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Original Article

A modified anterior temporal approach for low-position aneurysms of the upper basilar complex

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Abstract

Background: Although surgery for aneurysms of the upper basilar complex is generally accomplished by a pterional or subtemporal approach, both techniques have disadvantages. Therefore, attempts have been made to combine both the approaches, such as an anterior temporal approach, which exposes the anterior aspect of the temporal lobe during standard fronto-temporal craniotomy. However, in all these techniques, the temporal vein is sacrificed to allow posterior retraction of the temporal lobe, which may cause venous infarction in the temporal lobe.

Methods: Our institutional review board approved this prospective study. We modified the anterior temporal approach for low-position aneurysms of the upper basilar complex by performing posterior clinoidectomy as necessary, thereby preventing the sacrifice of all vessels.

Results: From 2007 to 2014, seven patients were operated on using this modified approach, and four patients underwent additional posterior clinoidectomy. Complete clip ligation was performed for all aneurysms without sacrificing any vessels, and there were no permanent complications attributable to manipulation for clipping or posterior clinoidectomy.

Conclusions: The modified anterior temporal approach allows a wider operating field within the retro-carotid space, without sacrificing any vessels, and permits safer posterior clinoidectomy and aneurysm clipping in patients with low-position aneurysms of the basilar complex.

Key Words: Anterior temporal approach, basilar artery, posterior clinoidectomy, surgery

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INTRODUCTION

Despite several technical advances, surgery of the upper basilar complex remains a formidable challenge.[14] Moreover, endovascular techniques have some disadvantages, such as the need for coil replacement for wide-neck aneurysms[4,17] or coil compaction after surgery.[9] Therefore, a safer and more secure procedure is required for aneurysms of the upper basilar complex. Although surgical access to the upper basilar complex has generally been accomplished with pterional[19] or subtemporal approach,[8] both the techniques have some disadvantages. The pterional method requires confirmation of the structures dorsal to the upper basilar aneurysm, whereas the subtemporal approach can result in retraction of the temporal lobe. Therefore, various modified approaches, such as the pretemporal or combined pterional/anterior temporal approach that allow both pterional and subtemporal views, have been recently described.[3,10,13] However, most techniques require sacrifice of draining veins from the temporal tip to the cavernous and sphenoparietal sinus,[3,10] which may cause venous infarction in the temporal lobe.[2] Thus, we have modified the anterior temporal approach to enable us to secure a wider operation field in the retro-carotid space without sacrificing any vessels. The wide retro-carotid space also allows a safer posterior clinoidectomy and complete clipping of low-position aneurysms of the upper basilar complex.

METHODS

This study and the prospective database were approved by the Abashiri Neurosurgical Rehabilitation Hospital institutional review board. The height of aneurysms was evaluated by the clinoid line that links the apices of the anterior and posterior clinoid process. The low-position aneurysms of the upper basilar complex were defined as those with necks that follow as located below the clinoid line. This study excluded the cases of combined mastoidectomy or petrosectomy because we aimed to evaluate the modified anterior temporal approach compared with pterional and subtemporal approaches to standard upper basilar complex aneurysms. Adverse events were evaluated according to postoperative complications, three-dimensional computed tomography angiography (3D-CTA) and magnetic resonance imaging (MRI).

Operative technique

Position, skin incision, and muscle dissection

The patients were placed in the supine position with the head rotated approximately 30°. Further head rotation resulted in projection of the temporal lobe beyond the Sylvian fissure impeding posterior retraction of the temporal lobe.

The skin incision in this approach was slightly modified from that of the standard pterional technique. The incision was slightly extended posteriorly to widely expose the temporal region [Figure 1a]. The skin flap was elevated along with the superficial temporal fascia and superficial fat pad to preserve the zygomatic branches of the facial nerve until exposure of the posterior rim of the zygomatic process of the frontal bone.[20]

The periosteum was cut along the linea temporalis from the posterior rim of the zygomatic process of the frontal bone to the edge of the skin incision and the temporal muscle was reflected posteriorly and inferiorly without injuring muscle fibers [Figure 1b]. This enabled a wider exposure of the temporal region and reduced postoperative temporal muscle atrophy to a minimum.

