REVIEW

Rhinology, 44, 2-7, 2006

Different surgical approaches to the sellar region: focusing on the "Two Nostrils Four Hands Technique"

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SUMMARY

After a brief overview of the most commonly discussed sellar approaches in literature, the authors focus on their "Two Nostrils Four Hands" technique. This approach allows otorhinolaryngologists and neurosurgeons to co-operate and its advantages are described. In the discussion the authors want to demonstrate how this collaboration can favour a true interdisciplinary improvement in the treatment of sellar pathology. They also want to demonstrate how this technique can be microinvasive with the use of the two nostrils at the same time, thus preserving the anatomical structures not involved.

Key words: endoscopy, transsphenoidal surgery, minimal invasive surgery, skull base, endonasal approach

INTRODUCTION

The access to the sellar region, over the last century, has been performed through a number of different surgical techniques utilising transcranial and transsphenoidal approaches, enabling experiences to be shared amongst experienced neurosurgical and ENT authors [1-10]. The application of the operating microscope was introduced by Hardy [11], and then combined with traditional surgical techniques such as the transnasal approach with submucous resection of the septum [3] and the oronasal sublabial approach [12]. The microscopic technique has been improved over the years and is currently the most widely performed.

In the 1990's, some authors combined this technique with the endoscope, creating what could be defined an "endoscopic assisted" microscopic technique [13].

In 1992, Jankowski [14] published a totally endoscopic transsphenoidal surgical approach and in 1996, Jho and Carrau [15-17] standardized and disseminated the endoscopic transsphenoidal approach through the nasal fossa, supported in 1997 by de Divitiis and Cappabianca [18]. These two latter authors performed a unilateral transsphenoidal approach with an instrument holder, emphasising the microinvasiveness of the technique. In 2001, Frank and Pasquini extended this technique to the cavernous sinus [19,20]. Castelnuovo and Locatelli in 1995 performed a unilateral endonasal technique for the treatment of CSF leaks, and in 1997 they started the treatment of sellar disease applying a four hands technique, without a holder, using access through both nostrils. This technique allows both surgeons to work simultaneously and can easily be used to approach the entire central skull base exposed from the frontal spine to the first cervical vertebrae, as recently evidenced by different authors [25-29].

The experience of all these groups has facilitated the first comparison of results from all these techniques, which in preliminary reports appear to overlap in respect of the conditions treated [30-34].

OVERVIEW OF TECHNIQUES

The transsphenoidal microscopic approach, introduced about a century ago, has recently undergone a number of important improvements, including neuronavigation and intraoperative MRI (iMRI), as clearly presented in the recent articles by Laws and Jane [35,36] and Mortini [37], amongst others.

Technically, the microscopic approach follows a transseptal pathway with undermining of a mucosal-periosteal flap and septal displacement to allow the introduction of a retractor speculum. This leads directly to the sphenoid sinus at the level of the rostrum, which is burred to access the sinus. Compared with the subsequent endoscopic techniques, this approach provides a better depth perception, through the microscopic binocular vision together with the possibility of using two operating hands. However, it needs to be emphasised that the surgical field is strictly limited to the distance between the two retractor blades and such a small working field limits the number of surgical tools that can be used, which are also placed along the visual line itself. The vision of the surgical field is represented

* Received for publication: July 28, 2005; accepted: January 3, 2006

by a cone with the apex at area of disease, which does not allow lateral vision. This is in contrast to endoscopic approaches. These manoeuvres on the septum also require a nasal pack, which is often a nuisance to the patient.

The endoscopic endonasal technique is performed through the nasal fossa [38,39] using a paraseptal approach directly into the sphenoid sinus. This can be achieved with gentle lateralization of the middle turbinate, allowing one to reach the sphenoethmoid recess. Then, the anterior wall of the sphenoid sinus is removed by widening the ostium [39] or burring the rostrum [38]. Once the sphenoid sinus is opened, a holder is put in place to support the optic fibre, allowing the use of both operating hands in the subsequent procedures of opening the sellar floor and removal of the intrasellar tumor.

"TWO NOSTRILS, FOUR HANDS" SURGICAL TECHNIQUE

In the endoscopic sinonasal field, May first described this bimanual technique in 1990, which was recently revisited by Briner and Simmen [40]. The technique implied the use of different surgical tools in a single nasal fossa, emphasizing the importance of the collaboration between the two surgeons in order to allow the first to use both surgical hands. The four hands technique which we apply is an evolution of the one presented by May [41], in that it takes advantage of the collaboration between the two surgeons, broadening the operating field to the second nasal fossa and adding a fourth surgical hand.

