Is the chiasm-pituitary corridor size important for achieving gross-total resection during endonasal endoscopic resection of craniopharyngiomas?

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OBJECTIVE Craniopharyngiomas arise from the pituitary stalk, and in adults they are generally located posterior to the chiasm extending up into the third ventricle. The extended endonasal approach (EEA) can provide an ideal corridor between the bottom of the optic chiasm and the top of the pituitary gland (chiasm-pituitary corridor [CPC]) for their removal. A narrow CPC in patients with a prefixed chiasm and a large tumor extending up and behind the chiasm has been considered a contraindication to EEA, with a high risk of visual deterioration and subtotal resection.

METHODS A database of all patients treated in the authors' center (Weill Cornell Medical College, NewYork-Presbyterian Hospital) between July 2004 and August 2016 was reviewed. Patients with craniopharyngiomas who underwent EEA with the goal of gross-total resection (GTR) were included in the study. Patients with postfixed chiasm or limited available preoperative imaging were excluded. Using preoperative contrast-enhanced T1-weighted sagittal midline MR images, the authors calculated the CPC as well as the distance from the chiasm to the top of the tumor (CTOT). From these numbers, they calculated a ratio of the CPC to the CTOT as a measure of difficulty in removing the tumors through the EEA and called this ratio the corridor index (CI). The relationship between the CI and the ability to achieve GTR and visual outcome were measured.

RESULTS Thirty-four patients were included in the study. The mean CPC was 10.1 mm (range 5.2–19.1 mm). The mean CTOT was 12.8 mm (range 0–28.3 mm). The median CI was 0.8; the CI ranged from 0.4 to infinity (for tumors with a CTOT of 0). Thirty-two patients had GTR (94.1%) and 2 had subtotal resection. The CPC value had no relationship with our ability to achieve GTR and no effect on visual or endocrine outcome.

CONCLUSIONS EEA for craniopharyngioma is generally considered the first-line surgical approach. Although a narrow corridor between the top of the pituitary gland and the bottom of the chiasm may seem to be a relative contraindication to surgery for larger tumors, the authors' data do not bear this out. EEA appears to be a successful technique for the majority of midline craniopharyngiomas.

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KEY WORDS craniopharyngioma; optic chiasm; pituitary gland; suprasellar approach; endoscopic endonasal surgery; pituitary surgery

CRANIOPHARYNGIOMAS represent less than 1% of all primary central nervous system tumors and arise within the pituitary stalk from the remnants of Rathke's pouch.⁸ They are histologically benign tumors, but their tendency to recur and their location within very close proximity to internal carotid artery (ICA), anterior cerebral arteries (ACAs), pituitary gland, hypothalamus,

third ventricle, and the optic apparatus, make them challenging lesions to treat.

Craniopharyngiomas in adults are most commonly located posterior to the chiasm and extend behind the chiasm into the third ventricle. They may present with hydrocephalus, visual loss, pituitary dysfunction, and diabetes insipidus (DI). Surgical management aims to achieve either

ABBREVIATIONS ACA = anterior cerebral artery; CI = corridor index; CPC = chiasm-pituitary corridor; CTOT = distance from chiasm to top of tumor; DI = diabetes insipidus; EEA = extended endonasal approach; GTR = gross-total resection; ICA = internal carotid artery; STR = subtotal resection.

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gross-total resection (GTR) or subtotal resection (STR), with STR being coupled with adjuvant radiation therapy. The latter strategy has gained some favor in recent years due to reduced morbidity and equivalent progression-free and overall survival,^{1,35} and there has been recent progress in use of targeted therapies against BRAF-mutated craniopharyngiomas.³ Nevertheless, surgery is still the treatment method that offers the highest chance of cure, if GTR can be achieved.²⁷

There are several transcranial routes that can be used for the resection of these lesions, including interhemispheric, frontobasal, or frontotemporal with or without orbitozygomatic modifications,¹ but transcranial approaches require varying degrees of brain retraction and manipulation of neurovascular structures.³⁷

