Endoscopic Endonasal Approach to Pituitary Adenomas

Abordagem endonasal endoscópica em adenomas de hipófise

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Received in February of 2008. Accepted in March of 2008.

ABSTRACT

Microscopic transsphenoidal surgery is beyond any doubt a widely accepted and highly effective therapy for pituitary adenomas. Currently several centers have converted to an endoscopic transsphenoidal approach; suggesting that this technique provides more complete tumor resection, better visualization and reduce complications. However, there have been few series to document the results of this procedure. This report presents the technical details and compares it to the results of the microscopic method based on the experience of the group and a literature review. The endoscopic transnasal/transsphenoidal technique is a safe and effective method for removal of pituitary adenomas. The results found in the literature suggest that the endoscope provides more complete tumor removal, and reduces complications. We believe that the advantages of the endoscopic technique will allow this procedure to become the future gold standard surgical therapy for pituitary adenomas.

Key-words: Pituitary Surgery, Endoscopic, Microsurgery, Transsphenoidal.

SUMÁRIO

A cirurgia trans-esfenoidal por meio de microscópio é sem dúvida um procedimento amplamente aceito e altamente efetivo no tratamento cirúrgico dos adenomas pituitários. Hoje em dia muitos centros tem modificado a via trans-esfenoidal endo-nasal, utilizando-se do endoscópio. Esta técnica tem demonstrado um maior índice de ressecção tumoral, uma visão melhor do leito cirúrgico, principalmente nos cantos e na margem junto ao seio cavernoso, e traz um menor índice de complicações. Os resultados da literatura têm demonstrado ser um procedimento seguro, e acreditamos que, devido às suas vantagens, se tornará uma conduta cirúrgica padrão ouro para os adenomas pituitários.

Palavras-chave: Cirurgia pituitária, endoscopia, microcirurgia, acesso transesfenoidal.

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Received in February of 2008. Accepted in March of 2008.
INTRODUCTION

The evolution of transphenoidal approaches has culminated in the endoscopic endonasal minimally invasive approach. The transseptal-transsphenoidal approach came to be the procedure of choice for the surgical management of most pituitary lesions. Transcranial techniques were reserved for use in the resection of large tumors with extensive parasellar and suprasellar invasion.

Significant advances in the recognition and management of pituitary adenomas have occurred over the last decade. Highly sensitive hormonal assays and magnetic resonance imaging with gadolinium enhancement have led to earlier and more frequent diagnosis of pituitary adenomas.

The microscopic transsphenoidal approach for pituitary tumors has demonstrated excellent results with minimal morbidity and almost no mortality; and has become the therapy of choice for the majority of pituitary adenomas. Continued attempts to improve surgical outcomes, reduce the incidence of complications, and hasten the patient’s post-operative recovery have led to the development of a minimally invasive endoscopic transsphenoidal approach to remove pituitary adenomas.

The modification of Hirsch’s original endonasal rhinoseptal route was first proposed by Griffith and Veerapen in 1987. It avoids an anterior nasal or sublabial incision, anterior dissection of the nasal or sublabial areas, anterior dissection of the nasal septum, and it requires only minimal dissection of the posterior nasal mucosa. This approach is better tolerated, with less postoperative pain, than the more traditional sublabial or rhinoseptal routes.

Recently, however, discussions regarding the most effective and least invasive way to perform pituitary surgery have been renewed. Attempts to improve surgical outcomes, reduce the incidence of complications, and hasten the patient’s post-operative recovery have led to the development of a minimally invasive endoscopic transsphenoidal approach to remove pituitary adenomas.

The instrumentation used in the endoscopic technique includes a cold light source, an endoscopic video camera and video and a digital CD recorder. The endoscopes are 0°, 30° and 45°, 4mm in diameter and 18 cm long. A cleaning system with pedal control is used in order to reduce the necessity of extracting the telescope from the nose every time the vision becomes unclear. A mechanical holder for endoscope may be convenient to make easier the work of the neurosurgeon using both hands, however, lately we have preferred to give the endoscope to assistant in surgery and work with both hands. The camera zoom permits better definition of anatomical features and the positioning of the endoscope further away from the surgical field reduces the possibility of contamination of the tip of telescope by blood.

