MINIMAL INVASIVE SURGERY OF LESIONS OF SELLAR, PARASELLAR REGION AND SKULL BASE

Summary of Ph.D. Thesis

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ABBREVATIONS in the text:

AC	**adenocarcinoma**
CCRCC	**clear cell renal cell carcinoma**
c.s.	**cavernous sinus**
CSF	**cerebrospinal fluid**
EEA	**extended endonasal approach**
ENB	**esthesioneuroblastoma**
FESS surgery	**functional endoscopic sinus**
ICA	**internal carotid artery**
lg-	**low-grade**
M	**meningioma**
m-SP (Schneiderian) papilloma	**malignant sinonasal**
MR	**magnetic resonance**
NF	**neurofibroma**
NPAC adenocarcinoma	**nasopharyngeal papillary**
orb.	**orbital**

RMS	**rhabdomyosarcoma**
SNUC	**sinonasal undifferentiated carcinoma**

LIST OF PUBLICATIONS RELATED TO THE SUBJECT OF THE THESIS

I. Bella Zs, **Fülöp B.**, Csajbók É., Magony S., Valkusz Zs., Herczegh Sz., Jóri J., Bodosi M., Czigner J., Barzó P.: Endoscopic, posterior transseptal pituitary surgery, learning curve of the surgical technique and equipment in 61 operations Ideggyogy Sz. 2012 Jul 30;65(7-8):271-9. Hungarian

II. **Fülöp B.** & Bella Zs., Palágyi P., Barzó P.: Endoscopic removal of the tuberculum sellae meningioma through endonasal transsphenoidal approach Ideggyogy Sz. 2016 Mar 30;69(3-4):133-8. Hungarian

III. Barzo P, Zador Z, Bodosi M, Bella Z, Jambor D, **Fulop B,** Czigner J.: Combined Minimally Invasive Supraciliary and Transfacial Approach for Large Tumors with Skull Base and Sinonasal Involvement. World Neurosurg. 2018 Jan;109:1-9. doi: 10.1016/j.wneu.2017.08.162. Epub 2017 Sep 4

INTRODUCTION AND AIMS:

The surgical treatment of pituitary tumors has been performed for just over a century. Even though transnasal approaches were used during mummification procedures in ancient Egypt, the first pituitary surgery was performed via transcranial (transfrontal, transtemporal) exploration. Parallel to transcranial exploration, transfacial and transsphenoidal techniques with lateral rhinotomy and partial resection of the nasal and nasal cavities developed. In 1907, *Schloffer* successfully removed a pituitary adenoma via the transsphenoidal route in Innsbruck. *Kocher's* modified midline nasal route, sparing the frontal ethmoid and maxillary sinuses, radically reduced post-operative infectious complications. Cushing completed the first sublabial, transepteptic, transsphenoidal surgery in 1910. The endonasal transsepteal transsphenoidal technique, which is wide spread in Europe, is associated with the name of *Hirsch* from Vienna, a student of *Hajek*. In the past century, pituitary surgery has undergone tremendous development and interventions have seen a renaissance since then. Following in the footsteps of *Dott*, *Hardy* and *Guiot*, first introduced an operating microscope, which was supplemented by an X-ray illuminator for proper intraoperative orientation. In the 1980s, the rigid endoscopic technique of *Messerklinger*, *Stammberger*, and *Kennedy* became not only a basic element of ear-nose-throat diagnostics but also of rhinological surgery. The gradual expansion of the indication areas of endoscopic exploration, as well as the neurosurgical and ear-nose-throat areas, have allowed for the use of cranial and pituitary adaptations. Interestingly, with the introduction of the microscope, *Guiot* and *Apuzzo* used an endoscope for the first time in the sella and the parasellar lesions, but the first "pure" endoscopic transsphenoidal tumor removal was only published 20 years later by *Jankowski* which, by the hands of *Jho* and *Carrau*, obtained routine application. Over the past 10 years, the procedure has become widespread throughout the world and many of its variants have been known for

endoscopically assisted microscopy interventions through one or both nostrils. There is also a debate between the "endoscopic" and "microscopic" camps as to the advantages and disadvantages of the two interventions and as to which is the first choice to be made on the basis of them.

The introduction of transnasal microscopic surgery in Hungary is connected to the work of *Pásztor* and *Piffkó* et al. Subsequently, *Czirják* used and further developed the paraseptal approach through the transsphenodial pathway. In addition, the work on suprasellar tumors is linked to the work of *Czirják,* with minimal invasive application of an eyebrow incision in Hungary.

