学位論文

Surgical Microanatomy of the Posterior Condylar Emissary Vein and its Anatomical Variations for the Transcondylar Fossa Approach

（経後頭顆到達法における後顆導出静脈の微小解剖学的破格に関する研究）

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BACKGROUND: It is essential to identify and be aware of the anatomy of the posterior condylar emissary vein (PCEV) for achieving an adequate operative field for the transcondylar fossa approach (TCFA).

OBJECTIVE: To describe the variations in the drainage patterns of PCEVs and the technical issues encountered in such cases.

METHODS: This was a retrospective analysis of the anatomy of PCEVs in 104 sides in 52 cases treated by the TCFA. Preoperative findings of multidetector-row computed tomography (CT) and CT venography (CTV) were compared with the intraoperative findings. The drainage patterns were classified as 5 types: the sigmoid sinus (SS), jugular bulb (JB), occipital sinus (OS), anterior condylar emissary vein (ACEV), and marginal sinus (MS).

RESULTS: The SS, JB, ACEV, and OS types were observed in 33 (31.7%), 42 (40.3%), 8 (7.7%), and 1 (1.0%) side(s), respectively. One side (1.0%) each had combined drainage from MS and JB, and ACEV and JB, respectively. In 17 sides (16.3%), the PCEVs and posterior condylar canals could not be identified on CT and CTV.

CONCLUSIONS: Preoperative CT and CTV findings correlated well with the intraoperative findings. To make a sufficient operative field for TCFA, PCEVs should be appropriately dealt with based on the preoperative knowledge of their running course, pattern, and origin.

KEY WORDS: Anatomic variation, Anterior condylar emissary vein, Jugular bulb, Marginal sinus, Occipital sinus, Sigmoid sinus, Transcondylar fossa approach

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The transcondylar fossa approach (TCFA)[1,2] is a variation of the transcondylar approach[3,4] for treating vertebral artery (VA) aneurysms (ie, clipping, trapping, or reconstructing the VA).[5-7] This approach is also effective for performing microvascular decompression (MVD) for hypoglossal neuralgia or compression of the medulla oblongata,[8-10] and for some tumors located in the cerebellopontine angle or the foramen magnum.[11-14]

ABBREVIATIONS: ACEV, anterior condylar emissary vein; **CT,** computed tomography; **CTV,** CT venography; **JB,** jugular bulb; **MS,** marginal sinus; **MVD,** microvascular decompression; **OS,** occipital sinus; **PCC,** posterior condylar canal; **PCEV,** posterior condylar emissary vein; **PICA,** posterior inferior cerebellar artery; **RAG,** radial artery graft; **SCS,** suboccipital cavernous sinus; **SS,** sigmoid sinus; **TCFA,** transcondylar fossa approach; **VA,** vertebral artery; 3-D, three dimensional

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Although the TCFA is well known, creating a complete operative field is not easy owing to the existence of the posterior condylar emissary veins (PCEVs). PCEVs have many anatomical variations, including differences in their respective diameters.[15-18] A safe and complete performance of this approach requires a thorough knowledge of the anatomical variations of PCEVs, and the techniques to deal with them. Some authors have reported anatomical studies of venous structures, including PCEVs at the craniocervical junction.[15-19] While these studies were cadaveric studies or image-based analyses, this study aimed to describe the variations in the drainage patterns of PCEVs in clinical cases, correlate preoperative computed tomography (CT) and CT venography (CTV) with intraoperative findings, and address the technical issues encountered in such cases.

METHODS

This retrospective study analyzed 52 patients (104 sides) who underwent TCFA between April 2012 and May 2015. This study was approved by the institutional review board. Patients who underwent a simple lateral suboccipital approach, which could not identify the PCEVs during the operation, were excluded. All 52 patients were preoperatively investigated by using multidetector-row CT and CTV. The preoperative findings were compared with the intraoperative findings. The anatomical drainage patterns were classified into 5 types according to the classification system by Matsushima et al,[15] which was modified as follows: the sigmoid sinus (SS) type: the intracranial orifice of PCEV in posterior condylar canal (PCC) opens into the posterojugular ridge, which is the boundary edge between the distal end of the sigmoid sulcus and the jugular foramen; jugular bulb (JB) type: the PCEV in PCC opens into the medial wall of the posterior part of the jugular foramen, and PCEV originating from the JB; occipital sinus (OS) type: the PCEV originates from the OS; anterior condylar emissary vein (ACEV) type: the PCEV connects to the ACEV in the hypoglossal canal; and marginal sinus (MS) type: the PCEV connects to the MS in the PCC (Figure 1). The running pattern of the PCC was classified into 2 types: straight and curved (Figure 2).

In each patient, helical CT of the head was performed by using a 320-row CT scanner (Aquilion ONE ViSION Edition; Toshiba Medical Systems, Tochigi, Japan). Scanning was performed with 0.5 mm scan collimation and a 0.25 mm slice reconstruction interval. Digital CT data were transferred to a workstation (Ziostation 2, version 2.1.x, Qi Imaging, Redwood City, California) for review, axial reconstruction, and three-dimensional (3-D) analysis.

Surgical intervention

The TCFA was performed in the park bench position by using an L-shaped skin incision that included the asterion and the superior nuchal line (Figure 3). The skin flap and suboccipital muscles were dissected as previously reported by us.[20] This was followed by a suboccipital craniotomy. After removing the bone flap, the transverse sinus and the SS were skeletonized by drilling. Subsequently, the extracranial orifices of the PCEVs were identified and the PCEVs were divided following bipolar coagulation. Drilling was then performed in a medial to lateral direction to expose the foramen magnum and the PCC. The PCEV was gradually excised and placed into the PCC from distal to the orifice of the origin of the PCEV. In general, PCEVs were either coagulated or sutured at the orifice. Then the condylar fossa was drilled and the blue line of the hypoglossal canal was identified. This was confirmed by stimulating the hypoglossal nerve. Finally, jugular tubercle drilling was performed.

RESULTS

The 52 included patients comprised 26 men and 26 women, with a mean age of 59.4 years (range, 26-90 years). Among the included patients, 39 underwent clipping or trapping for a VA aneurysm, with or without occipital artery-to-posterior inferior cerebellar artery (PICA) anastomosis (2 cases were operated on both sides because of bilateral VA dissecting aneurysms), 6 underwent clipping for a ruptured VA aneurysm, 6 underwent VA reconstruction for a complex VA aneurysm, 2 underwent MVD, and 1 patient underwent tumor removal for an acoustic neuroma.

