

One-Stage Clipping of Bilateral Middle Cerebral Artery Aneurysms Via the Bilateral Pterional Keyhole Approach

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Abstract

Five patients aged 55 to 73 years (mean 63 years) underwent one-stage clipping for unruptured aneurysms in the bilateral middle cerebral arteries (mean size 4.5 mm, range 2 to 7 mm) via the bilateral pterional keyhole approach in our institute. Important points are as follows: the head is affixed with no rotation; one side manipulation is started 5 minutes after the other side to avoid conflict of surgical instruments; a 5-cm curvilinear skin incision is made inside the hairline and pterional keyhole craniotomy is made bilaterally using 2 burr holes; the whole operating table is rotated 15 degrees to one side to facilitate the microsurgical trans-sylvian approach and aneurysm clipping; the operating table is rotated to the other side for the contralateral procedure; and particular care is taken to avoid bilateral brain injury. This approach provided minimum but sufficient working space required for trans-sylvian dissection. Aneurysm neck clipping was safely performed in a mean operation time of 5 hours 17 minutes. No complications occurred and satisfactory cosmetic results were obtained in all patients. Postoperative neuroimaging studies exhibited bilateral complete clipping with minimal intracranial air content and minimum consequences of brain retraction. One-stage clipping via the pterional keyhole approach is a safe and effective therapeutic option for small bilateral aneurysms.

Key words: bilateral aneurysms, cerebral aneurysm, keyhole approach, neck clipping

Introduction

Diagnosis of cerebral aneurysm generally indicates prompt treatment to prevent subarachnoid hemorrhage due to rupture.¹⁾ Cerebral aneurysms are multiple in up to 34% of cases.^{11,14)} Endovascular embolization is thought to be preferable to treat multiple unruptured aneurysms,¹²⁾ but the long-term efficacy has not been proved yet.¹⁾ The rate of hemorrhage after endovascular treatment is 0.9% per year,⁷⁾ whereas that after clipping is 1.4% in 10 years.¹³⁾ Therefore, direct neck clipping under craniotomy might also be a reasonable treatment option for therapeutic resolution despite its invasive nature. Recently, keyhole craniotomy has been used to treat cerebral aneurysms with minimum invasiveness.^{5,6,15)} The modified pterional or sphenoid ridge keyhole approach can overcome limitations of the narrow working space for aneurysm clipping.^{2,8,10)}

We thought that bilateral cerebral aneurysms would be very good candidates for minimally invasive treatment by the keyhole approach, and hoped to apply one-stage clipping for bilateral aneurysms, thus allowing clipping of aneurysms on both sides even if one aneurysm is too small for normal treatment indication. This approach needs careful patient selection and adoption of several specific surgical procedures. We describe our surgical technique and initial treatment outcomes.

Methods

One-stage clipping via a pterional keyhole approach was performed in 5 patients aged 55 to 73 years (mean 63 years) with small unruptured aneurysms of 2–7 mm diameter (mean 4.5 mm) of the bilateral middle cerebral arteries (MCAs) in our institute between 2003 and 2009. Location and size of the aneurysms were evaluated by cerebral angiography, magnetic resonance (MR) angiography, or computed tomography (CT) angiography. Written informed

consent was obtained from all patients.

The technique consisted of the pterional keyhole approach^{2,10)} and application to the bilateral hemispheres. Our method for the pterional keyhole approach induced preemptive analgesia of the supraorbital and infraorbital nerves to prevent postoperative pain of the patient. A curvilinear skin incision 5 cm in length is made inside the hairline from the upper end of the root of the zygomatic arch. The temporal fascia is reflected anteriorly along with the skin flap. The temporal muscle is only reflected posteriorly without incision. This minimal dissection of the temporal muscle facilitates preservation of the superficial temporal artery, deep temporal artery, and frontal branch of the facial nerve. A small pterional craniotomy is created by making burr holes in the pterion and just above the zygomatic arch just anterior to the reflected temporal muscle. The lesser wing of the sphenoid ridge is rongueured until the meningo-orbital band is revealed. The dura mater is opened in a U shape and an additional incision is made along the sylvian fissure to provide a wide working space along the fissure. After positioning the electrode for monitoring the motor evoked potential, the sylvian fissure is opened under the operating microscope. The manipulation

and clipping procedures are similar to the conventional ones through the pterional approach.

The bilateral application of this approach is as follows (Fig. 1). After general anesthesia, the head is fixed with no rotation. To avoid conflict of surgical instruments, one side manipulation is started 5 minutes after the other side. The whole operating table is rotated by 15 degrees to one side to facilitate the unilateral microsurgical trans-sylvian approach and then rotated to the other side for the contralateral procedure. Particular care is taken to avoid bilateral brain injury. Arachnoid plasty is performed before dural closure.

Intraoperative findings were evaluated by the neurosurgeons, and operation time was retrospectively extracted from medical records. Short-term neurological status was assessed before and after surgery along with the short-term cosmetic result from both subjective and objective assessments. Postoperative CT was performed just after the operation, and the aneurysm clipping was evaluated either by cerebral angiography, MR angiography, or CT angiography. Characteristics and surgical outcomes of the 5 patients are shown in Table 1.

