Endoscopic endonasal resection of midline cranial base tumors

Ressecção endonasal endoscópica de tumores da linha média da base do crânio

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ABSTRACT

Objective: The advent of the endoscope in transsphenoidal surgery has permitted to expand the indications of such approach also for the treatment of on tumors located in supra, para, retro and infrasellar regions, enabling the neurosurgeon to work under direct visual control in a minimally invasive way. Since 2004 we have started to use the extended endonasal transsphenoidal approach for a variety of lesions involving the midline skull base and, in particular, the suprasellar area, the cavernous sinus and the retroclival prepontine region.

Methods: Over a 36-month period, sixty-four procedures have been performed. The series consisted of 29 males and 35 females, aged from 24 to 80 years (median 49.8 years). The mean follow-up was of 18 months (ranging from 3 to 36 months). Among the patients with midline lesions, who were 90.6% of the total, seven patients had a pituitary adenoma, sixteen patients were affected by a craniopharyngioma, six patients had a suprasellar Rathke's cleft cyst, seven subjects had a tuberculum sellae meningioma, four had an olfactory groove meningioma, and six a clival tumor. Other lesions of the midline skull base were, 1 chiasmatic astrocytoma, 1 neuroendocrine tumor, 4 post-traumatic cerebro-spinal fluid rhinorrhea, and one optic nerve glioma. Three other patients had anterior cranial base meningoencephaloceles.

Results: Overall, gross total removal of the lesion was achieved in 30/49 tumoral lesions (61.2%); subtotal removal was achieved in 12/49 cases (24.5%). The three cases of meningoencephaloceles were all successfully treated. Among the patients with preoperative visual deficits, most of them fully recovered or improved and only two worsened in one eye.

Major complications consisted in 2 deaths (one not directly related with the surgical procedure), 6 postoperative CSF leak (one complicated with bacterial meningitis), one ICA injury, and 6 cases of permanent diabetes insipidus.

Conclusion: The extended transsphenoidal approach to the supra and parasellar lesions seems Endoscopy; Transsphenoidal surgery; Extended approach; Parasellar; Tumors; Anterior skull base. A promising minimally invasive technique for the removal of lesions affecting these areas, once thought to be suitable only of the transcranial routes.

Concerning the lesion removal and the recurrence rate compared with the transcranial routes, it is too early to pose a definitive word, since the follow-up is still too short.

Key-words: Endoscopy; Transsphenoidal surgery; Extended approach; Parasellar; Tumors; Anterior skull base.

SUMÁRIO

Objetivos: O advento do endoscópio na cirurgia trans-esfenoidal permitiu a expansão das indicações deste procedimento também para o tratamento de tumores localizados na região supra-, para-, retro- e infrasellar, e permitindo ao neurocirurgião trabalhar sob controle visual direto em uma forma minimamente invasiva. Desde 2004, iniciamos o uso da abordagem trans-esfenoidal extendida para uma variedade de lesões envolvendo a linha média da base do crânio e, em particular, a região supra-sellar, o seio cavernoso e a região pré-pontina retroclival.

Métodos: Em um período de 36 meses, 64 procedimentos foram realizados. A série compreendeu 29 pacientes do sexo masculino e 35 do sexo feminino, com idade entre 24 e 80 anos, com média de 49,8 anos. O seguimento médio foi de 18
meses, variando entre 3 e 36 meses. Dentre os apêndices com lesão da linha média, que consistiam em 90,6% da amostra, 7 eram portadores de tumores de hipofisite, 16 portadores de craniofaringiomas, 6 eram portadores de cistos supraselares da bolsa de Rathke, 7 com meningiomas do tubérculo da sela, 4 com meningiomas da fita olfativa e 6 com tumor clival. Outras lesões da linha média encontradas foram: um astrocitoma do quiasma óptico, um tumor neuro-endócrino, 4 fístulas liquóricas pós-traumáticas e um glioma do nervo óptico. Três outros pacientes eram portadores de meningoencefalocéle frontais.

