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Superolateral Orbital Rim Craniotomy for Middle Cerebral Artery Aneurysms

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Abstract

Objective : Recently, several approaches for middle cerebral artery aneurysms (MCA) have been developed from conventional method, that is pterional approach. However, the literatures contain no report about minimally invasive surgery for the treatment of MCA aneurysms. So the purpose of our study is to describe a new technique, that is superolateral orbital rim craniotomy (SLORC) approach—minimally invasive surgery and the outcome for the treatment of MCA aneurysms.

Methods : A retrospective review of 12 patients with MCA aneurysms ruptured or unruptured who were operated by SLORC approach was performed during October 1999 thru December 2001.

Results : All the aneurysms were clipped successfully. The mean aneurysm size was 6.8 mm ranged from 4 to 15 mm. The average hospital stay was 15.9±9.1 days and the operation time usually consumed 3 to 4 hours. No patients died and adverse effects directly related with surgery were minimal. Cosmetic result was also achieved just a few days after operation. We never used lumbar drain or extraventricular drainage. During operation, less retraction of neural structure and no transfusion were required. The modified Rankin scores at discharge and 6 months afterwards revealed 0 grade in all assessed patients.

Conclusion : The SLORC is a newly developed procedure for neurosurgeon to treat MCA aneurysms. Although this technique is not widely used, it is likely that this minimally invasive approach will become a promising operative technique in the future.

Key words : Cerebral aneurysm · Middle cerebral artery · Superolateral orbital rim craniotomy

Introduction

The middle cerebral artery (MCA) is one of the most common sites where the intracranial aneurysms usually locate. The MCA aneurysms, which can bring about subarachnoid hemorrhage, especially in the sylvian fissure or temporal lobe hematoma comprise approximately 15~25% of all cerebral aneurysms[4,10,33,35]. These lesions will lead to ipsilateral temporal region headache or partial neurological deficit including dysphasia, or even worse-mental change such as drowsy mentality. Therefore, surgical treatment and evaluating the outcome of patients with MCA aneurysms need to be recommended.

Much attention in the neurosurgical field has been focused on surgical technique and result for MCA aneurysms. Most vascular neurosurgeons would probably not hesitate to approach MCA aneurysms using classic pterional approach which Yasargil and Fox have been popularized since 1975[34]. Thus, the surgical procedure and clipping for MCA aneurysms can be performed with 3 basic techniques[10,35] : (1) medial trans-sylvian approach; (2) lateral trans-sylvian approach; (3) superior temporal gyrus approach. No matter which kind of procedure to be chosen, it requires brain retraction for wide exposure of the lesion and clipping the aneurysms exactly. At the same time, the outcome following these methods isn't always

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satisfied: flap necrosis, atrophy of the temporal muscle, temporomandinular dysfunction and CSF fistulae etc[29].

Recently, with the improvement of microneurosurgical technique, several approaches for MCA aneurysms have been developed that may decrease the size of the craniotomy, but increase surface exposure; minimize brain retraction without touching or even destroying the normal neural structures; and the most important, acquire cosmetic result of surgical incision[6,9,13,16,17,20,26]. Although the advantages of microsurgery for aneurysms have been described numerous times in the literature just as mentioned above, little attention has been focused on less invasive approach of MCA aneurysms. Therefore, the purpose of our study is to describe the surgical technique and outcome of superolateral orbital rim craniotomy (SLORA) approach in detail for its use in MCA aneurysm surgery and to delineate technical advances that have come from minimally invasive neurosurgery: the keyhole concept[22]. It is anticipated that the data and technique presented here will enhance the understanding of this theory, and allow reasonably accurate estimates of outcome.

Methods

Patient Population

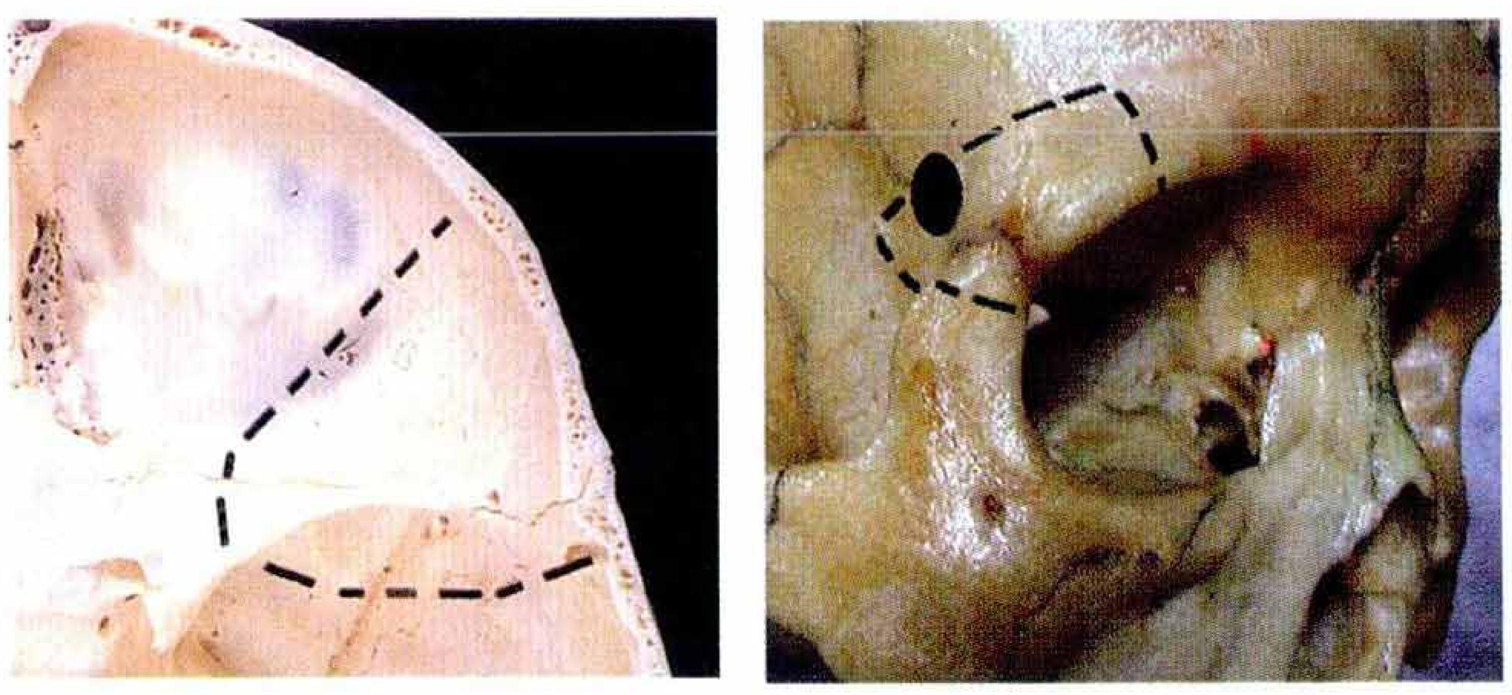
During October 1999 thru December 2001, 79 patients with cerebral aneurysms whether ruptured or unruptured were first operated using transciliary superior orbital rim or SLORC approach-minimally invasive method by the senior author (BC Jeon) in the Division of Minimally Invasive Neurosurgery at Kosin University Gospel Hospital, Busan, Korea. We retrospectively evaluated consecutive 12 patients of MCA aneurysms with preoperative, intraoperative and postoperative information, which was obtained from patient charts, operative records and a review of radiological investigation including CT scans, MR imaging and angiographic films. Table 1 illustrated the patients' clinical data during their hospital stay.

