



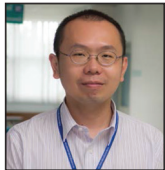
Original Article

Anterior temporal approach for clipping of ruptured basilar tip aneurysms: Surgical techniques and treatment outcomes

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ABSTRACT

Background: Basilar tip (BT) aneurysms are challenging to treat with microsurgical clipping, especially in subarachnoid hemorrhage cases. The anterior temporal approach is one of the surgical approaches for the treatment of aneurysms in this area. The majority of the previous reports on this approach have described unruptured cases. For the ruptured cases assessed in our study, the authors describe the surgical technique, patient characteristics, and surgical outcomes following the use of this technique.

Methods: Fourteen patients with ruptured BT aneurysms who received aneurysm clipping with an anterior temporal approach between December 2015 and August 2019 were retrospectively evaluated. The surgical techniques are described, an illustrative case is shown.

Results: The average patient age was 62.2 years (range: 46–78) for ten women and four men. Nine patients (64.3%) were classified as having a poor grade (World Federation of Neurosurgical Societies Grades 4 and 5) at the first presentation. All of the cases demonstrated complete aneurysm obliteration. Good outcomes (mRS 0 to 2) at 6 months were achieved in 58.3% of the patients and in 77.8% of the patients who had a good Glasgow Coma Score after resuscitation before surgery. Postoperative transient oculomotor nerve palsy and thalamic infarctions were detected in six patients (42.9%) and two patients (14.3%), respectively.

Conclusion: With appropriate case selection, the anterior temporal approach was effective and safe for the clipping of ruptured BT aneurysms.

Keywords: Anterior temporal approach, Basilar bifurcation aneurysm, Basilar tip aneurysm, Ruptured aneurysm

INTRODUCTION

The surgical treatment of basilar tip (BT) or basilar bifurcation aneurysms remains a challenge, especially in situations of subarachnoid hemorrhage. The surgical approach for BT aneurysms by itself is very complicated because the aneurysms are situated in the center of the skull base and are covered by critical structures such as internal carotid arteries (ICAs), posterior communicating arteries, posterior cerebral arteries, and many perforators.^[22,36] In addition, in ruptured cases, the surgical corridor is always limited due to brain swelling, resulting in higher rates of surgical morbidity. Due to better clinical outcomes and the avoidance of surgical complications, the recent trend in aneurysm treatment has shifted to endovascular treatment.^[12,18,24,26,33,36] Although better

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outcomes are accomplished with endovascular treatment, the rates of recurrence and further bleeding in the long-term are more frequent,^[24] with a lower obliteration rate of the aneurysms.^[32]

For BT aneurysm treatment, especially in complex cases or in conditions for which endovascular treatments are unavailable, open surgery for aneurysm clipping is still indicated.^[17,23,36] The appropriate surgical approach and careful selection of the patients are very important to reduce surgical morbidity.^[36]

Several surgical techniques have been described for BT aneurysm clipping. A well-known pterional transsylvian approach by Yasargil *et al.*^[38] and a subtemporal approach by Drake^[4] have been commonly used by most neurosurgeons. Later-developed approaches are combinations of the pterional and subtemporal approaches, such as the temporopolar approach by Sano,^[29] the pretemporal transzygomatic transcavernous approach by Krisht and Kadri,^[16] the extended lateral (half-and-half) approach by Drake^[5] and Bendok *et al.*,^[2] the pterional/anterior temporal approach by Heros and Lee,^[10] the pretemporal approach by de Oliveira *et al.*,^[3] and the transsylvian-trans-uncal approach by Post *et al.*^[28]

The anterior temporal approach, which is also called the modified distal transsylvian approach, was developed for approach to the upper basilar artery^[6-8,13,22,23,34] in the anterolateral direction and for access to an aneurysm arising from the posterior wall of the ICA.^[37] This approach allows a wide corridor through the retrocarotid space to the upper basilar region by posterolateral retraction of the temporal lobe without sacrificing any veins.^[13] Good results have been reported, but the majority of these reports involved unruptured cases.^[22,23]

The aims of our study were to evaluate the surgical outcomes and surgical complications and to describe the surgical techniques of the anterior temporal approach for clipping the ruptured BT aneurysms with illustrative cases.

