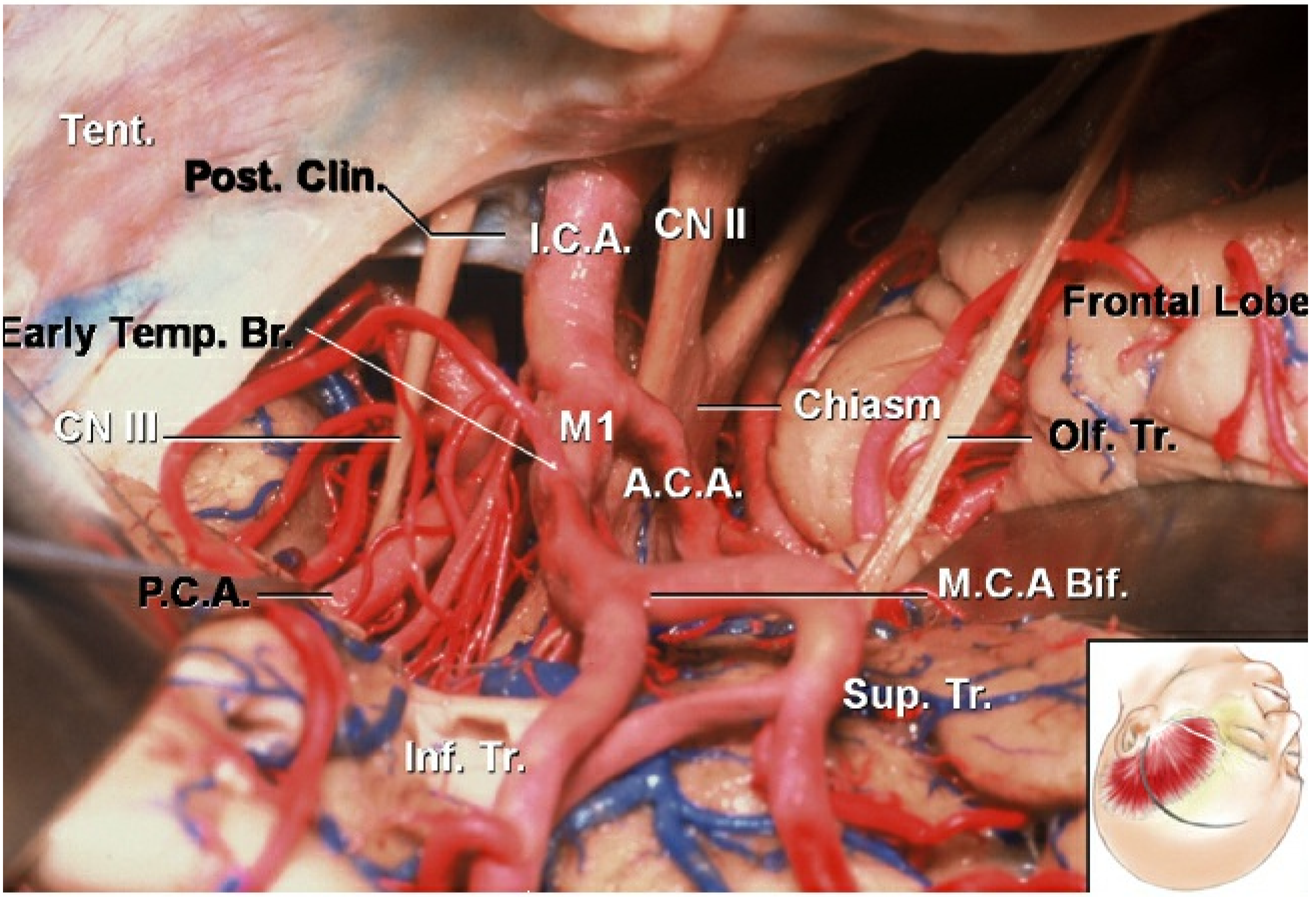
Figure 1: A typical MCA aneurysm is demonstrated. Dysplastic aneurysms are found in the pediatric population and offer special challenges in their treatment. MCA aneurysms can reach a giant size.

Operative Anatomy

The MCA is divided into four segments along its course after it emerges from the internal carotid artery (ICA.) MCA branches supply most of the lateral cerebral hemisphere, along with the insula, lentiform nucleus, and internal capsule.

The four MCA segments are named after the anatomic structures along which they travel in a stepwise angular fashion: M1 sphenoidal, M2 insular, M3 opercular, and M4 cortical. Almost all MCA aneurysms are found at the M1 bifurcation or trifurcation.





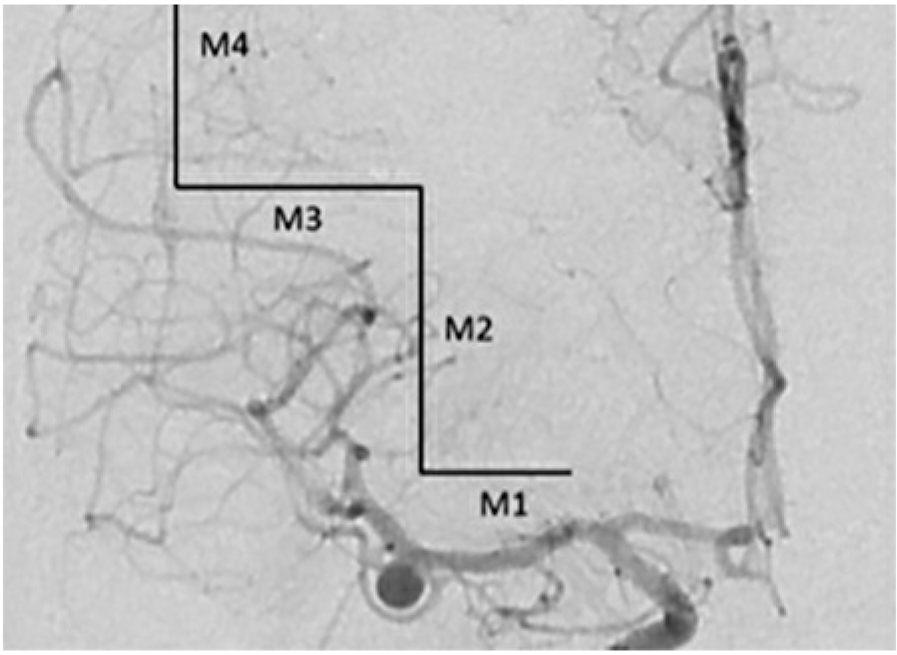


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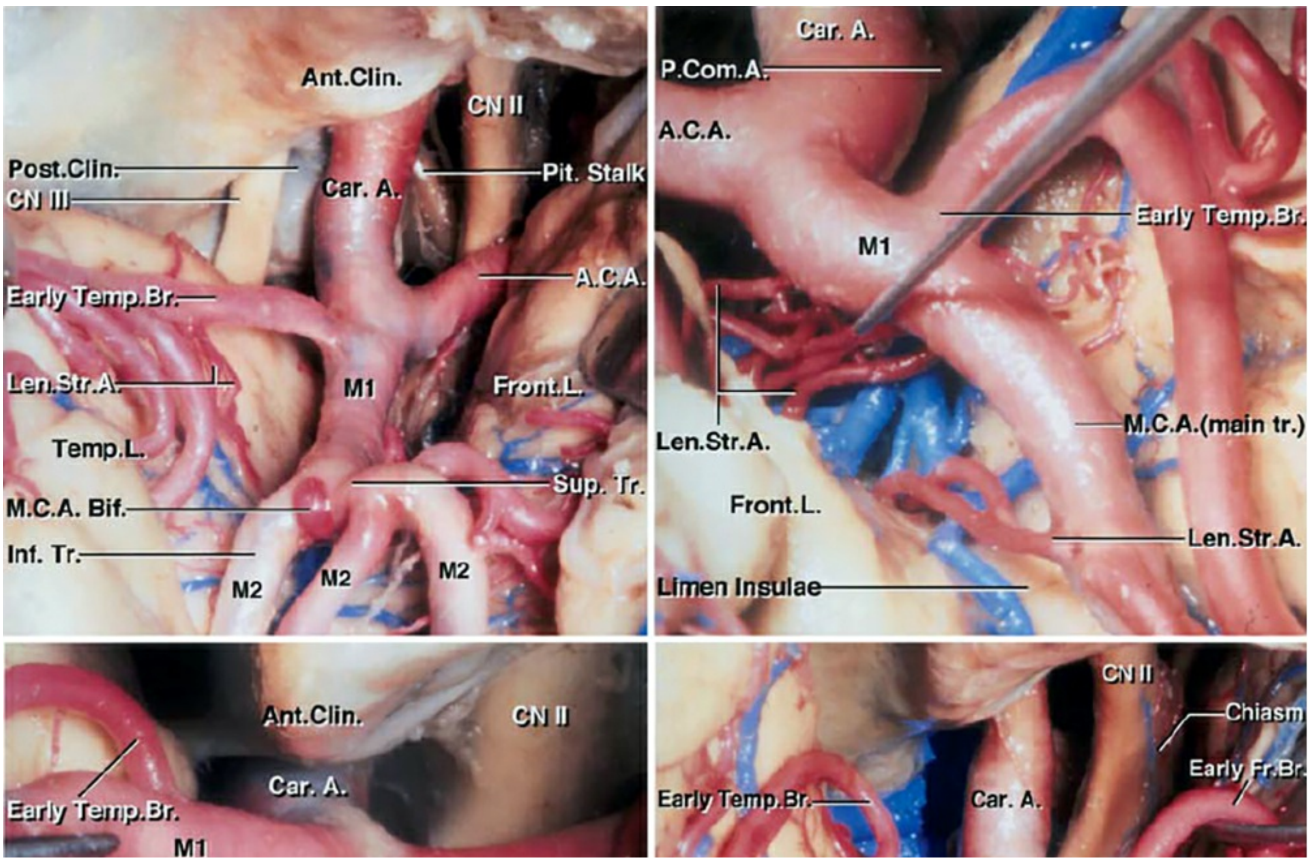
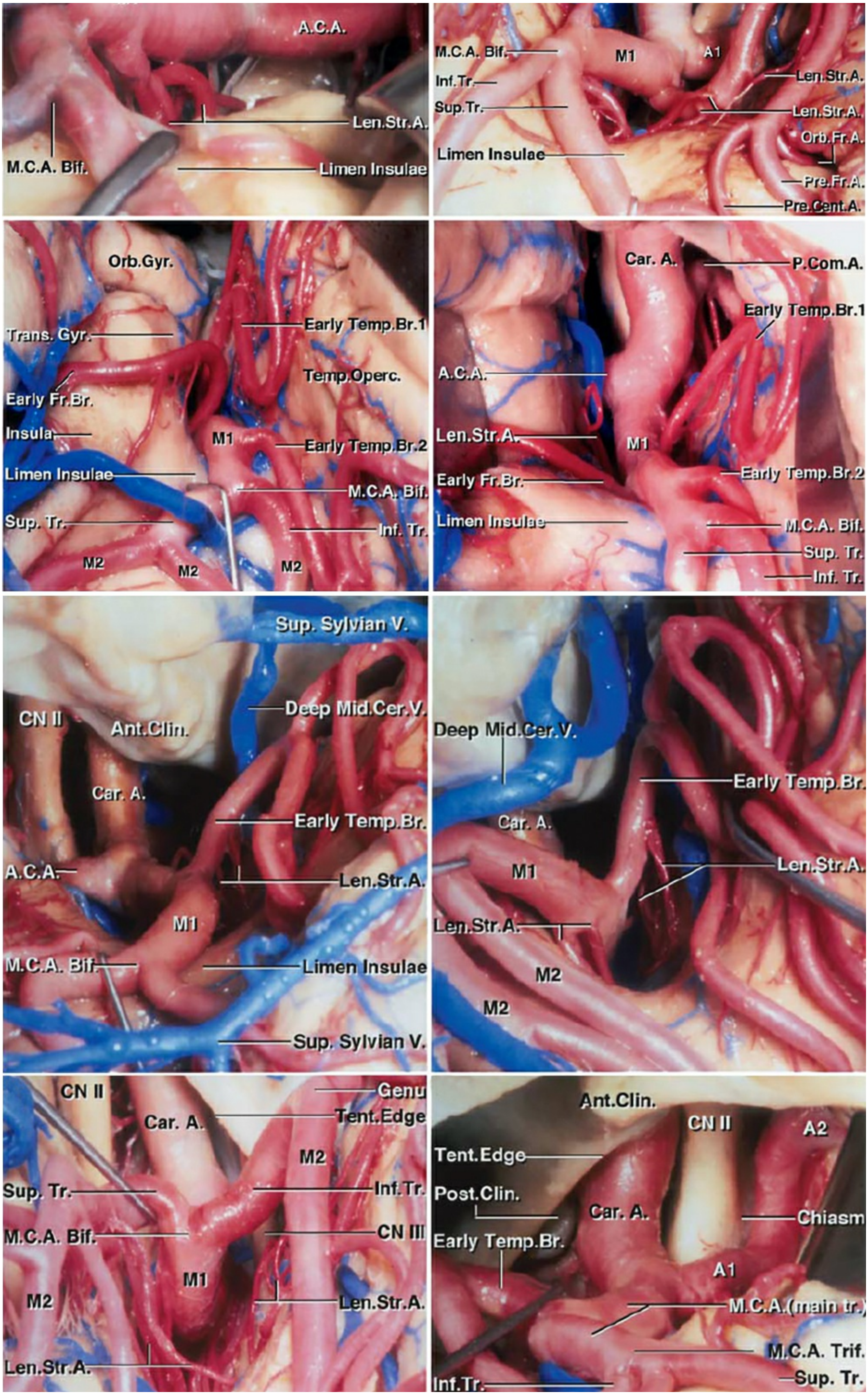
Figure 2: The MCA is divided into four segments which travel through the Sylvian fissure in a stepwise angular fashion as follows: M1 (sphenoidal segment), M2 (insular branches), M3 (opercular branches), and M4 (cortical branches). The upper images illustrate the MCA anatomy via a left-sided approach. The length of the M1 segment can be quite variable. The short M1 segments significantly increase the depth of the operative field and add to the technical complexity of the operation; the lenticulostriate perforators are placed at increased risk as they may originate from the bifurcation or proximal M2 trunks. The anteroposterior angiogram (bottom image) shows the MCA divisions in a patient with an MCA aneurysm.

