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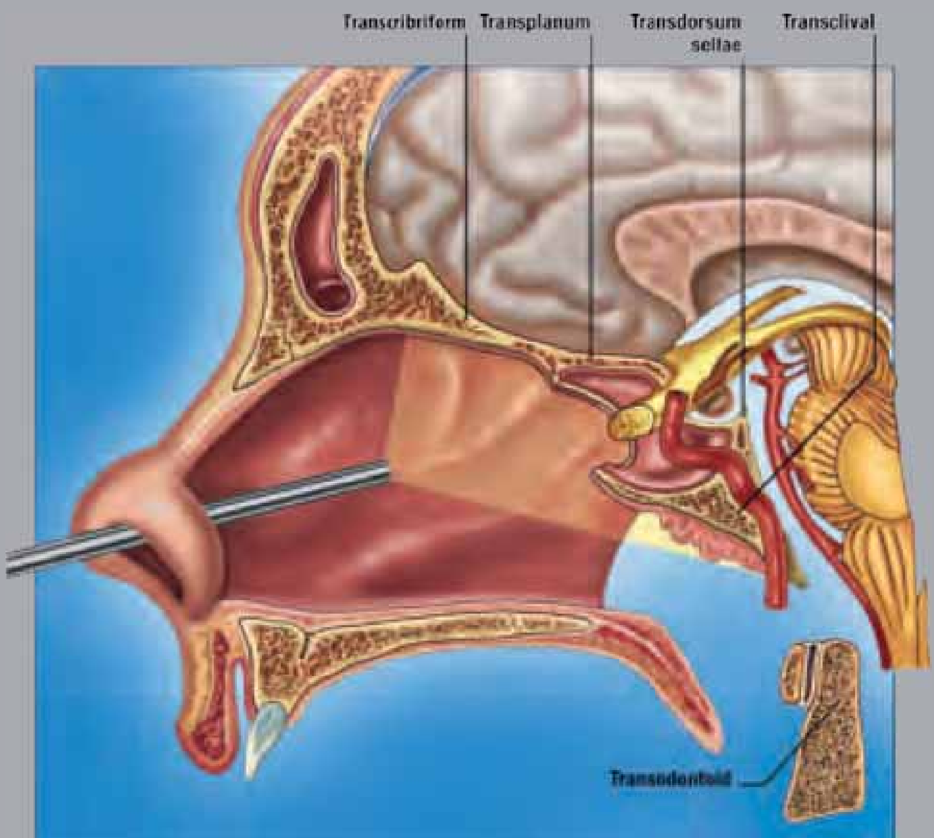
THE EXPANDED ENDONASAL APPROACH TO THE VENTRAL SKULL BASE: SAGITTAL PLANE



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1.0 Introduction

There is an ongoing revolution in multiple surgical specialties with the introduction of minimally invasive techniques. In otolaryngology, endoscopic sinus surgery is increasingly being used for the treatment of inflammatory as well as neoplastic disease. A natural extension of endoscopic sinus surgery has been the application of endoscopic techniques to the surgical treatment of pathologic conditions of the cranial base. In large part, this has been driven by the development of endoscopic technology. Increasingly, it is being driven by consumer demand. As the limits of endoscopic surgery are tested, the possibilities for cranial base surgery are expanded. It is wrong to think of this as minimally invasive surgery; it is truly **maximally** invasive endoscopic surgery.

Advances in cranial base surgery over the last two decades have only been possible with the collaboration of multiple surgical specialties[1]. This is even more apparent with endoscopic skull base surgery. Rather than working sequentially as is often done with open approaches, surgeons from different specialties work together simultaneously as a team: one person maintaining a view with the endoscope and the other working bimanually to dissect the tissues. The benefits of true team surgery include improved visualization, increased efficiency, and the ability to deal with a crisis such as a vascular injury. There is added value of having a "co-pilot" for problem-solving, avoiding complications, and modulating enthusiasm.

The primary advantage of the endoscope compared to other methods is improved visualization. Improved visualization results in increased access to difficult to reach areas, and may facilitate complete tumor resection and avoidance of complications due to poor visualization. Other potential benefits of endoscopic surgery include improved cosmesis and decreased morbidity from tissue trauma and manipulation of vessels and nerves. The consequences of decreased morbidity are a faster recovery, shortened hospitalization, and decreased cost of medical care.

Familiarity with endoscopic anatomy, proper instrumentation, an experienced surgical team, and adherence to endoscopic surgical principles are essential ingredients for avoiding severe complications. The basic principle of endoscopic cranial base surgery is internal debulking of tumors to allow extracapsular dissection of the tumor margin with early identification of neural and vascular structures. This principle is the same for open neurosurgical procedures and sharp dissection of tumor margins is performed without pulling on tumors. Adherence to this fundamental principle minimizes the risk of neural or vascular injury.

Since 1998, we have performed over 700 completely endoscopic cranial base procedures at the University of Pittsburgh Medical Center for a wide variety of pathologies (**Tab. 2**). The most common approaches are transsellar and transplanum approaches for pituitary macroadenomas and meningiomas, transclival approaches for chordomas, and "craniofacial" resections for sinonasal malignancies.

This booklet will outline the **E**xpanded **E**ndonasal **A**pproach (**EEA**), a completely endoscopic transnasal approach, providing access to the entire ventral skull base[2–4]. Anatomical subunits or surgical modules are defined based on their orientation in sagittal (midline) and coronal (paramedian) planes (**Tab. 1**).

Tab. 1: Classification of Endoscopic Approaches

Sagittal Plane (Midline)	Coronal Plane (Paramedian)
• Transfrontal	• Transorbital
• Transcribriform	• Petrous apex (medial transpetrous)
• Transplanum (suprasellar/ subchiasmatic)	• Transcavernous
• Transsphenoidal (sellar/ transcavernous)	• Transpterygoid
• Transclival	• Transpetrous
• Posterior clinoid/transdorsal	• Suprapetrous
• Mid-clivus	• Infrapetrous
• Cervicomedullary junction	• Parapharyngeal space
• Foramen magnum	
• Transodontoid	

Tab. 2: Pathology: Expanded Endonasal Approach

Trauma	• Cerebrospinal fluid leak • Optic nerve decompression
Infection	• Epidural abscess • Osteomyelitis
Inflammatory sinus disease	• Mucocoele • Allergic fungal sinusitis
Benign neoplasms	• Pituitary adenoma • Fibro-osseous lesions • Meningioma • Craniopharyngioma • Angiofibroma
Malignant neoplasms	• Sinonasal malignancies • Esthesioneuroblastoma • Chordoma • Chondrosarcoma • Metastases
Miscellaneous	• Rathke's cyst • Dermoid cyst • Arteriovenous malformation • Epidermoid

The sphenoid sinus is the epicenter and the starting point for all of these approaches. Key anatomical landmarks of the sphenoid sinus include the optic nerve and internal carotid artery. The limits of surgery extend from the frontal sinus and crista galli rostrally, to the second cervical vertebra in the sagittal plane and from the sella through the infratemporal fossa to the jugular foramen in the coronal plane. At the level of the cervicomedullary junction, the coronal plane extends through the lateral mass of C1.

Historically, these approaches developed as an extension of our experience with endoscopic transnasal approaches to the pituitary fossa, combined with our experience with traditional microscopic skull base techniques. The EEA **provides** surgical access to the ventral skull base to resect a wide variety of intradural and extradural pathologies and allows the reconstruction of the resulting defect. The evolution of these techniques has been enabled by technological advances including the design of specific endonasal instrumentation, surgical navigation technology and the development of new biomaterials for reconstruction.

Analysis of surgical outcomes has led to continual refinements of the techniques and their indications.This booklet will address key anatomical relationships of the ventral skull base comprising the area between the crista galli and the craniovertebral junction (CVJ), technical nuances of the EEA, and the instrumentation required during the approach, resection and reconstruction phases of endonasal surgery for extradural and intradural lesions. We will begin with the description of our two surgeon binarial approach to the sphenoid sinus as this is the common starting point for most procedures. Then, we will describe our technique for the resection of intrasellar lesions providing a discussion of general endoneurosurgical principles. This will provide a foundation for understanding and applying our modular EEA.

These modules can be used individually or in combination based on the origin, extension and histopathology of the lesion. Finally, we will discuss the most frequent complications and current limitations of the EEA, and provide some direction for the future evolution of these techniques.

At the onset it is important to define “endoneurosurgery”. This is a new and emerging field and represents the use of the endoscope as the sole and only tool used to visualize the entire neural axis. In the case of EEA in the Silver book and all the material shown and discussed, only the endoscope is used to access the ventral skull via a completely transnasal route. The microscope has not been used for any of these procedures.

2.0 Historical Perspective

In the early 1900’s, *Halstead* used the transnasal corridor to access the pituitary gland, an approach that was later popularized by *Cushing*. During this early stage, a large corridor was provided by a sublabial transeptal transsphenoidal approach. A wide corridor was critical in order to deliver adequate light and magnification, which at the time were provided by a head light and loupes. A transnasal transeptal approach was subsequently described, eliminating the need for the sublabial incision and midfacial degloving with its attendant morbidity. A transnasal transeptal approach, however, provides a much narrower corridor that limits the delivery of light and restricts the surgical field. Early transnasal approaches were not widely accepted due to their morbidity and difficulties with visualization.

A milestone was marked by the emergence of the microscope as a visualization tool. *Jules Hardy* championed and standardized the use of the operating microscope, thus establishing the microscopic transnasal transeptal approach as the preferred route to the sella turcica. This approach remained as the gold standard for the resection of intrasellar pituitary tumors until recently. Others extended the indications of the transnasal transeptal approaches to lesions beyond the sella; thereby expanding the indications to other types of histopathology. These new indications were restricted by the inherent characteristics of the microscope, which creates a “cone of light” that converges on the surgical field. Despite its advantages over the use of a headlight and surgical loupes, the microscopic approaches require a relatively large corridor for the delivery of sufficient light and the surgical field is limited by the line of sight. Rod lens endoscopy represents the next milestone in the historical development of endonasal approaches. In the 1980’s, spearheaded by the pioneering work of *Messerklinger* and *Wigand* and continued by *Stammberger*, *Kennedy*, and others, the rod lens endoscope became the primary visualization tool for surgery of the sinonasal tract. Sinonasal surgeons capitalized on the endoscope’s ability to deliver light and magnification to the surgical site through a small corridor. The optical characteristics of the endoscope obviated the need for a wide surgical corridor and allowed visualization beyond the confines of a microscopic view. Early applications of the endoscopic transnasal approach, pioneered by *Sethi*, *Jho* and *Carrau*, *Frank* and *Pasquini,* and *Cappabianca* and *de Devitiis,* were primarily restricted to lesions within the pituitary fossa.

Several obstacles impeded the expansion of the indications for the endoscopic approaches. An important barrier was the lack of understanding of endoscopic anatomy of the skull base viewed from the “other side” of the skull base without the benefit of binocular depth perception. Conceptualization and integration of two-dimensional endoscopic images into a three dimensional mental model was facilitated by the introduction of computer-based navigational systems. Concurrently, the development of instrumentation designed specifically to address the needs of the EEA enhanced our ability to safely dissect in the deep recesses of the ventral skull base. Other obstacles included the lack of experience of neurosurgeons (and skull base teams) with endoscopes and valid concerns about the ability to deal with hemorrhage and reconstruct large cranial base defects endoscopically.

Surgical approaches to the ventral skull base emerged from the interaction of four critical elements: the surgical corridor, the visualization tool, instrumentation, and reconstructive needs (i.e. separation of the subarachnoid and/ or intracranial space from the sinonasal tract). One should consider that all these elements are in a state of flux; hence, the approach continues to evolve further as changes occur with any of these elements.

3.0 Patient Selection

The EEA facilitates the initial diagnosis of skull base lesions and avoids the added morbidity of an open approach for diagnosis and treatment when the diagnosis cannot be ascertained preoperatively. An endoscopic biopsy can be performed with minimal morbidity and allows proper diagnosis and treatment planning, especially for lesions that are best treated by other means (plasmacytoma, lymphoma, infection, etc) or are judged to be too extensive for surgical therapy.

We use the EEA to treat a wide variety of neoplastic and non-neoplastic pathologies (**Tab. 2**). In our experience, the most common non-neoplastic diagnosis (other than inflammatory sinus disease) is a cerebral spinal fluid (CSF) leak (traumatic, iatrogenic, and spontaneous). The most common benign neoplasms are pituitary adenomas, meningiomas, craniopharyngiomas, and fibro-osseous tumors. Chordomas, esthesioneuroblastomas and sinonasal cancers with cranial base involvement are the most frequent malignant neoplasms treated with the EEA. The role of endoscopic techniques for the treatment of benign extradural neoplasms and CSF leaks has become well established and is now the preferred technique in most centers. Data regarding their role for malignancies of the sinonasal tract that extend to the skull base and for intradural tumors, either benign or malignant, is limited. Although early results are promising, additional outcomes data with adequate follow up from multiple centers is necessary before drawing any conclusions. The indications and limitations of the EEA, as well as the techniques themselves, will continue to evolve as new data is collected and technologies advance.

There are few absolute contraindications for the use of EEA for the surgical management of pathological conditions of the ventral skull base. Any pathology that is located distal or deep to critical neurovascular structures is usually best operated using a different approach; therefore, lesions that are located lateral to the optic nerve are usually not amenable to an endoscopic resection unless the pathology has displaced the critical anatomical structures and created a sufficient corridor. EEAs are ideal for lesions where the critical neurovascular structures are on the perimeter of the tumor, thus allowing for direct access to the tumor with minimal manipulation of normal neurovascular structures. Currently, EEAs are contraindicated when resection or reconstruction of a major vessel is needed. When a neoplasm involves superficial tissues, an open approach may be more practical and may be combined with an endoscopic approach.

In principle there are two factors that must be considered when planning the surgical approach: patient/tumor characteristics and the surgical experience of the operating team

Patient/Tumor Characteristics

General health and co-morbidities should be evaluated and their management optimized before surgery. The patient must be in adequate health to undergo surgery under general anesthesia. Inflammatory sinus disease should be treated, either medically or surgically, prior to endoscopic transcranial surgery to minimize the risk of intracranial infection.

Tumor volume has not been a limiting factor in appropriately selected cases. Tumors that are fibrotic or highly vascular are more difficult to dissect but can be safely resected using endoscopic techniques providing the team is experienced. Endoscopic surgery is predicated on the surgical team's experience, which is best acquired in clearly defined increments (as described later) (**Tab. 3**). Malignant neoplasms that require an orbital exenteration, resection of facial soft tissues, or that extend to the frontal bone or lateral recess of the frontal sinus are better approached with traditional techniques. Trans-nasal endoscopy, however, may play an adjunctive role. Invasion of the dura and/or brain represent the same limitation as they would for any traditional or other minimally invasive approaches. Brain invasion is not currently a specific contraindication.

Experience of the Surgical Team

The training and experience of the surgical team are of paramount importance in selecting a surgical approach. We recommend a systematic and incremental training program that requires mastery of a level before proceeding to the next level (**Tab. 3**). In addition to providing essential endoscopic skills (hemostasis, dural repair), lower level procedures reinforce anatomical knowledge and allow the surgeons to learn to function as a team. The training levels coincide with the surgical modules of the EEA and provide prerequisite skills for the next training level. The performance of a higher level procedure by a *single* surgeon (as opposed to a team) is not recommended due to the potential for disaster if there is a vascular injury.

The presence of adequate institutional support is also an important consideration. A suitable operating room environment with adequate staffing, flexible scheduling, dedicated personnel, proper equipment and endoscopic instruments, and available ancillary services (interventional neuroradiology, pathology, etc) should be present. We also believe strongly that the same endoscopic surgeon must be able to offer the patient the corresponding open procedure. If the same team cannot undertake removal of the lesion via a conventional open procedure, there is no way for the team to be aware of the advantages of the endoscopic approach, i.e. the same team must be able to perform both approaches to avoid any bias.

