Endoscopic Transnasal Craniotomy and the Resection of Craniopharyngioma

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Objectives/Hypothesis: To describe the utility of a large transnasal craniotomy and its reconstruction in the surgical management of patients with craniopharyngioma.

Study Design: Observational retrospective cohort study.

Methods: Retrospective review of patients treated in an academic neurosurgery/rhinology practice between 2000 and 2007. Patient characteristics (age, sex, follow-up), tumor factors (size, position extension, previous surgery), type of repair (pedicled mucosal flaps, free mucosal grafts), and outcomes (visual, endocrine, and surgical morbidity) were defined and sought in patients who had an entirely endoscopic resection of extensive craniopharyngioma (defined as requiring removal of the planum sphenoidale in addition to sella exposure in the approach).

Results: Seven patients had an entirely endoscopic resection of extensive craniopharyngioma during the study period. Mean age was 23.4 years (standard deviation \( \pm 16.3 \)). Mean tumor size was 3.2 cm (standard deviation \( \pm 2.0 \)). The majority of these pathologies had extensive suprasellar disease, and two (28.6\%) had ventricular disease. Cerebrospinal fluid leak rate was 29\% (2 of 7). These leaks occurred only in reconstructions with free mucosal grafts. There were no cerebrospinal fluid leaks in patients who had vascularized pedicled septal flap repairs.

Conclusions: The endoscopic management of large craniopharyngioma emphasizes recent advancements in endoscopic skull base surgery. The ability to provide exposure through a large (4 cm+) transnasal craniotomy, near-field assessment of neurovascular structures, and the successful reconstruction of a large skull defect have significantly advanced the field in the past decade. The use of a two-surgeon approach and bilateral pedicled septal mucosal flaps have greatly enhanced the reliability of this approach.

Key Words: Endoscopic, skull base, craniopharyngioma, septal flap, craniotomy.

INTRODUCTION

Craniopharyngioma is an uncommon benign tumor accounting for 2–5\% of all intracranial neoplasms.\(^1\) It is a difficult lesion to excise completely. Morbidity from intrapial tumor adherent to pituitary stalk, hypothalamus, and anterior cerebral vessels has always dictated the completeness of resection. Tumor involvement of these structures, combined with poor surgical access, limited sharp dissection, and visualization of anatomical relationships, has often hindered resection regardless of approach. Subfrontal and pterional craniotomies have been the traditional approaches to extensive craniopharyngioma, with the transphenoidal route used for purely intrasellar tumors. The endoscopic transphenoidal transplanum approach may benefit patients with extensive craniopharyngioma (Fig. 1). This approach allows direct access to pathology, minimal brain retraction, reduces manipulation of the optic chiasm, and reduces hospital stay\(^2\) and morbidity.\(^3\)

Morbidity from open approaches may be significant, especially when surgical resection is subtotal. The balance of surgical morbidity and long-term control is a decision for individual patients and the operating team. Karavitaki et al.\(^4\) recently reviewed the published literature on the long-term outcomes for craniopharyngioma. From reports of large series published in the past decade, with radiologic confirmation of total tumor removal,\(^4\) the 10-year recurrence-free survival rates were 74–81\% after gross total resection, 41–42\% after partial resection, and 83–90\% after surgery (defined as partial or minimal resection) and radiotherapy.

Similarly, the 10-year survival rates\(^4\) were 60–100\% after total removal, 25–60\% after partial removal, and 77–100\% after partial removal and radiotherapy.

The aggressiveness of craniopharyngioma in adults compared to children has been debated. There is little...
evidence to support a substantial difference in behavior from larger cohorts.4

The extended transphenoidal approach has been described with microsurgical dissection,5,6 and management of extensive nonadenomatous tumors has been performed with these techniques.6 The use of an extended sellar opening by removing the sphenoid planum and tuberculum sellae is described in these series.6 Transsphenoidal approaches have gained wide acceptance, for they offer direct access to the tumor site and avoid the morbidity of transcraniotomy surgery.7 Subsequently, this approach has evolved into totally endoscopic transnasal surgery. The result is a large transnasal craniotomy not limited by a long narrow surgical corridor, which previously combined both vision and surgical instruments (Fig. 2). Visualization can be superior with an endoscopic approach compared to microsurgical access.8 The endoscopic technique allows for a close-up and wide-angle view of anatomy and potential dissection planes. Over the past 10 years, there have been significant improvements in endoscopic instrumentation, video equipment, bipolar devices, two-surgeon approaches, and image guidance systems. All afford the endoscopic ability to dissect and remove pathology with a similar technique to open surgery.

The aim of this study was to describe the surgical management of craniopharyngioma via a wide endoscopic transnasal craniotomy. The resection, visual, and endocrine outcomes with complications are described. The philosophy of our approach, reconstruction, and comparison with other reported cases series are also discussed.

