Anterior Communicating Artery Aneurysms. Surgical approaches Review

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Introduction

There are two main types of approaches for anterior communicating artery (AcomA) aneurysms, namely pterional approach and an interhemispheric approach. A pterional approach is the most common for aneurysm surgery, not only for anterior circulation aneurysms but also for basilar tip aneurysms. There are some variations for the interhemispheric approach including bifrontal, unifrontal, basal interhemispheric, and transcrista galli interfalcine approaches.

This article describes the pterional and transcrista galli interfalcine because the transcrista galli approach can provide easy access to the prechiasmatic cistern. If the space is too small for approaching the aneurysm, you can cut one side of the falx to enlarge the operative field as in an unilateral basal interhemispheric approach.

Preparation

Preoperative imaging is important for deciding the approach. Three dimensional computed tomography (3D-CT) is useful for these cases. In the acute stage of subarachnoid hemorrhage (SAH), determining how to remove the hematoma takes precedence, and clipping is the second step. Therefore an approach must be based on the location of the SAH and intracerebral hematoma (ICH). The approach that can cope with intra-operative difficulties should be selected. It must be minimally invasive if possible.

Surgical Approaches

Pterional approach

The pterional approach has the following advantage: the subarachnoid space is widely opened and the hematoma can be removed as much as possible in the acute stages of SAH; damage of the olfactory nerve is minimized and bilateral parent arteries of the proximal side can be secured in early stage of the procedure. As a disadvantage, the brain must be compressed, and partial resection of the gyrus rectus is often required in cases of high-positioned anterior cerebral artery (ACA) aneurysms.

Because this area is composed of five densely aggregated arteries, it can be difficult to visualize the aneurysm and blood vessel in case of high-positioned and postero-superiorly directed aneurysms. The pterional approach to aneurysms of the AcomA is described from these viewpoints in this chapter.

Determinants of the Approaching Side

The determining factors include A1 predominance, direction of A2 fork, the direction of the aneurysm, the size of the aneurysm, and multiplicity of the aneurysms. The presence of fenestrations of the AcomA is an important factor in determining the side of approach. In cases of acute SAH, determining factors include the distribution of SAH and ICH.

In case of small and large sized aneurysms directed anteriorly (Fig. 1), the A1 dominance should be the most important factor, because it is sometimes difficult to secure the opposite side of A1. But there is no marked difference in surgical difficulty between the right and left approaches.

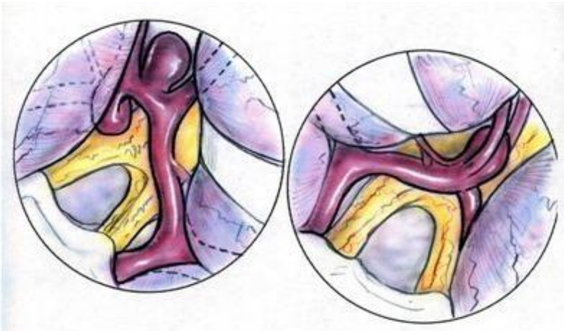

Figure 1 Aneurysm facing on inferiorly.
This type of aneurysm frequently adheres to or is embedded in the optic nerve. Premature rupture is most likely to occur during the retraction of the frontal lobe. Entry of the dominant A1 side is recommended.

In the case of aneurysms directed superiorly, the A1 is bilaterally secured before approaching the aneurysm. Therefore entry into the open part of the A2 (i.e. the side of A2 facing posteriorly) facilitates clipping (Fig. 2).

Figure 2 Aneurysm facing on superiorly.
(A): The entry into the closed side of the A2 fork makes the exposure of the neck difficult because the neck is behind the ipsilateral A2.
(B): On the other hand, entry into the open part of the A2 fork, (i.e the side of the A2 located posteriorly), makes clipping easier.

