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Review Article

Microsurgical Approach for True Posterior Communicating Artery Aneurysms: Literature Review and Illustrative Case

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Abstract

True posterior communicating artery (PCoA) aneurysms are rare. Although true PCoA aneurysms have been reported to be located close to the internal carotid artery, at the middle part of PCoA, or close to the posterior cerebral artery; the best surgical approach to treat true PCoA aneurysms in each location remains unclear. We conducted a literature review using data from PubMed. Data on demographics, location, and projecting direction of the aneurysm, surgical approach, and surgical complications were collected. A total of 47 true PCoA aneurysms were included. Twenty-nine aneurysms originated from the proximal portion, 10 from the middle portion, and 6 from the distal portion; there were two giant aneurysms. The ipsilateral pterional approach was used for 37 true PCoA aneurysms (27 in proximal portion, 8 in middle portion, and 2 in distal portion of PCoA). The anterior temporal approach was used for two distal-portion aneurysms and one giant aneurysm. The anterior subtemporal approach was used for one distal-portion aneurysm. The subtemporal approach was used for two middle-portion aneurysms and one giant aneurysm. The contralateral pterional approach was used for two proximal-portion and one distal-portion aneurysms. Although most true PCoA aneurysms can be treated by the pterional approach, other means such as anterior temporal and subtemporal approaches can be applicable for aneurysms in the middle and distal portions of the PCoA or giant aneurysms. Surgeons should select an appropriate approach for each aneurysm while considering the advantages and disadvantages of each technique.

Keywords
- ► true posterior communicating artery aneurysm
- ► surgical approach
- ► subtemporal approach
- ► premammillary artery

Introduction

True posterior communicating artery (PCoA) aneurysms are defined as aneurysms that arise from the PCoA itself and are attached to neither the internal carotid artery (ICA) nor the posterior cerebral artery (PCA), and constitute 1.3% of all intracranial aneurysms.[1] Although true PCoA aneurysms have been reported to be located close to the ICA, at the middle part of the PCoA, or close to the PCA, the best surgical approach for the treatment of true PCoA aneurysms in each

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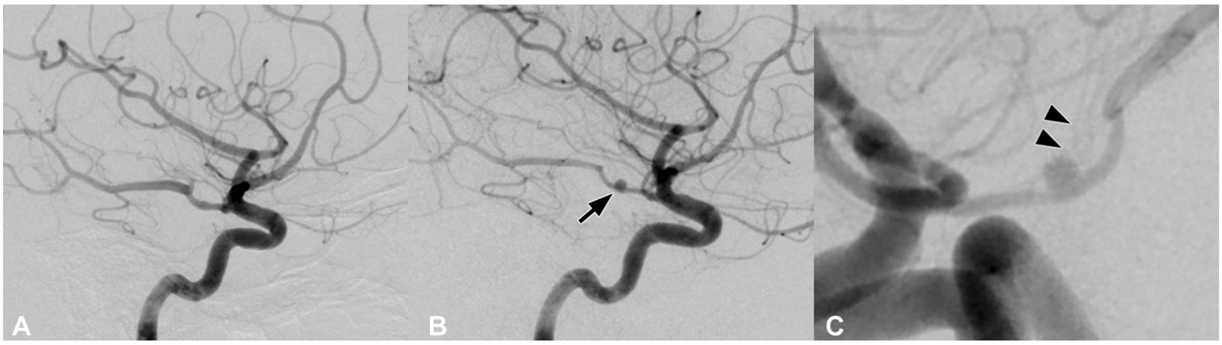

Fig. 1 Right carotid angiogram on the second day (**A**) and 14th day (**B**) after onset, and a high-magnification image of the aneurysm (**C**). Repeat angiography disclosed an aneurysm (*arrow*) in the middle portion of the posterior communicating artery. Some perforator branches (*arrowheads*) appeared to originate from the posterior aspect of the aneurysm.

location remains unclear. Here, we report the case of an aneurysm arising from the middle portion of the PCoA, which was successfully clipped via the subtemporal approach. We also review reported surgical approaches for true PCoA aneurysms and discuss the optimal treatment for these lesions.

