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Endoscopic endonasal transsphenoidal surgery: procedure, endoscopic equipment and instrumentation

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Abstract *Introduction:* In the last 10 years the endoscopic endonasal transsphenoidal approach has been proposed as a minimally invasive procedure for the treatment of pathologies of the sellar region. This procedure introduces various advantages compared with the transsphenoidal microsurgical approach such as a wider vision of the surgical field, less traumatism of the nasal structures, greater facility in the treatment of possible recurrences, and reduced complications. Nevertheless, as for any new procedure, there is an initial learning curve that is somewhat steep, due to the necessity of acquiring the specific endoscopic skills. It is equally essential to be supplied with dedicated endoscopic equipment and appropriate surgical instrumentation, in order to optimize the different stages of the operation.
Discussion: Therefore, after our extensive experience with over 250 patients treated by means of the endoscopic endonasal transsphenoidal approach for pathologies of the sellar region, we describe herein the characteristics of the proper endoscopic instrumentation, as well as a set of surgical instruments intentionally conceived to respond to the specific characteristics of this new procedure.

Keywords Endoscopic transsphenoidal surgery · Pituitary surgery · Endoscopic instruments · Endoscopic equipment neurosurgery · Neuroendoscopy · Minimally invasive neurosurgery

Introduction

The continuous search for less and less invasive procedures and the technological progress in the development of endoscopic equipment, which is able to provide images more and more similar to microscopic ones, have rendered possible the conception of an endoscopic endonasal transsphenoidal approach for the treatment of the pathologies of the sellar region [2, 5, 7, 10, 11, 13, 16, 17, 19], and also for lesions that originate or extend into the regions around the sella [12, 14, 15, 18, 20]. Adopting this approach, the endoscope will be used during the entire procedure as the only visual instrument.

Since 1997, in our Institute over 250 patients have been treated using this technique and various advantages have been noticed compared with the microsurgical transsphenoidal approach. The endoscopic approach:

- Offers a wider and adjustable view of the surgical field
- Makes the procedure more acceptable to the patient, because of the reduced traumatism and the lack of the postoperative nasal packing
- Makes the treatment of recurrences easier [4], thanks to the identification of a greater number of anatomical landmarks
- Reduces the prevalence of complications [8]

The evolution of the procedure from the microsurgical to the endoscopic one requires a rather steep learning curve, to acquire both familiarity with the endoscopic vision of the different structures inside the nasal cavities

and the sphenoid sinus and the specific endoscopic handling skill. Moreover, it is important to emphasize that, for the peculiar characteristics of this type of surgery, the availability of appropriate endoscopic equipment and surgical instruments, specifically conceived for the purposes of the endoscopic endonasal transsphenoidal approach, will be absolutely necessary.

Therefore, on the basis of our experience in the course of the procedures that has led us to transfer from the microsurgical transsphenoidal trans-rhino-septal approach to the unilateral endoscopic endonasal transsphenoidal one, we have been able to evaluate which seems to be the best endoscopic equipment and the proper instruments for carrying out this approach.

Material and methods

We have considered the different stages that have lead to the progressive transfer from the microsurgical technique to the endoscopic one during the 250 or more procedures carried out. The technical difficulties have also been marked, due to the malfunctioning of the endoscopic equipment, and to the inadequacy and/or lack of the surgical instruments necessary in the different phases of the surgical procedure. The duration of the surgical procedures were also noted at the end of every operation.

Surgical procedure

The standard endoscopic endonasal transsphenoidal procedure is currently performed through one nostril, without a nasal speculum, using the endoscope as the only tool to visualize the surgical field and with one or two instruments inserted in the same nostril close to the endoscope, gliding along it. Under general anesthesia and orotracheal intubation the patient is positioned supine with the trunk tilted 10° and the head turned 10° toward the surgeon and fixed in a Mayfield headrest without pins. After an adequate application in both nasal cavities of cottonoids soaked in a decongestant solution, the rigid endoscope (18–30 cm in length, 4 mm in diameter) is inserted in the chosen nostril up to the middle turbinate, which is gently pushed laterally to enlarge the space between it and the nasal septum (Fig. 1a). The endoscope is advanced along the floor of the nasal cavity, between the inferior turbinate and the nasal septum, up to the choana; then, angling the endoscope along the roof of the choana and into the spheno-ethmoid recess for about 1.5 cm, the natural sphenoid ostium is reached (Fig. 1b) and enlarged all around, mainly in a medial direction in order to join the contralateral ostium. The sphenoid rostrum is removed and an anterior sphenoidotomy is completed. The endoscope, from the sphenoidotomy to the removal of the lesion, is fixed to a table-mounted endoscope holder, in order to free both the surgeon's hands. Inside the sphenoid sinus one or more septum/a are removed as needed. On the posterior wall of the sphenoid cavity the sellar floor is recognizable, with the spheno-ethmoid planum above it and the clival indentation below; lateral to the sella the bony prominences of the intracavernous artery and the optic nerve can be seen and between them the opto-carotid recess (Fig. 2a). In the next steps, the mucosa covering the sellar floor is pushed laterally, the sellar floor is opened, the dura mater is incised in a linear or cross