In cases of aneurysms directed postero-inferiorly and located at the back of the AcomA, entry through the side of the A2 located more anteriorly is recommended, as if the posterior surface of A2, especially in cases of fenestration of the AcomA (fig.3)

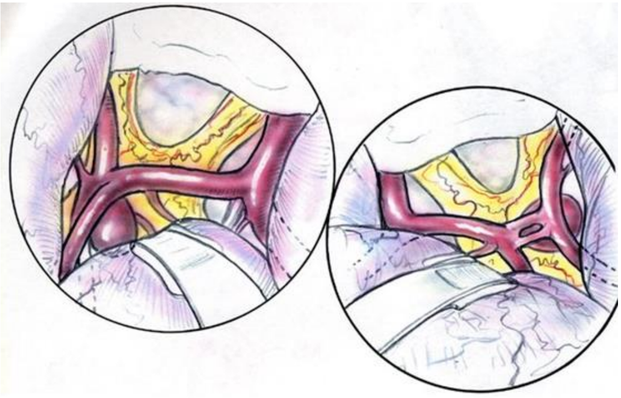

Figure 3 Aneurysm facing on posteriorly; combined with fenestration of the Acom. (A) In this case, the entry into the part on which the A2 faces anteriorly is recommended, because the mobility of the Acom is poor. With the entry into the contralateral part (2), the aneurysmal neck cannot be confirmed because of interruption with AcomA fenestration.

Giant aneurysm is, as a rule, treated by an approach from the direction in which early arrival at the aneurysm neck is accomplished. Approaching from the side of dominant A1 is generally recommended, but for such an aneurysm that projects anteriorly, the interhemispheric approach is recommended. Interhemispheric approach is also recommended in high positioned Acom aneurysm.

Positioning

The patient is placed in the supine position with the upper part of the body elevated to 20 degrees to control the venous pressure. The head is placed down about 0~10 degrees with the chin up and rotated to the contra lateral side of the craniotomy about 35 degrees on the right side and approximately 45 degrees on the left side (Figs. 4-A and -B).

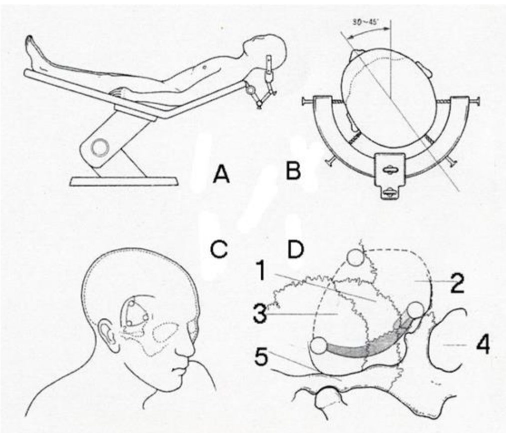

Figure 4 Procedure for craniotomy by the pterional approach. Craniotomy is performed, so that the temporal and frontal lobes will be included in the operative field in an almost symmetrical pattern of the lobes centring on the sylvian fissure.
(A)The upper body is elevated at 15 to 20 degrees so that the venous return will improve. (B) The patients head is turned at 30 to 45 degrees towards the unaffected side and fixed to the position.

(C) Skin incision and site of burr holes. One to two burr hole can be omitted and one burr hole craniotomy is enough.
(D) Basic craniotomy by the right pterional approach.
1. Sphenoid bone 2. Frontal bone 3. Temporal bone 4. Orbit 5. Zygomatic bone

Incision

A semi coronal incision is made along the hair line starting 5mm anterior to the tragus in the superior zygomatic margin to the medial of the forehead.
Because the facial nerve runs between the skin and galea, the skin is reflected over the muscle sheath to avoid injury to the facial nerve. Especially around the orbit it is not necessary to dissect the skin, but instead to dissect the attachment of the temporalis muscle 1 cm under the zygoma (fig 4-C)

Incision of the temporalis muscle

A pedicle bone flap is recommended to be prepared for the following reasons: 1) The side of head closure after craniotomy is cosmetically favorable with the pedicle flap and 2) the pedicle flap is more resistant to infection than the free flap. With regard to subcutaneous dissection, part of the temporal fascia particularly of the superior zygomatic margin near the orbit should be separated carefully because of the facial nerve. It should be noted that transient facial palsy may be caused by the heat of electric cauterization.

If a free flap is selected, the temporalis muscle must be separated with the skin. The pterion is adequately exposed by posterior eversion after separation of the temporalis muscle on the orbital margin (Fig. 4-D).