Case Description

A 34-year-old woman without cardiovascular risk factors presented with a sudden onset of headache and vomiting and was admitted to our hospital as an emergency. Brain computed tomography (CT) showed a diffuse subarachnoid hemorrhage (SAH). Although initial CT angiography could not detect a bleeding source, repeat digital subtraction angiography (DSA) revealed an aneurysm in the middle portion of the right fetal-type PCoA (►**Figs. 1A, B**). Some perforator branches appeared to originate from the posterior aspect of the aneurysm (►**Fig. 1C**). On the 20th day after onset, she underwent surgery via the right subtemporal approach. The dome of the aneurysm projected superiorly. The premammillary artery (PMA) arose very close to the neck of the aneurysm and ran superiorly, adhering to the dome of the aneurysm (►**Fig. 2A**), but no perforators originated from the posterior aspect of the dome. As it was difficult to thoroughly dissect the PMA from the aneurysm, the PMA was partially dissected from the aneurysmal neck to obtain a space for the blades of a clip, and a 7-mm bayonet clip was applied (►**Fig. 2B**). The patency of the PCoA and the PMA was confirmed by indocyanine green angiography. A postoperative magnetic resonance imaging scan revealed no perforator infarction or temporal lobe contusion. Angiography demonstrated complete obliteration of the aneurysm and preservation of the PCoA (►**Fig. 3**). The patient was discharged from hospital without any neurological deficit.

Materials and Methods

We conducted a literature review using PubMed, searching for cases of true PCoA aneurysm treated by direct surgery up to July 2021, using the search term “true posterior communicating artery aneurysm.” References cited by the retrieved articles were also thoroughly reviewed. Selection criteria were as follows: (1) available clinical information of the patient and angiographic findings of the aneurysm; (2) articles providing information on surgical approach and

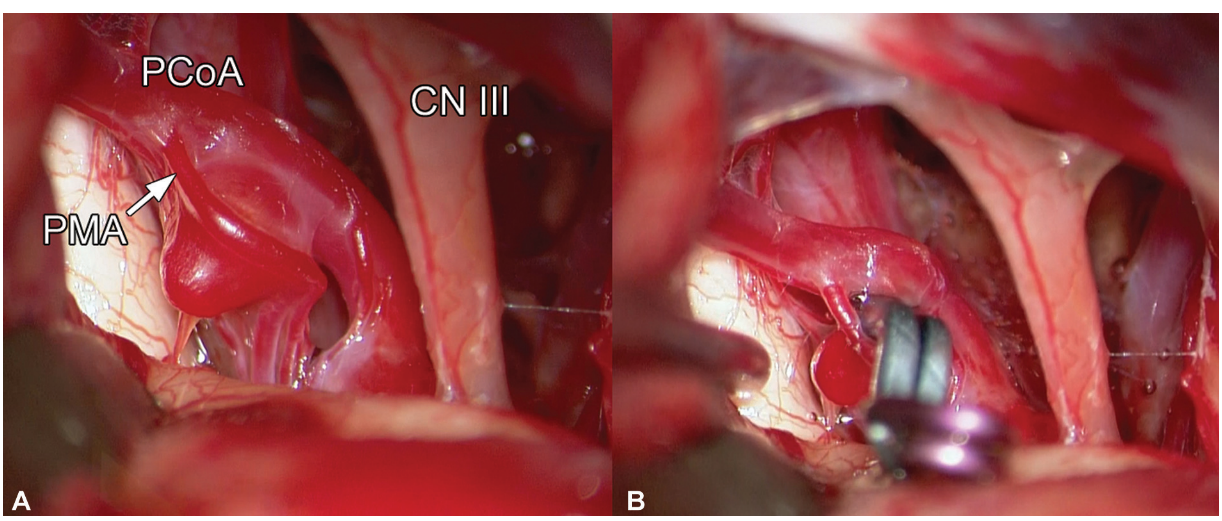

Fig. 2 Intraoperative photographs before (**A**) and after (**B**) clipping. Abbreviations: CN III, oculomotor nerve, PCoA, posterior communicating artery, PMA, premammillary artery.