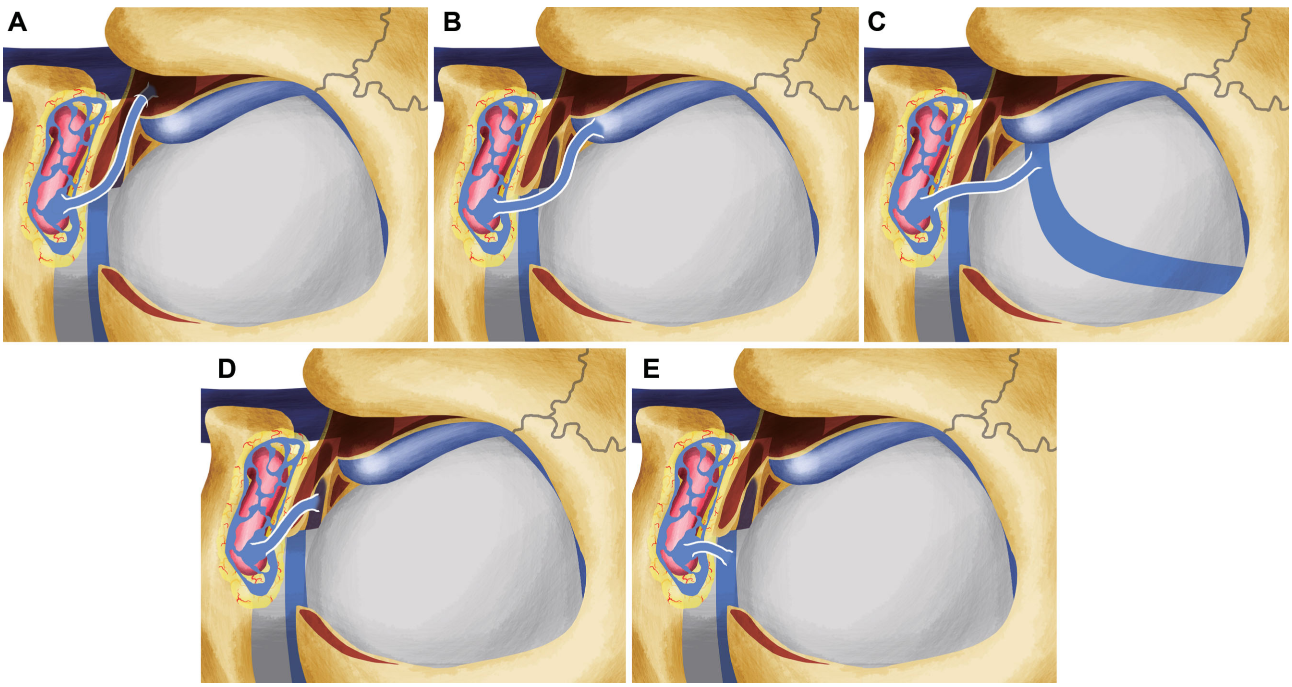

FIGURE 1. *Schema of the drainage pattern of the PCEV. This demonstrated the PCEV originating from* **A** *the SS,* **B** *the JB,* **C** *the OS,* **D** *the ACEV, and* **E** *the MS.*

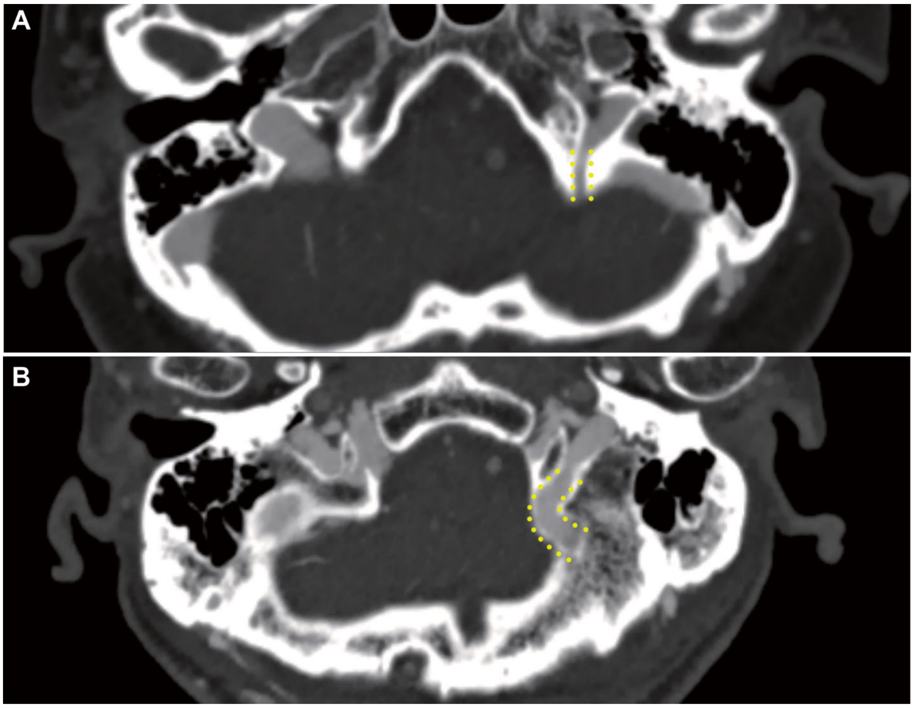

FIGURE 2. *The running pattern of the PCC.* **A** *The PCC runs in a straight course (yellow dotted lines).* **B** *The PCC runs in a curved course (yellow dotted lines).*

Drainage Patterns of the PCEVs

Among the 104 sides analyzed, the drainage pattern of the PCEVs was found to be of the SS, JB, ACEV, and OS types in 33 (31.7%), 42 (40.3%), 8 (7.7%), and 1 (1.0%) side(s), respectively (Table 1). One side (1.0%) originating from SS- OS junction. One side (1.0%) each had combined drainage from the MS and JB, and ACEV and JB, respectively. In 17 sides (16.3%), the PCEVs and PCCs could not be identified on CT or CTV. Among the 87 sides where PCCs were detected preoperatively by CT, the running patterns of the PCCs were found to be of the straight type in 39 sides (44.8%), and the curved type in 48 sides (55.2%).