Resultados: Remoção total das lesões tumorais foi obtida em 30/49 dos casos (61,2%); remoção subtotal em 12/49 dos casos (24,5%). Os três casos de meningoencefalocéle foram tratados com sucesso. Entre os pacientes com déficit visual pré-operatório, a maioria teve recuperação completa ou melhorada e apenas dois apresentaram piora visual. Complicações maiores consistiram em morte em dois casos, um deles não diretamente relacionado com o procedimento cirúrgico. Seis casos de fístula liquórica, um deles complicado por meningite, um caso de lesão da carótida interna e seis casos de diabetes insípido permanente.

Conclusão: A abordagem transesfenoidal extendida para lesões supra- e paraselares se constitui em promissora técnica minimamente invasiva para a remoção de tais lesões, inicialmente consideradas somente tratáveis por acessos trans-cranianos. É ainda preciso estabelecer de forma definitiva o grau de remoção completa e o índice de recorrências nestas lesões, dado o tempo de seguimento ser ainda de curta duração.

Palavras-chave: Endoscopia; Cirurgia trans-esfenoidal, Acesso extendido, tumours para-selares, base do crânio anterior.

**INTRODUCTION**

The extended transsphenoidal route, being a quite versatile approach, offers the possibility to expose the entire ventral midline skull base from below. In contrast to transcra-}

Overall, gross total removal of the lesion was achieved in 34/64 tumoral lesions (53.1%); subtotal removal was achieved in 21/64 cases (32.9%). The three cases of meningoencephaloceles were all successfully treated. Among the patients with preoperative visual deficits, most of them fully recovered or improved and only two worsened in one eye. Surgical mortality occurred in 2 patients, one with suprasellar intraventricular craniopharyngioma and the other with a tuberculum sellae meningioma. In all patients the presenting symptoms, pre and post-operative endocrine function, and ophthalmologic evaluation were recorded. Preoperative radiological investigations included Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) of nasal, sphenoidal and ethmoidal structures, in order to preoperatively know the peculiar anatomical conditions concerning the tumor itself and the bone involved in the approach.

On post-operative day #4, all patients underwent an endosco-
pic exploration of the nasal cavities under local anesthesia with the aim to check the effectiveness and the correct positioning of the reconstruction materials and to remove eventual blood clots from the choanae. All the patients had a 3-month postoperative 1.5 Tesla MRI.

A written informed consent was obtained from all patients that were informed that transcranial route would be carried out if difficulties were encountered. None of such patients were converted to transcranial technique.

ENDOSCOPIC EQUIPMENT AND INSTRUMENTS

A 0-degree straight endoscope, 4-mm (or 2.7-mm in narrow nostrils) in diameter and 18-cm in length (Karl Storz Endoscopy, Tuttingen, Germany) is used during the entire procedure. Angled endoscopes (30°, 45°) are employed sometimes during, but always at the end of the procedure, to look around the corner in order to control the proper removal of the lesion. In contrast with the microscopic technique where the surgical instruments are bayonet shaped, in the endoscopic approaches the instruments are straight, so that they can be inserted alongside the endoscope because of the lack of the working channel in the shaft.

A digital endoscopic HD video camera provides clear endoscopic images. For the image and video documentation, a DVD-based recording HD system (AIDA – Karl Storz Endoscopy, Tuttingen, Germany) integrated in an informatized operative room (OR1, Karl Storz Endoscopy, Tuttingen, Germany) has been employed. A full High Definition (HD) 16:9 flat monitor (1080p60) and a 300W Xenon light source complete the endoscopic set used during the procedures.

The use of image-guided systems is required for the extended approach. It provides information for midline and trajectory, and offers more precision in defining the boundaries of the area involved in the procedure. The neuronavigator (VectorVision² Compact; BrainLab, Kirchheim-Heimstetten, Germany) is put behind the head of the patient, with the screen close to that of the endoscopic cart, providing the surgeon with a simultaneous view of both the screens.

We used an intraoperative microDoppler ultrasonography system (Mizuho America, Beverly, MA, USA) is a useful tool to insonate the major vascular structures and also a high-speed electric microdrill (Anschach, Palm Beach Gardens, Florida, USA) with an extra long and low-profile handpiece, with diamond burr of small diameter (2-4mm).

Other instruments have been specifically designed for the extended approach (Karl Storz Endoscopy, Tuttingen, Germany). They have longer and differently-shaped tips for the removal of the lesion.