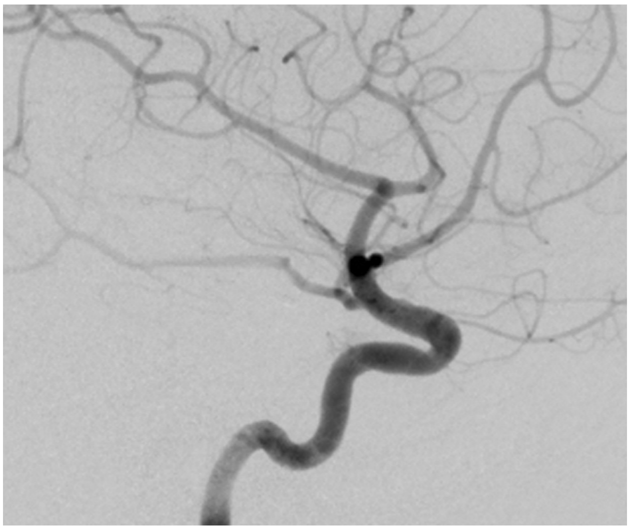

Fig. 3 Postoperative right carotid angiogram demonstrating complete clipping of the aneurysm and preservation of the posterior communicating artery.

complications; and (3) articles written in English and Japanese. Aneurysms associated with tumors or vascular malformations were excluded because the selection of surgical approach may have been affected by these concomitant lesions. Data extracted from these articles included patient age, patient gender, rupture status of the aneurysm, presence of fetal-type PCoA, location and projecting direction of the aneurysm, surgical approach, and surgical complications. Of the 439 articles found, 40 were finally considered eligible for our study (►**Fig. 4**).

Results

Including our own, we found 46 patients with 47 true PCoA aneurysms treated by direct surgery (►**Table 1**).[2–41] Thirty-nine patients (85%) presented with SAH. Thirty-four aneurysms arose on the fetal-type PCoA and 5 arose from a dilated PCoA, which supplies the principal collateral flow associated with the occlusion of major vessels. Twenty-nine aneurysms originated from the proximal portion, 10 from the middle portion, and 6 from the distal portion; there were two giant aneurysms (►**Table 2**). True PCoA aneurysms had a variety of projecting directions (►**Fig. 5**). Six aneurysms were fusiform with circumferential dilatation. Surgical approaches for these lesions were as follows (►**Fig. 6**). The ipsilateral pterional approach was used for 37 true PCoA aneurysms (27 in the proximal portion, 8 in the middle portion, and 2 in the distal portion of PCoA). Among these, 29 were approached via the retrocarotid route and 8 via the opticocarotid route. The anterior temporal approach was used for two distal-portion aneurysms and one giant aneurysm. The anterior subtemporal approach was used for one distal-portion aneurysm. The subtemporal approach was used for two middle-portion aneurysms and one giant aneurysm. The contralateral pterional approach was used for two proximal-