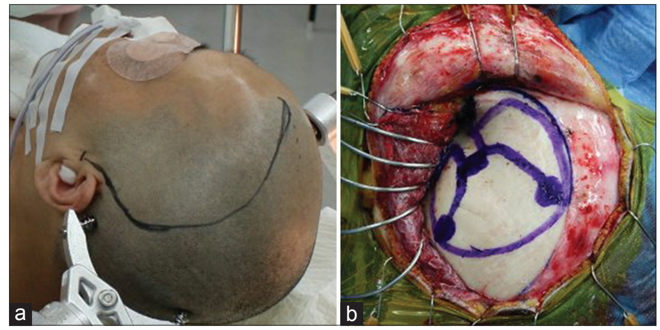

Figure 1: Left side skin incision and craniotomy. (a) The skin incision extended slightly posteriorly compared with the standard pterional skin incision. (b) The craniotomy extended posteriorly and inferiorly in the temporal region; three inside burr holes were made

Bone and dural opening

During craniotomy, surgeons must be aware of the maximal posterior and inferior extension in the temporal region to prevent postoperative cosmetic problems. Three burr holes were created inside the craniotomy line: On the pterion, on the coronal suture, and on the squamous suture [Figure 1b]. These inner burr holes were completely plugged with artificial bone during cranioplasty to prevent leaving gaps. Moreover, the frontal craniotomy line followed the linea temporalis because extension toward the forehead was not required, and a gap was not left after surgery. After cutting the bone flap, the anteroinferior portion of the temporal squama down to the floor of the temporal fossa was removed, followed by drilling of the lesser wing of the sphenoid and orbital roof until a flat surface was achieved and a straight trajectory to the proximal carotid could be visualized along the cranial base.

The dura was then opened, and the surface of the frontal and temporal lobes was exposed.

Dissection of the superficial sylvian vein

As sufficient mobility of the temporal lobe is necessary for its posterior retraction, some temporal veins must be sacrificed.[3,10] However, the sacrifice of temporal veins was not necessary in all of our cases. To preserve temporal veins, dissecting sufficient amount of the superficial Sylvian vein from the temporal lobe, particularly around the temporal tip, is important. Therefore, the superficial Sylvian vein was dissected from the temporal lobe without sacrificing all inflow vessels, such as cortical surface veins from the temporal lobe [Figure 2a], the insular vein [Figure 2b], or the common vertical trunk from basal veins [Figure 2c] and outflow vessels. After the presence of veins was confirmed, surgeons carefully dissected the point where blood flows into the superficial

Sylvian vein and drains into the sinus and peeled off the arachnoid membrane or skull base dura [Figure 3]. The high mobility of the superficial Sylvian vein obtained by these techniques also enabled safe posterior retraction of the temporal lobe without sacrificing any veins. However, standardization to the extent at which the superficial Sylvian vein should be dissected from the temporal tip considering the varieties of superficial Sylvian veins is impossible. Therefore, surgeons must perform the surgery with flexibility.

Dissection of arteries and oculomotor nerve

After dissection of the superficial Sylvian vein, the Sylvian fissure was opened to expose the insular segment of the middle cerebral artery (M2) up to its main bifurcation. The posterior trunk of the M2 and early temporal branch were then identified and dissected from the surface of the temporal lobe. After both the Sylvian vallecula and carotid cistern were opened, a spatula was inserted between the dissected vessels and temporal lobe, followed by posterior retraction of the temporal lobe to expose the temporal uncus. The uncus was gradually retracted posteriorly after dissection of the arachnoid membrane between the uncus and internal carotid artery (ICA), and the crural segment of the posterior cerebral artery in the interpeduncular cistern over the presence of anterior choroidal artery was confirmed. After posterior retraction of the uncus until exposure of the oculomotor nerve, veins were further dissected if necessary to prevent damage by excessive force during temporal retraction. The superior cerebellar artery (SCA) was exposed after the Liliequist's membrane present over the lateral of the oculomotor nerve, and the presence of basilar artery (BA) and interpeduncular segment of the posterior cerebral artery (P1) was confirmed using the membrane present over the medial of the oculomotor nerve. The wide operative field of the retro-carotid space was thus obtained without sacrificing any vessels and provided a surgical viewpoint comparable to that observed midway between the pterional and subtemporal approach [Figure 4].

