CASE REPORT

Nagoya J. Med. Sci. **85**. 157–166, 2023
doi:10.18999/nagjms.85.1.157

Single-lane clipping technique for a ruptured aneurysm of A1 fenestration of the anterior cerebral artery: a case report and literature review

Yuki Kubota[1], Yoshiki Hanaoka[1], Tatsuro Aoyama[2], Yu Fujii[1], Toshihiro Ogiwara[1], Tatsuya Seguchi[2] and Tetsuyoshi Horiuchi[1]

[1]*Department of Neurosurgery, Shinshu University School of Medicine, Matsumoto, Japan*
[2]*Seguchi Neurosurgical Hospital, Iida, Japan*

ABSTRACT

Fenestration of the A1 segment of the anterior cerebral artery is a rare vascular anomaly with a high risk of saccular aneurysm at the proximal end of the A1 fenestration. These aneurysms have a high risk of rupture. However, conventional surgical clipping can be technically challenging due to the anatomical characteristics. We report a case of A1 fenestration with a ruptured aneurysm wherein we successfully achieved complete obliteration of the aneurysm with a new "single-lane" clipping technique. A 64-year-old woman presented with a ruptured saccular A1 aneurysm at the proximal end of an A1 fenestration, resulting in subarachnoid hemorrhage. Microsurgical clipping was attempted; however, adequate exposure of the aneurysm could not be achieved. The recurrent artery of Heubner originated near the distal end of the lateral limb of the A1 fenestration. The lateral limb of the A1 fenestration had no perforating arteries, according to surgical examination. Thus, the aneurysm neck and lateral limb were concurrently obliterated using a nonfenestrated clip, preserving the medial limb of the A1 fenestration. The antegrade flow of the recurrent artery of Heubner was detected using the retrograde flow of the distal part of the lateral limb of the A1 fenestration during intraoperative indocyanine green video angiography. The postoperative course was uneventful without any evidence of ischemic stroke. For A1 aneurysms arising from the proximal end of the A1 fenestration, this technique may be a useful treatment option. Before using this technique, careful surgical exploration should be performed to assess the A1 perforating arteries.

Keywords: A1 aneurysm, anterior cerebral artery, medial lenticulostriate artery, nonfenestrated clip, subarachnoid hemorrhage

Abbreviations:
ACoA: anterior communicating artery
MLA: medial lenticulostriate artery
RAH: recurrent artery of Heubner

Received: December 28, 2021; accepted: March 2, 2022
Corresponding Author: Yoshiki Hanaoka, MD, PhD
Department of Neurosurgery, Shinshu University School of Medicine,
3-1-1 Asahi, Matsumoto 390-8621, Japan
E-mail: hanaoka@shinshu-u.ac.jp

INTRODUCTION

Fenestration of the A1 segment of the anterior cerebral artery is a rare but clinically important vascular anomaly.[1,2] It is frequently associated with saccular aneurysm at the proximal end of the fenestration. These aneurysms have a high risk of rupture, even when small.[3-15] Thus, surgical management of A1 fenestration aneurysms is commonly required to achieve a favorable outcome. However, surgical exposure of these aneurysms can be technically challenging due to the unique anatomical features at that location.

We have devised a new surgical clipping technique to concurrently obliterate the aneurysm neck and one limb of the A1 fenestration using a nonfenestrated clip, preserving the other limb of the A1 fenestration. We call this the single-lane clipping technique. Here we present a case of ruptured A1 fenestration aneurysm that was successfully treated with the single-lane clipping technique. We also review the literature on cases of A1 fenestration aneurysm treated with surgical clipping.