SURGICAL PROCEDURE

The patient, under general anesthesia with oro-tracheal intubation, is placed supine or in slight Trendelenburg’s position. To allow the use of the neuronavigation systems the head of the patient is put in the three-point Mayfield-Kees skeletal fixation headrest and turned 10°-15° on the horizontal plane, towards the surgeon, who usually is on the patient’s right side, in front of him. On the sagittal plane, accordingly with the type of approach, the head is extended or flexed for about 10-15 degrees: it is more extended in case of anterior cranial base approach, which requires a more anterior trajectory, to avoid that either the endoscope and the surgical instruments hit on the thorax of the patient; in case of transclival approach, since the trajectory of the route is inferior and directed downward, the head is more flexed.

BASIC MODULE

Differently from the standard endoscopic endonasal transsphenoidal approach to the sellar lesion, the surgical corridor for the extended approaches requires some modifications aimed to increase the working space and the manoeuvrability of the instruments: i) middle turbinectomy on one nostril; ii) lateralization of the middle turbinate in the other one; and iii) removal of the posterior portion of the nasal septum. These variations allow the use of both nostrils, with two or three instruments inserted plus the endoscope, which is used hand-free by one of the two surgeons (“three-four-hand” technique), since it needs to be guided to maintain anatomical orientation and optimal visualization of the lesion. 3D appreciation of the structures and to overcome the lack of the sense of deepness.

Then, the anterior sphenoidotomy is started by using a microdrill with a 4 mm-diamond burr and the nasal septum is elevated from the sphenoid rostrum.

Once exposed the sphenoid cavity, depending upon its degree of pneumatization, a series of bony protuberances and depressions are visible on its posterior wall. The sellar floor is at the center, surrounded by the tuberculum sellae and the sphenoid planum above it and the clival indentation below; laterally, the bony prominences of the intracavernous carotid arteries (ICAs) and the optic nerve can be seen and, between them, the opto-carotid recess, moulded by the pneumatization of the optic strut of the anterior clinoid process. A precise knowledge of location and relationships of these landmarks is of utmost importance for the correct orientation during the bony resection required for the approach.
SPECIFIC MODULES

TRANSTUBERCULUM/TRANSPLANUM APPROACH

The bone removal starts with the thinning of the tuberculum sellae, using a microdrill with a 2-mm diamond burr. The upper half of the sella is removed, to expose the superior intercarotid sinus (or anterior sinus); disruption of this sinus during such maneuvers results in a venous bleeding and is usually controllable with haemostatic agents and gentle pressure with cottonoids. Two horizontal dural incisions are made just few millimeters above and below the sinus that is then coagulated by a bipolar forceps and cut with microscissors.

The tuberculum sellae is freed from the two medial opto-carotid recesses and from theplanum sphenoidale, and is gently dissected from the dura and removed. A 2-mm Kerrison’s rongeur is used to complete the removal of the bone up to the falciform ligament and posterior ethmoidal arteries, which are a useful landmark and usually represent the anterior limit of the bony and dural opening; anyway, it can be passed over in case of more anteriorly extended lesions.

The boundaries of the approach are the following: anteriorly, the falciform ligament and the two posterior ethmoidal arteries; posteriorly, the upper half of the sella; laterally, the medial aspect of the opto-carotid recesses.

TRANScriBRIFORM APPROACH

This approach extends more rostrally the previous approach, from the anterior part of the planum until the posterior wall of the frontal sinuses. In such a way, passing through the anterior and posterior ethmoid is mandatory. The bulla ethmoidalis and the ethmoid cells are open to expose the lamina papiracea laterally, the floor of the anterior cranial base superiorly, and the superior half of the posterior nasal septum on the midline. This latter is removed to allow a wide exposure of the contralateral skull base. Finally, the superior portion of the lamina papiracea is removed and both the medial aspects of the orbits, the anterior and posterior ethmoidal arteries are exposed. The boundaries of this approach are: anteriorly, the back wall of the frontal sinuses, laterally, the two orbits, and posteriorly, the anterior part of the planum sphenoidale at the level of the posterior ethmoidal arteries.