There were 10 female and 2 male patients who demonstrated a strong female preponderance. Their ages ranged from 38 to 68 years old (mean 48.8 years). Ten patients (83%) had aneurysms on right side bifurcation, the other two (17%) on the left side. The symptoms of these 12 patients mostly were headache and presented with alert mentality. After admission, five patients GCS scores were 15; three got 14; three 13 and only one was 9. Eight patients' Hunt-Hess grade was II (67%); three was grade III (25%); and one got grade IV (8%). Fisher grade II found in 3 patients (25%); III in 7 patients (58%) and IV in 2 patients (17%). The size of these MCA aneurysms measured from angiograms. The mean aneurysm size was 6.8mm, with a range from 4 to 15 mm and there were three principal directions of fundus projection with these lesions according to Yasargil's classification[35]: 6 anterosuperior (medially or laterally) toward the surface of the sylvian fissure, 3 posterior between the two major trunks of the bifurcation and 3 inferior toward the insula. All patients underwent early operations within 48 hours after SAH. The operating time consumed 3 to 4 hours (mean 3.5 hours).

It is worth noticing that two patients suffered multiple aneurysms (Case 11 and Case 12). These patients got with anterior communicating artery aneurysms, which were treated with one-stage operation. There is no direct relationship with our surgical results. In this paper we just mention about MCA aneurysms with SLORC approach. Therefore, they are ruled out in the outcome assessment. All the patients were reevaluated by postoperative CT scans and 4-vessel DSA. The modified Rankin scores were determined at discharge and 6 months after operation. Surgical results and complications of this approach were also evaluated after operation.

Surgical Anatomy — Anatomy of The Orbital Roof

SLORC approach is a technically demanding operative method, which requires complete understanding of the surgical anatomy. The orbital cavity is a 30 ml, four-walled, pear shaped structure with a roof about 1 to 3 mm thick. The roof of orbit is triangular in shape, which is formed mainly by the orbital part of the frontal bone and lesser sphenoid wing (Fig. 1 *left*).



A B

Fig. 1: These two drawings show the bone anatomy of superolateral orbital rim craniotomy. A: superior view. B: lateral view. The black line displays the superolateral orbital rim approach for the range of the bone removal.

It is approximately horizontal and separates the orbital cavity by the direction from the superior to the anterior cranial fossa, inferior to the extraorbital muscles and eye ball, lateral to the zygomatic bone, frontozygomatic suture and temporalis muscle, medial to nasal cavity (Fig. 1 *right*). From the anterior view, the supraorbital notch or foramen of some skull locates in the middle of the supraorbital margin, which is the angular boundary between the supraorbital margin and orbital parts. Just above this, lies a ridge-the superciliary arch-which extends laterally on each side from the glabellas. The supraorbital artery and nerve penetrate the passage to dominate and supply the forehead and scalp. Between the outer and inner tables of the frontal bone are frontal sinuses that are posterior to the superciliary arches and the root of the nose. There exist variations of the frontal sinuses, where the right and left are rarely of equal size. The septum between the right and left sinuses usually is not situated entirely in the median plane. Sometimes it may be multiple on each side or none according to the congenital development. On the lateral view, the temporalis muscle proximally attaches to the floor of the temporal fossa and deep surface of the temporal fascia, distally attaches to the tip and medial surface of the coronoid process and anterior border of the ramus of the mandible.