CASE REPORT

A 64-year-old woman with no medical history presented to our hospital with a sudden onset headache. On admission, her score on the Glasgow Coma Scale was 14 (E3V5M6). No neurological deficits were present. A computed tomography scan revealed a diffuse subarachnoid hemorrhage (Figure 1A). An angiography found the following: 1) An A1 fenestration in the distal part of the left A1 segment; 2) The recurrent artery of Heubner (RAH) originating from the distal part of the lateral limb of the A1 fenestration; 3) A saccular A1 aneurysm (2.9 mm) arising from the proximal end of the A1 fenestration; and 4) A saccular anterior communicating artery (ACoA) aneurysm (2.4 mm) (Figures 1B, 1C). The A1 fenestration aneurysm projected superomedially, whereas the ACoA aneurysm projected anteriorly (Figures 1B, 1C). Due to the small size of the aneurysms, emergency clipping surgery was scheduled. The patient underwent microsurgical clipping via a left pterional approach. Figure 2A shows a preoperative three-dimensional rotational angiography corresponding to the surgical field. Surgical exploration demonstrated that the ACoA aneurysm was unruptured. A 4-mm bayonet clip (Yasargil Aneurysm Clip System, FT727T; Aesculap, Tuttlingen, Germany) was successfully applied to the neck of the ACoA aneurysm. Subsequently, surgical clipping of the A1 fenestration aneurysm was attempted. The lateral limb of the A1 fenestration, the RAH, and the medial limb of the A1 fenestration were identified (Figure 2B). Careful intraoperative inspection revealed that there were no medial lenticulostriate arteries (MLAs) arising from the lateral limb of the A1 fenestration (Figure 2B). A dense fibrin cap covered the A1 fenestration aneurysm, suggesting a rupture. The aneurysm neck on the side of the medial limb of the A1 fenestration was exposed but the aneurysm neck on the side of the lateral limb of the A1 fenestration could not be adequately visualized as it was behind the lateral limb of the A1 fenestration (Figure 2B). Thus, sufficient exposure of the A1 aneurysm was technically challenging. A 7-mm nonfenestrated straight clip (Yasargil Aneurysm Clip System, FT720T; Aesculap) was applied to both the aneurysm neck and the proximal part of the lateral limb of the A1 fenestration while preserving the medial limb of the A1 fenestration. This changed the two-lane vessel to a single-lane vessel (Figure 2C). The following was revealed by intraoperative indocyanine green video angiography: 1) The A1 fenestration aneurysm had no indocyanine green filling; 2) The antegrade flow in the anterior cerebral artery was preserved via the medial limb of the A1 fenestration; and 3) The antegrade RAH flow was maintained via the retrograde flow of the distal part of the lateral limb of the A1 fenestration (Figure 2D).

Additional clipping using a 5-mm nonfenestrated straight clip (Yasargil Clip System, FT710T; Aesculap) was performed (Figure 2E).

The postoperative course was uneventful. Postoperative angiography showed complete obliteration of both the ACoA and A1 aneurysms as well as patency of the medial limb of the A1 fenestration and RAH (Figure 3A). Postoperative magnetic resonance imaging found no evidence of ischemic stroke (Figure 3B). On postoperative day 48, the patient was discharged with no neurological deficits. The patient is clinically stable without disability three months after the surgery.

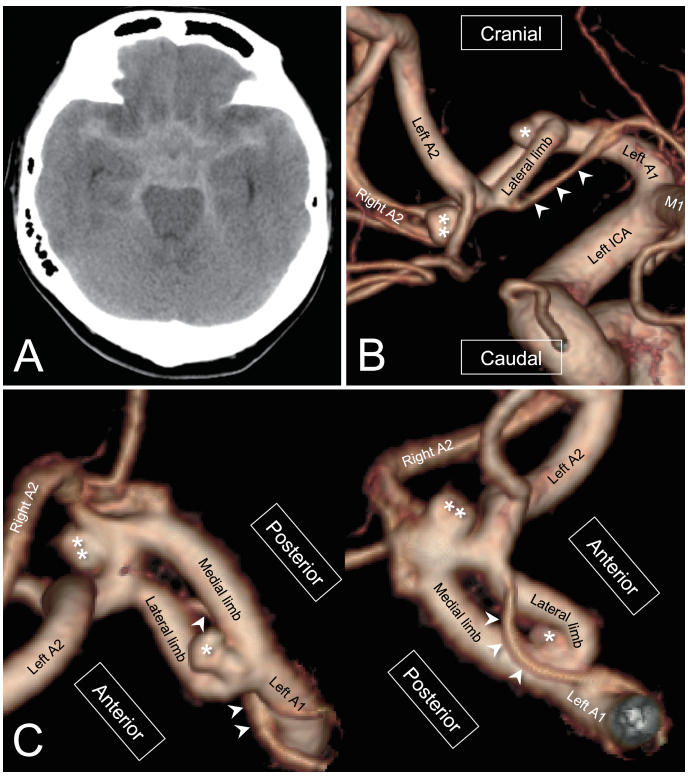

Fig. 1 Preoperative computed tomography (CT) (A) and three-dimensional rotational angiography (3D-RA) of the left internal carotid artery injection (B, C)

