Revascularization of the upper posterior circulation with the anterior temporal artery: an anatomical feasibility study

Ali Tayebi Meybodi, MD,^{1,2} Michael T. Lawton, MD,^{1,2} Dylan Griswold,^{1,2} Pooneh Mokhtari, PhD,² Andre Payman,² Halima Tabani, MD,^{1,2} Sonia Yousef,^{1,2} and Arnau Benet, MD^{1–3}

¹Department of Neurological Surgery, ²Skull Base and Cerebrovascular Laboratory, and ³Department of Otolaryngology–Head and Neck Surgery, University of California, San Francisco, California

OBJECTIVE In various disease processes, including unclippable aneurysms, a bypass to the upper posterior circulation (UPC) including the superior cerebellar artery (SCA) and posterior cerebral artery (PCA) may be needed. Various revascularization options exist, but the role of intracranial (IC) donors has not been scrutinized. The objective of this study was to evaluate the anatomical feasibility of utilizing the anterior temporal artery (ATA) for revascularization of the UPC.

METHODS ATA-SCA and ATA-PCA bypasses were performed on 14 cadaver specimens. After performing an orbitozygomatic craniotomy and opening the basal cisterns, the ATA was divided at the M₃-M₄ junction and mobilized to the crural cistern to complete an end-to-side bypass to the SCA and PCA. The length of the recipient artery between the anastomosis and origin was measured.

RESULTS Seventeen ATAs were found. Successful anastomosis was performed in 14 (82%) of the ATAs. The anastomosis point on the PCA was 14.2 mm from its origin on the basilar artery. The SCA anastomosis point was 10.1 mm from its origin. Three ATAs did not reach the UPC region due to a common opercular origin with the middle temporal artery. The ATA-SCA bypass was also applied to the management of an incompletely coiled SCA aneurysm.

CONCLUSIONS The ATA is a promising IC donor for UPC revascularization. The ATA is exposed en route to the proximal SCA and PCA through the pterional-orbitozygomatic approach. Also, the end-to-side anastomosis provides an efficient and straightforward bypass without the need to harvest a graft or perform multiple or difficult anastomoses.

<https://thejns.org/doi/abs/10.3171/2017.3.JNS162865>

KEY WORDS cerebral revascularization; superior cerebellar artery; posterior cerebellar artery; basilar apex aneurysm; orbitozygomatic craniotomy; vascular insufficiency syndrome; vascular disorders; anatomy; oculomotor-tentorial triangle

COMPLEX aneurysms involving the basilar apex, superior cerebellar artery (SCA), and posterior cerebral artery (PCA) may require bypass as part of their treatment strategy when dolichoectatic or fusiform morphology, dissecting etiology, or previous intervention makes them unclippable.^{14,16,20,21,24,26,31,37} Patients with vertebrobasilar insufficiency may also benefit from flow augmentation to the upper posterior circulation (UPC) using a bypass to the PCA or SCA.^{3,18,33,37} UPC revascularization^{3,14,16,18,20,21,24,26,27,31,33,37} can be performed using the superficial temporal artery (STA) in an STA-PCA or

STA-SCA bypass, and these more traditional extracranial (EC)-intracranial (IC) bypasses have been reported after trapping complex PCA or SCA aneurysms.^{5,6,14,20,22,35} The occipital artery has also been used for EC-IC revascularization of the PCA and SCA.^{4,9,18,19,32,36} The in situ SCA-PCA bypass is another way to revascularize the distal UPC in rare cases in which the STA is unavailable or diminutive,^{23,24,26,30} but this bypass is technically challenging and has a steep learning curve.²⁸ In our recently reported experience with the surgical treatment of dolichoectatic aneurysms of the basilar trunk, a bypass from the middle cere-

ABBREVIATIONS ATA = anterior temporal artery; EC = extracranial; IC = intracranial; MCA = middle cerebral artery; PCA = posterior cerebral artery; RAG = radial artery graft; SCA = superior cerebellar artery; STA = superficial temporal artery; UPC = upper posterior circulation.