MATERIALS AND METHODS

Between December 2015 and August 2019, we retrospectively reviewed patients with ruptured BT aneurysms. During this period of time, the patients needed to undergo open surgery due to the unavailability of endovascular instruments and financial issues. Our selection criteria for open surgery were good grade patients as well as poor grade patients whose consciousness improved after resuscitations, such as intubation and ventriculostomy. The inclusion criteria were as follows: (1) patients with ruptured BT aneurysm; (2) patients in whom the anterior temporal approach was successfully used for aneurysm clipping; and (3) patients with an aneurysm that was not more than 15 mm in size. Cases in which bypass surgery had been performed were excluded from our study.

The following preoperative data were collected and analyzed: age, gender, World Federation of Neurosurgical Societies (WFNS) grade (WFNS Grades 1, 2, and 3 are defined as good grade; WFNS Grades 4 and 5 are defined as poor grade), Glasgow Coma Score (GCS) after resuscitation, aneurysm size, aneurysm projection, height of aneurysm neck from the clinoid line (the straight line connecting the superior surface of the anterior clinoid process and the tip of the posterior clinoid process), additional skull base technique (zygomatic arch osteotomy, posterior clinoid process removal, postoperative thalamic infarction, postoperative oculomotor nerve palsy, and Modified Rankin Score (mRS) 6 months after discharge.

Our exclusion criterion for the use of the anterior temporal approach was the lack of space for proximal control at the basilar trunk. In patients with low-positioned BT aneurysms (aneurysm neck was more than 3 mm below the clinoid line), the subtemporal transtentorial approach was selected.

Operative techniques

Since December 2015, our first choice for an approach to the BT aneurysm was the anterior temporal approach. We selected the side of the surgical approach as the side that was more narrowly angled between the aneurysm neck and the posterior cerebellar artery (PCA), the lower position of the P1 segment of the PCA, and the nondominant posterior communicating artery. We also added a zygomatic arch osteotomy for high-positioned aneurysms that were more than 5 mm above the clinoid line. We also performed a posterior clinoidectomy in cases where the aneurysm neck was situated at or below the level of the posterior clinoid process to increase space for proximal control.^[14,15,22,23,33]

The patient was placed in the supine position with the head of the bed approximately 30 degrees above the level of the heart. The patient's face was turned to the opposite side approximately 35–45 degrees with the vertex parallel to the floor and the neck extended in the sniffing position [Figure 1a and b]. In cases with high-positioned aneurysm, a slightly down vertex was needed. The pterional incision was made with the preservation of the superficial temporal artery [Figure 2a-d]. The scalp flap was created just above the superficial temporal fascia and was reflected anteriorly; then, the temporalis muscle was dissected from the pterion and the frontozygomatic process and retracted posteroinferiorly. If a zygomatic arch osteotomy was needed for the transzygomatic anterior temporal approach, an interfascial dissection was used, and the zygomatic arch, including the marginal process, was cut with a craniotome before pterional craniotomy. A frontotemporal craniotomy was completed, and then the sphenoid ridge and anterior skull base were drilled until flat. The dura was opened in a "C" shape with its base on the sphenoid ridge and covered the Sylvian fissure for as long as

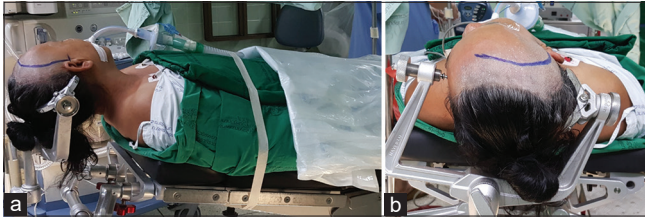


Figure 1: Surgical position for the anterior temporal approach. (a) The head of the bed was 30 degrees above the level of the patient's heart. The vertex of the head was parallel to the floor, and the neck was extended in the sniffing position. (b) The face was turned away from the side of the operation by approximately 35–45 degrees.