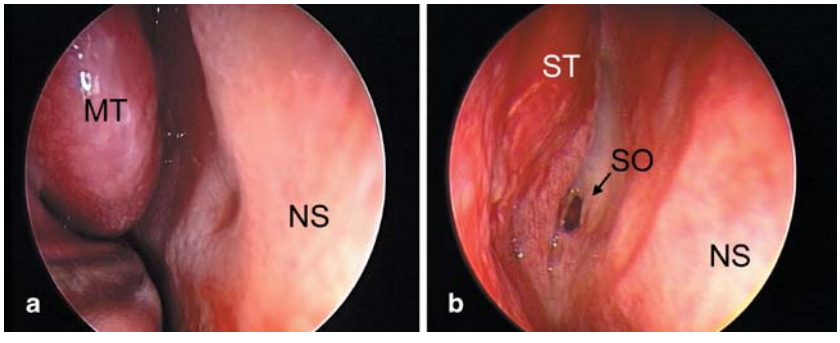

Fig. 1a, b Nasal phase of the endoscopic endonasal transsphenoidal approach (right nostril approach). **a** Identification of the middle turbinate, **b** identification of the sphenoid ostium. *MT* middle turbinate, *NS* nasal septum, *ST* superior turbinate, *SO* sphenoid ostium

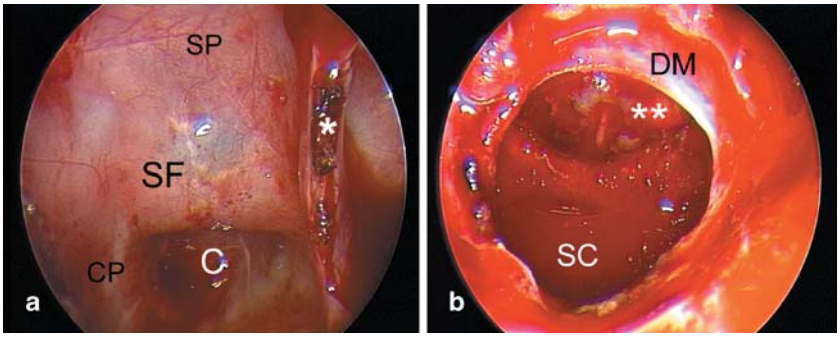

Fig. 2a, b Sphenoid and sellar phase of the operation. **a** Panoramic view inside the sphenoid sinus after the sphenoidotomy. *Asterisk* denotes the sphenoid septum. **b** Endoscopic exploration of the sellar cavity after removal of the lesion. *Double asterisk* shows the suprasellar cistern infiltrated by the tumor. *SF* sellar floor, *C* clivus, *CP* carotid protuberance, *SP* sphenoid planum, *DM* dura mater, *SC* sellar cavity

fashion, and an initial removal of the lesion is then performed. After the removal of the intrasellar portion of the lesion the sellar cavity is explored (Fig. 2 b) with 0° or angled (30°, 45°) endoscopes to remove the residual tumor tissue. At the end of the procedure the sellar floor is closed with a dural substitute and fibrin glue, if necessary, according to the common sellar reconstruction techniques [6, 9].

Results

The evolution from the microsurgical transsphenoidal trans-rhino-septal approach to the "pure" endoscopic endonasal transsphenoidal one happened gradually in the course of the first 15 procedures that concurred with increasing familiarity with the view of the nasal and sphenoid anatomical structures and with the physical properties of the endoscope itself.

