MODERN INDICATIONS FOR ENDOSCOPIC ENDONASAL SURGERY

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ABSTRACT

Endoscopic endonasal surgery has become a standard procedure for functional treatment of benign pathologies. Materials and improved surgeon skills have allowed the number of indications for this approach to increase. We describe some of the main pathologies, including malignancies, that can be treated endoscopically, focussing on the orbital and skull base pathologies. The orbital indications discussed here are dacryocystorhinostomy, orbital decompression, and optic nerve decompression. Advantages of endoscopic surgery for aggressive benign tumours such as inverted papilloma and juvenile nasopharyngeal angiofibroma are described. The skull base pathologies detailed are ethmoid adenocarcinoma and esthesioneuroblastoma for the anterior skull base surgery and endoscopic transsphenoidal approach to the sella for pituitary tumour surgery. Evidence of the safety and efficacy of endoscopic surgery is increasing but there is a lack of randomised long-term studies.

Keywords: Endoscopic sinus surgery, skull base surgery, orbital surgery.

INTRODUCTION

Over the last two decades, important progress has been made in endoscopic endonasal surgery. Functional endoscopic treatment of benign pathologies such as chronic sinusitis, nasal polyposis, and mucoceles have become standard procedures that are widely performed. Indications for endoscopic procedures are constantly increasing. This progress was made possible thanks to the development of surgeons' skills and dedicated instrumentation. This instrumentation includes, among others, long and small calibre cold instruments, powered instruments such as microdebriders and drills, navigation systems, endoscope-fitted irrigation systems, and haemostasis systems. Acquisition of video was also a key issue in the development of endoscopic endonasal surgery. Modern high-definition cameras offer good visualisation and magnification of the lesions and the anatomical landmarks. Ultra-high-definition (4K) cameras, screens, and three-dimensional endoscopic sinus surgery have recently become available and are very promising. This paper gives an overview of the new indications of this surgery, which are mainly related to orbital and skull base pathologies.

ADVANTAGES AND LIMITS OF ENDOSCOPIC ENDONASAL SURGERY

In comparison with open surgery, the endoscopic approach offers several advantages. Firstly, it is valuable for the education of residents and staff as they can follow the procedures in real-time on screens. Secondly, endoscopic surgery causes no facial incision, scars, or facial swelling. Additionally, the patient's hospitalisation is generally shorter and the postoperative pain is reduced,[1] and complication rates are notably lower. The most common complications of endoscopic nasal surgeries are: cerebrospinal fluid (CSF) leak, orbital injury (blindness, haematoma, diplopia, epiphora), prolonged crusting, infections, synechiae,

and bleeding. The complication rate naturally depends on the extent of the surgery. The major complication rate for primary functional endoscopic surgery is <1%. In the review published by Krings et al.[2] for example, the major complication rate was 0.36% including 0.13% skull base complications, 0.23% orbital complications, and 0.0001% major haemorrhagic complications. The major complication rate was higher during expanded endonasal surgery (involving skull base) with 0.9% vascular complications and 2% neural complications reported.[1] The most common complication of expanded endonasal surgery is CSF leak. This complication rate has however dramatically decreased with the evolution of reconstructive techniques and is now around 5% when the proper reconstruction technique is performed.[3] It can be managed with a lumbar spinal drainage or additional endoscopic surgery in 95% of the cases. Infectious complications are surprisingly rare with an incidence of 1–2%.[1,4] In light of this evidence, expanded endoscopic procedures can be considered safe.

The endoscopic approach, in comparison with the traditional open surgeries, reduces the need for soft tissue dissection, skeletal disassembly, and brain retraction for lesion access and resection.[5] The rate of complications following open craniofacial resection for malignancies of the skull base is around 36%, with 16% relating to central nervous system-related complications, 20% wound complications, 4.7% mortality, 2% orbital complications, and 5% systemic complications.[6] Concerning expanded endonasal surgery, procedural quality relies on experienced, multidisciplinary surgical teams. Patient selection is also very important. For instance, previous endoscopic sinus surgery is a bad prognostic factor. Finally, pathology topography is one of the main issues in endoscopic nose surgery. Indeed, the location and proximity to important neural and vascular structures will determine the feasibility of the procedure. The endonasal corridor provides the best access with the least manipulation of neural and vascular structures to many nasosinusal tumours. The endonasal corridor provides a direct pathway to an olfactory groove meningioma without the need for brain retraction, for example. Conversely, a tumour lateral to the optic nerve is best treated using another approach. Large tumours may require a combination of external and endonasal approaches.[4] The invasion of the following structures is a limit to

endoscopic resection: anterior wall or floor of the maxillary sinus, external part of the orbit, skin, lateral part of frontal sinus, or dura above the orbits.

