The interpeduncular cistern is located behind the pituitary gland and infundibulum. Its anatomical boundaries are the optic apparatus and anterior recess of the third ventricle superiorly, the mammillary bodies with the basilar artery and posterior cerebral arteries posteriorly, and the posterior communicating artery (PCoA) and its perforators along with the oculomotor nerve bracketing the region laterally.9,15 Accessing this region presents a challenge no matter what surgical approach is used. Although transcranial access via various cranial base approaches has been described,5,11,15,23,28–30,33,38 most of these approaches provide only limited exposure of the interpeduncular cistern. The optimal surgical approach remains controversial.

Anatomic comparison of the endonasal and transpetrosal approaches for interpeduncular fossa access

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Object. The interpeduncular cistern, including the retrochiasmatic area, is one of the most challenging regions to approach surgically. Various conventional approaches to this region have been described; however, only the endoscopic endonasal approach via the dorsum sellae and the transpetrosal approach provide ideal exposure with a caudal-cranial view. The authors compared these 2 approaches to clarify their limitations and intrinsic advantages for access to the interpeduncular cistern.

Methods. Four fresh cadaver heads were studied. An endoscopic endonasal approach via the dorsum sellae with pituitary transposition was performed to expose the interpeduncular cistern. A transpetrosal approach was performed bilaterally, combining a retrolabyrinthine presigmoid and a subtemporal transtentorial approach. Water balloons were used to simulate space-occupying lesions. “Water balloon tumors” (WBTs), inflated to 2 different volumes (0.5 and 1.0 ml), were placed in the interpeduncular cistern to compare visualization using the 2 approaches. The distances between cranial nerve (CN) III and the posterior communicating artery (PCoA) and between CN III and the edge of the tentorium were measured through a transpetrosal approach to determine the width of surgical corridors using 0- to 6-ml WBTs in the interpeduncular cistern (n = 8).

Results. Both approaches provided adequate exposure of the interpeduncular cistern. The endoscopic endonasal approach yielded a good visualization of both CN III and the PCoA when a WBT was in the interpeduncular cistern. Visualization of the contralateral anatomical structures was impaired in the transpetrosal approach. The surgical corridor to the interpeduncular cistern via the transpetrosal approach was narrow when the WBT volume was small, but its width increased as the WBT volume increased. There was a statistically significant increase in the maximum distance between CN III and the PCoA (p = 0.047) and between CN III and the tentorium (p = 0.029) when the WBT volume was 6 ml.

Conclusions. Both approaches are valid surgical options for retrochiasmatic lesions such as craniopharyngiomas. The endoscopic endonasal approach via the dorsum sellae provides a direct and wide exposure of the interpeduncular cistern with negligible neurovascular manipulation. The transpetrosal approach also allows direct access to the interpeduncular cistern without pituitary manipulation; however, the surgical corridor is narrow due to the surrounding neurovascular structures and affords poor contralateral visibility. Conversely, in the presence of large or giant tumors in the interpeduncular cistern, which widen the spaces between neurovascular structures, the transpetrosal approach becomes a superior route, whereas the endoscopic endonasal approach may provide limited freedom of movement in the lateral extension.

Key Words • cranial base • expanded endonasal approach • endoscope • interpeduncular cistern • pituitary transposition • transpetrosal approach • retrochiasmatic craniopharyngioma

Abbreviations used in this paper: ALT-VISION = Anatomy Laboratory Toward Visuospatial Surgical Innovations in Otolaryngology and Neurosurgery; CN = cranial nerve; PCoA = posterior communicating artery; WBT = “water-balloon tumor.”
tending into the interpeduncular cistern, called retrochiasmatic craniopharyngiomas, is associated with high rates of surgical morbidity and mortality due to the anatomical complexity of the interpeduncular cistern and with incomplete resection, resulting in a high recurrence rates.\textsuperscript{3,8,10,17,21,25,27,35,36}