Tab. 3: Endonasal Skull Base Surgery Training Program

Level I:	• Endoscopic sinonasal surgery • Endoscopic sphenoethmoidectomy • Sphenopalatine artery ligation • Endoscopic frontal sinusotomy
Level II:	• Cerebrospinal fluid leaks • Lateral recess sphenoid • Pituitary surgery
Level III: Extradural	• Medial orbital decompression • Optic nerve decompression • Petrous apex (medial expansion) • Transclival approaches (extradural) • Transodontoid approach (extradural)
Level IV: Intradural	**A** Presence of a cortical cuff • Transplanum approach • Transcribriform approach • Pre-infundibular craniopharyngiomas **B** Absence of cortical cuff (direct vascular contact) • Transplanum approach • Transcribriform approach • Infundibular and retro-infundibular craniopharyngiomas • Transclival approach • Foramen magnum approach
Level V: Cerebro-vascular surgery	**A** Coronal plane (paramedian) • Suprapetrous and infrapetrous carotid approaches • Transpterygoid approach • Inferotemporal fossa approach • Jugular foramen approach • Hypoglossal canal approach **B** Vascular disease • Aneurysms • Vascular malformations

Fig. 1a
The operating room is configured to provide maximal access to the nasal region for two surgeons.

Fig. 1b
Multiple viewing monitors provide comfortable viewing for surgeons and operating room personnel.

4.0 Preoperative Preparation

4.1 Patient Positioning and Preparation

We use frameless stereotactic image guidance (IG) in all EEAs. We find IG of value in corroborating the visual impression of the surgical anatomy, especially critical neurovascular structures, and to help define a targeted resection. We prefer a high resolution CT angiogram for most skull base surgeries, as it allows for the simultaneous visualization of osseous, vascular and soft-tissue anatomy. An exception is that of pituitary adenomas, for which we use MRI, as soft-tissue definition is of paramount importance. Increasingly, we utilize image fusion of CT and MRI scans to capitalize on the best features of each: CT for the bony anatomy of the cranial base and MRI for intracranial tumor margins. Critical features that must be considered when selecting an image guidance system for EEAs are discussed in the section dedicated to equipment. Currently, we use an optical tracking (LED) system with a registration based on fiducial markers or a registration mask. If fiducials are used, the patient is scanned the day of the surgery or the evening before. This also requires rigid fixation of the head to preserve the initial registration throughout the surgery.

Fig. 1c
Intra-operative use of a telestration monitor allows for improved communication among surgeons, enhances teaching and aids in intra-operative planning.

4.2 Operating Room Setup

The operating room setup is shown in **Fig. 1a**. The surgeons are positioned on the right side of the patient opposite the anesthesia team. The surgical technician or nurse is positioned towards the foot of the bed. This arrangement gives the surgeons unhindered access to the nasal region. The operating room is specifically designed for endoneurosurgery and includes separate viewing monitors for each surgeon and the operating room staff (**Fig. 1b**). Additional monitors for image guidance and telestration are positioned at the head of the patient. The telestration monitor can be sterilely draped to allow highlighting of anatomical structures on all of the monitor displays (**Fig. 1c**). This facilitates communication between the surgeons and is an excellent teaching tool. Some surgeons may prefer to operate in a sitting position or on opposite sides of the table. Electrical cords and suction tubing are directed away from the surgical field toward the head and foot of the bed to minimize interference with surgical instruments.

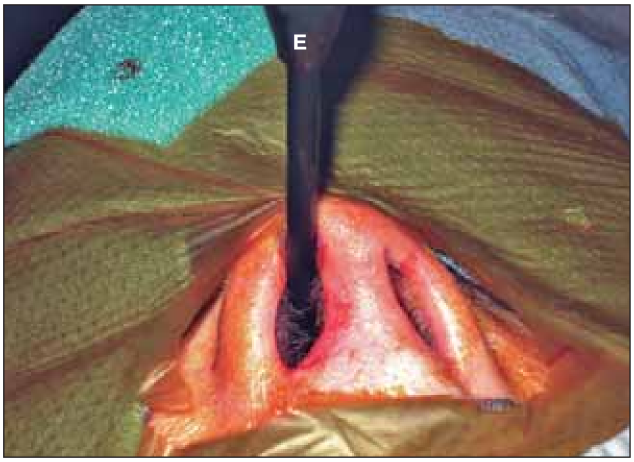

Fig. 2a
The endoscope (**E**) occupies the '12 o'clock' position and is used to retract the nasal vestibule anteriorly to elongate the nostril. The suction tip and other instruments can be introduced below the endoscope.

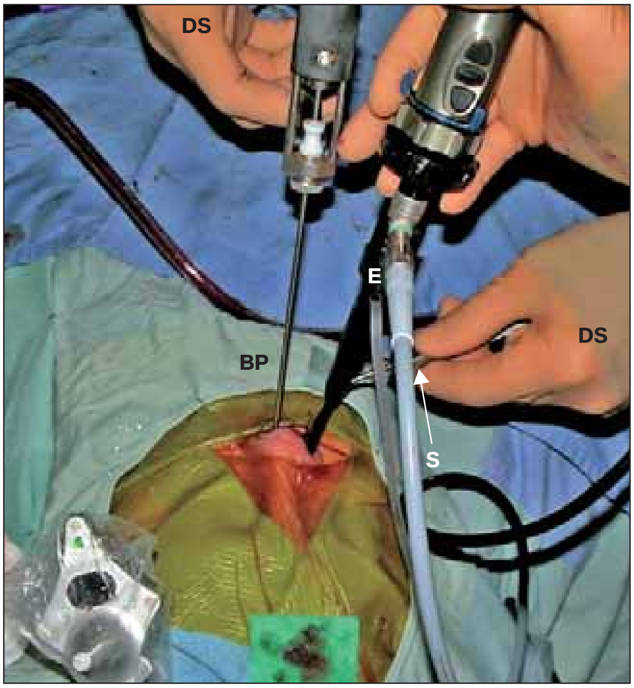

Fig. 2b
The dissecting surgeon (**DS**) uses a binarial approach with the endoscope (**E**) in the right nostril. Here, a suction (**S**) is in the right nostril and a bipolar (**BP**) electrocautery device is introduced in the left nostril.

We favor the use of a three pin fixation system to reduce the intraoperative movement of the head, especially during drilling and neurovascular dissection. The head is fixed following endotracheal intubation, with the neck in slight extension, turned to the right by 10–15 degrees, and with the patient as close to the right side of the surgical bed as possible. Greater extension of the neck is advisable if the lesion extends anterior to the cribriform plate or if a frontal sinusotomy is necessary, as this provides a better angle for the visualization of the most anterior skull base and frontal sinus. Flexion of the neck is helpful for low endonasal approaches to the upper cervical spine. These positioning suggestions help the surgeon to position him or herself in a manner that avoids strain and fatigue of the surgeon's back, neck and hands. Similarly, to avoid undue strain of the surgeon's neck, the display monitors should be facing the surgeons at eye level.

Neurophysiological monitoring of cortical function (somatosensory-evoked potentials) with/without brainstem function (brainstem-evoked responses) is routinely performed in all cases with exposure of the dura or dissection near the carotid arteries. Neurophysiological monitoring can identify changes in cerebral blood flow that may occur with blood loss or changes in blood pressure and alert the anesthesiologist to make adjustments. Monitoring of cranial nerves with electromyography is performed as appropriate.

A nasal decongestant, such as oxymetazoline 0.5%, is applied topically to the nasal mucosa using cottonoids. The skin of the external nose and nasal vestibule as well as the abdomen (fat graft donor site) is prepped with a povidone antiseptic solution. The patient is given a fourth generation cephalosporin for perioperative antibiotic prophylaxis.

5.0 Operative Procedure

5.1 General Principles

General Exposure

Two concepts are critical for the endoscopic exposure: bilateral nasal access (binarial) to allow for a two-surgeon, four-hand technique, and the maximum removal of bone at the skull base to create a wide surgical corridor. The former allows a bimanual dissection technique and the dynamic movement of the scope to provide optimal visualization of the surgical field at all times during the surgical procedure. The latter maximizes exposure of key anatomical structures and prevents crowding of instruments. This helps to avoid interference of the movement of the dissecting instruments by the presence of the scope, minimizes soiling of the lens of the endoscope, and helps to provide unobstructed and direct access to any neurovascular structure within the surgical field. This becomes more critical if there is a bleeding complication, so that the surgeons can maintain visualization while controlling the hemorrhage and avoiding injury to adjacent structures.

With the two-surgeon, four-hand binarial technique, we make optimal use of the available nasal corridor, from the anterior nares to the posterior choanae. The endoscope is introduced at the "12 o'clock" position of the nostril (usually the right) and is used to retract the nasal vestibule superiorly; therefore, elongating the nostril and increasing the available space for other instruments (**Fig. 2a**). A suction tip is introduced at the "6 o'clock" position on the same side. Dissecting instruments can be introduced through the left nasal cavity (**Fig. 2b**).

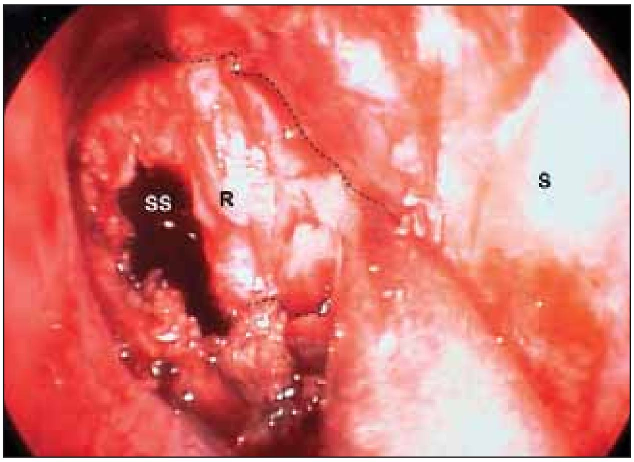

Fig. 3a
The posterior septum (**S**) is incised with a Cottle instrument and disarticulated from the rostrum (**R**) of the sphenoid bone.
The sphenoid sinus (**SS**) is subsequently opened. The dashed line is showing the posterior edge of the septum after it was disarticulated from the rostrum.

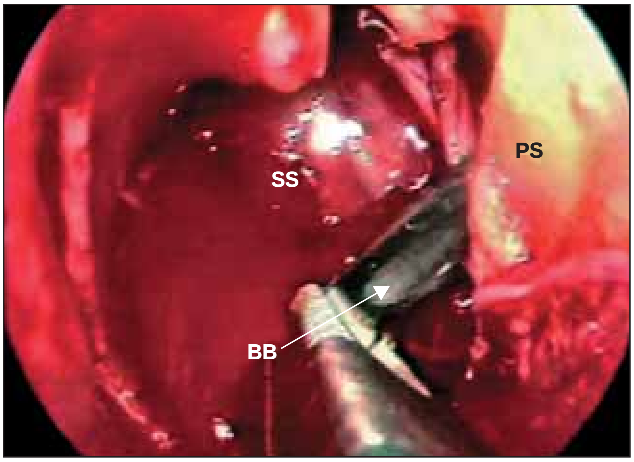

Fig. 3b
The posterior edge of the nasal septum (1 – 2 cm) is resected with back-biting forceps to provide room for instrumentation and improve visualization. (**SS**) sphenoid sinus, (**BB**) back biter, (**PS**) posterior septum.

A suction irrigation sheath or continual irrigation by an assistant or co-surgeon cleans the lens of the scope and preserves visualization without having to remove the scope for frequent cleaning.

If, for any reason, a bimanual (preferably binarial) approach cannot be pursued then proceeding further is absolutely contraindicated. Furthermore, we strongly argue against and discourage the use of an endoscopic holder for all EEAs.

Widening of the nasal corridor is achieved initially by out-fracturing of the inferior turbinates, followed by the removal of one or both middle turbinates to provide room for the endoscope. A formal septoplasty is rarely necessary but septal spurs are removed if they are obstructive. These steps provide a wider access to the posterior nasal cavity including the sphenoethmoid recess and the posterior choanae. Injection of vasoconstrictors is optional and is performed according to the surgeon's preference.

A sphenoidotomy is initiated by identifying and enlarging the natural ostium of the sphenoid sinus or by entering the sphenoid at the junction of the nasal septum and the rostrum of the sphenoid sinus. A Cottle instrument is used to incise and disarticulate the posterior septum from the rostrum of the sphenoid bone (**Fig. 3a**). Removal of the bony rostrum is completed using Kerrison rongeurs and/or a surgical drill. Wide bilateral sphenoidotomies are performed extending laterally to the level of the medial pterygoid plates and lateral wall of the sphenoid sinus, superiorly to the level of the planum sphenoidale and inferiorly to the floor of the sphenoid sinus. The posterior edge of the nasal septum (1– 2 cm) is resected with backbiting forceps (**Fig. 3b**). The posterior septectomy facilitates bilateral instrumentation without displacing the septum into the path of the endoscope, and increases the lateral angulation and range of motion of instruments. Wide bilateral sphenoidotomies and a posterior septectomy provide bilateral access and visualization of key anatomical structures (optic nerves and internal carotid arteries) (**Fig. 3c**).

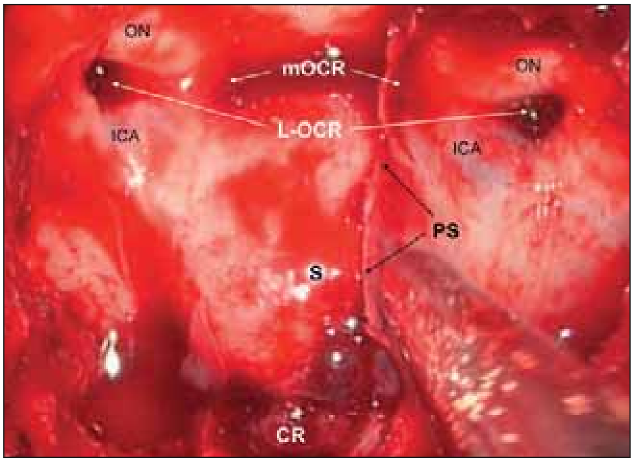

Fig. 3c
Intra-operative photograph taken after completion of a standard wide bilateral sphenoidotomy. A paramedian septum (**PS**) leading to the junction of the left optic nerve (**ON**) and internal carotid artery (**ICA**) can be seen. The sphenoid mucosa has been removed allowing for the identification of the key anatomical landmarks including the lateral optic-carotid recess (**L-OCR**) and the medial optic-carotid recess (**mOCR**), the sella face (**S**), the planum sphenoidale (**P**), and the clival recess (**CR**).

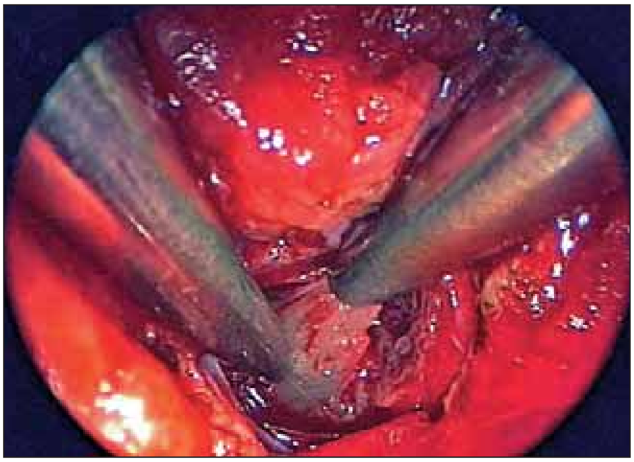

Fig. 4a
Two-suction technique for tumor resection. Note that the right-handed suction is providing traction while the other suction is dissecting soft tumor.

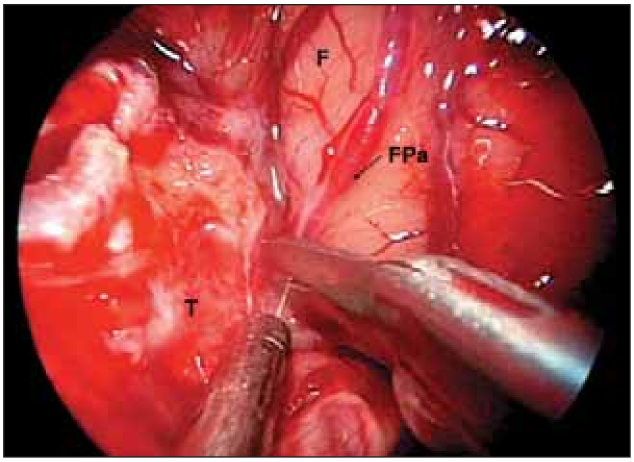

Fig. 4b
Sharp dissection is utilized to allow for extracapsular dissection. Note, that the suction provides retraction of the tumor (**T**) and tension along the band. The fronto-polar artery (**FPa**) is preserved along the frontal lobe (**F**) while an olfactory groove meningioma (**T**) is being removed.