The surgeon should have endoscopes of varying diameters and length available, and must improvise intra-operatively depending upon the intranasal and skull base anatomy of the patient.

TECHNIQUE OF STANDARD ENDOSCOPIC TRANSSPHENOIDAL APPROACH

Surgery is carried out under general anesthesia using orotracheal intubation. The patient is placed in a supine position with a gentle reverse Trendelenburg with his head turned towards the surgeon who is in on the right side of the patient. The head may be resting freely in a horseshoe head holder, or fixed in a three pin holder (Mayfield), if we use a neuronavigation as a technical adjunct. In our Department we use the neuronavigation from Meditronic (Stealth TR).

After general anesthetic is administered, we proceed under endoscopic guidance to inject the nasal mucosa of the septum and middle turbinates with a...
1:200,000 epinephrine solution to induce vasoconstriction, or use topical local anesthesia with epinephrine, which may avoid bleeding of mucosa observed after injections. The bony structures of the nose are easily understandable, and facilitates the administration of local anesthetic (figure 1).

The endoscope is advanced to the antero inferior border of the middle turbinate. An elevator as dissecting instrument is used to displace the middle turbinate laterally (figure 2). A long straight suction device may also be introduced to clear the nostril of any blood or mucoid secretions. As the nasal passage is widened, the endoscope is advanced farther posteriorly. The lateral dislocation of the middle and upper turbinate allows the localization of the spheno-ethmoidal recess and natural ostium of the sphenoid sinus... Ultimately, the sphenoid ostia and the anterior wall of the sphenoid sinus are exposed, marking the extent of the intranasal dissection (figure 2). The opening of the sphenoid sinus starts with enlargement of the natural ostium, with a Kerrison or a Stammberger punch. The mucosal lining of the anterior wall of the sphenoid sinus and posterior septum is dissected away from the bone. Resection of the anterior wall of the sphenoid, the mucosal lining of the sinus, and the floor of the sella (back wall of the sinus) proceeds under endoscopic visualization (figure 3). In cases of difficult exposure of the sphenoid ostium, the entry point to the sphenoid sinus may be obtained through a direct perforation of anterior wall at junction of the keel of the sphenoid bone and the posterior nasal septum approximately 1.5 cm above the rim of choana and close to the septum. The preferred method is to proceed with the identification of both sphenoidal ostia. Then, we enlarge the ostia with Kerrison rongeurs and remove the sphenoid rostrum and posterior vomer to open the whole anterior wall of the sphenoid sinus. The surgical instruments are passed through the nostril, below the shaft of the endoscope, and into the surgical field to gain access to the sphenoid sinus and sella turcica. The same principles of awareness of the limits of dissection apply. Injuries to the cavernous sinuses, carotid arteries, optic nerves and chiasm are still possible if caution is not exercised while working within the sinus or sella (figure 3).
After dural opening the pituitary adenoma is removed with combined use of curettes and aspiration (figure 4, figure 5, figure 6, figure 7). Subsequently either the opening of the medial wall created by the tumor is used to enter the medial compartment of the cavernous sinus or an incision of the medial wall is performed in a safe area20.

**Figure 4** - In many cases the exposure of the whole surface of the sella floor may be achieved.

**Figure 5** - After the opening of the sella floor we enlarge the lateral anterior superior limits with small Kerrison rongeur. The sella dura can be widely exposed.

After the removal of tumor hemostasis is obtained using Gelfoam packing; free hand exploration into the surgical field with angled 30° and 45° optic scopes is recommended to localize and remove any residual tumor. The surgical cavity is packed with Gelfoam. The sphenoid sinus may also be packed with fat, Gelfoam, and fibrin or thrombin glue, and the floor of sella is closed using a graft similar such as, polytetrafluoroethylene or bone. If a CSF leak is detected or suspected autologous fat is applied in the sellar cavity and the dura may also be closed with a turbinated-derived mucoperiosteal graft. Lumbar external drainage may be useful in the cases with suspect of CSF leak.

**Figure 6** - After dural opening the tumor is removed in piecemeal fashion with a pituitary curette and with a 90° dissector the spaces between the dura and the gland and between the tumor and gland are also developed.