Opening of the porus oculomotorius and posterior clinoidectomy

Although most of the upper basilar complex was sufficiently exposed by uncovering the retrocrotid space and could be clipped in case of aneurysm, there were some cases in which proximal control spaces were insufficient for clipping of low-position aneurysms of the upper basilar complex. In such cases, it was necessary to open the porus oculomotorius and perform posterior clinoidectomy. Opening of the porus oculomotorius should be performed before posterior clinoidectomy because it results in more mobility of the oculomotor nerve and wide exposure of the posterior clinoid process. The porus oculomotorius is reported to have an ellipsoid shape with a maximum diameter of 4.9 ± 1.1 mm, which is larger than the oculomotor nerve.[18] Therefore, it is possible to open the foramen to approximately 4 mm from the entry point without opening the cavernous sinus. Next, the tentorium cerebelli was everted at the apex of the anterior clinoid process as a fulcrum to expose even more of the posterior clinoid process. Then, a straight dural incision was made near the top of the posterior clinoid process after coagulation using bipolar electrocoagulation along the line of the anticipated dural incision. The dura was detached from the posterior clinoid process using a microdissector exposing the posterior clinoid process. The posterior clinoid process was resected using an ultrasonic surgical aspirator until the BA for proximal control was exposed. Normally, it is possible to control venous bleeding from the posterior intercavernous sinus by packing with absorbable hemostats.

Clipping

The wide lateral operative field in the retro-carotid space that were acquired by the described procedures allowed

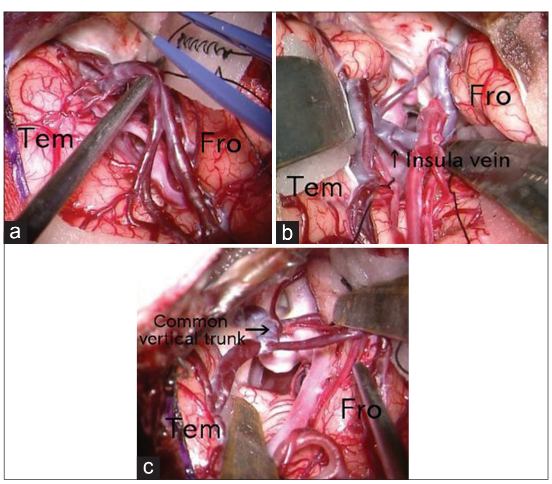

Figure 2: The same procedures of inflow veins for superficial Sylvian vein. (a) The cortical vein from the temporal lobe was identified and dissected to obtain temporal lobe mobility. Fro, frontal lobe; Tem, temporal lobe (b) The insular vein was identified and dissected to obtain temporal lobe mobility. Fro, frontal lobe; Tem, temporal lobe. (c) The common vertical trunk from the first segment of the basal vein (c) was identified and dissected to obtain temporal lobe mobility. Fro, frontal lobe; Tem, temporal lobe

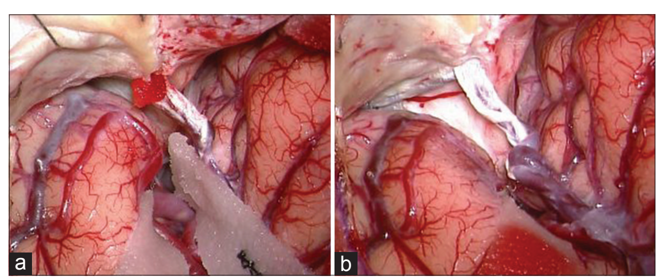

Figure 3: The procedure of outflow vein for superficial Sylvian vein. (a) Predissection of the drainage point from the superficial Sylvian vein into the sinus. (b) Post-dissection of the drainage point from the superficial Sylvian vein into the sinus. This procedure produces more mobility of the temporal lobe

us to observe the upper basilar complex, including not only the contralateral P1 and SCA but also the posterior thalamoperforating branches. Safe and secure clipping of low-position aneurysm of the upper basilar complex were performed under proximal control.