Fig. 1A: Preoperative CT showing diffuse subarachnoid hemorrhage.

Fig. 1B: Antero-posterior view of preoperative 3D-RA showing a fenestration in the distal part of the A1 segment of the anterior cerebral artery (ACA). A saccular aneurysm can be seen arising from the proximal end of the A1 fenestration (single asterisk) and the anterior communicating artery aneurysm (double asterisk). The recurrent artery of Heubner (arrowheads) originates from the lateral limb of the A1 fenestration.

Fig. 1C: Cranial view (left) and caudal view (right) of a preoperative 3D-RA depicting the ACA. The A1 fenestration aneurysm projects superomedially and is located in a narrow space enclosed with the A1 fenestration.

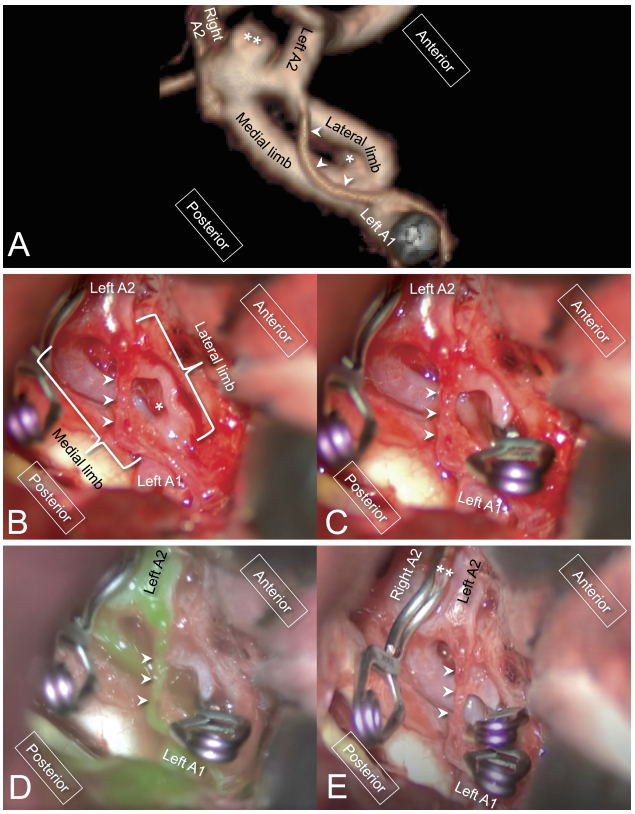

Fig. 2 Preoperative three-dimensional rotational angiography (3D-RA) (A) and intraoperative video images (B, C, D, E)

Fig. 2A: Preoperative 3D-RA corresponding to the surgical field (caudal view). The medial limb of the A1 fenestration, the lateral limb of the A1 fenestration, the recurrent artery of Heubner (arrowheads), the anterior communicating artery (ACoA) aneurysm (double asterisk) were found. Note that only the neck of the A1 fenestration aneurysm (single asterisk) is visible.

Fig. 2B: A microsurgical view through the left pterional approach after clipping of the ACoA aneurysm. The neck of the A1 fenestration aneurysm (single asterisk) on the side of the lateral limb could not be adequately visualized as the neck was behind the lateral limb. Surgical exploration revealed that the lateral limb had no A1 perforating arteries except for the recurrent artery of Heubner (arrowheads).

Fig. 2C: The aneurysm neck and the lateral limb were concurrently obliterated with a nonfenestrated straight clip, preserving the medial limb.