The M1 begins in the Sylvian cistern at the carotid bifurcation and travels horizontally within the proximal portion of the Sylvian fissure, before making a sharp turn superiorly around the limen insulae to enter the insular cistern. At this point, the M1 bifurcates into the M2 branches that have a superior course over the insula. Next, they make a lateral turn to course through the opercular portion of the Sylvian fissure as the M3 branches before making their final 90-degree turn superiorly over the cortex as the M4 branches.

The M1 has several important branches: the lateral lenticulostriate arteries and the anterior temporal artery (ATA). They usually originate on opposite sides of the M1 segment, the lenticulostriates superiorly and the ATA inferiorly. The lenticulostriate arteries enter the brain via the anterior perforating substance and supply the substantia innominata, putamen, globus pallidus, head and body of the caudate, internal capsule, corona radiata, and central portion of the anterior commissure. Their occlusion is associated with significant morbidity.




A.C.A.
Len.Str.A.
M.C.A. Bif.
Limen Insulae
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M1
A1
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Limen Insulae
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Pre.Cent.A.
Orb.Gyr.
Trans. Gyr.
Early Temp.Br.1
Temp.Operc.
Early Fr.Br.
Insula
M1
Early Temp.Br.2
Limen Insulae
M.C.A. Bif.
Sup. Tr.
Inf. Tr.
M2
M2
M2
Car. A.
P.Com.A.
Early Temp.Br.1
A.C.A.
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Early Fr.Br.
Limen Insulae
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Sup. Tr.
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Sup. Sylvian V.
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Sup. Sylvian V.
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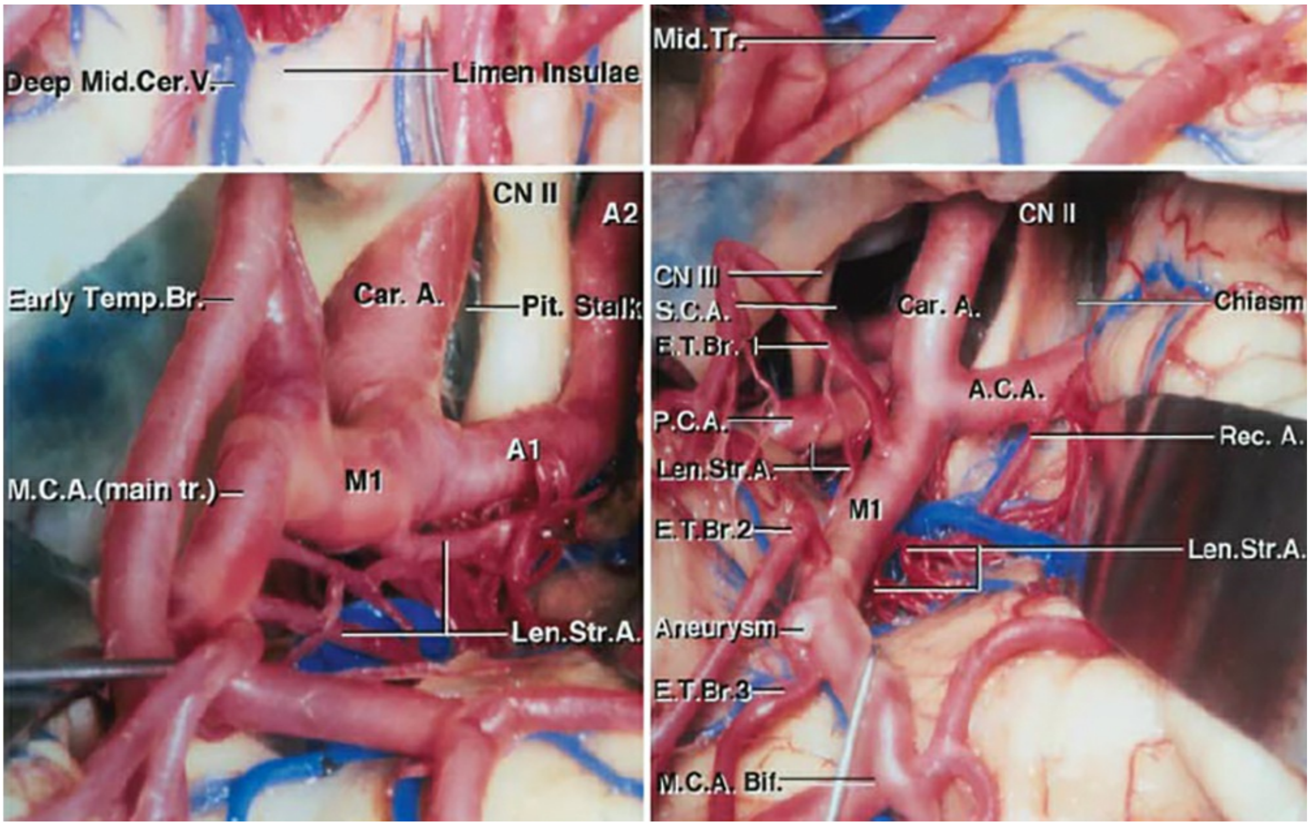

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Figure 3: Basal view of the brain showing the M1 originating from the ICA bifurcation and coursing along the insula, giving off multiple lenticulostriate arteries before its bifurcation. There is abundant diversity among individuals regarding the location of the early frontal and temporal trunks and the lateral lenticulostriate perforators. These vital perforators may even originate from the proximal portions of these trunks. The surgeon should exercise caution not to consider any fine vessel insignificant in the region. The above images emphasize the vast diversity in the anatomy of the MCA, its trunks, and perforating vessels (images courtesy of AL Rhoton, Jr).

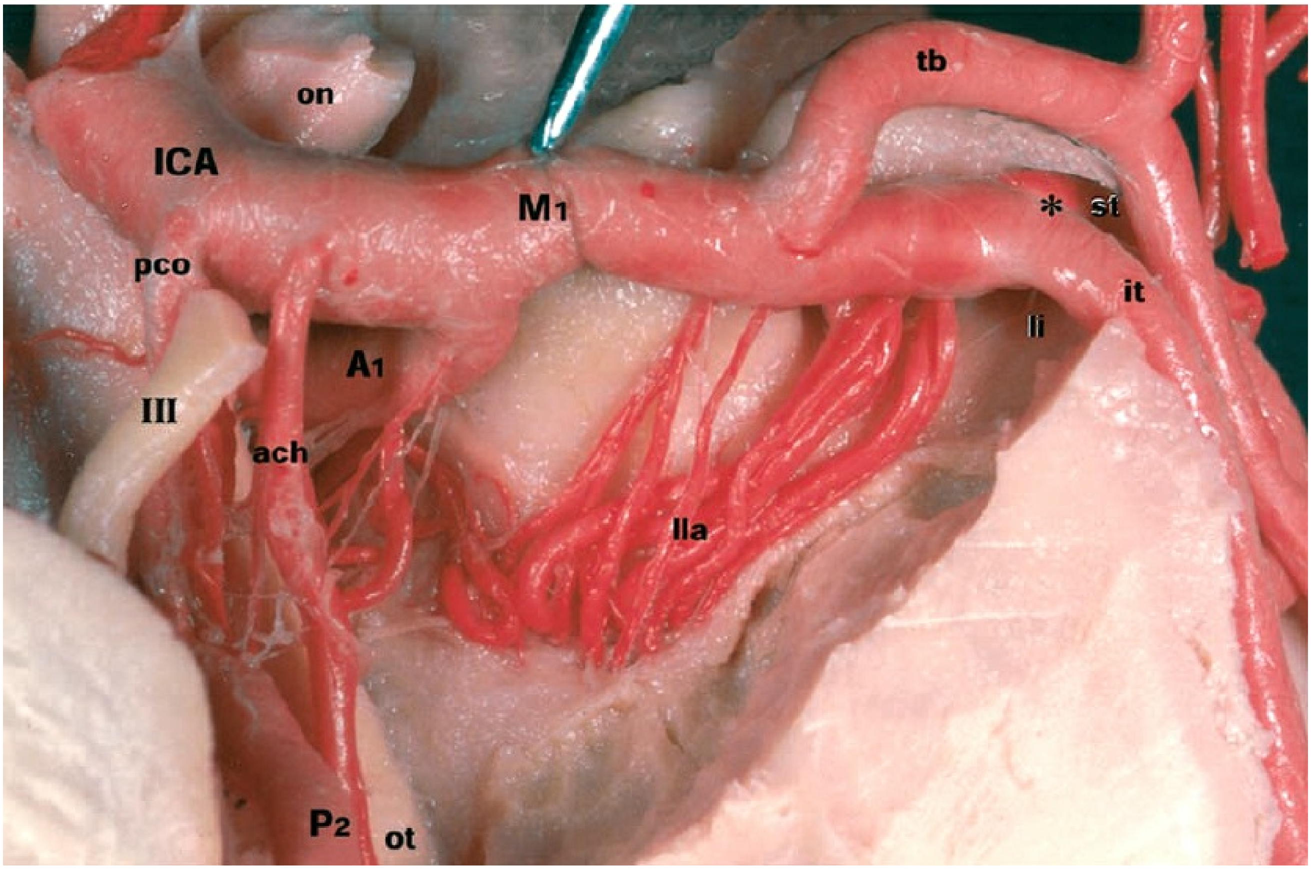


Figure 4: An inferior view of the left MCA in the region of the anterior perforated substance. Note how the lateral lenticulostriate arteries originate from the M1 segment as it bifurcates into the M2 branches (asterisk.) Abbreviations: III = oculomotor nerve; A1 = precommunicating segment of the anterior cerebral artery; ach = anterior choroidal artery; ICA = internal carotid artery; it = inferior trunk of M2 segment; li = limen insula; M1 = sphenoidal segment of the MCA; on = optic nerve; ot = optic tract; P2 = ambient segment of the posterior cerebral artery; pco = posterior communicating artery; st = superior trunk of M2 segment; tb = anterior temporal branch. From Türe U, Yaşargil MG, Al-Mefty O, Yaşargil DC. Arteries of the insula. *J Neurosurg*. 2000; 92: 676–687.