SUBMITTED November 29, 2016. **ACCEPTED** March 6, 2017.

INCLUDE WHEN CITING Published online September 22, 2017; DOI: 10.3171/2017.3.JNS162865.

bral artery (MCA) to the SCA with an interposition graft, in combination with distal clip occlusion of the aneurysm, showed promising results.²¹ These bypass choices that rely on scalp arteries or interposition grafts may not always be feasible. The STA or radial artery grafts (RAGs) may not be always available,²⁴ and the saphenous vein graft may be too large in caliber to match the PCA or SCA. Occipital artery harvest during a frontotemporal-orbitozygomatic approach may be difficult due to patient positioning.

Novel IC-IC bypasses require anatomical research to find potential IC donor arteries and minimize the need for EC dissection for grafts and/or donors. We have previously reported our clinical experience using the anterior temporal artery (ATA) as an IC donor for low-flow bypass both to the anterior and posterior circulations.²⁸ The ATA supplies a noneloquent region of the temporal lobe which, when the ATA is redirected in a bypass to a different territory, does not cause major permanent neurological sequelae after the ensuing infarction.^{12,13,23,28,29} Utilization of the ATA was first reported by Bederson and Spetzler to revascularize the MCA territory in a case of a giant

unclippable MCA aneurysm,⁷ and we have also used the ATA in various bypasses to the MCA and SCA (Fig. 1).^{1,28} However, reports on ATA utilization as a donor for IC-IC bypass to the UPC are scarce and do not provide relevant anatomical information regarding capacities and limitations. We were interested in the anatomical feasibility of utilizing the ATA as a donor for revascularization of the UPC and therefore assessed the feasibility of ATA-SCA and ATA-PCA bypass using surgical simulation in cadavers.

Methods

Seven cadaveric heads (14 hemispheres) were prepared for surgical simulation in the Skull Base and Cerebrovascular Laboratory at the University of California, San Francisco, using our customized formula.⁸ Each head was placed in a 3-pin clamp (Mizuho), with the vertex tilted approximately 15° toward the floor and turned 45° contralaterally, such that the malar eminence was the highest point of the simulated operative field. A large orbitozygo-

FIG. 1. A 55-year-old woman presented with subarachnoid hemorrhage from a multilobulated left (L) SCA aneurysm, seen on a rotational angiogram with 3D reconstruction (A). She was referred for surgery to protect her from rehemorrhaging. The aneurysm could not be clipped without occluding the SCA and a bypass was needed. A prominent ATA was found in the sylvian fissure (B), and it had sufficient length to reach the SCA (C). The ATA was divided at the M₃-M₄ junction and transposed to the crural cistern, and an end-to-side anastomosis was completed with the SCA (D; arrow). After bypass patency was confirmed, the aneurysm neck was dissected and clipped. A postoperative angiogram (left ICA injection, lateral view) confirmed SCA reconstitution (E; arrow). Note the course of the SCA over the cerebellar vermis. The patient tolerated ATA sacrifice without neurological sequela. ACA = anterior cerebral artery; ICA = internal carotid artery; Tr. = trunk. Figure is available in color online only.

FIG. 2. Artist's illustration showing transposition of the ATA to reach the PCA. AChA = anterior choroidal artery; ACoA = anterior communicating artery; BA = basilar artery; CN II = cranial nerve II; PCoA = posterior communicating artery; TPA = temporo-polar artery. Copyright Arnau Benet. Published with permission. Figure is available in color online only.

matic craniotomy was completed. Following dural opening, the sylvian fissure was widely split, and the ATA was identified. The cisternal segment of the ATA was freed from arachnoid attachments and its small branches to the temporal lobe were cut. Next, the pretemporal corridor was obtained by retracting the temporal lobe laterally and posteriorly, which allowed access to the upper basilar area. The carotid, chiasmatic, crural, and ambient cisterns were opened to expose the basilar apex, the ipsilateral P_1 and P_2 segments of the PCA, and the SCA. Next, the ATA was divided at its opercular-cortical (M_3 - M_4) junction and mobilized posteriorly to reach the SCA and PCA region. The feasibility of completing an end-to-side anastomosis without undue tension on the donor artery was assessed for the most distal accessible point on the PCA and SCA. The

anastomosis points on the SCA and PCA were reached though the corridor of the oculomotor-tentorial triangle, delimited by the oculomotor nerve medially and the tentorial edge laterally (Figs. 2 and 3; Video 1).