Discrepancies Between Preoperative CT Findings and Intraoperative Findings

There were no discrepancies seen between the preoperative CT findings and intraoperative anatomic findings in 52 cases (54 operative sides), except for 2 cases of non-PCC on CT and CTV (Table 2). Among the 7 cases classified as non-PCC on preoperative CT, 5 were found to be non-PCC and PCEVs, and 2 cases had thin PCEVs originating from the SS, as identified intraoperatively.

Illustrative Cases

1. PCEV originating from the SS (Figure 4)

A 63-year-old woman presenting with left-sided hemifacial spasm. She required MVD via TCFA because the root exit zone of her seventh cranial nerve was compressed by the VA on the left side.

Clinical nuance: The PCEV was well developed. Because its running pattern was of the curved type, significant manipulation was required. During the procedure, the vessel wall was torn near the SS, and was suture repaired.

2. PCEV originating from the JB (Figure 5)

A 67-year-old man presented with a left side VA-PICA unruptured aneurysm. Neck clipping was performed by the TCFA.

Clinical nuance: The PCEV in this case was well6pt developed and had a straight-type running pattern. The vessel wall of the PCEV was secured intracranially. Since the running pattern was straight, the vessel wall could be easily pushed into its origin.

3. PCEV originating from the ACEV (Figure 6)

A 59-year-old man presented with acute vertebral dissecting aneurysm. He underwent V3 segment-radial artery graft (RAG)-V4 segment (V3-RAG-V4) bypass with VA trapping.

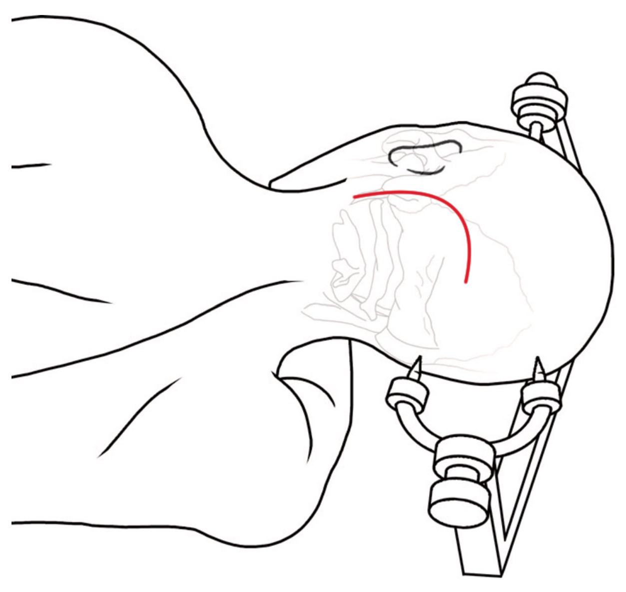

FIGURE 3. *Schema of the skin incision made for the TCFA. The patient is in the park bench position. The head position ensures that the contralateral internal jugular vein is not compressed. The skin incision includes the asterion and superior nuchal line, and is inferiorly directed at the digastric point, to the level of the C1 spinous process.*

TABLE 1. Distribution of PCEV Variants Among 104 Sides Evaluated by Preoperative Computed Tomography Venography

Drainage patterns of the PCEVs	No. of sides (n = 104)	%
JB type	42	40.3
SS type	33	31.7
ACEV type	8	7.7
MS type	0	0
OS type	1	1
Non-PCC	17	16.3
MS + JB	1	1.0
AC + JB	1	1.0
SS-OS junction	1	1.0

JB: jugular bulb, SS: sigmoid sinus, ACEV: anterior condylar emissary vein, MS: marginal sinus, OS: occipital sinus, PCC: posterior condylar canal; PCEV: posterior condylar emissary vein.

Clinical nuance: The PCEV was relatively thin and enabled easy manipulation of the vessel wall during drilling. After opening the PCEV, bone wax was effective in achieving hemostasis.

4. PCEVs originating from the MS and JB (Figure 7, and **Video, Supplemental Digital Content**)

TABLE 2. Distribution of the PCEV Variants Among 52 Cases of 54 Sides Treated Using TCFA

Drainage patterns of the PCEVs	No. of cases (n = 54)	%	Discrepancy between the operative findings (case [%])
JB	23	42.6	0
SS	18	33.3	0
ACEV	4	7.4	0
OS	1	1.9	0
MS + JB	1	1.9	0
Non-PCC	7	13.0	2 (28.6)

JB: jugular bulb, SS: sigmoid sinus, ACEV: anterior condylar emissary vein, OS: occipital sinus, MS: marginal sinus, PCC: posterior condylar canal, PCEV: posterior condylar emissary vein, TCFA: transcondylar fossa approach.

A 60-year-old man presented with bilateral VA dissecting aneurysms. First, the VA occlusion on the left side was treated with endovascular coiling, but the treated aneurysm recanalized and continued to increase in size. Thus, a V3-RAG-V4 reconstruction was performed by the TCFA.

Clinical nuance: The PCEV in this case demonstrated branching within the occipital bone, thus rendering it difficult to expose the vessel wall circumferentially, especially at the junction of both the branches. Owing to this reason, bipolar coagulation of this junction was unsuccessful. Initially, medial drilling was performed and the branch of the PCEV originating from the MS was manipulated. Here bone wax was effective in achieving hemostasis. Subsequently, drilling was extended laterally and the second branch of the PCEV originating from the JB was also gradually manipulated to its origin. Bipolar coagulation was successful in occluding this branch.

5. PCEV originating from the OS (Figure 8)

A 58-year-old man presented with a left-sided VA-PICA aneurysm. He underwent neck clipping along with occipital artery-PICA anastomosis by the TCFA.

Clinical nuance: The relatively thin PCEV made it obvious that it originated from the OS. The PCEV was easily manipulated and sealed by bipolar coagulation at an early stage of drilling. Following this, condylar fossa drilling was easily performed.