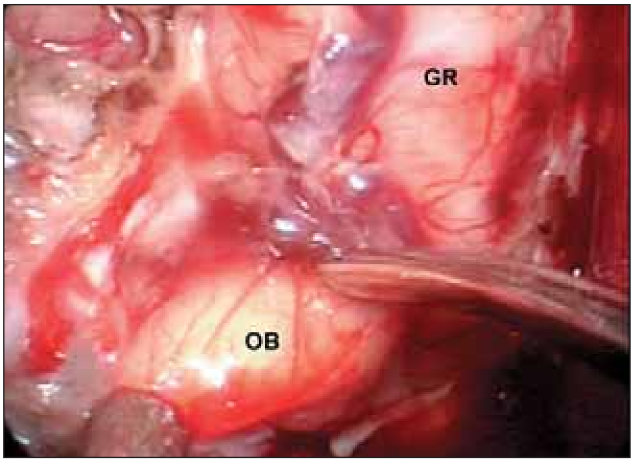

Fig. 4c
A blunt dissector is being utilized to establish a dissection plane between a left olfactory bulb (**OB**) invaded by cancer and the gyrus rectus (**GR**).

5.2 Intradural Endoneurosurgical Dissection Techniques

Microneurosurgical techniques for tumor removal include the internal debulking of the tumors, followed by the mobilization of the tumor capsule to allow early identification and extracapsular dissection of neurovascular structures, and the coagulation and removal of the remaining capsule. This sequence is repeated multiple times until final sharp dissection of the residual capsule is completed. These time-proven techniques are designed to minimize the risk of injury to important structures and are critical elements for the removal of any tumor with any surgical approach. Endoneurosurgical tumor removal adheres to the same dissection principles of open approaches and avoids blind dissection of tumors from vessels and nerves. Under no circumstances are tumors extracted by pulling without seeing the underlying structures. If the technique above cannot be performed the resection *must* be abandoned.

Different methods and instrumentation may be used for the debulking of the lesion, depending on the surgeon's preference, site of involvement, and consistency of the tumor. In our experience, a two-suction debulking technique has proven to be the safest and gentlest dissection technique. A small diameter suction tip is used in the left hand (non-dominant) to maintain gentle traction while a dissecting or debulking instrument is used in the right hand (**Fig. 4a**). For the debulking of soft lesions, such as pituitary tumors, a 6–8 French suction is adequate. Malleable suctions allow for distal angulation to improve the range of access (see Equipment section) and provide more room for the tip of the endoscope. An ultrasonic aspirator, with a tip that was specifically designed for the EEA (see Equipment section) can be used for firmer tumors. Occasionally, the intra-capsular tumor can be morselized using fine cutting forceps.

Internal debulking is continued until the capsule can be mobilized freely using gentle traction applied with the tip of a 4–6 Fr suction. It should be emphasized that traction should be applied using suction and not by using a grasping instrument. This prevents the potential disastrous complication of tearing extracapsular vessels on the back side of the tumor, which can then retract and bleed into the parenchyma. Sharp dissection is utilized to divide intratumoral bands and allow extracapsular dissection (**Fig. 4b**). Extracapsular dissection should be done sharply whenever possible or, alternatively, with a fine blunt endoscopic dissector (see Equipment section) (**Fig. 4c**). A second 4 Fr suction in the dominant hand can prove to be an effective blunt dissector also.

Critical neurovascular structures are then identified and protected using small pledgets. We prefer a synthetic collagen material (Duragen) that is easy to manipulate and does not stick to the structures. The tumor capsule is coagulated using the appropriately shaped endoscopic bipolar cautery (see Equipment section). Continuous irrigation is critical to avoid thermal injury to important neurovascular structures from the heat produced by the cauterization.

It must be emphasized that these endoneurosurgical dissection techniques should not be compromised in order to achieve a greater degree of tumor resection. If the tumor cannot be removed using these well established principles, the EEA is not the optimal approach for the tumor resection and alternatives should be considered. Furthermore, the preoperative goals of surgery must be clearly borne in mind. Specifically, based on tumor type, patient's age and preoperative symptoms, the goals of surgery should be established and respected. It is important to remember that the use of an endoscope does not change these goals or the nature of the underlying pathology.

5.3 Hemostatic Techniques

Preoperative strategies include devascularization of the tumor by angiographic embolization of the vascular supply when possible. The majority of tumors, however, receive blood supply from the intracranial circulation (internal carotid artery, ophthalmic artery) and embolization is either not possible or too risky. With EEA, circumferential exposure of tumors has obviated the need for embolization in the majority of cases.

The ability to achieve adequate intraoperative hemostasis during EEA, particularly for intradural tumors, has been one of our most important advancements. The first step is to devascularize the tumor as part of the approach or sequentially during the resection. Bulky intranasal tumors are first partially resected to expose the dural base. Initial hemostasis is achieved with bipolar electrocautery. The margins of the tumor can then be dissected circumferentially to identify and ligate/ cauterize the feeding arterial vessels. This concept is exemplified by meningiomas of the anterior cranial base which can be highly vascular tumors. Bilateral ethmoidectomies and limited medial orbital decompressions allow endoscopic ligation of the anterior and posterior ethmoidal arteries. The hypertrophied bone of the anterior cranial base is then removed with the drill and the dura is cauterized to effectively devascularize the tumor. Intracapsular tumor dissection is often then performed in a relatively bloodless field.

Hemostatic techniques have been developed to control specific capillary, venous and arterial bleeding, all of which are commonly encountered during EEA (**Fig. 5**).

Fig. 5
Various devices and materials are used for hemostasis.
① Hopkins® telescope
② Bipolar forceps
③ Hemoclip applier
④ Fibrillar collagen sandwiches
⑤ Surgifoam

Capillary and Venous Hemostasis

Diffuse capillary or venous bleeding arising from mucosa or bone responds to irrigation with warm saline (40 °C). A water heater is used to maintain the temperature of the saline for irrigation. For extradural application this is delivered through any irrigation device such as a bulb syringe but for intradural irrigation we use the tubing of an external ventricular drain. More focal venous bleeding, such as that arising from the cavernous sinus, can be controlled with focal application of a hemostatic material such as microfibrillar collagen delivered on a small dry cottonoid. Microfibrillar collagen is placed on the inside of a dry cottonoid which is then folded to create a “sandwich”. The cottonoid is introduced in the nasal cavity and is then unfolded to apply the hemostatic agent to the bleeding point, while maintaining pressure over the cottonoid. Another “sandwich” is then applied over the first one, and they are exchanged with removal of the first one by pulling its string, while maintaining pressure over the new one. This exchange may need to be repeated multiple times until the bleeding is controlled. This technique is extremely effective for all venous bleeding and avoids excessive hemostatic material in the surgical field.

Arterial hemostasis

Arterial bleeding can be high flow or low flow. In the case of high-flow bleeding, it is critical to segmentalize the bleeding to a specific portion of the artery to allow for direct bipolar cauterization. Blood disperses the heat needed for effective cauterization; therefore, diffuse cauterization without identifying the injured segment of the vessel is usually not effective. Isolation of the bleeding source when there is brisk bleeding may require more than one suction and the participation of the co-surgeon. Arterial bleeding can be directed up the lumen of the suction to prevent loss of visualization from blood on the lens of the endoscope.

Once the field is relatively dry (with the extravasating blood running into the suction), and the tear of the vessel is clearly seen, then the bipolar electrocautery may be used effectively. Achieving hemostasis in this setting can only be accomplished with a cosurgeon managing the scope rather than an endoscopic holder. Techniques to control low flow arterial bleeding are a combination of all the techniques previously discussed. However one should consider that small perforators, from which this type of bleeding may arise, often are located close to critical neurovascular structures. Avoidance of thermal injury to adjacent structures becomes paramount. Segmental packing can be used judiciously for low flow arterial bleeding. A variety of hemostatic materials, such as microfibrillar collagen, may be used for this purpose. We do not “pack” a wound, however, unless the packing can be applied focally with no possibility of the vessel retracting or allowing retrograde bleeding into the brain parenchyma.

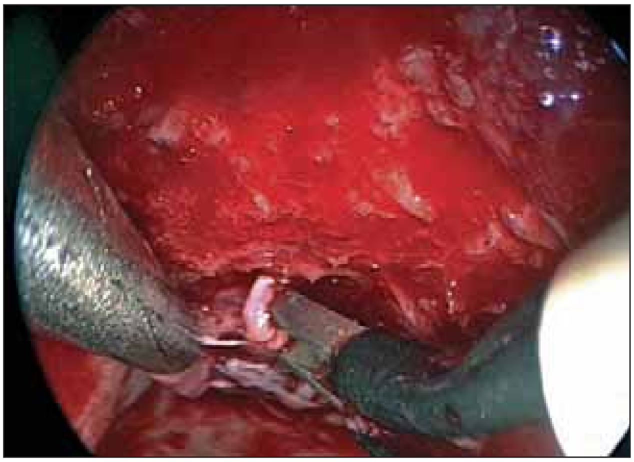

Fig. 6a
Intra-operative photograph demonstrating the use of a pistol grip endoscopic bipolar for the cauterization of tumor in a transplanum approach.

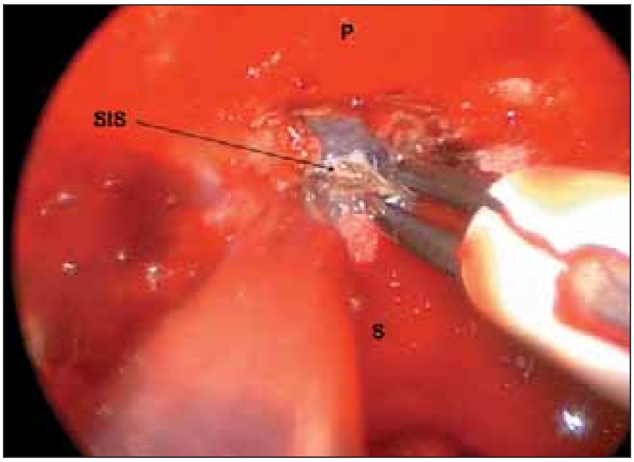

Fig. 6b
Intra-operative photograph demonstrating the fine bipolar being used to cauterize the superior intercavernous sinus (**SIS**) between the planum sphenoidale (**P**) and the sella turcica (**S**).

Tumor tissues are often cauterized prior to dissection; thus, preventing bleeding (**Fig. 6a, b**). Even the vascular channels of an intraosseous arteriovenous malformation can be individually cauterized. A bipolar electrocautery with a pistol-grip design must be part of the endoneurosurgery instrumentation tray. Standard bayonet designs close prematurely as they are introduced into the nostril and do not have an adequate angulation to reach into many of the areas of the nose and cranial cavity.

Prevention of catastrophic bleeding is avoided by a sound knowledge of the skull base anatomy and the performance of a dissection that proceeds from a well visualized territory to one that needs better exposure (from the known to the unknown). The endoneurosurgeon must adhere to the surgical principles that were previously outlined. After the central portion of a large tumor is debulked, its collapse facilitates dissection on the surface of the tumor capsule and its mobilization. Visualization of intracranial vessels that were initially obscured by the tumor allows their dissection from the tumor capsule with full control of the vessels (**Fig. 7**).

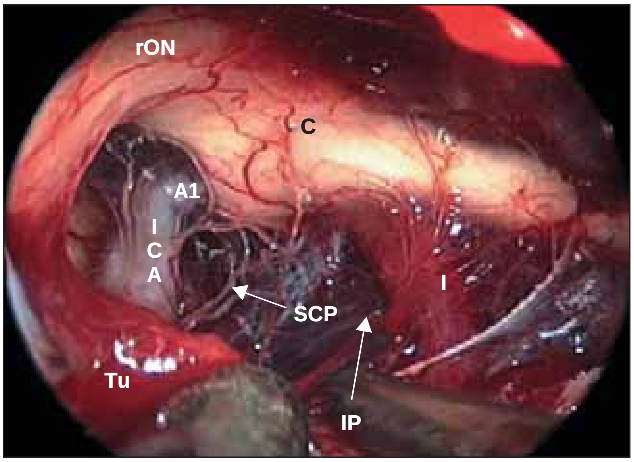

Fig. 7
Small subchiasmatic perforators (**SCP**) can be draped over the tumor (**Tu**) surface as seen in this intra-operative photograph. The optic chiasm (**C**), right optic nerve (**rON**), pituitary infundibulum (**I**), ICA and the anterior cerebral artery (**A1**) can also be seen. Infundibular perforators (**IP**), branches of the superior hypophyseal artery, can also be seen.

5.4 Pituitary and Sellar Surgery

Exposure

Once the general exposure is completed, we proceed with the exposure of the pituitary fossa. The objective of this exposure is to convert the sphenoid sinus into a large single rectangular cavity with walls that are completely flat, devoid of septations that would interfere with the visualization of neurovascular landmarks or with the movement of the scope or dissecting instruments (**Fig. 3c**). This becomes imperative in the event of bleeding, as it allows unhindered maneuverability of the endoscope and avoids soiling of the lens.

Full use of available space is made with widening of the sphenoidotomy toward the lateral recesses, lateral to the vertical carotid canal, and superiorly to expose the posterior cells of the ethmoid sinus, the planum-tuberculum junction and optic-carotid recesses. Finally the floor of sphenoid is reduced back to the level of the clivus. This step is particularly useful when emoving macroadenomas with significant suprasellar extension, as it allows for a greater caudal to rostral access into the suprasellar space. Any remaining sinus septations can be reduced with the drill, keeping in mind that most paramedian septations are directed to the vertical canal of the internal carotid artery (**Fig. 3c**). The sphenoid sinus mucosa is removed and the venous bleeding is controlled with irrigation of warm saline solution (40° C) or focal application of bone wax. This allows for the identification of key anatomical landmarks (**Fig. 3c**): the lateral and medial **o**ptic-**c**arotid **r**ecesses (OCRs), the parasellar and paraclival carotid canal, sella, clival recess, and the strut of bone over the superior intercavernous sinus (SIS).

The lateral OCR is formed by the pneumatization of the anterior clinoid through the optic strut forming a recess that extends between the optic nerve superiorly and the intracavernous carotid artery medially. The medial OCR represents the lateral aspect of the tuberculum sellae which is the area of contact between the point of origin of the optic canal medially and the posterior margin of the parasellar carotid artery. Intracranial entry at the level of the medial OCR allows for simultaneous access to the carotid canal, optic nerve canal, sella, and medial cavernous sinus. It is analogous to a “key hole” during a conventional pterional craniotomy (**Fig. 3c**). It is not necessary, however, to open the OCR for the removal of pituitary tumors unless there is significant suprasellar and lateral extension towards the optic-carotid cistern.

Removal of the bone overlying the superior intercavernous sinus is imperative for lesions that extend into the anterior cranial fossa. Therefore, bone removal over the sellar face should extend laterally over the medial portions of each cavernous sinus and vertically to expose both the superior and inferior intercavernous sinuses (**Fig. 8**). As the margins of the cavernous sinus are approached, venous bleeding is often encountered and is controlled with focal application of Avitene sandwiches. As bone is removed adjacent to the carotid canal, it is important to first undermine the bone with a blunt elevator or tip of the rongeur and then bite the bone with a 1 mm angled Kerrison rongeur with the tip angulated tangential to the wall of the vessel. It has been our experience that most novice endoscopic surgeons fail to undertake an adequate exposure and limit their access to that offered by a window that is just large enough to introduce a curette. This defeats the primary advantage of endoscopic surgery, i.e., to provide direct intrasellar visualization of the entire dissection.