possible [Figure 3a]. In patients with marked hydrocephalus and brain swelling, intraoperative ventriculostomy at Kocher's point, or opening of the lamina terminalis through the subfrontal route were performed before opening the Sylvian fissure. The route of Sylvian vein drainage was observed at the pretemporal dura to determine the entrance point of Sylvian fissure dissection. In cases, where the Sylvian vein drained to the cavernous sinus, the temporal side of the Sylvian vein was selected for dissection [Figure 3b]. In cases, where the Sylvian vein drained to the pterygoid plexus or superior petrosal sinus, the frontal side of the Sylvian vein was the target, and the frontobasal bridging veins were usually divided. The sphenobasal or sphenopetrosal veins were separated from the temporal dura for as long as possible to facilitate the posterior retraction of the temporal lobe. An extradural temporopolar approach was also an option in cases where the Sylvian vein drainage adhered to the temporal lobe and obscured the surgical corridor. With this technique, the entry point of Sylvian vein drainage to the skull base was preserved. If several Sylvian veins and tributaries were found and obstructed the corridor, the dissection side was changed depending on the intraoperative findings.^[23] Sharp dissection with microscissors under a high-magnification microscope was accomplished in an “outside in-inside out” fashion from the distal Sylvian fissure (approximately 5 cm or more from the temporal tip) to the temporal tip. Brain spatulas were used to separate and to elevate the frontal and temporal lobes. M2, M1, and then the ICA were identified. The anterior temporal arteries were mobilized from the medial temporal lobe. The brain spatula was inserted between the anterior temporal arteries and the medial temporal lobe to retract the temporal lobe posterolaterally. The arachnoid membranes between the temporal uncus and anterior choroidal arteries were incised. Then, the temporal uncus was retracted posteriorly to expose the retrocarotid triangle and oculomotor nerve [Figure 3b]. The arachnoid membranes around the oculomotor nerve were sharply incised with microscissors before the mobilization of the nerve [Figure 3c]. Through the retrocarotid space, the ipsilateral P2 and P1 were identified. The basilar trunk should be secured for proximal control before basilar

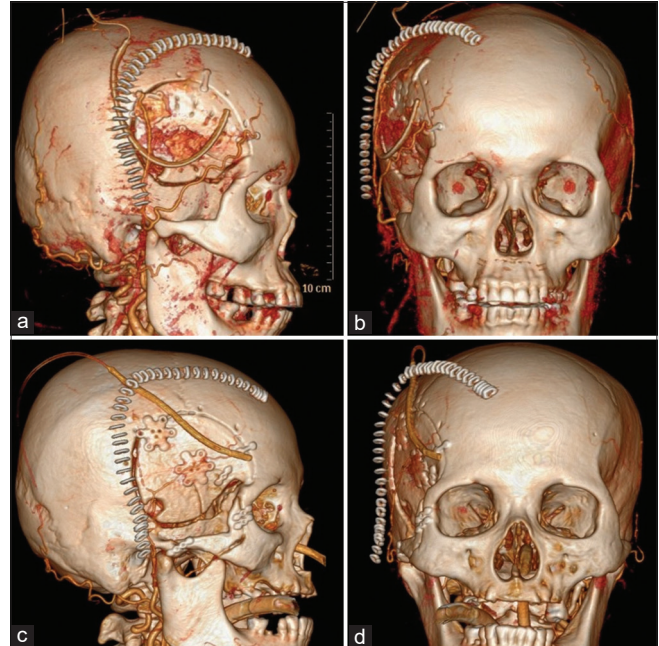


Figure 2: Postoperative three-dimensional computed tomography angiography. The skin stapler shows a skin incision with a relationship to the superficial temporal artery. The shape of the skull flap is also demonstrated (a and b). Skin incision and frontotemporal craniotomy for the anterior temporal approach (c and d). Skin incision, zygomatic arch osteotomy, and craniotomy were performed for the transzygomatic anterior temporal approach.

bifurcation and aneurysm exposure [Figure 3d]. In cases of low positioned BT, a posterior clinoidectomy should be performed to expose the basilar artery. Temporary clip placement of the basilar trunk in the perforator-free zone was completed before the identification of basilar bifurcation and contralateral P1. The aneurysm neck and surrounding perforating arteries were identified [Figure 3d]. Through the retrocarotid space, a permanent neck clipping was completed under direct vision without perforating artery compromise [Figure 3e and f]. The temporary clip was removed from the basilar artery. Microdopplers and indocyanine green angiography were used after final clipping to confirm the patency of both PCAs and perforators as well as the complete obliteration of the aneurysm. After complete suturing of the dura mater, a routine closure was performed.