Operative Technique

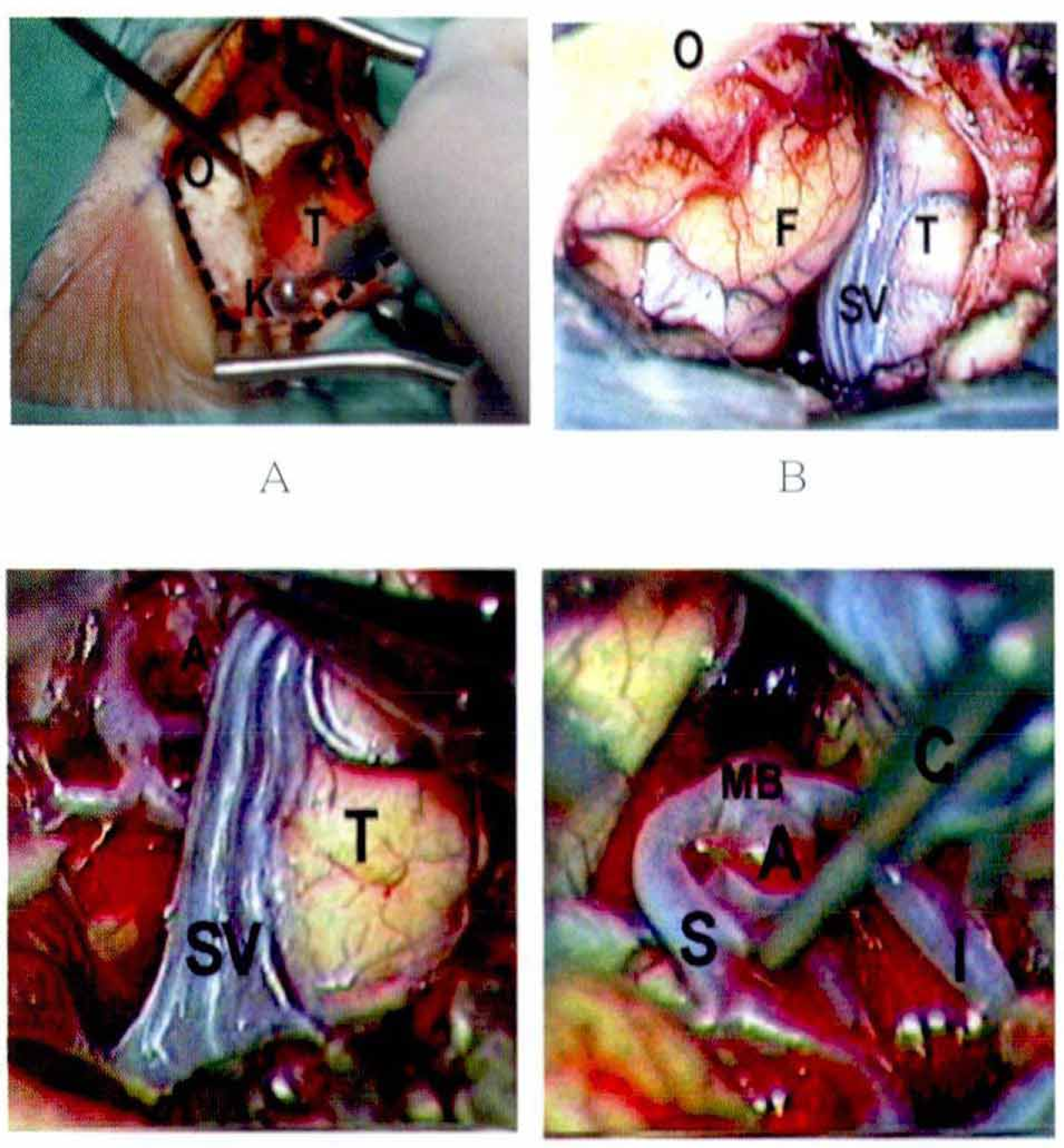
Just before operation, we never treat the patient with lumbar drain or third ventriculostomy. Usually, the patient is placed in supine position following the general endotracheal anesthesia; the head is rotated about 30-40 degrees to the contra-lateral side of the lesion and extended 10-15 degrees above the level of heart to lower the intracranial pressure. Then it is fixed using a Mayfield three-pin head fixation system. However, this position is not always invariable. We will change the position of head during operation to acquire an optimal angle-view of the lesion according to each patient.

Before operation all of our patients need not to have their hair shaved. The eyes were protected with ophthalmic ointment. Skin incision is made along the upper margin of eyebrow laterally from supraorbital foramen to the lateral orbital rim, extending over the line of the eyebrow and continuing up to the temporal region about 3-4 cm in length (Fig. 2).

Fig. 2: The photo shows the skin incision along the eyebrow.

Care must be taken not to retract or cut off the supraorbital nerve and vascular structure to reduce the postoperative complications. The subcutaneous layer, frontalis and partial temporalis muscle are incised in turn with monopolar coagulator to prevent bleeding until exposing the pericranium, which attaches on the underlying frontal bone. Then it is removed from the bone. Periorbita layer is dissected superiorly about 2 cm from the incision to the superciliary arch, lateral to the frontozygmatic suture and the temporal area and downward is detached the orbital roof with cottonoids and molt dissector. Once the periorbita is injured, the damage site should be repaired immediately to prevent orbital fat protruding into the operative field and influencing the view of operation.

The keyhole is placed just in the posterior aspect of superior temporal line using high-speed small drill about 3x4 mm^2 (Fig. 3 *upper left*).



A B

C D

Fig. 3: These photographs show the surgical procedure. The keyhole site corresponds with pterional approach. The black line illustrates the bone exposure (A). After temporal dura was opened, the frontal lobe and the temporal lobe were exposed and the sylvian fissure was also identified (B). After sylvian dissection, the middle cerebral artery and bifurcation were exposed clearly. The final clipping was done (C). The bone flap was repositioned and fixed with mini-plate system (D).

A: aneurysm C: clip D: dura mater F: frontal lobe I: inferior division K: Keyhole MB: middle cerebral artery bifurcation O: orbital rim OB: orbital S: superior division SV: sylvian vein T: temporal lobe