DISCUSSION

PCEVs are a part of the venous system termed the suboccipital cavernous sinus (SCS) by Arnautovic et al.[19] The SCS was described as the "alternative pathway for venous drainage from the intracranium," "second drainage system from the intracranial compartment," and "relay station, having multiple connections among cranial venous sinuses, internal jugular vein, and vertebral venous plexus" by the authors.[19] PCEVs drain into the SCS along

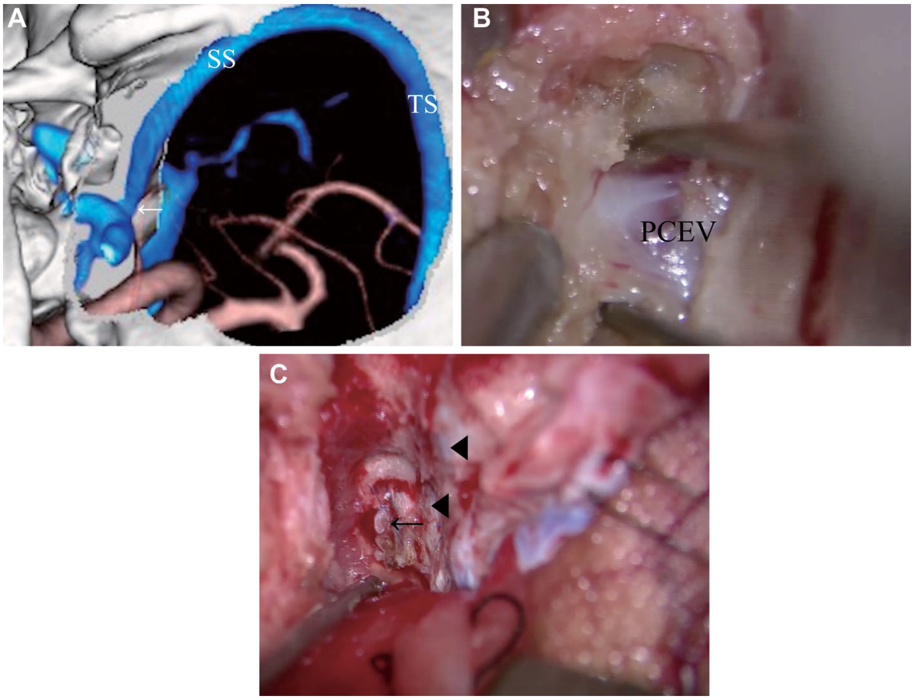

FIGURE 4. *Preoperative imaging and intraoperative findings of case 1.* **A**, *CT angiography (CTA) and CTV demonstrates the PCEV originating from the SS.* **B**, *The extracranial portion of the PCEV is secured circumferentially and divided after bipolar coagulation. The PCEV is gradually pushed into the PCC following drilling.* **C**, *The PCEV is dissected at its origin (arrowhead). The PCEV, here, originates from the SS (arrowhead). The vessel wall is sutured because the PCEV is too large for coagulation. TS, transverse sinus.*

with other emissary veins such as the mastoid emissary vein, and the lateral and anterior emissary veins.

Variations in the Drainage of the PCEVs

Generally, PCEVs originate from the JB or SS,[21] although they can originate from the ACEV or the OS. In addition, PCEVs originate from the MS or may have multiple drainage combinations, as aforementioned. Several authors have reported on the rates of these variations.[15-18] Matsuhima et al[15] identified PCEVs in 73% of the 50 patients (100 sides) that they analyzed, and reported the rates of these variations as follows: 29%, 67%, 4%, and 0% originate from the SS, JB, ACEV, and OS, respectively.[15] Their findings are similar to our results. Additionally, we also reported 2 cases wherein the PCEV originate from 2 parent vessels such as the MS and JB, or the ACEV and JB. This finding is important as it indicates that the PCC is not always a simple canal, and that it may sometimes demonstrate branching in the occipital bone.

Anatomic Importance of the PCEVs for the TCFA

The TCFA is one of the operative approaches from the lateral part of the foramen magnum, with the others being the lateral approach,[22] the transcondylar approach,[3] and the extreme lateral approach.[23] Each of these approaches has anatomical differences that reflect in the location of craniotomy and drilling. The TCFA specifically involves extradural removal of the posterior portion of the jugular tubercle through the condylar fossa, and leaves the atlanto-occipital joint intact. The TCFA can provide a more lateral and inferiorly placed operative field than the suboccipital approach.[5-7] As a part of this approach, during the drilling of the condylar fossa and the jugular tubercle, surgeons always encounter PCEVs. Although there is no report of an SS or internal jugular vein occlusion caused by inadequate manipulation of the PCEVs while performing the TCFA, such a possibility, and the resulting severe complications, cannot be ruled out. In addition, without appropriate manipulation and hemostasis of the PCEVs, the TCFA cannot be completed, and this may result in an inadequate operative field. Our study demonstrated a good correlation between the preoperative CT and CTV findings and the intraoperative findings. Thus, CT and CTV may enable preoperative prediction of the origin of the PCEVs, and its running course, and guide the operating surgeon in choosing the direction in which to dissect the PCEV. The knowledge of the running course of the PCEV may be helpful in

