

RHINOLOGY

Endoscopic expanded endonasal approach: preliminary experience with the new 3D endoscope

L'approccio endonasale endoscopico esteso: esperienza preliminare con il nuovo endoscopio 3D

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SUMMARY

The recent introduction of the 3D endoscope for endonasal surgery has been welcomed because of its promise to overcome the main limitation of endoscopy, namely the lack of stereoscopic vision. This innovation particularly regarded the most complex transnasal surgery of the skull base. We therefore discuss our early experience as ENT surgeons with the use of a purely 3D endoscopic expanded endonasal approach for supradiaphragmatic lesions in 10 consecutive patients. This article will focus on the surgical technique, the complications, the outcome, and more importantly the advantages and limitations of the new device. We believe that the new 3D system shows its main drawback when surgery is conducted in the narrow nasal spaces. Nevertheless, the improved knowledge of the three-dimensional nasal anatomy enabled the ENT surgeon to perform a more selective demolition of the nasal structures even in the anterior part of the nose. The depth perception obtained with the 3D system also permitted a better understanding of the plasticity of the surgical defects, increasing the confidence to perform successful skull base plasties. We believe that, for both the ENT surgeon and the neurosurgeon, the expanded endonasal approach is the main indication for this exciting tool, although larger prospective studies are needed to determine the equality to the 2D HD endoscope in oncological terms.

KEY WORDS: 3D • Endoscopy • Expanded endonasal approach • Skull base • Three dimensional

RIASSUNTO

La recente introduzione dell'endoscopia tridimensionale nella chirurgia endonasale è stata accolta con favore con l'aspettativa di superare la principale limitazione dell'endoscopia, ovvero la mancanza di visione stereoscopica. Questa innovazione riguarda soprattutto la complessa chirurgia endoscopica della base cranica. Discutiamo quindi la nostra esperienza preliminare come chirurghi ORL con l'approccio endoscopico endonasale esteso con visione 3D per lesioni sopradiagraffamiche in 10 pazienti consecutivi. Questo articolo discute la tecnica chirurgica, le complicanze, i risultati e soprattutto i vantaggi ed i limiti del nuovo strumento. Riteniamo che il sistema 3D mostri i suoi limiti principali quando la chirurgia è condotta in spazi stretti. Comunque, la maggiore consapevolezza dell'anatomia nasale tridimensionale permette al chirurgo ORL di eseguire una demolizione più selettiva delle strutture nasali, anche nella parte anteriore delle cavità nasali. La percezione della profondità che si ottiene con il sistema 3D permette inoltre una migliore comprensione della morfologia del difetto chirurgico, migliorando le capacità di eseguire una plastica efficace. Nella nostra opinione, sia per i chirurghi ORL che per i neurochirurghi, l'approccio endoscopico endonasale esteso è la principale indicazione per questo strumento innovativo, sebbene siano necessari ulteriori studi su popolazioni più numerose per determinarne la stessa affidabilità della tecnologia 2D HD in termini oncologici.

PAROLE CHIAVE: 3D • Endoscopia • Approccio endonasale esteso • Base cranica • Tridimensionale

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Introduction

In recent years, the transnasal endoscopic approach to the ventral midline skull base has rapidly become a widespread procedure. In fact, this approach occupies a crucial place in the armamentarium of neurosurgeons and otorhinolaryngologists for the management of diseases of the anterior skull base, the sella, the suprasellar and parasellar regions.