Outcomes

The surgical outcomes were evaluated 6 months after discharge with the mRS by direct examinations or telephone interviews. The outcomes, excluding nonsurgical mortalities (such as acute myocardial infarction and sepsis), were divided into overall outcomes and subgroup outcomes of the patients with good GCS (E3-4 M6) after resuscitation (intubation and ventriculostomy). A mRS of 0 to 2 was defined as a good

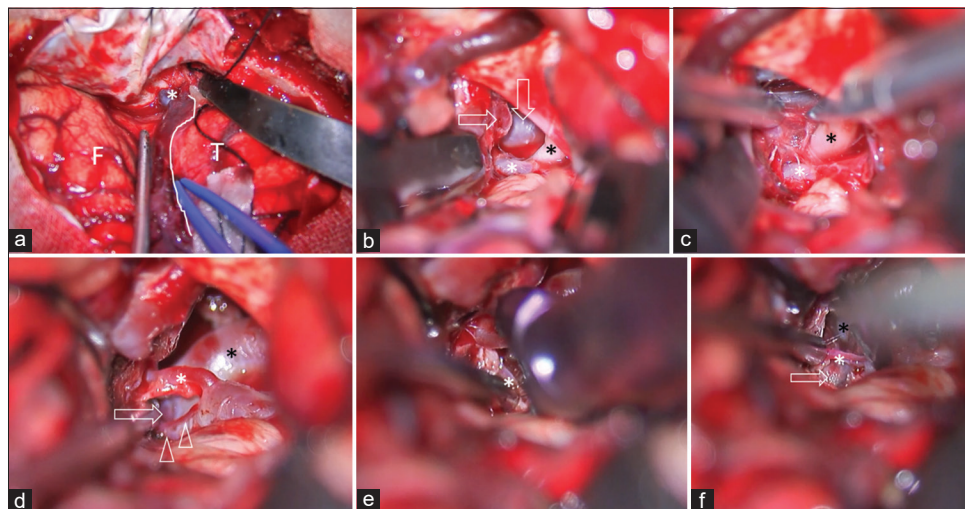


Figure 3: Intraoperative photographs of the right transzygomatic anterior temporal approach. (a) The dura was opened to expose frontal lobe, temporal lobe, and the Sylvian fissure. The route of Sylvian vein drainage to the base of skull (*) and temporal side of Sylvian vein (white line) were identified. (b) After the Sylvian fissure was widely opened through the temporal side, the Sylvian veins were retracted together with the frontal lobe. The temporal lobe was retracted posteriorly, and then the oculomotor nerve (black asterisk), posterior communicating artery (horizontal arrow), basilar trunk (vertical arrow), and P2 segment of the PCA (white asterisk) were identified. (c) The arachnoid membrane around the nerve (black asterisk) was sharply cut. The P2 segment of the PCA (white asterisk) was located just above the nerve. (d) After the ICA was retracted anteriorly, the basilar trunk (black asterisk), basilar tip aneurysm (arrow), posterior communicating artery (white asterisk), and perforators (arrowhead) were exposed through the retrocarotid space. (e) An aneurysm clip was applied to the aneurysm neck with perforator (asterisk) preservation. (f) After definite aneurysm clipping, the aneurysm dome (arrow), left P1 segment of the PCA (black asterisk), and perforator (white asterisk) were identified. F: Frontal lobe, PCA: Posterior cerebral artery, T: Temporal lobe. ICA: Internal carotid arteries.

outcome, and an mRS of 3 to 5, and perioperative death were defined as poor outcomes.

RESULTS

A total of 580 cases of open surgery for the treatment of intracranial aneurysms were performed at Vajira Hospital between December 2015 and August 2019. Fourteen cases of ruptured BT aneurysms were successfully treated with clipping through the anterior temporal approach [Table 1].

