

Superior Orbital Rim Approach for Anterior Communicating Artery Aneurysms: A Surgical Series of 27 Patients

There are debatable claims in the optimal approach for clipping of the anterior communicating artery (AcomA) aneurysm. The authors invented the superior orbital rim approach (SORA) as an alternative and minimally invasive approach for the treatment of AcomA aneurysm. The authors reviewed retrospectively all the medical records of 27 patients of subarachnoid hemorrhage due to ruptured AcomA aneurysm, who were admitted to Kosin University Gospel Hospital for last 2 yr. Fourteen women (51.9%) and 13 men (48.1%) were from 29 to 79 yr in age. The mean aneurysm size was 6.2 mm ranging from 4 to 12 mm. A favorable Glasgow outcome scale (GOS) of 4 or 5 was achieved in 92.6%, a GOS score of 3 in 3.7%, and 1 death (GOS 1) occurred in 3.7% of the patients. During the follow-up between 4 and 28 months (mean, 17.5 months) after the surgery, the prognosis of the patients and the cosmetic results were favorable compared with conventional approach. We became to believe that it was an alternative, effective and minimally invasive approach to the surgical treatment of AcomA aneurysm.

Key Words : Aneurysm; Intracranial Aneurysm; Circle of Willis; Neurosurgical Procedures; Subarachnoid Hemorrhage

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INTRODUCTION

The anterior communicating artery (AcomA) aneurysm represents the most common and difficult problem for neurosurgeons in the management because of its deep location, variable directions, and complex anatomy. Korsakoff's syndrome, paraparesis syndrome and psychological disturbance occurred more frequently in patients with subarachnoid hemorrhage (SAH) due to ruptured AcomA aneurysm than in patients with aneurysm at other locations (1, 2). A number of conventional surgical approaches have been performed to handle the AcomA aneurysm, such as pterional, interhemispheric, subfrontal and orbitozygomatic approach (3-10).

Despite the advances in the operative technic, the conventional approaches developed postoperative complications associated with large-sized craniotomy and excessive brain retraction. Recently, the minimally invasive technic (11, 12) decreasing the craniotomy size, reducing brain retraction and achieving better cosmetic outcome has been increasingly performed.

The successful management of anterior circulation aneurysms by minimally invasive transorbital or supraorbital craniotomy was reported (13-15). However, the literature contained rare report about the clinical outcome of the patients with AcomA aneurysms treated by minimally invasive aneurysm surgery via superior orbital rim.

Therefore, we developed superior orbital rim approach (SO-

RA) which consisted of a small incision along the eyebrow and superior orbital rim craniotomy. The purpose of this article was to describe the surgical technic of SORA and outcome of the patients with AcomA aneurysm.

MATERIALS AND METHODS

Patient Population

The first author used the SORA for the treatment of a consecutive series of 65 patients with cerebrovascular aneurysms during the last 2 yr. We performed a retrospective review of the medical records of 27 patients with AcomA aneurysms who were admitted at the Kosin University Gospel Hospital between October 1999 and October 2001. All patients were operated within 72 hr after admission. Of all the patients enrolled in this study, 14 were female and 13 were male ranging from 29 to 79 yr in age with the average of 64.8 yrs. All patients with acute subarachnoid hemorrhage were evaluated clinically on admission according to Glasgow coma scale (GCS), Hunt-Hess (HH) grade and Fisher (F) grade. We considered HH grade I through III as a good preoperative status consisting of 22 cases and grade IV through grade V as a poor preoperative status, consisting of 5 cases. Individual patient parameters were summarized in Table 1.