TRANSCLIVAL APPROACH

Access to the clivus requires a lower trajectory with respect to that necessary for the sellar region. The nasal mucosa is bilaterally elevated from the vomer, along the inferior wall of the sphenoid sinus, up to identify the Vidian nerves, which represent the lateral limits of the surgical corridor. The vomer and the inferior wall of the sphenoid sinus are completely removed permitting in this way the union of the sphenoidal and rhinopharyngeal part of the clivus. At this point, the clivus is exposed from the level of the pituitary gland up to the level of the Eustachian tubes. According to the extension of the lesion, the bone of the clivus is more or less extensively removed with a microdrill. The limits of the clival fenestration are represented by the sella superiorly, by the paracervical segments of the intracavernous carotid artery laterally and the inferior limit depends on the extension of the lesion. In case of intradural lesions, before the dural opening, venous bleeding from the basilar plexus must be controlled with haemostatic agent, paying attention to preserve the abducent nerve, which passes though such plexus before entering the cavernous sinus

CLOSURE

A relatively extensive osteodural defect has to be reconstructed at the end of the lesion removal, whatever the approach performed, because a watertight reconstruction is of utmost importance in preventing the complications related to a postoperative CSF leakage. After the removal of the lesion, fibrin glue is injected inside the residual cavity to protect the neurovascular structures. No collagen sponge and/or other materials are put inside, in order to avoid the risk of an overpacking and a misinterpretation of the postoperative image studies. One single large layer of dural substitute is positioned in the extradural space, covering the dural opening. A sized sheet of resorbable solid material (LactoSorb, Lorenz Surgical, Jacksonville, Florida, USA) is then overlapped to the layer of the dural substitute and positioned in the intradural space, having the borders of the dural substitute going inside the dural space and its borders remaining outside. In such a way a solid barrier between the intra and extradural compartments is created. The reconstruction is then reinforced by multiple layers of dural substitute and/or mucoperichondrium of the middle turbinate, which has been removed during the approach. Surgical glue (either Tisseel®, BioGlue® or Duraseal®) is used to fill the sphenoid cavity. In some cases a Foley catheter (12-14 French) is introduced within the sphenoid sinus and inflated to support the graft and left in place for 48-72 hours. The use of a vascularized mucosal nasal flap, based on the posterior septal artery, has been utilized in the most recent procedures.
ILLUSTRATIVE CASES

CASE #1: OLFACTORY GROOVE MENINGIOMA (FIGURES 1 & 2)

A 47-year-old female patient had been complaining mild to severe headache for about three months. A CT scan and a MRI revealed the presence of a spontaneously hyper-intense lesion, with strong contrast enhancement, arising from the olfactory groove, resembling a meningioma.

She underwent an uncomplicated endoscopic endonasal approach extended to the cribriform plate. Total lesion removal was achieved.

CASE #2: TUBERCULUM SELLAE MENINGIOMA (FIGURES 3 & 4)

A 50 year-old female complained of headache and progressive visual loss. Formal visual field examination revealed a bitemporal hemianopia. The sellar MRI showed the presence of a suprasellar lesion extended over the planum sphenoidale, suggestive of a tuberculum sellae meningioma. Endocrine testing were normal.

She underwent endonasal transsphenoidal approach extended to the tuberculum sellae and to the posterior portion of the planum sphenoidale, with a gross total removal of the lesion. The post-operative course was uneventful. One month post-op visual field examination revealed the improvement of the visual deficit. She did not have any endocrine dysfunction.
CASE #3: INTRA-SUPRASELLAR GIANT PITUITARY ADENOMA (FIGURES 5 & 6).

A 73-year-old male patient, already operated twice in another institution for the removal of an intra-suprasellar non-functioning pituitary adenoma by means of a microsurgical transsphenoidal approach. Four months after the second procedure he started complaining a progressive bitemporal hemianopia and blurred vision in the left eye.

A formal visual field examination confirmed the presence of a bitemporal hemianopia (OS>OD), while an MRI showed a slight hyperintense lesion in the suprasellar area with an homogeneous contrast enhancement, extending superiorly up to the chiasm and to the third ventricle infundibulum. He underwent an uncomplicated endoscopic endonasal approach extended to the tuberculum sellae. Lesion removal was gross total, as demonstrated by the three-month postoperative sellar MRI (Fig. 5 c,d).