Patients' characteristics

The average patient age was 62.2 years (range; 46–78) with ten women and four men. At the first presentation of subarachnoid hemorrhage, five patients (35.7%) had WFNS Grades 1–3 (good grade), and nine patients (64.3%) had WFNS Grades 4 and 5 (poor grade). After resuscitation, six cases of the poor grade group improved to a good GCS (E3–4 M6) (case no. 2, 4, 6, 9, 11, and 14). Therefore, the number of patients with a good GCS before surgery was 11 (78.6%).

Aneurysm characteristics

The mean aneurysm size and height from the clinoid line were 6.6 mm and 4.9 mm, respectively. A zygomatic arch osteotomy through the anterior temporal approach was

performed in four cases (28.6%). A posterior clinoidectomy was needed in four cases (21.4%).

Surgical outcomes and complications of the anterior temporal approach

Computed tomography angiography (CTA) was routinely evaluated in all cases. All cases demonstrated complete aneurysm obliteration. Thalamic infarctions occurred in two cases (14.3%), leading to postoperative mild hemiparesis and impaired consciousness. Postoperative third nerve palsy occurred in six cases (42.9%), and these patients, who were alive, spontaneously and completely recovered within 3 months. One case (case no. 9) demonstrated an ipsilateral anterior choroidal artery injury during clip application, causing severe postoperative hemiparesis. Two patients (cases no. 2 and 6) died from severe sepsis from hospital-acquired pneumonia.

Overall, good outcomes (mRS of 0–2) at 6 months were achieved in seven cases (58.3%) of the living patients (12 cases). For the living patients with good GCS after resuscitation (nine cases), a good outcome at 6 months was accomplished in seven cases (77.8%). Two cases in this group developed poor outcomes due to postoperative hemiparesis from intraoperative anterior choroidal artery injury (case no. 8) and a delayed recovery due to advanced age (case no. 9).

Table 1: Characteristics of patients with ruptured basilar tip aneurysms treated with microsurgical clipping through the anterior temporal approach.

Case no.	Age (years), sex	Location	Size (mm)	WFNS grade at the admission	Postresuscitation GCS	Aneurysm projection	Distance above clinoid line (mm)	Zygomatic arch osteotomy	PCP removal	Postoperative thalamic infarct	Postoperative CN3 palsy	mRS at 6 months
1	46, F	BT	4	2	15	A	3	N	N	N	N	2
2	64, F	BT	8	4	E4M6Vt	S	0	N	N	N	Y	D
3	56, F	BT	4	1	15	AS	3	N	N	N	N	1
4	74, M	BT	8	4	15	AS	6.6	N	N	N	N	2
5	63, F	BT	6	2	E4M6V4	S	3	N	N	Y	N	2
6	65, F	BT	10	5	E4M6Vt	AS	3	N	N	N	N	D
7	57, M	BT	4	1	15	S	10.2	Y	N	N	Y	2
8	56, F	BT	7	1	15	PS	3	N	N	N	N	3
9	78, M	BT	11	4	E4M6Vt	AS	-1	N	Y	N	Y	3
10	67, F	BT	5	5	E1M4Vt	AS	8	Y	N	N	N	4
11	62, M	BT	7	4	E4M6V4	S	8	N	Y	N	N	2
12	73, F	BT	4	4	E3M5V2	S	3.6	N	Y	N	Y	3
13	54, F	BT	11	4	E2M4Vt	PS	8.9	Y	N	Y	Y	4
14	56, F	BT	3	4	E4M6Vt	S	8.8	Y	N	N	Y	1

A: Anterior, AS: Anterosuperior, BT: Basilar tip, D: Dead, F: Female, L: Left, M: Male, mRS: Modified Rankin score, N: No, PS: Posterosuperior, R: Right, S: Superior, SCA: Superior cerebellar artery, WFNS: World Federation of Neurosurgical Societies, Y: Yes