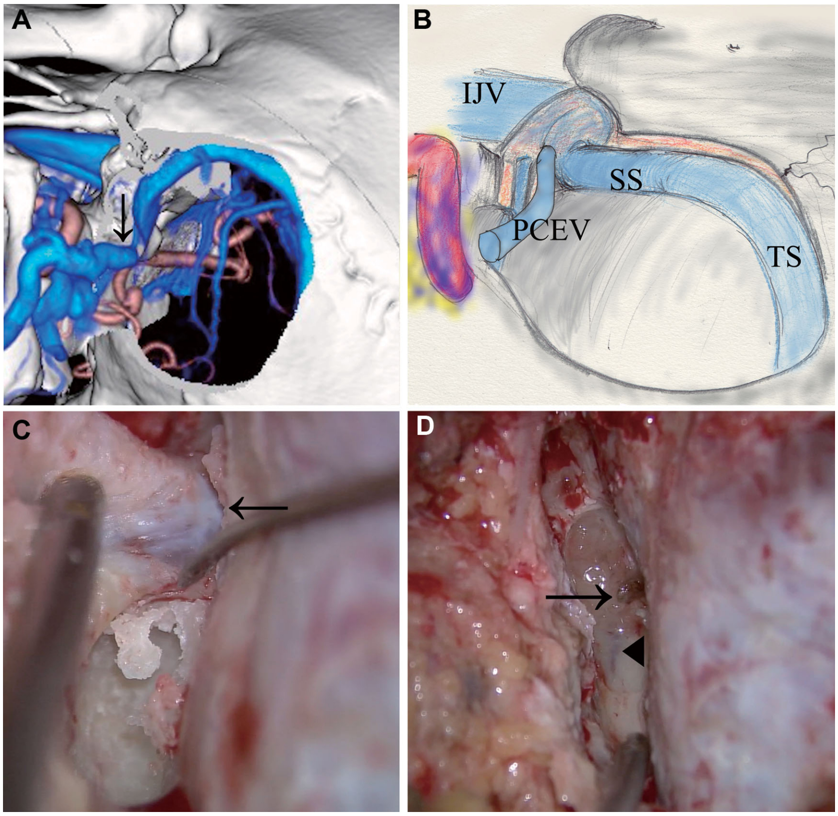

FIGURE 5. *Preoperative CT angiography (CTA), CTV, schema of the drainage pattern of PCEV, and operative findings of case 2.* **A**, *CTA and CTV demonstrate that the PCEV originated from the JB (arrow).* **B**, *Schema of the drainage pattern of case 2.* **C**, *Drilling is performed to expose the intraosseous PCEV and the PCC. The vessel wall of the PCEV is secured circumferentially (arrow).* **D**, *The drilling is completed. As the exposure of the JB is not necessary, the PCEV is still covered by the PCC (arrow). The hypoglossal canal is exposed (arrowhead). IJV, internal jugular vein; SS, sigmoid sinus; TS, transverse sinus; PCEV, posterior condylar emissary vein.*

creating an adequate operative field and performing the approach safely.

Operative Steps for Dissecting the PCEVs

Before performing TCFA, it is important to be aware of the running course, variations, and size of the PCEVs based on preoperative CT and CTV, and this information should guide the intraoperative plan regarding the steps of PCEV manipulation, and drilling.

To dissect the PCEV appropriately, the vessel wall should be first be secured circumferentially. Appropriate dissection of the PCEV should start distally, such as at the extracranial orifice of the PCC. There are 2 ways to secure the orifice of the PCC, extracranially, as in our case number 1, or by intercranial drilling, as in our case numbers 2 to 5. In the extracranial approach, the adipose tissue covering the vertebral venous plexus should be cleared. This requires the operating microscope to be at the highest magnification. The adipose tissue should be carefully removed by the use of bipolar coagulation and cutting, and care should be taken to avoid tearing the vertebral venous plexus. Although adipose tissue removal is difficult, it is advantageous as it can help in creating a wider operative space and enable easier drilling of the occipital bone and the condylar fossa. With the intercranial approach, the orifice of the PCC should first be identified extracranially, and drilling should be started medially until the opening of the lateral part of the foramen magnum is reached and then gradually proceed laterally. The eggshell skeletonizing of the PCC is an important component of this approach. After the PCEV is secured circumferentially, bipolar coagulation should be performed before it is divided. The PCEV should then be pushed into the PCC by using the microdissector, and covered with bone wax. Bone wax is effective in preventing the tearing of the PCEV during further laterally directed drilling. Then the