METHODS

Patient Population

Seven consecutive patients treated between February 2000 and May 2007 with a totally endoscopic approach to craniopharyngiomas were retrospectively reviewed. There was significant suprasellar or intracranial extension in all patients, and all were categorized as either C, D, E, or F by the Yasargil9 classification. The patients were treated at two regional referral centers in Sao Paulo, Brazil. The Institutional Investigational Review Board approved the research.

Preoperative Evaluation

Tumor classification was based on magnetic resonance imaging (MRI) and computed tomography (CT). The size, position relative to the optic chiasm, and the vertical extension was recorded. The vertical extension was defined as a combination of sellar, suprasellar, or ventricular. All patients underwent assessment by an endocrinologist. Endocrinologic assessment for follicle-stimulating hormone, luteinizing hormone, fasting growth hormone, insulin-like growth factor 1, thyroid-stimulating hormone, free triiodothyronine, free thyroxine, adrenocorticotropic hormone, serum cortisol, 24-hour urinary cortisol, and prolactin was performed on all patients. The diagnosis of preoperative diabetes insipidus was made with serum sodium levels and osmolarity, together with urine-specific gravity and osmolarity. Visual assessment was performed with an ophthalmologist, and the presence of hemianopia, impaired visual acuity, or blindness was recorded. Other cranial neuropathies were recorded. Previous surgical procedures were classified as either craniotomy, microsurgical, transphenoidal, or an endoscopic approach.

Outcomes Assessment

The type of skull base repair at surgery was recorded. Completeness of resection was defined by both gross operative removal and subsequent MRI assessment. Postoperative complications, mainly meningitis/ventriculitis, cerebrospinal fluid (CSF) leak, subdural hematoma, and epistaxis, were determined from the operative and postoperative notes. Pituitary function evaluation and detection of transient or permanent diabetes insipidus were part of the standard postoperative care. Preexisting and postoperative cranial neuropathies were determined from initial assessment and the last patient interview. Visual changes and significant hyperphagia or increases in the patient’s body mass index increase were also recorded.

Surgery

Endoscopic transphenoid-transplanum surgery10 is performed under general controlled hypotensive anesthesia. Cottonoids containing adrenaline 1:1,000 are placed in the nasal cavity over the areas of surgical access for 10 minutes. The septum is infiltrated with lidocaine with adrenaline 1:100,000. An uncinctomy is performed with permission from Centro de ORL, Sao Paulo, Brazil. (Reproduced with permission from Centro de ORL, Sao Paulo, Brazil).
nate is resected to allow access to the entire front wall of the sphenoid. Commencing at the sphenoid ostium, the maximum amount of the front wall is then removed. At this stage, posterior pedicled mucoperiosteal flaps based on the septal branch of the sphenopalatine artery are usually developed bilaterally (Fig. 3A and B). A posterior septectomy is then performed.

The mucosa of the posterior sphenoid wall is then removed. Drilling of the thick tuberculum sellae bone and the sella is then performed (Fig. 4). An area the width of the entire intercarotid is thinned down to “egg shell” thickness with a high-speed drill and then removed. A Kerrison rongeur (Karl Storz, Tuttingen, Germany) may be used for additional bone removal. The bone removal is much wider and higher than the area exposed in standard pituitary surgery (Fig. 5). Bone removal continues along the sphenoid planum. The intercavernous sinus is then coagulated or ligated. The dura is opened above and below the intercavernous sinus, exposing the suprasellar region and optic chiasm (Fig. 6). Sharp extra-arachnoid dissection of the tumor proceeds with a two-surgeon technique (Fig. 2). One surgeon utilizes the endoscope and sharp dissection, and the co-surgeon provides suction and forceps for retraction.

**Reconstruction**

A pedicled rotation flap forms the foundation for defect repair. This flap is raised from the septum and based on the septal branch of the sphenopalatine artery. Bilateral flaps are raised during the approach. The flaps are then guarded from subsequent trauma by relocating them to the ipsilateral maxillary sinus or nasopharynx until later reconstruction (Fig. 3, A and B). Free fat grafts are used to fill dead space and form a buttress for a subdural (or extradural intracranial) fascial graft. This is then covered with both pedicled mucoperiosteal/perichondrial flaps (Fig. 7). Fibrin tissue glue is used to secure the repair. Gel foam is layered to the area and followed by gauze packing. The packing is supported by a Foley balloon catheter (Fig. 8).

**Postoperative Care**

CT is performed at our institution on the first postoperative day for evidence of hemorrhage. Antibiotics are used perioperatively and continued postoperatively while nasal packing remains in situ. Packing is left in place for 7 to 14 days. The onset of diabetes insipidus is monitored with serum and urine sodium/
osmolality measurements. Patients are confined to bed for 48 hours with 30° head elevation, and told to avoid straining, valsalva maneuvers, and nose blowing. Lumbar drains are not routinely used unless there is an additional comorbidity such as raised intracranial hypertension or prior radiotherapy. Discharge usually occurs 3 to 5 days postoperative.