Illustrative case

A 56-year-old female presented with sudden severe headache and altered consciousness [Case No. 14 in Table 1 and Figures 4 and 5]. The initial GCS and WFNS grade were seven and four, respectively. Plain CT and CTA revealed diffuse subarachnoid hemorrhage and a 3-mm saccular aneurysm at the basilar bifurcation [Figure 4a-c]. The aneurysm projected superiorly and was situated 8.8 mm above the clinoid line [Figure 4d]. A right transzygomatic anterior temporal approach was successfully used for aneurysm clipping. Postoperative right oculomotor nerve palsy immediately occurred, with full recovery 3 months after the operation. The postoperative CTA showed complete obliteration of the aneurysm without any brain contusions or infarctions [Figure 5a-d]. The patient achieved an mRS of 1 at discharge day and 6 months after the operation.

DISCUSSION

At the present time, most BT aneurysms are treated with endovascular procedures. For endovascular treatment of BT aneurysms, good outcomes were reported in 73–96% of cases, with complete/near complete occlusion rates of 64–89%.^[36] At long-term follow-up, 17.5% of patients had developed a major recanalization that required retreatment,^[27] and the complete/nearcomplete occlusion rate had decreased to 48%.^[9] With open surgery, good outcomes vary from 57% to 92% overall. In the subgroup analyses, good outcomes were accomplished in 90.5% of the unruptured or lowgrade ruptured aneurysm groups and in 50% of the highgrade, ruptured, or large aneurysm groups.^[36] In our study, a good outcome was achieved in 58.3% of all ruptured cases and in 77.8% of ruptured BT aneurysms with good postresuscitation at 3 months after the operation.

The famous surgical approaches for BT aneurysms are the subtemporal approach by Drake^[4] and the pterional approach by Yasargil *et al.* The subtemporal approach provides a corridor in the lateral direction and the shortest distance to the aneurysm by upward retraction of the temporal lobe without Sylvian fissure dissection, but a temporal lobe contusion usually occurs due to retraction injury. The perforators' posterior to the aneurysm can easily be visualized with this approach, but the contralateral P1 segment is difficult to identify. With an additional transtentorial approach by tentorial incision, a downward corridor to posterior fossa can be offered, which is essential for low-positioned aneurysms, and the basilar trunk is easily exposed for proximal control. The surgical corridor may be narrow, especially in poor grade patients with subarachnoid hemorrhage and marked brain swelling.^[2,4,10,23,25]

The pterional approach offers an anterolateral direction to the BT aneurysm through the opticocarotid space or retrocarotid

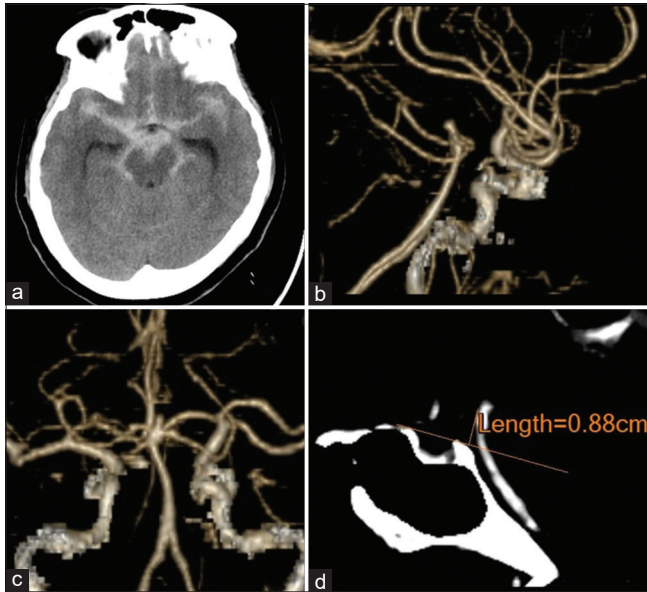


Figure 4: Case no. 14. Preoperative CT and CTA. (a) Plain CT scan shows diffuse subarachnoid hemorrhage and hydrocephalus. The three-dimensional CTA in the right lateral (b) and posterior views (c) demonstrates a superior projecting aneurysm at the basilar bifurcation. (d) The aneurysm neck was located 8.8 mm above the clinoid line. CTA: Computed tomography angiography, CT: Computed tomography.