Nasal diagnostics (1983) and later endoscopic surgery, at the oto-rhino-laryngology and head-neck-surgery department, in Szeged were among the first to be introduced in Hungary. Thus, we were able to use it early on in the borderline work of the two professions and pituitary surgery.

The introduction of endonasal technique in Szeged is associated with the activities of *Bodosi* and *Czigner* (1986) and as a result of the co-operation between the neurosurgery and oto-rhino-laryngology and head-neck-surgery departments, tumor surgery with transsphenoidal surgery has been extended to the nasal cavity and the intracranium.

Due to the combined endoscopic and microscopic surgery of hypopsy tumors, which are routinely used and our endoscopic experience with surgery on cerebral ventricles, we have extended the use of the endoscope to the treatment of cranial base tumors. For neuroendoscopic interventions, the surgeon’s perfect anatomical orientation, excellent endoscopic practice (joint team training, gradual learning curve) and use of the latest technical equipment is essential. To do this, continuous education, knowledge of special endoscopic devices, and their proper knowledge of exploration is required. A presentation of the special endoscopic posterior transepteptic transsphenoidal

surgical technique with a Live Cadaver Surgical Presentation at the Conference of the Hungarian Neurosurgery Society in Szeged in 2011, was complemented by a hands-on workshop. Regular practical training, including the specialty learning curve and professional consultations are provided at the annual SZERINA (Szegedi Rhinological Days) conference during lectures and special cadaver dissection exercises at the Institute of Pathology and Anatomy of the University of Szeged. Practical experience and regular training programs have enabled the development of new surgical combinations such as combined endo-microscopic pituitary surgery (CEMPS) and simultaneous multiportal skull base surgery (SMSBS), which have been introduced in everyday practice.

The treatment of sinonasal tumors involving the frontobasal area together with the nasal cavity and/or paranasal sinuses represents a major challenge because of the proximity of vital anatomical structures. The surgical resection remained the cornerstone of therapy, with a combination of transfacial and transcranial approaches for tumors invading both the sinonasal area and the anterior skull base. The general aim of the combined surgery is to achieve a tumor-free margin, i.e., an en bloc resection, together with a better scope and thus safer operative conditions for the resection of the intracranial extension. The extension of these tumors into the cranial vault, similarly to primary tumors of the anterior skull base, traditionally has been approached through pterional, subfrontal, or bifrontal craniotomy. These techniques are often complicated by iatrogenic injury induced by the extensive craniotomy and soft-tissue manipulation. A new combination of the limited transfacial approach and the minimally invasive eyebrow incision is described as an efficient and safe technique for the resection of tumors invading both the anterior fossa and the sinonasal area.

MY DUTIES AND AIMS IN THIS COMPLEX STUDY WERE:

1. How can we combine the use of a microscope and an endoscope in hypophysis operations, and how can we provide the technical background for this?
2. What innovation results from using an endoscope? What are the advantages and disadvantages of a pure endoscopic and purely microscopic technique? How can the benefits of both be highlighted if the two techniques are combined?
3. How can the technical background of purely endoscopic transsphenoidal skull base tumor removal be ensured?
4. How can the skull base team with the technical background of its design and education be accomplished?

I. INTRODUCTION

I.1. Introduction

We have been using the endoscope for two years in our clinic during hypophyseal surgery. In our study, we report on not only the experience gained during this time but primarily on the endoscopic tumor removal technique which we use and the resulting spontaneous learning process, comparing it with international literature and recommendations.

I.2. Introduction

With the development of both pituitary surgery and sinus surgery, endoscopic surgery has become more widespread as both the technical equipment and the application areas have evolved and widened. In our institute, the combined endoscopic and microscopic surgery of pituitary tumors was introduced in

2007 and has routinely been used successfully in more than 200 cases. In this field, and as a result of our experience in the endoscopic surgery of cerebral ventricles, we have extended the use of the endoscope for the treatment of cranial base tumors. There have been reports of endoscopic endonasal surgical treatment of primary tumors of the frontal skull in recent years. When a tumor in the anterior skull base is close to the nasal cavity, it seems logical that the surgical excision should be transnasal instead of transcranial to minimize damage to the brain tissue surrounding the tumor. The aim of our case study is to extend the minimally invasive, endoscopic treatment option for operative diseases affecting the skull base, in addition to standard procedures.