The increasing popularity of the endoscope for skull base surgery implies the necessity to acquire a whole new skill set. The neurosurgeon had to learn the use of an unfamiliar tool while the otorhinolaryngologist had to be introduced to a completely new set of pathologies and anatomical challenges, as during the microscopic era the ENT surgeon played only a marginal role in the treatment of midline skull base pathologies. Therefore, in the

beginning, the development of endonasal skull base surgery was limited by the anatomical knowledge of the skull base from an endoscopic endonasal perspective and also by the available technology. Cooperation between ENT and neurosurgeons has been crucial to overcome most of the limiting aspects, and finally the enhanced knowledge and understanding of the surgical anatomy of nose and skull base enlarged the anatomical area that can be reached, introducing the concept of the endoscopic expanded endonasal approach (EEA) ¹. Furthermore, the continuous technological improvement in imaging, image guidance, and microinstruments allowed better planning and precision during surgery ². However, the introduction of endoscopic surgery has meant the loss of the stereoscopic vision of the microscope. Therefore, the surgeon has to achieve depth perception through haptic and visual cues like the interaction of instruments or the continuous movement of the endoscope. Nonetheless, depth perception remains only fairly accurate. To overcome this limit, a novel 3D visualization system has been developed (Visionsense, Ltd., Petach Tikva, Israel) and more than one publication has demonstrated its effectiveness and safety during sinonasal and skull-base surgery ³⁻⁵.

We started using the 3D endoscopic system in transphenoidal surgery in May 2011 and since then we have performed more than 80 purely 3D endoscopic approaches to the skull base.

In this article, we present our early experience with the use of a purely 3D EEA for supradiaphragmatic lesions in 10 consecutive patients with focus on the surgical technique, the complications, the outcome, and more importantly the advantages and limitations of the new device.

Materials and methods

A retrospective review of all purely 3D endoscopic skull base approaches performed at the Istituto Clinico Humanitas between May 2011 and February 2012 was conducted. The surgical team was always composed of a neurosurgeon and an ENT surgeon. Ten consecutive patients who underwent an EEA for supradiaphragmatic lesions were selected. After ethics approval of the institutional review board, charts were reviewed for patient gender and age, presenting symptoms, tumour characteristics, surgical procedure, postoperative course and complications. All patients were studied preoperatively with a CT scan and gadolinium enhancement MRI. Neuronavigation sequences were acquired in all the cases. In some cases fusion of the CT and MRI images for neuronavigation purposes was obtained.

Surgical approach

The operating room set-up is similar to the one needed for 2D-HD endoscopic surgery and the surgical approaches are always performed under image guidance.

The ENT surgeon, after decongestion of the nose with epinephrine 1:20,000, performs a middle turbinate resection, usually monolaterally on the right side depending on tumour extension and/or anatomical variations. After having harvested a vascular pedicled naso-septal flap ⁶ (mono- or bilaterally, depending on the presumed extension of the defect), the posterior third of the nasal septum is removed. A complete sphenoidectomy with identification of the ethmoidal roof, cribriform plate and sphenoidal plane is then performed. Both cavernous sinuses, internal carotid arteries and opticocarotid recesses are identified and exposed. The contralateral nasal cavity is used as a corridor for instruments, after lateralization of the middle turbinate. The bony opening depends on the location of the tumour. In this series, to reach suprasellar lesions, a transplanum transtuberculum transsellar approach was performed in every case. At this point the neurosurgeon coagulates and divides the superior intercavernous sinus and then opens the dura to gain access to the intradural space. Tumours are debulked and then removed by meticulous microdissection. Preservation of the arachnoid plane is attempted in every case. Reconstruction of the bony and dural defect is performed positioning fascia lata previously harvested underlay, autologous fat to obliterate dead spaces, fascia lata overlay and the pedicled nasoseptal flap over the fascia. The plasty is stabilized with fibrin glue and a Foley catheter. Nasal packing is usually not necessary.

A lumbar drain is positioned at the beginning of the operation and is kept in place for five days. Perioperative antibiotics are always administered for a mean of seven days.

Technology

The 3D stereoendoscopes (0° wide angle and 30°) by Visionsense (Visionsense, Ltd., Petach Tikva, Israel) are based on a lenticular array and the three-dimensionality is conveyed by two single cameras mounted on the tip of the endoscope ⁷. The diameter of the endoscope at the tip is of 4.9 mm and its handle is very lightweight with 98 g. The image is displayed on a 42-inch dual-flatscreen mounted on the device's tower. Polarizing glasses are worn for 3D visualization. The system records still-frames and movies and allows a switch from 3D to 2D via a key on the handle of the endoscope.