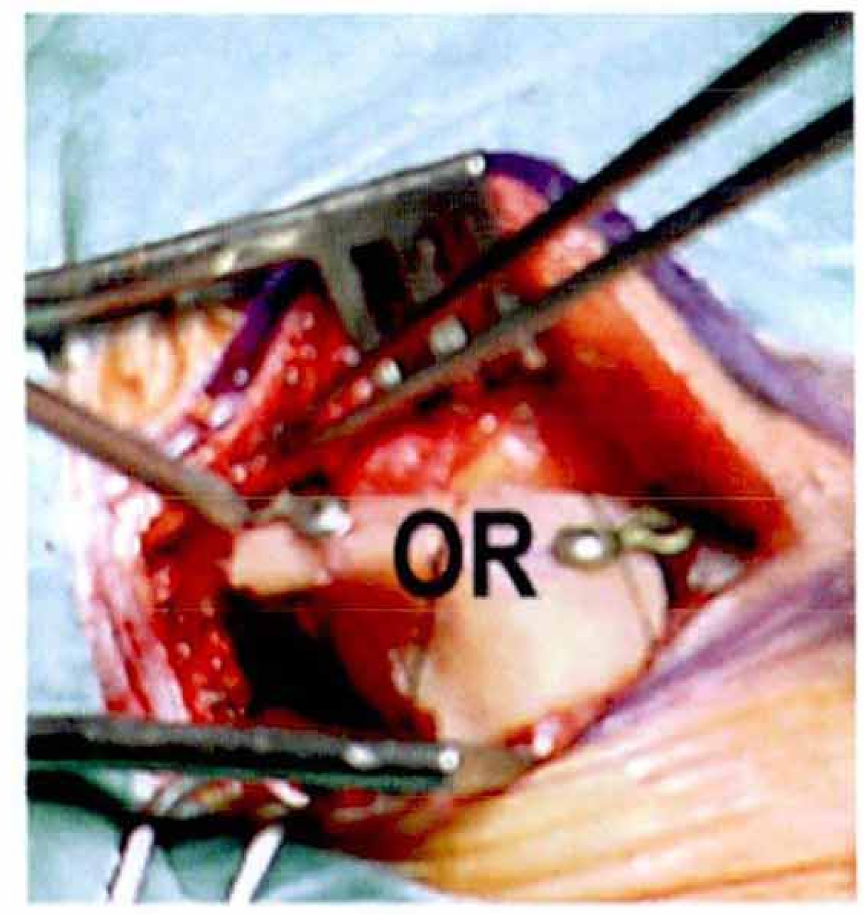


Fig. 4: The picture shows the repositioning of the bone flap OR : orbital rim

This site corresponds to that of pterional craniotomy. Outer table of frontal bone is drilled out from keyhole to frontozygomatic suture laterally, supraorbital foramen medially and 2cm above orbital rim with rotating footed drill. Inner table of frontal bone is removed by 2mm-sized Kerrison punch. After protection of periorbita using small brain spatula, orbital ridge, frontozygomatic suture and partial temporal squama are all drilled out. Then the orbital roof is fractured automatically using punch. The bone flap including the frontal bone, frontozygomatic process, superolateral orbital rim, orbital roof and temporal bone is removed as a single piece from operative field. This procedure allows surgeons to operate in the intraorbital space and extradural space. If the frontal sinus has been opened, the mucus should be eradicated and it had better be packed gelfoam pieces and bone wax to prevent intracranial bacterial contamination. Then removal of remaining orbital roof is performed to the superior orbital fissure so as to achieve a wide operative exposure

The dura mater is opened in a curvilinear shape crossing the sylvian fissure. The edge is tacked up with 4-0 black silk to the overlying skin; this establishes a greater field where the surgical microscope might be utilized. The sylvian vein, temporal lobe and frontal lobe are visualized under the view of the microscope (Fig. 3 *upper right*).

The dissection is extended into the proximal sylvian fissure toward the insula. SLORC approach provides a direct angle-view of the proximal sylvian fissure. Although several different surgical approaches including lateral-to-medial transsylvian, medial-to-lateral transsylvian, and superior temporal gyrus approaches can be used by our craniotomy, we prefer a proximal transsylvian approach similar with a lateral-to-medial transsylvian approach for most aneurysms. It will spare some time without requirement of complete sylvian dissection. In patients combined with ruptured AcomA aneurysms or a short middle cerebral artery trunk, a medial-to-lateral approach can be applied. In patients with temporal hematoma, a superior temporal approach is also available using our craniotomy. Once the branch of MCA is confirmed, the sylvian dissection should be halted and attention is focused on the aneurysm itself. In most cases, when the sylvian fissure is opened, the MCA bifurcation could be identified directly by our approach without difficulty (Fig. 3 *lower left*). Moreover the bifurcation is the common site for MCA aneurysms to occur. Therefore, it would be helpful to find aneurysms quickly without necessity of distal sylvian dissection, which will lead to shorten the operating time. Furthermore, the direction of the MCA aneurysm, which often projects superficially, laterally and backward within the sylvian fissure, even somewhat inferiorly toward the temporal lobe, is easily identified from this approach. Then clipping the aneurysms will be successful (Fig. 3 *lower center*).

A watertight dura suture is utilized with 4-0 black silk. The bone flap is repositioned and fixed with 5 mm, 3 holes miniplate system to acquire cosmetic results (Fig. 3 *lower right*). During this procedure no transfusion is done to the patients.

Results

Surgical Result

All the aneurysms were clipped successfully judged by follow-up postoperative angiography. One patient (Case 5) developed premature rupture of the aneurysm, but it was controlled successfully. In 2 patients combined with AcomA aneurysms (Case 11 and Case 12), medial-to-lateral transsylvian approach was done using our craniotomy. The procedure was performed in one-stage operation for clipping of multiple aneurysms. One patient with temporal lobe hematoma (Case 7) was treated with a superior temporal gyrus approach by current craniotomy.

No procedure-related mortality was found. The operation time usually consumed 3 to 4 hours. The average hospital stay in our series was 15.9±9.1 days the shortest day was 7 days and the longest was 25 days, which acquired less costly hospital stays. None of the patients who were operated by this approach needed a blood transfusion during surgery. Cosmetic result was also achieved just a few days after operation (Fig. 4).

Fig. 5: The picture shows the cosmetic results after SLORC approach for MCA aneurysm before the patients were discharged.

Procedure-Related Complications

Complications of our approach are very rare comparing to the other approaches. Table 2 lists the postoperative complications and defects with following time. There are three factors that have the closest relationship with our technique. After operation all 12 patients sustained transient hypesthesia of the frontal region appearing on the side of incision. However, between 10 to 20 days after operation, it disappeared. Immobility, that is, inability to raise the eyebrow, and periorbital edema were the other complications detected in all patients, however, these symptoms had subsided gradually within 2 weeks before the patients were discharged. Among these 12 patients, hydrocephalus was not identified except Case 12. Additionally two patients (Case 2 and Case 12) developed persistent CSF leakage, which were treated with lumbar drain for 5 days.