ORBITAL INDICATIONS

Dacryocystorhinostomy

Until recently, surgery of nasolacrimal duct obstruction was performed using the external approach with very good outcomes. The endonasal endoscopic approach was first described in 1989 by McDonogh and Meiring.[7] The outcomes of this procedure improved over time through the development of techniques and instrumentation. It has now become a standard procedure routinely performed by many teams with excellent results, comparable to those achieved using an external approach.[8-11] Among the benefits of the endoscopic approach are: absence of skin incisions and facial scars, palpebral ligaments as well as angular facial vessels, orbicularis oculi muscle and lacrimal pump preservation, and direct access to lacrimal sac through the lacrimal bone thus avoiding double-side dissection.[12] The indications of this procedure are now expanding beyond primary acquired nasolacrimal duct obstruction to include dacryocystorhinostomy revisions, acute lacrimal sac abscesses, and nasolacrimal duct obstructions in patients who have received chemotherapy or radiation.[12,13]

Orbital Decompression

Described in 1990 by Kennedy et al.,[14] endoscopic endonasal orbital decompression has been demonstrated to be a safe and effective technique for the treatment of Graves' orbitopathy.[15] Indeed, endoscopy provides the surgeon with an enhanced visualisation and a good access to the medial orbital wall and to the medial part of the floor. The main complication after this procedure is new-onset diplopia or worsening pre-existing diplopia. Strabismus surgery is sometimes needed and the patient should always be informed about this complication. A lacrimal duct wound is also a possible complication. CSF leak and blindness are uncommon but have been reported.

Optic Nerve Decompression

The main indication for this procedure is optic neuropathy. This neuropathy is often traumatic but can also result from compression caused by a tumour (such as meningioma, neuroma, fibrous dysplasia) or an infection.[16] Optic nerve

decompression remains controversial in whether it should be mandatory in the treatment of traumatic optic neuropathy.[17] For this procedure, the endoscopic approach offers very good access to the inferior medial part of the optic canal. When the roof of the optic canal has to be decompressed, an open approach is preferred. Endoscopic surgery should be performed when possible. Indeed, it offers a very good visualisation of orbital apex and the bony structures covering the neurovascular complex. It avoids brain retraction and therefore preserves olfaction. It also avoids external scars.[18,19]

Orbital Tumour Surgery

Many different kinds of tumours such as cavernous haemangioma, schwannomas, haemangiopericytomas, lymphomas, etc. can occur in the orbit. It can also be invaded secondarily by tumours of brain, skin, bone, and sinus origin. Endoscopic endonasal surgery offers a minimally invasive approach for tumours located inferomedially in the orbit. The window between the medial and inferior rectus muscle represents an ideal corridor to access the inferomedial orbital spaces, from the eyeball to the orbital apex.[20] Crossing of the optic nerve should be avoided during surgery.[21,22] Tumours located superiorly and laterally are thus not good candidates for endonasal approach. Cavernous haemangiomas, which are the most common intraorbital primary tumours in adults, are easily manipulated with low-risk of rupture and can thus be ideally assessed endoscopically if located medially.[23,24] Some series have now been published demonstrating the safety and feasibility of this approach in properly selected cases.[25] Direct transorbital endoscopic approaches have recently been described and appear to be a very promising alternative for posterolateral orbital tumours.

TUMOURAL INDICATIONS AND SKULL BASE SURGERY

Benign Tumours

There is a wide variety of sinonasal benign tumours. These include: epithelial tumours (keratotic papilloma, inverted papilloma, etc.), mesenchymal tumours (osteoma, chondroma, fibroma, etc.), neural tumours (schwannoma, neurofibroma, meningioma), fibro-osseous tumours (fibrous dysplasia, ossifying fibroma, giant cell tumours, etc.), and vascular tumours (haemangioma, etc.).[13]

Endoscopy and radiology can sometimes lead to the correct diagnosis but biopsy and histology are often needed for confirmation. The surgical management of those tumours has been dramatically improved by using endoscopic surgery. We will here describe two examples of benign tumours whose management was challenging before the introduction of endoscopic techniques.

Inverted Papilloma

Sinonasal inverted papilloma is the most common benign lesion that occurs in the nasal cavity and paranasal sinuses. It is characterised by a high recurrence rate and malignant transformation potential.[26,27] Although its aetiology is unknown, there seems to be a link with the human papilloma virus.[28] The management of inverted papilloma can be challenging because despite its benign histology it can be aggressive, causing bone erosion, remodelling, or destruction. It may also lead to squamous cell carcinoma in 5–15% of the cases.[29] In a meta-analysis published by Busquets and Hwang,[30] a total cohort of 1,060 patients was analysed and showed that patients treated endoscopically had a lower recurrence rate (12%) than patients treated non-endoscopically (20%). The study indicates that endoscopic surgery is a favourable treatment option for most cases of sinonasal inverted papilloma. Attention should be paid to extracting all of the tumoural tissue. The bone underlying the origin of the papilloma can be burred to microscopic remnants. A medial maxillectomy is performed endoscopically when needed.