The ATA ascends along the temporal lobe inside the Sylvian fissure and is consistently found on the anterior or inferior face of the mid-M1 segment. The ATA may occasionally drape over the aneurysm and can be mistaken for an early temporal M2 trunk if adequate distal M1 dissection is not accomplished. Exceedingly rare M1 variants include a duplicated MCA, which is a second M1 arising from the ICA, and an accessory MCA, which is a second M1 that arises from the anterior cerebral artery and appears like a recurrent artery of Huebner from which cortical branches arise.

As mentioned above, the length and arch of M1 have significant surgical implications. A shorter M1 presents a more challenging surgical dissection because it is deeper in the Sylvian fissure and there is a higher likelihood of lenticulostriate branches distal to the bifurcation, whereas a long M1 results in a more superficial operative field; most of the lenticulostriate arteries arise away from the bifurcation. An upward (convex) or anterior arch to the M1 often results in a bifurcation aneurysm embedded in the temporal lobe, whereas a downward (concave) or posteriorly shaped arch brings the aneurysm up into the frontal lobe.

The M2s give rise to eight to twelve branches before becoming M3s at the periinsular sulcus. The location of these M2s varies considerably based on the length of the M1. Often there is a dominant M2 trunk bifurcating shortly after the M1 bifurcation, thereby creating a trifurcation appearance. This configuration may also confuse the operator regarding the exact location of the bifurcation if a distal-to-proximal dissection along the fissure is attempted.

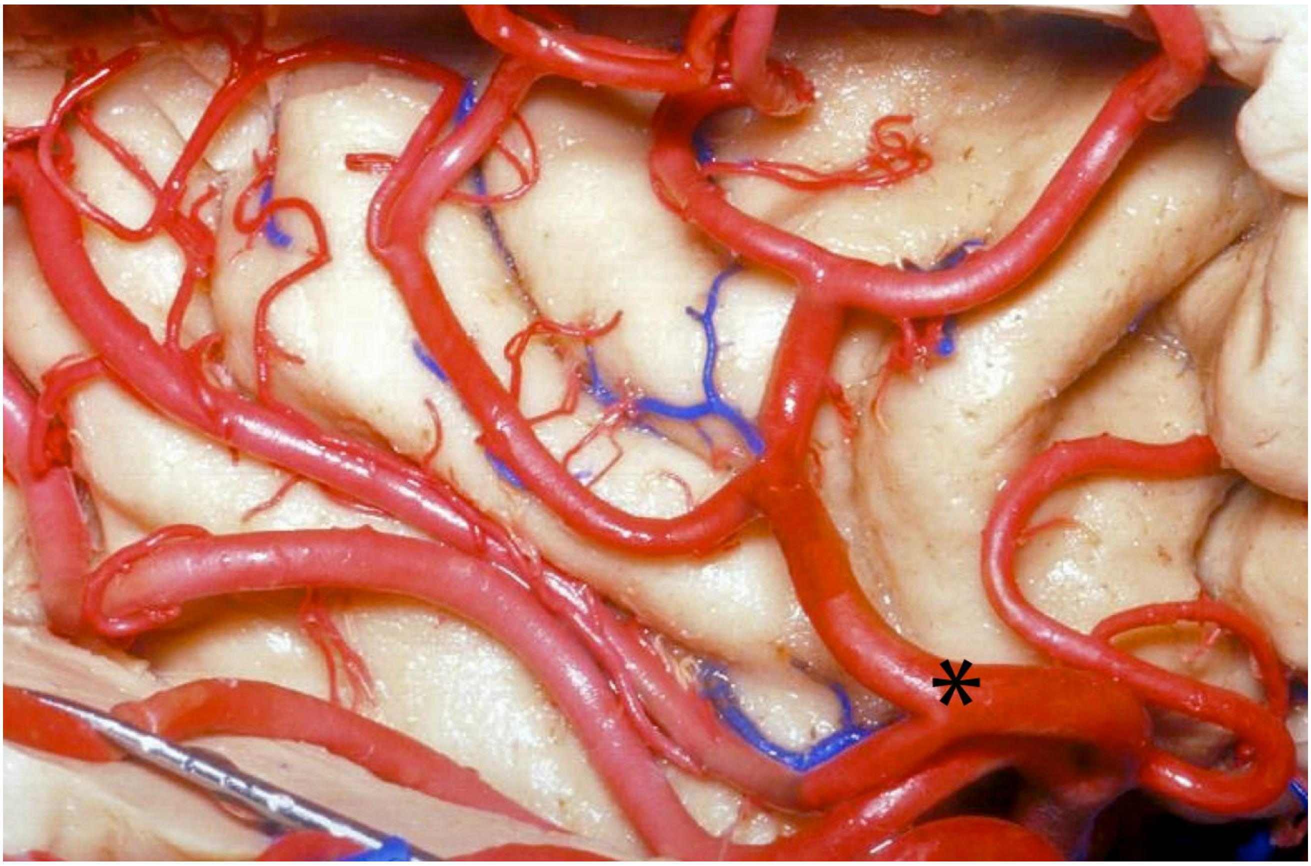


Figure 5: The M2 trunks course over the insula before traveling as M3 branches along the opercular surface toward the cortical surface. The early bifurcation of dominant M2 branches (*) should not be confused with the M1 bifurcation during a distal-to-proximal fissure dissection (image courtesy of AL Rhoton, Jr.)

The M3 vessels continue on either the frontal or temporal surfaces of the Sylvian opercula and generally do not cross over. Although they may belong to one side, they may adhere to the other operculum. Nonetheless, they can be microsurgically mobilized. Their atraumatic mobilization is is an important maneuver during Sylvian fissure dissection. The M4 segments are located on the lateral surface of the hemisphere after emerging from the Sylvian fissure.

The venous anatomy of the Sylvian fissure is quite variable.

The superficial Sylvian vein is the most important vein encountered during dissection of the fissure for MCA aneurysms. It arises on the posterior aspect of the Sylvian fissure with a single or multiple tributaries that eventually drain into the sphenoparietal sinus and, in some cases, directly into the cavernous sinus. There are often multiple superficial Sylvian veins, and the dissection should be directed between them since they do not contain tributaries among them, but rather receive tributaries from the adjacent opercula.

The superficial Sylvian vein almost always courses on the temporal side of the Sylvian fissure. Therefore, I start the superficial Sylvian fissure split on the frontal lobe side of the vein so that I can mobilize the vein toward the temporal side.

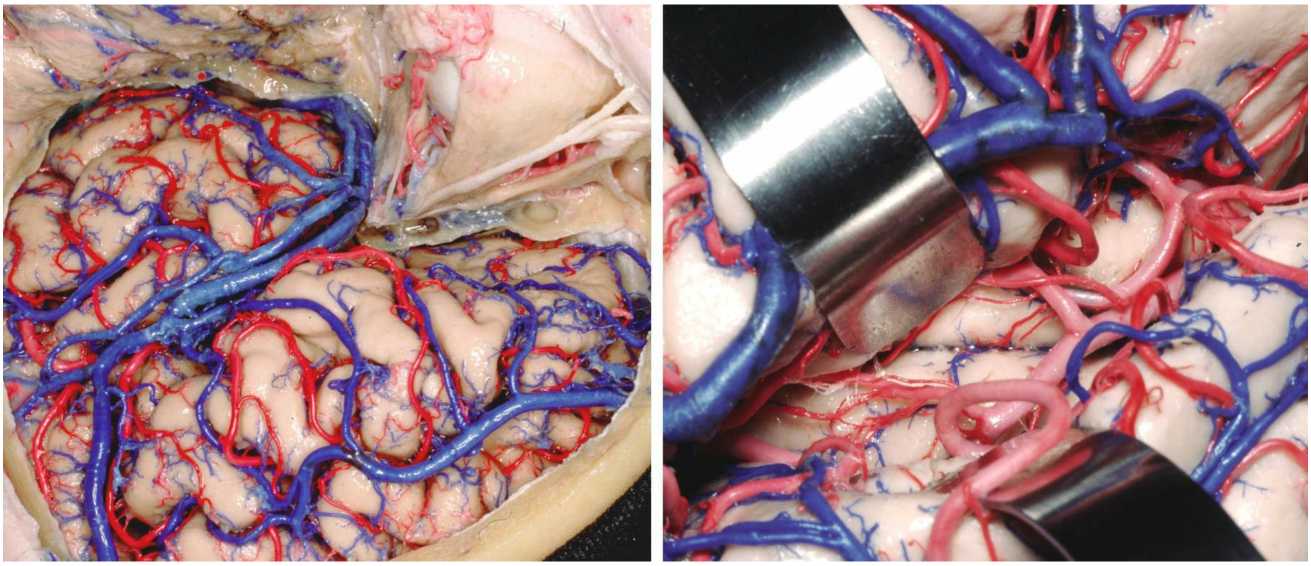


Figure 6: The superficial Sylvian vein is located on the temporal side of the Sylvian fissure, and dissection of the fissure should begin on the frontal side to mobilize the vein temporally.

Small venous branches traversing between the frontal and temporal lobes may be coagulated and sharply divided in order to allow access to the deeper Sylvian fissure cisterns. However, the main trunk(s) of the superficial Sylvian vein should remain intact to avoid venous infarction. The small veins of the anterior temporal pole may also be sacrificed if needed.

MICROSURGICAL CLIP LIGATION OF MIDDLE CEREBRAL ARTERY BIFURCATION ANEURYSMS

A pterional craniotomy is the ideal approach for exposing an MCA aneurysm.

Briefly, the patient is placed in the supine position and the patient's neck is extended slightly with the head turned approximately 30 degrees contralateral to the side of the aneurysm, in order to orient the Sylvian fissure perpendicular to the floor. A significant subfrontal dissection and drilling of the orbital roof is not usually needed, but the lateral aspect of the sphenoid wing is resected. It is important to preserve the superficial temporal artery during the initial dissection, if a potential need for a bypass is expected.

The pterional craniotomy for MCA aneurysms extends more distally along the Sylvian fissure than for anterior communicating artery aneurysms. This factor is especially applicable for long M1 segments harboring posteriorly projecting aneurysms.

By measuring the distance from the ICA bifurcation to the aneurysm along the M1 and the vertical distance of the aneurysm from the zygomatic arch, I develop a sense of the size of craniotomy needed and the necessary extent of Sylvian fissure dissection. Although a smaller craniotomy through a vertical linear incision is often adequate for small and medium size unruptured aneurysms, the primary goals of proximal control and the availability of a full spectrum of clipping angles should be respected.