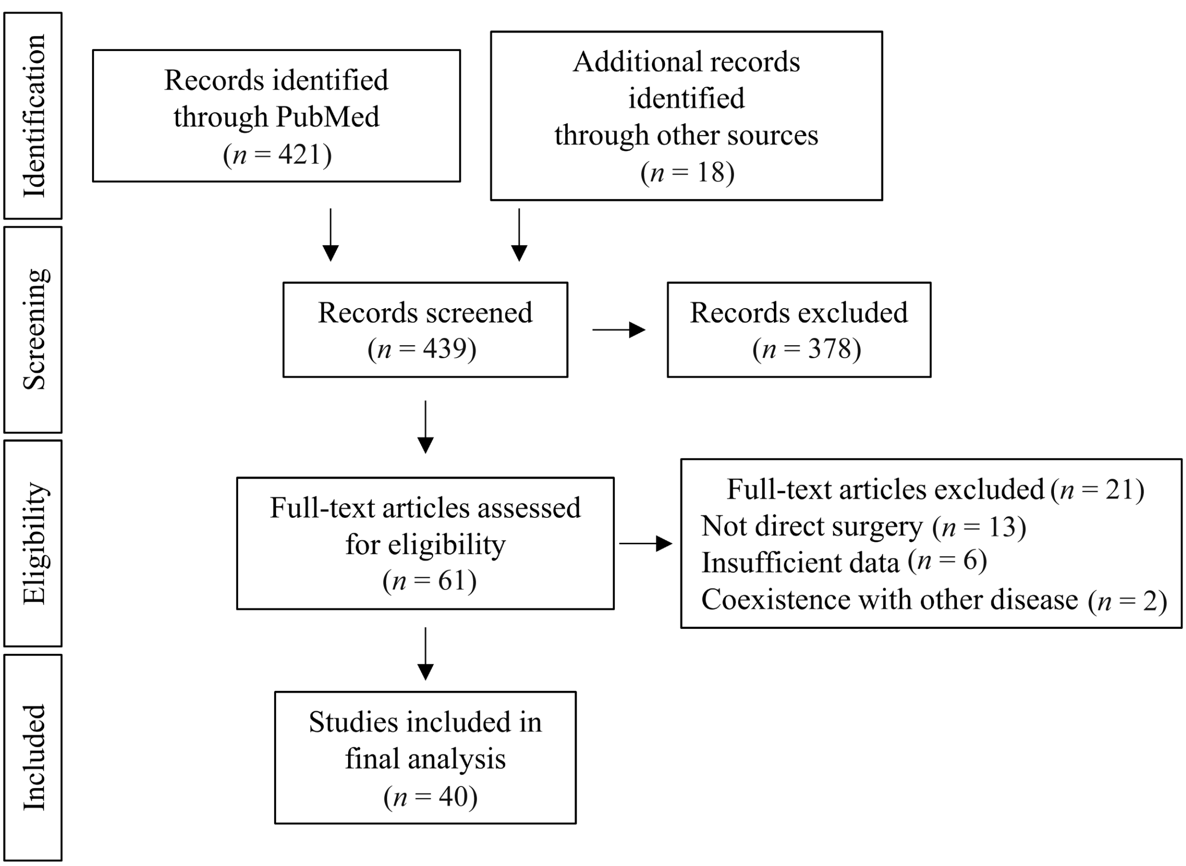

Fig. 4 PRISMA flow diagram.

Table 1 Summary of reported cases of true posterior communicating artery aneurysms treated by direct surgery

