A new transvenous approach to the carotid-cavernous sinus via the inferior petrooccipital vein

Clinical article

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Object. The transvenous approach via the inferior petrosal sinus (IPS) is commonly used as the most appropriate for carotid-cavernous fistula (CCF) or cavernous sinus sampling. However, sometimes the IPS is not accessible because of anatomical problems and/or complications, therefore an alternative route is needed. In this paper, the authors present and discuss the utility of a transvenous approach to the cavernous sinus via the inferior petrooccipital vein.

Methods. Four patients, 3 with dural CCFs and the other with Cushing disease, in whom endovascular surgical attempts failed using a conventional venous approach via the IPS, underwent a transvenous approach to the cavernous sinus via the inferior petrooccipital vein (IPOV). One dural CCF case had only cortical venous drainage, the second CCF also mainly drained into the cortical vein with slight inflow into the superior ophthalmic vein and inferior ophthalmic vein, and the third demonstrated drainage into the superior and inferior ophthalmic veins and IPOV.

Results. In all cases, the cavernous sinus could be accessed successfully via this route and without complications.

Conclusions. The transvenous approach to the cavernous sinus via the IPOV should be considered as an alternative in cases when use of the IPS is precluded by an anatomical problem and there are no other suitable venous approach routes. (DOI: 10.3171/2011.4.JNS102155)

Key Words • carotid-cavernous fistula • transvenous approach • endovascular surgery • inferior petrooccipital vein • pituitary surgery • interventional neurosurgery • surgical technique

THE transvenous approach via the IPS is the first established and most commonly used endovascular surgical method for CCFs and venous hormone sampling. However, the IPS route is not usually available and when it is obstructed or anomalous through communication to the IJV, other venous drainage routes—such as through the superior petrosal sinus, the intercavernous sinus via the contralateral cavernous sinus, and the SOV—may be attempted. When the SOV is the sole drainage route except for cortical venous drainage, it often shows dilation. However, peripheral tributaries (roots) do not show a remarkable enlargement and often exhibit tortuous running and focal narrowing. Advancement of the catheter may fail. We have experienced 3 cases of dural CCFs and 1 case of Cushing disease in which the conventional IPS approach proved impossible but which could be successfully accessed via the IPOV (Table 1). The efficacy and safety of this access route in such difficult cases is discussed in this paper.

Methods

Since 1992, we have treated 76 patients with dural CCFs using endovascular surgery. The most recent 18 patients underwent transvenous embolization in addition to transarterial embolization. In 3 of these 18 patients, a conventional venous approach via the IPS failed. One dural CCF had only cortical venous drainage, another mainly drained into the same cortical veins but with slight inflow into the SOV and IOV, and the remaining CCF mainly drained into the SOV, IOV, and IPOV. During this period, a further 5 patients with Cushing syndrome underwent
superselective hormone sampling from the cavernous sinus. In 1 of these 5 patients, the conventional transvenous approach via the IPS failed. For these 4 total patients (Table 1), the transvenous approach to the cavernous sinus via the IPOV was attempted.

Preoperatively, the activated coagulation time was assessed through a 5 Fr femoral arterial sheath under local anesthesia, followed by a bolus infusion of 2000 units of heparin. During endovascular surgery, heparin was continuously infused to maintain activated coagulation time at 2–3 times the control value. A 5 Fr catheter (Envoy, Cordis/Johnson & Johnson) was placed in the affected carotid artery for repeated angiography and road mapping during endovascular surgery. A 6 Fr sheath was inserted into the contralateral site of the femoral vein. A 6 Fr catheter (Envoy, Cordis/Johnson & Johnson) was inserted via the sheath and placed in the affected site of the jugular vein. Initially, a conventional angiogram from the femoral artery was obtained to make a road map in the venous phase. A 6 Fr catheter placed in the jugular vein was rotated in the anteromedial direction, followed by advancement of the microcatheter (Excelsior, Stryker) preceded by a microguidewire (Agility 10, Cordis/Johnson & Johnson; or Transcent 10, Boston Scientific) into the cavernous sinus. With all 4 cases the transvenous approach via the IPS was initially attempted but failed. Next, the transvenous approach via the IPS was initially attempted but failed. Next, the microguidewire was advanced slightly medial to the IPS route and the microcatheter was gently advanced, preceded by the microguidewire. After the microcatheter was placed in the affected cavernous sinus, its tip was defined by venography and advanced into a suitable position to stop the cortical venous drainage in patients with CCFs or the center of the cavernous sinus in the case with Cushing disease, followed by platinum coil embolization or venous sampling.