Closure

When posterior clinoidectomy was performed, it was necessary to repair the dura. The incised edge of the dura at the posterior clinoid process was attached and sealed with fibrin glue sealants. Moreover, excessive resection of the posterior clinoid process resulted in the opening of the sphenoid sinus. In these instances, packing of abdominal fat and sealing with fibrin glue sealants were necessary to prevent leakage of cerebrospinal fluid.

RESULTS

From 2007 to 2014, 38 patients with unruptured basilar complex aneurysms underwent surgery using the modified anterior temporal approach in our institute. In seven patients (four males and three females), the necks of aneurysms were located in the low-position [Table 1]. All patients received the modified anterior temporal approach, and four aneurysms were exposed by opening the porus oculomotorius and by posterior clinoidectomy. Clip ligation was performed under proximal control without sacrificing any vessels. Although three patients suffered oculomotor nerve palsy after the surgery, the palsy resolved within 6 months in all the cases. One patient presented asymptomatic cerebral infarction near the central artery due to excessive retraction of the ICA. There were no permanent complications attributable to the surgical approach, manipulation for clipping, or posterior clinoidectomy. All patients underwent postoperative 3D-CTA documenting complete occlusion of their aneurysms.

Illustrative case

A 68-year-old female was diagnosed with a BA bifurcation aneurysm. The aneurysm size was 5.6 mm and located 5.5 mm below the clinoid line [Figure 5a and b]. The patient underwent surgery using the right modified anterior temporal approach with opened porus oculomotorius and posterior clinoidectomy [Figure 6a-c]; the aneurysm was ligated using three clips under proximal control without sacrificing any vessels [Figure 6d]. The incised edge of the dura at the posterior clinoid process was reattached and sealed with fibrin glue sealants after clipping [Figure 6e]. Postoperative 3D-CTA showed disappearance of the aneurysm [Figure 5c], and MRI showed no abnormal lesions, such as cerebral infarction or contusion. The patient made an excellent postoperative recovery and was discharged from our hospital without any complications.

DISCUSSION

Here we report successful and safe clipping of cerebral aneurysms that were accomplished under better visualization owing to the wide operative field obtained using a modified anterior temporal approach. This operative view of the upper basilar complex included not only the contralateral P1 and SCA but also the posterior thalamoperforating branches.

The ultimate goal of the anterior temporal approach is to provide better access to the retro-carotid space during posterior retraction of the uncus. However, a requisite for posterior retraction of the temporal lobe is sacrifice of

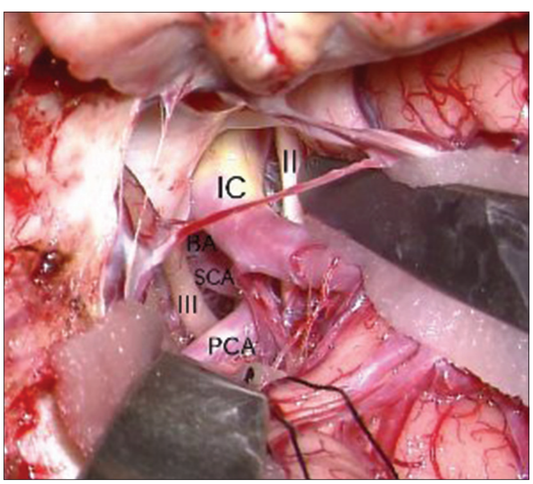

Figure 4: Final view of tissues exposed according to the left modified anterior temporal approach. A wider operative field was created in the left retro-carotid space without sacrificing any vessels. II: Optic nerve; IC: Internal carotid artery; BA: Basilar artery; SCA, superior cerebellar artery; PCA: Posterior cerebral artery; III: Oculomotor nerve