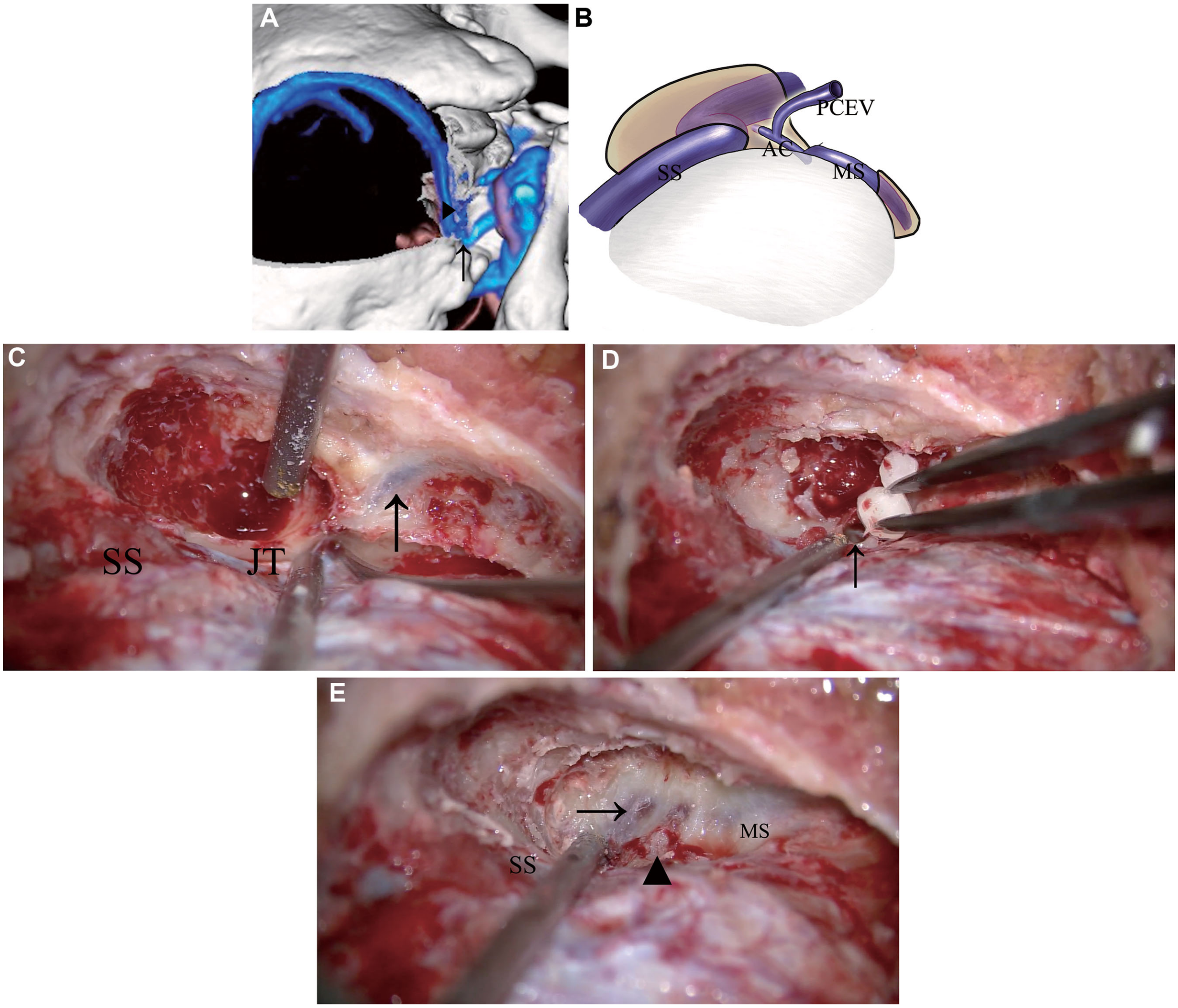

FIGURE 6. *Preoperative CT angiography (CTA), CTV, schema, and operative findings of case 3.* **A**, *The PCEV (arrow) originates from the anterior condylar vein (arrowhead).* **B**, *Schema of case 3.* **C** *Drilling is performed and the PCEV is gradually exposed (arrow).* **D**, *The PCEV is opened by drilling, and venous bleeding is visible (arrow). Bone wax is applied to the PCEV to achieve hemostasis.* **E**, *The drilling is completed. The anterior condylar vein is visible through the bone (arrow), and the origin of the PCEV is identified (arrowhead). The PCEV is covered with bone wax. SS, sigmoid sinus; AC, anterior condylar vein; JT, jugular tubercle; MS, marginal sinus.*

drilling can be gradually extended laterally. These steps can be repeated until the origin of the PCEV is exposed. At the origin of the PCEV, the vessel should be sealed by bipolar coagulation. A torn vessel wall near the sinus may be repaired by suturing or by the use of a venous patch. Bone wax should not be used here, as SS occlusion due to bone wax migration has been reported.[24,25] For the same reason, liquid hemostatic agents such as fibrin glue too should not be injected into PCEV or the venous sinus.[26] Thus, we recommend that final hemostasis of PCEV close to its origin should be performed by bipolar coagulation, suturing, or a venous patch.

Technical Implications of the PCEV Anatomical Variations

The origin of the PCEV is directed superiorly, and is sometimes large when originating from the JB, SS, and OS, owing to the large size of the parent sinus. Hence, the aforementioned

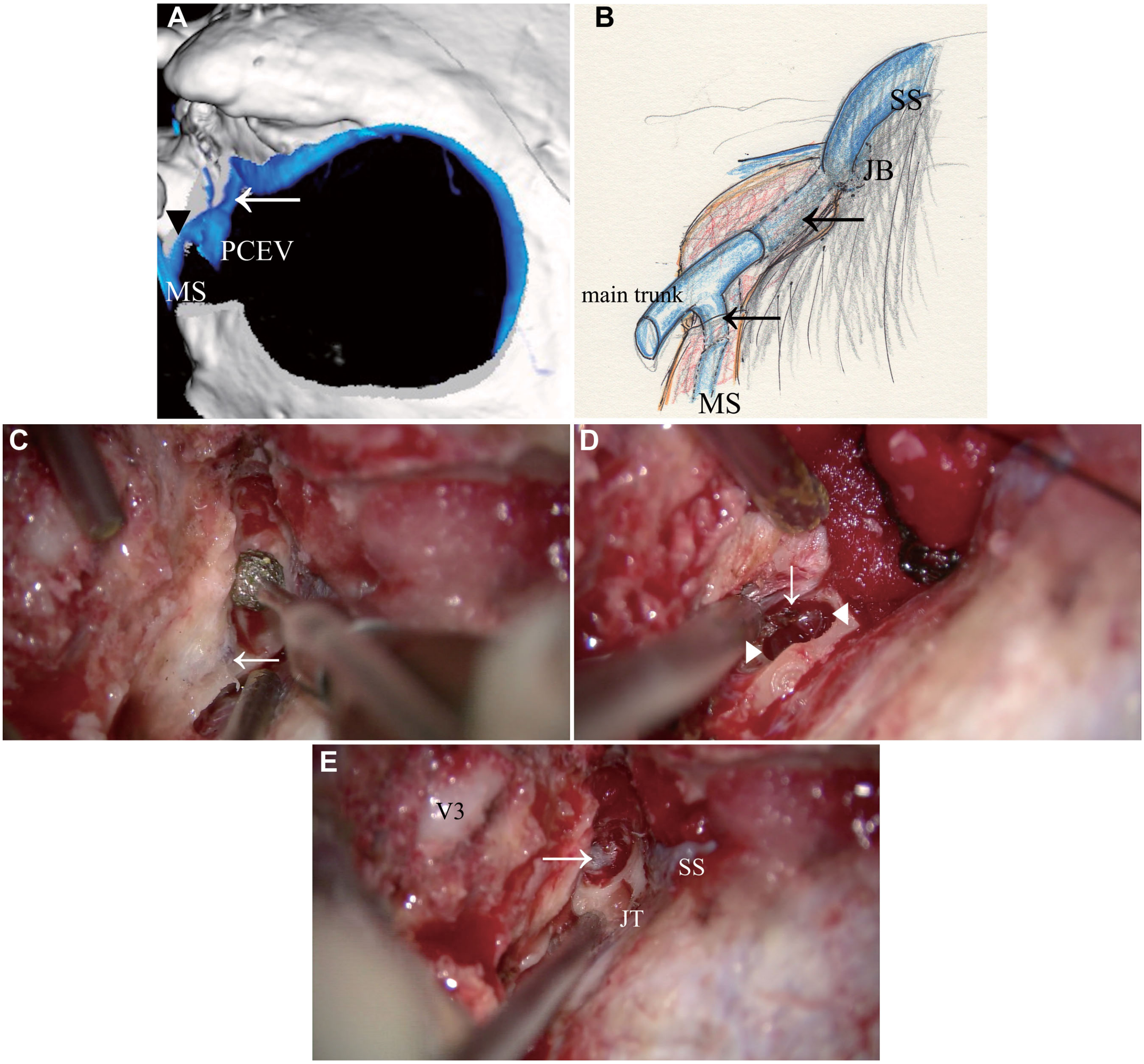

FIGURE 7. *Preoperative CTV schema, and operative findings of case 4.* **A**, *Preoperative CTV demonstrates a bifurcated PCEV within the occipital bone. One branch originates from the MS (arrowhead), whereas the other originates from JB.* **B**, *Schema of case 4. Arrows indicate the branching of the PCEV. The 2 branches fuse to become the main trunk.* **C**, *The main trunk of the PCEV is identified through the bone (arrow).* **D**, *The main trunk is coagulated and divided (arrow). The junctions of the 2 branches are identified (arrowhead).* **E**, *The drilling is completed. The PCEV originating from the JB is pushed into the PCC (arrow). SS, sigmoid sinus; V3, V3 portion of the VA; JT, jugular tubercle.*