Results

The pterional keyhole approach provided the minimal but sufficient working space that was required for the distal trans-sylvian approach in all patients (Fig. 2). One patient underwent clipping of all 3 aneurysms of the bilateral MCAs. Aneurysm neck clipping was safely performed without perioperative morbidity or mortality. Cosmetic results were also satisfactory in all patients. Operation time ranged from 4 hours 20 minutes to 6 hours 16 minutes (mean 5 hours 17 minutes). Postoperative neuroimaging detected minimal intracranial air content and minimal consequences of brain retraction (Figs. 2 and 3). Bilateral complete clipping was confirmed either by cerebral angiography, MR an-

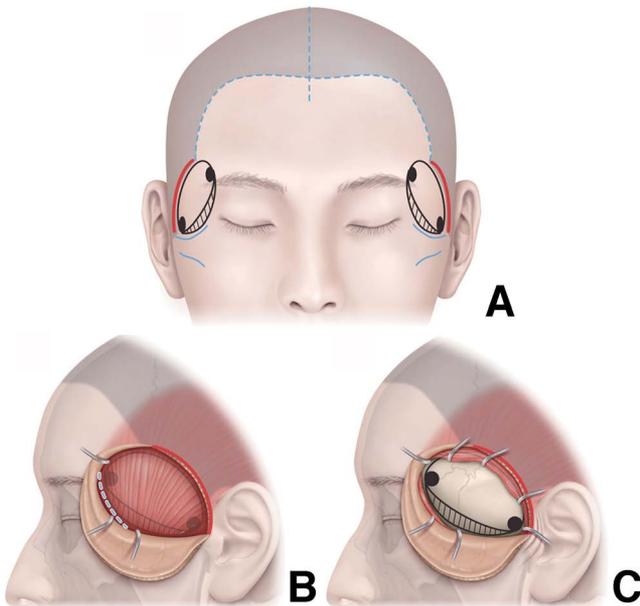


Fig. 1 Schematic drawings of the bilateral pterional keyhole approach. **A:** A 5-cm curvilinear skin incision (red lines) is made from just above the root of the zygomatic arch inside the hairline bilaterally. **B:** The skin flap and the temporal fascia are reflected anteriorly. **C:** The temporal muscle is only reflected posteriorly without incision (blue dotted line in B), and pterional keyhole craniotomy is made by 2 burr holes.

Table 1 Characteristics and surgical outcome of 5 patients

Case No.	Age (years)	Sex	Aneurysm size (mm)	Operation time (hours:minutes)	Follow-up period (years)
1	70	F	7, 4	5:37	1.6
2	68	F	7, 2	4:20	1.8
3	51	F	6, 4, 2	4:32	4.2
4	73	F	6, 4	5:41	3.5
5	55	F	5, 2	6:16	6.4
Mean	63		4.5	5:17	3.5

F: female.