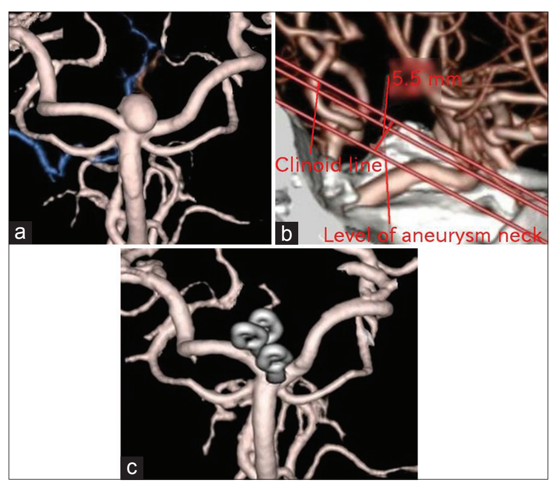

Figure 5: The pre- and postthree-dimensional computed tomography angiography (3D-CTA) of Case 3. (a) Preoperative 3D-CTA demonstrated a saccular aneurysm at the basilar bifurcation. (b) The aneurysm was located 5.5 mm below the clinoid line. (c) Postoperative 3D-CTA showed disappearance of the aneurysm. PCA, posterior cerebral artery

Table 1: Summary of the clinical data of seven patients who underwent surgery using the modified anterior temporal approach

Patient	Age (years)/ Sex	Aneurysm			Additional techniques	Adverse event
		Location	Size	Height from the clinoid line		
1	46/Male	Right BA-SCA	6.6 mm	-4 mm	PO & PC	Transit III palsy
2	52/Male	BA bifurcation	3 mm	-5 mm	PO & PC	-
3	68/Female	BA bifurcation	5.6 mm	-5.5 mm	PO & PC	-
4	32/Female	BA bifurcation	8 mm	-8 mm	PO & PC	Transit III palsy
5	58/Male	Right BA-SCA	3 mm	-3 mm	-	Transit III palsy
6	57/Male	BA bifurcation	11 mm	-0.5 mm	P-comA	Asymptomatic CI
7	63/Female	Right BA-SCA	3 mm	-1 mm	-	-

BA: Basilar artery, SCA: Superior cerebellar artery, PO: Opened of porus oculomotorius, PC: Posterior clinoidectomy, P-comA: Cut of posterior communicating artery, III: Oculomotor nerve; CI: Cerebral infarction

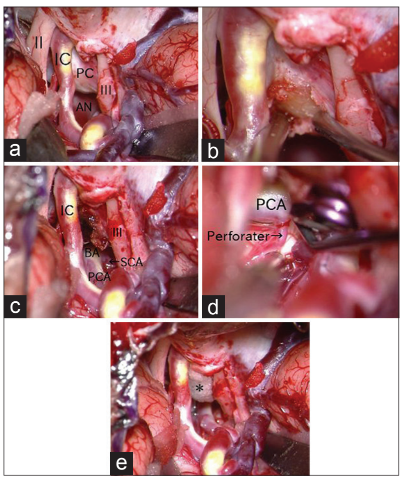

Figure 6: Intraoperative photographs obtained during a right modified anterior temporal approach in Case 3. (a) The tentorium cerebelli was everted after opening of the porus oculomotorius to increase exposure of the posterior clinoid process. (b) The dura over the posterior clinoid process was detached using a microdissector after the linea of the dural incision. (c) The proximal basilar artery was exposed after posterior clinoidectomy under the controlled venous bleeding from the basilar plexus. (d) Intraoperative photograph showing aneurysm clipping and preservation from the contralateral posterior cerebral artery. (e) The incised edge of the dura at the posterior clinoid process was attached and sealed by fibrin glue sealants. II: Optic nerve; IC: Internal carotid artery; PC: Posterior clinoid process; III: Oculomotor nerve; AN,: Aneurysm; BA: Basilar artery; PCA: Posterior cerebral artery; ✳: Fibrin glue sealants

anterior temporal bridging veins, risking venous infarction and predisposing patients to retractor injury.[8] Therefore, we attempted a modified anterior temporal approach that retracted the temporal lobe posteriorly while preserving most vessels.