manipulation should be performed meticulously. The straight-running type of the PCEV is easy to manipulate because the PCEV directly reaches the orifice. On the other hand, the curved-running type of the PCEV needs repetitive dissecting steps. For the ACEV pattern, the origin of PCEV is at the hypoglossal canal and the PCEV is thin because the parent vessel is thin. In this condition, it is not necessary to open the hypoglossal canal; instead, eggshell drilling can be performed until the blue line of the hypoglossal canal is identified. Adequate hemostasis may be achieved by bone wax alone. However, as the packing of the bone wax into the PCEV may cause hypoglossal nerve injury, special care should be taken to avoid the same. For the MS pattern, when it is not required to open the foramen magnum, eggshell drilling can be performed until the blue line of the MS is identified.

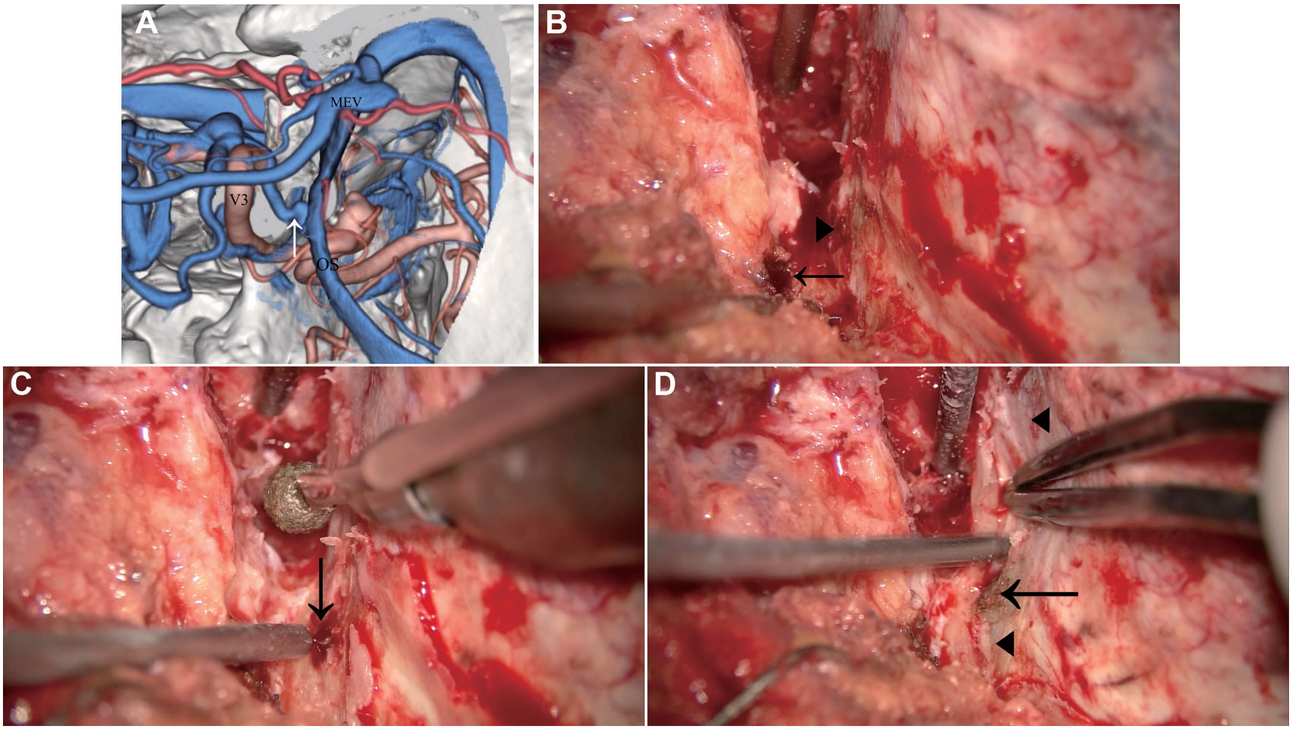

FIGURE 8. *CT angiography (CTA), CTV, and operative findings of case 5.* **A**, *Preoperative CTA and CTV demonstrate that the PCEV originates from the OS (arrow).* **B**, *Drilling is performed. As the PCEV is thin, the vessel wall cannot be secured, resulting in venous bleeding, distally (arrow), and from its origin (arrowhead).* **C**, *The wall of the PCEV is identified (arrow).* **D**, *Hemostasis is achieved at the origin of the PCEV (arrow) by bipolar coagulation. The OS is identified (arrowhead). MEV, mastoid emissary vein; V3, V3 portion of the VA; TS, transverse sinus; SS, sigmoid sinus.*

In this type also, adequate hemostasis may be achieved by bone wax alone. Where the foramen magnum requires opening, it is recommended to expose the origin of the PCEV with the aid of bipolar coagulation. In the case of a branched PCC, as in some of the cases we described, PCEV hemostasis may be difficult to perform; the vessel wall cannot be secured because it is branched. Hence, branched PCEVs may need to be divided to separate them, and bone wax may be used to achieve temporary hemostasis. Finally, the vessel walls can be coagulated to each other. Severe bleeding may occur if the surgeon is unaware of the existence of branched PCEVs.

Limitations

This was a small case series that included 52 patients, and we reported only 2 cases of branched PCEVs. As the anatomy of the venous network around the SCS is very complex, other anatomic variations of the PCEVs may exist.

CONCLUSION

The study aimed to describe the variations in the drainage patterns of PCEVs, correlate CT and CTV results with intraoperative findings, and address the technical issues encountered in such cases. We demonstrated that preoperative CT and CTV findings correlated well with the intraoperative findings. We recommend appropriate management of the PCEVs based on their preoperatively identified running course, pattern, and origin in creating an adequate operative field for the TCFA.

