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What is This?
Endoscopic Endonasal Transpterygoid Transmaxillary Approach to the Infratemporal and Upper Parapharyngeal Tumors

Paolo Battaglia, MD¹, Mario Turri-Zanoni, MD¹, Iacopo Dallan, MD¹, Stefania Gallo, MD¹, Eleonora Sica, MD¹, Giovanni Padoan, MD¹, and Paolo Castelnuovo, MD¹

Abstract

Objectives. To describe the endoscopic transnasal approach to the infratemporal fossa (ITF) and upper parapharyngeal space (UPS) and to analyze the indications and outcomes of this surgical technique in the management of the tumors localized in this critical area.

Study Design. Case series with chart review.

Setting. Tertiary-care referral center.

Patients and Methods. Retrospective review of patients with benign and malignant tumors arising in or extending to the ITF and UPS, treated from 2002 to 2012 at a single institute. The tumors were surgically resected using an endoscopic endonasal transpterygoid transmaxillary approach.

Results. Thirty-seven consecutive patients with benign tumors (20 juvenile nasopharyngeal angiofibromas, 2 extra-cranial trigeminal Schwannomas, 2 meningiomas, 1 cavernous hemangioma) and nonmetastatic malignant tumors (2 adenoid-cystic carcinoma, 1 mucoepidermoid carcinoma, 1 squamous cell carcinoma, 1 adenocarcinoma, 1 recurrence of chondrosarcoma, and 6 recurrences of undifferentiated carcinoma of nasopharyngeal type) were treated with curative intent. A gross-total resection was achieved in 35 of 37 patients. Major complications were observed in 1 case (intraoperative internal carotid artery blowout). Postoperatively, 8 patients received some form of adjuvant treatment. Mean follow-up was 30 months for malignancies and 60 months for benign tumors. All patients are now alive without recurrences. Stable intracranial persistence of disease was reported in 2 cases (1 meningioma and 1 adenoid-cystic carcinoma).

Conclusion. The purely endoscopic endonasal technique may provide a minimally invasive and safe approach to radically resect selected tumors involving the ITF and UPS. Larger case series and longer follow-up are needed to validate the reproducibility and efficacy of this technique.

Keywords

skull base tumor, infratemporal fossa, parapharyngeal space, endoscopic endonasal, internal carotid artery

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Introduction

The infratemporal fossa (ITF) and upper parapharyngeal spaces (UPS), due to their deep location in the skull and the important neurovascular structures contained therein, are challenging areas to approach even for skilled surgeons. Anatomically, the ITF is bordered superiorly by the greater wing of the sphenoid and the squamous part of the temporal; laterally by the zygomatic arch, ascending ramus of the mandible, parotid gland, and masseter muscle; and anteriorly by the postero-lateral wall of maxillary sinus. Postero-medially, this space continues directly into the UPS without a stable and fixed anatomical structure as a border. So we can consider the ITF and UPS as a single common space, reaching the prevertebral muscles posteriorly and the tensor/levator veli palatini muscles with the superior constrictor muscle medially. Two main surgical routes have been proposed for addressing the ITF/UPS: lateral approaches (pre-auricular and post-auricular) and anterior transfacial approaches (extended maxillectomy, facial translocation, midfacial degloving, lateral rhinotomy). Recently, transnasal endoscopic approaches have been added to the armamentarium of skull base surgeons, reducing the functional and cosmetic morbidity related to the traditional open approaches. The purpose of this study was to analyze the
advantages and limitations of the endoscopic transnasal approach to this region by reporting the outcomes from a series of patients with benign or malignant tumors arising in or extending to the IFT/UPS.

**Patients and Methods**

We analyzed the patients with benign and malignant tumors involving the IFT/UPS who underwent an exclusively endoscopic transnasal resection at the Otorhinolaryngological Department of the University of Insubria (Varese, Italy) between 2002 and 2012. Approval was obtained from the Varese Institutional Review Boards. All the patients gave their informed consent to participate in this survey. Preoperative assessment was based on nasal endoscopy, paranasal CT scans, and MR scans, performed in all the patients studied. Since epidemiologic, endoscopic, and radiologic findings were consistent with juvenile nasopharyngeal angiofibroma (JNA), biopsy was avoided and intraarterial angiography with concomitant vascular embolization was scheduled 24 to 48 hours before surgery. Moreover, when the tumor appeared to be in close relationship with the internal carotid artery (ICA), an angio-CT scan was obtained, and if considered opportune, intravascular stent placement was contemplated. The Solitaire-AB Neurovascular Remodeling Device (ev3 Inc, Plymouth, Minnesota) was the self-expanding stent employed. To reduce the risk of thromboembolic complications, dual antiplatelet therapy was administrated for 30 days after stenting and then reduced to single-drug treatment. In this subset of patients, a preoperative balloon occlusion test was performed to evaluate the possibility of eventual intraoperative sacrifice of the vessel. In the case of malignant tumors, neck-ultrasound and total-body PET-CT scans were performed to rule out any systemic dissemination of disease, which represents an exclusion criterion for this survey. Moreover, massive intracranial extension, encasement of ICA, and large infiltration of the masticatory space were considered contraindications for an exclusively endoscopic endonasal resection. Postoperative contrast-enhanced MR images were obtained for all patients on postoperative day 1, at 4 months after surgery, and then every 6 months for the following years.