Results

Of the 10 patients, 7 were female and 3 were male. Median age at surgery was 49 years (mean 47.2 ± 12.0 years). Common presenting symptoms included headache (7/10) and visual field defects (9/10). Depending on the pathology, a variable degree of endocrinological deficits were present. Four patients had been previously operated on elsewhere (1 to 3 times); operations for recurrences were not associated with an increased rate of complications.

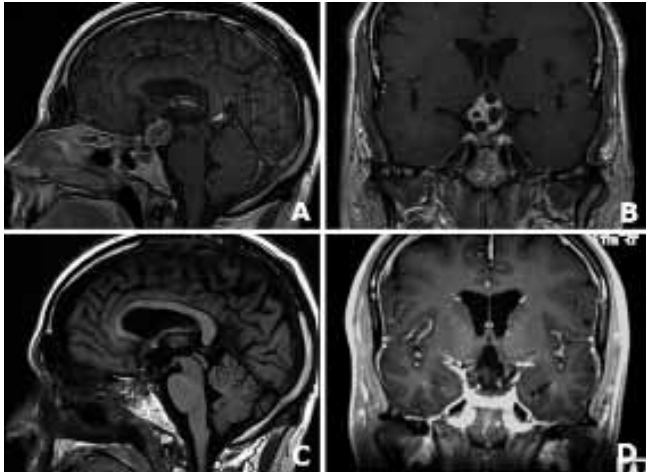


Fig. 1. Pre- (A, B) and postoperative (C, D) MRI of a craniopharyngioma: total removal after a purely 3D extended endonasal approach.

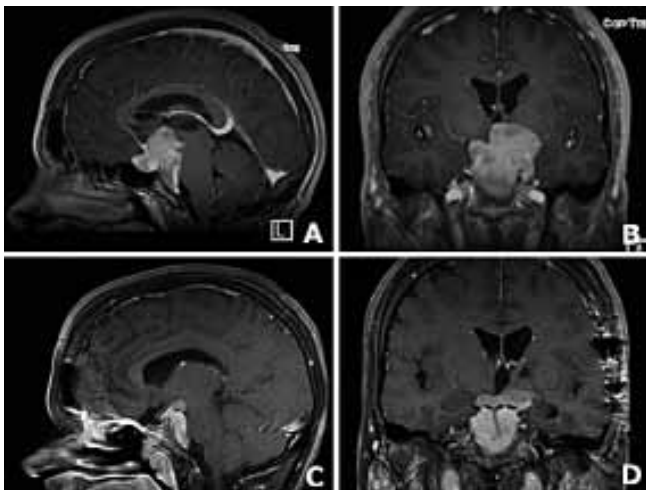


Fig. 2. Pre- (A, B) and postoperative (C, D) MRI of a giant GH-secreting pituitary adenoma extending into the posterior fossa: partial resection after a transcranial pterional approach and a purely 3D extended endonasal.

Gross total resection was obtained in 6 patients (5 craniopharyngiomas, 1 metastatic tumour) (Fig. 1). Subtotal resection was obtained in 3 patients (2 tuberculum sellae meningiomas with cavernous sinus invasion; 1 giant macroadenoma reaching the basal ganglia); in one case (giant adenoma extended into the posterior fossa) only a partial resection was done (Fig. 2). Both giant adenoma cases had been operated on by a staged procedure: first a craniotomic route was performed, followed by an EEA.

Intraoperative blood loss has never been significant. Surgical time varied between 3 and 9 hours, mainly related to the neurosurgical time of the operation.