VIDEO 1. 3D clip demonstrating the ATA-PCA bypass in a cadaveric surgical simulation. Copyright Arnau Benet. Published with permission. [Click here to view.](#)

The diameter of the ATA stump and the diameters of the PCA and SCA at anastomosis points were recorded. The lengths of the PCA and SCA segments between their origin on the basilar artery (BA) and the anastomosis points were measured using a frameless stereotactic navigation system (Stryker). Also, the cisternal length of the ATA was recorded from its origin to the M_3 - M_4 junction. The

FIG. 3. Cadaveric simulation of the ATA-PCA bypass. A left orbitozygomatic approach is completed. **A:** The sylvian fissure is opened and the ATA is identified. **B:** The ATA is divided at the M_3 - M_4 junction and mobilized toward the crural cistern lateral to the oculomotor nerve. The P_2 PCA is isolated between temporary clips, and an end-to-side anastomosis is completed between the ATA and PCA. **C:** Completed ATA-PCA bypass. Figure is available in color online only.

branching map of the MCA was recorded to find possible correlations between specific branching patterns and the feasibility of bypass to the PCA and SCA.

Results

There were 17 ATAs in the 14 hemispheres assessed (3 had duplicate ATAs). ATA-P₂ PCA and ATA-SCA bypasses were feasible in 14 ATAs (82%). All ATA-PCA and ATA-SCA bypasses were completed through the oculomotor-tentorial window using a pretemporal trajectory, without retracting the oculomotor nerve. Of the 14 ATA donors with a successful bypass, 9 (64%) had a diameter greater than 1 mm (average 1.3 mm). The diameters of the PCA and SCA at the anastomosis points were 2.7 ± 0.4 mm and 1.9 ± 0.3 mm, respectively. The ATA could be successfully anastomosed 14.2 ± 4.8 mm from the PCA origin and 10.1 ± 2.7 mm from the SCA origin. The mean cisternal length of the ATA in cases with successful bypass was 38.5 mm, while the average cisternal length of the ATA in specimens in which bypass failed was 15.6 mm. All early-branching ATAs (i.e., ATAs originating prior to MCA bifurcation) were successfully mobilized to reach the UPC complex (Type I, $n = 4$). From the non-early-branching ATAs (Type II, $n = 13$), 9 originated from the insular segment of the MCA (Type II_A), and 3 originated distally (on the opercular surface; Type II_B). Only Type II_B ATAs did not have sufficient cisternal length to complete the bypass ($n = 3$; Fig. 4).

Discussion

This study demonstrates that the ATA can be transposed to complete an end-to-side anastomosis to the UPC region in most cases (82% of ATAs). Overall, in more than 50% of all specimens, the ATA had enough cisternal length and more than 1 mm of distal diameter to allow bypass to the UPC (9/17). The results of the present work, as well as the provided clinical example (Fig. 1), validate the use of the ATA to augment flow in the UPC in selected cases.