Table 1. Clinical characteristics of 27 patients with AcomA aneurysm treated by the superior orbital rim approach

Patient No.	A/S	HHG	FG	GOS
1	56/F	III	III	5
2	41/F	I	III	5
3	61/F	II	II	5
4	38/M	III	III	5
5	55/F	III	II	4
6	42/M	II	III	5
7	49/M	III	III	5
8	45/F	III	IV	4
9	41/M	III	IV	5
10	59/F	II	III	5
11	79/F	IV	IV	4
12	43/M	IV	III	5
13	42/F	IV	IV	3
14	42/F	II	III	5
15	54/F	II	IV	5
16	65/F	III	III	5
17	35/M	III	IV	5
18	62/M	II	II	5
19	49/M	IV	IV	1
20	59/M	II	II	5
21	61/F	II	IV	5
22	29/M	II	III	5
23	47/M	IV	III	5
24	31/M	II	III	5
25	58/F	III	III	5
26	57/F	II	III	5
27	65/F	III	III	5

*A/S, Age/Sex; HHG=Hunt-Hess Grade; FG, Fisher Grade; GOS, Glasgow Outcome Scale.

For each patient, the presence of aneurysm, its size, projection of fundus and dominant vessels were assessed, using four-vessel digital subtraction angiography or MRA (Table 2, 3). The size of AcomA aneurysm was classified into four groups according to the angiographic measurement: below 6mm in diameter as small, from 6 to 10 mm as medium, between 10 and 25 mm as large, above 25 mm as giant. The direction of the aneurysm fundus was determined by the angle between the dominant A1 and the projecting axis of the aneurysm. As far as our study was concerned, 23 patients had a solitary saccular aneurysm (one patient with a large aneurysm) and 4 patients had multiple aneurysms (one patient with 3 aneurysms, others with 2 aneurysms).

Surgical Procedure

For this approach shaving of hair is also not necessary. The patient was placed in the supine position. The head was rotated about 15 degrees to the contralateral side and fixed in Mayfield fixator (Fig. 1). Fine adjustment of the head rotation during the procedure was accomplished by tilting the operating table. The neck of the patient was extended, resulting in a 10 to 20 degrees angle between the plane of the orbital roof and the floor. This position allowed the frontal lobe to fall away natural-

Table 2. Summary of AcomA aneurysms by size

Aneurysm Size	Diameter (mm)	No. of patients (%)
Small	1-5	5 (18.5)
Medium	6-10	21 (77.8)
Large	11-25	1 (3.7)
Giant	>25	0 (0)

Table 3. Classification of AcomA aneurysms by direction of the fundus

Aneurysm projection	No. of patients (%)
Anterior	10 (37.0)
Superior	8 (29.6)
Posterior	2 (7.4)
Inferior	7 (26.0)



Fig. 1. The picture illustrating the position of patient. The head was rotated 15 degrees to the contralateral side.

ly from the orbital roof without necessitating a retraction system. All aneurysms were approached principally from the side of the dominant A1 segment.

A standard skin incision about 4 cm in length was made at the upper edge of the eyebrow. It began medially just lateral to the supraorbital foramen in order to avoid injury of supraorbital neurovascular structures. It ended laterally 5 to 10 mm beyond the lateral edge of the eyebrow. The periorbita was dissected carefully from the orbital roof. When the periorbita was injured, it should be repaired immediately to prevent the orbital fat bulging into the operative field.

Frontal bone was drilled out from the keyhole to the frontozygomatic suture laterally, and just lateral to the supraorbital foramen medially. After the protection of periorbita and orbital contents using a retractor, the medial and lateral parts of the

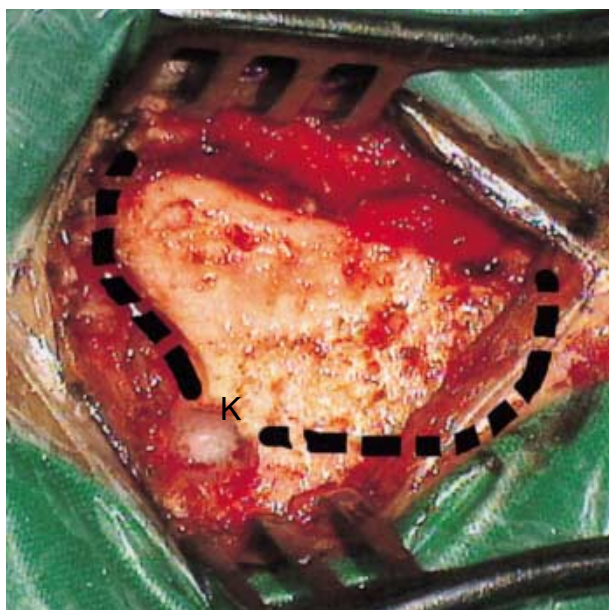


Fig. 2. The picture depicting the craniotomy which incorporated portions of orbital roof and rim, and zygomatic process of frontal bone. The keyhole was placed at the anterior aspect of superior temporal line. K, keyhole; dotted line, image line for craniotomy.