**Figure 7** - After radical removal of tumor, the diaphragm can become visible, and care is taken to avoid opening it.

Computer assisted navigation and a microdoppler may be used when removing tumors from the cavernous sinus20.

Summarizing the technique, Frank and Pasquini, 200620 divided the functional endoscopic pituitary procedure into 3 stages (Frank): stage I – Localization of sellar wall, stage II – adenectomy and stage III – Final exploration and closure of surgical field.
HISTORICAL RECORDS

In 1889 Horsley, using a transcranial approach is credited with performing the first operation for a pituitary tumor. In 1906 Schloffer reported the first removal of a pituitary tumor through an extracranial transsphenoidal approach. Hirsch later modified this approach in 1909. In 1912, Cushing described the transsphenoidal approach to the sella turcica. Guiot and Hardy refined the technique and added intraoperative fluoroscopic guidance and the use of the surgical microscope. It wasn’t until the late 1950’s when Guiot, who learned Cushing’s transseptal-transsphenoidal method from Dott, reintroduced this approach. Guiot improved the transsphenoidal approach with the addition of intraoperative fluoroscopy to guide the insertion of instruments into the sella, allowing for safer and more complete tumor removal. Since then, this approach has become the standard for lesions of the sella and those extending to the midline in a suprasellar direction. The complications of the approach are well described and include septal perforation, septal deviation, tearing of the nares, persistent nasal discharge, recurrent nosebleeds, tooth anesthesia, asymmetry of mucosal contour, devitalization of pulp of the anterior teeth, sinusitis, and mucocele, among others.

It was Hardy, however, who deserves much of credit for re-establishing the validity of the transsphenoidal approach, when in the 1960’s he combined fluoroscopy and microsurgical techniques to further augment transsphenoidal pituitary tumor resection. These new technologies provided the transsphenoidal approach with significant advantages over the transcranial procedure. The improved visualization allowed for more complete tumor removal, and reduced the incidence of complications. In the ensuing 40 years several large series have established the transsphenoidal approach as the procedure of choice for all but the most massive pituitary adenomas, demonstrating outcomes equivalent to or better than those reported for the transcranial procedure, with fewer complications.

The use of rigid endoscopes for sinus surgery provided the inspiration for their application to pituitary surgery. Isolated reports of the use of endoscopes to remove pituitary tumors appeared in the literature as early as the 1970’s. However, it wasn’t in the early 1990’s that technologic advances in optics, digital cameras, light sources, holding arms, and monitors have allowed endoscopes less than 5 mm to provide high-quality panoramic exposure that surpasses the visualization provided by operating microscopes. Spencer compared and quantified the exposure provided by the 0° endoscope vs. the operating microscope.

In 1992 Jankowski provided the first description of fully endoscopic transnasal-transsphenoidal technique. Since then experience with this approach has for the most part been limited to a few subspecialty centers, while outcomes data for patients undergoing this procedure are just beginning to be reported.

Jho and Carrau, in 1997, published a series of 44 treated pituititary adenomas along with a review of several other small series and suggested that in addition to providing more complete tumor removal, the endoscopic technique may also result in a lower incidence of complications related to blind dissection.

Currently endoscopic surgery is a safe and accepted method of sinus surgery. Stankiewicz had described an endoscopic approach to the sphenoid sinus, and Gilain, et al. described the results of endoscopic surgery for inflammatory, infectious, and polypoid conditions of the sphenoid sinus. Building on this experience, otolaryngologists have reported pituitary tumor resection aided by endoscopic techniques, even in children harboring skull base tumors.

Catapano et al. through an anatomical study in 5 formalin fixed, silicone-injected adult cadaveric heads believed that an adequate exposure of the sellar, suprasellar, and infrasellar/upper clival regions could be achieved via a simple, direct endonasal approach. From a direct endonasal route, there is a preferential visualization of the structures contralateral to the approach. The endoscope affords a more panoramic view that extends the area covered by the operating microscope.

Kassam et al. in 2007 demonstrated that it is quite possible and safe to perform a fully endoscopic expanded endonasal approach to treat skull base lesions in pediatric patients.