**Surgical Technique**

All procedures were performed with the patient under general anesthesia, after decongestion of the nasal cavities. A perioperative prophylactic antibiotic regimen included third-generation cephalosporin with cerebral spinal fluid penetration. The surgical procedure can be divided into 5 steps, tailored to the tumor extension and histology (**Figure 1**):

(1) **Exposure of the Sinonasal Corridor.** The bulky tumor mass occupying the nasal cavity is disassembled according to an oriented resection, to obtain more working space. Posterior septectomy is performed to allow 2 surgeons to work simultaneously with “four hands” through the “two nostrils.” The inferior portion of the middle and superior turbinate are trimmed while preserving the olfactory mucosa. The sphenopalatine artery (SPA) is cauterized and divided. Anterior-posterior ethmoidectomy, maxillary antrostomy, and sphenooidotomy with removal of the intersphenoidal septa are necessary in order to identify guiding landmarks: lamina papyracea and infra-orbital canal laterally, anterior and posterior ethmoidal arteries superiorly, and opto-carotid recess and sellar floor posteriorly.

(2) **Lateral Extension of the Surgical Fulcrum.** To obtain a greater angle of view with a 0° scope and to increase the working space, it is necessary to progressively move the fulcrum laterally for the movement of the endoscope and instruments (**Figure 2**). For this reason, endoscopic medial maxillectomy with removal of the inferior turbinate and the medial wall of maxillary sinus was always performed. Moreover, in selected cases with deep-lateral tumor extension, the fulcrum has to be moved further laterally. To this purpose, the medial maxillectomy can be extended anteriorly as far as the pyriform aperture (modified Sturman-Canfield approach). If required, also the antero-medial part of the maxillary sinus can be removed by means of an endoscopic Denker’s approach, preserving V2.

(3) **Opening the Access to the ITF/UPS.** By removing the vertical part of the palatine bone, the descending palatine nerve and greater palatine artery are detected and sacrificed. Then,
the Vidian nerve (VN) and artery (if present) together with the palato-vaginal artery are identified and cut. In such a way, the pterygo-palatine fossa (PPF) content is lateralized, exposing the medial and lateral pterygoid plates. The posterior wall of maxillary sinus can be removed to the extent required, in a medial to lateral direction, using Kerrison bone pincers, to expose the ITF periostium (transmaxillary window). Superiorly, the infra-orbital nerve, dividing the PPF from the ITF, can be recognized. In this phase, the periosteal layer has to be preserved to avoid herniation of fat tissue into the maxillary sinus.