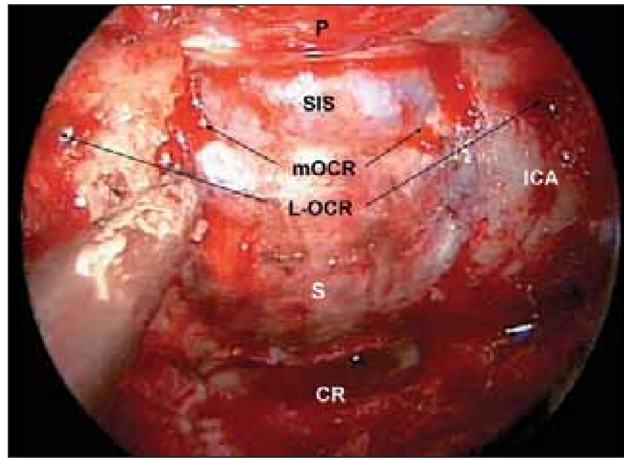

Fig. 8
Exposure of the sella dura extends to the margins of the cavernous sinus in all directions. Laterally, the carotid siphon (**ICA**) is the limit. Superiorly, the superior intercavernous sinus (**SIS**) is exposed above the sella turcica (**S**) and below the planum sphenoidale (**P**). The medial optic-carotid recess (**mOCR**) is removed to exposure the junction between the ICA and the optic nerve. The lateral optic carotid recess (**L-OCR**) marks the pneumatization of the anterior clinoid through the optic strut, lateral to the ICA.

Intrasellar Dissection

We do not use curettes for tumor removal but instead rely on the endoneurosurgical techniques previously described. We believe that the superior visualization provided by the endoscope allows the use of these techniques even within confined spaces such as the sella. We recognize, however, that extracapsular dissection of pituitary tumors is not often possible. We are staunch advocates of debulking the tumor using the two suctions technique, or for the rare firmer tumor, an EEA ultrasonic aspirator. These techniques yield a more controlled removal with more effective and less traumatic separation of the tumor from the normal gland, stalk and cavernous sinus contents. Extracapsular dissection is in fact possible in many cases, as a result of the improved visualization provided by the endoscope.

As a macroadenoma is resected, the diaphragma may descend and thereby obstruct visualization. A systematic intrasellar dissection is mandatory to optimize visualization while protecting the normal gland. Following bipolar cauterization, the dura is opened using a sickle knife or a retractable blade in the center of the sellar face (**Fig. 9**). The opening is extending caudally and obliquely towards “8 o’clock” and “5 o’clock” positions creating an inferior flap of dura as the initial opening (**Fig. 10**). The superior flap is left intact to act as a retractor and hold the anterior face of the tumor overlying the diaphragma. Macroadenomas will often herniate through this inferior opening.

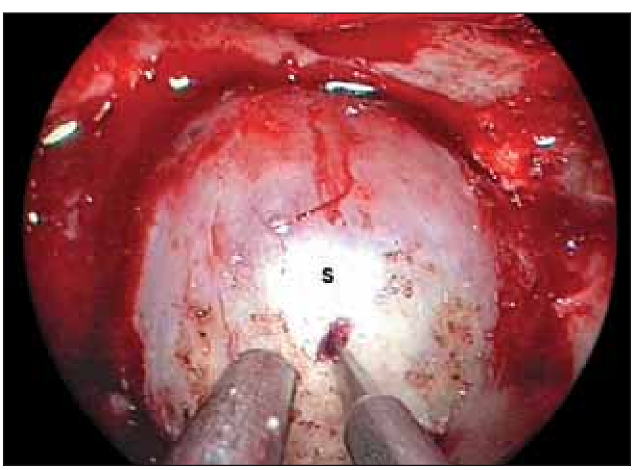

Fig. 9
The dura of the sella (**S**) is sharply incised with a sickle knife or a retractable blade to create an opening large enough for scissors. Care should be taken to avoid incisions too close to the cavernous sinus where the internal carotid arteries are situated.

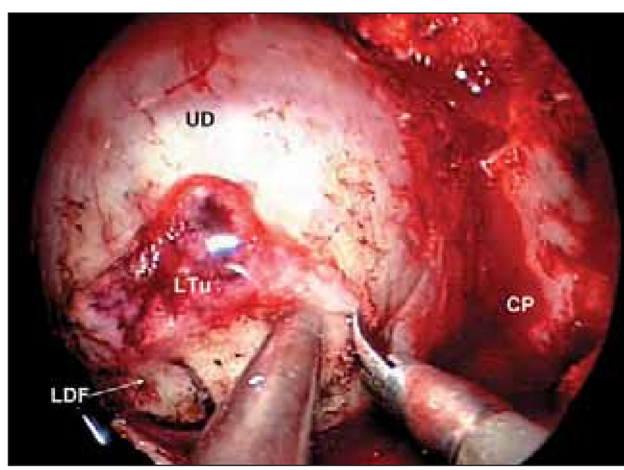

Fig. 10
Once the dura has been opened with the sickle knife, the endoscopic scissors are used to first open the lower based dural flap (**LDF**). This facilitates dissection of the lower aspect of the tumor (**LTu**) first. The upper portion of the dura (**UD**) is kept intact until the lower part of the adenoma is clearly removed. The durotomies are then extended to provide lateral and superior access.
The carotid protuberance (**CP**) is shown as a landmark.

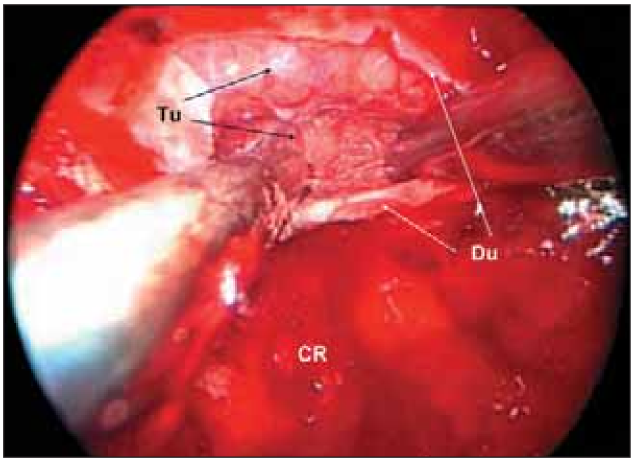

Fig. 11
Pituitary tumor resection using 2-suction technique. Note that the dura (**Du**) has been opened only inferiorly. The lower portion of the tumor (**Tu**) is dissected posteriorly towards the dorsum, while leaving intact the superior portion which is attached to the diagphragma. The clival recess (**CR**) is shown as a landmark.

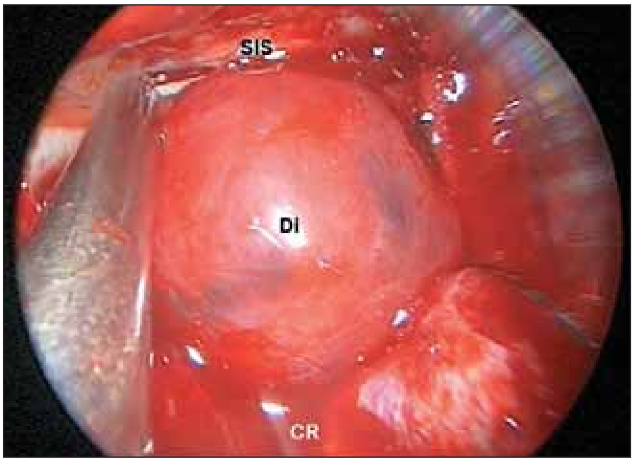

Fig. 12
The diaphragma (**Di**) balloons into the surgical field after complete tumor resection. In this case, the diaphragma is extruding into the sphenoid sinus in between the superior intercavernous sinus (**SIS**) and the clival recess (**CR**).

This inferior portion of the tumor is removed in a posterior trajectory towards the clival-dorsum junction, proceeding widely, from cavernous sinus to cavernous sinus (**Fig. 11**). Care should be taken since macroadenomas may erode the posterior dorsum leaving the dura of the basilar cistern at risk for transgression, which can result in injury to the basilar artery. The pituitary stalk is most commonly located in this position.

Once this inferior "cavity" is created, the dural flap can be coagulated and we proceed with the dissection and removal of tumor in the lateral gutters along the cavernous-carotid recesses. At this point the dura is opened superiorly (superior flap) to increase the exposure by retracting the tumor and gland superiorly. Each recess is dissected in an inferior to superior direction vertically. Bilaterally, the medial OCR and the angle between the optic nerve and carotid artery as seen from the inside the sella superolaterally should be examined carefully. This is one of the two most common sites for persistent tumor. The other common site is under the anterior lip of dura at the level of the superior intercavernous sinus directly beneath the sellar/tuberculum junction. In order to optimize visualization of this latter segment it is necessary to remove the bone and underlying tumor along the anterior face overlying the diaphragma. This will allow the diaphragma to descend opening up the superior angle. The superior dural flap can be coagulated shrinking it back to the SIS. Removal of the bone over the SIS allows the anterior retraction of this dural margin; thus, improving the visualization of this area.

Final inspection of the sella is undertaken in a clockwise fashion starting inferiorly at the "6 o'clock" position and using angled endoscopes as required. At this stage the diaphragma should descend concentrically (**Fig. 12**). In our experience, the most common location for the residual gland is as an apron adherent to the undersurface of the diaphragma. If the diaphragma fails to descend concentrically and, rather, has a "dimpling" appearance, it is indicative of retained tumor in the suprasellar space. If the primary goal of surgery is that of optic decompression, tumor removal is deemed adequate only when pulsations are visible in the diaphragma. If the diaphragma descent is not concentric and additional removal is needed (e.g. functional tumor, or compression of the optic apparatus) the diaphragma is electively opened and the residual tumor in the suprasellar cistern is removed under direct visualization until the optic nerves are fully visible.

Endoneurosurgical dissection techniques are mandatory in this area, as opposed to the use of curettes, since small subchiasmatic and infundibular perforators must be preserved. When this type of suprasellar dissection is required, then, it is imperative to remove the bone overlying the medial OCRs. This allows the identification of the optic nerves and carotid arteries; thus, facilitating the extracapsular dissection, while avoiding the need for excessive traction. These maneuvers will minimize the risk of injury to these perforators.

Cavernous Sinus Extension

Once the superior and inferior margins of the cavity have been explored, the endoscope can be introduced inside the sella to examine the lateral margins, which consist of the medial cavernous walls. Angled scopes may be needed to achieve superior visualization. Macroadenomas often expand the volume of the sella and this extra space facilitates inspection and allows the elective opening of the cavernous sinus to access tumor within its medial segment (**Fig. 13**). The carotid siphon is usually anterior; therefore, the area between the posterior clinoid and the carotid siphon is the ideal entry point. Most often, however, the tumor has created an entry through this space and the surgeon can follow the same pathway (**Fig. 14a, b**). Tumor posterior to the internal carotid can be removed using the two suction technique. Once again, "blind" curetting on the deep surface of the carotid artery is to be avoided. Bleeding from the cavernous sinus is controlled using hemostatic "sandwiches" (discussed in the section on hemostasis). If there is an opening in the diaphragma (intentional or inadvertent), it is important to avoid the exchange of blood for CSF, which could lead to a significant subarachnoid hemorrhage with its associated complications.

Reconstruction

If the diaphragma has been opened to access the suprasellar cistern, we use fascia (cadaveric pericardium or acellular dermis) placed as an onlay graft (see Reconstruction section), to separate the suprasellar cistern from the pituitary fossa. The sella and sphenoid are then obliterated with an abdominal fat graft followed by fibrin glue. If a pinhole is opened in the diaphragma, then an onlay graft is placed and then fixed with fibrin glue. If there is no CSF leak, the sella is covered with fibrin glue only. We do not advocate any form of bony reconstruction as all available materials are hard to fixate, may cause injury to adjacent neurovascular structures or may act as a foreign body leading to infectious complications. Please refer to the section on reconstruction for a detailed discussion of these techniques and that of the repair of larger defects, such as those resulting from combined transellar and transplanum approaches.

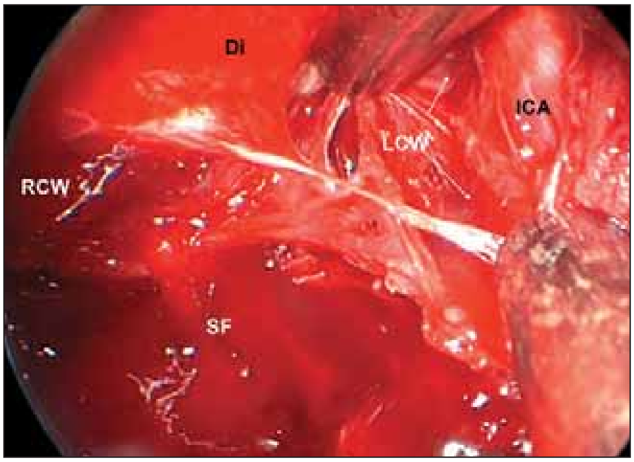

Fig. 13
Photograph showing the lateral wall of the sella at the left cavernous wall (**LCW**) free of tumor including the region behind the left cavernous internal carotid artery (**ICA**) shown by the white arrows. The suction is elevating the diaphragma (**Di**) to help in the exposure. The right cavernous wall (**RCW**) and the sellar floor (**SF**) are shown.

Expanded Approaches

Based on our experience with pituitary and other transellar surgeries, we proceeded to extend our indications, applying the same principles to design a series of modular approaches. These modules expanded the approaches to adjacent anatomical areas. The first natural modification was to extend the approach superiorly to access the suprasellar cistern and anterior cranial base directly, without disturbing the sella. The transtuberculum/transplanum and transcribriform approaches are described below.

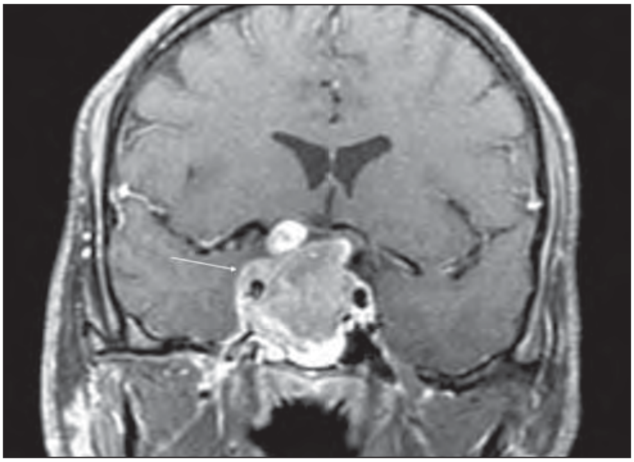

Fig. 14a
Coronal MRI with contrast showing a pituitary adenoma expanding the medial cavernous sinus on the right side (**white arrow**).

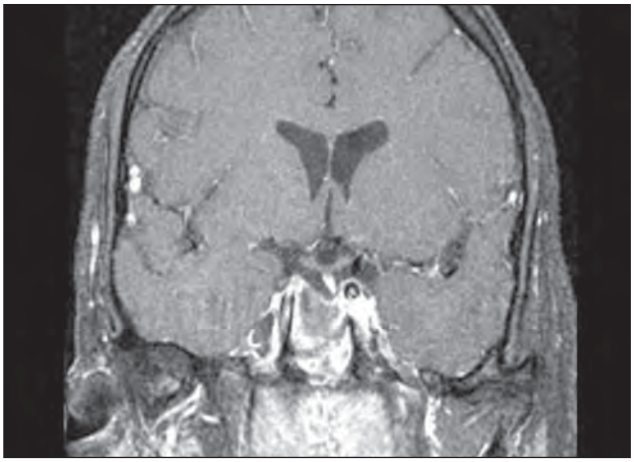

Fig. 14b
Postoperative coronal MRI with contrast demonstrating removal of the adenoma.