Juvenile Nasopharyngeal Angiofibroma

Juvenile nasopharyngeal angiofibroma is a benign vascular tumour which affects young males, especially teenagers. It accounts for 0.05% of all head and neck tumours[1] and its prevalence is higher in India and the Middle East. It arises from the sphenopalatine foramen and it is the most common tumour involving the pterygopalatine and infratemporal fossa. It is highly vascularised, mainly by the internal maxillary artery. This tumour is characterised by typical radiological findings (computed tomography [CT] and magnetic resonance imaging [MRI]). Biopsy is not recommended in this scenario due to the bleeding risk. Preoperative identification of tumour vascularisation is essential to choose the best treatment option. Preoperative embolisation

24–48 hours before surgery is recommended by most authors as a standard procedure to reduce blood loss during surgical resection.[31] Surgery is the treatment of choice where feasible. Increasing experience in endoscopic surgery together with better understanding of complex sinonasal anatomy, the possibility to safely reach adjacent sites through the nose such as the orbit, infratemporal fossa, masticatory space, parasellar region, the availability of navigation systems, and the well-known morbidity associated with external procedures have made an endoscopic approach a viable alternative.[31] Lesions with large skull base infiltration, extensive vascular supply from internal carotid artery (ICA), or encasement of the artery itself should be treated with an external or combined approach. Radiation therapy is sometimes recommended in unresectable tumours. Endoscopic surgery is also contraindicated for residual tumours involving critical areas (ICA, optic nerve, cavernous sinus, dura). However, Nicolai et al.[32] suggested that it may be used in the management of residual lesions in critical areas that have been shown to increase in size.

Cerebrospinal Fluid Leak Repair

CSF leak can occur spontaneously or it can occur after head trauma, surgery, neoplastic invasion, inflammatory erosion of the skull base, or malformation. In most cases, surgical repair of the leak is needed. The classical intracranial approach is associated with high morbidity and mortality. Endoscopic management of CSF leak, first mentioned by Wigand[33] in 1981, has now become a standard procedure. Large series have been published showing minimal morbidity and recalibrating the risk-benefit ratio of early leak closure versus watchful waiting.[34] CSF leak from the sphenoid sinus used to be especially challenging due to the anatomical relationships and the variable shape of the sinus. It is now commonly treated endoscopically with lower morbidity and better outcome.[35] One of the main challenges concerning CSF leak repair is to identify precisely the leak location. High-resolution CT scan is the best option for the identification of skull base defects while MRI can help in differentiating mucosal oedema from meningoencephalocoele. Intrathecal fluorescein is sometimes administered preoperatively to help to localise the leak using blue light endoscope. Various materials can be used to close the skull base defect: fat, fascia, collagenous matrix, pericranium, mucoperichondrial (nasal septum), or mucoperiosteal (middle turbinate) graft, etc., the use of pedicled septal flap relying on the sphenopalatine artery, and the multilayer reconstruction are some of the latest advances.[36] For example, collagenous matrix can be inserted intradurally (underlay) and mucoperichondrial, mucoperiosteal, or pedicled flap can be used extradurally (overlay). All layers are then fixed with fibrin glue and nasal packing is generally recommended.[35]

ONCOLOGIC AND SKULL BASE SURGERY PRINCIPLES

Endoscopic surgery has definitely improved the management of endonasal benign tumours by offering an effective local tumour control and decreasing morbidity compared with open approaches. One of the main issues concerning endoscopic resection in malignant lesions is *en bloc* resection.

It is often impossible to resect the tumour *en bloc* endoscopically. There is actually no evidence that debulking the tumour first increases the risk of local recurrence. Even with open techniques, *en bloc* excision is often not possible because of fragmentation of the specimen and proximity to vital structures. An endonasal approach may actually decrease the risk of tumour seeding compared with an open approach since there is less transgression of uninvolved tissues and visualisation of margins is improved. Ultimately it is the final resection margin that is important, not the method of tumour removal.[37]

Another important issue in skull base surgery is the reconstruction of the dural defect caused by the surgery. Endoscopic treatment of CSF leaks has become a standard procedure but the reconstruction of the defect caused by a skull base tumour removal can be much more challenging. This reconstruction is even more critical if radiotherapy is scheduled or has been previously performed. There are several benefits of proper closure techniques: to avoid CSF leakage that is a common complication of those procedures, to protect the uncovered carotid artery, to speed up healing, and to avoid radionecrosis and meningitis. Different materials can be used: cartilage, free mucosal flaps, pediculate flaps (nasoseptal, temporalis fascia, pericranial) fascia lata, fat, human thrombin and fibrinogen, dural substitute, etc. The dura is generally closed using several layers (known as the sandwich technique). The development of closure techniques was an essential part of

endoscopic skull base surgery development. A lumbar drainage is rarely needed. Reconstruction is not necessary in the absence of meningeal tear and CSF leak, particularly following pituitary surgery.[38]