(4) Oriented Resection of the Tumor, Reaching the ICA. In the case of benign tumors such as JNA, dissection around the lesion is safe and recommended. In other cases, the surgical resection has to be oriented by identifying constant landmarks within the surgical field. Following a subperiosteal plane, the foramen rotundum containing V2 is seen supero-laterally to the VN. The periosteal plane behind the maxillary antrum is then opened and the first structure that comes into view is the fat pad of the ITF that continues with the Bichat’s fat pad. Lying on the fat pad, the internal maxillary artery (IMA) and its terminal branches are visible. A clip is positioned on the lateral aspect of the IMA to avoid bleeding. After the fat pad is removed, the 2 heads of the lateral pterygoid muscle (LPM) inserting on the lateral pterygoid plate (LPP) come into view, bordered laterally by the deep portion of the temporalis muscle (sphenomandibular muscle). The LPM is detached from its medial insertion. The root of the pterygoid is drilled out following the VN, as far as the medial genu of the ICA. Then, the medial pterygoid plate (MPP) is drilled out, showing the medial aspect of the cartilaginous Eustachian tube (ET). In this phase, the insertion of the medial pterygoid muscle (MPM) is distinguished and detached from the lateral aspect of the MPP, showing the tensor veli palatini muscle and, behind, the levator veli palatini muscle. Remarkably, the superior edge of the LPP can be a useful landmark for identifying V3: by drilling out this bone the surgeon can find and cut V3 emerging from the foramen ovale (FO) and lying on the upper part of the cartilaginous ET. Moving in a postero-lateral direction at bony skull base level, the middle meningeal artery passing through the foramen spinosum (FS) is detected and cut. Just behind the FS, the spine of the sphenoid bone is exposed. Then, the cartilaginous ET is resected as far as the bony tube that is a critical landmark for identifying the junction between the intrapetrous and the parapharyngeal segment of the ICA (lateral genu) (Figure 3). From an anterior to posterior viewpoint, an anatomical sequence can be utilized to localize the ICA entering the carotid canal: FO, FS, spine of the sphenoid bone, and bony...
tube. In such a way, the surgeon can localize and safely skeletonize the upper portion of the parapharyngeal ICA. During these steps, a magnetic navigation image guidance system (Medtronic Navigation, Inc, Louisville, Colorado) is employed to recognize the neurovascular structures and the limits of tumor. The acoustic ultrasound Doppler is frequently used in order to localize major vascular structures. In all the cases, the surgical margins were carefully examined with frozen section and the surgical procedure was continued until the tissue margins were clear of tumor or if previous treatments have damaged the nasoseptal flap temporarily stored in the antrum during the surgical procedure. If the nasal septum has been involved by the tumor or if previous treatments have damaged the nasoseptal vascular supply, a tempo-parietal fascia flap (TPFF) introduced into the nose through a temporal-zygomatic tunnel is preferred. Connectival grafts such as the ilio-tibial tract, widely used before the introduction of vascularized flaps, are now rarely used.

(5) Coverage of the Surgical Defect. When an expanded resection with exposure of major neurovascular structures such as the ICA or dura of the middle cranial fossa is performed, the surgical defect is resurfaced. To this purpose, the mainstay is the nasoseptal flap, harvested from the contralateral nasal fossa and temporarily stored in the antrum during the surgical procedure. If the nasal septum has been involved by the tumor or if previous treatments have damaged the nasoseptal vascular supply, a tempo-parietal fascia flap (TPFF) introduced into the nose through a temporal-zygomatic tunnel is preferred. Connectival grafts such as the ilio-tibial tract, widely used before the introduction of vascularized flaps, are now rarely used.

Results

Thirty-seven consecutive patients affected by skull base tumors with ITF/UPS involvement were treated through an exclusively endoscopic transnasal approach. The specific sites of origin and extension of tumors are detailed in Table 1. Twenty-seven patients were men (73%) and 10 were women (27%). Median age at referral was 35 years (range, 12-81 years). The most common presenting symptom was unilateral epistaxis (52%), followed by pain (23%) and facial swelling (17%). In detail, 25 of 37 (67%) were previously untreated benign tumors: 20 JNA, 2 extracranial trigeminal Schwannomas, 2 meningiomas, and 1 cavernous hemangioma. Preoperative embolization was performed uneventfully in all the cases of JNA, which were then classified according to the Andrews staging-system as follows: stage IIIA in 8 cases, stage IIIB in 12 cases. The remaining 12 of 37 (33%) patients were affected by nonmetastatic malignant tumors: 2 adenoid-cystic carcinomas (ACC), 1 mucoepidermoid carcinoma, 1 squamous cell carcinoma, 1 adenocarcinoma, 1 recurrence of chondrosarcoma, and 6 recurrences of undifferentiated carcinoma of nasopharyngeal type (UCNT, WHO type III). The malignant tumors were staged according to the UICC staging system, 7th edition, as follows: pT4b in 5 cases, yrpT3 in 5 cases, yrpT4 in 2 cases. Preoperative ICA stenting was performed in 2 cases (1 recurrent UCNT, 1 mucoepidermoid carcinoma) because of the close relationship of tumor with the vessel (lacerum segment in one case, parapharyngeal portion in the other one). Globally, all the patients underwent surgery with curative intent, and a radical resection was achieved in 35 of 37 patients. In 1 case of meningioma with cavernous sinus involvement, a macroscopic intracranial persistence of disease was considered unresectable (subtotal resection); in 1 case of ACC, a gross-total resection was achieved but microscopic positive surgical margins were found upon definitive histopathological examination. Remarkably, in 10 cases of expanded resection with ICA or skull base exposure, the surgical wound was covered with either a pedicled nasoseptal flap, fascial graft, or a TPFF, tailored to the extension of the tumor and the resulting defect, to speed the healing process and to decrease the risk of postoperative complications. A major surgical complication occurred in 1 case of adenocarcinoma attached to the parapharyngeal tract of the ICA so firmly that it caused the rupture of the vessel during the dissection of tumor. The bleeding was controlled by immediately transferring the patient to the interventional radiology suite for embolization of the ICA. Moreover, the patient developed a Claude Bernard-Horner syndrome as the result of damage to the pericarotid sympathetic fibers. Minor complications, alone or combined, were observed in 8 of 37 patients: numbness of the cheek and/or hard palate ipsilateral to the surgical resection in 4 cases, dry eye syndrome in 1 case, persistent glue ear with disabling conductive hearing loss in 4 cases, and temporary postoperative masticatory impairment in 3 cases (Table 1). Intraoperative blood loss varied from 150 to 1700 ml (mean: 280 ml) and intra- or postoperative blood transfusion was required in 7 patients (6 cases of JNA and 1 case of adenocarcinoma with intraoperative ICA rupture). Nasal packing was removed 1 to 2 days after surgery. Mean hospitalization stay was 6 days (range, 3-13 days) and all patients were discharged with nasal irrigation and systemic antibiotic therapy. Postoperative adjuvant treatments were administered to 8 of 37 (21%) patients, including chemoradiotherapy in 3 cases and intensity-modulated radiotherapy in 5 cases (Table 1). Follow-up ranged between 5 and 132 months (mean: 60 months; median: 57 months) for benign tumors and 12 to 84 months (mean, 30 months; median 19 months) for the malignancies. All patients are now alive: the 2 cases of persistence of disease are stable in size, and no other recurrences are observed.