CASE #4: RETROSELLAR-RETROCLIVAL-PREPONTINE MENINGIOMA (FIGURES 7 & 8).

A 34 years-old female presented with secondary amenorrhea for 8 years and, more recently, with a right sixth nerve palsy. A sellar MRI revealed a retrosellar, retroclival, prepontine mass, consistent with the diagnosis of meningioma. The hormonal testing revealed a mild hyperprolactinemia. The tumor was removed through an endoscopic endonasal transsphenoidal approach extended to the upper two thirds of the clivus. Postoperative MRI showed a subtotal removal of the lesion, with the persistence of a remnant of the lesion behind the dorsum sellae. Few weeks after the discharge the patients returned to our attention with a CSF leak, which was successful treated with reoperation for CSF repair.
RESULTS

Total removal is defined by neuroradiological evidence of residual tumor according with the postoperative imaging.

The three-month postoperative 1.5 Tesla MRI revealed complete removal of the lesion in 4/7 pituitary adenomas, 10/16 craniopharyngiomas, 6/6 Rathke’s cleft cyst, 6/7 tuberculum sellae meningiomas and 4/4 olfactory groove meningiomas. Subtotal removal (> 80%) was obtained in one case of tuberculum sellae meningioma, in three giant pituitary adenomas with main suprasellar component (2 non-functioning and 1 PRL-secreting), in 5 craniopharyngiomas, in the case of chiasmatic pilocytic astrocytoma, for the neuroendocrine tumor. For one of the suprasellar craniopharyngiomas only a partial removal of the lesion was possible. Among the clival tumors, the meningioma and two of the chordomas were subtotally removed, while the other two chordoma cases and the fibro-osseous dysplasia had a partial debulking. The three subjects with anterior cranial base meningoencephalocele were all successfully treated with the removal of the sac and the sealing of the resulting dural defect.

Among the subjects with pre-operative visual field defects, all but two had either a complete recovery or improved; in 2 cases there was a worsening of the visual function. One of them was a patient with a giant non-functioning pituitary macroadenoma with preoperative severe bitemporal haemianopia; postoperatively, she presented with a further worsening of her vision in the left eye, with only persistence of the light perception. Concerning the surgical complications, 6 patients, two with a craniopharyngioma, one with a recurrent non-functioning pituitary adenoma involving the cavernous sinus, one with a tuberculum sellae meningioma, one with a giant olfactory groove meningioma and one with a retrollosellar retroclival meningioma presented with a postoperative CSF leak, which required a second operation for CSF leak repair. One of these patients had bacterial meningitis treated with intravenous antibiotic therapy. One patient with an intra-suprasellar non-functioning adenoma presented with a generalized epileptic seizure few hours after the surgical procedure, due to the intraoperative massive CSF loss and consequent presence of intracranial air.

Major complications consisted in 2 deaths: one patient with craniopharyngioma died 5 weeks after surgery due to a brainstem hemorrhage that induced hypothalamic dysfunction and fluid and electrolyte disturbance; the other patient had a tuberculum sellae meningioma and the postoperative course was complicated by CSF leak that required two reoperations for CSF leak repair. Few hours after the last operation an intraventricular hemorrhage occurred definitely resulting in death.
Six patients had postoperative CSF leak (one complicated with bacterial meningitis), one ICA injury, and 5 cases of permanent diabetes insipidus.

Postoperatively six patients suffered of de novo diabetes insipidus, 5 of those operated on for craniopharyngioma.

The mean post-op stay of the patient series was of 5.9 days.

**DISCUSSION**

The microscopic transsphenoidal route, initially limited to the removal of infradiaphragmatic lesions, more recently has been successfully used by some authors\(^9,20,21,41\) for removal of suprasellar and supradiaphragmatic lesions, associated with an enlarged sella (trans-sellar transdiaphragmatic approach). Other authors have adopted a modified trans-sphenoidal microsurgical approach, the so-called extended approach, which requires additional bone removal of the cranial base\(^1,15,35,48\) providing direct access to the supradiaphragmatic space allowing sufficient exposure for the removal of the suprasellar tumors, with preservation of normal pituitary gland. Recently, this approach has been helped by important diagnostic and technical contributions, such as frameless neuronavigation, Doppler ultrasonography, intraoperative magnetic resonance and the endoscope.