Craniotomy

Craniotomy should be performed, so that the temporal and frontal lobes will be included in the visual field in an almost symmetrical pattern centering on the sylvian fissure. Burr holes are opened at the following three points (Fig. 4-D, Fig 5): 1) a point near the orbit beneath the temporalis muscle on the superior orbital margin; 2) the deep side of the temporal bone near the posterior part of the zygoma and 30 beneath the temporalis muscle above the sylvian fissure. For cosmetic purposes a titanium miniplate is positioned before bone separation.
An airtome is used for bone separation and the burr holes are at points 1 and 2 may be omitted for cosmetic reasons.

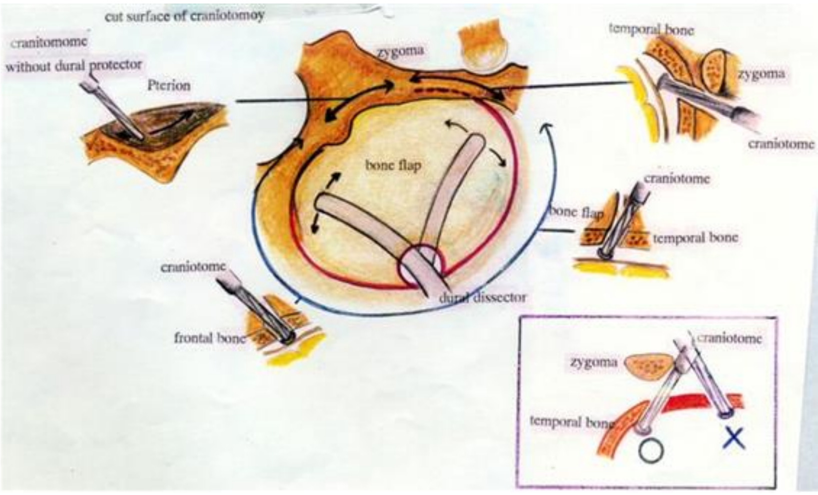

Figure 5 The craniotomy must be done in oblique direction, making the outer table of the bone lateral and the inner table medial. But the basal port of the temporal bone under the zygoma is used for craniotomy. However if the oblique direction is reversed, making the outer table medial and inner table lateral, then the craniotomy will not be convenient. For the pterion only grooving of the outer table is necessary to facilitate reflection of the bone by bone elevators.

On this occasion, it is important that the dura mater be adequately separated with a dural separator through the burr hole at point 3. The separation of the dura mater must be performed while the inner surface of the bone is touched with the tip of dural dissector. After bone flap separation, the bone flap is elevated and reflected. The pterion is eliminated with a Luer's rongeur and removed with an air drill especially the inner surface. Bleeding is controlled with bone wax. Dural bleeding is controlled by coagulation, tenting of the dura with gel foam (Johnson & Johnson, New Brunswick, NJ) and oxidized cellulose with fibrin glue.

Dissection of sylvian fissure

The sylvian fissure is, as a rule, separate from the side of the frontal lobe of the sylvian veins (Fig 6). Because of the number of small veins enter the medial side of the sylvian vein from the frontal lobe, the lateral side of the vein is spared as long as possible and particularly the thick walled large veins must be preserved. In cases where the vein must be cut, the venous circulation must be considered.