I.3. Introduction

The treatment of sinonasal tumors involving the frontobasal area together with the nasal cavity and/or paranasal sinuses represents a major challenge because of the proximity of vital anatomical structures. The extension of these tumors into the cranial vault, similarly to primary tumors of the anterior skull base, traditionally has been approached through pterional, subfrontal, or bifrontal craniotomy. These techniques are often complicated by iatrogenic injury induced by the extensive craniotomy and soft-tissue manipulation. A new combination of the limited transfacial approach and the minimally invasive eyebrow incision is described as an efficient and safe technique for the resection of tumors invading both the anterior fossa and the sinonasal area. Our series of 11 patients demonstrate minimal mortality and morbidity with excellent cosmetic outcomes.

II. METHODS AND MATERIALS

II.1. Methods and materials

Between November 2006 and December 2010, at the Department of Neurosurgery of the University of Szeged, we operated on 61 patients using the transsphenoidal approach. After the interventions, we performed routine endocrinological check-ups (continuous postoperative hormone determination) as well as control head MRIs (6 to 8 weeks post-surgery). Initially, an endoscope was used exclusively to identify the anatomical structures during the preparation of the surgery and to clarify the developmental variations effecting the operation (i.e., the operation was performed exclusively by microscopy). The positive experiences gained in this regard have prompted us to endoscopy the endonasal phase first and then, almost invisibly, the sphenoidotomy and intrasellar tumor removal. Since the endoscopic equipment is still not entirely optimal, we still have to undergo microscopic continuation of the operation from time to time during the intrasellar phase.

II.2. Methods and materials

The 49-year-old female patient who was completely healthy, was subjected to several eye examinations over the course of several months due to vision problems. Based on the examination, a weaker papilla was found in her left eye as well as the discovery of a previous retrobulbar neuritis. However, VEP examination on the left side confirmed a functional impairment of her central optic fibers. As a result, the skull-MR scans showed a proliferative tumor that seemed to be tuberculum meningioma. The images showed the compression of both optic nerves and the optic chiasm due to the tumor. Neurological examination showed a visual impairment in the right eye also through confrontal visual field examination in addition to the impairment of the left eye.

II.3. Methods and materials

Eleven patients were diagnosed with a tumor invading both the anterior skull base and the nasal cavity and/or paranasal sinuses by means of contrast-enhanced magnetic resonance imaging. Intracerebral propagation or tumor size was not considered as exclusion criterion. All patients gave written informed consent before the operation.

III. RESULTS

III.1. Results

Of the 61 endoscopic patients, 25 had complete endoscopic removal of their tumor. In the first 20 cases, only the endoscope was used three times, while 10 in the last 20 cases alone. In the examined group of patients, postoperative bleeding was observed (4.9%) in the form of minimal postnasal epistaxis. Postoperative MRI examinations showed clear tumor residuum in five cases, but due to its silent and non-spatial nature, no further surgery was required. During operation, 12 cases of CSF leakage (19.6%) were observed, spontaneously or spinal drainage was almost completely eliminated with the exception of one patient who had their fistula closed with intranasal endoscopy (fat, surgycel, fastia lat, fibrin glue). Four weeks after surgery, 54 patients were excellent, three patients were good, and two patients reported satisfactory nasal breathing. Perforation of the back third of the septum was detected in four cases. In one case, on the second day after surgery, the patient suffered a stroke and accordingly, right hemiplegia, anisocoria developed. Despite intensive treatment, after a temporary improvement, the patient died on the 10th postoperative day. Pathological examination revealed a pons haemorrhage and lung microembolisation. One patient died due to a

complication not at all related to the surgery. There were four cases of transient (<5 days) diabetes insipidus, but a sustained, hormone replacement condition developed in three cases. Abnormal hormone production was completely abolished in 59 cases, except for two acromegalic patients, although the decrease was significant, the daily GH level normalized and no further treatment was required, but the level of insulin-like growth factor binding protein remained elevated. In sixteen cases (26.2% of the patients), substitution was completely abandoned later.

III.2. Results

In the post-operative period, spinal drainage was used to prevent transient nasal liquorrhoea for four days, with no CSF leakage. Only one time, due to diabetes insipidus, there was a need for desmopressin because of the divergence and ion displacement. In addition to these, there were no signs of fever and no clinical signs of meningitis appeared. Histopathological examination confirmed chordoid meningoma (grade II). When the patient came for the control examination, they reported reduced vision in the right eye and a decreased sense of smell. Six months later, the control head MRI showed no residual tumor and compression of both optic nerves and the optic chiasm ceased.