Hakuba et al.\textsuperscript{15} first reported the usefulness of the transpetrosal approach in removing these tumors. This approach allows direct visualization with preservation of the hypothalamus, third ventricle walls, and the inferior surface of the optic chiasm. The transspenoidal approach using either a microscope or an endoscope has been applied to address various types of craniopharyngiomas;\textsuperscript{7,8,10,17,21,25,27,35,36} however, the pituitary gland and the infundibulum guard the tumor when a transphenoidal route is undertaken for removing retrochiasmatic craniopharyngiomas. Kassam et al.\textsuperscript{19,20} described the usefulness of a superior transposition of the pituitary gland and infundibulum in removing retrochiasmatic craniopharyngiomas via an endonasal endoscopic approach. Both the transpetrosal approach and the endoscopic endonasal approach with pituitary transposition appear to be good surgical options for the treatment of retrochiasmatic craniopharyngiomas. Nevertheless, a review of the literature yields only a small number of surgical series and no comparison studies.\textsuperscript{1,2,12,15,19,22,24}

We performed an anatomical investigation to demonstrate the difference between the endonasal and transpetrosal approaches to the interpeduncular cistern and to clarify the advantages and limitations of each approach for the removal of retrochiasmatic craniopharyngiomas. In addition, we present a review of the literature.

Methods

Anatomical dissections were performed in the Anatomy Laboratory Toward Visuospatial Surgical Innovations in Otolaryngology and Neurosurgery (ALT-VISION) at The Ohio State University. Four fresh cadaver heads, without obvious intracranial disease, injected with blue and red latex to the venous and arterial systems, respectively, were used for anatomical dissection. The heads were rigidly fastened with standard cranial fixation pins in a position similar to that used during live operative approaches.

Endonasal Approach to the Interpeduncular Cistern With Pituitary Transposition

For the endonasal approaches we used 18-cm-long, 4-mm-diameter endoscopes with 0°, 30°, and 70° lenses (Karl Storz GmbH), connected to a light source via a fiber optic cable and to a camera fitted with 3-charge-coupled device, high-definition sensors (Karl Storz GmbH). Images were recorded and stored with the Karl Storz Aida system. Nasal instrumentation was placed, and a wide sphenoidotomy was carried out through both nares. The bone covering the sellar face was removed to expose the superior and inferior intercavernous sinus and the sella clivus junction. A cruciform dural opening was placed above the superior intercavernous sinus and on the face of the sella, taking care not to transgress the pituitary capsule. Then, the dural openings were connected, and the diaphragma was incised all the way to the central aperture to free the pituitary stalk. The soft tissue connecting the pituitary capsule to the medial cavernous sinus walls was cut along the lateral contour of the gland, whereupon the gland could be mobilized superiorly, enabling exposure of the posterior sellar dura. The inferior intercavernous sinus was transected exposing the dorsum sellae and posterior clinoids. After removing these bony structures, the retroclival dura was opened to gain access to the interpeduncular cistern.

Transpetrosal Approach to the Interpeduncular Cistern

For the transpetrosal approach we used standard neurosurgical instruments with microscopic visualization. Microscopes (OPMI CS-NC, Carl Zeiss, Inc.; and Leica M320, Leica Microsystems GmbH) were used for dissections and photography. The skin incision extended along the preauricular crease, approximately 1 cm anterior to the level of the tragus, continuing superiorly, and turning posteriorly 2–3 cm above the ear, and then descending posterior to the mastoid cavity. After temporoorbital-sigmoid craniotomy, the dura was dissected and elevated from the temporal fossa, exposing the upper portion of the petrous bone. The mastoid was drilled, exposing the sigmoid and superior petrosal sinuses. The petrous bone was then drilled medially, preserving the entire labyrinth, toward the petrous apex to maximize the exposure of the interpeduncular cistern. The presigmoid dura was then opened and the incision was extended under the superior petrosal sinus. The sinus was transected at a point anterior to the entrance of the petrosal vein, preserving its normal drainage route, and then the tentorium was cut toward a point just posterior to the entrance of cranial nerve (CN) IV. Following superior retraction of the temporal lobe and medial mobilization of the sigmoid sinus, we dissected the arachnoid to obtain access to the interpeduncular cistern.