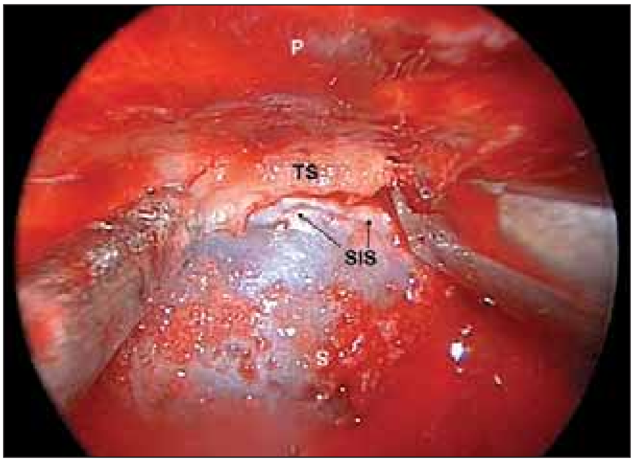

Fig. 15
Transplanum Approach. The thinned bone of the tuberculum strut (**TS**) is elevated and fractured with a blunt dissector or Kerrison rongeur exposing the superior intercavernous sinus (**SIS**) between the planum sphenoidale (**P**) and the sella turcica (**S**).

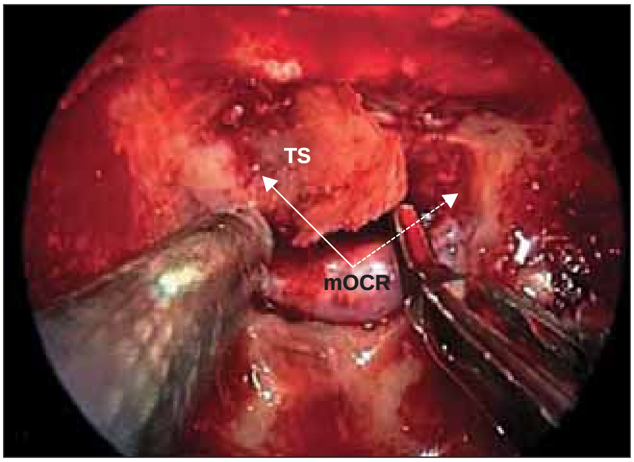

Fig. 16
The bony tubercular strut (**TS**) is thinned and then fractured inferiorly or removed with a 1 mm Kerrison rongeur. The medial optic-carotid recess (**mOCR**) is seen laterally.

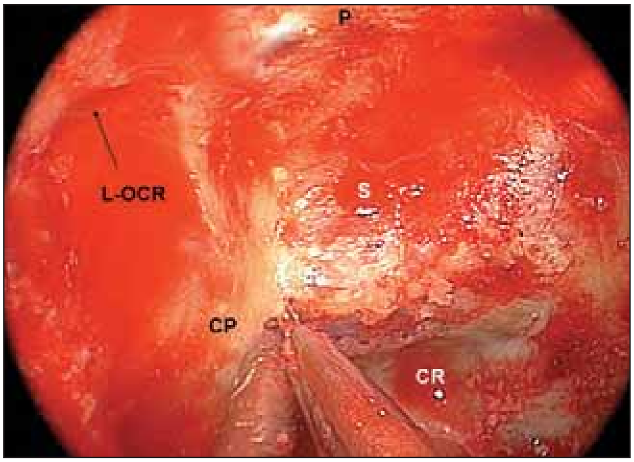

Fig. 17
The paraclinoid carotid canal is removed with a 1 mm Kerrison rongeur. Note that the bone is removed parallel to the carotid artery the carotid protuberance (**CP**) in order to avoid injury. The planum (**P**), right lateral optic-carotid recess (**L-OCR**), the sella (**S**), and the clival recess (**CR**) are shown.

Rostral Extension

■ Transtuberculum/Transplanum

Extradural Exposure

Once a wide sphenoidotomy with posterior septectomy is completed, further rostral exposure is obtained by completing wide bilateral posterior ethmoidectomies. All ethmoidal septations are removed flush with the anterior cranial base and the lamina papyracea bilaterally. During a transplanum approach, the anterior margin of the exposure should not extend anterior to the posterior ethmoidal arteries in order to avoid injury to the olfactory neuro-epithelium.

After the planum is completely exposed, its bone is drilled in a rostral to caudal direction until it is thin as an eggshell. The thinned bone can be fractured inferiorly using a blunt dissector or removed using Kerrison rongeurs (**Fig. 15**). The most rostral portion of the sella can be opened to expose the SIS which is cauterized and mobilized or divided. In order to mobilize the SIS, the overlying bony strut is drilled until egg-shell thin and is then fractured inferiorly or removed using a 1 mm 45 degree Kerrison rongeur (**Fig. 16**). Mobilization of the SIS allows direct access to the suprasellar extensions of tumor in the parachiasmatic cisterns. Removal of the underlying strut of bone allows the retraction and mobilization of the SIS without the need to transect it. It is common to encounter bleeding from the SIS where it inserts laterally into the cavernous sinus. SIS bleeding can be controlled with bipolar electrocautery or microfibrillar collagen "sandwiches". The optic strut and the medial clinoids are removed using the drill with a 3 mm hybrid bit (see Equipment section). Irrigation with normal saline is required to avoid a thermal injury to the optic nerves.

The paraclinoid carotid canals can be removed using a 1 mm Kerrison rongeur. This should be done using the footplate of the rongeur as a dissecting instrument, dissecting and pushing the dura away from the bone (**Fig. 17**). Only the most distal third of the tip, positioned vertically and parallel to the underlying subclinoid carotid, is used to remove bone. Removal of the remaining optic strut and medial clinoid is required to be able to access the optic-carotid recesses intradurally without having to retract the tumor and risk injury to the perforator vessels.

Devascularization

During the resection of anterior skull base meningiomas, it is common to find an arterial feeder arising from the distal portion of the paraclinoid carotid at the level of the optic-carotid recess. Coagulation of this artery helps to devascularize the tumor. Ligation of the posterior ethmoidal arteries devascularizes the tumor even further. Care should be taken to avoid retraction of the posterior ethmoidal artery into the orbit resulting in a retrobulbar hematoma.

At this point, we are working through a relatively wide corridor extending from the planum/cribriform junction anteriorly to the clival recess posteriorly and from lamina papyracea to lamina papyracea laterally. The exposed dura, extending from the sella to the anterior portion of the planum is then thoroughly coagulated to provide even further devascularization.

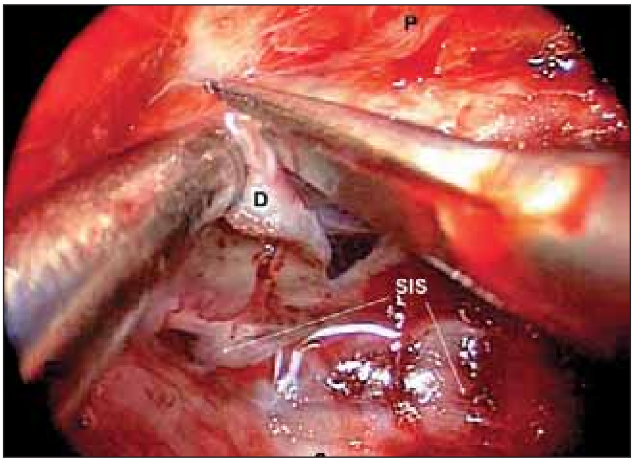

Fig. 18
The suprasellar dural opening (**D**) is completed with endoscopic scissors in a cruciate fashion. The superior intercavernous sinus (**SIS**) is demonstrated in between the sella turcica (**S**) and the planum sphenoidale (**P**).

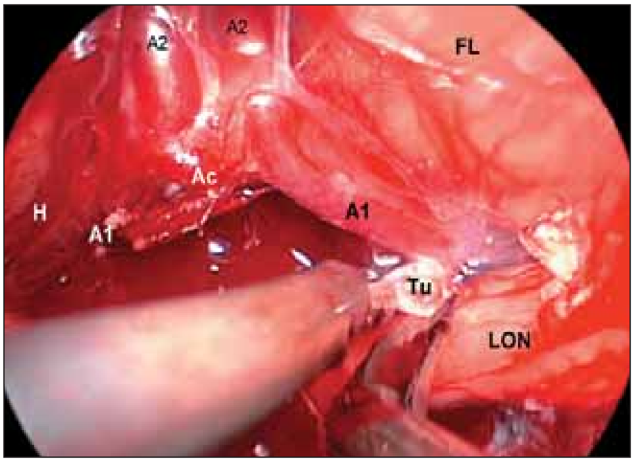

Fig. 19
Suprasellar dissection of tumor (**T**) from the left optic nerve (**LON**) using sharp dissection with endoscopic scissors and suction. The frontal lobe is exposed with both anterior cerebral arteries (**A1** and **A2** segments). The anterior communicating complex (**Ac**) and the right recurrent artery of Heubner (**H**) are shown.

The dura is opened widely with a cruciate incision, taking care not to open the prechiasmatic cisterns if possible (**Fig. 18**). The dural opening must be precise, as excessive exposure will allow the herniation of normal brain anteriorly and block visualization. The anterior margin of the lesion and the brain-tumor interface mark the anterior extent of the required opening. Any additional bone or dura that may interfere with this exposure should be removed at this stage.

Intradural Dissection

Systematic extracapsular dissection is performed through the parachiasmatic cisterns with identification of critical neurovascular structures and adherence to the principles of endoneurosurgery (**Fig. 7**). The first and perhaps the most important anatomical landmark is the paraclinoid carotid artery as it emerges intradurally at the level of the OCR. This requires prior removal of the bone covering this segment of the ICA. Following the ICA the surgeon will find the optic nerve, which is located slightly superiorly. The optic nerve in turn can be followed using extracapsular dissection (**Fig. 19**). A similar dissection exposes the contralateral optic nerve and carotid. We should emphasize that in order to perform an extracapsular dissection in this region, the capsule of the tumor must be thin and pliable enough to allow its retraction using suction tips no larger than size 4 or 6 French. This gentle retraction produces enough tension to allow the sharp dissection of arachnoid bands in the parachiasmatic cisterns.

Adjacent critical structures need to be identified and dissected before the coagulation of the capsule. The infundibulum is usually adherent to the posterior margin of the capsule and could be injured during the coagulation of the base of the tumor at the tuberculum/sellar junction.

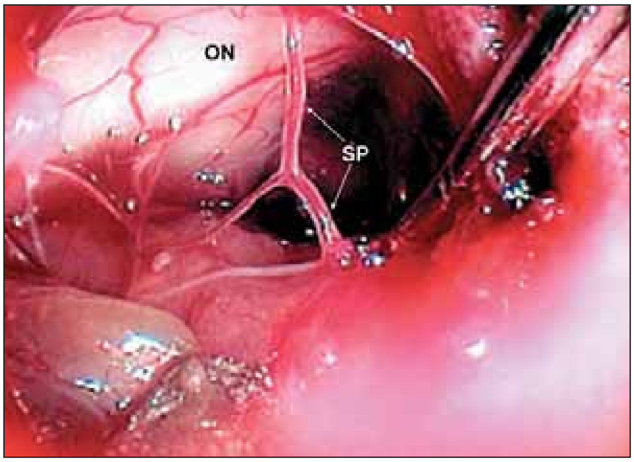

Fig. 20
Suprasellar exposure demonstrating the preservation of small subchiasmatic perforators (**SP**) leading to the optic nerve (**ON**).

Bipolar cauterization should be avoided until the stalk has been identified. Small subchiasmatic perforators are often draped around the circumference of the tumor but they can be spared with adequate debulking and mobilization of the capsule (**Fig. 20**). Branches that supply the tumor may be individually coagulated and transected. Finally, during the parachiasmatic dissection, injury to the anterior communicating artery, in particular, the recurrent artery of Huebner that may be found draped over the superior surface of the tumor, should be avoided.

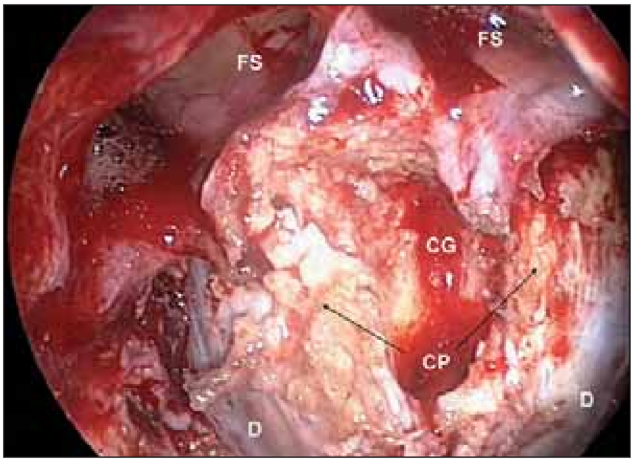

Fig. 21
Transcribriform approach. The floor of the frontal sinus (**FS**) is removed anterior to the crista galli (**CG**) demonstrating the anterior limit of resection. The area of the cribriform plate (**CP**) is demonstrated. The dura mater (**D**) of the anterior skull base is exposed bilaterally.

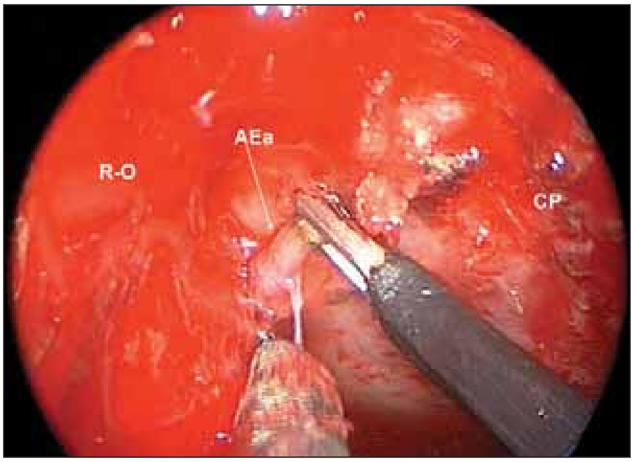

Fig. 22a
The anterior ethmoidal arteries (**AEa**) can be cauterized with bipolar electrocautery. Right orbit (**R-O**), cribriform plate (**CP**).

■ Transcribriform Approach

Extradural Approach

This module allows for a more rostral extension of the previously described approach to reach anteriorly to the level of the crista galli or even the frontal sinus.

Due to the pathological processes intrinsic to this area, it is likely that olfaction is already compromised. This approach is typical for olfactory groove meningiomas and esthesioneuroblastomas.

The middle turbinates are resected to the level of the skull base bilaterally and complete ethmoidectomies are performed with exposure of the medial orbital walls. The nasofrontal recess is exposed anteriorly with complete removal of agger nasi cells. The frontal sinuses are connected across the midline by creating a defect in the nasal septum superiorly and drilling the bone between the sinuses anterior to the crista galli and posterior tables of the frontal sinuses (**Fig. 21**). This creates the anterior limit of the resection. The ethmoidal arteries are cauterized and ligated at the margins of the tumor on the orbital side of the skull base to devascularize the tumor (**Fig. 22a, b**). The thin bone of the lamina papyracea is fractured and elevated with a Cottle instrument up to the skull base. The anterior ethmoid artery is located at the junction of the nasofrontal recess with the roof of the ethmoid sinus. With image guidance, the artery is found crossing the skull base in a coronal plane that is tangential to the posterior surface of the globe. The anterior and posterior ethmoid arteries diverge slightly with the posterior ethmoidal artery located near the junction of the sphenoid sinus and posterior ethmoid sinuses. The periorbita is elevated on both sides of the vessels and hemoclips are placed. The vessels are then transected medially, taking care to avoid retraction of the proximal stumps of the vessels into the orbital tissues.

Septations over the anterior skull base and orbit are removed using the drill in a rostro-caudal direction to mitigate the obscuring effects of blood running posteriorly.

Soft tissue medial to the attachments of the middle turbinates and overlying the cribrifrom plates is cauterized with bipolar electrocautery and partially resected to improve visualization of the adjacent bone (**Fig. 23**).

Fig. 22b
The anterior (and posterior) ethmoidal arteries can also be ligated with hemoclips and transected with scissors.

