Endoscopic resection of malignant sinonasal tumours: current trends and imaging workup

AA Dmytriw1, IJ Witterick2, E Yu3*

Abstract

Introduction

Modern advances in endonasal endoscopic surgery have expanded its utility in the management of malignant sinonasal tumours, and the degree to which cases are eligible. Knowledge of the indications, inclusion and exclusion criteria and imaging workup that empowers judicious patient selection is essential. This article discusses the endoscopic resection of malignant sinonasal tumours.

Conclusion

Studies describing the impact of patient quality of life will surely affect the fate of endoscopic resection, but the current trend suggests that this technique stands to replace an open approach when outcomes are similar. Combined craniofacial/endoscopic and craniofacial-only approaches to sinonasal malignancy remain an important option in the management of complex disease.

Introduction

Over the past two decades, advances in endonasal endoscopic surgery in terms of both experience and technology have expanded its efficacy in the management of malignant sinonasal tumours. An external approach remains the gold standard for resection of these tumours, undesirable morbidity can include facial incision and scarring, the need for craniotomy or facial bone osteotomy, surgical complications, longer hospitalisation period and slower recovery. When applicable, brain retraction with associated encephalomalacia and oedema can also be avoided.

Traditional external approaches seek to achieve an en bloc resection of all involved bone and soft tissue with negative histopathological margins, most commonly via the techniques of lateral rhinotomy or midface degloving. Should the cribriform plate or fovea ethmoidalis be involved by the superior extent of the tumour, anterior craniofacial resection is typically required. The goal in any approach is to adequately expose the nasal cavity, while preserving function and cosmesis for the patient.

Purported advantages of technical advances in endoscopic resection, particularly with the advent of angled endoscopes, include the ability to navigate difficult anatomic corners, with the subsequent provision of superior tumour visualisation. As opposed to en bloc removal, endoscopic resections sometimes require piecemeal removal of tumour. Due in part to this difference, concern has historically been raised about the ability to achieve clear margins comparable to open approaches (e.g. lateral rhinotomy plus anterior craniotomy). Surgical margins are one of the strongest predictors of disease control, and thus this remains a critical factor in the assessment of evolving techniques. Advances in tumour imaging, surgical techniques, appropriate patient selection and the ability to apply combined endoscopic/craniofacial approaches to difficult cases have increased the utility of transnasal endoscopic surgery. The aim of this review is to discuss the current trends and imaging workup of endoscopic resection of malignant sinonasal tumours.

Discussion

The authors have referenced some of their own studies in this review. These referenced studies have been conducted in accordance with the Declaration of Helsinki (1964), and the protocols of these studies have been approved by the relevant ethics committees related to the institution in which they were performed. All human subjects, in these referenced studies, gave informed consent to participate in these studies.

Current indications

Endoscopic management of nasoethmoidal malignancies with or without involvement of the adjacent anterior skull base or orbital invasion has been shown to be an appropriate indication for pure endoscopic or cranioendoscopic surgery, with careful patient selection.

An endoscopic approach should be considered for tumours which occupy the central nasal cavity between the frontal and sphenoidal sinuses but do not extend to the lateral lamella of the pterygoid bone. Tumour invasion of the nasal bones, anterior/posterior table of the frontal sinus or frank orbital invasion are considered contraindications. Posteriorly, it is important to assess invasion of the carotid and cavernous sinuses. If tumour is noted tracking along nerves (most...
Importantly trigeminal), these are also relative contraindications to an endoscopic approach. Tumour can be resected from the periorbita, but the tumour-invading ocular muscle will typically require orbital excision and thus an open approach. Endoscopic orbital exenteration has been described but is not widely practiced. Malignant tumour types that have been resected with favourable results include adenocarcinoma, adenoid cystic carcinoma, chordoma, malignant melanoma, olfactory neuroblastoma, osteosarcoma and squamous cell carcinoma.