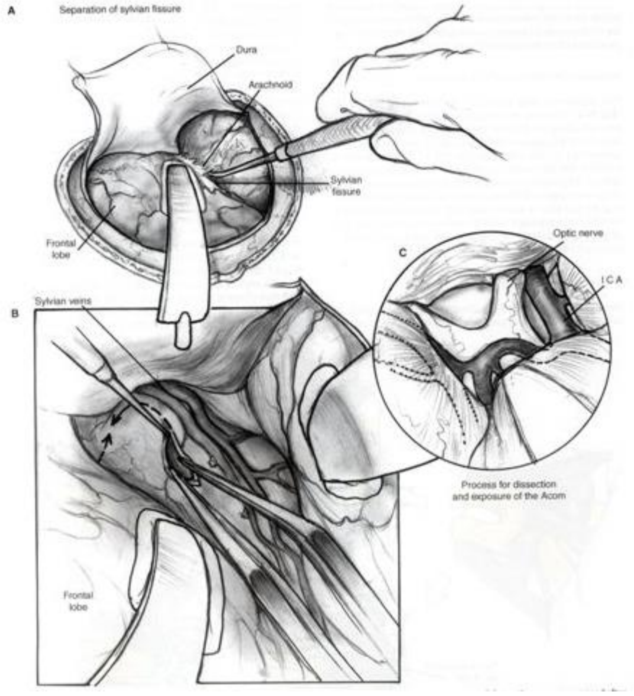

Figure 6 (A) Separation of the sylvian fissure. As a rule, the fissure is separated on the side of the frontal lobe of the sylvian veins. (B) Of the veins entering on the side of the frontal lobe, those of particular thickness should be preserved. (C) The process of dissection and exposure of AcomA. The internal carotid and the optic nerve are exposed after preparation of the sylvian fissure, then the anterior part of the optic chiasma is dissected. After the contralateral A1 is secured beyond the inferior surface of the AcomA, the AcomA is separated.

A micro knife (disposable tuberculin syringe with 21-23 gauge disposable injection needle) is used for the dissection of the arachnoid membrane of the sylvian fissure. For successful incision of the arachnoid membrane, the vein is protected with an aspirator in the surgeon's left hand, tension is added to the membrane, and the blade of the micro knife is pulled towards the surgeon, being used like a knife rather than a needle. On this occasion neurosurgical spatula should placed over the frontal lobe to give mild tension to the arachnoid membrane of the sylvian fissure.

The arachnoid membrane is dissected with a bipolar forceps or micro-scissors after it is incised with a micro-knife and the tight connective tissue is cut with scissors. After the entry into the sylvian fissure, the arachnoid membrane is separated and raised from inside of the sylvian fissure with an aspirator in the surgeon's left hand and the arachnoid membrane is incised sharply with scissors. The angle of the microscope and the position of spatula should be changed in order to facilitate the surgical procedure. Retrograde dissection of the sylvian fissure leads to the oculomotor nerve. Therefore the parachiasmatic cistern may be opened by way of dissection of the sylvian fissure and be connected to the sylvian fissure. A tight ligament exists in the boundary between frontal lobe and temporal lobe and also between the parachiasmatic cistern and the sylvian fissure as if it is connecting the frontal lobe with the temporal lobe. After the ligament is sharply dissected, the sylvian fissure is opened and the approach becomes possible by mild compression of the frontal lobe.

After the sylvian fissure is opened, the spatula is inserted to hold the frontal lobe, and gradually retracted toward the parachiasma. The internal carotid artery (C2) is secured, and then the arachnoid membrane is incised, so that the contra lateral optic nerve will be exposed. The parent artery (A1) is secured, and followed by the approach to the aneurysmal peduncle.

Approach to the aneurysm

The direction of the A1 is generally correlated with that of the aneurysm; in cases where the A1 takes an anterior bend in it's the posterior part, the aneurysm will be present on the extension line, (i.e., to face antero-inferiorly (Fig. 7). In cases where the A1 extends straight toward the poster superior part, the aneurysms will be present on the extension line (i.e., to face postero-superiorly) (Fig. 2). In case of the aneurysm facing on anteriorly or inferiorly, A1 is directed anteriorly and posteriorly (fig 1).

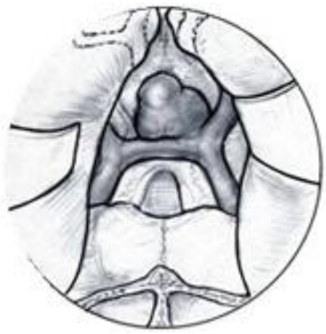

Figure 7 Tentative clipping method.
When complete exposure of the neck is impossible because of risk of aneurysmal rupture, tentative clips are placed at the dome or neck, sometimes including the arterial branches. After dome coagulation is performed for making the wall of the aneurysm thicker, the neck is adequately separated and clips are placed in the accurate site.

Many aneurysms may adhere to or be embedded in the optic nerve. Because this type of aneurysm is most likely to rupture prematurely during retraction of the fontal lobe, the surgeon should focus on gentle retraction so that the approach to the aneurysm neck can be accomplished using temporary clipping to ipsilateral A1 and the aneurysm. Even in case where the aneurysm adheres to the optic chiasma, the adhesions can be dissected after the tentative clipping on the aneurysm, and the contra lateral A1 patency can be confirmed. Permanent clipping should then be reapplied if necessary.