Author, year	Age/ Sex	Presentation	Fetal PCoA	Location	Dome projection	Surgical approach	Treatment	Procedure-related complications
Yoshida et al,[2] 1979	46/M	SAH	–	P	Inferolateral	Pterional	Clipping	No
Kamiyama et al,[3] 1980	28/F	SAH	–	M	Inferior	Subtemporal	Trapping	Emotional incontinence
Abiko et al,[4] 1981	57/F	SAH	+	D	Fusiform	Pterional	Trapping	Internal capsule infarction CN III palsy
Tanizaki et al,[5] 1982	69/F	SAH	+	P	Superior	Pterional	Clipping	Transient CN III palsy
Miyazawa et al,[6] 1983	68/M	SAH	+	M	Inferolateral	Pterional	Clipping	No
Masuda et al,[7] 1984	45/F	SAH	+	P	Inferior	Pterional	Clipping	No
Waga et al,[8] 1984	54/M	SAH	+	P	Inferolateral	Pterional	Clipping	No
Waga et al,[8] 1984	64/M	SAH	+	P	Inferolateral	Pterional	Clipping	No
Takeda et al,[9] 1985	73/F	SAH	+	M	Inferolateral	Pterional	Clipping	No
Okada et al,[10] 1988	40/F	SAH	–	P	Inferolateral	Pterional	Clipping	No
Kudo et al,[11] 1990	57/M	SAH	+	P	Inferolateral	Pterional	Clipping	CN III palsy
Akimura et al,[12] 1991	45/F	SAH	+	M	Superolateral	Pterional	Clipping	No
Mandai et al,[13] 1992	42/F	SAH	–	D	Fusiform	Pterional	Trapping	Occipital infarction
Takahashi et al,[14] 1992	27/F	SAH	+	M	Lateral	Pterional	Clipping	No
Takahashi et al,[14] 1992	23/M	Traumatic	–	M	Inferolateral	Pterional	Clipping	No
Hayashi et al,[15] 1993	51/F	SAH	+	P	Superolateral	Pterional	Clipping	No
Koga et al,[16] 1994	65/F	Unruptured	+	P	Inferior	Contralateral	Clipping	No
Ogasawara et al,[17] 1995	58/F	SAH	Dilated	D	Inferior	Contralateral	Clipping	No
Timothy et al,[18] 1995	72/M	SAH	+	P	Fusiform	Pterional	Proximal clipping	Rerupture
Matsumoto et al,[19] 1997	27/M	SAH	+	Giant	Inferior	Subtemporal	Clipping	No
Matsumoto et al,[20] 1997	62/F	SAH	+	P	Fusiform	Pterional	Trapping	No
Abe et al,[21] 2000	45/F	SAH	+	P	Superior	Pterional	Clipping	No
Okuchi et al,[22] 2000	66/M	SAH	Dilated	P	Inferomedial	Pterional	Clipping	No
Muneda et al,[23] 2001	51/M	SAH	+	P	Lateral	Pterional	Clipping	No
Kaspera et al,[24] 2002	63/M	SAH	Dilated	M	Superomedial	Pterional	Clipping	No
Cho et al,[25] 2003	57/F	SAH	+	P	Superior	Pterional	Clipping	Thalamic infarction CN III palsy
Matsumori et al,[26] 2003	72/F	Unruptured	+	P	Inferior	Pterional	Clipping	No
Nakazaki et al,[27] 2004	51/F	SAH	+	P	Superomedial	Pterional	Clipping	No

(*Continued*)

Table 1 (*Continued*)

Author, year	Age/Sex	Presentation	Fetal PCoA	Location	Dome projection	Surgical approach	Treatment	Procedure-related complications
Sorimachi et al,[28] 2004	55/F	SAH	+	P	Inferior	Pterional	Clipping	CN III palsy
Nakatsuka et al,[29] 2007	32/F	SAH	+	M	Fusiform	Pterional	Trapping	No
Ishikawa et al,[30] 2010	83/F	Unruptured Unruptured	+	P P	Superior Lateral	Pterional	Clipping Clipping	No
Nakano et al,[31] 2011	43/M	SAH	+	P	Superolateral	Pterional	Clipping	No
Nakano et al,[31] 2011	71/F	SAH	+	P	Inferolateral	Pterional	Clipping	No
Vuignier et al,[32] 2011	82/F	SAH	+	P	Superomedial	Pterional	Clipping	No
Abe et al,[33] 2012	73/F	SAH	+	P	Inferolateral	Pterional	Clipping	No
Abe et al,[33] 2012	61/F	Unruptured	+	P	Superior	Pterional	Clipping	No
Nagatani et al,[34] 2013	59/F	SAH	+	P	Inferolateral	Pterional	Clipping	No
Guo et al,[35] 2014	46/M	SAH	–	M	Fusiform	Pterional	Trapping	No
Takeda et al,[36] 2015	83/M	SAH	Dilated	D	Superomedial	ATA	Clipping	No
Nery et al,[37] 2016	51/F	SAH	+	P	Superior	Pterional	Clipping	Transient CN III palsy
Nery et al,[37] 2016	53/F	Unruptured	+	P	Inferior	Contralateral	Clipping	No
Mochizuki et al,[38] 2017	85/M	Mass effect	–	Giant	Superior	ATA	Trapping	No
Yokoya et al,[39] 2017	65/M	SAH	Dilated	D	Superomedial	ATA	Clipping and proximal ligation	Multiple infarction
Aso et al,[40] 2019	41/F	SAH	+	P	Inferomedial	Pterional	Clipping	No
Yang et al,[41] 2019	63/F	SAH	–	D	Superior	ASA	Clipping	No
Present case	34/F	SAH	+	M	Superior	Subtemporal	Clipping	No