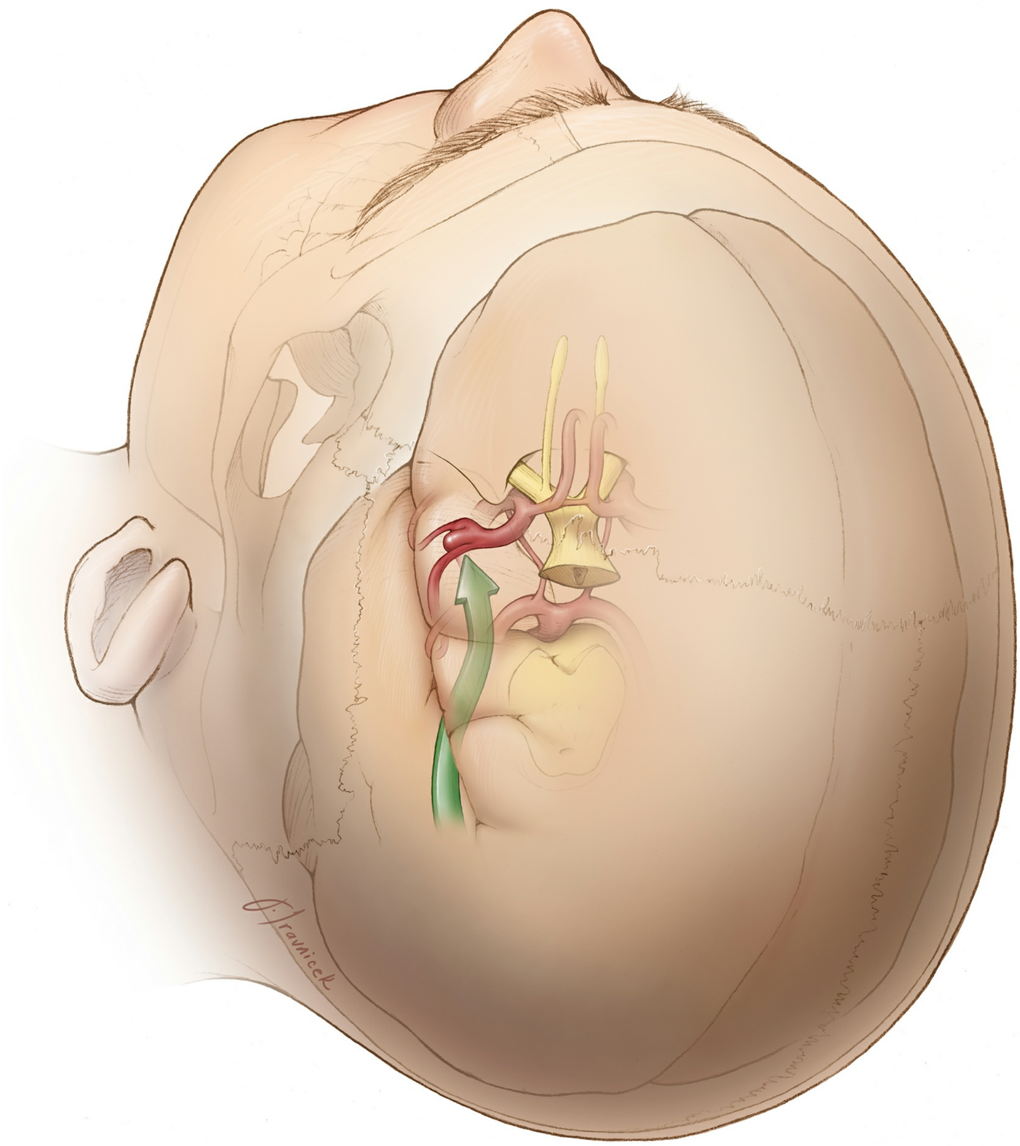


Figure 7: The direction and operative trajectory for approaching an MCA bifurcation aneurysm is illustrated. I start dissection through the Sylvian point and follow the M2 branches on their frontal side toward the M1. Once I find the

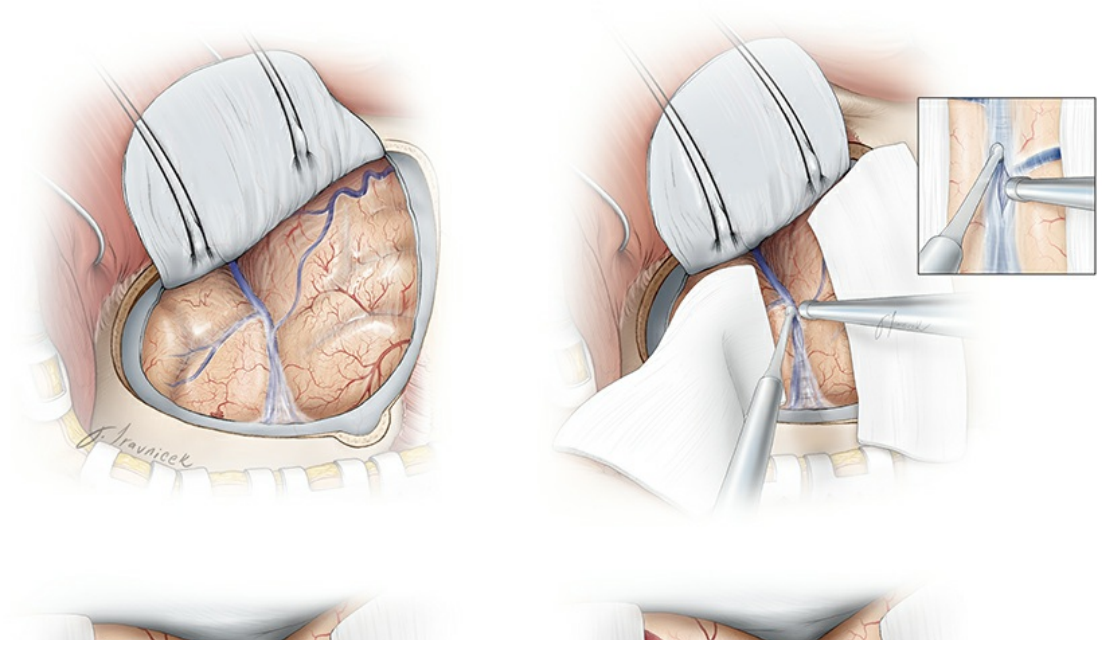
M1 and proximal control is secured, I redirect my dissection from M1 toward the bifurcation to expose the aneurysm neck.

The MCA aneurysms are more posterior along the fissure than often expected. The most common mistakes of the novice surgeon are dissecting too anteriorly or too deeply within the fissure, overlooking the exact location of the aneurysm. The aneurysm is typically 1.5-2.0 cm posterior to the anterior border of the insular portion of the fissure and 2.0 cm deep to the superior and middle temporal gyri.

INTRADURAL DISSECTION

Initial Exposure

Please refer to the chapter on Techniques of Sylvian Fissure Split for discussion regarding the initial steps of fissure dissection. For MCA aneurysms, the dissection of the fissure begins approximately 3 cm posterior to the sphenoid wing. These steps are summarized below.



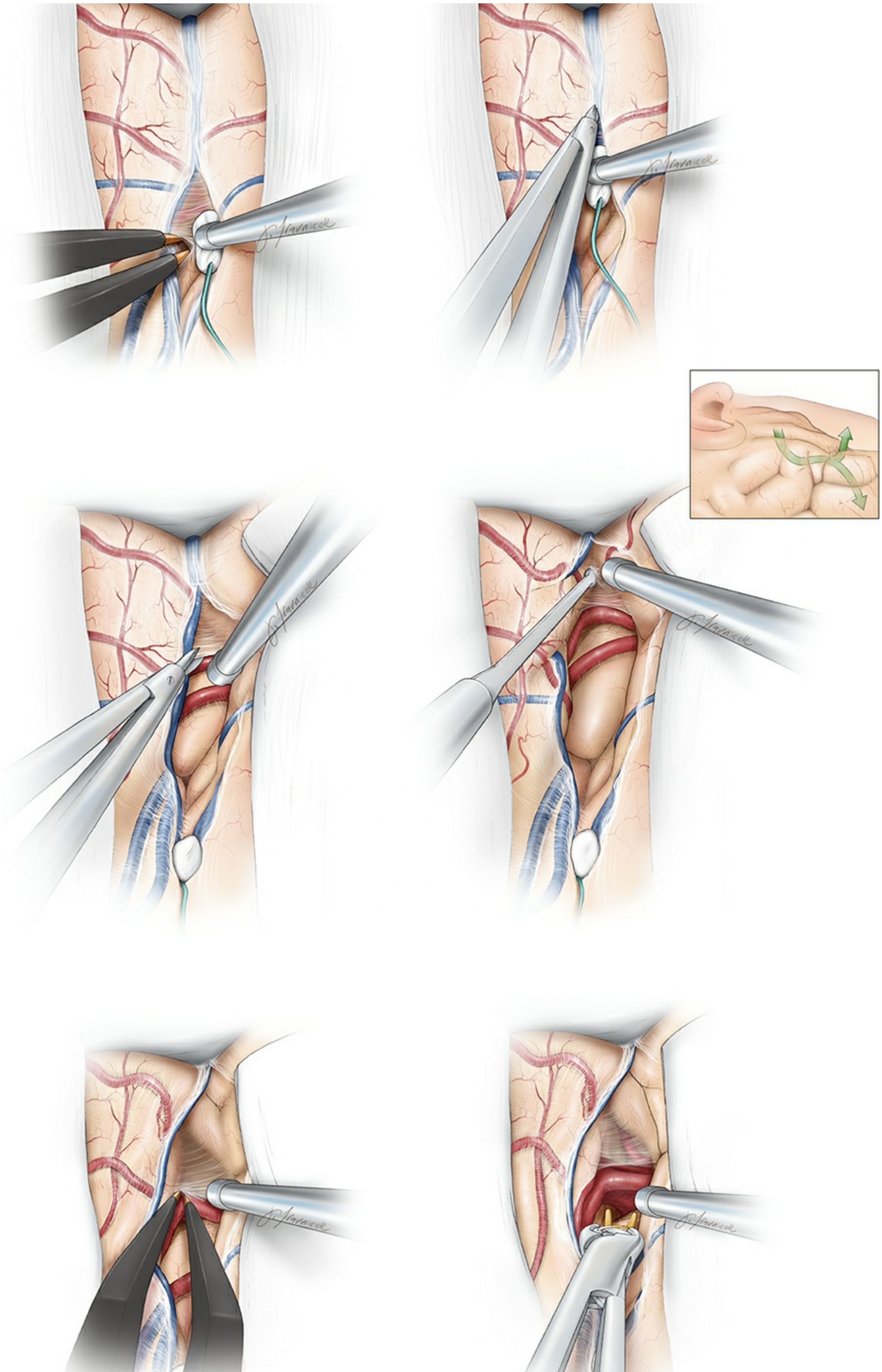


Figure 8: The superior extent of the craniotomy is just above the superior temporal line because minimal subfrontal exposure is necessary (upper images.) The surface of the brain is covered to avoid heat injury from the intense light of the microscope. I use the "inside-to-outside" technique by reaching deep into the distal fissure and separating the opercula from deep to superficial. The fissure may be opened either proximally to distally, or distally to proximally. I routinely use the distal-to-proximal dissection technique for both unruptured and ruptured cases to avoid aggressive frontal lobe retraction. I use the M2s as a guiding map to find the M1 while I avoid the neck and dome of the aneurysm. Enough of the distal M1 is exposed to support a temporary clip (lower images).

In patients with subarachnoid hemorrhage, many colleagues prefer to start the dissection proximally at the level of the carotid cisterns, in order to drain cerebrospinal fluid to relax the inflamed brain and gain proximal control by dissecting anterograde along the ICA to the MCA bifurcation. I believe that with strategic dissection of the fissure, one can avoid the aneurysm during the initial stages of fissure dissection while securing proximal control.

The presence of tenacious and thick clot within the fissure (especially if present for a few days to organize) can offer technical challenges. If the M2 dissection is not methodically performed in the distal-to-proximal dissection and the pathoanatomy of the M2s relative to the neck is not well understood, it is very easy to wander in the fissure and inadvertently land on the aneurysm sac. The early bifurcation of dominant M2 branches should not be confused with the M1 bifurcation during the distal-to-proximal fissure dissection.

Presence of subarachnoid hemorrhage within the fissure leads to significant adherence of the opercula and pial banks, requiring patience and the application of microsurgical techniques for atraumatic fissure dissection. However, despite these measures, occasional subpial entry into the friable opercula is not uncommon, but should be kept to a minimum. Injection of saline into the fissure using a syringe and an angiocath may assist with expansion of the Sylvian cisterns.

In ruptured cases, if the brain is tense, a ventriculostomy catheter may be placed at the Paine's point. This point is defined as the apex of an isosceles triangle with its base measuring 3.5 cm along the Sylvian fissure and its two equal borders each measuring 2.5 cm. I usually do not use this method and instead create an additional burr hole at the Kocher's point to install the ventricular catheter.