We have applied this technique since 1997 for sellar approaches [21,22] and it has been used by different authors for advanced approaches [25-29,42], allowing the ENT specialist and the neurosurgeon to alternate as first and second operator during the different stages of the surgical procedure.

The bilateral approach to the sphenoid sinus may be performed in 3 different ways: *direct paraseptal approach, transethmoid-sphenoid approach, or transethmoid-pterygoid-sphenoid approach* (Figure 1).

The indication for the *direct paraseptal approach* is the removal of tumors localized only in the sellar region or with moderate spread to the medial part of the cavernous sinus. This approach, after the endoscopic removal of the septal crest, allows one to follow the nasal septum parallel to the floor of the nasal fossa. After reaching the posterior choana, an upward direction is followed to detect the natural ostium of the sphenoid sinus lying medial to the tail of the supreme (or superior) turbinate. To access the sphenoid sinus, the ostium needs to be inferomedially widened using circular biting forceps, Citelli forceps or an intranasal drill with a cutting burr. If the sphenoid rostrum has a lateral extension obscuring a good view of the ostium, burring will be required (Figure 2).

By repeating the same surgical manoeuvres in the contralateral

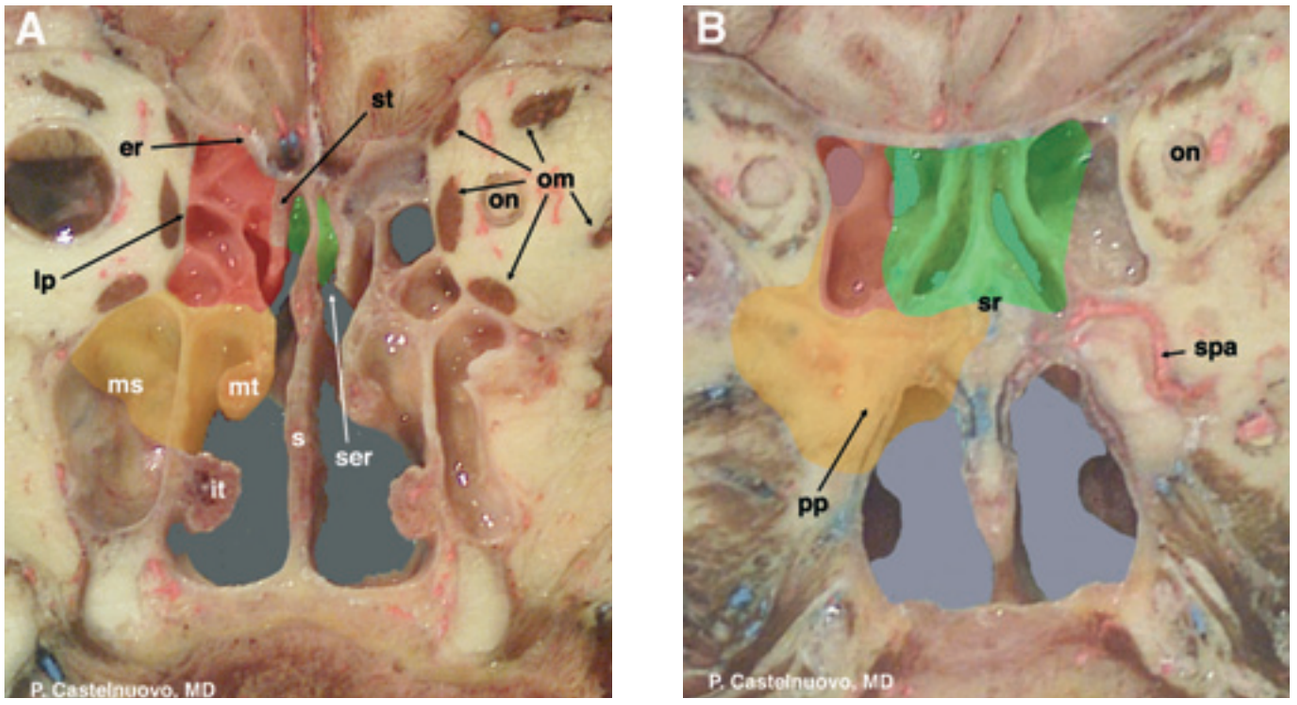

Figure 1. A) Macroscopic anatomical specimens in the coronal plane showing with different colours the structures removed in the 3 different approaches, from an endoscopic perspective. The anatomical structures removed with the bilateral paraseptal approach are highlighted in green, those additionally removed following the transethmoidal approach are in red, and those removed by the transethmoidal-pterygoidal approach are in yellow. B) A more posterior section. om = orbital muscles, lp = lamina papiracea, er = ethmoidal roof, ms = maxillary sinus, s = nasal septum, it = inferior turbinate, mt = middle turbinate, st = superior turbinate, on = optic nerve, ser = sphenoethmoid recess, sr = sphenoidal rostrum, spa = sphenopalatine artery, pp = pterygoidal process