III.3. Results

All patients had intracranial, intranasal, and ethmoid sinus (plus at least one additional paranasal sinus) involvement, 9 had intradural extension, and 9 presented with orbital, and 3 with cavernous sinus extension. The mean duration of surgery was 3.0 ± 0.9 hours. No case required orbital exenteration. Intraoperative and postoperative approach-related mortality was zero.

Postoperative meningitis occurred in 2 cases, both healing to vancomycin or meropenem within a couple of days. Postoperative CSF leak rate was zero. Only few patients required 1 or 2 days in the intensive care unit, and all patients were discharged from the ward within 2 weeks (mean hospital stay was 9.2 _ 1.9 days). Although, as an open technique, this approach may inherently be associated with a relatively greater risk of postoperative wound infection as compared with fully endoscopic approaches, no such event occurred in our case series. The histological diagnoses included, sinonasal adenocarcinomas of different types and grades, esthesioneuroblastoma, rhabdomyosarcoma, malignant Schneiderian papilloma, neurofibroma, meningioma, and in one case a clear cell renal cell carcinoma, suggestive of an unusual distant metastasis. Only 3 of 11 patients had a histologically benign neoplasm. Among patients alive at the time of publication, 1 patient has less than 3 years of follow-up. Three patients died within 3 years, corresponding to a 3-year survival rate of 70%, 2 of them were the only patients not having received postoperative irradiation, whereas the third suffered of an anaplastic (undifferentiated) carcinoma. The cause of death was local recurrence in all 3 cases. One patient died years after the operation as the result of an unrelated condition. In 3 patients, local recurrence due to insufficient primary surgery in another institute necessitated the reoperation, 2 of them being still alive and well.

IV. DISCUSSION

IV.1. Discussion

We were among the first clinics in Hungary to introduce nasal diagnostics (1983) and later, intranasal endoscopic surgery in the oto-rhino-laryngology

and head-neck-surgery department, thus we were able to take part in early neurosurgery of the pituitary surgery, thus combing the two fields. Initially, without any prior commitment to any of the procedures, we sought to find out how the endoscope could be more beneficial than conventional microscopic techniques. In order to judge this, the endoscope was first used exclusively in the preparation of the operation to identify the anatomical structures and to clarify the developmental variations affecting the operation, and the positive experiences gained with this, prompted us to first enter the endonasal section and almost unnoticably the sphenoidotomy and finally intrasellar tumor removal wass also performed with an endoscope. The first operations lasted 2–2.5 hours, despite the fact that the intrasellar part was always microscopically, which is also very favorable in international comparisons, since in the largest centers, at the beginning, 3.5–4 hours of surgery was achieved after 30-40 patients reduce to 2-2.5 hour. However, in the last 10 patients, total tumor removal was done with only endoscope in six patients, with an average time of 1 to 1.5 hours (the shortest endoscopic intervention was 40 minutes). The shorter surgical time, in international comparisons, is probably also due to the fact that we do not feel compelled to use the endoscope at all costs and, if the operation becomes cumbersome, we can easily and quickly use the well-proven microscope technique. This is probably also due to the fact that the endoscopic equipment is still not optimally optimized, especially in the instrumentation of the intrasellar phase. In order to maintain this level of safety, we have not been able to ignore the continuous use of the retractor, although this is likely to be the next big step in the learning process. Our experiences mainly support the statements that support the equivalent practice of microscopic and endoscopic techniques, since the alternate use of the two interventions, at each stage, allows for the most appropriate exploration for the given anatomical and pathological situation. Introducing the use of the endoscope is a great help in mapping the pre- and