ETHMOID ADENOCARCINOMA AND OLFACTORY NEUROBLASTOMA: ANTERIOR SKULL BASE SURGERY

Sinonasal malignancies are rare, accounting for only 1% of all malignancies.[39] Their management however, is often challenging due to their late presentation, histologic diversity, poor prognosis, and proximity to important structures such as orbit and skull base. We chose to emphasise the contribution of endoscopic surgery in the management of ethmoid tumours. In Europe, adenocarcinoma (AC) is the most common epithelium-derived neoplasm of the ethmoid. Wood dust and leather dust have been shown to be associated with the development of this tumour in several countries with a considerable delay between exposure and presentation, of up to 40 years.[40] Olfactory neuroblastoma (ON), also known as esthesioneuroblastoma, classically arises from olfactory epithelium in the upper nasal cavity and therefore spreads intracranially at an early stage to involve the olfactory bulb and tracts.[13] Skull base involvement occurs in 38% of ACs and 50–75% of ONs.[41] The management of these tumours is surgery followed by radiotherapy. The surgery is difficult and classically requires craniofacial resection using transfacial and sometimes transcranial approaches. However, these procedures entail significant morbidity such as pneumatocele, cerebral oedema, cerebral abscess, CSF leakage, meningitis, stroke, and even death in up to 4.5% of cases.[6] ACs and ONs are midline tumours; they are then easily accessible by an endoscopic approach. Successful endoscopic resection of those tumours has been described by several teams with excellent results.[42-45] An exclusively endoscopic approach has anatomic limitations such as invasion of lateral frontal sinus above the orbit or significant intradural invasion.[43] The main steps of the endoscopic anterior skull base approach are: biopsies made at the beginning of the surgery to ensure tumour-free margins; debulking of the tumour sometimes needed to ensure a wide field of vision; DRAF III procedure and removal of the anterior wall of the sphenoid sinus; exposition of the dura by drilling the roof of the ethmoid; resection of the crista galli; section of the falx cerebri; and

resection of the dura. The skull base specimen can then be taken out and duraplasty is performed generally using layers of fascia latae.[43]

ENDOSCOPIC TRANSSPHENOIDAL APPROACH TO THE SELLA FOR PITUITARY TUMOUR SURGERY

First described by Jankowski et al.[46] in 1992, the endoscopic approach for pituitary surgery has become a standard procedure. The traditional transseptal/translabial microscopic approach is still performed by many teams with good surgical outcomes and little morbidity. Several reviews have compared the two techniques in the treatment of pituitary adenomas. The meta-analysis of Gao et al.[47] for example, concluded that endoscopic transsphenoidal pituitary adenoma surgery is associated with a higher rate of gross tumour removal, decreased hospital stay, and reduced observed postoperative complication (septal perforation). The meta-analysis of DeKlotz et al.[48] concluded that recent literature demonstrated superior outcomes and decreased postoperative complications with the endoscopic approach, potentially justifying a shift toward endoscopic pituitary surgery. The review of Ammirati et al.[49] concluded that the endoscopic technique is associated with a higher incidence of vascular complications compared with microscopic transsphenoidal removal of pituitary adenomas. That review was commented on by Laws,[50] who concluded that in the future there might be identical benefits between the two techniques, but it is too soon to be certain and keeping an open mind is still a very good strategy for now.

OTHER INDICATIONS

Some indications of endoscopic endonasal surgery were not detailed in this report. For example, septoplasty, probably the most common surgical indication for rhinologists, has quite recently started being performed endoscopically. The comparison between the classical and endoscopic approach is a recent concern. Some reports show that endoscopy offers a better approach to posterior deformation, fewer complications, and quicker patient recovery.[51-54] Transplanum, transclival, and transodontoid approaches are new applications. Their indications are mainly central nervous system benign tumours such as craniopharyngioma, chordoma, meningiomas, schwannomas, etc. The petrous apex can also be

reached to treat cholesterol granuloma. Those indications respect the same principles described above. Special attention should be paid to the noble structures located close to the pathology, such as the ICA and cranial nerves.

CONCLUSIONS

New indications of endoscopic nasal surgery involving orbital and skull base pathologies are expanding. Studies show a superiority of this technique in many indications including some malignant diseases. These studies however, have to be interpreted cautiously, as their follow-up is limited and their design does not include randomisation. Further studies will allow us to have a better view of the long-term outcomes, the precise indications, and limitations of this procedure. Development of new technologies as well as surgical training methods are likely to improve our ability to manage more pathologies endoscopically.

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