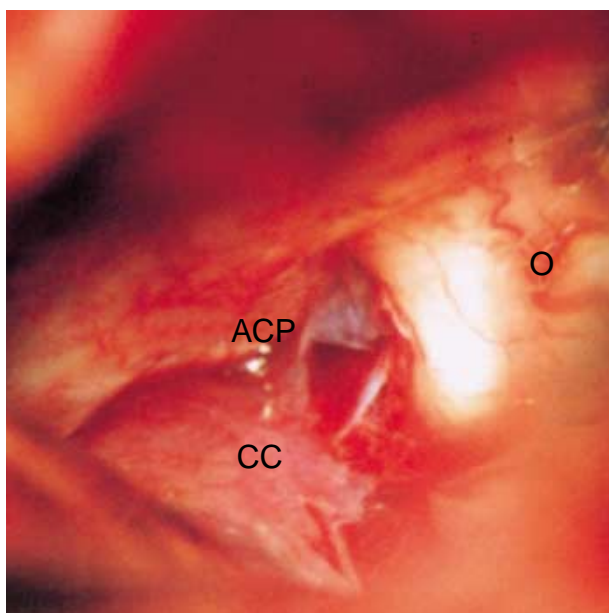


Fig. 4. The picture showing opened carotid cistern, optic nerve and anterior clinoid process. O, optic nerve; CC, carotid cistern; ACP, anterior clinoid process.

superior orbital rim are drilled out with 2-mm drill bit. Then the one-piece bone flap measuring about 2×3 cm in size was elevated (Fig. 2). During craniotomy, attention should be paid to avoid opening frontal sinus cavity and consequent postoperative bacterial contamination. Once the frontal sinus was opened, the mucus membrane should be removed completely. The

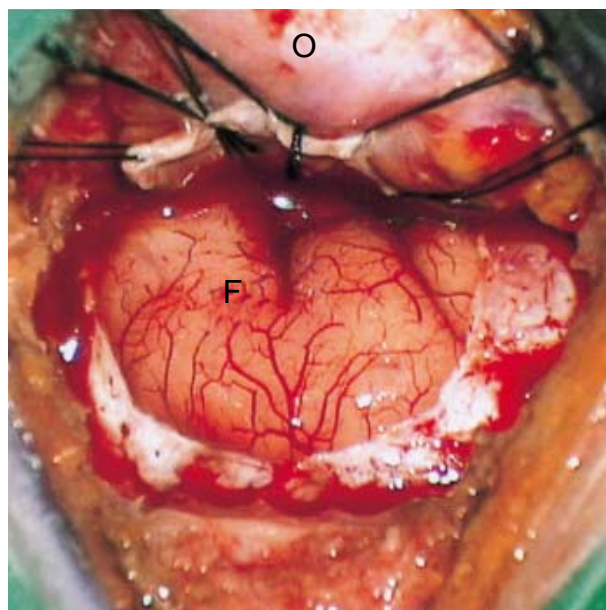


Fig. 3. The picture showing the operative field after opening the dura. O, orbital fat; F, frontal lobe.