Vascular lesions of the UPC can be accessed through 3 main approaches: 1) the frontotemporal-orbitozygomatic

craniotomy for lesions from the basilar apex to the proximal P_{2A} segment of the PCA and s₁ segment of the SCA; 2) the subtemporal approach for distal P_{2A} and P_{2P} segments of the PCA, and s₂ segment of the SCA; and 3) posterior interhemispheric approaches to lesions of the P₃ and P₄ segments of the PCA and s₄ segments of the SCA.^{10,18,25,34,37} Current evidence seems to weigh in favor of endovascular therapy for lesions of the distal PCA (P₂–P₄), and bypass has not been shown to be of much benefit in these segments.⁹ In contrast, aneurysms of the proximal PCA and SCA are good candidates for surgical treatment.^{2,10,11,27} Of those lesions amenable to surgery, certain unclippable aneurysms may require bypass after aneurysm trapping, based on the pre- and/or intraoperative studies.^{15,17,20,21,26–28} Similarly, the surgical results with dolichoectatic aneurysms affecting the basilar trunk favor the use of MCA-PCA bypass.²¹ We have shown that the frontotemporal-orbitozygomatic approach provides excellent exposure of the proximal PCA and the SCA through the pretemporal corridor while minimizing temporal lobe retraction.³⁷ Most lesions of the UPC requiring bypass can be addressed via a frontotemporal-orbitozygomatic approach, which includes ATA exposure during the wide splitting of the sylvian fissure. These factors combined show that the ATA (when of optimal diameter) can serve as a reliable IC donor to the UPC and therefore may eliminate the need for harvesting a graft vessel.

The ATA-PCA and ATA-SCA bypasses are performed in an end-to-side fashion, which is technically simpler than the side-to-side SCA-PCA bypass.²⁴ Furthermore, the recipient arteries for posterior circulation bypasses are located in deeper corridors, which increases the technical difficulty of anastomosis and limits its clinical application. Therefore, the availability of the ATA as a donor is of great value when considering a bypass to the UPC. In addition, the overall anastomosis time for the ATA-SCA or ATA-PCA bypass may be less than the MCA-RAG-PCA bypass because it requires only 1 anastomosis in the former as opposed to 2 in the latter. These features make the ATA a promising donor in selected cases requiring bypass to the UPC.

FIG. 4. Main branching patterns of the ATA and adjacent arteries regarding the feasibility of bypass to the PCA. **A:** Early-branching ATA (Type I), branching from the MCA prior to its bifurcation. **B:** Non-early-branching ATA originating from the insular segment of the MCA (Type II_A). **C:** Non-early-branching ATA originating from the opercular segment of the MCA (Type II_B). All ATAs that failed a bypass to the PCA were Type II_B. MTA = middle temporal artery. Copyright Arnau Benet. Published with permission. Figure is available in color online only.

Clinical Evaluation of ATA-UPC Bypass Feasibility

The branching pattern of the ATA determines the feasibility of bypass to the UPC. All ATAs studied had sufficient length to reach the UPC except 3 (18%). In these specimens, the ATA origin was located distally on the opercular segment of a stem branch of the MCA (Fig. 4C). Such a branching pattern can be easily recognized in the preoperative angiogram to rule out the use of the ATA as a potential donor in those cases (Fig. 5). Moreover, the cisternal length of the ATA, the caliber match between the ATA and the recipient, and the length from the origin of the ATA to the plausible anastomosis point on the SCA or PCA can be measured on preoperative angiograms, allowing preoperative evaluation of the donor artery.

The present study reports the anatomical feasibility of the use of the ATA in IC-IC bypass procedures using surgical simulation in cadavers. This work builds on our clinical experience using the ATA as an intracranial donor for

UPC revascularization, as well as our greater experience with IC-IC bypasses. However, the present work includes a single clinical case illustration. Only further large-scale clinical applications will establish the impact of this bypass strategy and the role of the ATA in revascularizing the UPC. The clinical sequelae of ATA sacrifice have not been studied extensively, but anterior temporal lobectomy has shown that removal of the anterior temporal lobe (ATA territory) does not produce clinical deficits.^{12,13,23,28,29} Possible memory and cognitive deficits should be considered before using the ATA as a bypass donor, but these risks appear minimal.