### Table 1: Summary of 4 cases with a successful transvenous approach to the cavernous sinus via the IPOV

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Initial Sx (Disease)</th>
<th>Venous Drainages</th>
<th>Purpose</th>
<th>Treatments</th>
<th>Outcome</th>
<th>FU (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>72, M</td>
<td>Diplopia (dural CCF)</td>
<td>SMCV, DMCV, SOV, IOV</td>
<td>TVE</td>
<td>TAE &amp; TVE</td>
<td>Cure</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>76, F</td>
<td>Diplopia (dural CCF)</td>
<td>SMCV, DMCV</td>
<td>TVE</td>
<td>TAE &amp; TVE</td>
<td>Cure</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>77, F</td>
<td>Lt chemosis (dural CCF)</td>
<td>IPOV, SOV, IOV</td>
<td>TVE</td>
<td>TAE &amp; TVE</td>
<td>Cure</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>67, F</td>
<td>Moon face (Cushing)</td>
<td>None</td>
<td>Venous sampling</td>
<td>Surgical removal</td>
<td>Complete removal</td>
<td>2</td>
</tr>
</tbody>
</table>

* There were no complications in any of the cases. Abbreviations: FU = follow-up; TAE = transarterial embolization; TVE = transvenous embolization.

Results

Two of 3 cases with dural CCFs demonstrated main inflow into cortical veins and the affected cavernous sinus could be successfully accessed via the IPOV and completely occluded without complications. One patient with a dural CCF and inflow into the SOV, IOV, and IPOV also underwent transvenous embolization through the IPOV route and complete occlusion was established. Similarly, with the Cushing disease case, access to the cavernous sinus via the IPOV proved possible and venous sampling was successfully performed without complications.

**Case 1**

This 72-year-old man suddenly developed diplopia, and was followed up conservatively in an outpatient clinic because the symptoms caused by left cranial nerve III palsy gradually improved with time. Six months later, the diplopia disappeared. However, left pulsating exopthalmos, conjunctival chemosis, and pulsatile tinnitus developed after 1 year. The patient was examined using MR imaging at another hospital and referred to our institution. Magnetic resonance angiography showed an increase of the vascular structure in the left cavernous sinus communicating with a dilated cortical vein. Angiography showed a dural CCF in the left cavernous sinus draining into the cortical veins (the SMCV and DMCV), SOV, and IOV (Fig. 1A). Initially, transarterial embolization of the inflowing ECAs was performed to decrease the inflowing arterial flow. Next, the transvenous approach via the IPS was tried, but this approach failed because of an obstruction. The peripheral roots of SOV and IOV showed lack of dilation. The left IPOV route was then attempted (Fig. 1B and C), which proved successful without any complications. Angiography after the endovascular surgery showed no residual fistula and no cortical venous drainage (Fig. 1D and E). Although left cranial nerve VI palsy developed 2 days later, this disappeared 3 months after the treatment. Follow-up MR angiography showed no recurrence of the CCF.

**Case 2**

This 76-year-old woman suddenly developed diplopia and she was followed-up conservatively in an outpatient clinic because her symptoms caused by left cranial nerve VI palsy gradually improved with time. Six months later, the diplopia disappeared. However, after 2 years, the patient developed symptoms and was examined using MR imaging at another hospital and referred to our institution. Magnetic resonance angiography showed an increase of the vascular structure in the left cavernous sinus communicating with a dilated cortical vein. Angiography showed a dural CCF in the left cavernous sinus draining into the SMCV and DMCV only (Fig. 2A and B). Initially, transarterial embolization of the inflowing ECAs was performed to decrease the inflowing arterial flow.
Next, the transvenous approach via the IPS was tried, but this failed because of an obstruction of the IPS. The left IPOV route was then attempted (Fig. 2C), and this proved successful without any complications. Angiography after the endovascular surgery showed no residual fistula and no cortical venous drainage (Fig. 2D). Although, the left cranial nerve VI palsy worsened 2 days later, this disappeared 3 months after the treatment. Follow-up MR angiography showed no recurrence of the CCF.