Patient Outcome

There exist a variety of grading systems provided for the outcome assessment of aneurysm operation[19]. We assessed these 10 patients that directly operated by SLORC approach for outcome evaluation with the modified Rankin scores. The MRS was determined at discharge and 6 months after treatment[4]. Just as described, Grade 0 equals to normal; Grade 1 indicates abnormal neurological examination but no function disability; Grade 2, get slight disability and can do most things but needs assistance with some activities; Grade 3, moderate disability but ambulatory; Grade 4, moderate to severe disability no ambulatory; Grade 5, bedridden and Grade 6, dead. The modified Rankin scores at discharge and 6 months after operation showed 0 grade in 10 patients. Because our sample is limited to results in a small number of patients, it needs further evaluation.

Illustrative Case

History. This 50 year-old male patient was referred to our hospital for further treatment of subarachnoid hemorrhage.

Examination. On arrival at emergency room, he was alert. Neurological defect, pathological reflex and motor change were not examined. Brain CT scan showed high density in the right sylvian fissure (Fig. 5 *upper left*). Four-vessel DSA and 3-Dimentional CT scan revealed a ruptured aneurysm of right MCA bifurcation, inferior-posterior direction (Fig. 5 *upper right, lower left and lower right*). The HHG was II and FG was III.

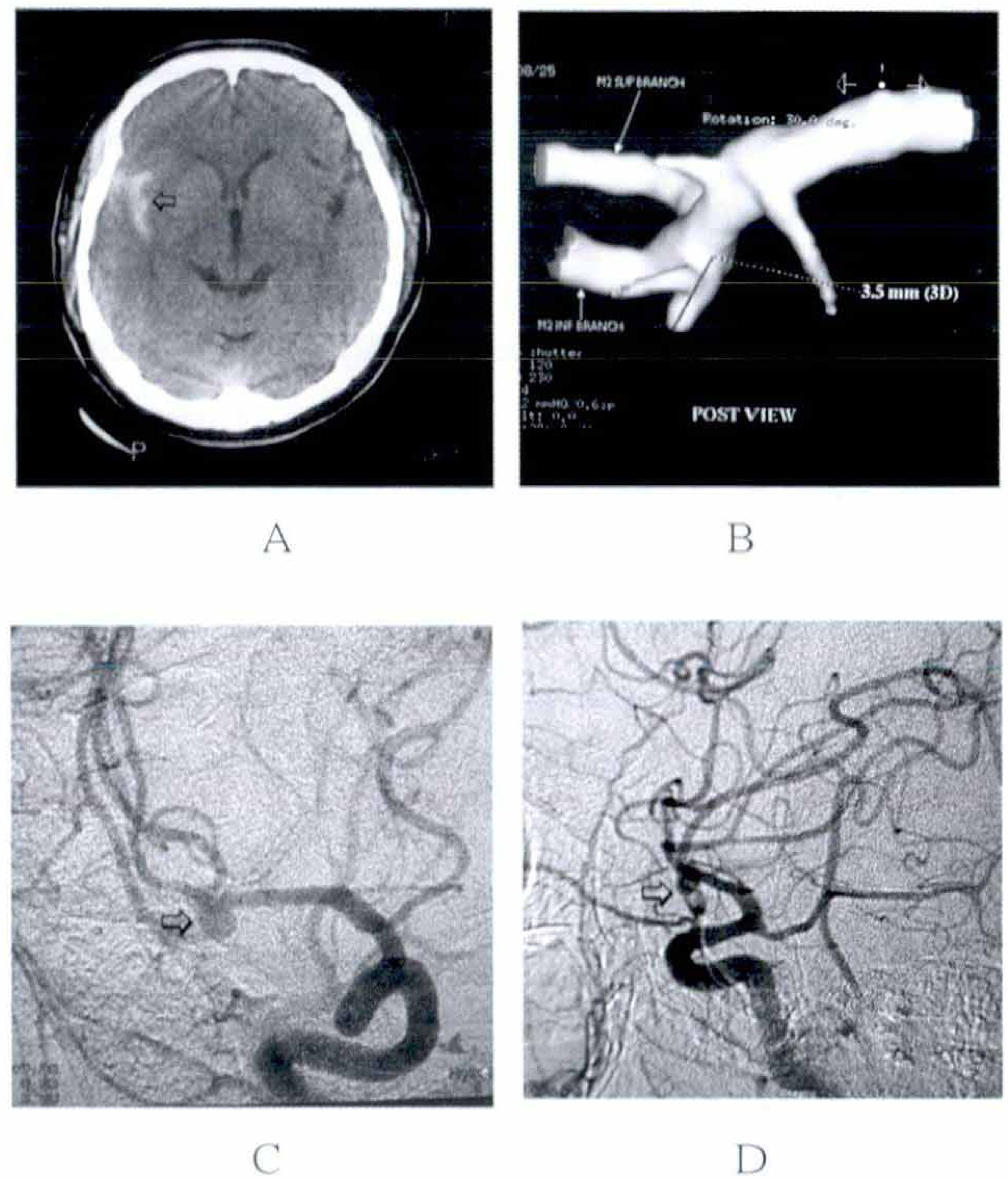


Fig. 6: These 4 films show preoperative result he was checked. A : CT scan shows high density in right sylvian fissure. (FG: II) B : 3-D CT scan shows in MCA bifurcation there is a posterior, inferior aneurysm. C & D : Angiography reveals an aneurysm on MCA bifurcation, posterior and inferior direction. The black arrow indicates the site and direction of the aneurysm.