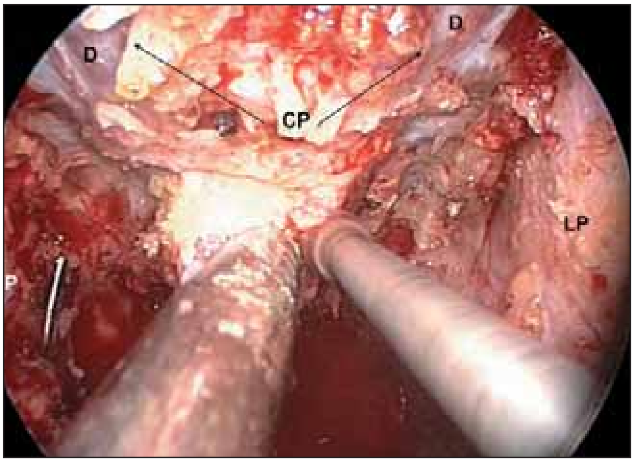

Fig. 23
To complete the extradural exposure, the cribriform plate (**CP**) is drilled and the soft tissue is cauterized and partially resected to improve visualization. The dura (**D**) of the anterior fossa is exposed from lamina papyracea (**LP**) to lamina papyracea (**LP**).

The plane of the cribriform plates is often lower than the rest of the skull base and creation of a CSF leak is to be avoided at this time. The bone lateral to the cribriform plates is then thinned and elevated from the underlying dura from the frontal sinuses to the planum sphenoidale. In the midline just posterior to the frontal sinuses, the crista galli is exposed. The crist galli can extend for a variable depth into the intracranial cavity and that may be particularly prominent in the case of olfactory groove meningiomas with secondary hyperostosis. Removal of the crista galli requires internal drilling of this bone until it becomes eggshell thin and can be fractured or removed with a cutting forceps (**Fig. 24**).

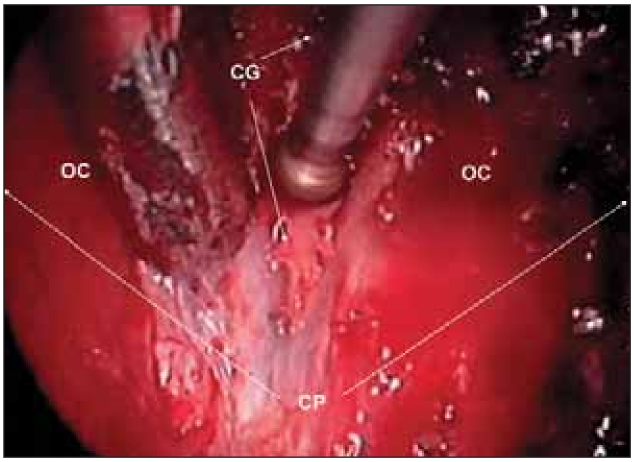

Fig. 24
The crista galli (**CG**) is removed using a high speed drill. The location of the olfactory crests are demonstrated (**OC**) along with the area of the cribriform plate (**CP**) indicated by the arrows.

Intradural Dissection

At this point, the tumor is effectively devascularized as a result of ethmoidal artery ligation, removal of underlying bone, and cauterization of the dura. Following bipolar electrocoagulation, the dura is opened individually on both sides of the falx (**Fig. 25**). The midline is kept intact, as tumor in this region may still be vascularized along the falx. Sequential internal tumor debulking is performed on each side exposing the free edge of the falx bilaterally. At this point, we coagulate the falx and any feeding vessels arising from the anterior falcine artery. The falx is transected to providing a single intradural space (**Fig. 26**). Any dura anterior to the brain/tumor interface is spared to prevent herniation of the brain.

It is common to encounter subpial invasion of the tumor into the overlying cortex during the extracapsular dissection of large tumors. In these cases a subpial dissection must be performed using a 4 Fr suction and fine endoneurosurgical bipolars at low power (see Equipment section) (**Fig. 27**).

This dissection proceeds to the level of the interhemispheric fissure (IHF) along the superior pole of the tumor. Dissection of the superior aspect should be extremely cautious, as the A2 segments and the frontopolar artery will be draped over the surface of the tumor (**Fig. 27**).

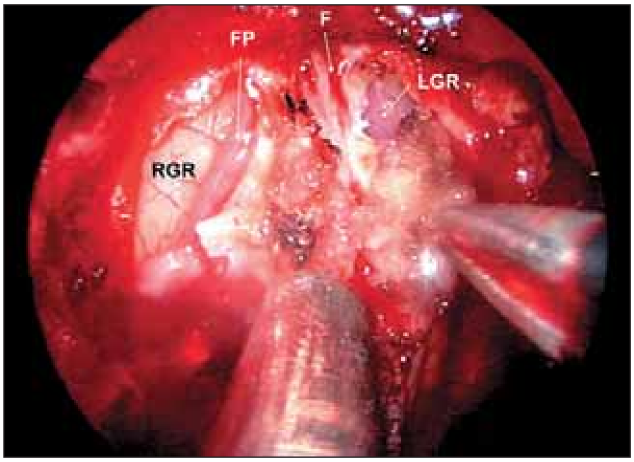

Fig. 25
The dura is opened on each side of the falx (**F**). The right gyrus rectus (**RGR**) is exposed and the right fronto-polar artery (**FP**) can be seen. The left gyrus rectus (**LGR**) is being exposed, still covered by arachnoid membrane and tumor.

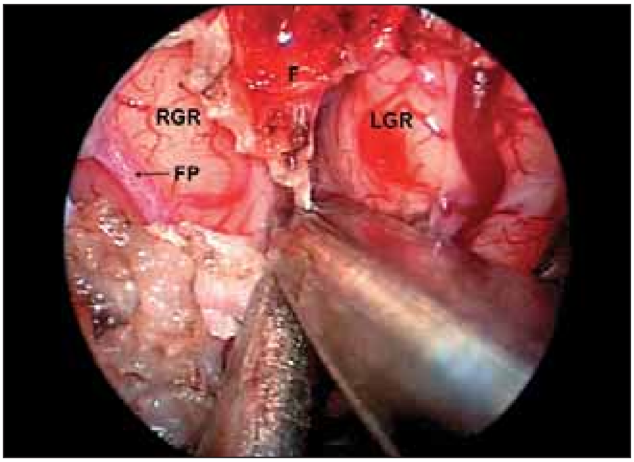

Fig. 26
The falx (**F**) is transected in order to mobilize the dural specimen. The right gyrus rectus (**RGR**) with a fronto-polar artery (**FP**), and the left gyrus rectus (**LGR**) can be seen.

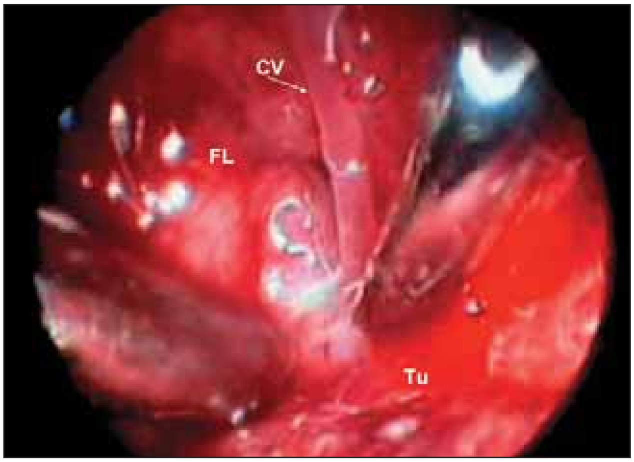

Fig. 27
Subpial dissection is performed with preservation of cortical vessels (**CV**) of the frontal lobe (**FL**) from the tumor (**Tu**).

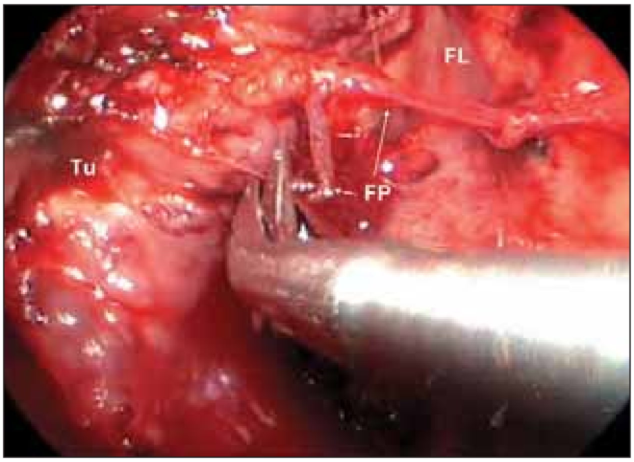

Fig. 28
Sharp dissection is performed to preserve the frontal polar artery (**FP**) while the tumor (**Tu**) is separated from the frontal lobe (**FL**).

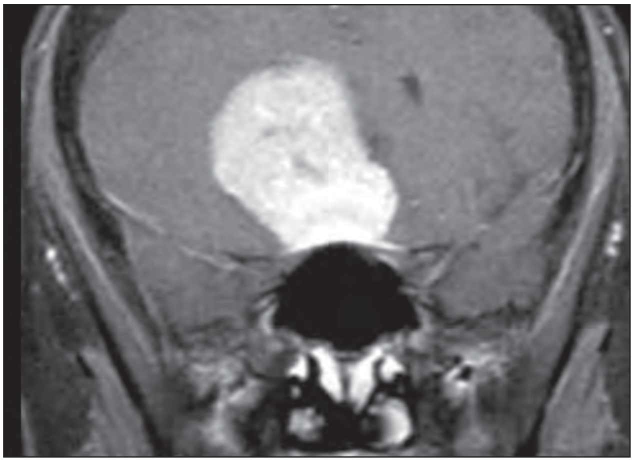

Fig. 29a
Staged tumor resection may be a preferred option for larger tumors with growth along the sagittal or coronal plane. A second stage is done to resect the residual portion once the tumor has collapsed into the cavity.

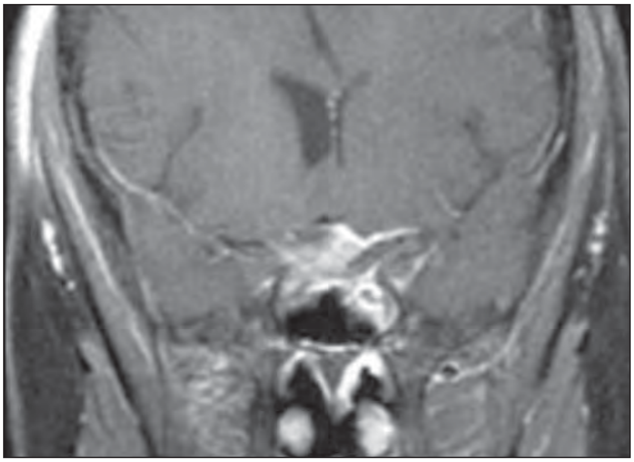

Fig. 29b
Postoperative MRI in the sagittal plane after a second stage expanded endonasal approach.

It is useful to proceed towards the parasellar space caudally (inferior pole) after adequate internal debulking of the tumor. This allows access into the parasellar cistern and the dentification of the key neurovascular landmarks described previously in the Transplanum section. Identification of the optic nerves and anterior communicating arteries facilitates the extracapsular dissection of the A2 segments along the IHF, in the preferred proximal to distal direction. This provides further proximal control during the dissection of these vessels at their interface with the tumor capsule. Visualization with a 70 degree endoscope is needed for the most anterior and rostral dissection of the tumor. Placement of the 70° scope in the right nasal cavity at the "6 o'clock" position is necessary for optimal visualization. This requires switching the placement of the suction to the "12 o'clock" position.

Staged tumor removal may be a preferred option, especially for exceptionally large tumors where circumferential extracapsular dissection is not possible because of growth along the sagittal or coronal planes (very "tall and wide tumors") (**Fig. 29a, b**). In this situation, debulking should yield transmitted brain pulsations that can be observed at all the walls of the tumor cavity. If this requirement is met, the remaining tumor will likely collapse into the cavity from all directions. A second stage for resection of residual tumor can be performed several days later.

Caudal Extension

Exposure of the Upper Third of the Clivus

The rostral aspect of the upper third of the clivus is bounded by the dorsum sella (DS) in the midline and the posterior clinoids (PC) paramedian. Removal of these structures provides unparalleled access to the basilar and interpeduncular cisterns, which are located directly posteriorly. The DS and PC can be removed either intradurally via a transellar approach or extradurally by a subsellar approach, elevating the soft-tissue contents of the pituitary fossa en bloc.

■ Transellar Exposure

If the lesion is intrasellar or extends suprasellar, it is easiest to remove the DS and PC via a transellar approach (e.g., to access a retroinfundibular/ retrochiasmatic craniopharyngioma). The first step is to complete the transplanum/ transtubercular approach. The anterior margin of this exposure is the tuberculum/ planum junction and does not need to extend to the posterior ethmoidal artery (as described previously). The bone over the entire sellar face is completely removed to expose the SIS above and IIS below, exposing the junction of sella and clivus.

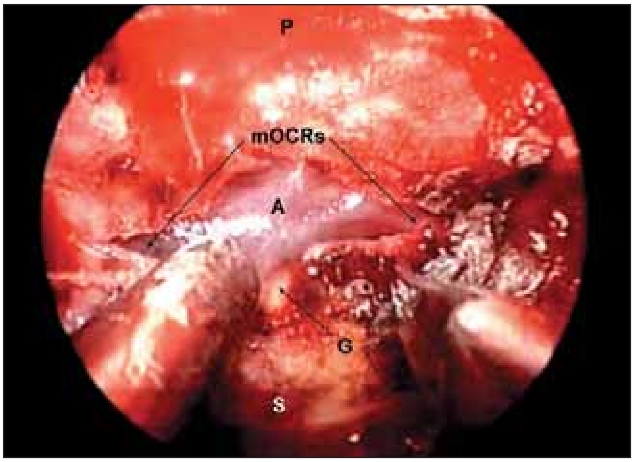

Fig. 30
The suprasellar dural opening is completed with endoscopic scissors in a cruciate fashion from one medial optic-carotid recess (**mOCR**) to the other. The suprasellar arachnoid (**A**) is exposed along with the pituitary gland (**G**). The sella (**S**) and the planum sphenoidale (**P**) are shown.

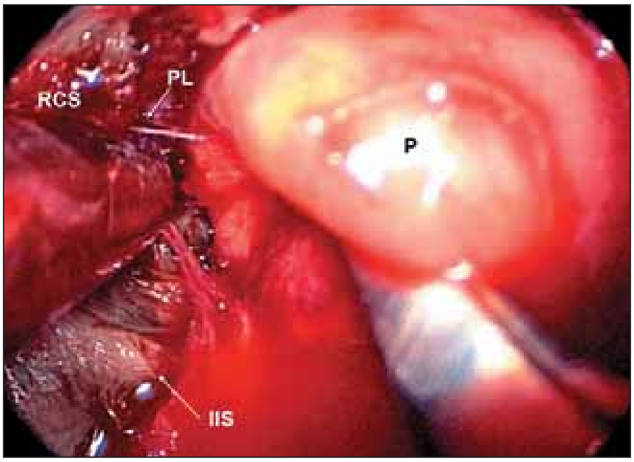

Fig. 31
The lateral soft tissue attachments or pituitary ligaments (**PL**), extending from the lateral pituitary (**P**) to the cavernous sinus (**RCS**), are sharply cut (**right side**). The inferior intercavernous sinus (**IIS**) is previously coagulated and ligated.

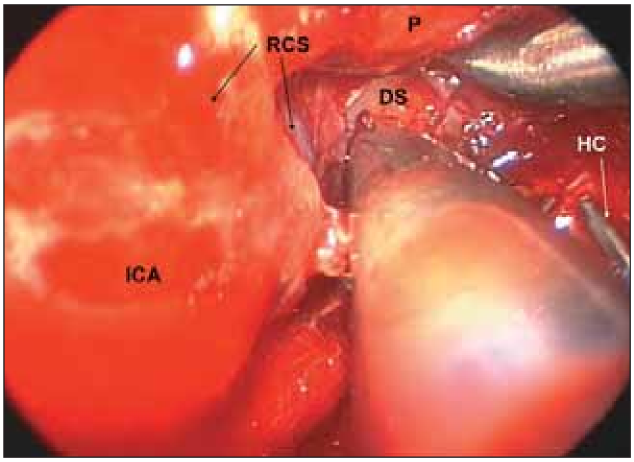

Fig. 32
The pituitary gland (**P**) is separated from the medial walls of both cavernous sinus. The medial wall of the right cavernous sinus (**RCS**) is shown containing the internal carotid artery (**ICA**). The dura over the posterior clinoid is incised exposeding the dorsum sellae (**DS**) and the pituitary gland (**P**) is transposed superiorly. A hemoclip (**HC**) was used to ligate the inferior intercavernous sinus.