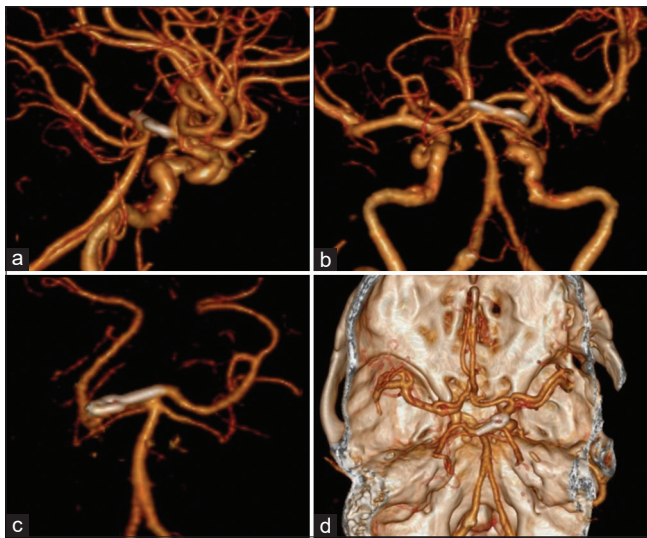


Figure 5: Case no. 14. Postoperative CTA. The three-dimensional CTA in right lateral (a), posterior views (b), anterior view (c), and superior view with skull base (d) shows the complete obliteration of the aneurysm with the preservation of both posterior cerebral arteries. CTA: Computed tomography angiography.

space with Sylvian fissure opening. The advantages of this approach are that it provides a good visualization for aneurysm necks located between the midpoint of the sella turcica, which is 1 cm above the posterior clinoid process,

and it offers better exposure of the contralateral P1 segment of the PCA with less brain retraction when compared to the subtemporal approach. With this approach, the perforators' posterior to the aneurysm neck is difficult to see.^[2,10,23,38]

The later-developed surgical approaches to BT aneurysm include a combination of the previously described anterolateral and lateral corridor by posterolateral retraction of the temporal lobe, such as the extended lateral (half-and-half) approach,^[2] the temporopolar approach,^[29] the pterional/anterior temporal approach,^[10] the pretemporal approach,^[3] the transsylvian-trans-uncal approach,^[28] and the pretemporal transzygomatic transcavernous approach.^[16] This temporal lobe retraction usually requires sacrificing the venous drainage of the Sylvian vein to the base of the skull, which may cause temporal venous infarction.^[1]

The anterior temporal approach was a modification for anterolateral access to the upper basilar artery and posterior projecting ICA aneurysms. The distinctive point of this approach is the posterolateral retraction of the temporal lobe without sacrificing venous drainage of the Sylvian vein to the base of skull and with less tension to the main trunk of the middle cerebral artery than with the previously described techniques.^[6-8,13,22,23,34]

Several published studies of open surgery for BT aneurysms with various preoperative conditions, surgical approaches and postoperative outcomes are shown in Table 2.^[11,15,17,19-23,30,31,35] Most of these were studied in patients with a high percentage of unruptured cases. One study by Lusseveld *et al.* described 44 patients with BT aneurysms, in which all of the patients were ruptured cases and 98% of these patients had good grade before surgery, in which good clinical outcomes were achieved in 71% of patients.^[21]

For the anterior temporal approach, which is similar to the approach used in our study but with 100% unruptured cases, Matsukawa *et al.* reported a study of microsurgical clipping for 23 patients with complex unruptured BT aneurysms in 2015. BT aneurysms with necks >4 mm, posterior projection, retro/subsellar, and dome-to-neck ratios <1.2 were classified as complex BT aneurysms. Eleven patients (48%) had a good outcome (mRS 0 to 1) at discharge, and 87% had a good outcome at the 12-month follow-up. Postoperative oculomotor palsies were detected in 65% of patients. Postoperative diffusion-weighted imaging also revealed ischemia in the posterior thalamoperforating artery distribution in 8.7% of patients and in the anterior choroidal artery distribution in 8.7% of patients.^[23] Matsukawa *et al.* also reported the use of open surgery for the treatment of unruptured BT and BA-SCA aneurysms in 56 patients (37 BT and 19 BA-SCA aneurysms) in 2017. A good (mRS 0–2) overall outcome was accomplished in 89% of patients at 6 months. Symptomatic and asymptomatic perforator territory infarctions were detected in 20%