As a result of the different techniques employed, we passed from using the semi-sitting position, as in the microsurgical transsphenoidal trans-rhino-septal approach, to the "crib" position. The patient is positioned supine on the operating table, with the trunk raised 10°, knees slightly flexed, and the pelvis lower than the legs; the Mayfield headrest is not used and the head is secured with a plaster. The head's position changes according to the direction of growth of the lesion. In those lesions that grow predominantly toward the suprasellar region, or frontward, toward the sphenoid planum, the head is left in a neutral position with the neck slightly hyperextended and turned 15° toward the operator; in those lesions that develop toward the bottom into the sphenoid sinus, or toward the clivus, the head is slightly flexed and tilted 15° toward the operator. These variations in head position are also necessary to enable the correct placing of the endoscope in the surgical field during the sphenoid and sellar phases of the procedure, i.e., neither too close to the thorax, where it could interfere with the maneuverability of the surgical instruments, nor too high, where it could be exposed to the risk of damages from accidental dropping.

The use of C-arm fluoroscopy, routinely used during the microsurgical transsphenoidal approach, has been progressively abandoned after the employment of the endoscopic technique, which permits the visualization of a greater number of findings inside the sphenoid sinus and consequently a better guide for the surgeon. In fact, during the second 100 procedures, it has been used in only four cases in which a pre-sellar or a conchal type of sphenoid sinus was found. The utilization of a neuronavigation system can be helpful assist with the identification of the anatomic landmarks [21].

At the end of the endoscopic procedure, since the submucosal dissection of the nasal septum has not been performed, it is only very rarely necessary to carry out packing of the nasal cavities. In only 11 patients the affixing of cottonoids in one nostril for 24 h was necessary because of the presence of bleeding from the nasal mucosa (6 out of 11 patients were affected by GH secreting pituitary adenomas, with an extreme hypertrophy and fragility of the nasal mucosa).

The duration of the surgical procedure has varied in a significant way in the course of the 250 or more procedures. In fact, we went from an average time of 126 min required for microadenomas and 164 min for the removal of macroadenomas or for other lesions of the sellar region during the first 100 procedures to an average time of 85 min for microadenomas and 113 min for macroadenomas and other sellar lesions in the second 100 procedures. The time needed for preparing the patient was longer at the beginning, due to the necessity of connecting several cables of the TV camera of the optical fibers of the endoscope, to fixing the holder, and to organizing everything in an ergonomic manner; however, after only a few procedures, the time needed for the patient's preparation became close to that required for the preparation of a transsphenoidal intervention with the microsurgical technique (about 10 min).

The type of endoscopic equipment and the surgical instrumentation varied during the course of the different procedures. During the first 70 procedures a mono charged couple device (CCD) video camera was used, with a halogen light source and a U-matic video recording system. Later on, a digital 3CCD video camera, a xenon light source, a high-resolution monitor and a digital video recording system were used. In the course of the various procedures, different combinations of diagnostic rigid endoscopes have been tried, maneuvered freely or fixed to a holder.

At the moment we use endoscopes 18–21 cm in length, 4 mm in diameter, mostly 0°, maneuvered hands-free, in the nasal and sphenoid phases, and endoscopes 30 cm long, 0° and 30°, for the sellar stage. During the sellar phase the endoscope is fixed to a holder that was initially custom-made.

As far as the surgical instrumentation is concerned, the lack of the nasal speculum and of the operating microscope has lead to the necessity of conceiving surgical tools suitable for the endoscopic procedure. Their conception has been gradually realized by experiencing prototypes of various shapes and length [3], before designing a new set of instruments that we have used since our 103rd procedure [1].

Discussion

In endoscopic surgery the results of each technique definitely depend on the quality of intraoperative images and on the possibility of managing those visually explored by technology. Consequently, we refer to video instrumentation and surgical instruments.

The video-instrumentation system may be artificially divided into four main parts:

– The generator of the light (light source)
– The transmission of the light (endoscope and cable)
– The image acquisition (camera)
– The image displayer (video monitor)

Each of them is necessary to obtain the endoscopic picture on the video monitor, so it is very important to check that every component of the endoscopic equipment is working correctly before the operation starts.

Concerning the light source, even though several types are currently available (mainly halogen and xenon), it is better to use cold xenon light sources, which determine a lower heat dispersion with a subsequent reduced risk of damage to the neurovascular structures. Furthermore, the xenon light source has a color temperature of 6,000 K, the same as solar light; it is as if we were using the sun to light the operating field, with a chromatic return similar to reality.