Abbreviations: ASA, anterior subtemporal approach; ATA, anterior temporal approach; CN III, oculomotor nerve; D, distal; M, middle; P, proximal; PCoA, posterior communicating artery; SAH, subarachnoid hemorrhage.

portion aneurysms and one distal-portion aneurysm. Neck clipping was performed for 38 aneurysms, trapping for 7 aneurysms, proximal clipping for 1 aneurysm, and neck clipping and accidental proximal ligation for 1 aneurysm. With respect to procedure-related complications, oculomotor nerve (CN III) palsy occurred in six patients, cerebral infarction (including emotional incontinence) in five, and rerupture of the aneurysm in one.

Table 2 Surgical approach according to location of the aneurysm

Approach	Location of the aneurysm				Total
	Proximal	Middle	Distal	Giant	
Pterional	27	8	2	0	37
Anterior temporal	0	0	2	1	3
Anterior subtemporal	0	0	1	0	1
Subtemporal	0	2	0	1	3
Contralateral pterional	2	0	1	0	3
Total	29	10	6	2	47

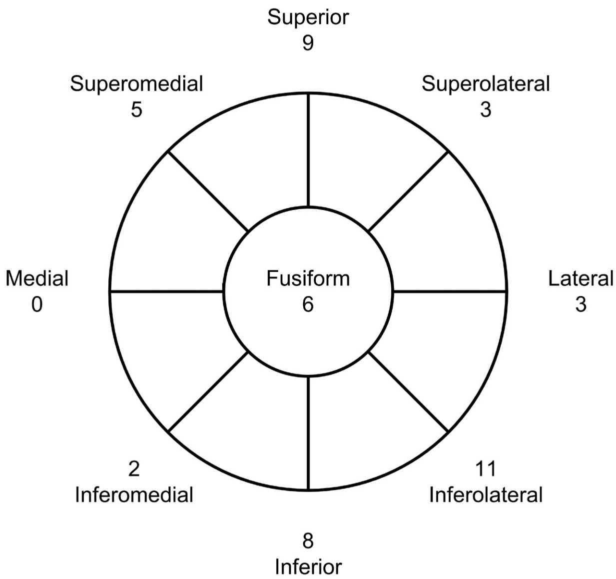

Fig. 5 Direction of true posterior communicating artery aneurysms. The dome of the aneurysm has a variety of projecting directions.