There was no mortality. Major postoperative complications consisted in two cases of postoperative CSF leak with meningitis in one of them. Both patients underwent successful revision surgery with the 3D endoscopic system. No postoperative deterioration of the visual field or visual status was observed. All the patients with preopera-

tive visual impairment showed at least partial improvement, except one (tuberculum sellae meningioma).

Postoperative anosmia was always present and resulted permanent in 3 out of 10 patients. This problem is probably related to a damage to the olfactory mucosa. An additional common postoperative complication has been excessive nasal crusting with or without cacosmia, both improved or resolved after daily nasal irrigation, weekly toilette of the nasal fossae by the ENT surgeon and topical antibiotic treatment.

From an endocrinological perspective, the 5 patients with craniopharyngioma were found to be hypopituitary one month after the surgical procedure. They are currently under follow-up and undergo substitution therapy with cortone acetate, L-thyroxine, testosterone or oestrogen and with rhGH. Two of them are also treated with desmopressin due to the presence of diabetes insipidus. The patient with non-functioning pituitary adenoma is currently under treatment with L-thyroxine. The patient with the GH-secreting adenoma, affected by acromegaly, is currently under treatment with somatostatin analogues and cortone acetate. The other 3 patients did not have endocrinological deficits. No patient showed signs of hypothalamic dysfunction.

Neither symptoms nor signs of neuropsychological deterioration were recorded, and all patients have resumed their previous occupation, except for the case of metastatic tumour who died 8 months after surgery due to progression of his primitive cancer.

Discussion

The transnasal resection of extensive suprasellar tumours was first described in 1987 by Weiss⁸, who proposed a sublabial microscopic route with extension of the removal of the sellar floor anteriorly to include the tuberculum sellae and posterior part of the planum sphenoidale to approach suprasellar craniopharyngiomas. The microscope allows a bimanual dissection and a three-dimensional vision, but its main limitation consists in a limited conic surgical view. Since then, transnasal surgery has seen many changes, and the introduction of the endoscope in replacement of the microscope allowed further expansion of the technique to access the full extent of the midline cranial base from the cribriform plate to the anterior foramen magnum¹⁹. The field of view of the endoscope allows the surgeon to explore “around the corner” and makes recognition of anatomical structures easier. This permitted a progressive increase of complexity and extension of the endoscopic skull base approaches. Subsequently several authors have shown that, partly due to the introduction of new reconstruction techniques^{6 10 11}, these expanded approaches are feasible and safe in well-selected cases. The consequent widening of indications for endoscopic endonasal skull base surgery has brought to an exponential

increase in the development of new tools that may allow more precise, safe and extensive surgery. The development of 2D HD systems has allowed a better recognition of anatomical landmarks, but it did not solve the major pitfall of endoscopy: the loss of depth perception. ENT surgeons performing sinus surgery do not necessarily feel this problem, but it becomes apparent when dealing with the delicate vascular and neural structures of the skull base. The novel introduction of a 3D endoscopic system has therefore been welcomed by ENT surgeons but even more by neurosurgeons.

The advantages and limitations of the novel 3D device in visualization and depth perception have already been reported by the first comparative publications on the matter^{4 5 7 12} and clinical utility has been proven in small case series^{3 13 14}.

From an ENT perspective, the new 3D system shows its main drawback when surgery is conducted in the narrow nasal spaces. The bigger scope diameter makes surgical manoeuvres more difficult during the first steps of the procedure. Also due to wider diameter of the scope and the position of the cameras on the tip, the latter are prone to getting dirty, consequently loosing the 3D image (both cameras are needed to convey a 3D image). Nonetheless, through a more frequent irrigation, this problem is easily solved, but remains a time consuming drawback. Furthermore, the characteristics of the autofocus feature make an adjustment period necessary to understand the importance of correct alignment and positioning of the scope. These features made initial adaptation more difficult for ENT surgeons than for neurosurgeons. Anyway, less than ten operations were needed to become fully familiar with the instrument.