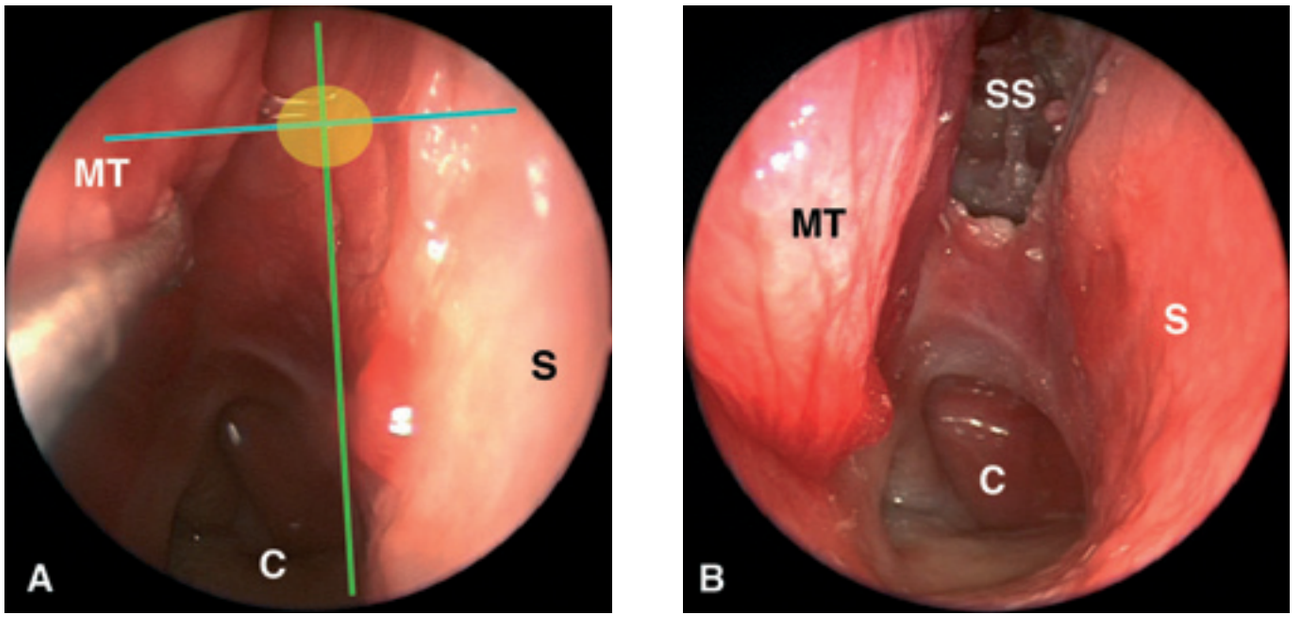

Figure 2. A) Endoscopic view (4mm, 0°) of the sphenoethmoidal recess. The green line is parallel to the interchoanal septum; the light blue line is between the tail of the middle and the superior turbinate. The yellow area indicates the safe-point in which to drill the spetal rostrum without damaging the optic nerve or the internal carotid artery.
B) Endoscopic view of the sphenoethmoidal recess after drilling of the septal rostrum, showing the internal part of the sphenoid sinus.
MT = middle turbinate, S = nasal septum, C = choana, SS = sphenoid sinus

nasal fossa, and subsequently combining the two sphenoid ostia, a bilateral approach to the sphenoid sinus will be achieved, allowing the second surgeon to collaborate: from this moment onwards, the second surgeon will be able to keep the surgical field clear with suction, or support the endoscope allowing the first surgeon to work with both hands.
The indication for the *transethmoid-sphenoid approach* is related to lateral and anterior spread of the pituitary tumor. The involvement of the cavernous sinus medial to the internal carotid artery (ICA) and the rare involvement of the posterior ethmoid require a lateral widening of the surgical approach. The techniques follow a traditional anteroposterior ethmoidectomy with preservation of the middle turbinate. Once detected, the inferior margin of the superior turbinate is cut so as to expose the natural ostium of the sphenoid sinus. This will have to be widened until the entire anterior wall of the sphenoid sinus has been removed. This allows the visible surgical field to be widened laterally, exposing the apex of the orbit. Contralaterally, a traditional paraseptal approach is performed to allow four hand sellar procedures.