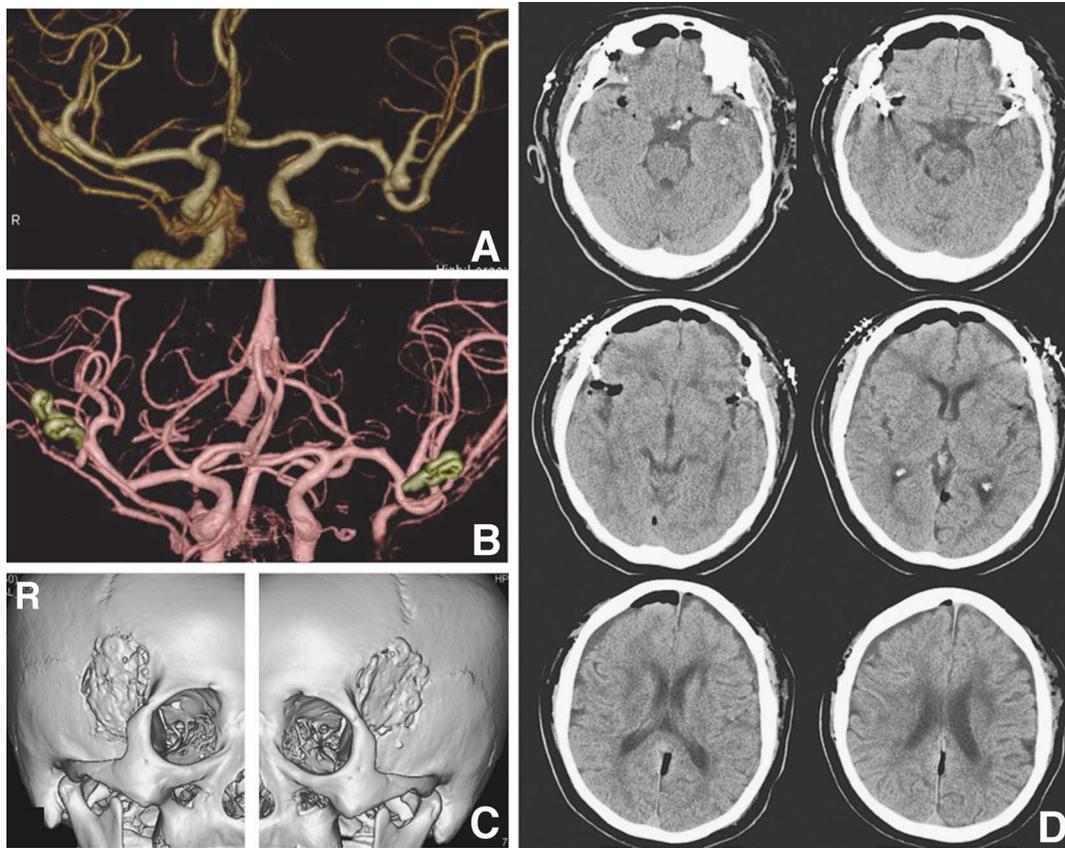


Fig. 2 Illustrative case of one-stage clipping of bilateral middle cerebral artery aneurysms in a 70-year-old woman. **A, B:** Magnetic resonance angiograms showing bilateral middle cerebral artery aneurysms (**A**) were clipped successfully (**B**). **C:** Bone computed tomography (CT) scans indicating the location of the bilateral keyhole craniotomy. **D:** CT scans just after the operation showing minimal intracranial air content and minimal consequences of brain retraction.

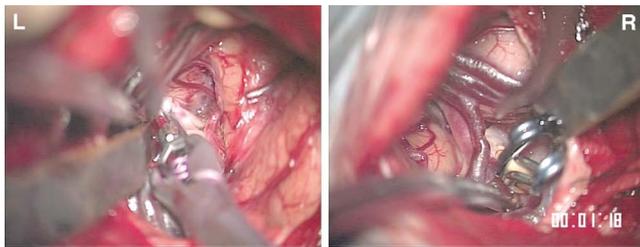


Fig. 3 Intraoperative photographs of the illustrative case in Fig. 2. Aneurysms in both the left (**L**) and right (**R**) sides were clipped with minimal but sufficient working space using standard surgical instruments.

giography, or CT angiography in all patients (Fig. 2). All patients were followed up for a median and mean of 3.5 years after clipping, which disclosed no adverse events including hemorrhage from treated aneurysms.

Discussion

This evaluation of the technical aspects and effectiveness of one-stage clipping of unruptured bilateral MCA bifurcation aneurysms via the bilateral pterional keyhole approach showed that it is extremely important to pay attention to several preconditions to perform this approach safely and effectively. We believe that bilateral cerebral aneurysms are the most suitable use of minimally invasive treatment including the keyhole approach. Our approach has several advantages as follows: treatment is curative with one-time risk of general anesthesia; the procedure is minimally invasive and operation time is acceptably short; the procedure provides minimal but sufficient working space, similar to conventional frontotemporal craniotomy^{8,15}; no special surgical instrument for narrow working spaces, as required for the trans-sphenoidal approach, is necessary; and the operation can be performed using only standard surgical instruments. The supraorbital keyhole ap-

proach sometimes requires special surgical instruments including an endoscope because of the relatively narrow working space,^{5,15)} which may hinder the approach to the proximal M1 for temporary clipping or to manage premature rupture during surgery. Some authors have reported the usefulness of one-stage clipping of bilateral aneurysms via the supraorbital keyhole approach.^{3,6)} However, our approach provides the wider working space that is required for aneurysm clipping via the transsylvian approach.

Bilateral MCA bifurcation aneurysms are relatively common among multiple intracranial aneurysms.¹¹⁾ The present technique was applied only to bilateral MCA aneurysms, but bilateral internal carotid artery aneurysms could be treated after careful patient selection. On the other hand, ruptured aneurysms would not be amenable to our approach because a much wider working space is usually required. Our approach still has some limitations in the angles of observation and dissection, which result in limitations in clip selection and angle of clip applicator.^{5,15)} However, this issue is much less important than in the supraorbital keyhole approach. Considering these limitations, appropriate selection of patients is the key for the success, by careful assessment of the vascular anatomy before surgery.⁴⁾

Our series included some tiny aneurysms (2 mm in diameter). These aneurysms were treated simultaneously with the contralateral aneurysms, and only patients with aneurysms of no less than 5 mm in maximum diameter can be considered within the treatment indications in general.^{9,16)} In addition, multiple occurrences are highly indicative of invasive treatment for smaller aneurysms, because the risk of rupture from multiple unruptured aneurysms is higher than that from single aneurysms.¹⁾ The present technique is minimally invasive, so patients with such small aneurysms, who are not normally candidates for treatment, can be treated in a single stage along with the contralateral side. From this point of view, our technique is extremely useful and reasonable.

One-stage clipping via the bilateral pterional keyhole approach is a safe and effective therapeutic option for small unruptured aneurysms at the bilateral MCA bifurcations. This approach is a promising treatment option because of the minimal invasiveness and satisfactory treatment outcomes. Bilateral cerebral aneurysms are the most suitable target for keyhole craniotomy, but surgical success requires adoption of several specific surgical procedures.

Conflicts of Interest Disclosure

The authors declare that they have no conflict of interest.

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