Endoscopic Endonasal Surgery for Tumors of the Cavernous Sinus: A Series of 234 Patients

Maria Koutourousiou[1,4], Francisco Vaz Guimaraes Filho[1], Juan C. Fernandez-Miranda[1], Eric W. Wang[2], Susan Tonya Stefko[3], Carl H. Snyderman[2], Paul A. Gardner[1]

BACKGROUND: **Cavernous sinus (CS) tumors often are considered inoperable. We present our experience with endoscopic endonasal surgery (EES) and compare the outcomes for different tumor.**

METHODS: **EES (medial or lateral approach) was used in 234 patients with CS tumors. The cohort included 175 (75%) pituitary adenomas and 59 (25%) nonadenomatous lesions.**

RESULTS: **Presenting symptoms were significantly different between the 2 groups, with cranial neuropathies occurring mainly in nonadenomas ($P < 0.0001$). The overall gross total tumor resection rate from the CS was 37.3% (37.1% in adenomas, 38.1% in non-adenomas). In total, preexisting cranial nerve (CN) dysfunction improved in 56.4% of the patients. After treatment completion (including radiation of residual tumor), 83.3% of acromegalic patients, 50% of prolactinomas and 33.3% of Cushing's disease, were in remission. Visual loss improved in 86.8% of adenomas and in 70.8% of nonadenomas. Intracavernous CN palsies improved in 77.3% of adenomas and 42.4% of nonadenomas. New permanent CN palsies occurred in 7 nonadenomas, which is significantly greater than in adenomas ($P = 0.007$). The leak rate of cerebrospinal fluid was 6.3% for adenomas and 11.9% for nonadenomas. Four patients suffered an internal carotid artery injury with no neurologic sequelae in 3 cases and 1 death (0.4%).**

CONCLUSIONS: **EES provides an easily accessible midline corridor to the CS with equivalent or superior results to transcranial approaches in the management of select tumors. Symptomatology due to CS invasion is more likely to improve in pituitary adenomas and the rate of surgical complications is greater in nonadenomas. Using a team approach, the overall mortality due to vascular injury is low.**

INTRODUCTION

The cavernous sinus (CS), the "anatomic jewel box" as Parkinson described it, is a complex region with a high density of neurovascular structures within its dural walls.[1] Vascular, neoplastic, and inflammatory diseases may affect the CS, which for years was described as a "no-man's land." During the past 3 decades, detailed microsurgical studies have described numerous approaches to the CS, so that the long-standing neurosurgical dogma that lesions in the CS are inoperable has been abandoned partially.[2-13] Despite this, and although the anatomy of this region has been described extensively,[3,13-23] controversy remains related to the best treatment and approach for different kinds of lesions, especially given the widespread safe application of radiosurgery.[2,24-36]

The vast majority of publications on surgical management of CS tumors are about invasive pituitary adenomas, which are known to invade the medial wall of the CS and secondarily extend into it.[37-49] The surgical literature on nonadenomatous tumors with CS invasion is focused mainly on meningiomas,[2,29-31,50-54] with fewer papers discussing other intracavernous pathologies.[55-60] We

Key words
- Cavernous sinus
- Endoscopic endonasal approach
- Endoscopic skull base surgery
- Intracavernous tumors

Abbreviations and Acronyms
CN: Cranial nerve
CS: Cavernous sinus
CSF: Cerebrospinal fluid
EEA: Endoscopic endonasal approach
EES: Endoscopic endonasal surgery
GH: Growth hormone
GTR: Gross total resection
ICA: Internal carotid artery
MRI: Magnetic resonance imaging

From the Departments of [1]Neurological Surgery, [2]Otolaryngology, and [3]Ophthalmology, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania; and [4]Department of Neurological Surgery, University of Louisville, Louisville, Kentucky, USA

To whom correspondence should be addressed: Paul A. Gardner, M.D. [E-mail: gardpa@upmc.edu]

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describe the outcomes of endoscopic endonasal surgery (EES) in the treatment of both invasive pituitary adenomas and non-adenomatous lesions either primarily confined to the CS or secondarily extending into it. Included in the latter group are midline tumors (craniopharyngiomas, suprasellar meningiomas), parasellar tumors (sphenocavernous/sphenopetrocavernous/sphenopetroclival meningiomas, intracavernous hemangiomas, and schwannomas), and posterior fossa tumors (petroclival meningiomas, chordomas, and chondrosarcomas). We analyze the surgical outcomes between the 2 tumor groups and compare the results with the published literature.