The extended endonasal approach (EEA) has been introduced as an alternative to craniotomy for craniopharyngiomas extending up into the suprasellar cistern and third ventricle. This approach provides a clear surgical view inferior and posterior to the chiasm into the third ventricle, which may promote higher rates of resection with better visual outcomes and sustained quality of life.^{5,6,19,21,28,29}

EEA can provide an ideal corridor between the bottom of the optic chiasm and the top of the pituitary gland (chiasm-pituitary corridor [CPC]) for removal of craniopharyngiomas. However, a narrow CPC with a large tumor extending up and behind the chiasm has been considered a contraindication to EEA, with a high risk of visual deterioration and consequent STR.²⁵ Patients with prefixed chiasms will tend to have a narrow CPC, while those with postfixed chiasms will have a large CPC. Classifications based on the location of craniopharyngiomas with respect to the infundibulum have been used to provide guidance for approach strategies.¹⁷ We retrospectively reviewed our series of craniopharyngiomas resected using EEA by the senior author (T.H.S.) to answer the question whether a narrow CPC along with a high-rising tumor above the level of the chiasm can prevent GTR and impact visual outcome.

Methods

A database of all patients treated in our center (Weill Cornell Medical College, NewYork-Presbyterian Hospital) between July 2004 and August 2016 was reviewed. Patients with craniopharyngiomas who underwent EEA with the goal of GTR were included in the study. The patients excluded were elderly or frail patients who might not tolerate an aggressive operation, patients in whom pituitary function needed to be preserved, children with hypothalamic invasion, and patients with previously operated/radiated tumors with cyst growth that required drainage for optic chiasmal decompression. No patient was excluded because the chiasm location was thought to limit our approach, since this would bias the results. Patients with a postfixed chiasm were excluded, since the tumor is in front of the chiasm and the corridor between the chiasm and gland is not a factor in removing the tumor. Patients with limited available preoperative imaging were also excluded. At Weill Cornell, all of our surgeries are performed through the corridor from the top of the pituitary gland to

the bottom of the chiasm; we do not work above the chiasm to enter the third ventricle due to the presence of the anterior communicating artery complex and its blood supply to the chiasm. Using preoperative contrast-enhanced T1-weighted sagittal midline MR images, we measured this chiasm-pituitary corridor (CPC) as the distance between the top of the pituitary gland and the bottom of the optic chiasm. We also measured the distance from the top of chiasm to the top of the tumor (solid or cystic). To ensure that the measurements would not be affected by anatomical differences, we drew a line connecting the top of the chiasm to the most inferior point of the splenium and measured the perpendicular distance from the most superior aspect of the tumor to this line (CTOT) (Figs. 1 and 2). This factor is also critical because the greater the amount of the tumor that sits above the chiasm, the harder it will be to remove the tumor through the CPC corridor. From these 2 numbers we then calculated a ratio of the CPC to the CTOT as a measure of the difficulty in removing the tumors through the EEA and called this ratio the corridor index (CI). The relationship between the CI and the ability to achieve GTR as well as endocrine and visual outcomes were analyzed to determine if these factors are critical to the success of the surgery.

Endocrine outcome was defined as the presence of any new endocrine deficiency including anterior pituitary hormones, desmopressin, and obesity, versus no change relative to preoperative status.

Visual outcome was defined as stable or improved versus worsened visual acuity and/or visual fields.