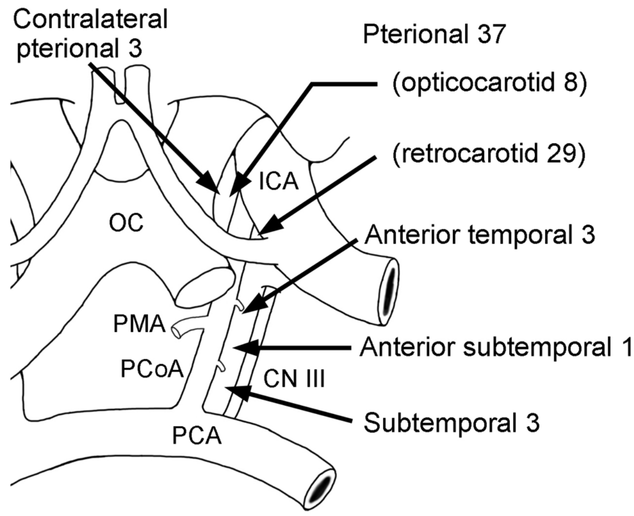

Fig. 6 Schematic representation of microsurgical approaches for true posterior communicating artery aneurysms. Selected approaches include 37 pterional (29 retrocarotid, 8 opticocarotid), 3 anterior temporal, 1 anterior subtemporal, 3 subtemporal, and 3 contralateral pterional approaches. Abbreviations: CN III, oculomotor nerve; ICA, internal carotid artery; OC, optic chiasm; PCA, posterior cerebral artery; PCoA, posterior communicating artery; PMA, premammillary artery.

Discussion

In this study, 85% of patients presented with SAH and 72% of aneurysms arose on the fetal-type PCoA. He et al suggested that true PCoA aneurysms have a larger PCoA relative to the ipsilateral P1 segment of the PCA and are more prone to rupture than ICA–PCoA aneurysms.[42] Moreover, true PCoA aneurysms have been located near the curvature of fetal PCoA or dilated PCoA supplying collateral flow.[15,22,36] These findings indicate that hemodynamic stress may play an important role in the development and rupture of true PCoA aneurysms.

Several authors have reported that true PCoA aneurysms project inferiorly or laterally, unrelated to the branching site of the perforating arteries, and that they could be clipped with relative ease.[8,14,23] However, our results indicate that true PCoA aneurysms have a variety of projecting directions.

An average of eight (range, 4–14) perforating branches arise from the PCoA, mostly from the superior and lateral surfaces, and course superiorly to supply critical structures including the thalamus, hypothalamus, optic tract, and internal capsule. The PMA is the largest branch of the PCoA and originates on the middle third of the PCoA.[43] Therefore, the superiorly projecting aneurysms in the middle portion of the PCoA may carry a risk of ischemic surgical complications. In addition, CN III usually runs below and lateral to the PCoA, meaning that inferolaterally projecting aneurysms may bear a risk of CN III injury. In this study, we could not clarify the relationship between the aneurysmal location/direction and surgical complications. Further studies of large series are needed to elucidate the risk factors for surgical complications.

We now review several reported surgical approaches for the treatment of PCoA aneurysms.

Pterional Approach

True PCoA aneurysms typically arise at 2 to 3 mm distal to the junction of the ICA with the PCoA; therefore, most of the aneurysms can be clipped using a standard pterional approach. In most cases, the PCoA should be followed posteriorly through the retrocarotid space to visualize the aneurysm neck.[44] When it is difficult to achieve a satisfactory visual angle through the standard pterional approach, additional techniques are necessary to acquire a wider surgical space. Two medially projecting aneurysms in the proximal portion of the PCoA were successfully clipped after widening the opticocarotid space.[22,32] After the removal of the anterior clinoid process and opening of the optic canal, the carotid dural ring was incised for mobilization of the ICA and optic nerve, which allowed acquirement of a wider opticocarotid space. Given that the surgical corridor of the contralateral pterional approach is deep and narrow, its application has been limited to cases of unruptured lesions associated with a contralateral ruptured aneurysm or cases in which for some reason the surgeon is unable to perform ipsilateral craniotomy.[16,17,37]

Subtemporal Approach

Matsumoto et al successfully clipped a giant true PCoA aneurysm by reconstructing the PCoA and proximal PCA via the subtemporal approach,[19] demonstrating that this technique allows for good visualization of the distal portion of the PCoA; however, it poses the risk of temporal lobe contusion and venous injury resulting from excessive brain retraction. If the aneurysmal neck is located higher than usual, it is difficult to access the aneurysm. We selected a subtemporal approach for the present case to obtain the best view of the posterior aspect of the aneurysm from where some perforators appeared to arise on the preoperative DSA. In addition, there were no bridging veins in the temporal base and the aneurysmal neck was 2 mm above the interclinoid line, circumstances which we considered suitable for this approach. To avoid temporal contusion, we inserted a lumbar drain to achieve adequate brain relaxation, and the temporal lobe was carefully retracted to expose the free margin of the tentorium in stepwise manner from the posterior part of the temporal lobe because the temporal lobe extends deeply into the middle cranial fossa anteriorly.