intraoperative anatomy, by bringing the operative area "near the instrument", and lateral recesses can be seen with the use of angular optics. Endoscopic techniques involving the removal of the back of the septum and the front wall of the sphenoid sinus with the mucosa are widespread. In the method we use, the multilayer closure with sparing the mucoperiosteal lobes of the front wall of the septum and the sphenoid sinus and the mucous membrane of sinus result in restitution ad integrum healing. In addition to the introduction of the new endoscopic technique, and using the microscope as needed, we have retained the unique benefits of binocular (stereo) vision and superior depth of field. In addition, hydroscopy in the sinus cavity provides the possibility of viewing 180 ° for minor bleeding, and for finding residual tumor parts. Introducing the device intradurally, it provides insight into the parasellar skull base through minimally invasive gates for transnasal techniques. The extension of endoscopic techniques may mean the possibility of further advancement primarily for the endoscopically assisted removal of tumors affecting the anterior skull base. In our cases, with the introduction of endoscopic technique, the operative time and intraoperative blood loss significantly decreased. The intervention is further minimally invasive, significantly modifying the size of the intranasal exploration, enabling early mobilization of the patient, which significantly improves the patient's perioperative comfort. As a result, nasal breathing problems detected by previous interventions have drastically decreased, as the integrity of the cartilage and bone of the septum remains largely in tact, and the development of possible post-operative intranasal connective tissue contractions can be eliminated by endoscopic revision.

IV.2. Discussion

Surgical treatment of lesions affecting the skull base can be challenging for both neurosurgery and oto-rhino-laryngology and head-neck-surgery. Due to the common work of these professions, a close co-operation has been developed in our departments since the work of *Bodosi* and *Czigner* in the mid-1980s. As a result of the collaborative work of the different fields, many transcranial, transacial explorations have been created, with which, we can achieve tumor remove at almost any localation. In tumor surgery, the advantage of the endoscope over standard microbial surgery is to bring the "hidden places" into the field of vision, aiming at both the complete removal of the tumor and the protection of critical nerve elements. To do this, the optics provided at different angles by rigid endoscopes, provide a high degree of freedom and flexibility. The advantages of endoscopic skull base surgery were found to have lower surgical burden, shorter hospitalization time in the post-operative period, minimal post-operative discomfort and the cosmetic advantage of open skull surgery. In transcranial surgery, to get to the intracranial pathology, up to the center of the skull, after the opening of the dura, the basal cisterns must be opened and the brain must be held slightly, even without the use of retractor blade. In transnasal routes, nasal meatus and paranasal sinuses do not require brain maintenance to achieve basal lesion, thus avoiding brain retractor induced ischemia, intra- or post-operative brain swelling.

Endoscopic surgery, in addition to being minimally invasive, has maximum aggressive interventions. In the case of the operation indicated in our case report, the endoscopic transnasal transsphenoidal exploration could be visualized by planum sphenoid, sella, optic and carotid protuberance, as well as clivus. When a meningoma affecting planum sphenoidal, tuberculum sella and sella was confirmed in our patient, we were sure that the lesion could be removed by endoscopy. On the basis of the MRI images, it was evident that

in the present case the patient had extensive sphenoid sinus, which made the endoscopic exploration considerably easier.

IV.3. Discussion

Toward Minimally Invasive Approaches

The introduction of the keyhole concept was a major step in the evolution of neurosurgery. This minimally invasive technique uses a small (3- to 5-cm sized) surgical incision and craniotomy, positioned after careful preoperative planning to optimally expose the intracranial lesion. As part of this concept, the supraciliary approach (eyebrow incision) was developed to access the anterior and middle fossa for the surgical treatment of aneurysms, frontobasal, suprasellar, or parasellar tumors. In our Institute, the supraciliary approach was introduced in the beginning of the 2000s for frontobasal tumors and aneurysms of the Willis-circle. As we found, the supraciliary exposure provides adequate access to intracranial extensions of tumors invading both the sinonasal area and the anterior fossa. This resulted in the development of a combined method of the supraciliary and transfacial exposure as a minimally invasive approach for the treatment of such surgically complex tumors. Even though in the hereby proposed combined technique (where the supraciliary incision is connected to the facial incision) the nerves passing through the supraorbital notch are necessarily divided, in our experience, the majority of the function comes back within a few months in most of the patients. We experience that this technique provides a convenient anatomical access for a reliable, watertight sealing of the dura even in such a difficult site as that above the lamina cribrosa. In selected cases, with relatively simpler anatomical situation, an isolated lateral (thus nerve-saving) supraciliary incision would

be sufficient and thus also can be recommended in conjunction with the proposed limited transfacial approach.