“Water Balloon Tumor”

To compare the endoscopic endonasal approach and transpetrosal approach with respect to the visibility of structures surrounding the interpeduncular cistern, we inserted a water balloon in the interpeduncular cistern via a contralateral transpetrosal approach. It was connected to a 10-ml syringe for the infusion of different volumes of water (Fig. 1). This “water balloon tumor” (WBT) mimicked a cystic tumor, similar to those commonly seen in patients with a craniopharyngioma. The cadaver head was positioned with the vertex down, about 60° from the horizontal plane, to minimize downward displacement of the WBT. To test and compare the visibility of surrounding structures with endoscopic endonasal approach and transpetrosal approach, 2 different volumes were used to inflate the water balloon: 0.5 and 1 ml.

The transpetrosal approach was used to address the WBTs with volumes ranging from 0 ml up to 6 ml (n = 8). During this approach, 2 measurements were obtained: 1) the maximum distance between CN III and the PCoA; and 2) the maximum distance between CN III and the edge of the tentorium. To determine the width of the surgical corridor to the interpeduncular cistern we used a millimeter-scale ruler.

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Statistical analyses were performed using SPSS statistical software (version 22.0 for windows, IBM Japan, Ltd.). All data were analyzed using a paired t-test, with Bonferroni correction for multiple comparisons used to compare the width of surgical corridors to the interpeduncular cistern with different volume of WBTs via the transpetrosal approach. A p value < 0.05 indicated statistical significance.

Before the balloon was inflated, the arachnoid membrane and trabeculae around the interpeduncular cistern were dissected as much as possible to maximize the mobility of structures surrounding the interpeduncular cistern and simulate their anatomical displacement by tumors of different sizes over a relatively long period of time compared with the immediacy of balloon inflation. To keep the WBT in the interpeduncular cistern, we kept the posterior clinoids intact until after we measured the surgical corridor via the transpetrosal approach. We then performed posterior clinoidectomy via the endoscopic endonasal approach followed by pituitary transposition.

Results

Visibility of the Interpeduncular Cistern HARBORING a WBT

Both surgical approaches, the endoscopic endonasal and transpetrosal, provided direct access to the interpeduncular cistern. With a 0.5-ml WBT, visualization of both CN III and the PCoA was adequate with the endoscopic endonasal approach (Fig. 2A), while the visualization of anatomical structures on the contralateral side was obstructed in the transpetrosal approach (Fig. 2B). With a 1.0-ml WBT accessed via the endoscopic endonasal approach, visualization of both CN III and the PCoA was partly obstructed under the 0° endoscope; however, gentle medial mobilization of the WBT facilitated good visualization of both structures. With the 30° and 70° endoscopes both structures could be observed from below without requiring WBT mobilization (Fig. 2C). Using the transpetrosal approach to address a 1.0-ml WBT in the interpeduncular cistern provided no visualization of structures on the contralateral side even with gentle mobilization of the WBT (Fig. 2D).

Width of the Surgical Corridor With the Transpetrosal Approach

The maximum distances (mean ± SD) from CN III to the PCoA and from CN III to the tentorium when the WBT volume was sequentially increased from 1 to 6 ml (Fig. 3A) are shown in Table 1. The corridors between CN III and the PCoA and between CN III and the tentorium were narrow when the WBT volume was small; however, the width increased gradually as the WBT volume increased (Figs. 3B and 4). There was a statistically significant increase in the maximum distance between CN III and the PCoA (p = 0.047) and between CN III and the tentorium (p = 0.029) when the WBT volume was 6 ml (Fig. 4). One of our specimens had a fetal-type PCoA on the right and a hypoplastic PCoA on the left, and in this specimen the surgical corridors were wider on the left side (Fig. 2B and D).