The indication for the surgical *transethmoid-pterygoid-sphenoid* approach is based on the tumor spread to the lateral part of the cavernous sinus, to the base of the middle cranial fossa, to the infratemporal fossa, or to well-pneumatized pterygoid-sphenoid recesses. This approach required the partial removal of the middle and superior turbinates, of the posterior ethmoid cells, and of the anterior wall of the sphenoid sinus, followed by electrocauterization of the spheno-palatine artery, and by the removal of the posterior fontanelle, to expose the posterior wall of the maxillary sinus which will subsequently be removed. Once the contents of the pterygomaxillary and infratemporal fossae have been exposed in this way, the Vidian canal and the foramen rotundum can be identified, and electrocoagulation of the Vidian artery can be performed. At this point, if required, the pterygoid base and the basisphenoid can be burred to surgically control both the cavernous sinus and the base of the middle cranial fossa (Figure 3). The approach to the lateral part of the cavernous sinus is made possible due to the devascularization brought about by the tumour, and it is extremely important to detect the VI cranial nerve within the sinus. As in the previous surgical approaches, work with four hands is required to match the paraseptal approach on the other side of the nose.
The subsequent approach to the sellar region, which is common to all the three approaches, requires the identification of essential anatomical landmarks, which are differently represented in the different types of sphenoid (presellar, sellar and conchal). Such landmarks are the following: bone protrusion at the level of the paraclival and cavernous ICA and at optic nerve (ON) level, and the bony depression at the level of interoptical-carotid recesses and of the clivus anterior wall.
After the removal of bone in the sellar floor, which is located in the middle of the abovementioned anatomical landmarks, the procedure continues with the incision of the sellar periosteum-dura mater and accurate tumor debulking.
Tumor spread to the superior parasellar region necessitates the

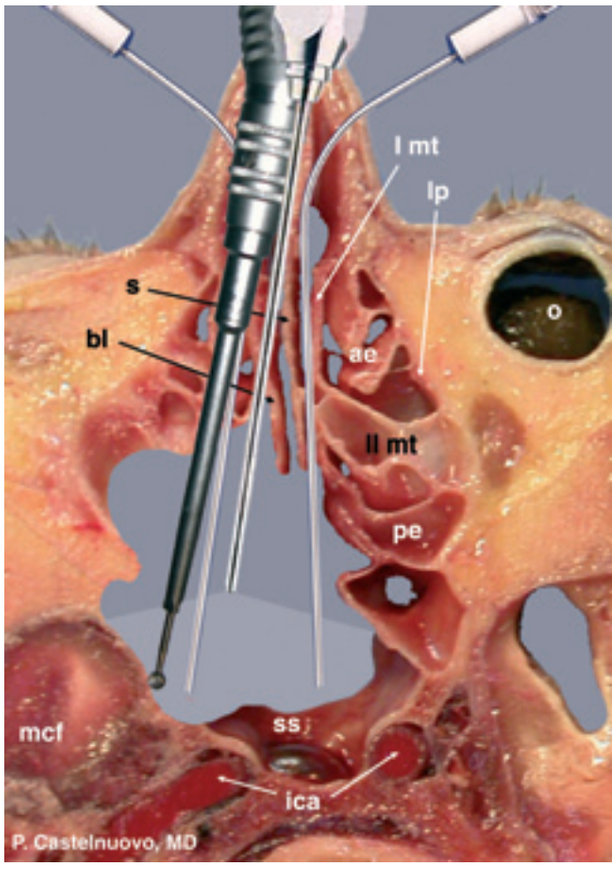

Figure 3. Macroscopic anatomical specimens in the axial plane of the transethmoidal-pterygoidal-sphenoidal approach showing which structures are removed to reach and drill the middle cranial fossa.
I mt = first portion of the middle turbinate, II mt = second portion of the middle turbinate, ae = anterior ethmoid, pe = posterior ethmoid, s = nasal septum, bl = basal lamella, ss = sphenoid sinus, ica = internal carotid artery, mcf = middle cranial fossa, lp = lamina papyracea, o = orbit