Operation. Surgery was undergone just on attacking 18 hours with the patient in supine position after general endotracheal anesthesia. The head was fixed with 3-pin Mayfield system and a little tilt toward left side. A right-sided superolateral orbital rim craniotomy approach was performed about 4×2.5 cm ^{2}. Following proximal sylvian fissure dissection, the MCA was found and the bifurcation was exposed directly. The aneurysm was encountered. Complete dissection of adjacent structures was performed. And then a straight clip was used for the lesion. Finally, the bone flap was fixed using 3-hole-miniplate system. No transfusion was done and the operation was done within 3 hours.

Postoperative Course. The patient was alert and no neurological deficit occurred after awaking from general anesthesia. He had only mild periorbital edema and decreased mobility of the eyebrow. But one week later the eyebrow discomfort disappeared. Postoperative CT scan and angiography depicted the results of our operation: well placed clip on the aneurysm lesion (Fig. 6 *left*). No remnant aneurysm neck existed (Fig. 6 *right*). The patient recovered uneventfully. No complication took place. Skin suture was removed at 4 days after operation. Two weeks later, he was discharged with MRS of 0 and surgical result was excellent.

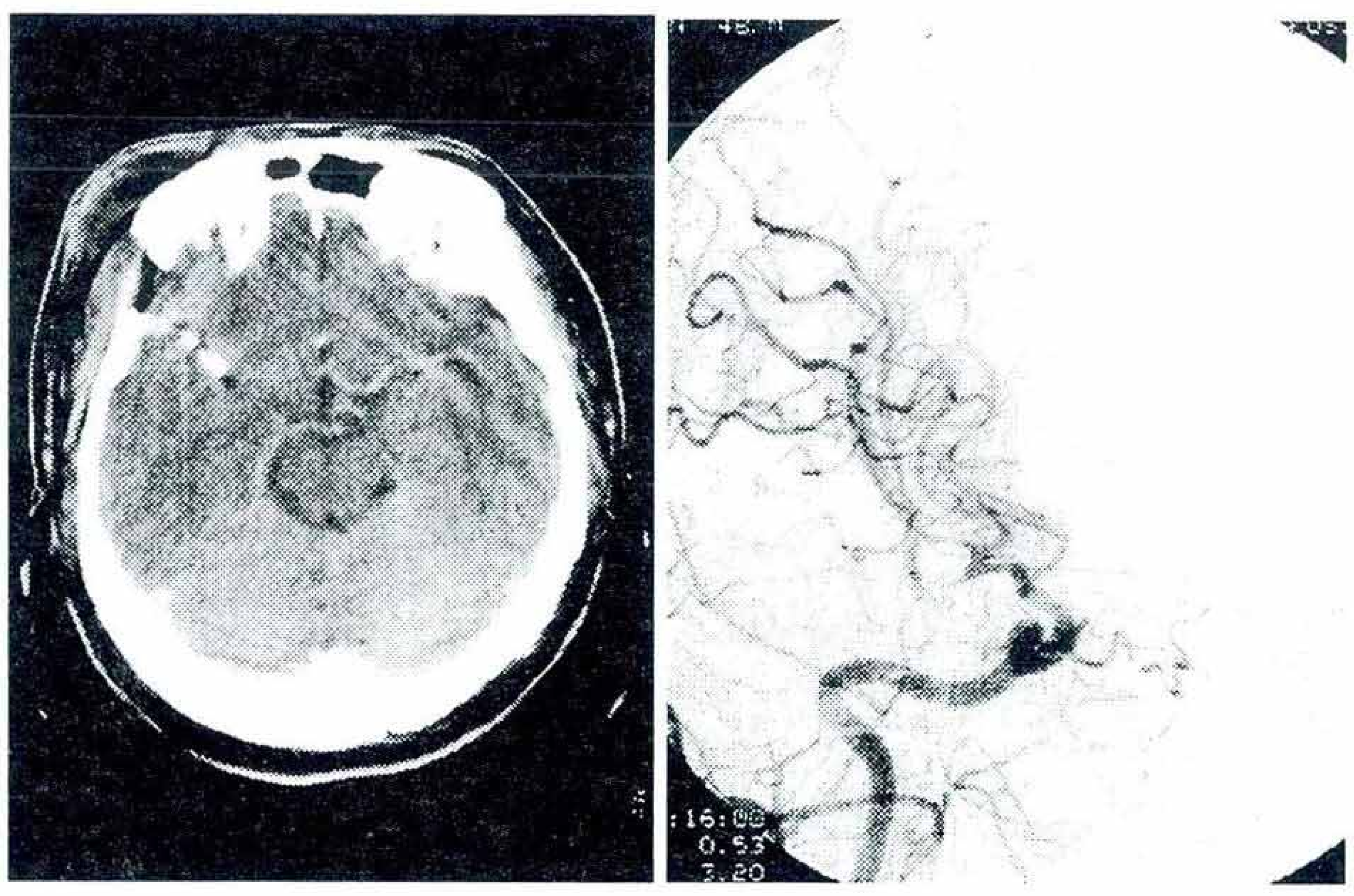


Fig. 7: The postoperative results of this patient. CT scan showed the clip was put in the right place and the bone flap was suitable (A). DSA showed no aneurysm sac was remained. The MCA bifurcation aneurysm was completely clipped (B).

Discussion

The Minimally Invasive Keyhole Concept

The minimally invasive neurosurgery is facing a new tendency and becoming popularized in neurosurgical field[24]. When new things are created, it will be challenged and even be disturbed by the traditional custom. The aim of minimally invasive neurosurgery is to minimize the trauma of surgical intervention but to achieve a satisfied outcome and eventually perform a risk-free surgery. Thus many neurosurgeons now make great efforts to confirm its effectiveness and applications. Keyhole concept is the essential of the minimally invasive neurosurgery. Its implication is not that the craniotomy has the size of a keyhole, just as Perneczky and Fries described in 1998, but that the craniotomy performs a minimally incised corridor to achieve a particular and maximally effective working space for intracranial lesions[22]. Therefore there are two principles to define the keyhole concept: (1) the intracranial optical field widens with increasing distance from the keyhole; (2) contralateral structures are visualized[31]. The advantages of keyhole surgery are reducing the size of craniotomy, less brain retraction, less postoperative complications to produce and acquire a satisfactory cosmetic result.