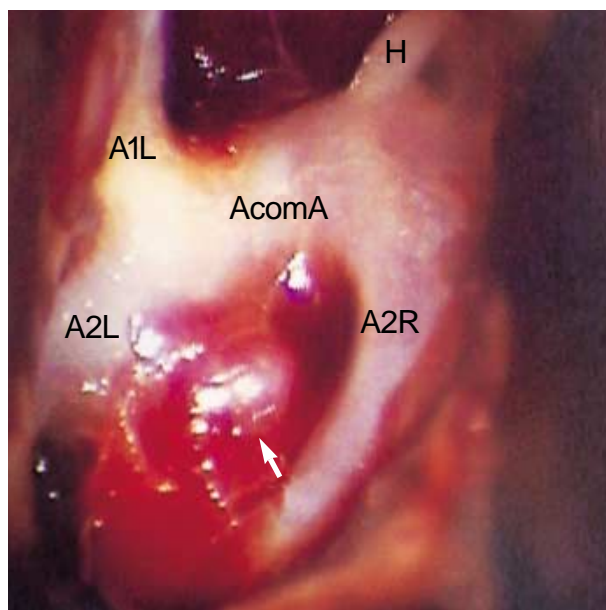


Fig. 5. The picture showing the aneurysm arising at the junction of AcomA and dominant A1 segment (arrow). A2R, A2 segment of right anterior cerebral artery; A2L, A2 segment of left anterior cerebral artery; AcomA, anterior communicating artery; A1L, A1 segment of left anterior cerebral artery; H, artery of Heubner.

defect was plugged with gelfoam pieces and bone wax instead of a pericranial flap or temporalis muscle. The antero-posterior skull film should be examined carefully before surgery to know the size and contour of the frontal sinus.

The dura was opened in a semicircular fashion for exposing the orbitofrontal cortex. The anteriorly reflected dura was tack-

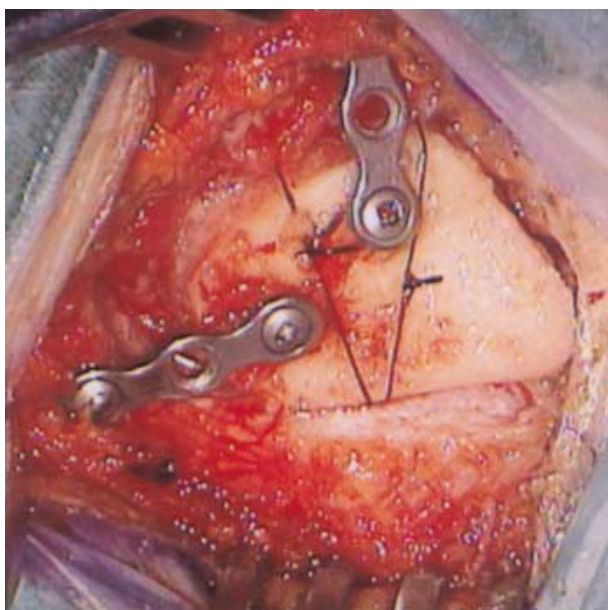


Fig. 6. The picture showing the bone flap repositioned and fixed with miniplates.

ed up to overlying skin to yield a greater working space (Fig. 3). At this time, elevation of patient's head and adjusting view angle of microscope could facilitate looking at anterior clinoid process and optic nerve. The orbital roof was followed and the optico-carotid cistern was opened (Fig. 4). We have never performed the spinal drainage or the ventriculostomy. Once the cerebrospinal fluid (CSF) was drained, the brain has fallen away from the base of the skull by gravity providing a wide natural working field. Brain retractors were not used.

Then, all segments of AcomA around the aneurysm were identified and dissected without brain retraction. A superior projecting aneurysm could be visualized with gyrus rectus removal (Fig. 5). Through a pterional approach, the visualization axis was somewhat lateral, but this approach offered a more anterior line of view along the orbital roof. This approach offered somewhat narrow but much better exposure of an aneurysm.

Any maneuver which might lead to premature rupture of the aneurysm must be forbidden until the control of A1 segment has been obtained. To avoid the development of the post-operative hydrocephalus secondary to external CSF blockage by subarachnoid hemorrhage, the lamina terminalis was fenestrated after clipping when it was needed. Sometimes it also was necessary to penetrate the Lilliequist's membrane.

The dura was closed in a standard watertight fashion. The bone flap was replaced and fixed by using two pieces of three-hole miniplates and screws (Fig. 6).