**Follow-Up**

A baseline MRI is performed at 3 months. This is important as postsurgical MRI signaling is often difficult to interpret. Endocrine assessment is performed routinely in follow-up; however, ophthalmologic evaluation is undertaken only if clinically indicated. The long-term follow-up is multidisciplinary, but the endocrinologist is the central team member who coordinates care.

**RESULTS**

Seven patients were included in the study. Six of the patients were male. Mean age was 23.4 (standard deviation ± 16.3). Follow-up ranged from 5 to 93 months with a mean of 36.2 months. All seven patients had an entirely endoscopic resection of extensive craniopharyngioma during the study period. Mean tumor size was 3.2 cm (standard deviation ± 2.0). The majority of these pathologies had extensive suprasellar disease (Fig. 1), and three (42.9%) had ventricular disease (Fig. 9). A total of 85.7% of the tumors were in a dominantly prechiasmatic position.

CSF leak rate was 29% (2 of 7). These leaks occurred only in reconstructions with free mucosal grafts. There were no CSF leaks in patients who had vascularized pedicled septal flap repairs. Both CSF leaks were repaired suprasellar an endoscopic approach.

Four patients had preexisting diabetes insipidus (DI). No patient experienced a reversal of DI, two patient had transient DI, and no patient suffered a new permanent DI. Three patients (43%) had visual deficits preoperative (right hemianopia, bilateral hemianopia, and bilateral quadrantopia). Two (67%) of these patients had an improvement in visual field defects. No patient had meningitis, ventriculitis, new cranial nerve palsy, nasal bleeding requiring intervention, or subdural hematoma. At the

Fig. 6. The skull base defect prior to reconstruction. The tumor had been in a mainly prechiasmatic position and the optic chiasm is posteriorly distorted. (Reproduced with permission from Centro de ORL, Sao Paulo, Brazil).

![Fig. 6](image)

![Fig. 7](image)

Fig. 7. The pedicled septal flaps in reconstruction showing 1) nasopharynx, 2) right septal flap, and 3) left septal flap with an additional free mucosal graft superiority. (Reproduced with permission by Centro de ORL, Sao Paulo, Brazil).

![Fig. 8](image)

Fig. 8. The multilayered skull base reconstruction showing 1) fat, 2) fascia lata, 3) pedicled mucosal flaps, 4) fibrin glue, 5) gelfoam, 6) antibiotic-impregnated gauze, and 7) balloon support. (Reproduced with permission from Centro de ORL, Sao Paulo, Brazil).

![Fig. 9](image)

Fig. 9. Sagittal magnetic resonance imaging (MRI) demonstrating the extensive superior ventricular extension that can occur with larger tumors. (Reproduced with permission from Centro de ORL, Sao Paulo, Brazil).
mean follow-up of 3 years, no patient had significant hypotalamic injury or body mass index increase.

Four patients (57%) had a complete resection at the time of operation and remained free of disease. The remaining three patients had a subtotal resection where intrapial tumor capsule or tumor around the pituitary stalk in which, due to the patient age, resection was deferred. Adjuvant radiotherapy was used. Follow-up MRI had not revealed significant tumor regrowth that warranted reoperation.

DISCUSSION

In many institutions, endoscopic skull base surgery has evolved from CSF leak closures and the management of pituitary adenomas. These procedures often have emphasized minimal tissue dissection and preservation of dura at all cost. In retaining these principles, many central skull base lesions are managed through small sphenoidotomies (to preserve closure options) and limited openings in the skull base (usually just the sellar floor). Subsequently, dissection proceeds with limited instrument access, curette dissection by a single surgeon, and the need for angled endoscopes to view pathology. We describe a technique that borrows surgical principles from open procedures.

Wide Exposure via a Large Transnasal Craniotomy

A large transnasal craniotomy forms the basis for our approach. This allows optimal visualization of pathology (Fig. 10) and critical anatomy, less manipulation of brain tissue, and easy access for several instruments. This is fundamentally different from the small sellar floor openings that are described in most adenomatous pituitary surgery.12 The wider approach also enables two operators to work concomitantly binasally without constant “criss-crossing” of instruments (Fig. 2).

Fig. 10. The near field wide-angled view that is possible with the endoscopic approach. This visualization of intracranial anatomy is unique even for open approaches and shows 1) optic chiasm, 2) left intrapial internal carotid, and 3) A1 or first part of the left anterior cerebral artery. (Reproduced with permission by Centro de ORL, Sao Paulo, Brazil).