Discussion

Although the extended transsphenoidal approach using either a microscope or endoscope provides direct access to suprasellar craniopharyngiomas, 6,10,21,25–27,35,36 the pituitary gland and its stalk are natural anatomical barriers that hamper access to lesions arising in the retrochiasmatic area. Kassam et al. 20 demonstrated the feasibility of the pituitary transposition, the mobilization of the pituitary gland from the sella, to obtain direct access to the interpeduncular cistern via the endoscopic endonasal approach with a high likelihood of preserving pituitary function.
function. As the endoscopic endonasal approach allows for an unparalleled midline corridor into the entire interpeduncular cistern inferiorly and the anterior third ventricle superiorly, this approach has been used to address retrochiasmatic craniopharyngiomas.\(^{12,19,22}\)

In the present study, we placed WBTs in the interpeduncular cistern to compare differences between the endoscopic endonasal approach and transpetrosal approach, and the limitations and advantages of each approach for the surgical treatment of retrochiasmatic craniopharyngiomas are summarized based on our experimental results, as well as the review of literatures, and presented in Table 2. In the following discussion, we compare the 2 approaches focusing on their surgical field and endocrinological outcomes.

**Visibility of the Interpeduncular Cistern**

Analysis showed that the endoscopic endonasal approach provides adequate visualization of CN III and the PCoA bilaterally with no need for cerebral retraction, whereas the transpetrosal approach did not provide visualization of anatomical structures on the contralateral side. We acknowledge one potential caveat associated with using our current model in regard to the visualization comparison: in patients, the tumor often creates anatomical distortion that permits visualization and access to the other side as surgery progresses. This is particularly true when treating patients with cystic craniopharyngiomas. However, this difficulty in visualizing contralateral structures is well known. Kunihiro et al.\(^{24}\) reported that

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**Fig. 2. A:** View via the endoscopic endonasal approach with pituitary transposition with a 0.5-ml WBT in the interpeduncular cistern. There is good visualization of both CN III and the PCoA (Pcom) with the 0°, 30°, and 70° endoscopes (upper, lower left, and lower right, respectively). **B:** View via the transpetrosal approach on both sides of the specimen with a 0.5-ml WBT in the interpeduncular cistern. The visualization of anatomical structures in the contralateral side was obstructed. This specimen had a hypoplastic PCoA on the left (Lt.) and a fetal type PCoA on the right (Rt.). The surgical corridor to the WBT is wider on the left side. **C:** View via the endoscopic endonasal approach with a 1.0-ml WBT in the interpeduncular cistern. Although visualization of both CN III and the PCoA was obstructed when we used the 0° endoscope (upper left), gentle medial mobilization of the WBT facilitated good visualization of both structures (upper right). With the 30° (lower left) and 70° (lower right) endoscopes, both structures were readily observed without WBT mobilization. **D:** View via the transpetrosal approach on both sides of the specimen with a 1-ml WBT in the interpeduncular cistern. The WBT completely obstructed visualization of the structures on the contralateral side. As stated above, this specimen had a hypoplastic PCoA on the left and a fetal type PCoA on the right. The surgical corridor to the WBT is wider on the left side. III = CN III; IV = CN IV; Acho = anterior choroidal artery; BA = basilar artery; ICA = internal carotid artery; MB = midbrain; PCA = posterior cerebral artery; Pcom = posterior communicating artery (PCoA); SC = semicircular canal; SCA = superior cerebellar artery; WBT = water balloon tumor.
Endonasal and transpetrosal approaches to interpeduncular cistern

of 16 patients with retrochiasmatic craniopharyngiomas treated via the modified transpetrosal approach, 7 (43.8%) required a second operation due to difficulties with dissection of vascular structures on the contralateral side during the first operation. Their clinical results and our experimental results are well correlated and suggest that problems with the visualization and safe dissection of neurovascular structures on the contralateral side in the interpeduncular cistern are technical limitations of the transpetrosal approach. Some of their patients underwent a second operation via the transsphenoidal approach because the surgeons had trouble accessing a part of sella turcica and/or superior-posterior part of the third ventricle. As the endoscopic endonasal approach provides direct access to the retroinfundibular area with complete interpeduncular cistern exposure, we favor the use of endoscopic endonasal approaches for most interpeduncular fossa tumors.