The key points of this approach include the preparation for posterior retraction of the temporal lobe from the setting position. In addition, high mobility of the superficial Sylvian vein from the temporal lobe is the most important aspect. In cases where the Sylvian vein cannot be dissected, providing venous extensibility for this vein by completely denuding it from the surrounding arachnoid membrane is necessary. This meticulous dissection results in venous mobility and extensibility, which, in turn, allows a wider operative field without sacrificing any vessels in most cases. Nevertheless, there are cases in which it is impossible to proceed because small cortical veins surrounding the temporal tip are present. Therefore, surgeons should consider using this alternate surgical approach over the extra-dural temporopolar approach.[6] Furthermore, we previously had to alter our approach during surgery on several patients in another case series.[12] Although this approach allows extra-dural posterior retraction of temporal lobe by elevation of the dura propria, the elevation range is limited by the entry point from the superficial Sylvian vein to the sinus. Therefore, surgeons must be aware of the cortical vein and sinus when attempting the extra-dural temporopolar approach.

Even with complete execution of the modified anterior temporal approach, the retro-carotid space, where aneurysms of the upper basilar complex are located, is limited by the ICA, optic tract, oculomotor nerve, and tentorium cerebelli. Among these components, the ICA and oculomotor nerve can be fairly mobilized using additional techniques. Anterior clinoidectomy includes cutting of the distal dural ring around the ICA and posterior communicating artery (P-comA)[16] and opening of the porus oculomotorius to increase obtain mobility of the ICA or oculomotor nerve. Nevertheless, asymptomatic cerebral infarction and transit oculomotor nerve palsy occurred in some patients. Asymptomatic cerebral infarction occurred in the territory of central artery in one patient. We speculated that the cause of this infarction was excessive retraction of the ICA despite cutting the P-comA. Moreover, postoperative transient oculomotor nerve palsy occurred in three patients. In two of these three patients, opening of the porus oculomotorius and posterior clinoidectomy was performed. The overall incidence of oculomotor nerve palsy after surgical treatment of BA aneurysm varies from

30% to 75%,[1,5,11,15] where the incidence of oculomotor nerve palsy, particularly in patients who undergo posterior clinoidectomy, remains unknown. Several factors might have contributed to this postoperative oculomotor nerve palsy, for example, namely, a large aneurysm, backward projection of a SCA aneurysm, and vascular injury of small perforating arteries,[5,11] although mechanical stress on the nerve during the procedure likely contributed the most. Nevertheless, handling the ICA or oculomotor nerve with care to prevent postoperative complications, even if these additional techniques are performed, is important.

Aneurysms of the upper basilar complex situated in low areas behind the dorsum sellae cannot be adequately visualized through an anterolateral trajectory without the removal of the posterior clinoid process. Therefore, posterior clinoidectomy is often necessary to accomplish surgical treatment of low-position aneurysms of the basilar complex. In our study, four patients required posterior clinoidectomy, which enabled visualization up to 8 mm below the clinoid line. However, mastoidectomy or petrosectomy may be required for proximal control at the BA in cases that are 8 mm or more below the clinoid line. The risks associated with posterior clinoidectomy include venous bleeding from the basilar plexus, cerebrospinal fluid fistula from excessive drilling into the sphenoid sinus, oculomotor nerve injury, abducens nerve injury in Dorello's canal, and possible injury to the ICA in the posterior cavernous portion. Consequently, various posterior clinoidectomy techniques have been attempted to protect the surrounding structures.[7,21] Based on our experience, the linea of the dural incision lines before posterior clinoidectomy is the most suitable procedure. This incision is easily sealed by covering it with fibrin glue sealants to control venous bleeding or cover the sphenoid sinus. Moreover, the use of an ultrasonic surgical aspirator is considered to be more useful to protect surrounding structures than that of a high-speed drill. However, continuous irrigation is required when using the ultrasonic surgical aspirator and high-speed drill to prevent heat injury of surrounding structures.

In conclusion, the modified anterior temporal approach allows a wide operative field in the retro-carotid space and preservation of all vessels; thus safe and secure clipping of an aneurysm of the upper basilar complex can be accomplished.

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