Case 3

This 77-year-old woman developed left chemosis, and she was followed-up conservatively in an outpatient clinic. The symptoms worsened with time and proptosis also appeared. One month later, the patient was examined using MR imaging at another hospital and was referred to our institution. Magnetic resonance angiography showed an increase of the vascular structure in the left cavernous sinus. Angiography showed a dural CCF in the left cavernous sinus draining into the SOV, IOV, and IPOV (Fig. 3A and B). Initially, transarterial embolization of the inflowing ECAs was performed to decrease the inflowing arterial flow. Next, the transvenous approach via the left IPOV route was then attempted (Fig. 3C and D), and this proved successful without any complications. Angiography after the endovascular surgery showed no residual fistula and no cortical venous drainage (Fig. 3E). Three months after treatment, the symptoms had completely disappeared and follow-up MR angiography showed no recurrence of the CCF.

![Fig. 1. Case 1. Left carotid angiogram, lateral view (A), showing a CCF with drainage into the SMCV (double arrows), the DMCV (single arrow), SOV, and IOV. The peripheral roots of the SOV and IOV lack any dilation. Digital subtraction angiography, anteroposterior view (B), and skull radiograph, anteroposterior view (C), showing venography from the microcatheter into the left cavernous sinus via the IPOV (4 arrows). SMCV = double arrows, DMCV = single arrow. Left carotid angiogram, anteroposterior (D) and lateral (E) views, after endovascular surgery showing complete obliteration of the fistula and no cortical venous reflux.]

![Fig. 2. Case 2. Left carotid angiogram, anteroposterior (A) and lateral (B) views, showing a CCF with drainage limited to the SMCV (double arrows) and DMCV (single arrow). Skull radiograph, anteroposterior view (C), showing venography from the microcatheter into the left cavernous sinus via the IPOV (arrows). Left ECA angiogram, anteroposterior view (D), after endovascular surgery showing complete obliteration of the fistula and no cortical venous refluxes.]
Case 4

This 67-year-old woman was referred to our department for cavernous venous sampling to distinguish between Cushing disease and ectopic adrenocorticotropic hormone syndrome. The patient showed no suppression by means of a high-dose dexamethasone suppression test (Liddle test), but a micropituitary adenoma was suspected on MR imaging. A transvenous approach to the right cavernous sinus via the right IPS was initially attempted, but failed because of an obstruction of the IPS. Next, the right IPOV route was attempted, which was successful. The left transvenous approach to the left cavernous sinus via the left IPS was conventionally performed (Fig. 4). Venous sampling from the bilateral cavernous sinuses and femoral veins was possible and resulted in a diagnosis of Cushing disease caused by a micropituitary adenoma in the left side of the pituitary gland, which was successfully removed by a transsphenoidal approach.

Discussion

The transvenous approach via the IPS for dural CCF and hormone sampling from the cavernous sinus is the standard access route. However, when there is obstruction of the IPS or other problem such as noncommunication with the IJV, other venous drainage routes should be attempted. Benndorf et al. stated that a thrombosed IPS may also become an alternative transvenous approach route for dural CCFs, reporting 4 cases and a review of the literature. Obstructions caused by secondarily formed thrombi that are not organized and not of great age may allow introduction of a microcatheter preceded by a guidewire.

However, when the obstruction of the IPS is stiff with an organized old thrombus, the other access route to the cavernous sinus is needed. In the present series, in 2 (11%) of 18 patients with dural CCFs (Cases 1 and 2) the conventional venous approach via the IPS failed. These 2 patients were referred to our institute more than 1 year after development of initial symptoms, which may have contributed to obstruction of the IPS with an organized old thrombus. In Case 2 with only cortical venous drainage, another suitable access route other than the IPS was not present. In Case 1, the SOV was another drainage route, but the SOV and IOV did not show an adequate dilation; peripheral tributaries (roots) did not show any

**Fig. 3.** Case 3. Left carotid angiogram, anteroposterior (A) and lateral (B) views, showing a CCF with drainage into the SOV, IOV, and IPOV (4 arrows). Skull radiograph, anteroposterior (C) and lateral (D) views, showing the microcatheter with microguidewire introduced into the left cavernous sinus via the IPOV (4 arrows). Left carotid angiogram, anteroposterior view (E), after endovascular surgery showing complete obliteration of the fistula and no cortical venous reflux.
enlargement, suggesting that the SOV was not a feasible access route.