After M1 is exposed and proximal vascular control is deemed adequate, the dissection proceeds distally along the anterior and inferior aspects of M1 to reach the aneurysm neck at the MCA bifurcation. Posteriorly pointing aneurysms allow M1 exposure along their anterior pole, and anteriorly pointing aneurysms allow M1 exposure along their posterior pole. The latter can be challenging because of the obstructive pulsating aneurysm sac. Some mobilization of the M2 trunks may be necessary for creating enough space to place a temporary clip on M1. Nonetheless, proximal control is mandatory before proceeding with aneurysm dissection.

Next, the neck and origin of the temporal and frontal trunks are exposed via proximal-to-distal dissection. The temporal M2 is buried under the temporal operculum, away from the surgeon's working space and within the operative blind spot, and depending on the orientation and projection of the aneurysm, its origin may be hidden beneath the aneurysm dome. Temporary M1 occlusion can assist with mobilization of the aneurysm and isolation of the temporal trunk away from the neck to ensure an adequate pathway for passage of the clip blades.

The surgeon should not overlook the possibility of MCA trifurcation; the blades should not compromise the third M2 branch. This third division may not be apparent until the initial tentative clip is placed and additional mobilization of the dome is possible to circumdissect the neck.

The frontal M2 is more readily dissected and should be mobilized to provide additional cues for the surgeon's orientation and translating the angiographic data to the intraoperative findings. The dissection continues along the proximal frontal M2 toward the neck and onto the proximal temporal M2. Great care should be paid to identify and preserve any postbifurcation lenticulostriate arteries.

Aggressive forceful manipulation of the sac without temporary M1 occlusion can easily lead to premature rupture.

I avoid fixed retractor blade during this entire dissection process since the blades often obstruct my working angles and lead to cortical injury. I may use a fixed retractor's blade as a "third hand" during the very final fine adjustments of the permanent clip while I use the suction device to manipulate the neck and dome. Early in the dissection process, I avoid any significant retraction on the aneurysm-bearing lobe (most often the temporal lobe) in order to prevent an inadvertent rupture.

Aneurysm Dissection

With the M1 and both M2s exposed, the next step in dissection involves exposure of the proximal and distal aneurysm neck. Temporary clipping is tremendously beneficial for softening the aneurysm sac during difficult and risky dissection maneuvers, and is particularly helpful for isolating branching and perforating arteries adherent to the dome.

The temporary clip must preferably be placed just distal to the lenticulostriate vessels and should not interfere with the clip construct. Large and giant aneurysms may require aneurysmal trapping to deflate and/or thrombectomize the sac. Once M1 temporary clipping has been performed, the aneurysm neck must be fully circumdissected free of any adhesions. The dome may be dissected free from the surrounding parenchyma in the case of small and moderate size aneurysms to expose the entire neck.

I prefer to pursue dissection under temporary proximal M1 occlusion for 5-minute intervals interspersed with 2-minute reperfusion periods. Calcified plaques in the M1 interfere with temporary clipping and may be recognized preoperatively. In these instances, temporary ligation of the internal carotid artery may be considered if portions of this vessel are not affected by plaque. In elderly patients and those with very atherosclerotic arteries, the collateral support is deficient and temporary clipping should be avoided or used very sparingly.

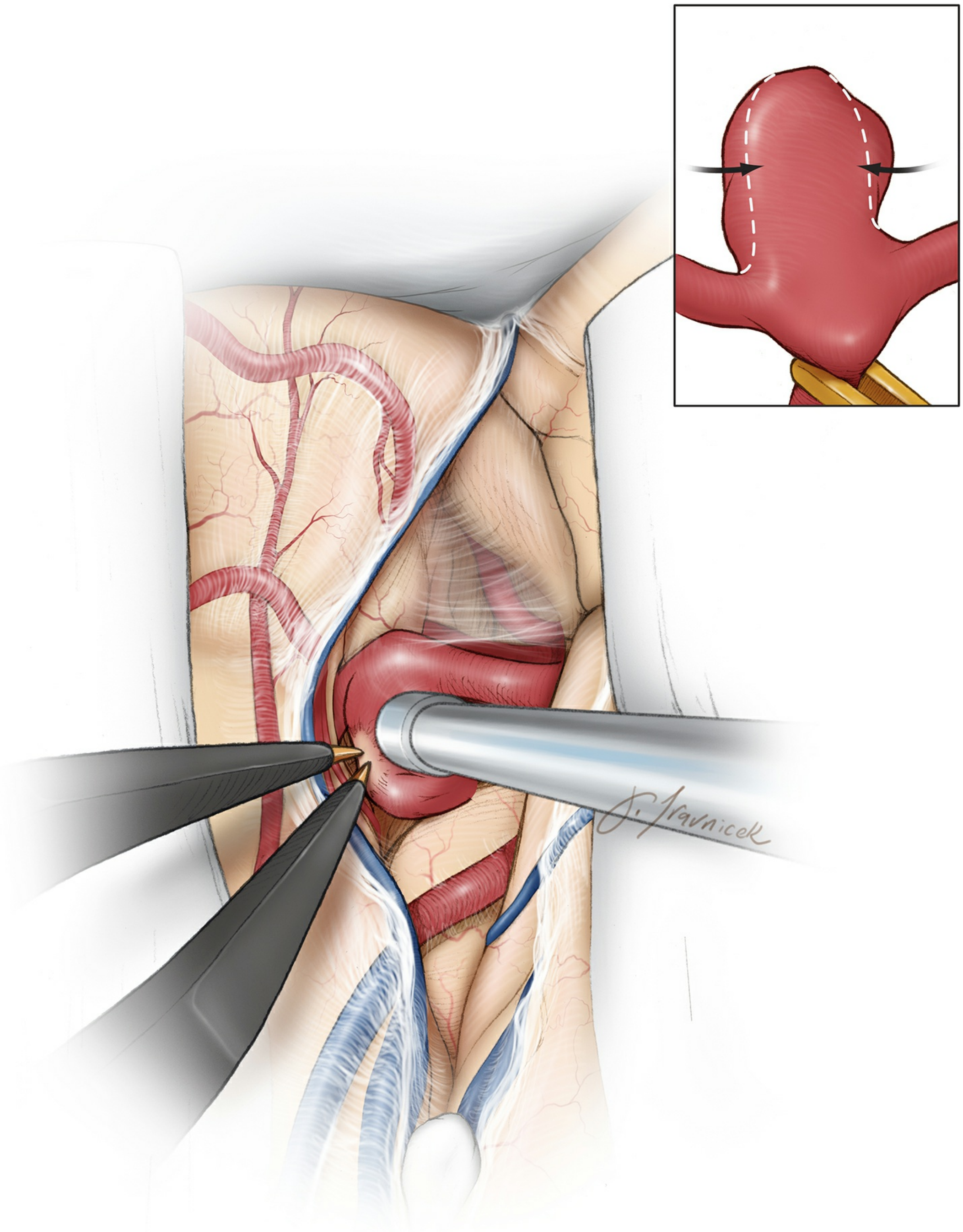


Figure 9: Upon application of the temporary clip, the hidden left temporal trunk is identified (near the tip of the bipolar forceps.) The origin of this branch should be dissected away from the neck; this can be challenging to do, but persistence pays off. Large aneurysm sacs can be shrunken via bipolar aneurysmorrhaphy (inset image,) but the neck should be left untouched. This maneuver gathers the sac and creates more ideal visualization angles around the neck for desirable clip

constructs.

The surgeon must be vigilant with the dissection, remain patient, and not proceed with premature permanent clip deployment until the lenticulostriate vessels, anterior temporal artery, and both M2s are completely dissected free and the local anatomy is thoroughly understood. It is easy to overlook one of the M2s, especially the temporal M2 which is often hidden behind the aneurysm under the temporal operculum.

Clip Ligation

The simplest clipping strategy, using a straight or curved clip, is often the best. Clipping should be performed under temporary proximal circulatory "low-flow" situations after complete dissection of the neck, proximal and distal vessels, and dome has been performed. I use the microdoppler flow probe prior to clipping to gauge the baseline flow for postclipping comparison.

The neck should usually be reconstructed along the plane of the M2 branches and perpendicular to the M1. If the dome has been well mobilized, it can be easily manipulated into a straight clip.

The length of the blade of a single occluding clip should be approximately 1.5 times the width of the base of the aneurysm. I may occasionally use a fixed retractor blade during the final clip application so that the suction device can be used to manipulate the aneurysm into the clip blades and complete a desirable clip construct. Usually one of the blades is initially inserted around the hidden portion of the neck; this portion of the neck should be thoroughly prepared before clip application.

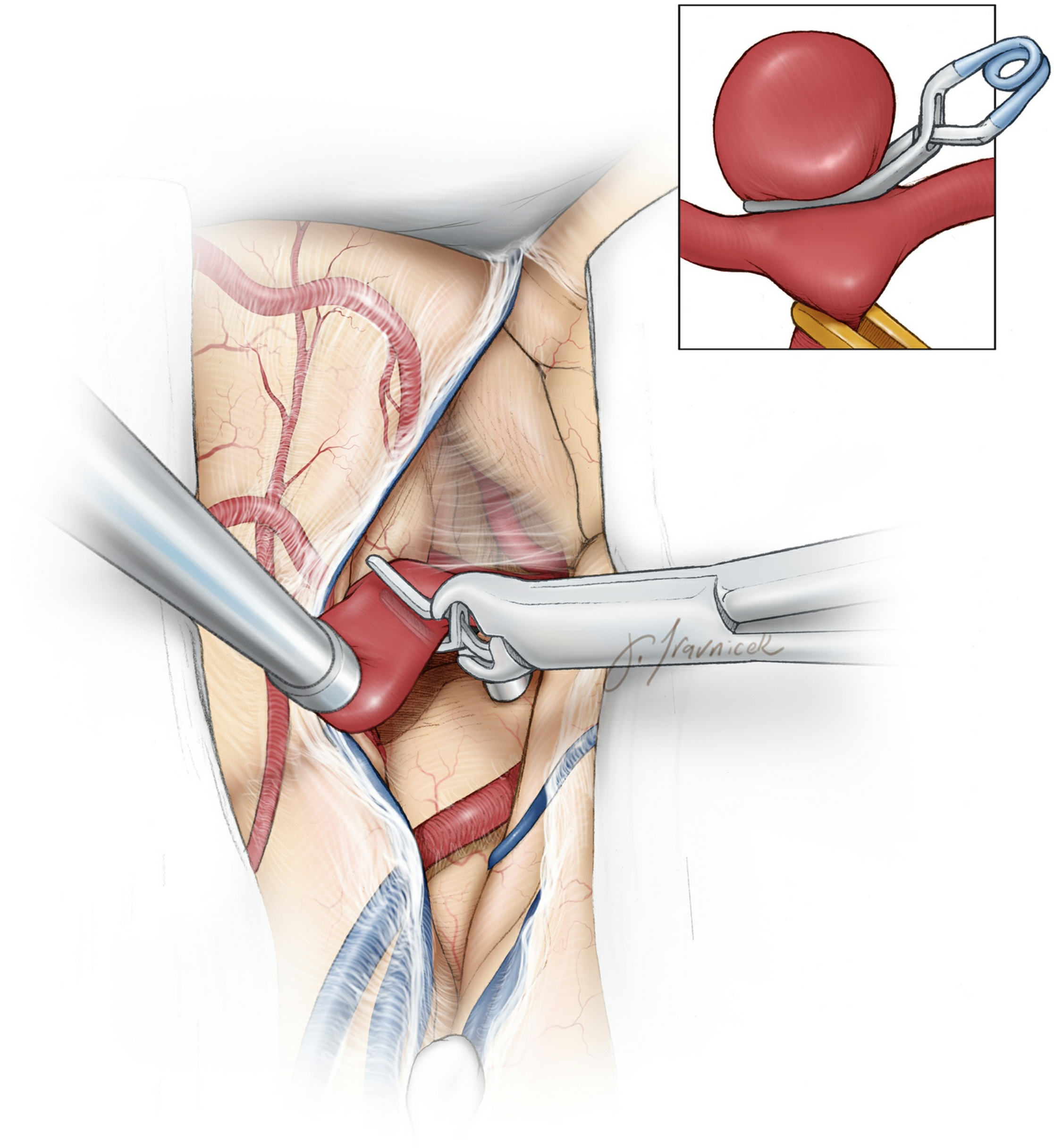


Figure 10: After clip application, the tips of the blades should be inspected to ensure the safety of all branching and perforating vessels. Care must be taken not to kink the frontal or temporal M2s. "Perfect" clip application is dangerous and often leads to stenosis of the M2 outlets. The

extra-aneurysmal inspection often underestimates the degree of luminal stenosis of proximal trunks because of the thickness of the neck wall and presence of atherosclerosis. In this illustration, you can see the generous atrium at the bifurcation.

