Minipterional and Supraorbital Keyhole Craniotomies for Ruptured Anterior Circulation Aneurysms: Experience at Single Center

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- BACKGROUND: **Keyhole craniotomy is a type of pterional craniotomy that involves a minimally invasive approach for the treatment of cerebral aneurysms. Currently, the minipterional keyhole craniotomy and supraorbital keyhole craniotomy procedures are frequently performed.**
- METHODS: **We evaluated the feasibility and safety of supraorbital keyhole craniotomies and minipterional keyhole craniotomy for the clipping of ruptured intracranial aneurysms in the anterior cerebral circulation as an alternative to the pterional approach in a consecutive series of 25 patients.**
- RESULTS: **The rate of intraoperative aneurysmal rupture was 8% (2/25), and all ruptures were safely controlled.**
- CONCLUSION: **The success solely depends on careful selection of patients and the experience of the surgical team.**

INTRODUCTION

Minimally invasive surgery has become a standard of care in neurosurgery. Keyhole approaches for treating intracerebral aneurysms are effective and advantageous. Their smaller incisions result in less muscle dissection, minimal craniotomy, and less brain retraction, with a similar microsurgical field and full access to the lesions. These approaches can expose critical anatomic structures that aid in successfully clipping an aneurysm.[1] The minipterional keyhole craniotomy (MPKC) and supraorbital keyhole craniotomy (SOKC) procedures have been developed as alternative modalities for the treatment of unruptured anterior circulation aneurysms.[1-3] However, these approaches have some safety issues, especially when an intraoperative rupture occurs. The small corridor poses a challenge for the neurosurgeon for bleeding control.

Keyhole surgery is not a novel topic for the global neurosurgical community, especially in advanced medical countries. However, in Vietnam, the application of the minimally invasive keyhole approach to intracranial injuries is only beginning in most medical centers. For cases treated with the keyhole approach, complicated injuries such as ruptured aneurysms that require a minimally invasive approach are even more rare. Thus we started this case series to compare its treatment efficacy with that of the traditional approach applied in previous patients. Our objective is to apply the minimally invasive approach to alleviate complications resulting from the conventional approach.

In this article, we describe our experiences treating 25 cases of ruptured aneurysms using MPKC and SOKC approaches and discuss how to avoid and manage intraoperative aneurysm rupture.

METHODS

Approval for the study was issued by the Scientific Research & Medical Ethics Committee at our hospital. Written consent and authorization were obtained before the surgeries and submission of this article.

Key words
- Aneurysm
- Craniotomy
- Keyhole
- Minipterional
- Supraorbital

Abbreviations and Acronyms
AcomA: Anterior communicating artery
CT: Computed tomography
H-H: Hunt and Hess Scale
ICA: Internal carotid artery
IOR: Intraoperative aneurysmal rupture
MCA: Middle cerebral artery
MPKC: Minipterional keyhole craniotomy
PcomA: Posterior communicating artery
SOKC: Supraorbital keyhole craniotomy

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From June 2015 to January 2017, we conducted a prospective case series of 25 patients with ruptured anterior circulation aneurysms. All were treated with clipping using SOKC or MPKC approaches by a single neurosurgical team. All cases presented to the emergency department with subarachnoid, intraventricular, and/or intraparenchymal hemorrhages. We consulted a neurointerventional radiologist for each case and then selected the approaches on a case-by-case basis according to the location of the aneurysm and computed tomography (CT) and CT angiography findings. We excluded patients with severe clinical presentations (Hunt and Hess [H-H] grade IV–V) and/or aneurysm necks >15 mm or hemorrhagic lesions causing a mass effect.