Surgery

The EEA transtuberculum transplanum approach has been previously described in detail by various groups.^{4,7,16,21} In brief, a lumbar drain is placed and 0.25 ml of 10% fluorescein (AK-FLUOR, Akorn) is injected slowly into the intrathecal space after being mixed with 10 ml of CSF.³⁰ A vascularized nasoseptal flap is raised after lateralization of the middle turbinates and set aside in the nasopharynx for subsequent reconstruction. The inferior two-thirds of the left superior turbinate is often removed to create space for the endoscope. The transplanum transtuberculum approach is performed to expose the top of the pituitary gland and the tuberculum sellae is opened to expose the top of the optic chiasm. The superior intercavernous sinus is coagulated and resected along with the diaphragma sellae. The CPC corridor is cleared free of arachnoid, the superior hypophyseal arteries are swept laterally, and the tumor and pituitary stalk are dissected free of the arachnoid (Fig. 3). The tumor is internally debulked; the capsule is then dissected from the surrounding neurovascular structures and removed. Angled endoscopes and instruments are valuable in visualizing the uppermost aspect of tumors extending toward the roof of the third ventricle from below the chiasm. The stalk is preserved as long as possible and is only resected at the end of the operation if required to achieve GTR.³¹ The superior hypophyseal arteries are preserved unless they feed a stalk infiltrated with tumor that is to be resected. If the tumor extends into the sella, the top of the pituitary gland is also removed to ensure complete resection. The closure is performed with a fascia

FIG. 1. Measurement of chiasm-pituitary corridor (CPC, *double-headed arrow*) on a preoperative contrast-enhanced T1-weighted sagittal midline MR image. The CPC was defined as the distance between the top of the pituitary gland and the bottom of the optic chiasm.

lata onlay with Medpore wedged into the defect to achieve a gasket-seal closure, and covered with a nasoseptal flap and then Duraseal (Integra).^{10,22,26}

Results

During the study period, 62 patients with craniopharyngiomas were operated upon using an EEA. The goal was GTR in 41 cases. Reasons for not pursuing a GTR were previous surgery and/or radiation (in 8 cases), pediatric age with likely hypothalamic invasion (in 2), goal of cyst drainage and biopsy in an attempt to preserve pituitary function (in 4), and goal of decompression of the optic apparatus (in 7). Patients with postfixed chiasm (1 patient) or limited available preoperative imaging (6 patients) were excluded. Thirty-four patients were included in the study.

The mean CPC was 10.1 mm (range 5.2–19.1 mm). The mean CTOT was 12.8 mm (range 0–28.3 mm). The median CI was 0.8, and the CI ranged from 0.4 to infinity (for tumors with a CTOT of 0). The median was chosen since the upper limit was infinity. Thirty-two patients had GTR and 2 had STR (CIs 1.1 and 0.6). GTR was achieved in 95% of patients. In the 2 patients with STR, the locations of residual tumor were ICA branches and the pituitary stalk ($n = 1$) and “diffuse” due to prior operations and radiotherapy ($n = 1$). The CPC and CI values had no statistically significant relationship with our ability to achieve GTR. New anterior pituitary dysfunction occurred in 44% of patients and new posterior pituitary dysfunction (DI) occurred in 29%, with a total new endocrinopathy rate of 44%. The presence of new endocrinopathy did not correlate with CI ratio. The visual outcome was stable or im-

FIG. 2. Measurement of the distance from the chiasm to the top of the tumor (CTOT) on a preoperative contrast-enhanced T1-weighted sagittal midline MR image. The CTOT was measured as the length of a perpendicular line (*short double-headed arrow*) from the most superior aspect of the tumor to a line connecting the top of the chiasm to the most inferior point of the splenium (*long double-headed arrow*).

proved in 94% of patients and worse in 6%, which also did not correlate with the CI number.

Discussion

The major finding of this report is that the size of the surgical corridor between the bottom of the optic chiasm and the top of the pituitary gland does not impact the likelihood of GTR in patients undergoing craniopharyngioma resection via EEA. Moreover, the amount of tumor extending up into the third ventricle above and behind the chiasm, even relative to the size of surgical corridor, is not a factor in GTR. Likewise, the size of this corridor has no effect on either visual or endocrine outcome. Our results of 6% visual worsening, 29% new DI, and 44% new hypopituitarism are better than the published transcranial results of 11.3% visual worsening, 54.8% new DI, and 48.1% new hypopituitarism, and are comparable to transcranial and transsphenoidal results of 5.6% visual worsening and 49.8% new hypopituitarism.^{19,34} Although this could be considered a “negative” study, the results are important as they impact surgical decision making and case selection and serve to debunk a false contraindication to EEA for craniopharyngioma resection.