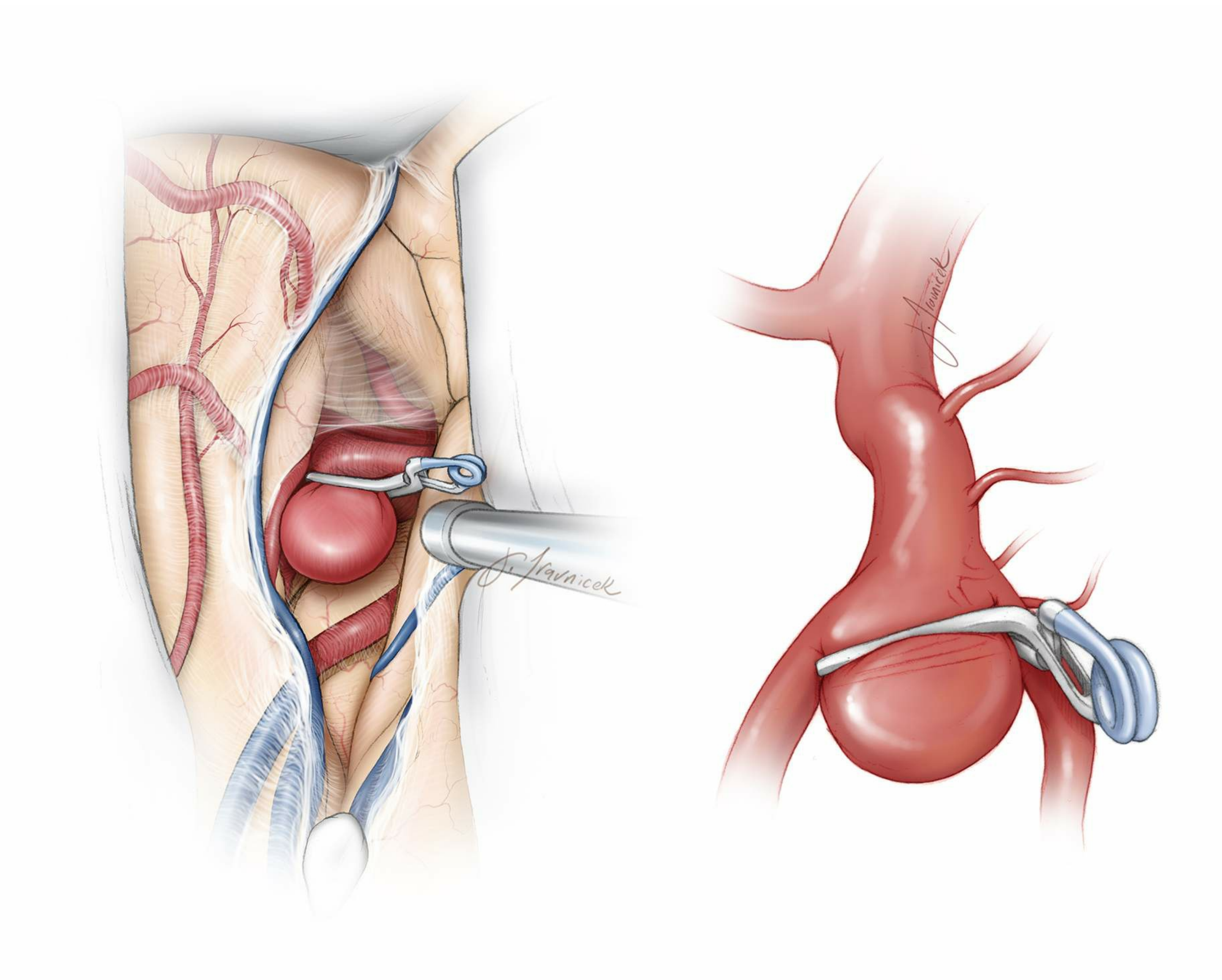


Figure 11: Postclipping flow should be assessed via microdoppler ultrasonography and indocyanine green/fluorescein angiography to document the patency of desired vessels and exclusion of the aneurysm. If there is any question of diminished or retrograde flow within the trunks, the clip should be repositioned. If fluorescence imaging confirms obliteration of the aneurysm, I routinely penetrate the dome to confirm the fluorescence findings. False

negative results are not uncommon, and are partially related to inadequate emission fluorescent signal compromised by the thick wall of the sac.

Premature aneurysm rupture before the availability of proximal control should not force the operator to indiscriminately clip the aneurysm and, potentially, one of the branching arteries. Control should first be established via a large bore suction device for localization and compression of the bleeding site using a small cottonoid patty. Hypotension is rarely helpful and increases the risk of ischemia. If uncontrollable torrential bleeding occurs, intravenous adenosine will induce a brief period (30–45 seconds) of cardiac arrest and allows dissection and inspection of the rupture point.

Next, the M1 is dissected efficiently, but not impatiently. I tolerate some retrograde bleeding to avoid distal ischemia through trapping the aneurysm. Aneurysm neck dissection is then also carried forth efficiently with placement of a tentative or pilot clip. If a small tear in the neck is found, a small piece of cotton between the neck and the clip will seal the defect at the neck while maintaining the patency of the parent vessel(s). Please see the chapter on Management of Intraoperative Rupture for relevant nuances of technique.

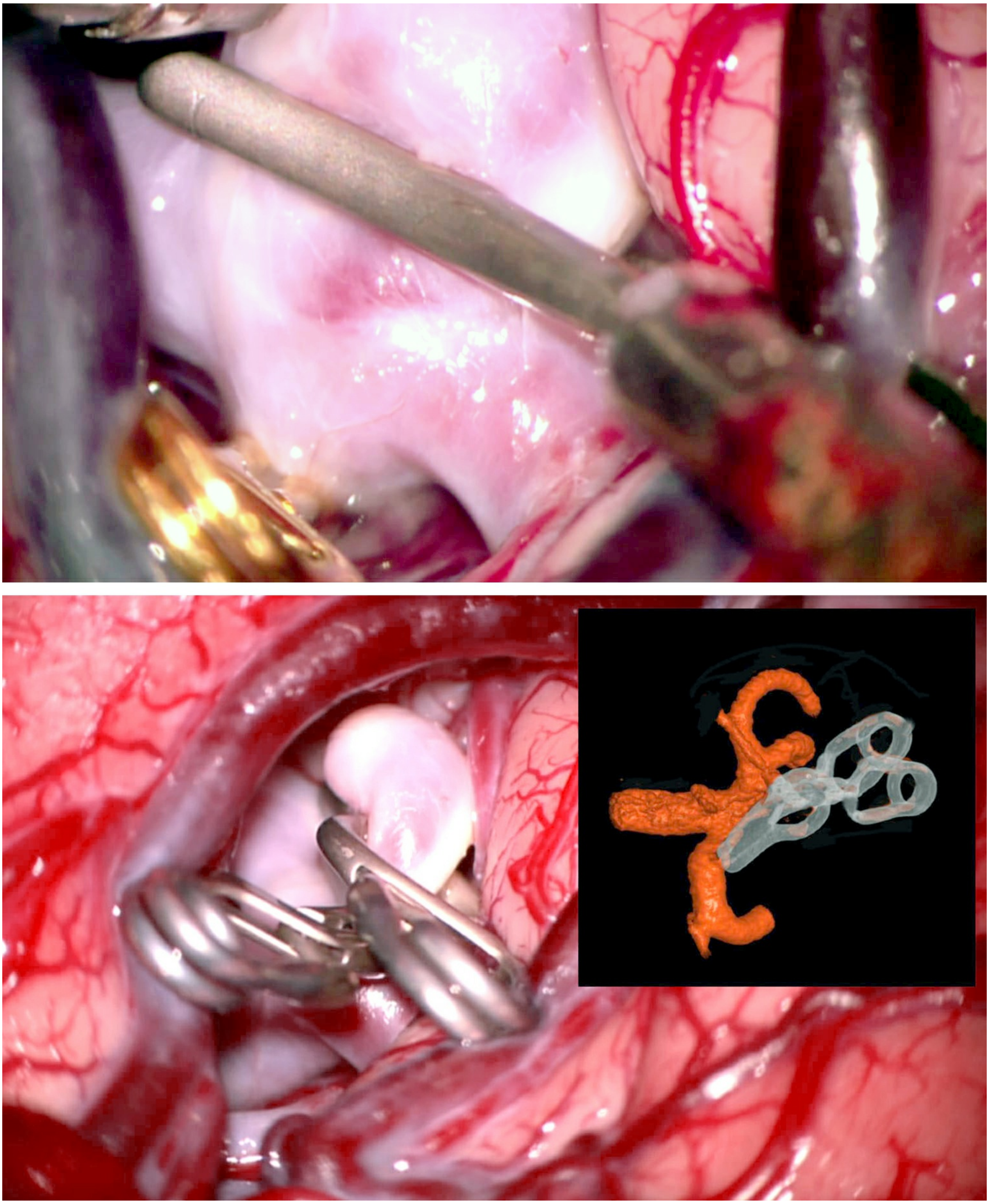


Figure 12: A typical broad-based MCA aneurysm was clipped using a curved clip parallel to the axis of the M2's. The second tandem fenestrated clip provides additional support for the closure of the distal neck.