Extended Endoscopic Approaches

With the emergence and expanding experience in the field of endoscopic endonasal approaches, it has become increasingly possible to access multiple previously endoscopically less accessible intracranial regions, including the anterior fossa, via techniques referred to as extended endonasal approaches (EEAs). Accordingly, EEA, as a minimally invasive approach, can be suitable in experienced hands for the treatment of tumors invading both the anterior fossa and the sinonasal area. However, the use of EEA is limited by the locoregional extension of the pathology.Furthermore, the rate of postoperative CSF leak, as the most common complication after EEA, has been reported to be remarkably greater compared with open transcranial surgical procedures, especially in reports before the development of endoscopic reconstructive skull base techniques. Our team has more than 10 years of experience with endoscopic endonasal approaches and has increasing experience with EEA for the resection of tumors of the anterior fossa. To our observation, the duration of the surgical procedure with an EEA may be remarkably greater compared with the craniofacial approach presented here, especially in cases in which dural reconstruction is needed. Especially for such rare and anatomically complex conditions that invade both the sinonasal area and the anterior fossa, our proposed combined minimally invasive open craniofacial approach might be a suitable technique for a broader range of rhinologic and neurosurgical communities, even for centers with limited patient volume.

V. CONCLUSIONS

V.1. Conclusion

Based on our experience, the foundation of the success of the operation include, careful endocrinological preparation and post-operative care, as well as intraoperative alternation of microscopic and endoscopic techniques as needed. The combination of the two techniques and the use of posterior transeptal-transsphenoid exploration, fully complies with the minimally invasive principles and thus provides the surgeon with continuous, ideal adaptation to the current situation, while providing the patient with the surest healing opportunity.

V.2. Conclusion

In our case study, we report on our experience with endoscopic removal of a skull base tumor located in the frontal skull base, discussing its benefits and potentially dangerous complications. In general, we can conclude that endoscopic skull base surgery cannot yet replace standard microsurgery. But with correct indication, in some cases, it can replace or complete the existing surgical repository of the underlying pathological lesions affecting the skull base. After reviewing the data from different literature, this is the first reported case in Hungary for the endoscopic transsphenoidal removal of a skull base meningoma and the nasoseptal *Hadad* lobe skull base reconstruction.

V.3. Conclusion

The main goal in sinonasal and skull base surgery include being radical, while at the same time, being as minimally invasive as possible, while retaining functionality. Our results, presented as a whole, indicate the successful

application of the novelty of the minimally invasive and time-saving combination of supraciliary keyhole surgery and limited facial translocation. The resulting being: an overall low mortality rate, a good 3-year survival rate, a high frequency of gross total tumor removal, along with satisfactory results in secondary outcome measures, such as post-operative complications, hospital stay, and esthetic results. Based on these, we highly recommend this combination technique for widespread use in the surgical treatment of tumors involving both the sinonasal area and the anterior cranial fossa, especially in extensive cases falling out of evidence for wholly endoscopic surgery, and for neurosurgical units in centers with limited patient volume.

NEW RESULTS (according to the aims of this thesis)

1. In the pituitary surgery, we had an early opportunity to use the endoscope, thanks to the start of the nasal endoscopic surgery in the oto-rhino-laryngology and head-neck-surgery department here, in Szeged. In the initial period, we used only an endoscope to identify anatomical structures and developmental variations in the first phase of surgery. Based on our positive experiences with this, the use of the endoscope was gradually extended to sphenoidotomy and then to intrasellar tumor removal.

2. Introducing the use of an endoscope is a great help in mapping pre- and intraoperative anatomy, as it brings the operative area "near the instrument" and lateral recesses can be seen with the help of angular optics.

   In addition to the introduction of the endoscopic technique, the unique advantages of binocular (stereo) vision and excellent depth of field, were preserved by using a microscope as needed. In

addition to these, the hydroscopy applied in the sinus cavity also offers the possibility of a 180 ° view for residual tumor parts, even in cases of minor bleeding.
The alternate use of the two interventions at every stage, with maximum adaptation to the given anatomical and pathological situations, allows for the most appropriate exploration.

3. Expanding the endoscopic techniques of pituitary surgery, is an opportunity for advancement, especially for the endoscopically assisted removal of tumors affecting the frontal skull base. The combined endoscopic and microscopic surgery of pituitary tumors, used routinely, and with our endoscopic experience with surgery on intracranial ventricules, we have extended the use of endoscope to the treatment of cranial base tumors.
4. For neuroendoscopic interventions, the surgeon's perfect anatomical orientation, excellent endoscopic practice (joint team training, gradual learning curve) and the use of the latest technical equipment, are essential.
To this end, necessary and further training, as well as cadaver exercises for level courses, have been developed.

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