The use of this visualizing tool provides an unobstructive varied angled view with a better identification of many surgical landmarks, either in the sphenoid sinus or intradurally. The close-up vision provided by the endoscope permits a clear intradural cut dissection of the tumor from the surrounding structures.

Significant controversies remain as to the indications for the approach to the cranial base tumors using this extended approach from below. Since craniotomy is the dominant approach with good results in terms of radicality of tumor resection, with good outcome and low complications rates\(^18,21,42,43\), transnasal technique is requested to provide at least equivalent results. To achieve this goal, is vital a collaborative surgery among surgeons experienced in the use of the endoscope and consistent previous experience in standard pituitary surgery; besides, better instrumentation, dedicated and ad hoc designed and manufactured equipment to render more comfortable and capable the surgical team, are needed. A carefully examination of the patient to define the appropriate indications for a transnasal route is mandatory.

As a matter of fact, only properly selected cases can be effectively approached by transnasal technique because of several limitations concerning surgical pathway, type, size and shape of the tumor, its location and relationships with the surrounding neurovascular structures.

The grade of pneumatization of the sphenoid sinus can influence the approach. A pre-sellar or conchal-type sphenoid sinus, where the bony landmarks are not well recognizable, represent a major obstacle, while a well pneumatized sphenoid sinus renders easier the surgeon’s orientation\(^11,13\). In case of a small or normal sella, usually the rule, special attention must be taken in the dural opening, since the two intracavernous carotid arteries are closer, causing a narrower approach between the two medial opto-carotid recesses\(^16\).

A high dorsum sellae and/or hypertrophic posterior clinoids can make the access to the retrosellar area more difficult, particularly in case of a craniopharyngioma with retrosellar extension.

Tumor size and extension, its relationships with the surrounding structures, pose a separate set of challenges and concerns. The direction of the longer axis of the tumor, especially for masses in the suprasellar area, is important. When the axis of the tumor is oblique to the third ventricle, low-route approach provides an excellent trajectory for the resection of these lesions, while, in case of vertical main axis, the tumor dissection and its removal are more difficult\(^30,33,35\), since a more extensive bone removal is required. The bone resection and the dural opening, in case of a pre-fixed or anteriorly displaced chiasm, should be carefully performed because the chiasm, just positioned behind the tuberculum, can be injured\(^45,46\).

Encasement of the main vascular structures renders the operation more challenging, but it is not an absolute contraindication. Sometimes, such structures are displaced but not truly encased by the mass, and the tumor removal is possible with cautious dissection.

When lateral extension of the tumor pass beyond the limits of the potential exposure even angled endoscopes and related instruments are not able to provide visualization and management of the lesion.

A peritumoral brain edema corresponding to a potential breach of the pial arachnoidal plane renders challenging the extraarachnoidal dissection of the lesion, with high risk of penetration of the brain.

In such a way, the complexity of the decision-making process, the resectability of some types of tumors located in certain anatomic areas remains an open question. The neurosurgeon should apply this concept on an individual basis for each individual patient\(^49,52\). Concerning outcome and complications, related to this novel technique, is difficult at the present gather reliable informations.

Concerning technical nuances related to the different surgical
techniques, some points can be highlighted. Suprasellar approach either transcricribriform or transtubercular provides an adequate approach and exposure of the suprasellar neurovascular structures; an arachnoidal plane separates these structures from the dome of the tumor, thus avoiding their surgical manipulation, without any brain retraction. In case of meningiomas located in this area, the early coagulation of the dural attachment allows to perform an almost bloodless debulking.

The clear and panoramic view afforded by the endoscope allows an extraarachnoidal tumor dissection, a prompt chiasm decompression and a good preservation of the optic pathways with a frequent improvement of the visual function, a rare visual worsening and high rate of total resection, as confirmed by other authors that employ microscopic transnasal techniques.

In case of craniopharyngiomas, the side of origin, path of growth, location of the tumor and the side of invasion of the third ventricle play an important role in the choice of the proper intradural route.