Statistical Analysis

Statistical analyses were performed using SAS 6.12 (SAS Institute Inc., Cary North Carolina, U.S.A.). The tendency of

Table 4. The main complications in relation with preoperative condition*

	Vasospasm	Meningitis	HCP	Subdural hygroma	CSF leakage
H-H Grade					
I	0	1	0	0	0
II	2	1	4	2	4
III	1	1	3	0	1
IV	2	0	2	1	0
V	0	0	0	0	0
Fisher Grade					
I	0	0	0	0	0
II	0	1	0	1	2
III	3	1	5	0	2
IV	2	1	4	2	1
Total	5 (18.5%)	3 (11.1%)	9 (33.3%)	3 (11.1%)	5 (18.5%)

*HH Grade, Hunt and Hess Grade; HCP, hydrocephalus; CSF, cerebrospinal fluid.

GCS, HH grade, F grade, discharge state and different complications to GOS were tested by Mantel-Haenszel trend test. The Wilcoxon rank sum test or Kruskal-Wallis test were applied for two or more groups, and level of significance was set up at the point of probability less than 0.05. We compared GOS with GCS and HH grade by chi-square test or Fisher's exact test.

RESULTS

Surgical Outcome

All aneurysms were clipped successfully. No transfusion was given in all patients. Two patients developed premature rupture during the dissection of the aneurysm. Eight patients underwent opening of lamina terminalis cistern to prevent chronic hydrocephalus.

There was no mortality related to the approach. The main surgical complications and deficits compared with HH grade and F grade on admission were summarized (Table 4). Nine patients (33.3%) developed hydrocephalus, but only 2 patients underwent ventriculoperitoneal shunt. Meningitis occurred in 3 cases (11.1%). Vasospasm occurred in 5 cases (18.5%) especially in the patients with F grade 3 or 4. CSF leakage occurred in 5 patients (18.5%), which resolved by lumbar drainage. One of the three patients, who were complicated with subdural hygroma, underwent subduroperitoneal shunt. Except for these main complications, conjunctivitis developed in 2 cases. Wound infection, hyposmia and anosmia were not presented.

In short, favorable cosmetic outcome was achieved compared with the traditional approach. None of the patients were complicated with paresthesia along the eyebrow. Although most patients suffered from transient periorbital edema, it resolved completely within 2 weeks. No patients suffered from eyebrow



Fig. 7. The picture showing postoperative wound.

paralysis. Neither the atrophy of the frontal and temporal muscle nor the injury of facial nerve occurred in all cases. Alopecia in the healed cicatrix was not observed on follow-up examination (Fig. 7).

Clinical Outcome

The clinical outcome of the patients was assessed by GOS, defined as follows, at discharge: Excellent (return to normal social life), Good (mild neurological deficits but independent in social life), Fair (neurological deficits, dependent in social life), Poor (neurological deficits, dependent for daily support), and Dead. The clinical results related to preoperative HH grade and F grade were demonstrated (Table 5, 6).

Of 27 cases, 22 (81.5%) patients gained excellent outcome at discharge, 3 patients (11.1%) gained good outcome, 1 patient (3.7%) gained fair outcome, and 1 patient (3.7%) was dead. In general, a favorable GOS score of 4 or 5 was achieved in 92.6% of the patients. Patients with GOS score 1 to 3 occupied in 7.4%. Poor result was not found in the patients with good preoperative condition. From Table 5 and Table 6, it seemed that the satisfactory results leveled with the good preoperative grade. During the follow-up between 4 and 28 months (mean 17.5 months), the majority of patients performed the satisfactory social activity except one who presented with chronic dementia.

Statistical Results

The analysis in which the GCS score was compared with different complications indicated a strong tendency that the occurrence of vasospasm would decrease with GCS score incre-

Table 5. Surgical outcome compared with preoperative grade*

Preop Grade	No. of cases	Surgical outcome				
		Excellent	Good	Fair	Poor	Dead
I	1	1	0	0	0	0
II	11	11	0	0	0	0
III	10	8	2	0	0	0
IV	5	2	1	1	0	1
V	0	0	0	0	0	0
Total	27	22 (81.5%)	3 (11.1%)	1 (3.7%)	0 (0%)	1 (3.7%)

*Preoperative grade corresponds to Hunt and Hess Grade. The definition of surgical outcome was described in detail in the text.