Disclosure

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

REFERENCES

1. Matsushima T, Fukui M. Lateral approaches to the foramen magnum: with special reference to the transcondylar fossa approach and the transcondylar approach (Japanese). *No Shinkei Geka*. 1996;24:119-124.
2. Matsushima T, Kawashima M, Masuoka J, Mineta T, Inoue T. Transcondylar fossa (supracondylar transjugular tubercle) approach: anatomic basis for the approach, surgical procedures, and surgical experience. *Skull Base*. 2010;20:83-91.
3. Bertalanffy H, Seeger W. The dorsolateral, suboccipital, transcondylar approach to the lower clivus and anterior portion of the craniocervical junction. *Neurosurgery*. 1991;29:815-821.
4. Bertalanffy H, Sure U, Petermeyer M, Becker R, Gilsbach JM. Management of aneurysms of the vertebral artery-posterior inferior cerebellar artery complex. *Neurol Med Chir (Tokyo)*. 1998;38(suppl):93-103.

5. Kubota H, Tanikawa R, Katsuno M, et al. Vertebral artery-to-vertebral artery bypass with interposed radial artery or occipital artery grafts: surgical technique and report of three cases. *World Neurosurg*. 2014;81: 201.e1-8.
6. Kubota H, Tanikawa R, Katsuno M, et al. Reconstruction of intracranial vertebral artery with radial artery and occipital artery grafts for fusiform intracranial vertebral aneurysm not amenable to endovascular treatment: technical note. *Acta Neurochir (Wien)*. 2013;155:1517-1524.
7. Todaka T, Hamada J, Yano S, Kai Y, Morioka M, Ushio Y. Successful clipping of a distal posterior inferior cerebellar artery aneurysm located on the anterior surface of the medulla oblongata–case report. *Neurol Med Chir (Tokyo)*. 2002;42: 158-161.
8. Kawashima M, Matsushima T, Inoue T, Mineta T, Masuoka J, Hirakawa N. Microvascular decompression for glossopharyngeal neuralgia through the transcondylar fossa (supracondylar transjugular tubercle) approach. *Neurosurgery*. 2010;66:275-280.
9. Matsushima T, Goto Y, Natori Y, Matsukado K, Fukui M. Surgical treatment of glossopharyngeal neuralgia as vascular compression syndrome via transcondylar fossa (supracondylar transjugular tubercle) approach. *Acta Neurochir (Wien)*. 2000;142:1359-1363.
10. Nakahara Y, Kawashima M, Matsushima T, et al. Microvascular decompression surgery for vertebral artery compression of the medulla oblongata: 3 cases with respiratory failure and/or dysphagia. *World Neurosurg*. 2014;82: 535.e11-6.
11. Bertalanffy H, Gilsbach JM, Mayfrank L, Klein HM, Kawase T, Seeger W. Microsurgical management of ventral and ventrolateral foramen magnum meningiomas. *Acta Neurochir Suppl*. 1996;65:82-85.
12. Ladziński P, Majchrzak H, Kaspera W, et al. Meningiomas of the anterior portion of the craniovertebral junction: immediate and late outcome following surgical removal using a partial transcondylar approach. *Neurol Neurochir Pol*. 2012;46:205-215.
13. Moon BH, Park SK, Han YM. Large solid hemangioblastoma in the cerebellopontine angle: complete resection using the transcondylar fossa approach. *Brain Tumor Res Treat*. 2014;2:128-131.
14. Tange Y, Uto A, Wachi A, Koike J. Transcondylar fossa approach to treat ventral foramen magnum meningioma–case report. *Neurol Med Chir (Tokyo)*. 2001;41:458-462.
15. Matsushima K, Kawashima M, Matsushima T, Hiraishi T, Noguchi T, Kuraoka A. Posterior condylar canals and posterior condylar emissary veins-a microsurgical and CT anatomical study. *Neurosurg Rev*. 2014;37:115-126.
16. San Millán Ruíz D, Gailloud P, Rüfenacht DA, Delavelle J, Henry F, Fasel JH. The craniocervical venous system in relation to cerebral venous drainage. *AJNR Am J Neuroradiol*. 2002;23:1500-1508.
17. Takahashi S, Sakuma I, Omachi K, et al. Craniocervical junction venous anatomy around the suboccipital cavernous sinus: evaluation by MR imaging. *Eur Radiol*. 2005;15:1694-1700.
18. Tanoue S, Kiyosue H, Sagara Y, et al. Venous structures at the craniocervical junction: anatomical variations evaluated by multidetector row CT. *Br J Radiol*. 2010;83:831-840.
19. Arnautović KI, al-Mefty O, Pait TG, Krisht AF, Husain MM. The suboccipital cavernous sinus. *J Neurosurg*. 1997;86:252-262.
20. Katsuno M, Tanikawa R, Uemori G, Kawasaki K, Izumi N, Hashimoto M. Occipital artery-to-posterior inferior cerebellar artery anastomosis with multiple-layer dissection of suboccipital muscles under a reverse C-shaped skin incision. *Br J Neurosurg*. 2015;29:401-415.
21. Haas LL. The posterior condylar fossa, foramen and canal, and the jugular foramen. *Radiology*. 1957;69:546-552.
22. Heros RC. Lateral suboccipital approach for vertebral and vertebrobasilar artery lesions. *J Neurosurg*. 1986;64:559-562.
23. Sen CN, Sekhar LN. An extreme lateral approach to intradural lesions of the cervical spine and foramen magnum. *Neurosurgery*. 1990;27:197-204.
24. Crocker M, Nesbitt A, Rich P, Bell B. Symptomatic venous sinus thrombosis following bone wax application to emissary veins. *Br J Neurosurg*. 2008;22:798-800.
25. Hadeishi H, Yasui N, Suzuki A. Mastoid canal and migrated bone wax in the sigmoid sinus: technical report. *Neurosurgery*. 1995;36:1220-1223.
26. Sekhar LN, Natarajan SK, Manning T, Bhagawati D. The use of fibrin glue to stop venous bleeding in the epidural space, vertebral venous plexus, and anterior cavernous sinus: technical note. *Neurosurgery*. 2007;61:E51.

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COMMENT

The authors provide a detailed anatomic and radiographic description of the anatomy of the posterior condylar emissary vein and correlate their findings with intra-operative observations. Although the transcondylar approaches are not common, the area of the lateral and ventral occipital bone is an important area often accessed in various different approaches used by almost any neurosurgeon practicing brain surgery. A clear understanding of the anatomy of the condylar vein and its drainage variations is critical for patient safety and maximization of surgical exposure. The authors' careful pre-operative assessment of the venous anatomy should be the standard for any transcondylar approach.

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