In contrast with the transcranial route, where several approaches have been advocated and various intradural corridors are used to manage all of the different extension of the craniopharyngioma, transnasal route, using only one surgical corridor, permits the surgeon to work either below or above the chiasm or through both sides of the stalk to manage both the suprasellar prechiasmatic and the intraventricular cranioopharyngiomas. Pituitary macroadenomas with a significant suprasellar component and an anterior extension over the planum sphenoidale, are a potential indication for this technique. In case of fibrous adenomas or when the superior pole of an adenoma with a suprasellar component does not fall into the sella, despite classical maneuvers (Valsalva maneuver, air pumping) the transcribriform/transplanum route, allowing for a more anterior approach to the dome of the adenoma, makes possible the tumor capsule dissection from the optic apparatus and ACoA complex under direct endoscopic control.

Transnasal approach for lesions located in the anterior clival region presents some limits due to a limited lateral exposure. It is usually reserved for lesions confined to the sella and the superior two-thirds of the clivus. The most frequent extradural masses and, among them, clival chordomas, habitually present themselves less challenging than the intradural ones. Concerning intradural lesions, the procedure is much more challenging for different reasons: i) control of the bleeding arising from a very large venous network located on the anterior clival dura; ii) preservation of the sixth cranial nerve, which runs in the dura before entering in the cavernous sinus; iii) lesion management before facing the basilar artery and the brainstem; iii) repair of the osteodural defect more difficult; iiiii) limited lateral extension of the osteodural opening because of the presence of paraclival ICAs.

In the last decade tremendous efforts have been made to overcome the major problems that provoked criticisms to such technique: more effective bleeding control, better quality of endoscopic pictures and new surgical instruments render safer and more effective the procedure.

The use of the microDoppler probe before and during the surgical maneuvers may help in preventing the injury to the main vessels, whose bleeding is usually quite difficult to control. Low-profile bipolar forceps, specifically designed with a tips up to 0.3 mm are now available, making possible the bipolar coagulation of the arterial bleedings in a narrow space, while the availability of a vascular clips with the applicator, designed for endonasal use, are useful in case of main vessel injury.

The continuous improvements in endoscopic images quality offer tremendous visualization of the operative field, of the lesion and its relationships with the surrounding neurovascular structures. That is due to the advancements in the quality of the endoscope itself and also on the updates in endoscopic camera, monitors and recording systems that, with the high definition (HD) technology, offer endoscopic pictures with fine details and the sense of deepness, even though not yet comparable with that of the microscope.

The instruments need to be inserted along the same axis as the endoscope and need to be maintained in the same position with respect to the endoscope for their entire length. For such reason they need to be straight and not bayoneted. Recently miniaturized instruments have been designed in order to allow them to move easily and safely in the restricted spaces.

A further and real major problem that may limit the procedure is the high rate of postoperative CSF leak, as compared with the transcranial approaches. Considering the difficulty in suturing the dura through the nose, accurate reconstruction with a multilayer strategies is habitually performed in this kind of surgery. Despite many proposed tricks to lower such rate, no radical effective solutions have been found. The use of U-clips and balloon buttress, different reconstruction material either homologous or heterologous, and more recently the nasal septal vascularized flap, the reconstruction strategies not yet fit the purpose.
CONCLUSIONS

The extended transsphenoidal approach seems a promising technique for the removal of lesions affecting the areas beyond the sella, once thought to be suitable only for the transcranial routes. It offers an extracranial approach with minimally invasiveness, no brain retraction, minimal neurovascular manipulation and a quicker postoperative recovery.

Longer operative times, at least at the beginning of the learning curve, and higher post-op CSF leak rate and related complications (meningitis and tension pneumocephalus) are the reverse of the medal and demand careful management and awareness of this problem. Besides, such approach requires as a prerequisite an adequate endoscopic equipment, neuronavigation systems, microDoppler guidance, low-profile surgical tools and coagulation forceps and an increased experience and confidence with the endoscope in the transsphenoidal technique.

Concerning the lesion removal and the recurrence rate compared with the transcranial routes, it is too early to pose a definitive word, since the follow-up is still too short.

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