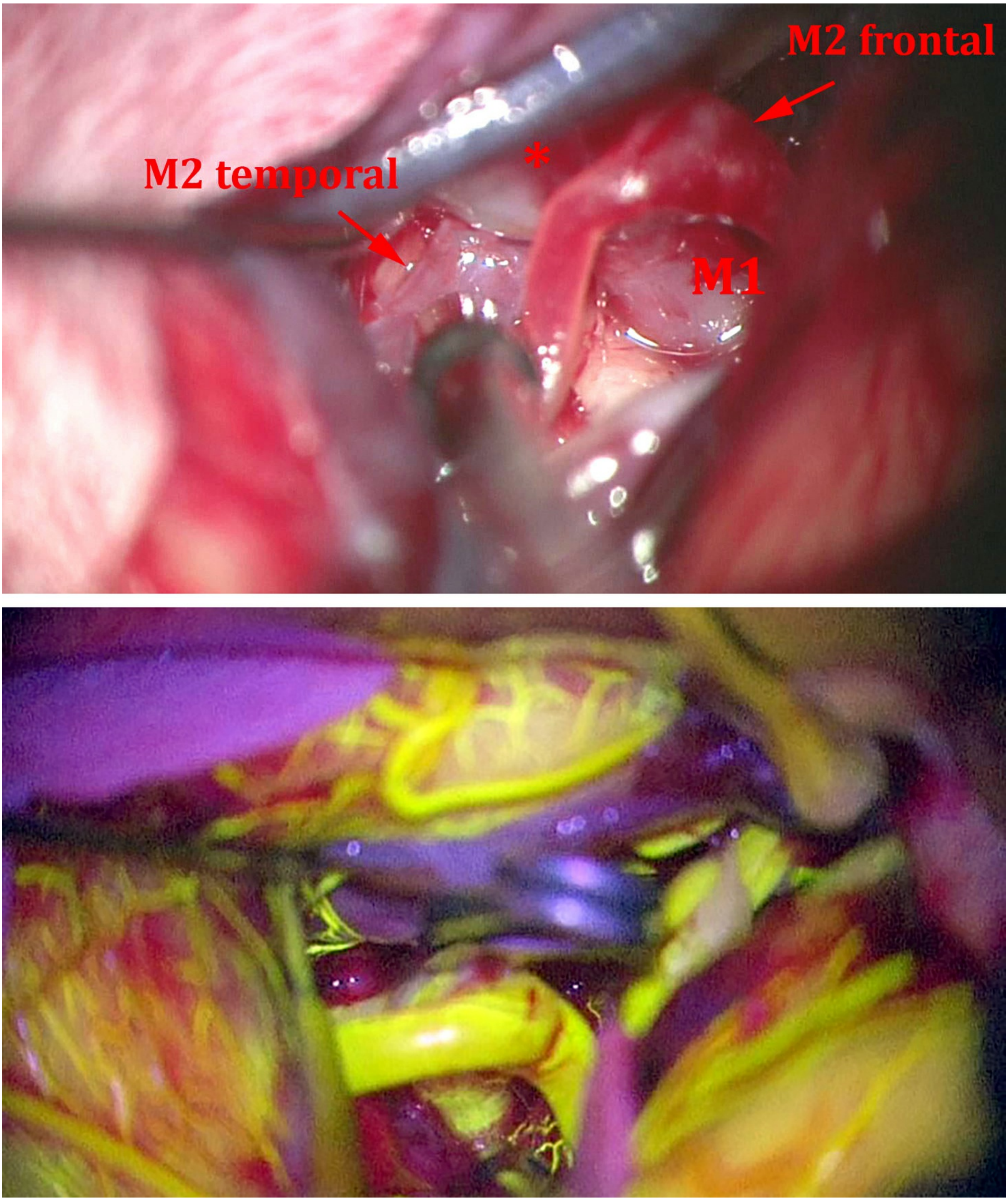


Figure 13: Note the hidden location of the left temporal M2 on the other side of the aneurysm away from the operator’s line of sight (upper image, aneurysm dome is marked with *). A straight clip preserved this branch and excluded the aneurysm (lower image).

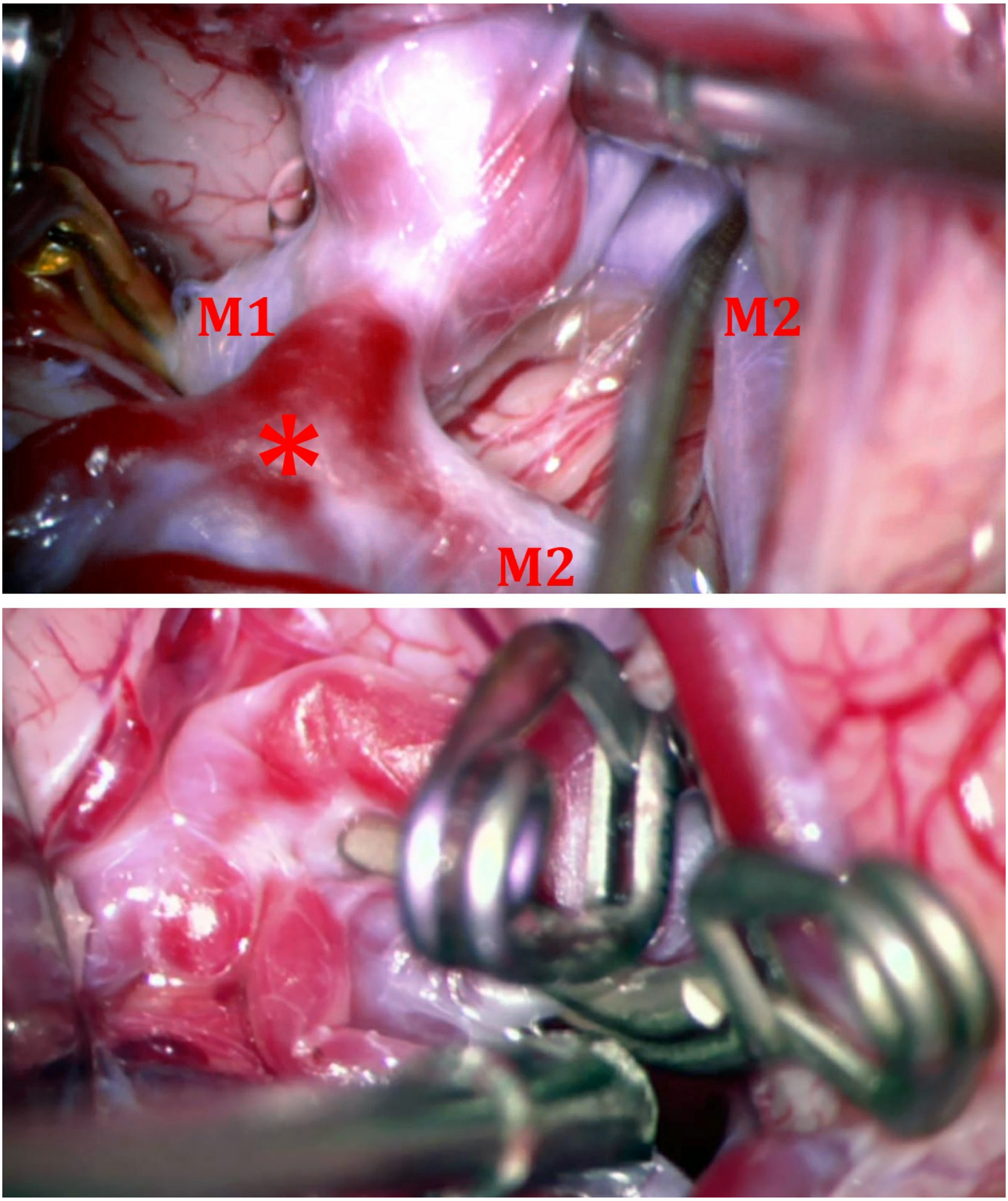


Figure 14: Note another vascular configuration at the right MCA bifurcation. The temporal M2 is covered by the sac. The early division of the frontal M2 (*) harbors a second aneurysm. This early M2 bifurcation can be mistaken for the M1 bifurcation. Two clips were used for obliteration of both aneurysms.

Variations in Neck Morphology

There are many variations affecting the morphology of the MCA aneurysms, and some variations are discussed below.

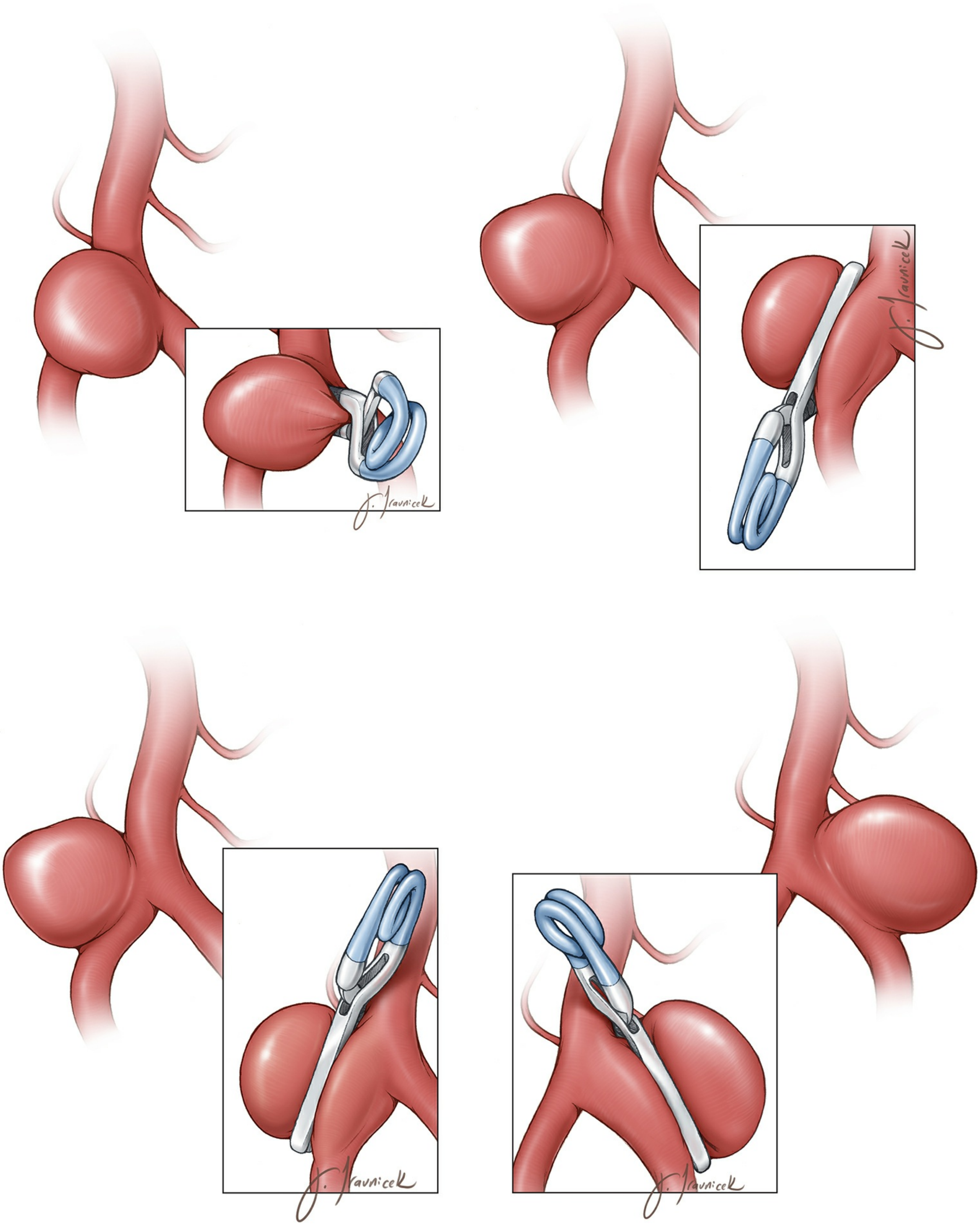


Figure 15: MCA bifurcation aneurysms are primarily clip ligated using a straight, curved or angled clips. Based on the exact location of the neck, different working angles are used

to apply the permanent clip.