Anterior Subtemporal Approach

Horiuchi et al described the anterior subtemporal approach for posteriorly projecting ICA-PCoA aneurysms,[45] and Yang et al applied this approach to a true PCoA aneurysm in the distal portion.[41] After frontotemporal craniotomy and zygomatic osteotomy, the temporal lobe was elevated without opening the Sylvian fissure. In this approach, the aneurysm can be observed from the more lateral side in comparison with the pterional approach. However, using this method the aneurysms are occasionally hidden under the tentorial edge because of an upward viewing angle from the anterior temporal base. In such a situation, the tentorial edge should be incised to obtain good visualization of the aneurysm, which may increase the risk of CN III injury. Moreover, the temporal tip bridging veins should be sacrificed to retract the temporal lobe posteriorly, which may create a risk of venous infarction.

Anterior Temporal Approach

This approach enables posterior retraction of the temporal lobe by dissection of the superficial Sylvian vein and the anterior temporal artery from the temporal lobe, and provides the middle surgical corridor of the pterional approach and subtemporal approach.[46] A wider retrocarotid space obtained with this approach provides better visualization of true PCoA aneurysms, particularly in the middle and distal portions. Additional orbitozygomatic osteotomy may allow clipping of high-position true PCoA aneurysms situated higher than 10 mm from the interclinoid line.[47] We considered this approach unsuitable for our case because the superficial Sylvian vein was short and emptied into the sphenoparietal sinus lateral to the superior orbital fissure, which might have restricted posterior retraction of the temporal lobe. In such a situation, a useful alternative may be the extradural temporopolar approach,[48] whereby the meningo-orbital band is incised and the dura propria of the temporal lobe is peeled from the superior orbital fissure to the lateral wall of the cavernous sinus, after which the temporal lobe is retracted posteriorly with the dura mater. Great care must be taken not to injure the sphenoparietal sinus while peeling the dura propria.

Endovascular Treatment

Detailed information on patients with true PCoA aneurysms treated by endovascular means is limited. Recently, Wang et al reported 43 true PCoA aneurysms treated endovascularly.[49] In their study, 41 aneurysms originated from the proximal portion, 1 from the middle portion, and 1 from the distal portion. All aneurysms were successfully treated without complications; however, the recurrence rate was higher than usual. The acute angle of PCoA origin from the ICA and the thinness of PCoA as a parent artery may be a disadvantage of this approach, hindering the appropriate stability of the microcatheter and the use of adjunctive techniques, thus making it difficult to achieve dense packing.[50] There are a few reports on endovascular treatment for aneurysms in the middle and distal portions of the PCoA, and the safety and efficacy of the treatment of such lesions remains unclear.

Limitations

The major limitations of this research are the small number of participants and the absence of evidence stronger than level IV. The choice of surgical approach may depend not only on the aneurysm's characteristics but also on other factors such as brain edema, venous drainage patterns, and deviation of the ICA. None of these factors were evaluated in this study. Nonetheless, this review provides the most recent and largest overview of microsurgical approaches to the management of true PCoA aneurysms.

Conclusion

True PCoA aneurysms most commonly originate from the proximal portion of the PCoA, followed by the middle portion, then the distal portion, in a variety of projecting directions. Most true PCoA aneurysms can be treated by the pterional approach; however, others such as the anterior temporal approach and subtemporal approach can be applicable for aneurysms in the middle and distal portions of the PCoA or giant aneurysms. Surgeons should select an appropriate approach for each aneurysm while considering the advantages and disadvantages of each technique.

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None.

Conflict of Interest
None declared.

Declaration of Patient Consent
The authors certify that they have obtained all appropriate patient consent.

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