History

For several years, many neurosurgeons have exercised a great care about how to treat MCA aneurysms efficaciously and achieve sufficient outcome for surgical technique. With the keyhole concept developing little by little, surgical advancement improves the overall survival rate of patients with MCA aneurysms.

In general, all middle cerebral artery aneurysms could be approached by the classical and conventional pterional approach which was provided by Yasargil and Fox in 1975—a frontolateral sphenoid craniotomy modified Dandy's classical approach (1939)[4,10,34,35] and sometimes combined with frontal lobe retraction. Since then most neurosurgeons have approached MCA aneurysms by dissecting and splitting the sylvian fissure and either following the MCA distally to the aneurysm or following its branches proximally to the aneurysm or from the superior temporal gyrus[10]. No matter how to explore the aneurysm lesion, the large craniotomy, wide exposure of surgical area, complete sylvian dissection, long time operation and intensive protection of the adjacent brain structure by sylvian fissure approach are demanded undoubtedly. Therefore, space for brain retraction and hemostasis will be confronted and the normal structure might be damaged occasionally due to large exposure. During the sylvian fissure dissection, it may consume more of surgeon's time and energy to confirm the aneurysm lesion and normal brain tissue around it. Additionally, the field-angle view of pterional approach directing from the sylvian fissure to the bifurcation or proximal end of MCA may result in several procedure related complications[35]. Although the large and extensive exposure of this traditional approach is popularized, a corridor or even a key point to the lesion is the final purpose for the surgical working area. Thus it inspires a lot of neurosurgeons to discard the conventional approach and explore the minimally invasive technique in the aneurysm surgery[3]. The keyhole concept has been introduced into the neurosurgical society.

Jane and his colleagues[12] in 1982 first reported a modification of the old frontal craniotomy-the supraorbital approach which produced adequate exposure and decreased the need for retraction of brain. But their incision was large and no cosmetic effect was acquired. Ten years later, Delashaw et al.[7,8] described a modified supraorbital craniotomy combining with fracture of the anterior orbital roof which was easy to perform and offered wide exposure of the skull base, and the bone segments could be secured easily back into position for an excellent cosmetic result. With the minimally invasive keyhole concept widely accepted in the neurosurgical society, this technique develops further more. Especially the transorbital eyebrow surgery is introduced for the purpose to treat anterior circulation vascular disease, frontal fossa and cavernous sinus lesion[1,2,14,17,18,28,32]. Since 1989 to 1995, van Lindert and Alex Perneczky[31] have used the supraorbital keyhole approach to the supratentorial aneurysm for 291 cases including 48 cases of ipsilateral MCA aneurysms and 2 cases of contralateral ones. But their approach has not included removal of the superolateral orbital rim, which is different from our technique. In 1997, Jho[13] described orbital roof craniotomy via an eyebrow incision. The working space of his approach was about 2x3 size craniotomy sufficient for surgeon to handle two-blade surgical instrument and it could reach orbital, subfrontal, presellar and parasellar lesions. Although the record was only for tumor patients, it gained good results: no brain retraction and no special treatment such as hyperventilation and head elevation were undergone during operation. Paladino and his co-workers[20] applied an eyebrow keyhole approach to operate on intracranial aneurysm. But it was a pity that among 40 aneurysm patients no MCA aneurysm was found. Afterwards transciliary subfrontal craniotomy, transpalpebral orbital roof through eyelid, transorbital craniotomy, frontolateral keyhole craniotomy and lateral orbital rim osteotomy, etc. were all presented[5,9,11,16,20,23,25,26]. More recently, Dare et al.[6] reported eyebrow incision transsupraorbital minicraniotomy. This was very similar to ours and five patients with MCA aneurysms were treated by this approach in Dare' s data. One piece supraorbital craniotomy, measuring 2.5x3.5cm^2 incorporates the orbital rim and roof and the frontal process of the zygomatic bone through an eyebrow incision. The head position was rotation of no more than 10 to 20 degrees. Postoperative complications were periorbital edema, decreased supraorbital sensation and mobility of the eyebrow, etc. The outcome of all their patients was good.

Advantages of Surgical Technique and The Influence Factors

Most middle cerebral artery aneurysms arise at the primary bifurcation of the middle cerebral artery. Although several different surgical approaches can be used by our craniotomy, we prefer a proximal transylvian approach for most aneurysms. It involves opening of proximal sylvian fissure first, then tracing the superior division of the middle cerebral artery to aneurysm and the bifurcation, which is similar with lateral-to-medial transsylvian approach of pterional craniotomy. The proximal transsylvian approach provides excellent exposure of the aneurysm and minimizes the risk of injury to the brain and vascular structures. In some cases we use another approach. For example, we used medial-to-lateral transsylvian approach in 2 patients combined with ruptured

AcomA aneurysm (Case 11 and Case 12) by our craniotomy. The procedure was performed in one-stage operation for clipping of multiple aneurysms. One patient with temporal lobe hematoma (Case 7) was treated with a superior temporal gyrus approach using this craniotomy.

At the same time, we have used the current approach in the treatment of patients presenting with acute subarachnoid hemorrhage and small to medium sized aneurysms and some cases such as large-sized aneurysm, temporal lobe hematoma, multiple aneurysms, poor-grade patients, and bloody CSF. Brain retractor was not used except that the frontal lobe overlaps the temporal lobe within the sylvian fissure or vice versa to avoid further difficult dissection. We never used lumbar drain or external ventricular drainage. No transfusion was given.

Another advantage is that to make lower exposure of the skull base, the temporalis muscle is dissected or even incised partially, but no injury to the frontalis branches of the facial nerve and the superficial temporal artery and no atrophy of the muscle appear because these structures do not cross the surgical field of our approach.