The dura over the parachiasmatic cistern is opened with a wide cruciate shaped incision based inferiorly along the SIS. The dura over the pituitary is opened using a similar technique. The SIS is ligated (ligated with hemoclips or preferably coagulated with a bipolar cautery) and then transected creating a T-shaped opening vertically through the sella (**Fig. 30**)

The entire pituitary gland is exposed and the diaphragma is cut in the midline to expose the stalk. The paramedian diaphragma is then transected releasing the stalk circumferentially. The lateral soft tissue attachments ("pituitary ligaments" extending from the lateral pituitary to the cavernous sinus are sharply cut (**Fig. 31**). Branches of the superior hypophyseal artery must be spared. The dura over the posterior clinoid is exposed and the gland carefully retracted superiorly (**Fig. 32**). With the gland protected, the dura is coagulated and dissected, controlling any venous bleeding with "sandwiches" of microfibrillar collagen. A 1 mm diamond bit (see equipment section) is used to drill the posterior clinoids until egg-shell thin (**Fig. 33a**). They are carefully removed (**Fig. 33b**) avoiding injury to the ICA and abducens nerve, which are located laterally and posteriorly. Removal of both posterior clinoids and dorsum provide a direct view of the retrosellar space.

During drilling of these bony elements, significant venous bleeding is encountered arising from the rostral portion of the basilar and intercavernous venous plexuses. This can be controlled with the meticulous exchange of microfibrillar collagen "sand-wiches". Following completion of the bony removal and prior to opening the dura, the microfibrillar collagen is covered with fibrin glue to prevent its dislodgement. If additional bone removal is needed at the median aspect, the gland needs to be transposed. To transpose the gland it should be dissected sharply 360°, completely freeing it from any soft-tissue attachments. Then, the gland can be elevated and covered with a thin coating of fibrin glue to prevent desiccation. In our experience the gland tolerates this transposition remarkably well provided that the dissection is very gentle and preserves the stalk and vascular supply.

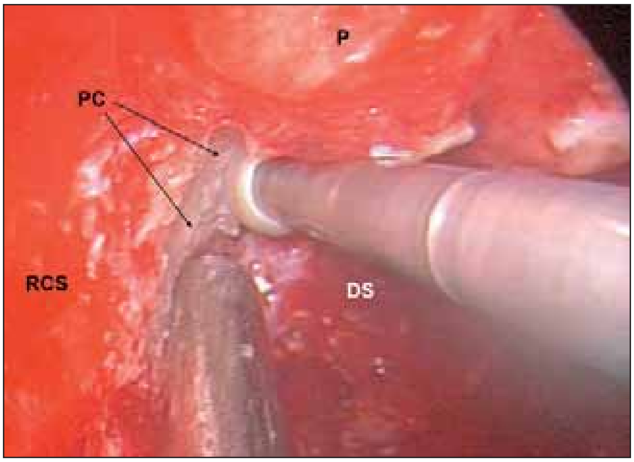

Fig. 33a
The posterior clinoid (**PC**) is thinned with a high speed drill in between the dorsum sellae (**DS**) and the medial wall of the cavernous sinus (**RCS**). The pituitary gland (**P**) is transposed superiorly.

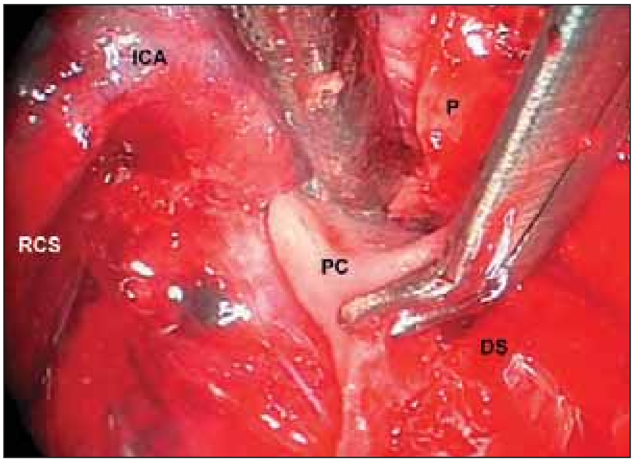

Fig. 33b
The posterior clinoid (**PC**) is then fractured away from the internal carotid artery (**ICA**) and completely removed. The pituitary gland (**P**) has been transposed superiorly. The medial wall of the right cavernous sinus (**RCS**) and the dorsum sellae (**DS**) are seen.

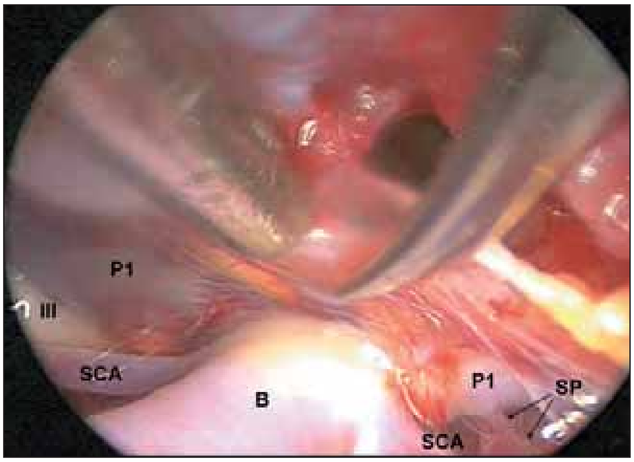

Fig. 34
Intradural dissection displays the basilar artery (**B**), posterior cerebral arteries (**P1 division**), superior cerebellar arteries (**SCAs**), small perforators (**SP**) from the posterior circulation and cranial nerve III (**III**).

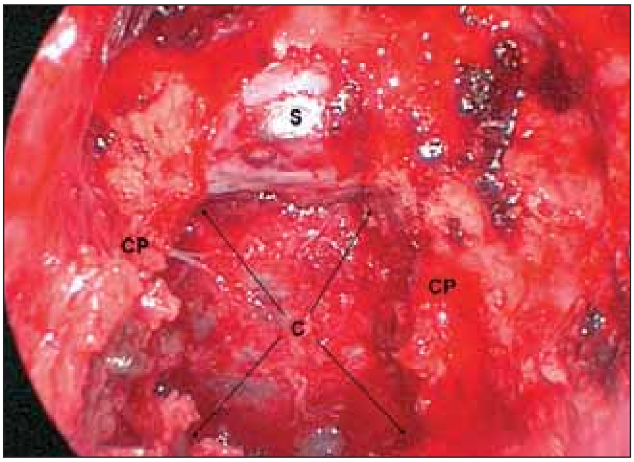

Fig. 35
Completed clival bone resection (**C**) is shown by the arrows bounded by the carotid canals laterally forming the paraclival carotid protuberances (**CP**). The sella (**S**) is shown superiorly.

Subsellar Extradural Removal of the Posterior Clinoid and Dorsum Sella

The PC and DS can also be removed via a completely extrasellar approach. This is ideal for retrosellar lesions in the midline with a predominant caudal, as opposed to rostral extension, such as midline petroclival meningiomas. Transplanum access is not necessary for this approach unless it is needed for specific access to a rostral extension of the tumor. The sellar face is completely removed, and then the portion of the middle third of the clivus between the vertical carotid canals, directly below the sella, is removed using a 3 mm coarse bit. Obviously great care should be taken to avoid transgressing the carotid canals. The dura underlying this bone is exposed and venous bleeding is attended to as described previously. The dura over the sella is not opened. However the bone over the SIS is resected to allow the contents of the pituitary fossa to be mobilized superiorly en bloc. With the pituitary gland elevated, the DS and PC can be drilled using a 1 mm diamond bit. As the DS and PC are removed significant venous bleeding arises from the bone marrow, requiring meticulous packing with microfibrillar collagen or bone wax.

Intradural Dissection

Once the exposure is completed providing access to the basilar and interpeduncular cisterns, the intradural dissection proceeds using endoneurosurgical techniques. Absolute adherence to these techniques is mandatory, particularly in this location, as perhaps no other region is less tolerant to technical mistakes. Submillimeter perforators from the posterior circulation along with cranial nerves III and VI are contained within these cisterns (**Fig. 34**). Sequential dissection should identify the posterior communicating artery and third cranial nerve laterally before proceeding circumferentially through the basilar cistern and its contents (**Tab. 4**). Every effort should be made to avoid transgression of the membrane of Liliquist, as it will prevent the subarachnoid spread of blood and reduces the likelihood of a postoperative CSF leak.

Middle Third of the Clivus

It is very rare to need an isolated removal of this segment of the clivus. Removal of this area is usually undertaken as a part of a panclival exposure as described below.

Panclival Approach

General Exposure

Several modifications of our basic exposure are needed to gain access to more caudal areas. First the floor of the sphenoid sinus should be completely removed to establish the superior limit of resection and visualize critical anatomical landmarks. It is important to perform wide sphenoidotomies to allow identification of critical anatomic landmarks such as the ICA canals, medial pterygoid plates (MP) and the pterygoid canal transmitting the Vidian artery and nerve (VC). The field of view extends from the sella and clival recess superiorly to the paraclival ICA, medial pterygoid plates, and Eustachian tubes laterally to the level of the soft palate inferiorly.

The pharyngeal fascia is completely stripped from the anterior surface of the clivus and the sphenoid sinus floor is removed flush with the clival recess (**Fig. 35**). A high speed drill with a 3mm coarse bit is used to remove the clival bone. Bleeding from the bone marrow is controlled with bone wax applied on a cottonoid. In general we continue drilling through the cancellous bone and do not stop for hemostasis until we get to the inner cortex. After the bleeding is controlled the inner cortex is removed using a combination of drilling and Kerrison rongeurs.

Tab. 4: Summary table describing the modular EEAs, the bone removed for each approach, the cistern exposed, the brain regions, cranial nerves and vessels that can be accessed. Also shown are the most common pathologies encountered for each module.

Approach	Bone	Cistern	Brain	Cranial Nerve	Vessel	Common Pathologies
Transcribriform	Cribriform plate Crista galli	Interhemispheric fissure	Gyrus rectus Orbito-frontal Gyrus	Olfactory	A2, frontopolar, orbital frontal arteries	Olfactory groove meningiomas, Esthesioneuro-blastomas, Encephalocoeles, CSF leaks, Sinonasal tumors
Transplanum Transtubercular	Planum sphenoidale, Tuberculum planum, Optic strut, Medial clinoid	Suprasellar cistern, Pre-chiasmatic cisternrne	Gyrus rectus, Orbito-frontal Gyrus	Optic nerve, Optic chiasm	Anterior circle of Willis	Planum meningiomas, Suprasellar pituitary macroadenoma, Craniopharyngioma, Optic nerve gliomas
Posterior clinoid (trans/subsellar approaches)	Upper third of clivus, posterior clinoids, dorsum sella	Suprasellar cistern, Anterior recess of III ventricle, Basilar cistern, Interpeduncular cistern	Uncus, Hypothalamus, Infundibulum, Mammilary body, Midbrain, Cerebral peduncles	II, III, VI	Basilar apex, P1, Pcom, P2, Perforators, SCA	Retrosellar craniopharyngioma, Pituitary macroadenomas, Petroclival meningiomas
Transclival	Middle and lower third of clivus, Petrous apex, Dorello's canal	Pre-pontine cistern, Ponto-medullary cistern	Ventral pons, Upper medulla	V, VI, VII, VII	Mid basilar, AICA, VBJ	Petroclival meningiomas, Chordomas, Chondrosarcomas, Sinonasal tumors
Cranial-vertebral junction	Foramen magnum, Medial occipital condyle	Ponto-medullary cistern	Lower medulla Cervico-medullary junction	IX, X, XI, XII	VBJ Medullary perforators Vertebral	Foramen magnum meningiomas Chordomas
Odontoid	Foramen magnum Ring of C1 Odontoid Upper body of C2	Caudal extension of ponto-medullary cistern	Cervico-medullary junction, Ventral cervical spinal cord at C1 and C2	XI	Vertebral artery at intradural insertion, Anterior spinal arteries	Rheumatoid arthritis/ basilar invagination, Foramen magnum meningiomas

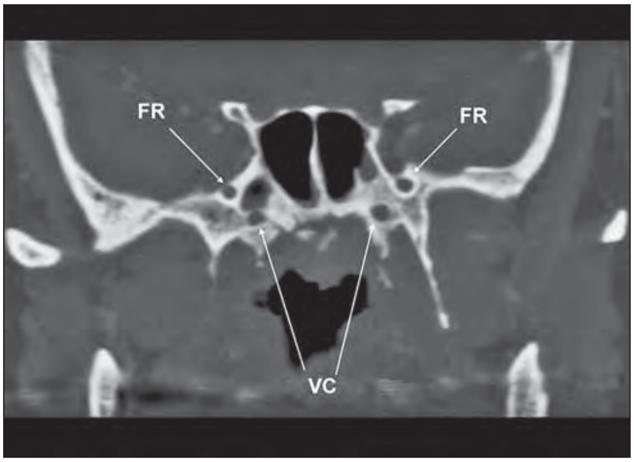

Fig. 36a
Coronal CT demonstrating the vidian (pterygoid) canal (**VC**) and foramen rotundum (**FR**).

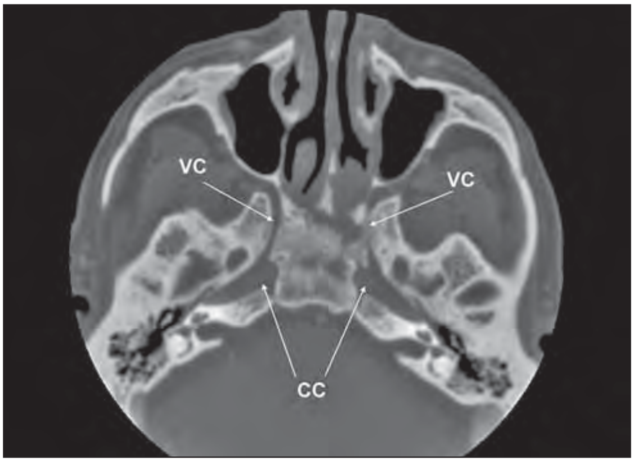

Fig. 36b
Axial CT demonstrating the relationship of the vidian (pterygoid) canal (**VC**) to the carotid canal (**CC**).

Lateral removal of bone under the horizontal petrous segment of the ICA is completed by following the vidian canal with its artery and nerve. These represent critical landmarks as they travel in the vidian canal to join the anterior genu of the ICA (**Fig. 36a, b**). When removing the median clival bone rostral to the level of the vidian nerve it is imperative to drill between the ICA canals only. If we need to remove the petrous bone that is inferior and lateral to the anterior genu of the ICA, then the vidian canal is used as a safety landmark. Drilling of this portion of the petrous bone under the horizontal carotid should be done in a caudal to rostral direction staying exclusively below the vidian canal (**Fig. 37**).

Intradural Dissection

Once the overlying clivus is removed, the underlying dura and its basilar venous plexus are exposed and controlled. Bleeding from the basilar dural plexus can be profuse, particularly if it has not been thrombosed by the invasion of tumor. This requires coagulation of the dura, which can be segmentally opened in the midline, while microfibrillar collagen "sandwiches" are used to thrombose the sinus. The lateral dural opening, under the horizontal segment of the petrous carotid, is extended to the level of the fossa of Rosenmuller just as the Eustachian tubes disappear obliquely into the skull base. Opening of the dura laterally and at a level that is superior to the ICA genu should be done under direct visualization as the abducens nerve enters Dorello's canal just medial, superior and dorsal to the anterior carotid genu.