Table 6. Surgical outcome compared with preoperative Fisher grade

Fisher Grade	No. of cases	Surgical outcome				
		Excellent	Good	Fair	Poor	Dead
I	0	0	0	0	0	0
II	4	3 (75%)	1 (25%)	0	0	0
III	15	15 (100%)	0	0	0	0
IV	8	4 (50%)	2 (25%)	1 (12.5%)	0	1 (12.5%)
Total	27	22 (81.5%)	3 (11.1%)	1 (3.7%)	0 (0%)	1 (3.7%)

*Preoperative grade corresponds to Hunt and Hess Grade. The definition of surgical outcome was described in detail in the text.

asing on admission ($p=0.02$). Although the vasospasm was related to F grade, these differences were not statistically significant due to the small sample size. There also was a trend indicating that the older patients had tendency of developing subdural hygroma after the surgery compared with young patients ($p=0.02$). Of the variable predictors which would influence on the result of surgical procedure, the statistical test supported that the GCS score and HH grade both correlated significantly with the GOS score ($p=0.004$, $p=0.006$ respectively). The patient's sex, age, and F grade did not appear to have an effect on GOS score in our study. The poor outcome was associated with the severity of the initial clinical presentation which was evaluated by HH grade. Patients with higher GCS score were less likely to have lower GOS score, and the similar trend was revealed by single linear regression analysis.

DISCUSSION

Satisfactory obliteration of AcomA aneurysm still poses a challenge on modern neurovascular surgery due to its complicated anomalies, size, and variable perforating arteries (16, 17).

The most popular approach utilized to obliterate aneurysm was pterional trans-Sylvian approach which was described by Dandy in early time (18). In the following years, Yasargil (19) and Fox (3) modified this approach by drilling away different portion of sphenoid wing which was essential step to expose AcomA complex and its neighboring structures widely. Because of good visualization and safe maneuver, this approach was

more acceptable in modern neurosurgical procedures. A lot of revolutionary methods also have been introduced based on this standard route. Different from interhemispheric approach, encountering frontal sinus, sacrificing bridging veins and damaging olfactory tracts have been overcome successfully by pterional approach. Diraz et al. compared these two basic methods for AcomA aneurysm and drew a conclusion that if the aneurysm neck is located 13 mm above the level of anterior clinoid process, interhemispheric approach was suitable, otherwise, pterional approach should be applied (20).

To sum up, common features of all those traditional approaches were relatively large craniotomy, more brain retraction, time consuming, and poor cosmetic results. Simultaneously extensive craniotomy and invasive exposure could increase surgical morbidity not due to lesion itself. Therefore, current focus on aneurysm surgery has been placed on the safe control of the aneurysm and the minimal trauma to the normal structures.

As the concept of keyhole microneurosurgery was popular in recent years, small skin incision, small craniotomy and less retraction have been more emphasized. Minimal approach with favorable outcome has become a new goal of surgery.

McArthur (21) and Frazier (22) performed the early practice of removing supraorbital arch. As a milestone, Jane et al. described a modification of supraorbital approach so that this technique was not suitable for orbital tumor but suitable for AcomA aneurysm (7). However, it sacrificed the supraorbital nerve and artery. In order to gain good access to deeply located lesions or complex aneurysm, Smith and Al-mefty et al. applied craniobasal approach with section of superolateral orbital rim to obtain enough space for approach (23, 24). Delashaw et al. also innovated this approach making it easy to master and ideal for some special cases (5, 6). In 1997, Jho modified subfrontal craniotomy via an eyebrow incision for anterior fossa and parasellar tumor (25). The SORA, we presented here, was developed from the supraorbital craniotomy and transorbital approach, particularly on the basis of Jho's orbital roof craniotomy. With partial removal of superior orbital rim, we created a small but effective operative field through the potential space between the orbital roof and frontal lobe.

As far as our experience was concerned, one of the advantages of the SORA was safe control of AcomA complex with minimal exposure. The working area was enlarged by retraction of orbital contents and cisternal opening. Some meticulous steps such as using intravenous infusion of mannitol, turning patients head to contralateral side and downward to relax naturally were also helpful for the exposure. Properly changing the visual angle could improve the inspection of aneurysm neck. The key point of the operation was securing the dominant A1 segment of anterior cerebral artery.