Aneurysms directed laterally or superiorly.

The aneurysm may exist on the extension line of the A1 (Fig 7). This type of aneurysm projects to contra lateral side along the Acom A. The aneurysm is observed parallel to A2; if an approach from the side on which the A2 faces anteriorly, (i.e., the side on which the A2 fork is closed), is selected, the aneurysm is covered by A2 and the contra lateral A1-A2 junction is concealed behind the aneurysm.

This situation makes it difficult not only to secure the contra lateral A1 but also to dissect and clip the aneurysm neck; therefore the approach should be selected from the open side of the A2 fork. Prior to clipping, the aneurismal neck is dissected between the A2 and AcomA.

Aneurysms directed posteriorly.

The approach to the posteriorly directed aneurysm must be selected to visualize the back side of the AcomA n which the aneurysm exists (fig 3). Usually it is the nondominant side of A1. After the A1 is secured at the bifurcation of the internal carotid artery, the anterior part of the optic chiasma is dissected, when the A1 is located in the high position, and the contra lateral A1 is easily secured beyond the anterior inferior surface of the AcomA. The gyrus rectus is sometimes partly aspirated and removed in the case of high positioned AcomA, and the distal A1 and proximal A2 are exposed. The proximal control site can also be secured, and the contra lateral A1 is confirmed. Subsequently the medial side of A2 on the approaching side of the aneurysm is approached. When the surrounding area of the aneurysm neck is dissected, the origin of the contra lateral A2 is exposed beyond the aneurysm.

Clipping

In this region five blood vessels must be confirmed before neck clipping of the aneurysm, namely, the bilateral A1 and A2 and the AcomA. In some cases it may be difficult to dissect the neck of the aneurysm completely. For such cases, a tentative clipping method is useful (Fig 7).

There are two types of tentative clipping methods: (1) dome clipping on the proximal side of the rupture point to prevent further rupturing, and (2) aneurysmal neck clipping, sometimes including arterial branches behind the aneurysm.

After tentative clipping the aneurysm can be dissected completely, and then the ruptured point is coagulated with or without trimming of the aneurysm. This makes the aneurysm small and accurate neck clipping becomes easy for dissection, bipolar forceps, silver dissector is useful. When the bipolar forceps is used as a dissector the tip must be placed accurately at the dissecting point; otherwise it causes bleeding.

In the acute stages of SAH, Jet irrigation is very useful. The surgeon can irrigate the blood clot to recognize blood vessels of the arachnoid membrane. Water itself raises the arachnoid membrane, so that the arachnoid membrane can be cut sharply, accurately and safely. The point of dissection is dissected using bipolar forceps or a dissector and the strong adhesion is cut with a micro scissors. The dissection is performed towards the direction of aneurysm and the space for the clip blade is secured without tension to the aneurysm. Exposure of the whole aneurysm is not necessary and is avoided. Before clipping, the area surrounding the aneurysm should be inspected for arterial branches and perforators. During clipping, the clip holder should be gradually inserted to allow visibility of the blade tip during opening and closing of the clip. The clip is placed parallel to the parent artery as a rule.

It should be kept in mind that the natural morphology of the parent artery should remain for avoiding stenosis and kinking. Intra-operative rupture most frequently occurs at the time of aneurismal preparation. Temporary or tentative clipping under the administration of cerebral protective drugs facilitates the surgical procedure.

The full circumference of A1 at the side of the temporary clip must be separated. Usually an average of eight perforating arteries branch from the posterior surface of A1.

Because disorders of the anterior hypothalamus cause emotional change, personality disorder and intellectual deficit, damage to it must be avoided. The absence of involvement of branch by clipping or neck residual must e confirmed by dome puncture and coagulation following neck clipping. Attention must be paid to the occlusion of the contra lateral A2 in the case of aneurysm facing supero-laterally and that of the contra lateral A1 in the case of aneurysm facing antero-inferiorly. Care must be taken to prevent occlusion of the perforating arteries arising from the AcomA, particularly the hypothalamic artery, in the case of an aneurysm facing posteriorly. In this situation trapping should be avoided as much as possible.