Fig. 2D: Intraoperative indocyanine green angiography with GLOW800 (Leica Microsystems, Wetzlar, Germany) showed obliteration of the A1 fenestration aneurysm and patency of the A2 segment and recurrent artery of Heubner.

Fig. 2E: A second clip was placed parallel to the first to reinforce the closure.

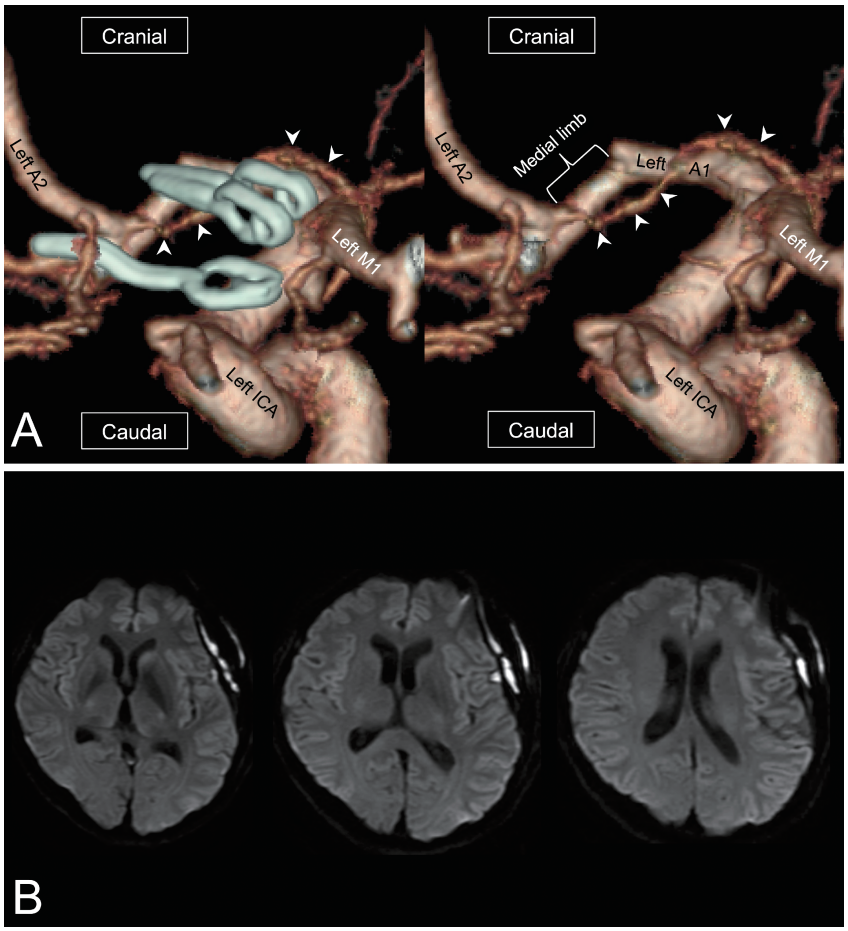

Fig. 3 Postoperative three-dimensional rotational angiography (3D-RA) (A) and diffusion-weighted imaging (DWI) (B)

Fig. 3A: The anterior communicating artery aneurysm and the A1 fenestration aneurysm were completely obliterated, preserving the medial limb of the A1 fenestration and recurrent artery of Heubner (arrowheads).

Fig. 3B: A postoperative DWI showed no evidence of ischemic stroke.

DISCUSSION

A review of the literature identified 19 cases of A1 fenestration aneurysms treated with surgical clipping. These are shown in Table 1.[3-18] We have included our own for comparison. The cases comprised 11 males and 9 females with a mean age of 55.7 years (range: 33–78 years). All 20 aneurysms were saccular, and 15 (75.0%) were ruptured. In 18 cases (90.0%), the aneurysm was located at the proximal end of the A1 fenestration. Of the remaining two, one (5.0%) aneurism was located on the medial limb of the A1 fenestration and one (5.0%) on the lateral limb of the A1 fenestration. Of the 20 cases, aneurysm projections were described in 18 cases: superomedial projections in 13 cases (72.2%), inferior projections in two cases (11.1%), medial projections in two cases (11.1%), and an inferomedial projection in one case (5.6%). Aneurysm size was recorded in 11 of the 20 cases. The mean aneurysm size was 5.4 mm (range: 2.9–10.0 mm).