The endoscope employed must be a rigid one, 4 mm in diameter, 18–30 cm in length, and with 0°, 30°, 45° lenses, according to the different steps of the operation. The endoscope must be introduced into a shaft, connected to a cleaning/irrigation system controlled by a manual or foot switch. The irrigation system permits the distal lens to be cleaned, thus avoiding repeated entrances and exits from the nostril. The use of a 18-cm, 0° endoscope is advised during the nasal and sphenoid steps of the operation, because it is easier to handle. During the sellar step, a 30-cm, 0° endoscope connected to an adjustable holder is used, leaving both of the surgeon's hands free and allowing for the simultaneous introduction of two instruments gliding along the scope. The use of angled endoscopes (30° and 45°) is advised in the sellar phase of the procedure, to explore the residual cavity, after lesion removal, or to inspect the suprasellar and parasellar compartments.

The endoscope is connected to a cable, made up of a bundle of optical fibers that must be handled carefully to avoid twisting them.

The camera connected to the endoscope should be fitted with 3CCD sensors. These sensors are electronic systems, which transform the real image (photons) into electronic images, visible on the screen. The 3CCD camera offers significantly enhanced sharpness and contrast of the video images compared with the mono CCD camera, because each of the sensors processes one of the primary colors of the image separately. Furthermore, the visual acuity is significantly better using the 3CCD camera compared with the mono CCD [23].

The 3CCD camera has to be combined with a 21″ monitor, supporting the high resolution of the 3CCD camera. The high-resolution monitor has an horizontal resolution of >750 lines. Since the resolution of the 3CCD digital camera is superior to 750 lines, if a monitor with a lower resolution is used, some of the sharpness of the endoscopic images is lost.

Finally, in order to guarantee a suitable file of surgical images, the use of a digital video recorder system (DV-CAM), which gives superior quality and lasting images, or a direct acquisition system on hard disk in DV "broadcasting" format or on DVD-R RW are recommended.

Concerning the surgical instruments, it must be kept in mind that the endoscopic endonasal access for the surgical tools through one nostril is narrower than that of the microsurgical procedure, since working room is given by the nostril and not by the nostril widened by the nasal speculum. But, on the contrary, the maneuvering angle is much wider, and not conditioned by the nasal speculum. Moreover, so that the neurosurgeon can work with both hands, as he is accustomed to doing, the adoption of a table-mounted endoscope holder is useful, of which many different versions exist, either purely mechanical (see Fig. 3 a) or pneumatic (see Fig. 3 b). From the time when the instruments used in the microsurgical approach were of a bayonet shape, due to the requirement of not rendering visible the surgeon's hands in the operating field (a conflict between the surgeon's hands and the lens of the microscope), and the lens of the microscope being far from the surgical field, we switched to straight instruments that slide along the endoscope, whose lens is now near to the surgical target.

The instruments for the endoscopic approach have been realized in order to:

1. Move easily and safely in the nasal-sinusal and sellar regions
2. Provide safe handling and grasping, avoiding the conflict between the surgeon's hands and the endoscope
3. Be well balanced and ergonomic
4. Allow easy reaching of every visible zone of the surgical field, both using 0° and, above all, angled optics [22]

This set consists of various tools commonly employed in the endoscopic surgery of the nasal and paranasal cavities such as:

– An elevator, to laterally dislocate the head of the middle turbinate
– A unipolar ball electrode, to coagulate the sphenoethmoid recess
– A bipolar micro-forceps, to coagulate branches of the spheno-palatine artery, in case of bleeding
– A paranasal sinus shaver system, to remove hyperplastic tissue
– Nasal scissors and forceps, to remove, when necessary, the superior and/or supreme turbinate
– A high speed INTRA-Handpiece Drill with an extra long bit and a diamond burr, to detach the nasal septum