In Case 3, the IPOV developed as the main venous drainage route for a dural CCF, which showed a new appropriate access route to the cavernous sinus. In Case 4 with Cushing disease, the right IPS was not in communication with the IJV, as defined by venography of the right cavernous sinus (Fig. 4A).

**Anatomy and Variation in the IPS and IPOV**

The IPS is a dural sinus that extends from the posterior aspect of the cavernous sinus 23–28 mm laterally and posteriorly to the IJV. It courses just lateral to the clivus, along the posterior inferior edge of the petrous ridge. It usually leaves the cranial cavity through the jugular foramen, in an opening separated from the rest of the foramen by the anterior petrooccipital ligament. As it enters the jugular foramen, the IPS becomes a vein, approximately 2 mm in diameter, and enters the anteromedial aspect of the jugular bulb approximately 6 mm inferior to the level of its entrance to the jugular foramen. Shiu et al. described 4 types of variations of the junction between the IPS and the IJV, on the basis of their experience with cavernous sinus venography. In Type I, the IPS anastomosis with the IJV and the anterior condylar vein is small or absent (45%). In Type II, the anterior condylar vein is large and there is a prominent anastomosis of this vessel with the IPS (24%). In Type III, the IPS exists as several small channels, which may form a plexus. In Type IV, the IPS does not join the IJV, emptying directly into the anterior condylar vein (7%). Mitsuhashi et al. evaluated morphological aspects of the caudal end of the IPS using 3D rotational venography. They described IPS drainage into the jugular bulb in only 1 (1.2%) of 83 sides, the remainder draining into the IJV below the jugular bulb. The IPS was found to drain directly into the vertebral plexus with no connection to the IJV in 3 (3.6%) of 83 sides and the IPS was absent in 14 (16.9%) of 83 sides. In this series, the IPS with no connection to the IJV was 1 (10%) of 10 found during venous sampling in the bilateral cavernous sinus in 5 patients.

Trolard initially named a small vein different from IPS as the IPOV. San Millán Ruiz et al. reported the venous plexus of Rektorzik, corresponding to Trolard’s IPOV found coursing extracranially along the petrooccipital suture, which regularly contributed in forming the anterior condylar confluent.

Katsuta et al. called the IPOV the inferior petroclival vein and stressed its utility: a small vein running in the extracranial groove (Fig. 5) of the petrooccipital fissure, flowing into the petrosal confluens (anterior condylar confluent) and acting like a mirror image of the IPS (Fig. 6). They reported that, although it is small, it may be dilated by high venous pressure in dural arteriovenous fistula cases, making it a useful route to introduce an intravenous catheter into the cavernous sinus. This proved to be case in all of our present series of patients. To our knowledge there have been no previous reports of its use.
as an actual access route to the cavernous sinus through the IPOV. The IPOV might be mistaken as the IPS because their running courses resemble each other.

**Techniques to Navigate the Microcather Into the Cavernous Sinus Through the IPOV**

To navigate a small-diameter and soft-tip microcather into the IPOV, use of a preceding small soft guidewire is essential because it is a small vein, even if it is dilated. The microcatheter should be advanced taking into consideration the running course of the IPOV. Initially the IPOV origin from the medial part of the petrosal confluence runs comparatively sharply medial to the IPS, and thereafter runs parallel and slightly deep with the IPS (mirror image), and finally changes to a lateral course as shown in the present series.

**Conclusions**

In the event the IPS is unavailable as an access route in patients with dural CCFs and in cases requiring hormone sampling, and other transvenous approaches are not available, our original IPOV approach to the cavernous sinus can be considered safe and reliable.

**Disclosure**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Kurata. Acquisition of data: Kurata, Suzuki, Satou. Analysis and interpretation of data: Kurata, Iwamoto, Nakahara. Drafting the article: Kurata, Inukai. Critically revising the article: Kurata, Niki, Yamada. Statistical analysis: Kurata, Fuji. Study supervision: Kan, Katsuta.

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