Discussion

Tumors arising in or extending to the ITF/UPS are rare, and their treatment is challenging because of the deep location and anatomical complexity of these areas. Classically, lateral and anterior approaches have been described to treat these lesions; they provide a wide window of exposure to address the surgical target but entail significant morbidity. Lateral approaches may result in hearing loss, dysfunction of facial nerve, and dental malocclusion, while anterior approaches can carry an increased risk of facial deformity together with infra-orbital nerve and lacrimal dysfunctions. In the past 2 decades, expanded endonasal approaches (EEA) have gained increasing popularity and consensus in the treatment of midline cranial base lesions. Recently, there has been increasing interest in the endoscopic endonasal...
management of ITF/UPS tumors. The first experiences focused mainly on the treatment of benign lesions such as JNA, which is the most common tumor extending into these areas. In this context, Nicolai et al. reported 17 cases of lateral extended JNA (14: stage IIIA; 3: stage IIIB) in a series of 46 patients radically resected through an EEA. In the past few years, improvement of endoscopic instruments and neuronavigation systems and advances in radiology (preoperative evaluation and interventional procedures) and anesthetic techniques have all contributed to allow the management even of malignancies extending into the ITF/UPS. Data from a series of 20 endoscopic endonasal nasopharyngectomies for selected nasopharyngeal cancers with lateral extension in the ITF/UPS were reported also 2 cases of malignancies arising directly in the UPS, radically resected through the endonasal corridor. Moreover, we reported also 2 cases of malignancies arising directly in the UPS, radically resected through an EEA. In 1 case of ACC. Moreover, we reported also 2 cases of malignancies arising directly in the UPS, radically resected through an EEA. In the limited follow-up period and the risk of major complications (ICA blowout encountered in 2 cases of this series) still remain open issues. Similarly, Castelnovo et al. reported 18 cases of nasopharyngeal cancers with lateral extension in the UPS/ITF in a series of 36 endoscopic endonasal nasopharyngectomies, with persistence of tumor in 3 cases, underlining the importance of adequate patient selection for this kind of approach. There is also a paucity of data concerning the endoscopic management of sinonasal cancers extended into the ITF/UPS: the largest series available reported only 1 case in which the cancer was resected transnasally, in a series of 184 patients, and 2 cases in which it was removed by combining the endonasal and transeptal approaches, in a series of 120 patients. In the present study, 4 patients affected by sinonasal cancers extending into the ITF/UPS were treated through a purely endonasal approach, with microscopic positive margins in 1 case of ACC. Moreover, we reported also 2 cases of malignancies arising directly in the UPS, radically resected through the endonasal corridor.