Table 2: Published case series of patients with basilar tip aneurysms treated with open surgery.^[11,15,17,19-23,30,31,35]

References	Number of patients	Rupture (%)	Surgical approach	Good outcomes (%)
Lawton, 2002 ^[19]	BT/56	55	Orbitozygomatic-pterial transsylvian approach	84
Lusseveld <i>et al.</i> , 2002 ^[21]	BT/44	100	No data	71%
Lozier <i>et al.</i> , 2004 ^[20]	BT/98	50	Pterional transsylvian approach (64%) Temporopolar approach (36%)	79% at 3 months
Krisht <i>et al.</i> , 2007 ^[17]	BT/50	50	Pretemporal transzygomatic transcavernous approach	88% at discharge
Jin <i>et al.</i> , 2009 ^[11]	BT/28	63	No data	75% at discharge 70.9% at 6 months
Sekhar <i>et al.</i> , 2013 ^[30]	BT/37	63	Orbitozygomatic-pterial transsylvian transcavernous approach	71% at 3 months (ruptured group) 92% at 3 months (unruptured group)
Matsukawa <i>et al.</i> , 2015 ^[23]	BT/23	0	Anterior temporal approach	48% at discharge 87% at 12 months
Tjahjadi <i>et al.</i> , 2016 ^[35]	BT/96	49	Subtemporal approach (64.6%) Lateral supraorbital approach (27.1%) Presigmoid approach (8.3%).	88% (unruptured group) 86% (good grade subarachnoid hemorrhage group)
Matsukawa <i>et al.</i> , 2017 ^[22]	BT/37 (66.1%) BA-SCA/19 (33.9%)	0	Anterior temporal approach	89% at 6 months (include 19 BA-SCA aneurysms)
Seng <i>et al.</i> 2018 ^[31]	BT/9	0	Anterior temporal approach	100% at 6 months
Katsuno <i>et al.</i> , 2019 ^[15]	BT/6 High position (> or = 10 mm)	2/6=33.3	Zygomatic anterior temporal approach	66.7% (overall) and 80% (good grade subarachnoid hemorrhage and unruptured group) at 6 months
Our study	14	100	Anterior temporal approach	58.3% at 6 months (all cases) 77.8% at 6 months (good postresuscitation GCS patients)

BA-SCA: Basilar artery-superior cerebellar artery, BT: Basilar tip

of patients. Postoperative oculomotor nerve palsy was reported in 64% of patients.^[22]

In our study, 100% of patients were ruptured cases, in which 64.3% were poor grade at initial presentation and 78.6% were good GSC before surgery. All cases were operated with the anterior temporal approach. At 6 months after operation, the rate of an overall good outcome was 58.3%, which was lower than that in the study by Lusseveld *et al.* (71%)^[21], possibly due to the higher percentage of good grade patients before surgery in their study (98% vs. 78.6%). If the outcome was analyzed separately in the group of good grade patients before surgery, then 77.8% achieved a good result, which was comparable to that of other studies of open surgery^[11,15,17,19-23,30,31,35] and endovascular treatment.^[36] Postoperative thalamic infarctions were detected in 14.3% of cases, which were comparable to the previous reports (20 and 8.7%).^[22,23] The thalamic infarctions were found in cases with superior (case no. 5) and posterosuperior (case no. 13) projecting aneurysms. The authors believe that the superior and posterior aneurysm projections obscure the visualization

of the thalamic perforators, especially in the contralateral side. An improvement of the vascular imaging for perforator identification and a surgical approach from the appropriate side may avoid this complication. Transient postoperative third nerve palsies occurred in 42.9% of cases, which was lower than previous reports (64 and 65%)^[22,23] and is possibly due to a smaller patient size with different aneurysm characteristics.

CONCLUSION

With the appropriate case selection, the anterior temporal approach was effective and safe for the clipping of ruptured BT aneurysms.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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