The recurrent artery of Heubner runs in the reverse direction along the A1 around the AcomA or from the origin of the A2. A large recurrent artery of Heubner may be confused with the A1. Care must also be taken to avoid confusing the fronto-orbital artery originating from the proximal side of the A2 with a recurrent artery because it also runs on the inferior surface of the frontal lobe.

Closure

The dura mater is sutured watertight; sometimes fibrin glue with an antibiotics may be sprayed for the purpose of preventing leakage of the cerebrospinal fluid.
A drain is kept extradurally and bone flap is fixed at several sites with titanium mini-plates which were marked during craniotomy. The temporalis muscle and the fascia are sutured from the pterion and the scalp is sutured in bilayered pattern.

Because the pterional approach is a common craniotomy procedure to the anterior circulation and to the tip of the basilar artery, surgeons should become experts in the procedure, so that these operations will proceed smoothly.

Interhemispheric approach

Another main approach for anterior communicating aneurysms is the interhemispheric approach. There are several kinds of interhemispheric approaches such as bifrontal interhemispheric, unifrontal interhemispheric, basal interhemispheric, transcrista galli interfalcine approach and so on.
Advantage of interhemispheric approach is midline approach so that bilateral A1 and A2 can be visualized equally and long enough. Disadvantage of this approach is the possibility of venous injury and a slight difficulty of dissecting the interhemispheric fissure.

Procedure

The patient is placed in the supine position. A coronal skin incision is made behind the hairline. The skin flap is reflected to expose the craniotomy site down to the nasion. The periorbital bone is detached bilaterally from the superior margin of the orbital rim. Two burr holes are made paramedian, situated 4 cm above the nasion. The dura is gently dissected using a dural dissector or 5 mm spatula. The dura in the basal portion is thin and requires careful dissection. A 4X4 cm craniotomy is performed in the centro-basal portion of the bone. The upper portion of the lateral side of the craniotomy is performed with a craniotome. The lower part of the craniotomy involving the frontal sinus is performed with a surgical saw. However only the outer table of the sinus is dissected and the inner table is fractured by elevation of the bone flap. Titanium miniplates required for closure are placed at this time.

The mucous membrane of the frontal sinus is completely dissected. It is trimmed and pushed into the fronto-nasal duct. The frontal air sinus region is subsequently sterilized with betadine and packed with bone dust and fibrin glue several times. The crista galli and the inner table of the frontal sinus are removed with rongeurs, a bone punch, and an air drill (fig 8).

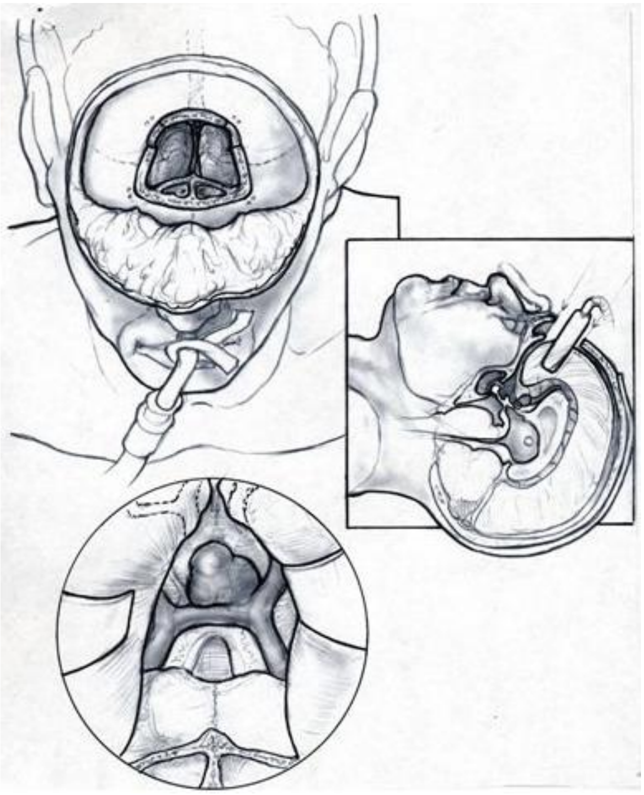

Figure 8 Craniotomy of transcrista galli interfalcine approach. After coronal skin incision, two burr holes are made paramedian at 4cm above the nasion. A 4 X 4 cm craniotomy is performed after dural dissection. Complete removal of the inner table of the frontal sinus and packing of the frontal nasal duct with bonedust and fibrin glue are most important to prevent cerebrospinal leakage.