Table 1 Cases of A1 fenestration aneurysms treated with surgical clipping

Authors	Age (years)/ sex	A1 fenestration aneurysm				Associated vascular anomalies	Surgical procedure	Clip shape	Surgical complications	Outcome (GOS) at discharge
		Type	Location	Projection	Size (mm)					
Korosue et al[3] (1983)	41/M	Ruptured	Proximal end of right A1 fenestration	Superomedial	NA	None	Simple neck clipping	NA	None	D
Handa et al[4] (1984)	50/F	Ruptured	Proximal end of right A1 fenestration	Superomedial	NA	NA	Simple neck clipping	NA	NA	GR
Minakawa et al[5] (1985)	56/M	Ruptured	Proximal end of left A1 fenestration	Superomedial	NA	Extracranial VA fenestration	Simple neck clipping	NA	NA	NA
Wakabayashi et al[6] (1985)	41/M	Ruptured	Proximal end of right A1 fenestration	NA	5.0	None	NA	NA	NA	D
	38/M	Ruptured	Proximal end of right A1 fenestration	NA	6.5	None	NA	NA	NA	MD
Friedlander et al[7] (1996)	33/M	Ruptured	Proximal end of right A1 fenestration	Superomedial	NA	Contralateral A1 fenestration and azygos ACA	Simple neck clipping	NA	None	GR
Kachhara et al[8] (1998)	50/F	Ruptured	Proximal end of right A1 fenestration	Superomedial	NA	Contralateral A1 aplasia	Simple neck clipping	NA	None	GR
Ogasawara et al[9] (1988)	65/F	Ruptured	Proximal end of left A1 fenestration	Inferior	NA	None	Simple neck clipping with wrapping	NA	NA	VS
Talor et al[10] (2000)	68/M	Ruptured	Medial trunk of left A1 fenestration	Inferior	5.0	Ipsilateral M1 hypoplasia	Simple neck clipping	NA	None	GR
Wanibuchi et al[16] (2001)	52/F	Unruptured	Proximal end of left A1 fenestration	Superomedial	4.3	None	Simple neck clipping	NA	None	GR
Ihara et al[11] (2003)	78/F	Ruptured	Lateral trunk of left A1 fenestration	Superomedial	NA	Contralateral A1 hypoplasia and azygos ACA	Simple neck clipping	Non-fenestrated clip	None	GR
Leyon et al[12] (2008)	49/M	Ruptured	Proximal end of right A1 fenestration	Superomedial	4.0	None	Simple neck clipping	Non-fenestrated clip	None	GR
Aktüre et al[13] (2012)	50/F	Ruptured	Proximal end of right A1 fenestration	Superomedial	NA	Contralateral A1 fenestration	Simple neck clipping	Non-fenestrated clip	None	GR

doi:10.18999/nagjms.85.1.157

Kwon et al[14] (2013)	59/F	Ruptured	Proximal end of right A1 fenestration	Inferomedial	2.9	MCA aneurysm, azygos ACA, and contralateral A1 aplasia	Simple neck clipping	Non-fenestrated clip	None	GR
Iwabuchi et al[17] (2018)	72/M	Unruptured	Proximal end of left A1 fenestration	Superomedial	10.0	NA	Clipping of aneurysm neck and lateral limb of A1 fenestration	Fenestrated clip	None	GR
	73/M	Unruptured	Proximal end of left A1 fenestration	Superomedial	7.0	NA	Clipping of aneurysm neck and lateral limb of A1 fenestration	Fenestrated clip	None	GR
Gill et al[15] (2019)	49/F	Ruptured	Proximal end of right A1 fenestration	Superomedial	8.0	Contralateral A1 hypoplasia and azygos ACA	Simple neck clipping	Fenestrated clip	None	GR
Mamadaliev et al[18] (2019)	62/M	Unruptured	Proximal end of right A1 fenestration	Medial	4.2	None	Simple neck clipping	Fenestrated clip	None	GR
	63/M	Unruptured	Proximal end of right A1 fenestration	Medial	NA	None	Simple neck clipping	Non-fenestrated clip	None	GR
Current case	64/F	Ruptured	Proximal end of left A1 fenestration	Superomedial	2.9	ACoA aneurysm	Clipping for aneurysm neck and lateral limb of A1 fenestration	Non-fenestrated clip	None	GR