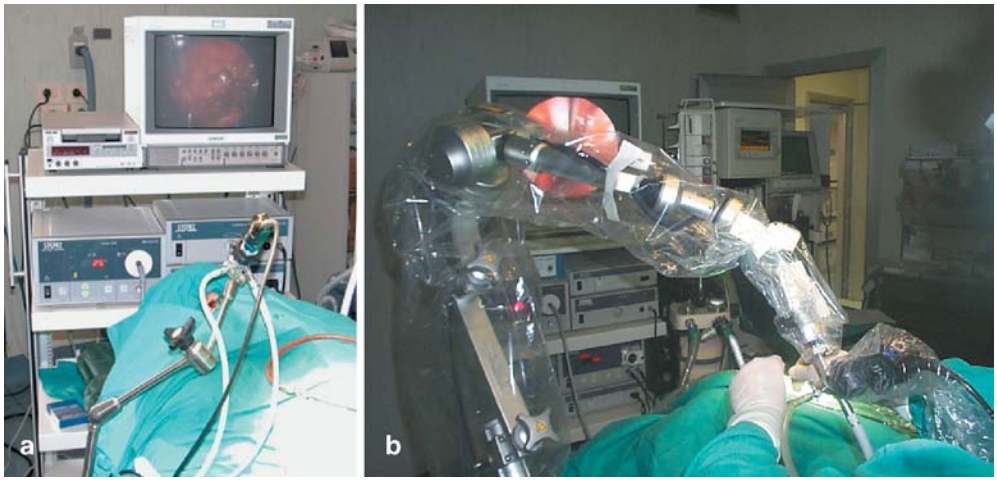

Fig. 3a, b Endoscopic holder devices. **a** Mechanic endoscopic holder, **b** pneumatically powered endoscopic holder (more expensive, but easier to maneuver)

from the sphenoid rostrum, to perform the sphenoidotomy, and to open an intact sellar floor
– Bone punches (Kerrison's, McKenty's, Stammberger's), to carry out the anterior sphenoidotomy, or to widen the sellar floor opening, and sphenoid forceps (Blakesley, Takahashi), to remove the rostrum and sphenoid septa

Other instruments specific to the endoscopic endonasal approach to the sellar region have been added to those above, in order to permit adequate management of the sellar phase of the surgical intervention. All the instruments are straight and between 15 and 25 cm long. This set of surgical instruments includes:

– A new lancet with extractable blade, for the opening of the sellar dura, realized to reach the target with the hidden blade, which is extracted when it becomes visible in the field of the endoscope, thus avoiding accidental damage to the previously encountered nasal structures [1]
– Straight standard pituitary curettes, with various tips and diameters (3, 5, and 7 mm), differently angled on the frontal and sagittal planes
– Double-function curettes that allow curettage and suction at the same time (they combine the action of the curette in removing the pathological tissue with that of the aspirator), and reduce the number of entrances and exits from the nostril. There are two different types of double-function curettes: the pimer (see Fig. 4), a kind of whisk with helicoidal movement, which digs inside the central part of the lesion (especially those of considerable dimensions) and at the same time suctions the mobilized fragments; and additional suction-curettes (see Fig. 5), whose ring-shaped ends continue with a suction-cannula [1]

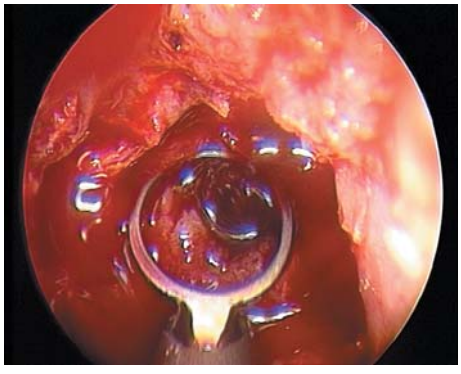

Fig. 4 A suction-curette removing a macroadenoma

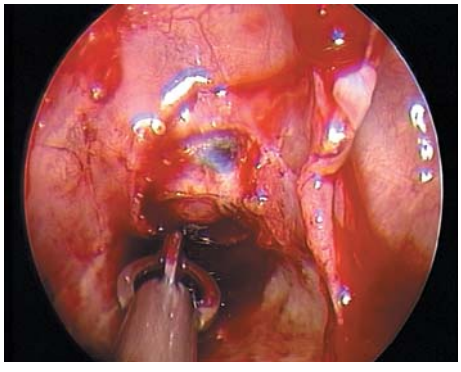

Fig. 5 A pimer removing a small microadenoma

– Angled suction cannulas, with lateral fenestration for suctioning in the zones of the surgical field, visible only via the angled endoscopes [1]

Conclusion

The endoscopic endonasal transsphenoidal approach to the sellar region is a technique in which endoscopic equipment and surgical instruments used in neighboring surgical specialties must be replaced by modern tools dedicated to this particular surgery. The "ideal" instruments have not yet been conceived and further development is expected. In this way, it is possible to make the procedure safer and more effective.

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