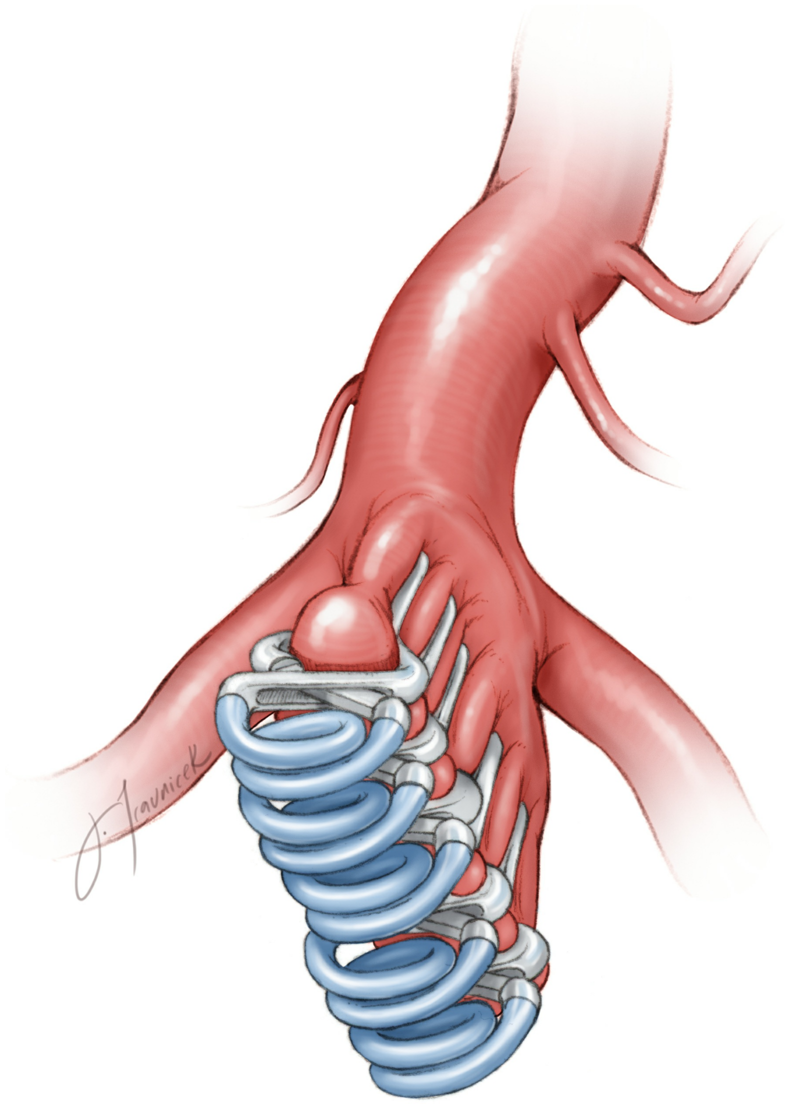


Figure 16: Dome tube vessel reconstruction technique with stacked fenestrated clips is illustrated. The clips are stacked from the middle of the aneurysm dome to its periphery; straight clips may be used at the periphery. Blood flow is unimpeded at the proximal neck of the aneurysm. Imperfect clipping is important to avoid even subtle flow changes that can lead to ischemia in distal MCA territories.

In patients with large or calcified aneurysms, a variety of clip constructs are described to adequately close the aneurysm neck while preserving the M2 branches and associated perforating vessels. Fenestrated clips may be used to preserve adherent perforating vessels that cannot be safely separated from the aneurysm dome.

If the neck is atherosclerotic and calcified, intra-aneurysmal calcium may prevent a clip from collapsing the neck completely, and bolster clips (over the primary clip), stacked clips, or a fenestrated clip (with higher distal closing pressure) may be needed. If calcium plaque is present at the proximal neck, its collapse can also occlude the parent or daughter vessels. In this situation, a fenestrated clip around the calcium closes the distal neck while a straight clip just above the first clip collapses the proximal neck. This tandem construct and other alternatives are discussed on the Permanent Clip Application chapter.

For large, wide-neck aneurysms, two straight or slightly curved clips may be used to close the neck, one parallel to each M2, but care must be taken to ensure that there is perfect clip apposition or slight overlap to ensure complete occlusion of the sac.

For large and giant aneurysms, if temporary clipping does not adequately soften the aneurysm and distal control is not available, the dome may be pierced with a small-gauge angiocatheter connected to suction tubing for suction decompression.

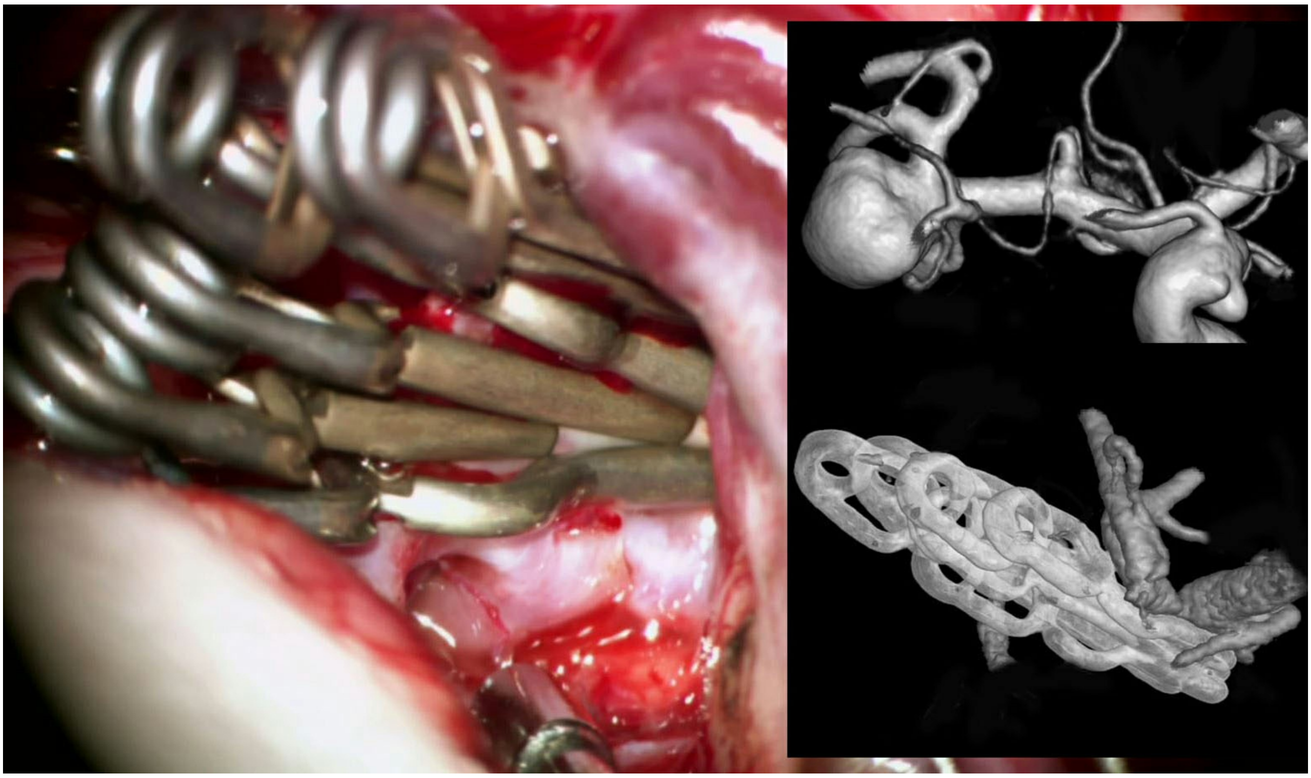


Figure 17: Large atherosclerotic aneurysms often require multiple clips for their exclusion as the calcium in the neck interferes with the closure of the initial clip blades.

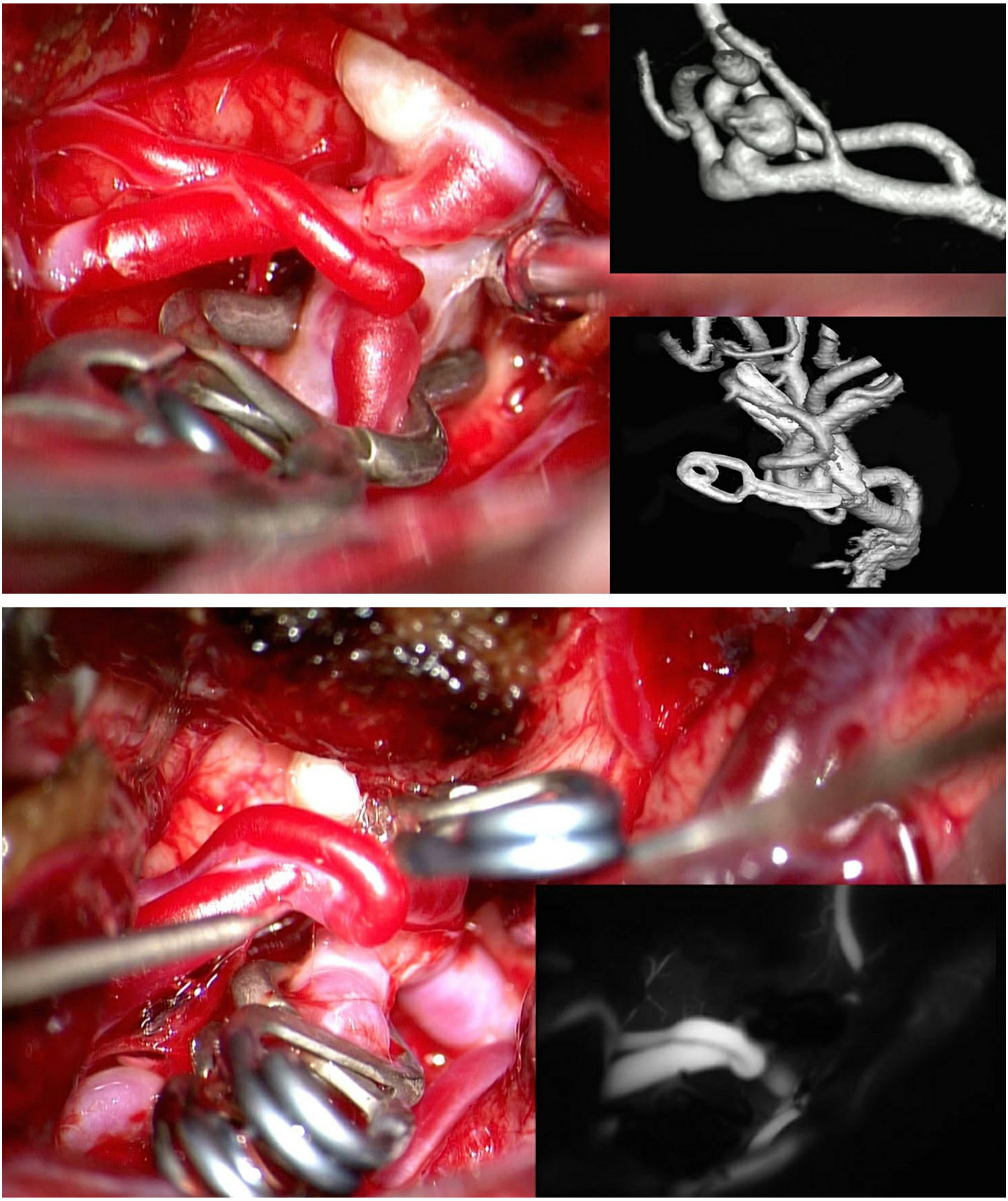


Figure 18: Dysplastic MCA aneurysms in young patients require creative clipping strategies.

Special Considerations for Non-Bifurcation MCA Aneurysms

MCA aneurysms, other than bifurcation aneurysms, demand location-specific considerations. M1 aneurysms are usually projecting superiorly if they are associated with a lenticulostriate branch. The dome may be buried within the anterior perforated substance; dissection requires isolation and protection of the surrounding lenticulostriate vessels.

A small straight clip is usually sufficient to occlude M1 aneurysms, but the surgeon must take great care to spare the associated perforating vessel often emerging from the aneurysm neck. Even M1 temporary clipping and stretching/deforming of these fine vital arteries may result in their dissection and occlusion.

Inferiorly and anteriorly-pointing aneurysms associated with the anterior temporal artery are more straightforward to expose, but they have a very broad base and often require bipolar aneurysmorrhaphy of the dome under M1 temporary clipping. This maneuver exposes the neck for complete clip exclusion of the aneurysm without neck remnant. A small curved clip is desirable.

Most distal MCA aneurysms (M3 and M4) are mycotic or traumatic. They are often dissecting and friable, and require trapping and excision, with or without revascularization, based on their location and the extent of collateral support. If infected, they may be initially treated with antibiotics, as these aneurysms may resolve without surgery.

Other MCA Aneurysms

With giant aneurysms, intra-aneurysmal debulking of the thrombus and aneurysmorrhaphy with tandem clip constructs may be required. Please refer to the Giant MCA Aneurysm chapter for further details.

Clip ligation of MCA aneurysms that cause an intraparenchymal hematoma requires a different strategy. Please refer to the MCA Aneurysm Associated with a Hematoma chapter for further details.

Pearls and Pitfalls

- A detailed understanding of Sylvian fissure anatomy and the patients' MCA angioarchitecture based on preoperative vascular imaging is critical to successful clip ligation.
- Inadvertent compromise of M2 branch origins is the most common cause of morbidity from microsurgery.

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