In many situations, a lateral rhinotomy incision and craniotomy can be avoided by endoscopic resection of the extracranial portion of a sinonasal malignancy with transcranial resection at the anterior skull base. In such cases, margins of the mucosa, periorbita and dura should be microscopically clear to ensure local control on par with open traditional approaches. A number of studies have shown that locally advanced malignancy across a variety of histopathological types can be treated endoscopically. However, long-term data are lacking in terms of a direct comparison between open and endoscopic techniques. If the tumour extends lateral to the midpoint of the orbital roof, typically by way of dural spread, it becomes difficult to resect. Moreover, the dural reconstruction is challenging, leading to higher rates of cerebrospinal fluid leak in the postoperative period. As a result, open craniotomy is combined with endoscopic resection to avoid lateral rhinotomy. As robotic surgery and 3D high-definition endoscopy technologies advance, it is anticipated that these boundaries and the capabilities for skull base reconstruction will both improve.

Lastly, endoscopic sinus surgery has also achieved acceptance in the management of epistaxis and nasal obstruction in the palliative setting of sinonasal malignancy. Inclusion and exclusion criteria

Single olfactory bulb resection, such as in olfactory neuroblastoma, is challenging with a standard craniofacial approach, and thus an endoscopic approach is proposed as the preferred method of resection. However, contralateral olfactory bulb salvage is currently rare. In addition, these patients are only eligible in the absence of intraorbital or intracranial involvement, which underscores the importance of appropriate patient selection. In cases such as these where clear margins will be challenging, endoscopic resection should be avoided.

Endoscopic resection of sinonasal tumours that are centrally located in the nose and sinuses should be considered before the external approach is used. While adenocarcinoma, olfactory neuroblastoma, squamous cell carcinoma, adenoid cystic carcinoma and malignant melanoma are the most frequent indications for endoscopic surgery, it remains unclear which tumour types are most appropriate given anatomically favourable positions. An endoscopic approach is also recommended for surgical biopsies of tumours which penetrate into the sphenoid sinus from the sella, the petrous apex and/or adjacent areas.

Unfortunately, there are still no criteria which absolutely indicate whether a sinonasal malignancy is resectable by endoscopic means. Generally, however, tumours that demonstrate invasion of the cavernous sinus are associated with significant patient morbidity and should not be approached endoscopically. In addition, transdural extension is a relative contraindication for both open and endoscopic resection. In some cases, such as optic chiasm invasion, these tumours are not resectable by any means.

Other contraindications to a pure endoscopic approach include extension into facial and orbital soft tissues. Resection of a malignant tumour of the naso-ethmoidal complex through a purely endoscopic approach is also contraindicated as is extensive involvement of the lacrimal pathways, extension through orbital contents, the superior and lateral aspects of the frontal sinus and the floor of the nasal cavity. Patients with involvement of the medial wall of the maxilla and the medial portion of the posterior wall are often excellent candidates for endoscopic resection. However, involvement of the superior, anterior, inferior and lateral walls may require conversion to an open approach. Involvement of the brain or other extension which would require resection of the anterior cranial fossa dura lateral to approximately the mid-orbital roof is also contraindicated.

Standard imaging tests

The main role of imaging in the setting of sinonasal malignancy is to identify malignant disease, its anatomical extent and any metastatic lymphadenopathy. Radiological findings suggestive of malignancy include bony involvement (erosion and destruction), a soft tissue component, a unilateral disease process and soft tissue necrosis with or without lymphadenopathy. The clinician should be aware of factors which are associated with particularly poor patient prognosis, such as tumour encasement of the carotid artery, extension to involve the periorbita or dura, cavernous sinus invasion and perineural tumour spread. Metastatic lymphadenopathy is suggested by the presence of nodal clustering, rounded shape, inhomogeneity on contrast-enhanced studies and peripheral spread, all in the context of a plausible drainage pathway.

When tumours occur in the maxillary or ethmoid sinuses, the American Joint Commission on Cancer T-category

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is applied to imaging findings.\textsuperscript{22} Computed tomography (CT) represents the best modality with which to assess for the presence of bony remodelling or bony invasion, for example of the sinus walls, orbital margins and the floor of the anterior cranial fossa (Figure 1). Coronal and axial views are essential for complete assessment of the pterygoid plates, maxillary sinus, ethmoid bullae and sinus and sphenoid sinus recess. Magnetic resonance imaging (MRI) is an important tool for the assessment of bone marrow invasion, where the high T1 signal fatty marrow is replaced by that of tumour.\textsuperscript{20,23} Displacement of the periorbita is typically diagnosed on CT, with a reported NPV of 86\% and PPV of 75\%.\textsuperscript{24} The essential orbital finding is invasion beyond the periorbita (i.e. fat, muscle) as periorbital invasion can be approached endoscopically, but involvement of the fat or muscle will usually necessitate orbital exenteration (Figure 2). MRI is also valuable in the assessment of dural involvement and brain invasion. The former is evidenced by focal thickening and enhancement of the dura. Brain invasion is suggested by the presence of both brain oedema and parenchymal enhancement and cortical disruption (Figure 3).