METHODS

Patient Population

With approval by our institutional review board, we retrospectively reviewed the imaging studies, medical files, and operative reports of patients with sellar and parasellar tumors treated with EES at the University of Pittsburgh Medical Center from April 2002 to November 2012. Tumors originating from the middle fossa and Meckel's cave (even with evidence of compression/invasion of the lateral wall of the CS) are the topic of another paper and were excluded from this project. Also, tumors with large, lateral exophytic components and minimal invasion of the CS (like sphenoid wing meningiomas) in which symptoms occur due to mass effect on the brain rather than on the CS are best managed with transcranial approaches and are not included in our analysis.

A total of 234 patients were identified with sellar/parasellar tumors invading the CS as shown on preoperative imaging studies and confirmed by intraoperative observation and exploration of the CS. In every case, the diagnosis was confirmed histologically, and patients were categorized based on pathology into pituitary adenomas and nonadenomatous lesions. In pituitary adenomas, CS invasion was reported according to the Knosp criteria and was confirmed by intraoperative observation in every case. All pituitary adenomas had a baseline preoperative hormone evaluation, including serum cortisol, free thyroxine, thyroid-stimulating hormone, adrenocorticotrophic hormone, growth hormone (GH), insulin-like growth factor-1, prolactin, luteinizing hormone, follicle-stimulating hormone, testosterone, or estradiol. The diagnosis of functioning pituitary adenomas was established in consultation with endocrinology at our pituitary center. In nonadenomatous cases, to simplify and better categorize the imaging findings, CS invasion is described as medial (including the medial wall and superior compartment of the CS), lateral (including the lateral, inferior, and posterior compartments), or entire, based on preoperative magnetic resonance imaging (MRI) available in all but one patient with a pacemaker, who had a preoperative contrasted computed tomography scan.

Anatomical Consideration and Surgical Technique

CS anatomy and the attendant endonasal corridors have been described elsewhere.[21,61,62] In summary, the critical aspects are that the oculomotor, trochlear, and ophthalmic (first trigeminal division) nerves are embedded in the reticularis membrane that forms the lateral wall of the CS[20] whereas the abducens nerve, the intracavernous carotid artery, and the sympathetic plexus around it have a true intracavernous course. The intracavernous course of the carotid artery divides the cavernous venous spaces into 4 virtual compartments: superior (between the horizontal cavernous internal carotid artery [ICA] and the roof of the CS, often referred to as the medial compartment), anterior/inferior (below the horizontal intracavernous ICA), posterior (behind the vertical intracavernous ICA), and lateral (between the ICA and the lateral wall of the CS). The superior compartment does not contain nerves, representing a medial surgical corridor with minimal risk of neural damage; the lateral, inferior, and posterior compartments contain cranial nerve (CN) VI and the wall of the lateral compartment contains CN III, IV, and V1 and thus pose greater potential risk of neural injury when they are used as surgical corridors.[61,62]

The exact endoscopic endonasal corridor is chosen based on tumor origin, the involved compartments of the CS, and the goals of surgery. For lesions located in the superior or posterior (medial) CS compartments, the endoscopic endonasal transsellar/transcavernous or medial approach is used. For lesions occupying the lateral and/or inferior CS compartment, the endoscopic endonasal transpterygoid/transcavernous or lateral approach is used. A combination of medial and lateral approaches is used when the lesion occupies the entire CS and when the goal of surgery is total/maximum possible tumor resection (Figure 1); when the surgery is limited to biopsy, the single most favorable corridor is chosen. These surgical techniques have been described previously,[37,43,44,62-66] and therefore we will provide a limited summary of our technique based on the aforementioned compartments.

Medial (Transsellar/Transcavernous) Approach. After the initial endonasal and transsphenoidal steps, all bone overlying the ICA on the affected side is removed. After confirmation with image guidance and micro-Doppler, the dura overlying the lateral aspect of the sella close to the affected CS is opened (Figure 1B). Tumor resection proceeds from medial to lateral with the opening of the medial wall of the CS enlarged to achieve complete resection of the tumor as needed in the superior and posterior CS compartments. In nonadenomatous intracavernous lesions, the medial wall of the CS may be intact, in which case the pituitary gland is lateralized carefully toward the healthy CS so that the medial wall of the affected CS is seen under direct visualization with the 0° endoscope (Figure 1C) before the CS is opened.

Lateral (Transpterygoid/Transcavernous) Approach. With the vidian nerve as a landmark, a transpterygoid approach is performed to access the anterior/inferior and lateral compartments. The bone overlying and lateral to the intracavernous carotid is removed to expose the underlying dura using the transmaxillary corridor. After confirmation of the exact location of the intracavernous carotid artery with image guidance and micro-Doppler and identification of the abducens nerve with electrostimulation, the dura lateral to the intracavernous carotid artery, on the anteroinferior face of the lateral CS, is opened with a retractable blade and Kurze scissors or hook blade (Figure 1D), allowing tumor dissection with the electrostimulator probe throughout the procedure.

Evaluation of Outcome

The degree of tumor resection was evaluated with volumetric analysis of the postoperative MRI compared with preoperative.