The basal portion of the falx which is visible after the removal of the crista galli is split into two leaves with a back side of knife. Venous bleeding from the superior saggital sinus is controlled by packing with oxidized cellulose and fibrin glue. Both olfactory nerves and bridging veins that lead into the saggital sinus are protected by the split basal leaves of the falx.

After basal interhemispheric fissure is opened, the optic chiasma and the AcomA are visible. The method of neck clipping and head closure are the same as for the pterional approach.

An important key point of skull base approach is the repair of the frontal sinus. The complications associated with this are CSF leakage, pneumocele, and infection.

Usually the frontal sinus is repaired with the temporalis fascia, fascia lata or a packing of fat tissue. We recommend the defect to be covered with bone; pack the frontal sinus with bone dust and fibrin glue mixed with antibiotics. This packing procedure is performed three times. We have performed this procedure several times to close frontal sinus defect and have successfully prevented CSF leakage.

References

1) Fujitsu K, Anterior communicating aneurysm--Pteted using dural dissector or 5mm spatula. The dura in the basal portion is thin and required careful dissection. 4 x 4 cm craniotomy is performed in the centrobasal portion of the bone. The upper portion and the lateral side of the craniotomy are performekino T, Sakata K, et al (1994) Basal interfalcine approach through a frontal sinusotomy with vein and nerve preservation. J Neurosurg 80: 575-579
2) Fukumitsu T: Chapter 9. The points of aneurysm operation according to sites. In: E. Anterior communicati In: E. Anterior communicating aneurysm. Cerebral aneurysm. (ed by Fukumitsu T), p. 110-122, Bunko-do, Tokyo, 1987.
3) Hashimoto N, Kikuchi H: Anterior communicating aneurysm. In: Treatment of cerebral aneurysms (ed by Takakura K). p. 139-150, Gendai Iryo-sha, Tokyo, 1990.
4) Kato Y, Sano H, Katada K, Ogura Y, Shu Z, Kanaoka N, Kanno T: The usefulness of helical scanning CT (HES-CT), particularly 3-dimensional (3-D) CT endoscopy, for the decision of aneurysm treatment. No Shinkei Geka (Neurological Surpproach has the following advantages (3, 5, 3, 6, 7, 10, 11):
5) Kikuchi H: Anterior communicating aneurysm--Pterional approach. In: Microsurgery in neurosurgery (ed by Kikuchi H), p. 13-20, Igaku Shoin, Tokyo, 1988.
6) Saito I: Anterior communicating aneurysm. In: Operation for neurosurgical diseases and the indication. Part II. (ed by Abe H), p.8-22, Asakura Shoten, Tokyo, 1990.
7) Sano H, Kanno T, Ishiyama N, Kato Y, Adachi K, Shinomiya Y: The points of operation for acute ruptured cerebral aneurysms. Collected Lectures of the 12th Meeting of Stroke Surgery. Cerebral aneurysms--Various intraoperative problems. p. 237-241, 1983.
8) Sano H: Middle cerebral aneurysm. In: Operation for neurosurgical diseases and the indication. Part II. (ed by Abe H), p. 56-83, Asakura Shoten, Tokyo, 1990.
9) Sano H, Kato Y, Zhou J, Watanabe S, Okuma I, Hayakawa M, Kanno T: New jet irrigation bipolar system. Neurosurgery 38: 1251-1253, 1996.
10) Sano H, Kato Y, Hayakawa MM, Akashi K, Kanno T: A transcrista galli, translamin terminalis approach for highly placed basilar bifurcation aneurysms. Acta Neurochirurgica, 139:1020-1025, 1997.
11) Yasagil MG: Microneurosurgery. II: Clinical considerations, Surgery of the Intracranial Aneurysms and results. Georg Thime Verlag,