ENDOSCOPIC TECHNIQUE

The safety of the approach described requires that the surgeon identify the posterior middle turbinate and the ostium of the sphenoidal sinus located in the sphenoid recess between the septum and the superior turbinate. Care must be taken to identify normal intrasphenoidal anatomical landmarks and to be cognizant of the positions of the optic nerves and carotid arteries at all times. Angled endoscopes allow the surgeon added panoramic visualization. Entry to the sphenoid sinus can also be accomplished directly through the anterior wall of the sphenoid or via the ethmoidal bulla and sinus if the anatomy of the nasal cavity, previous nasal surgery, or other limitations...
hinder access to the sphenoidal ostium. The technique can be also be performed transeptally, analogous to the microscopic approach.

Endonasal endoscopic surgery may be performed through a single nostril, which acts as a portal for the endoscope and the surgical instruments, however, the dual-portal technique allows superior maneuverability, flexibility, and efficiency over a single portal approach. The endoscopic approach should be individualized to the patient and assessed preoperatively by inspection of computerized tomography and magnetic resonance imaging studies and ultimately by endoscopic assessment at the time of operation. The endoscopic approach can also be used as an adjunct to the microscopic approach in inspecting the operative site for residual disease. Using the endoscope in this way can be particularly helpful in advancing surgeons along the learning curve in endoscopy.

TUMOR REMISSION

Evaluation of microscopic results for functioning adenomas revealed early remission in the majority of the cases of prolactin secreting adenomas, and in also growth hormone secreting adenomas. There are few published reports documenting early post-operative tumor remission rates for non-functioning adenomas, as only recently have physicians begun to perform early post-operative MRI studies to ascertain residual disease and look for tumor recurrence. With a mean follow-up of only 11.4 months, post-operative MRI imaging for an endoscopic series revealed the remission rate for non-functioning adenomas to be 95% (18/19 cases). Two long-term reports documenting outcomes for non-functioning adenomas with an average of 72 months follow-up noted an 82% remission rate (based on tumor recurrence).

TECHNIQUE OF SELLAR CLOSURE IN THE ENDOSCOPIC ENDONASAL APPROACH

The role of reconstruction of the sella turcica after transsphenoidal surgery is a matter of some debate. In the reconstructive matrix, the role of reconstructing the sellar dura has also been discussed. Many techniques for reconstruction have been attempted. As suggested by Hardy in his classic description, most neurosurgeons have used muscle, fat, or fascia lata to reconstruct the sella, with a piece of nasal bone or nasal cartilage to support these grafts. We have used fat graft (figure 8). Also the floor of sella may be closed using expanded polytetrafluoroethylene dural substitute which provides a safe and effective adjunctive method for reconstruction of the sellar dura. The surgical cavity may be packed with Gelfoam if there is no CSF leak. The sphenoid sinus may also be packed with fat, Gelfoam, and fibrin or thrombin glue. The floor of sella is closed using a graft such as polytetrafluoroethylene plate or bone.

Figure 8 - Surgical view after insertion of the fat graft, filling the sellar cavity.

MAIN COMPLICATIONS OF THE TRANSPHENOIDAL APPROACH WITH THE MICROSCOPE

Complications in transsphenoidal pituitary surgery are typically related to blind dissection, inability to distinguish normal gland from tumor, injury to the optic tracts and chiasm, or aggressive tumor dissection near the lateral and posterior aspects of the sella turcica. Improved visualization allows the surgeon to identify and avoid injury to the normal pituitary gland, carotid prominences, hypothalamus, and optic chiasm. Recognizing these structures during pituitary tumor removal is critical to avoid catastrophic complications, which have been reported in several microscopic series.

MAIN COMPLICATIONS OF THE ENDOSCOPIC ENDONASAL APPROACH

Complications associated with endoscopic surgery for paranasal sinus disease may give clues as to some of the complications.
that might be encountered using this procedure for tumors of the sella turcica.