Craniopharyngioma treatment remains a controversial area of neurosurgical therapy. One area of continued discussion is the debate over radical versus conservative surgery. Although there is no Level I or Level II evidence favoring one or the other approach, retrospective literature review supports the conclusion that GTR provides an improved rate of progression-free survival,^{12,13,27,36} with the exception of cases involving tumors that invaded the hypothalamus.^{9,27} A second area of debate is the preferred sur-

FIG. 3. Intraoperative image obtained during an EEA for a craniopharyngioma showing the pituitary gland, optic chiasm, and CPC. The full length of the arrow is the measurement of the CPC. Figure is available in color online only.

gical approach, transcranial versus EEA. Until recently, transsphenoidal approaches have been thought to be only suitable for treatment of sellar craniopharyngiomas, and tumors with suprasellar or intraventricular extension were thought to require transcranial approaches. Traditional transcranial approaches generally entail brain retraction and manipulation of cerebrovascular structures that lie between the surgeon and the pathology.^{15,23,37} As the technology and experience with EEA improved, the limitations of EEA diminished and the applicability to midline craniopharyngiomas with suprasellar and intraventricular extension increased. Recent literature suggests that the results of EEA for craniopharyngioma resection are superior to transcranial approaches with respect to extent of resection and endocrine and visual outcomes.^{5,6,8,11,14,19–21,28,29} The Achilles' heel of EEA, the CSF leak rate, has also dramatically diminished with use of the vascularized nasoseptal flap and multilayer reconstruction.^{2,24}

In this paper, we investigate another potential anatomical limitation to EEA, particularly for those craniopharyngiomas with extension behind the chiasm into the third ventricle. A narrow CPC with a large tumor extending up and behind the chiasm has been considered a contraindication to EEA, with a high risk of visual deterioration and consequent STR.²⁵ Our review reveals that neither a narrow corridor nor a high-rising tumor behind the chiasm should be considered a contraindication for craniopharyngiomas. Although pituitary transposition has been described to increase the working corridor into the suprasellar cistern, this maneuver really only increases the view to the interpeduncular cistern, and it increases the rate of pituitary dysfunction and the rate of CSF leak.¹⁸ For this

reason, we do not recommend this maneuver and prefer using an above-and-below approach or extradural posterior clinoidectomy.^{32,33} We find that gentle upward pressure on the chiasm and downward pressure on the top of the pituitary gland can safely enlarge this corridor for removal of even craniopharyngiomas that extend up to the roof of the third ventricle. Our findings hold true regardless of whether the tumor is cystic or solid. Although one might think cystic tumors would be easier to remove than solid tumors, the opposite is the case. We find that the cystic tumors are slightly more difficult to remove completely than the solid tumors because the thin cyst wall sticks to the third ventricle roof more so than the solid tumor, which is more easily removed in one piece. The use of angled endoscopes and instruments is critically important to safely visualizing the superior extent of the tumor under the chiasm. Preservation of superior hypothalamic perforators to the chiasm is also important for preserving vision.

Conclusions

The location of the chiasm (prefixed or postfixed), the size of the corridor between the top of the pituitary gland and the bottom of the chiasm, or the superior extent of the tumor should not be considered an absolute contraindication to EEA for craniopharyngioma. Careful case selection and experience will always dictate the preferred approach in the hands of any given surgeon.

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Disclosures

Dr. Schwartz reports direct stock ownership in VisionSense.

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Conception and design: Schwartz, Omay, Anand. Acquisition of data: Omay, Almeida, Chen. Analysis and interpretation of data: Schwartz, Omay, Shetty, Liang, Ni. Drafting the article: Omay, Almeida, Chen. Critically revising the article: Schwartz. Reviewed submitted version of manuscript: Schwartz, Omay. Approved the final version of the manuscript on behalf of all authors: Schwartz. Statistical analysis: Omay. Administrative/technical/material support: Schwartz. Study supervision: Schwartz, Anand.

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