Dissection Techniques Similar to External Approaches

Surgical techniques with curettes and even blind dissection were common in endoscopic management of early pituitary surgery. There has been a concerted effort in endoscopic skull base surgery at our institution and elsewhere13 to move away from the curettage-based surgery to accurate sharp dissection. This improves the ability to remove pathology, control bleeding, and minimize morbidity. Bimanual dissection with tumor debulking, extracapsular sharp dissection, and countertraction using gentle suction form the foundation of our endoscopic surgery as it did when microsurgery was performed.13 The surgical technique we describe allows excellent assessment of anatomy, the concomitant use of endoscope, suction, scissors dissection, and even retraction (Fig. 10).

Hypothalamic and Pituitary Dysfunction

Even with the best preoperative imaging, the relationship of tumor to intracranial structures can be difficult to determine. It is still extremely difficult to evaluate before surgery whether some tumors are extra-arachnoidal, extrapial-subarachnoidal, or partially intraparenchymal-subpial.14 This weighs heavily on considerations to obtain complete resection. Suprasellar pathologies such as craniopharyngiomas may encase the pituitary stalk or involve the hypothalamus. Resection of the pituitary stalk carries considerable morbidity with hormone replacement and reductive dysfunction for adults and even greater impact on growth and development for children. Hypothalamic injury may result in severe and life-threatening squealae such as adipsia, morbid obesity, sleep disturbances, and behavioral and cognitive disorders.15 The decision to attempt complete tumor removal, when resection or injury to these structures is inevitable, should be discussed with the patient prior to surgery and not left to an intraoperative dilemma when such circumstances arise.16 Endocrine recovery has not been widely reported after resection and is likely to be extremely rare.4 The compressive or vascular effects on the pituitary and hypothalamus may be potentially irreversible. Such long-term sequela might be predetermined prior to surgical intervention. Published rates of hyperphagia/excessive weight gain and manifestations of severe hypothalamic injury at 10 years postoperative are about 39%.4 Although the endoscopic visualization of tumor and critical anatomy can be precise, careful preoperative assessment with an endocrinologist, within a multi-disciplinary team, for pituitary and hypothalamic dysfunction is essential in the operative planning for these patients.15,17

Reconstruction of the Skull Base Defect

Very large defects in the skull base can be repaired with an innovative combination of pedicled mucosal flaps.18 We have found that multilayered reconstruction with pedicled flaps are a more robust and reliable repair than free grafts. Bilateral rotation septal mucosal flaps based on the septal branch of the sphenopalatine artery are the most common solution to closing a large transnasal craniotomy from transplanum-transsphenoid surgery. The use of these closure techniques needs to be carefully
considered during the approach. Injudicious early posterior septectomy may limit the reconstructive options.

Reported case series from skilled endoscopic units have low patient numbers and are described in Table I. The visual, endocrine, and resection outcomes define clinical recovery for these patients. The rates of CSF leaks and meningitis are the most significant immediate postoperative complications requiring substantial intervention. Data on hyperphagia and excessive weight gain is important to describe hypothalamic dysfunction as this often dominates long-term quality of life. Not all published series describe the management of extensive disease, especially in otolaryngologic literature, many include only small Yasargil A, B, or C tumors.

**CONCLUSIONS**

Endoscopic skull base surgery for lesions such as craniopharyngioma may greatly reduce the morbidity associated with traditional craniotomy and sublabial/transseptal approaches. The endoscopic route provides direct access to tumors of the anterior and central skull base. Brain retraction and optic chiasm manipulation is minimal with a direct endoscopic route. Importantly, endoscopic surgery should not imply limited surgical access or incomplete resection with curettes. There is a learning curve for those who are not familiar with endoscopic surgery. Fostering a relationship between endoscopic skull base surgeons (rhinologists) and neurosurgeons greatly enhances this process. Proficiency with endoscopic techniques, the control of nasal vasculature, skull base reconstruction, and the management of cerebrovascular structures should be available to the operative team. These skills, combined with a detailed knowledge of endoscopic skull base anatomy and its distortion from disease, serve as a foundation for addressing pathology of the skull base.

<table>
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<th>TABLE I.</th>
<th>Case Series Reporting the Use of the Endoscopic Transphenoid/Transplanum and the Microscopic Supradiaphragmatic Approach for Craniopharyngiomas.</th>
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<td><strong>Series</strong></td>
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<td>Stamm 2007</td>
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<td>Rudnik 2005</td>
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<td>Jho 1997</td>
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<td>Cappabianca 2002</td>
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Most reports do not classify the extent of the tumors. The included outcome field should be considered mandatory for describing the disease management. CSF = cerebrospinal fluid; BMI = body mass index; DI = diabetes insipidus; NR = not reported; NFIA = no further information available.

* = outcomes for collective suprasellar pathologies (not exclusively craniopharyngioma).
BIBLIOGRAPHY