ACA: anterior cerebral artery
ACoA: anterior communicating artery
D: death
F: female
GOS: Glasgow Outcome Scale
GR: good recovery
M: male
MCA: middle cerebral artery
MD: moderate disability
NA: not available
VS: vegetative state
VA: vertebral artery

doi:10.18999/nagjms.85.1.157

Simple neck clipping for A1 fenestration aneurysms can be technically problematic. Most of the A1 fenestration aneurysms in our literature review were ruptured at presentation and projected superiorly. Therefore, frontal lobe retraction should be minimized to prevent premature rupture of aneurysms.[12] Given the surgical trajectory, aneurysm projection, and narrow operative space, it can be challenging to entirely expose aneurysms arising from the proximal end of an A1 fenestration. Particular attention must be paid to the preservation of the A1 perforating arteries, including the MLAs and RAH. The MLAs supply the septum pellucidum, the medial part of the anterior commissure and pallidum, the pillars of the fornix, the paraolfactory area, the anterior limb of the internal capsule, the anterior-inferior part of the striatum, and the anterior hypothalamus. The RAH perfuses the anterior-inferior striatum, the anterior limb of the internal capsule, the olfactory region, the anterior hypothalamus (overlapping the MLAs), the frontobasal cortex, and subcortical white matter.[19] Therefore, serious neurological deficits can result from damage to these arteries.

Small aneurysms are a well-known risk factor for aneurysm perforation during cerebral aneurysm coil embolization.[20] Both the ACoA and A1 fenestration aneurysms were small in this patient. Thus, we employed clipping surgery for the aneurysms. The clip head used for the ACoA aneurysm did not appear to interfere with the clipping of the A1 fenestration aneurysm because the ACoA aneurysm was located in the deep operative field compared to the A1 fenestration aneurysm. Hence, initially, the ACoA aneurysm was clipped, followed by the A1 fenestration aneurysm. Simple neck clipping was considered technically difficult and potentially hazardous because surgical exposure of the A1 fenestration aneurysm could not be adequately achieved. A previous report found that the vital MLAs commonly arise from the medial limb of an A1 fenestration.[12] In our case, no MLAs arose from the lateral limb of the A1 fenestration. Therefore, the aneurysm neck and the proximal part of the lateral limb of the A1 fenestration were concurrently obliterated with a nonfenestrated clip, preserving the medial limb of the A1 fenestration. Additional clipping was performed to reinforce the closure.

This technique enables neurosurgeons to achieve aneurysm neck clipping without total exposure of an A1 fenestration aneurysm. Neck clipping of A1 fenestration aneurysms using fenestrated clips has been reported.[16] However, neurosurgeons must pay meticulous attention to both the tip and heel of the fenestrated clip blade to place the clip correctly through the limited surgical field.[16] The single-lane clipping technique is simple as neurosurgeons need only ensure that the tip of the nonfenestrated clip blade does not clip the medial limb of the A1 fenestration. This technique can be a useful treatment option for A1 aneurysms arising from the proximal end of A1 fenestrations, especially for ruptured and superiorly projecting aneurysms, which account for most A1 fenestration aneurysms.

Perforator territory infarction can occur as a result of delayed thrombosis at the occluded parent artery's blind end.[21,22] The MLAs mostly originate from the proximal part of the A1 segment.[19] The A1 fenestration is commonly located in the distal part of the A1 segment.[23] Therefore, our method may be applied in many cases of A1 fenestration aneurysms. However, before applying this method, surgical exploration is essential to evaluate whether A1 perforating arteries arise from the target limb of the A1 fenestration.

AUTHOR CONTRIBUTION

YK and YH contributed equally as first authors to this work.

CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

ETHICS APPROVAL

This study was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments.

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