SURGICAL TECHNIQUES

Supraorbital Keyhole Approach

The patient was placed in a supine position, with his or her head elevated 15°, retroflexed, and rotated 20–30° to the contralateral side. A 3.5- to 5-cm skin incision was made within the eyebrow or frontal skin fold, starting from the lateral supraorbital foramen, following the orbital rim, and extending to the end of the scheduled craniotomy. The temporal fascia was incised about 10–15 mm and retracted from the superior temporal line using fish hooks and rubber bands. A single burr hole was drilled at the orbital-zygomatic articulation posterior to the temporal line, and a supraorbital bone flap with a diameter of 2–2.5 cm was created using a high-speed craniotome. If lateral extension was needed, the lesser wing of the sphenoid bone was partially removed (lateral variation of the supraorbital craniotomy).[4,5] After bone flap removal, the inner edge of the bone above the orbit and small osseous extensions of the superficial orbital roof were drilled away to flatten the frontal base.[4,6,7] The dura was opened in a curved fashion. The arachnoid membrane was incised, and cerebrospinal fluid was carefully aspirated at the Sylvian fissure, chiasma, and carotid cistern and allowed to drain until the brain became slack. The Sylvian fissure was opened. The optic nerve, internal carotid artery (ICA), anterior cerebral artery A1 segment, anterior communicating artery (AcomA) complex, and middle cerebral artery (MCA) M1 segment were exposed. The posterior communicating artery (PcomA) and anterior choroidal artery were also visualized. The neck of the aneurysm was exposed and clipped. After surgical field hemostasis was verified, the dura was closed and made watertight using nonabsorbable sutures. The bone flap was replaced and fixed medially and frontally using a titanium miniplate to achieve the best cosmetic results. The skin and muscles were closed in layers without using suction drainage.

Minipterional Keyhole Approach

This approach is a modification of the pterional approach. The Sylvian point is the center of the skin incision and craniotomy. The skin incision was started 1.0 cm above the base of the zygomatic arch, extended posteriorly parallel to the hairline border, and then gradually curved superiorly toward a point crossing the ipsilateral midpupillary line. Dissection of the temporalis muscle and fascia and protection of the frontalis branch of the facial nerve were performed as they are in the classical pterional approach. The muscular flap was retracted posteriorly and caudally to expose the Sylvian point. A burr hole was placed just above the frontozygomatic suture. The bone flap was formed so that it included part of the frontal bone anterior to the lesser wing of the sphenoid and a portion of the temporal bone posterior to the lesser wing of the sphenoid.[8] The remaining part of the sphenoid ridge was deeply drilled away and flattened down to the superior orbital fissure to approach the structures of the skull base. The dural sac was opened in a semilunar fashion, and the Sylvian fissure was visualized at the center of the surgical field. Dissection of the Sylvian fissure was performed directly with microsurgical instruments, without the use of brain spatulas, to expose the M2, M1, ICA, A1, PcomA, ipsilateral optic nerve, and optic chiasm. The aneurysm neck was visualized and clipped. Hemostasis was verified, and the dura was closed and made watertight. The bone flap was replaced and fixed with a titanium plate. The skin and muscles were closed in layers.

Table 1. Subarachnoid Hemorrhage on Computed Tomography (Fisher Scale) at Presentation

Fisher	Grade 1	Grade 2	Grade 3	Grade 4
Patients	6	5	12	2

RESULTS

Twenty-eight aneurysms were clipped in 25 patients. The median age was 55 (range: 32–75) years, with a female-to-male ratio of 14/11. One case had 2 aneurysms that were treated with a single SOKC, and 1 had 3 aneurysms that were clipped by an MPKC. We selected patients with good preoperative conditions (H-H I–III): 21/25 (84%) were H-H I–II cases, and 4 were H-H III (16%) cases. The majority (96%, 24/25) of the cases were evaluated, and the surgical plan was based on the CT angiography results. Only 1 case underwent magnetic resonance angiography. The CT findings of subarachnoid hemorrhages were assessed with the Fisher Scale (Table 1), and the largest percentage of patients (48%, 12/25) were grade 3 (subarachnoid hemorrhage accompanied by ventricular hemorrhage).

All AcomA aneurysms were selected for SOKC, while all MCA aneurysms were treated with MPKC. For ICA and PcomA aneurysms, the approach choice was based on the aneurysm projection (Table 2). In 1 patient, 3 MCA aneurysms were treated via a single MPKC. Another patient had 2 AcomA and ICA aneurysms clipped via a single SOKC.

Table 2. Aneurysm Location

Approach \ Location	AcomA	MCA	ICA	PcomA
Minipterional	0	13*	2	1
Supraorbital	11	0	1†	0

AcomA, anterior communicating artery; MCA, middle cerebral artery; ICA, internal carotid artery; PcomA, posterior communicating artery.
*Single minipterional craniotomy was used to treat a ruptured MCA aneurysm and 2 additional ipsilateral unruptured MCA aneurysms.
†Single supraorbital craniotomy was used to clip a ruptured AcomA aneurysm and an unruptured ICA aneurysm.