We found that the working space obtained via the transpetrosal approach was narrow when the WBT volume was small and that it gradually increased as the WBT volume increased. In the series reported by Kunihiro et al., the hypoplastic PCoA was often cut and mobilized to enlarge the operative space provided by the transpetrosal approach; such sacrifice of vascular structures in the surgical field is rarely required when the endoscopic endonasal approach is used to gain access to the interpeduncular cistern. Al-Mefty et al. reported on 3 patients whose retrochiasmatic craniopharyngiomas were removed via the transpetrosal approach. They concluded that this approach

**Fig. 3.** A: Using WBTs of different volumes, we measured the maximum distance between CN III and the PCoA (left) and between CN III and the edge of the tentorium (right) to show the width of surgical corridor to the interpeduncular cistern when the transpetrosal approach was used. B: View via the transpetrosal approach on the right side with WBTs of different volumes in the interpeduncular cistern. The possible surgical corridors between CN III and the PCoA and between CN III and the tentorium were narrow when the WBT was small and gradually increased as the volume of the WBT increased. PC = posterior clinoid.
is indicated in patients with large or giant retrochiasmatic craniopharyngiomas. Similarly, Kunihiro et al.\textsuperscript{24} reported that such tumors measuring more than 30 mm in diameter are a strong indication for the transpetrosal approach. We agree with their observation, since the present study shows that the surgical corridor becomes wider as the size of the tumor increases, as represented by the WBTs.

For reasons stated under \textit{Study Limitations}, below, we were unable to simulate the surgical view of the endoscopic endonasal approach using WBTs with a large volume. Traditionally the extended transsphenoidal approaches were performed using the microscope, which provided a deep and narrow view of the suprasellar space, making any attempt to resect large and/or calcified tumors via the transsphenoidal route very difficult. Nevertheless, the introduction of the endoscope in transsphenoidal surgery and the design of several new endonasal surgical instruments have helped to surmount such difficulties, and favorable outcomes were obtained when the endoscopic endonasal approach was applied for the removal of complex lesions as such as retroinfundibular craniopharyngiomas.\textsuperscript{4,6,10,13,22}

The present study demonstrated the endoscopic endonasal approach to be the most direct route into tumors in the interpeduncular cistern; however, the lateral extension of the tumor can be the main limitation, particularly in craniopharyngiomas that do not respect the Liliequist membrane and progress into the middle fossa and sylvian fissure.

\textbf{Endocrinological Outcomes}

The preservation of pituitary function may be one of possible advantages of the transpetrosal approach, since there is no need to transpose the pituitary gland to reach the interpeduncular cistern. However, craniopharyngiomas are by nature intimately related to the pituitary stalk and, independent of the approach, pituitary function may be compromised after a radical resection. Hakuba et al.\textsuperscript{15} were the first to remove craniopharyngiomas via the posterior transpetrosal approach. Although they did not provide information on their patients’ preoperative endocrine function, 7 patients manifested postoperative endocrine dysfunction, and pituitary function was normal in only 1 patient. More recently, Kunihiro et al.\textsuperscript{24} reported that 12 of 16 patients with a retrochiasmatic craniopharyngioma presented with endocrinological deficits and received preoperative hormonal replacement therapy; 2 (50\%) of the other 4 patients whose preoperative pituitary function was normal developed new endocrinological deficits postoperatively.

Our findings and those of others\textsuperscript{1,2,24} showed that the transpetrosal approach is suitable for relatively large tumors that can open the gap between the surrounding neurovascular structures and consequently provide a wider surgical corridor for the tumor removal. However, in patients with large craniopharyngiomas the pituitary function tends to be impaired preoperatively, and its restoration after removal of the tumor is unlikely despite the anatomical preservation of the normal pituitary gland.\textsuperscript{7,18} Therefore, from the perspective of functional preservation of the pituitary gland, the transpetrosal approach may be useful for relatively small craniopharyngiomas with normal preoperative pituitary function. However, in the presence of small tumors, the very narrow working space between the surrounding neurovascular structures may result in iatrogenic cranial nerve or vascular injuries or may require sacrificing normal neurovascular structures. Nevertheless, the transpetrosal approach should still be considered an option in