Purely endonasal resections within the frontal sinus are also limited by the lesion laterality. Using the modified Lothrop procedure, the floor of the frontal sinus can be removed to approach tumours. However, this is typically limited to those tumours which have extended into the sinus with minimal or no bony involvement. Tumour occupying the frontal sinus is often heterogeneous on a gadolinium T1 sequence. Vascular encasement and nerve involvement, best identified with MRI, are also contraindications to pure endoscopic resection, but a combined external and endoscopic approach may facilitate circumferential dissection around these structures.\textsuperscript{23,25} Last, MRI has been shown to have a 100\% sensitivity and 94\% specificity in the identification of jugular vein and venous sinus invasion.\textsuperscript{26}

**Treatment outcomes**

Morbidity and mortality are significant concerns with both craniofacial-only and combined craniofacial/endoscopic resection, including but not limited to meningitis, encephalomalacia/oedema, pneumocephalus, trismus, blindness and bone flap necrosis.\textsuperscript{4,15,27} However, the most common serious complication is CSF leak, and contemporary advances in endoscopy have yielded rates comparable with open resection. With the advent of the vascularised nasoseptal flap, CSF leak rates have dramatically fallen in most centres. A study of 800 endonasally treated patients revealed a CSF leak rate of 15.9\%, in which all but one case was treated successfully with repeat endonasal endoscopy or lumbar drainage.\textsuperscript{28} These data are favourable for endoscopic over external resection, though the majority of the tumours in the study were benign.

A large series of malignant sinonasal tumours treated with pure endoscopic (72.8\%) or cranioendoscopic (27.2\%) techniques involving 184 patients showed a 5-year disease-specific survival of 91.4\% and 58.8\% respectively. The authors concluded that while operator experience is a significant factor, endoscopic

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**Figure 1:** Sagittal CT bone algorithm image of a squamous cell carcinoma in the ethmoid sinus (asterisk) that has eroded the overlying floor of the anterior cranial fossa.
In their study of 120 patients, where the most common site of tumour origin was the nasal cavity (52%), positive margins were present in 15% of patients and the 5- and 10-year disease-specific survival rates were 87% and 80%, respectively. Recurrence rates did not differ between the two groups. Encouragingly, CSF leak occurred in 3% of patients and was also not significantly different between the groups. It is notable that in both studies, the proportion of olfactory neuroblastoma was high, as these are often associated with good prognosis for 5–10 years before possible recurrence. In addition, the proportions of patients in either treatment group were not necessarily matched for disease stage.

Last, there is great theoretical benefit for elderly patients undergoing resection of sinonasal malignancies. Outcome of craniofacial resection in patients 70 years of age and older are significantly worse in terms of mortality, complication and disease-specific long-term survival. Given that elderly patients often do not tolerate brain retraction well, pure endoscopic resection stands to improve outcomes in this population.

Conclusion

Endoscopic techniques are being employed with increasing frequency in the setting of sinonasal malignancy. In order to best utilise this approach, appropriate patient selection is essential. Concurrent advances in MRI are poised to assist in the discrimination of surgical candidates, particularly with improved detection of perineural and vascular involvement.

As international trials continue, long-term follow-up and further insight into oncologic outcomes will become apparent, ideally with disease-specific data. Additional information about the potential for improved quality of life will undoubtedly be a major determinant in the future use of endoscopic resection.
Combined craniofacial/endoscopic and craniofacial-only approaches to sinonasal malignancy remain an important option in the management of complex disease.

Abbreviations list
CSF, cerebrospinal fluid; CT, computed tomography; MRI, magnetic resonance imaging.

References