Conclusions

This study demonstrates the anatomical feasibility of using the ATA in revascularization of the UPC. Based on our clinical application (ATA-SCA bypass) and the results

FIG. 5. Radiological illustration of the different branching patterns of the ATA relevant to the ATA-UPC bypass. Type I ATA in a patient with a previously clipped ACoA aneurysm (A–C). **A:** Anteroposterior digital subtraction angiogram showing a Type I ATA originating as an early MCA branch. Red arrow shows the MCA bifurcation point and the cisternal segment of the ATA is highlighted in green (length = 49.7 mm). **B:** Coronal CT angiography depicting the MCA bifurcation (red arrow) and the origin of the ATA (yellow arrow). **C:** 3D reconstructed CT angiogram illustrating the required length of an ATA-PCA bypass (29.8 mm; dashed double-headed line). The distance is calculated from the ATA origin (yellow arrow) to the approximate P₁-P₂ junction. Type II_a ATA (D and E). **D:** Left anterior oblique digital subtraction angiogram showing the Type II_a ATA originating from the insular (M₂) segment of the MCA. Red arrow shows the MCA bifurcation point. The cisternal segment of this Type II_a ATA (from its origin to the M₂-M₃ junction) is marked in green with a length of 40.1 mm. **E:** 3D reconstructed CT angiogram of the same patient depicting the required length of the ATA (from its origin at the M₂ MCA) for an ATA-PCA bypass to the P₁-P₂ junction (28 mm). **F:** Anteroposterior digital subtraction angiogram showing a Type II_b ATA originating from the opercular segment of the MCA (highlighted in green; note the MCA bifurcation aneurysm in this patient). Although a common early MCA branch gives rise to the ATA (red arrow), TPA, and MTA, the ATA is originating from the opercular segment of this branch and cannot be mobilized. Figure is available in color online only.

of this study, we propose that the ATA can be considered as a donor in bypasses to the SCA or PCA. The ATA expands the bypass armamentarium for neurosurgeons needing an alternative to traditional EC-IC and interpositional bypasses.

Acknowledgments

We would like to express our gratitude to the body donors and their families, who, through their altruism, contributed to this project. We also thank Ken Probst for the illustrations included in this article.