\begin{table}[h]
\centering
\caption{Width of surgical corridor via the transpetrosal approach to the IPC harboring "water balloon tumors" with different volumes*}
\begin{tabular}{|c|c|c|}
\hline
Water Balloon Vol (ml) & Distance Btwn CN III & Distance Btwn CN III & \\
& PCoA (mm) & Tentorium (mm) \\
\hline
0 & 2.24 ± 0.84 & 1.35 ± 0.92 \\
1 & 2.70 ± 1.09 & 1.26 ± 1.15 \\
2 & 3.05 ± 1.30 & 2.45 ± 1.15 \\
3 & 3.16 ± 1.44 & 2.68 ± 1.51 \\
4 & 3.40 ± 1.22 & 3.04 ± 1.86 \\
5 & 3.84 ± 1.34 & 3.30 ± 2.04 \\
6 & 3.81 ± 1.26 & 3.34 ± 1.83 \\
\hline
\end{tabular}
\* Data are expressed as the mean ± SD (n = 8).
\end{table}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig4.png}
\caption{The width of the surgical corridors via the transpetrosal approach to the interpeduncular cistern with different WBT volumes. Values represent means ± SDs (error bars). *p < 0.05 versus 0 ml; paired t-test with Bonferroni correction for multiple comparisons.}
\end{figure}
Endonasal and transpetrosal approaches to interpeduncular cistern

**TABLE 2: Limitations and advantages of the endoscopic endonasal and transpetrosal approaches for retrochiasmatic craniopharyngiomas**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Endoscopic Endonasal Approach w/ Pituitary Transposition</th>
<th>Transpetrosal Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>surgical field</td>
<td>optimal caudal-cranial view, neurovascular structures on the periphery, limited accessibility to the part of lateral expansion</td>
<td>optimal caudal-cranial view, neurovascular structures in the way, insufficient exposure of contralateral side, good for larger/giant tumors w/ lateral expansion</td>
</tr>
<tr>
<td>visual outcome</td>
<td>satisfactory</td>
<td>satisfactory, superior to other transcranial approaches</td>
</tr>
<tr>
<td>endocrinological outcomes</td>
<td>satisfactory result in early series, possible pituitary dysfunction</td>
<td>minimal pituitary manipulation, possible functional preservation</td>
</tr>
<tr>
<td>surgical complications</td>
<td>CSF leakage, pituitary dysfunction</td>
<td>neurovascular injury (vein of Labbé, PCoA, CN III), CSF leakage, hearing loss, brain contusion, encephalomalacia</td>
</tr>
</tbody>
</table>

patients with relatively small craniopharyngiomas whose pituitary function is normal.

A pituitary transposition may require sacrifice of inferior hypophyseal arteries and some venous drainage routes from the gland. Therefore, it is still uncertain whether pituitary function can be completely preserved. Taussky et al.\(^\text{32}\) reported that “hemi”-pituitary transposition with fat interposition helped to preserve pituitary function in patients requiring postoperative radiation therapy for tumors involving the cavernous sinuses and that their postoperative and postirradiation results were satisfactory. Their sacrifice of feeding vessels on just one side of the pituitary gland probably contributed to the preservation of normal pituitary function. Kassam et al.\(^\text{20}\) who performed “complete” pituitary transposition for the removal of tumors arising in the interpeduncular cistern (3 craniopharyngiomas, 3 chordomas, and 2 meningoctasias), obtained good preservation of pituitary function in 7 (87.5%) of their 8 patients. The rates of functional preservation of the gland in the patients with craniopharyngioma and other pathologies were 66% (2 of 3 patients) and 100% (all 5 patients), respectively. It appears that even with pituitary transposition, preservation of pituitary function is more difficult in patients with craniopharyngiomas than in those with other tumors. This may be attributable to factors other than pituitary transposition, for example, surgical manipulation of the hypothalamus and/or the stalk and to the tumor-induced functional fragility of the hypothalamic-pituitary axis. More clinical evidence is needed to clarify this issue, and technical refinements should be considered to preserve as much pituitary function as possible. Silva et al.\(^\text{31}\) reported the usefulness of the endoscopic endonasal “above and below” approach to the interpeduncular cistern. They created 2 small skull base openings above and below the pituitary gland without pituitary transposition; this yielded good endoscopic visualization of the interpeduncular cistern. For specific lesions, their approach is a possible surgical option to gain access to the interpeduncular cistern endonasally while avoiding pituitary manipulations and potential consequent loss of pituitary function. However, their case illustrations were of soft tumors that do not require fine microsurgical dissection in the subarachnoid space but can be removed using suction tips.