Disadvantages and Limitations of Surgical Technique

Although SLORC approach for MCA aneurysm just described has many advantages: a shorter incision, a small craniotomy, less exposure of the brain, reducing operating time and no transfusion, it leaves us some disadvantages: limited size of the surgical corridor and the poor illumination which could obstacle the operative visualization and restrict manipulation of surgical instruments. Therefore, many neurosurgeons worry about the effectiveness and applications of this keyhole approach. Sometimes it may be dangerous for aneurysm surgery without a thorough visualization around the aneurysm. But it could be solved by several methods: using multiple angles of surgical microscope; intraoperative endoscope-assisted microsurgery[15,21] changing the patient's head to the contra-lateral side etc. All of these are to acquire a maximal view through this minimal approach. Among our patients with MCA aneurysms, only one operation was assisted by endoscope to make illumination and confirm the structure around lesion especially, the lenticulostriate artery. It was not always necessary to use the endoscope or special instrument.

Other factors that have some relationship with our approach should also be noticed: the first is the premature intraoperative ruptured aneurysm. Although unexpected aneurysmal rupture is encountered before proximal control it has not been a big problem. A potential space can be prepared for placement of temporary clip using our approach. Second, if the patient suffered large temporal lobe hemorrhage, that is, poor clinical grade (HHG IV-V), which often occur in MCA aneurysms, or even ICH with diffuse SAH or severe brain edema[27], delayed surgery or other approach may be chosen instead of our method. In addition, MCA giant aneurysm is also contraindication of SLORC approach, which requires full dissection, temporary clip and reconstruction.

Surgical Complications and Outcome.

A lot of references have reported the outcome of the surgical treatment of MCA aneurysms; Yasargil[35] got 7% of 231 patients unfavorable result; Suzuki et al[30] provided 9% poor result; Sundt was 14% frequency for poor results. However all of them assessed on the pterional approach. There are few literatures to describe the results of minimally invasive neurosurgery about MCA aneurysms except Perneczky's 94% effective clipping[21]. Dare and his colleagues[6] recently treated 5 patients with MCA aneurysms by supraorbital minicraniotomy among 9 aneurysm patients in their data and they all got good results after operation.

The general outcome of SLORC approach for MCA aneurysms is good according to our all 10 patients. The modified Rankin scores at discharge and 6 months after operation revealed 0 grade in 10 patients (Table 1). Although the sample of our patients is too small to predict the general tendency of the outcome of this approach, it will serve as some meaningful analysis of inspiration for further exploration.

Furthermore, the procedure related complications are rare, too. Periorbital edema, motionless eyelid and hypesthesia are the most common complications immediately after operation due to retraction of the orbital content, the supraorbital nerve or even injury of them. But this could be prevented by accurate dissection of the periorbital structure, gentle retraction of the orbit, tightness of dura closing suture and shortening the operating time.

Table 1. Preoperative and postoperative clinical characteristics of 12 patients who underwent SLORC approach for MCA aneurysms*

Cas No.	Age (yrs), Sex	Aneurysm Site	HHG	FG	MRS D	MRS FU	Postop complication	Comment
1	38, F	Ruptured aneurysm rt. MCA bif.	II	II	0	0	none	PT approach
2	50, M	Ruptured aneurysm rt. MCA bif.	II	III	0	0	CSF leakage	PT approach
3	45, F	Ruptured aneurysm rt. MCA bif.	II	III	0	0	none	PT approach
4	40, F	Ruptured aneurysm rt. MCA bif.	II	II	0	0	none	PT approach
5	47, F	Ruptured aneurysm rt. MCA bif.	II	III	0	0	none	PT approach, rematupre rupture
6	47, F	Ruptured aneurysm rt. MCA bif.	II	II	0	0	none	PT approach
7	61, M	Ruptured aneurysm rt. MCA M1, TLH	II	IV	0	0	none	STG approach
8	68, F	Ruptured aneurysm lt. MCA bif.	II	III	0	0	none	PT approach
9	45, F	Ruptured aneurysm rt. MCA bif.	III	III	0	0	none	PT approach
10	40, F	Ruptured aneurysm rt. MCA bif.	III	III	0	0	none	PT approach
11	65, F †	Unruptured rt. MCA bif. Aneurysm & Ruptured AcomA aneurysm	III	III	0	0	none	one stage operation, MTL approach
12	54, F †	Unruptured lt. MCA bif. Aneurysm & Ruptured AcomA aneurysm	IV	IV	2	1	HCP and CSF leakage	one stage operation, MTL approach

* bif. = bifurcation; D=discharge; FU= 6 month follow-up; HCP = hydrocephlus MTL = medial to lateral; PT=proximal transsylvian; STG = superior temporal gyrus; TLH = temporal lobe hemorrhage

† The last two patients were ruled out for the outcome assessment.

Conclusions

The SLORC offers equal possibilities of surgical treatment of MCA aneurysms as pterional approach. Although several different surgical approaches can be used, we prefer a proximal transylvian approach for most aneurysms using our craniotomy. In some cases, medial-to-lateral approach or superior temporal gyrus approach was also available. Unexpected aneurysmal rupture before proximal control is obtained has not been a big problem from our experience. Routine use of the brain retractor was not required. It was not always necessary to use the endoscope or special instrument. Furthermore it not only provides more direct to the desired lesion, less sylvian dissection, less brain retraction, no transfusion and shortening operating time, but also will acquire cosmetic results and reduce procedure related complications. Although SLORC approach is a newly developed technique, the result of our patients suggests it might be an optional approach, which fits with surgeon' s philosophy of minimally invasive keyhole concept, and it keeps the principles of excellent surgical techniques and satisfied outcomes. Therefore it is likely that this approach will become a promising operative technique for neurosurgeons to treat MCA aneurysms in the near future.

Table 2. Summary of the postsurgical defects and complications.

Time after operation	Complications or Defects*		
	Hypesthesia (%)	Immobility (%)	Periorbital edema (%)
Just after operation	12(100)	12(100)	12(100)
7 days	4(33)	5(42)	2(17)
15 days	2(17)	1(8)	0(0)
1 month–6 months	0(0)	0(0)	0(0)

* Three factors were evaluated for SLORC approach.

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