Another advantage of our approach was less brain retraction. We fractured the orbital roof and retracted the contents of orbital cavity instead of exerting physical force on frontal lobe. This maneuver contributed to decrease the morbidity related to brain retraction. The operation was dealt with suction tip

and bipolar coagulator without brain retractor. In some patients, we removed the gyrus rectus. The extent of its removal was decided by the size and the projection of the aneurysm. This was a useful method when the aneurysm was located in a high position or projected in a complicated direction.

The size of aneurysm was one of the basic factors which influenced upon the choice of surgical approach, the risk of intraoperative complications, and outcome. Based on our series, all patients with aneurysm size smaller than 10 mm underwent successful management. There was no statistically significant difference between small and medium sized aneurysm. Although we performed operation on one case of large AcomA aneurysm, we maintained that our approach was most suitable for small and medium sized AcomA aneurysm as a routine surgical procedure.

Direction of the fundus of AcomA aneurysm was also an important factor that needed to be considered in the microsurgical dissection of the aneurysm, which secured safe clipping of the aneurysm neck. Even though complex bilobulated or multilobulated aneurysms could present in all of the projections, Yasargil described them as four basic types that concurred with the direction of the dome of the aneurysm: anterior, superior, posterior, and inferior (19). Among these four basic groups, inferior aneurysms were more challenging and troublesome for the neurosurgeon, but we also performed direct obliteration in 7 cases by this approach. With gyrus rectus removal, the aneurysm neck was well visualized without damage to the perforating vessels. So our approach, utilizing a special operative corridor between orbital roof and frontal lobe with minimal brain retraction could manage AcomA aneurysm projecting in any direction.

Yasargil described that 87.5% of patients achieved with good outcomes (19). Hori and Suzuki reported 85% of patients gained excellent or good results (26). Ogawa et al. presented that 83% of patients had excellent or good outcomes (27). Of our 27 cases, 92.6% achieved with excellent or good outcomes at discharge. Intracerebral hemorrhage or low density related to the operation has not been found on postoperative CT scan. All patients who had good preoperative grade achieved excellent outcome. Moreover, 10 patients (66.7%) of 15 patients with bad preoperative grade obtained excellent result and 2 patients obtained poor result.

The most common complication in our cases was hydrocephalus (33.3%). All patients involved in this complication presented with F grade 3 or 4. Especially among the patients with intraventricular hemorrhage, 80% of patients developed hydrocephalus. Although the exact mechanism was unknown, it indicated the close correlation between the preoperative condition and hydrocephalus after SAH (28). Two patients (7.4%) needed shunt procedure. We considered that opening the lamina terminalis at the same time of the rinsing the subarachnoid space was effective and helpful strategy, if patient showed high preoperative F grade.

Three patients developed postoperative meningitis associated

with unplanned opening of a large frontal sinus. It could be managed well by the conservative therapy. However, relative contraindication included the presence of a large frontal sinus. CSF leakage accounted for 18.5% of all patients in our complications. Usually it vanished soon through lumbar drainage. The only one mortality case was due to severe vasospasm rather than approach itself. All vasospasm cases presented with high F grade. The incidence of premature rupture during dissection of aneurysm was similar to that of the pterional approach. Furthermore, the patients who developed intraoperative rupture obtained good recovery.

Even though we could apply clipping on AcomA aneurysm via SORA without difficulty and have treated four patients with multiple aneurysms of anterior circulation in one stage surgery, some cases were still limited to this approach for example, giant aneurysm, posterior circulation aneurysm. To evaluate the surgical outcome objectively, it was necessary to collect larger series of cases.

In summary, mixing traditional skull base theory with modern minimally invasive concept, we designed a new approach for clipping AcomA aneurysm. This approach provided enough space for aneurysm manipulation with less brain retraction than conventional approaches and obtained favorable outcome. The satisfactory cosmetic results have been gained due to successful preservation of neurovascular supply to frontal and temporal muscles. We came to believe that it was one of the safe and effective methods for surgical treatment of AcomA aneurysm.

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