removal of part of the ethmoid-sphenoid planum, while lateral tumour spread requires the removal of the bony wall covering the cavernous part of the ICA and of the posterior-lateral wall of the sphenoid extending up to the orbital apex (and, in extremely well-pneumatized sphenoid sinuses, up to the medial part of the greater sphenoid wing).
Tumor debulking is performed with a four hand technique, allowing simultaneous washing, undermining, clearing, cauterizing and monitoring the prolapse of the suprasellar cistern, to identify any residual lateral and posterior tumour.
To perform such manoeuvres the following tools are required: 0° and 45° optics, cutting microforceps, a microdebrider, angled aspirators and a hydrodissection system.
In our practice, tumour removal is completed by an "immersion" control, with sellar cavity irrigation, continuously applying the optics cleaning system.
This procedure allows us to identify any tiny tumour remnants without vision being hindered by bleeding, and to also use irrigation as a sort of "hydrodissector".
In most cases, when tumour removal is complete, reconstruction of the sellar floor is not required. In cases presenting with a CSF leak, closure is effected with a multilayer procedure, using whenever possible autologous material harvested from the nasal cavities during the approach to the sphenoid sinus (e.g lateral part of a concha bullosa, septal spur, part of the vomer, quadrangular cartilage), or temporalis fascia.
In the absence of such graft material, the application of heterologous material is recommended (eg dural substitutes). The repair requires the positioning of at least an intrasellar underlay graft and of an extracranial overlay graft, but different combinations may be fashioned depending on the patient.

DISCUSSION

The treatment of pituitary adenomas is targeted at the resolution of endocrine symptoms, the normalization of the hypothalamus-pituitary axis, and the resolution of possible optic nerve compression. Therapeutic options are surgery, medical treatment and radiotherapy [37].
To provide scientific relevance to outcomes, with all these variables at stake, a long follow-up period and a high number of reported cases are required.
Reports in the literature to date, even with considerable differences between the number of cases presented using either microscopic and endoscopic techniques, have demonstrateded similar preliminary results, although definitive long-term results in term of completeness of lesion removal, recurrence rate and endocrinological cure are not yet available [30-34,38].
Our experience, based on 176 surgical procedures for sellar disease, demonstrates an extremely low percentage of major and minor complications, in line with the outcomes achieved by other teams of expert endoscopists [43], emphasising the importance of a minimally invasive approach, which preserves the anatomy and physiology of the nose and paranasal cavities. This surgical approach allows one to achieve, with the same therapeutic effectiveness, two important results: avoidance of iatrogenic damage and improved patient compliance [31].
The "Two nostrils-four hands" technique allows streamlining of both instrumental and human resources, tailoring the surgical procedure to each patient.
In particular, the procedure via both nasal fossae allows a broad range of combinations in the application of surgical tools:

1) less tools per nasal fossa may be associated with less surgical trauma;
2) better direct access to the surgical target may be associated with less trauma to structures along the access pathway;
3) the ability to use endoscopes with different angles of view (0°, 45°, 70°) improves identification of the surgical target and allows exploration of the lateral recesses of the sellar region in search of residual tumour. The use of both nasal fossae also allows more dynamism taking maximum advantage of the endoscopic view;
4) the use of three different tools, apart from the endoscope,

allows one to combine washing and suctioning during the immersion technique, or to combine surgical Doppler with neuronavigation.

The reduction of surgical trauma leads to a reduction in intraoperative bleeding, a reduction of nasal packing, and subsequently a shortened wound healing time, with significant reduction of crusting, synechiae and postsurgical septal perforations.

From a human resources perspective, such a technique allows the combination of different technical skills, achieving 2 results: the respect of the anatomy and physiology and the improved ability to deal with any nasal or intracranial complications. Moreover, the presence of two surgeons and only one nurse throughout the procedure allows cost saving for the hospital [40]. This technique requires a long learning curve to coordinate the joint activities of the two surgeons and of the whole operating room staff, and should be performed only by experienced surgeons. Finally, it is noteworthy that this technique has fostered a true interdisciplinary improvement in the treatment of such patients.

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