Although Stammberger\textsuperscript{76} reported no serious complications in more than 2000 patients undergoing functional endoscopic surgery, Wigand and co workers\textsuperscript{85,86} reported CSF leaks in 2\% of 1000 patients. Stankiewicz\textsuperscript{77,78} reported an incidence of 3.9\% of serious complications in 180 patients undergoing endoscopic procedures for ethmoidal sinus disease: two with massive hemorrhage, one with a CSF leak, one with temporary blindness, and five with orbital hematomas that developed intraoperatively. Schaefer, et al.,\textsuperscript{69} reported that the most common complication following endoscopic sinus surgery for paranasal sinus disease was synchia between the middle turbinate and the lateral nasal wall in 6\% of patients. Delayed epistaxis is a complication characteristic of this approach for pituitary lesions.

**ADVANTAGES**

The main advantages of this approach include, no risk of air embolism, comfortable work position for the surgeon, spontaneous drainage of blood and irrigation fluids, favorable projection to dissect the suprasellar part of tumor, and the risks of the endoscope or of other instruments falling into the operating field due to their inclination inferiorly, as in the pure supine position, are minimized\textsuperscript{5,8}. Excellent lateral vision to the sides of the field is obtained.

Other advantages include the absence of a nasal speculum, reduction of the surgical trauma, lack of sublabial or septal dissection, providing quick, minimally invasive, and easy access to the sphenoid, better visualization of the structures of the sella turcica, and with angled endoscopes better visual operative control of supra-and parasellar areas. Easy and widened maneuverability of the surgeon’s view allows better access to various paranasal sinus regions, more radical removal of large lesions and better inspection of remote areas. Angled lenses allow the surgeon to see around corners, get closer to the pituitary gland and tumors, inserting the surgeon’s “eye” directly adjacent to the pathology allows an unobstructed view of the operative field. With the lessened mucosal dissection, mucociliary transport may be better preserved than the traditional approaches. Access to recurrences is easier and safer because of the previous sphenoidectomy and wider anatomical view\textsuperscript{47,48,49}. In addition to the benefits to patient and surgeon, from an educational perspective, the assistants, nursing staff, and students actually observe the same field as the surgeon, thus facilitating teaching and recording of events often there is a reduction of length and cost of hospital stay.

**DISADVANTAGES**

The main disadvantages are the inferior ability to magnify the area being viewed as well as the possibility of lenses being occluded by fogging or blood.

**NEW DEVELOPMENTS IN ENDONASAL ENDOSCOPIC SURGERY**

**NEURONAVIGATION**

Videofluoroscopy served the purpose of localization extremely well, for many decades, however, frameless stereotaxy with archived computed (CT) or magnetic resonance imaging (MRI) exploits the whole concept of neuronavigation to its fullest\textsuperscript{19}. Frameless stereotaxy allows precise planning of the approach with reference to lesion perimeters, anatomic landmarks such as the carotid arteries, and other potential operative hazards. Neuronavigation is particularly helpful in reoperative pituitary surgery where few anatomic landmarks remain. We believe that frameless stereotaxy adds greatly to surgeon comfort and confidence during the procedure. It is extremely important to emphasize that the surgeon using the technique must always remember that the information used is based on navigation points that are prerecorded and are only as accurate as the system allows in a perfectly set-up state. Minor movement in the pin holders can result in significant loss of accuracy\textsuperscript{79}.

**IMAGE – GUIDED PITUITARY TUMOR RESECTION**

In our opinion intraoperative MRI takes away the reliance on experience and should be a major advance in resection control. Surgery is performed with the patient lying directly on the table of MRI scanner\textsuperscript{79}. After the endoscopic transphenoidal or standard transphenoidal procedure, an intraoperative MRI is performed while the operative exposure and sterile field are both maintained so that if residual tumor is seen, further resection is undertaken.

**CONCLUSION**

It is a fact that the evolution of modern neurosurgical techniques follows a continuous trend toward less traumatic procedures. The fully endoscopic transnasal-transphenoidal procedure may result in improved rates of complete tumor removal and a reduced incidence of complications, when compared to the microscopic transphenoidal approach.
The early results of the endoscopic series reviewed in literature are quite encouraging. In our opinion the inherent advantages of endoscopic visualization, along with continued refinement of the endoscopic technique and instruments will allow this method to become the future gold standard surgical approach to pituitary adenomas.

**REFERENCES**