**Study Limitations**

We designed this study to demonstrate the difference in surgical corridors to the interpeduncular cistern obtained via the endoscopic endonasal approach and the transpetrosal approach using a WBT. Craniopharyngiomas are pathologically benign tumors and most form a cystic lesion. Their growth rates differ from case to case. Our WBT could simulate a rapidly growing tumor in the interpeduncular cistern that would just push on and displace neurovascular structures around the interpeduncular cistern. However, our WBT cannot represent a slow-growing tumor in the interpeduncular cistern; these lesions tend to push on and gradually extend the anatomical structures around the interpeduncular cistern, and they can enlarge the surgical corridor to the interpeduncular cistern via the transpetrosal approach. This is particularly relevant when the transpetrosal approach is used to access large tumors. Moreover, our WBT could only simulate the surgical view in the presence of round tumors, although craniopharyngiomas arise in various shapes. Lastly, we were not able to simulate the surgical view of the endoscopic endonasal approach using balloons containing a large volume of water because after a posterior clinoidectomy was performed for pituitary transposition, the large water balloon failed to stay in the interpeduncular cistern and migrated into the nasal cavity.

**Conclusions**

Both the endoscopic endonasal approach and transpetrosal approach facilitate sufficient exposure of the interpeduncular cistern. The endoscopic endonasal approach provides a midline surgical corridor to the tumor in the interpeduncular cistern without traversing neurovascular structures around the interpeduncular cistern. Although the transpetrosal approach yields direct access to the interpeduncular cistern without pituitary manipulation, the surgical corridor is narrowly limited by surrounding neurovascular structures and the visibility of the side contralateral of the tumor is unsatisfactory, especially in the early stage of dissection.

While both approaches represent adequate surgical options for addressing retroinfundibular craniopharyngio-
mas, we suggest using the transpetrosal approach in patients with large or giant tumors due to the optimization of the space between neurovascular structures in these cases. Furthermore, endoscopic endonasal approaches can be limited in cases of large craniopharyngiomas with lateral extension beyond the oculomotor nerve.

As there are few reports that compare the 2 approaches for retroinfundibular craniopharyngiomas, further clinical experience must be collected to clarify the advantages and limitations of these approaches to the interpeduncular cistern in the clinical settings.

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Disclosure

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

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Author contributions to the study and manuscript preparation include the following. Conception and design: Oyama. Acquisition of data: Oyama, Ditzel Filho, Muto, Gun. Analysis and interpretation of data: Prevedello, Oyama, Ditzel Filho, Muto, Kerr, Otto, Carrau. Drafting the article: Prevedello, Oyama. Critically revising the article: Prevedello, Ditzel Filho, Muto, Kerr, Otto, Carrau. Reviewed submitted version of manuscript: all authors. Approved the article: Prevedello, Ditzel Filho, Muto, Gun, Kerr, Otto, Carrau. Drafting the article: Prevedello, Oyama. Critically revising the article: Prevedello, Ditzel Filho, Muto, Kerr, Otto, Carrau. Study supervision: Prevedello, Carrau.

References

for removal of retrochiasmatic craniopharyngioma via the endoscopic endonasal extended transsphenoidal transtuberculum approach. Neurosurg Focus 30(4):E14, 2011


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