References

1. Abila AA, Lawton MT: Anterior cerebral artery bypass for complex aneurysms: an experience with intracranial-intracranial reconstruction and review of bypass options. **J Neurosurg** 120:1364–1377, 2014
2. Atalay B, Altinors N, Yilmaz C, Caner H, Ozger O: Fusiform aneurysm of the superior cerebellar artery: short review article. **Acta Neurochir (Wien)** 149:291–294, 2007
3. Ausman JI, Diaz FG, de los Reyes RA, Pak H, Patel S, Mehta B, et al: Posterior circulation revascularization. Superficial temporal artery to superior cerebellar artery anastomosis. **J Neurosurg** 56:766–776, 1982
4. Ausman JI, Diaz FG, Vacca DF, Sadasivan B: Superficial temporal and occipital artery bypass pedicles to superior, anterior inferior, and posterior inferior cerebellar arteries for vertebrobasilar insufficiency. **J Neurosurg** 72:554–558, 1990
5. Ausman JI, Lee MC, Chater N, Latchaw RE: Superficial temporal artery to superior cerebellar artery anastomosis for distal basilar artery stenosis. **Surg Neurol** 12:277–282, 1979
6. Avery M, Chehab S, Wong JH, Mitha AP: Intraoperative indocyanine green videoangiography to guide decision making regarding need for vessel bypass: A case report and technical note. **Surg Neurol Int** 7 (Suppl 2):S36–S39, 2016
7. Bederson JB, Spetzler RF: Anastomosis of the anterior temporal artery to a secondary trunk of the middle cerebral artery for treatment of a giant M1 segment aneurysm. Case report. **J Neurosurg** 76:863–866, 1992
8. Benet A, Rincon-Torroella J, Lawton MT, González Sánchez JJ: Novel embalming solution for neurosurgical simulation in cadavers. **J Neurosurg** 120:1229–1237, 2014
9. Chang SW, Abila AA, Kakarla UK, Sauvageau E, Dashti SR, Nakaji P, et al: Treatment of distal posterior cerebral artery aneurysms: a critical appraisal of the occipital artery-to-posterior cerebral artery bypass. **Neurosurgery** 67:16–26, 2010
10. Goehre F, Lehecka M, Jahromi BR, Lehto H, Kivisaari R, Hijazy F, et al: Subtemporal approach to posterior cerebral artery aneurysms. **World Neurosurg** 83:842–851, 2015
11. Honda M, Tsutsumi K, Yokoyama H, Yonekura M, Nagata I: Aneurysms of the posterior cerebral artery: retrospective review of surgical treatment. **Neurol Med Chir (Tokyo)** 44:164–169, 2004
12. Ipekdağ HI, Karadas O, Erdogan E, Gokcil Z: Spectrum of surgical complications of temporal lobe epilepsy surgery: a single-center study. **Turk Neurosurg** 21:147–151, 2011
13. Jones JE, Blocher JB, Jackson DC: Life outcomes of anterior temporal lobectomy: serial long-term follow-up evaluations. **Neurosurgery** 73:1018–1025, 2013
14. Kalani MY, Hu YC, Spetzler RF: A double-barrel superficial temporal artery-to-superior cerebellar artery (STA-SCA) and STA-to-posterior cerebral artery (STA-PCA) bypass for revascularization of the basilar apex. **J Clin Neurosci** 20:887–889, 2013
15. Kalani MY, Ramey W, Albuquerque FC, McDougall CG, Nakaji P, Zabramski JM, et al: Revascularization and aneurysm surgery: techniques, indications, and outcomes in the endovascular era. **Neurosurgery** 74:482–498, 2014
16. Kalani MY, Spetzler RF: Internal carotid artery-to-posterior cerebral artery bypass for revascularization of the brainstem. **J Clin Neurosci** 24:151–154, 2016
17. Kalani MY, Zabramski JM, Hu YC, Spetzler RF: Extracranial-intracranial bypass and vessel occlusion for the treatment of unclippable giant middle cerebral artery aneurysms. **Neurosurgery** 72:428–436, 2013
18. Kazumata K, Yokoyama Y, Sugiyama T, Asaoka K: Occipital-posterior cerebral artery bypass via the occipital interhemispheric approach. **Surg Neurol Int** 4:90, 2013
19. Korinth MC, Thron A, Bertalanffy H, Gilsbach JM: Coil embolization of an incidental posterior cerebral artery aneurysm after initial OA-PCA bypass surgery. **Zentralbl Neurochir** 61:158–161, 2000
20. Lamis FC, De Paiva Neto MA, Cavalheiro S: Fusiform superior cerebellar artery aneurysm treated with STA-SCA bypass and trapping. **Surg Neurol Int** 5 (Suppl 4):S139–S142, 2014
21. Lawton MT, Abila AA, Rutledge WC, Benet A, Zador Z, Rayz V, et al: Bypass surgery for the treatment of dolichoectatic basilar trunk aneurysms: a work in progress. **Neurosurgery** 79:83–99, 2016
22. Mizutani T, Kojima H, Asamoto S: Healing process for cerebral dissecting aneurysms presenting with subarachnoid hemorrhage. **Neurosurgery** 54:342–348, 2004
23. Quiñones-Hinojosa A, Lawton MT: In situ bypass in the management of complex intracranial aneurysms: technique application in 13 patients. **Neurosurgery** 57 (1 Suppl):140–145, 2005
24. Rodríguez-Hernández A, Huang C, Lawton MT: Superior cerebellar artery-posterior cerebral artery bypass: in situ bypass for posterior cerebral artery revascularization. **J Neurosurg** 118:1053–1057, 2013
25. Rodríguez-Hernández A, Rhoton AL Jr, Lawton MT: Segmental anatomy of cerebellar arteries: a proposed nomenclature. Laboratory investigation. **J Neurosurg** 115:387–397, 2011
26. Saito H, Ogasawara K, Kubo Y, Tomitsuka N, Ogawa A: Treatment of ruptured fusiform aneurysm in the posterior cerebral artery with posterior cerebral artery-superior cerebellar artery anastomosis combined with parent artery occlusion: case report. **Surg Neurol** 65:621–624, 2006
27. Sanai N, Tarapore P, Lee AC, Lawton MT: The current role of microsurgery for posterior circulation aneurysms: a selective approach in the endovascular era. **Neurosurgery** 62:1236–1253, 2008
28. Sanai N, Zador Z, Lawton MT: Bypass surgery for complex brain aneurysms: an assessment of intracranial-intracranial bypass. **Neurosurgery** 65:670–683, 2009
29. Sindou M, Guenot M, Isnard J, Ryvlin P, Fischer C, Manguière F: Temporo-mesial epilepsy surgery: outcome and complications in 100 consecutive adult patients. **Acta Neurochir (Wien)** 148:39–45, 2006
30. Sundt TM Jr, Campbell JK, Houser OW: Transpositions and anastomoses between the posterior cerebral and superior cerebellar arteries. Report of two cases. **J Neurosurg** 55:967–970, 1981
31. Taqi MA, Lazzaro MA, Pandya DJ, Badruddin A, Zaidat OO: Dissecting aneurysms of posterior cerebral artery: clinical presentation, angiographic findings, treatment, and outcome. **Front Neurol** 2:38, 2011
32. Touho H, Karasawa J, Ohnishi H, Kobitsu K: Anastomosis of occipital artery to posterior cerebral artery with interposition of superficial temporal artery using occipital interhemispheric transtentorial approach: case report. **Surg Neurol** 44:245–250, 1995
33. Tulleken CA, Streefkerk HJ, van der Zwan A: Construction of a new posterior communicating artery in a patient with poor posterior fossa circulation: technical case report. **Neurosurgery** 50:415–420, 2002