<table>
<thead>
<tr>
<th>Biologic behavior</th>
<th>Histotype</th>
<th>Origin</th>
<th>Extension</th>
<th>Resection</th>
<th>Adjuvant therapy</th>
<th>Complications</th>
<th>Follow-up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign</td>
<td>20 angiofibroma</td>
<td>NP 20, PPF+ITF</td>
<td>RR</td>
<td>None</td>
<td>3, c/p-numb</td>
<td>NED (5-132)</td>
<td></td>
</tr>
<tr>
<td>2 Schwannoma</td>
<td>ITF</td>
<td>none</td>
<td>RR</td>
<td>None</td>
<td>None</td>
<td>NED (28-56)</td>
<td></td>
</tr>
<tr>
<td>2 meningioma</td>
<td>1, MCF</td>
<td>1, ITF</td>
<td>RR</td>
<td>1, none</td>
<td>None</td>
<td>I, NED (62)</td>
<td></td>
</tr>
<tr>
<td>1 hemangioma</td>
<td>UPS</td>
<td>None</td>
<td>RR</td>
<td>None</td>
<td>None</td>
<td>I, NED (59)</td>
<td></td>
</tr>
<tr>
<td>Malignant</td>
<td>2 ACC</td>
<td>SN ITF</td>
<td>1, RR</td>
<td>2, IMRT</td>
<td>None</td>
<td>I, NED (19)</td>
<td></td>
</tr>
<tr>
<td>1 chondrosarcoma</td>
<td>SN ITF</td>
<td>RR</td>
<td>CRT</td>
<td>None</td>
<td>NED (84)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 SCC</td>
<td>SN ITF</td>
<td>RR</td>
<td>IMRT</td>
<td>c/p-numb</td>
<td>NED (24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ADC</td>
<td>UPS ITF</td>
<td>RR</td>
<td>IMRT</td>
<td>ICA blowout, CBH syndr</td>
<td>NED (38)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 mucoepidermoid</td>
<td>UPS ITF</td>
<td>RR</td>
<td>None</td>
<td>CHL + dry eye</td>
<td>NED (12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 UCNT</td>
<td>NP ET, UPS, SS, SKB</td>
<td>RR</td>
<td>4, none</td>
<td>3, CHL + MI</td>
<td>NED (13-19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2, CRT</td>
<td></td>
<td>I, AWD (48)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ACC, adenoid-cystic carcinoma; SCC, squamous cell carcinoma; ADC, adenocarcinoma; UCNT, undifferentiated carcinoma of nasopharyngeal type; NP, nasopharynx; ITF, infratemporal fossa; MCF, middle cranial fossa; UPS, upper parapharyngeal space; SN, sinonasal; PPF, pterygo-palatine fossa; SS, sphenoid sinus; CS, cavernous sinus; ET, Eustachian tube; SKB, skull base; RR, radical resection; GTR, gross-total resection; STR, subtotal resection; IMRT, intensity-modulated radiotherapy; CRT, combined chemoradiotherapy; ICA, internal carotid artery; c/p-numb, numbness of the cheek and/or hard palate; CBH syndr, Claude Bernard-Horner syndrome; CHL, disabling conductive hearing loss; MI, temporary masticatory impairment; AWD, alive with disease; NED, no evidence of disease.
endoscopic surgery is not a conservative or less radical approach, but rather that the endoscope is a tool helping the surgeon in a resection that follows the same principle of open approaches. Moreover, the surgeon has to be skilled both in endoscopic and traditional approaches in order to select the adequate surgical procedure in relation to the tumor biology, localization, and extension. On the other hand, the patient has to be informed about the possibility of switching to the appropriate open procedure if the endoscopic approach becomes too difficult or ineffective. At the present time, the preliminary outcomes from our series are promising, but the oncologic benefits of this approach remain still unproven. Larger case series and longer follow-ups are needed to validate the reproducibility and efficacy of this technique.

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Author Contributions

Paolo Battaglia, conception and design of the study, drafting the article, final approval of the version to be published; Mario Turri-Zanoni, conception and design of the study, drafting the article, final approval of the version to be published; Iacopo Dallan, analysis and interpretation of data, revising the manuscript critically for important intellectual content, final approval of the version to be published; Stefania Gallo, acquisition of data, drafting the article, final approval of the version to be published; Eleonora Sica, acquisition of data, drafting the article, final approval of the version to be published; Giovanni Padoan, acquisition of data, drafting the article, final approval of the version to be published; Paolo Castelnuovo, analysis and interpretation of data, revising the manuscript critically for important intellectual content, final approval of the version to be published.

Disclosures

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