Another potential limit is the absence of a 45° or 70° angled scope, but in our practice we have tried to use these scopes (2D) and we think that dissection of neurovascular structures with such angled scopes is difficult and sometimes dangerous. The 30° scope is sufficient to “look around corners” and permits to perform dissection under direct vision.

The LED-light powered instrument has the advantage of a low footprint and no risk of overheating, but it limits the sharpness of the conveyed image colours. Through a different software set-up this has been ameliorated during the last procedures.

The adjunction of depth perception to all the other well-known features of endoscopic surgery made the new 3D endoscopic system the ideal tool for a wide range of procedures.

As already demonstrated for laparoscopic surgery¹⁵, we believe that efficiency of surgical gestures in transnasal endoscopy is greatly increased with the 3D system. For the ENT surgeon this may not be particularly revolutionary while preparing the anterior nasal corridor, but it remains a radical innovation for the poste-

rior ethmoidectomy and sphenoidotomy due to a more profound knowledge of the three-dimensional anatomy. Working in a 3D environment allowed us to perform a more selective resection of nasal structures. Particularly, the only partial removal of the superior turbinate permits the preservation of more olfactory mucosa, leading to a better postoperative recovery of smell. Moreover, a more selective demolition of the nasal structures fastened the healing process of the mucosa, leading to less postoperative crusting and cacosmia.

The depth perception obtained with the 3D system also permits a better understanding of the plasticity of the surgical defects. Indeed, our ability to perform a successful skull base plasty is increased.

The slightly inferior resolution of the 3D system when compared to the latest 2D HD systems has not been significant in our experience. We feel that depth perception made this technology superior to the 2D HD and, given the dynamic nature of endoscopy, superior to the microscope when working in deep narrow fields at high magnification. To optimize vision, surgeons have to stand as far as possible from the monitor (Fig. 3). In addition the scope is lighter than the traditional instrument: a very useful feature in long EEA procedures. Surgical time indeed increased using the new 3D system, but not significantly. Oncologically speaking, this series is too heterogeneous and small to state a superiority of the 3D device compared with the 2D HD endoscope, particularly regarding the rate of gross total removal of the tumours and the relative surgical complications.

Although we observed two cases of postoperative CSF leaks requiring revision surgery, we believe this complication is related to the approach itself and not to the device. Dissection and handling of neurovascular structures with the three-dimensional scope is safer and enables the surgeon to use the microsurgical technique with the same



Fig. 3. The operating room set up for 3D endoscopic surgery is similar to that needed for 2D endoscopic surgery. Both surgeons stand on the right side of the patient, wearing polarizing glasses. The monitor should be as far as possible to optimize vision. Intraoperative neuronavigation is always available in case of EEA.

precision offered by the microscope. Certainly, in supra- and parasellar surgery the close relationship between pituitary gland and stalk, optic chiasm, carotid arteries and other neural and vascular structures and tumour are better appreciated working in a three-dimensional environment. Excluding the initial costs related to the acquisition of the 3D system, each procedure is about 500 euros more expensive than a standard 2D HD skull base procedure. This is due to the frequent (about once every 50 procedures) reconditioning of the endoscope requested by the manufacturer. Given the great advantages that the 3D system provides in complex endoscopic skull base procedures, we believe that this technology should be considered cost-effective. New technologies, such as robotic-assisted surgery¹⁶, are currently under evaluation for endonasal skull base surgery, but at the moment we are convinced that 3D endoscopy is the most concrete and promising evolution in endoscopic endonasal skull base surgery.

Conclusions

The new 3D endoscopic system can overcome the main limit of 2D HD endoscopic surgery: the lack of depth perception. The main drawback of the 3D system is the manoeuvrability in narrow spaces, while it reaches its best in the posterior nose and in the intracranial space where a three-dimensional view is highly advisable. As a consequence of all this, in our opinion, the expanded endonasal approach is the main indication for this exciting, although still expensive, tool.

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