34. Turner JD, Spetzler RF: Surgical approaches to arteriovenous malformations near the posterior incisura. **World Neurosurg** **82**:314–315, 2014
35. Ulku CH, Cicekcibasi AE, Cengiz SL, Ustun ME, Buyukmumcu M: Proximal STA to proximal PCA bypass using a radial artery graft by posterior oblique transzygomatic subtemporal approach. **Neurosurg Rev** **32**:95–99, 2009
36. Vishteh AG, Smith KA, McDougall CG, Spetzler RF: Distal posterior cerebral artery revascularization in multimodality management of complex peripheral posterior cerebral artery aneurysms: technical case report. **Neurosurgery** **43**:166–170, 1998
37. Zador Z, Lu DC, Arnold CM, Lawton MT: Deep bypasses to the distal posterior circulation: anatomical and clinical comparison of pretemporal and subtemporal approaches. **Neurosurgery** **66**:92–101, 2010

Disclosures

Dr. Tayebi's research fellowship at the University of California, San Francisco, is supported by Medtronic.

Author Contributions

Conception and design: Benet, Tayebi Meybodi, Lawton. Acquisi-

tion of data: Tayebi Meybodi, Griswold, Mokhtari, Payman. Analysis and interpretation of data: Tayebi Meybodi, Griswold. Drafting the article: Tayebi Meybodi. Critically revising the article: all authors. Reviewed submitted version of manuscript: Benet, Tayebi Meybodi, Lawton, Mokhtari, Payman, Tabani, Yousef. Approved the final version of the manuscript on behalf of all authors: Benet. Statistical analysis: Griswold. Administrative/technical/material support: Benet. Study supervision: Benet.

Supplemental Information

Videos

Video 1. <https://vimeo.com/216012464>.

Current Affiliations

Drs. Tayebi Meybodi and Lawton: Department of Neurological Surgery, Barrow Neurological Institute, Phoenix, Arizona.

Correspondence

Arnau Benet, Department of Neurosurgery, Barrow Neurological Institute, Phoenix, AZ, 350 W Thomas Road, Phoenix, AZ 85103. email: arnaubenet@gmail.com.