Intradural dissection in this segment starts with the identification of the vertebral artery which is then followed to the vertebrobasilar junction (VBJ) (**Fig. 38**). The abducens nerve can be identified lateral to the VBJ. The basilar artery can then be followed in a rostral direction to expose the remainder of the posterior circulation, pons, and cranial nerves V, VI, VII, VIII, IX, and X (**Fig. 39**). If exposure of the oculomotor nerve is needed, this will require a posterior clinoidectomy as previously described.

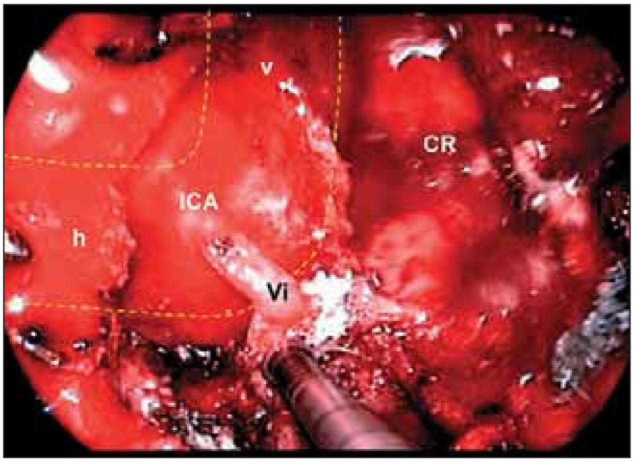

Fig. 37
Drilling of bone medial and inferior to the vidian artery (**Vi**) is done to expose the junction of the horizontal (**h**) and vertical (**v**) portions of the internal petrous carotid artery (**ICA**) at the foramen lacerum (**right side**). The clival recess (**CR**) is shown.

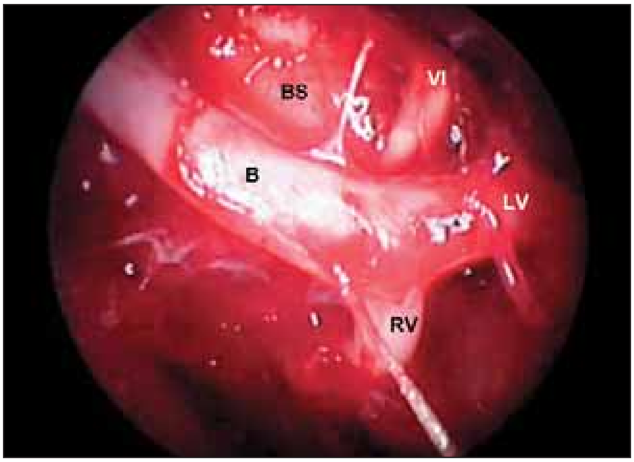

Fig. 38
Intradural exposure with identification of the vertebral-basilar junction (**VBJ**). The abducens nerve (**VI**) can be identified lateral to the VBJ as it ascends to enter Dorello's canal. Right vertebral artery (**RV**), left vertebral artery (**LV**), basilary artery (**B**), brain stem (**BS**).

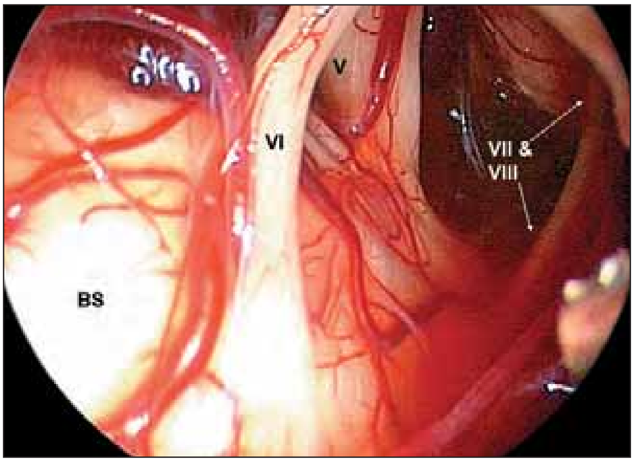

Fig. 39
Ventro-lateral view of brainstem and cranial nerves (**V, VI, VII, VIII**) with an angled endoscope.

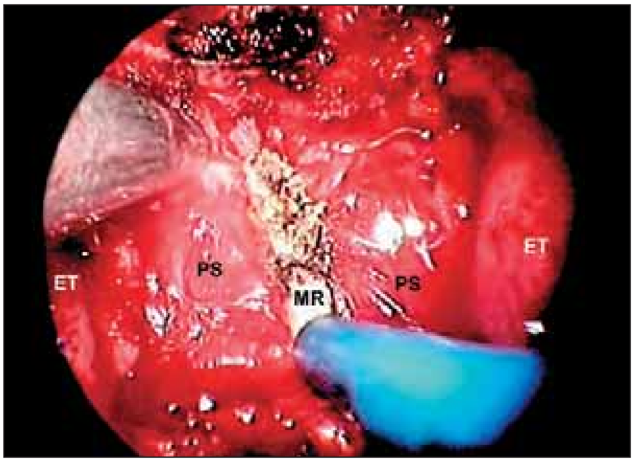

Fig. 40
The midline fascia over the paraspinal muscles (**PS**) is incised along the midline raphe (**MR**) using monopolar electrocautery.
The nasopharyngeal soft tissues are then resected to the margins of the Eustachian tubes (**ET**) laterally and to the level of the soft palate inferiorly.

Transodontoid and Foramen Magnum/Craniovertebral Approaches

General Exposure

A panclival exposure creates a single cavity that extends from the sphenoid sinus to the level of the fossa of Rosenmuller. To expose the odontoid and foramen magnum additional soft-tissue removal is required. The nasopharyngeal mucosa is cauterized with monopolar electrocautery and then resected from the spheno-clival junction to the level of the soft palate (**Fig. 40**). The longus capitis and longus colli muscles are exposed and partially resected to expose the ring of C1 (**Fig. 41**). Image guidance (IGS) can be very useful during this part of the surgery. Care should be taken to stay medial to the Eustachian tubes, especially when using electrocautery, as the parapharyngeal carotid is directly posterolateral to the Eustachian tube. Rarely, an ectatic carotid artery may be encountered within the nasopharynx.

Osseous Exposure

Bone removal is tailored to the pathology and according to concerns regarding craniocervical stability. If exposure of only the foramen magnum is needed then the ring of C1 is drilled at its most superior aspect to expose the tip of the dens only (**Fig. 41**). The anterior face of the basion and lower third of the clivus are removed. At this point the lateral bone removal needs to be tailored based on the pathology. The medial aspects of the occipital condyles are removed without entering the synovial joint capsule. Venous bleeding from the circular sinus is encountered during the drilling of the basion at the level of the foramen magnum and the occipital condyle junction and is managed with microfibrillar collagen "sandwiches". We have found that this degree of bone removal is adequate even for lesions that extend intradurally down to the level of C2. The rostral-caudal trajectory offered by the endoscopic approach and the occasional use of angled endoscopes allows for excellent visualization of the cervical spinal cord down to the level of C1–C2.

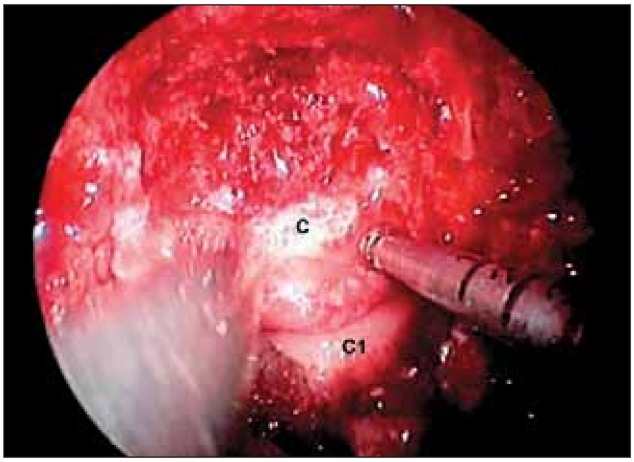

Fig. 41
The longus capitus and longus colli muscles are partially resected to expose the clivus (**C**) and the ring of C1 (**C1**).

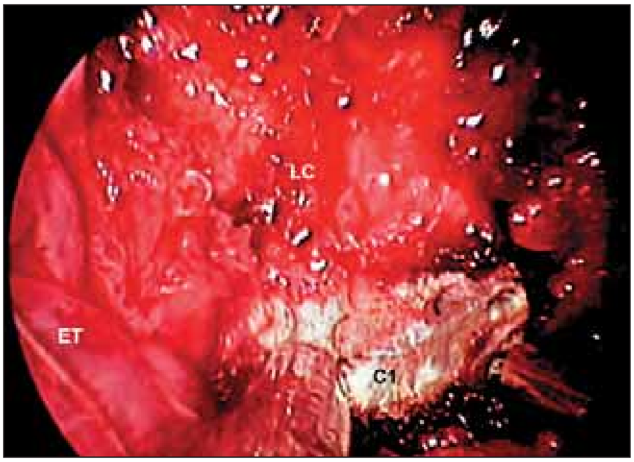

Fig. 42
After a lower clivectomy (**LC**) is performed, the central portion of C1 (**C1**) is then removed with a drill and the lateral portion is then removed with a Kerrison rongeur. The right Eustachian tube (**ET**) is shown.

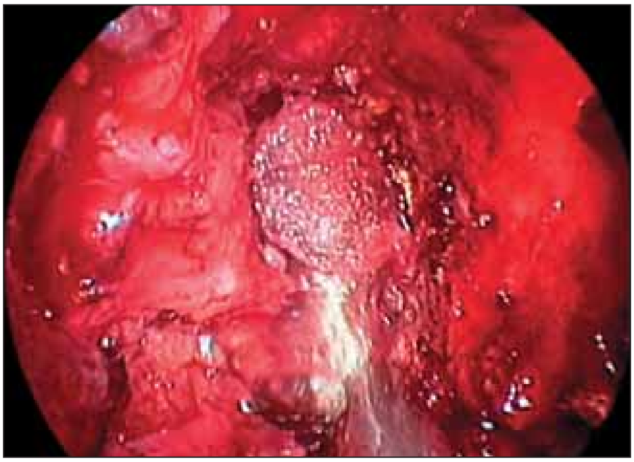

Fig. 43
After the exposure, the central portion of the odontoid is excavated with the rill.

If the patient's craniocervical junction is unstable preoperatively or if degeneration of the odontoid represents the primary pathology, then additional removal of the odontoid will be needed. To accomplish this, the entire ring of C1 is resected exposing the odontoid (**Fig. 42**). The amount of C1 removal will be determined by the degree of dens that will need to be exposed and removed.

Removal of extradural compressive lesions

The most common indication for this is basilar invagination secondary to rheumatoid arthritis. Pannus under the ring of C1 and ventral to the dens can be removed using the EEA aspirator and the dens can be completely exposed (**Fig. 43**). The dens may disappear rostrally as it angles dorsally to extend through the foramen magnum, which can form a cap over the tip of the odontoid in cases of cranial settling. If this is the case, the ventral portion of the foramen magnum (inferior clivus) must be removed to visualize the tip of the dens. This requires resection of the disrupted and infiltrated atlantoaxial membrane using a Kerrison rongeur or cutting forceps and then drilling away the ventral foramen magnum. The degree of cranial settling is variable and its severity determines the extent of lower clivus and foramen magnum removal.

After coring out the dens using an extended drill bit (see Equipment section) we prefer sharp dissection rather than Kerrison punches to remove the remaining cortical shell (**Fig. 44**). Sharp dissection, using rotatable pistol grip scissors to transect the bands that tether the dens and the pannus to the dura minimizes the risk of a cerebrospinal fluid leak. Once both lateral margins are resected the cap is mobilized and removed using sharp dissection. Removal of the underlying pannus is pursued until strong pulsations are visible, suggesting adequate decompression. A wide resection can be confirmed using angled endoscopes and image guidance.

The nasopharyngeal tissues do not need reapproximation and the surgical defect is covered with fibrin glue. The nasal passages are cleared of blood and silastic septal splints are inserted to minimize the risk of postoperative synechiae.

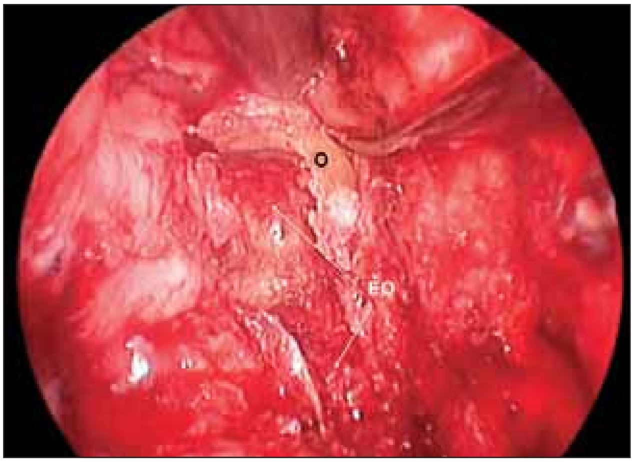

Fig. 44
The shell of the drilled odontoid (**O**) is dissected free from the surrounding ligaments and pannus. The excavated odontoid (**EO**) is demonstrated.

6.0 Reconstruction

6.1 General Principles of Reconstruction

The basic principle of reconstruction is the separation of the sinonasal tract and intracranial cavity. The initial reconstruction provides a temporary seal of the defect while the underlying tissues heal to form a permanent barrier. This temporary seal should resist the forces of gravity, pulsations of the brain and the CSF pressure to allow for the grafts to adhere and form a water-tight barrier. Migration of the graft or overwhelming CSF pressure allows the formation of channels of CSF that will prevent subsequent closure of the defect and formation of a permanent scar. Reconstruction of the cranial base following endoscopic brain surgery is an evolving technique but we have developed multiple reconstructive methods to prevent the migration or separation of the reconstructive tissues and to minimize the CSF pressure.

We started with a technique that was similar to the one that we were using for the reconstruction of spontaneous and post-traumatic cerebrospinal leaks (CSF). This involved the use of a multilayered barrier comprised of free tissue grafts. Initially we used cadaveric pericardium as an inlay graft placed in the epidural space. We discovered, however, that it is frequently impossible to place the graft as an inlay graft (between the dura and bone) due to the loss of the bone edges, the geometry of the defect or its proximity to critical neurovascular structures. We also found the cadaveric pericardium to be less pliable than other tissues and difficult to contour. Initially, we covered the inlay graft with a fibrin sealant to minimize migration and then placed an onlay fascial graft over the ventral surface of the bone defect (sinonasal tract side). The use of fibrin glue proved to be counterproductive as it prevented the onlay graft from making direct contact with the bone and the inlay graft, thus, preventing vascularization. When placing an onlay graft, it is critical to prepare the defect by removing the mucoperiosteum covering the bone so that the graft is in contact with bone around its perimeter.

On top of the onlay fascial graft, an abdominal fat graft was used as a bolster and a biological dressing. A fibrin sealant was applied to help fixate the fat graft. Sponge packings (Merocel tampons) were placed intranasally to support the fat graft and provide some compression. During the early period of our experience we placed a lumbar drain for three to five days to minimize CSF pressure. We used this basic reconstruction technique for several years and in the process discovered several risk factors for failure. We identified that the incidence of CSF leaks after EEA varied according to the pathology, the site of the lesion and whether arachnoid cisterns or ventricles needed to be opened. The size of the lesion and the size of the resultant defect were not nearly as important as whether an arachnoid cistern had been opened. Other possible risk factors included a history of prior surgery, the amount of blood contaminating the subarachnoid space during surgery, and the body habitus (obesity) of the patient.

During the repair of postoperative CSF leaks we invariably found that most of the grafts had taken but there were one or more small persistent fistulas at the perimeter of the grafts. Leaks were often found where the grafts were folded on themselves and not in contact with the tissues or where the edge of the graft had migrated (**Fig. 45**). In these patients, we removed only those segments of graft that had not taken and once the fistulas were identified we reinforced the repair by placing a new inlay and/or an onlay graft followed by another fat graft. CSF diversion was used in those patients suspected to have increased CSF pressures and in those in whom a cistern was opened.

As a result of our findings during these persistent CSF fistulas we made several modifications. We started placing the initial inlay graft subdurally, i.e. directly between the brain and the dura, rather than epidurally, i.e. between the dura and the skull base (**Fig. 46**).

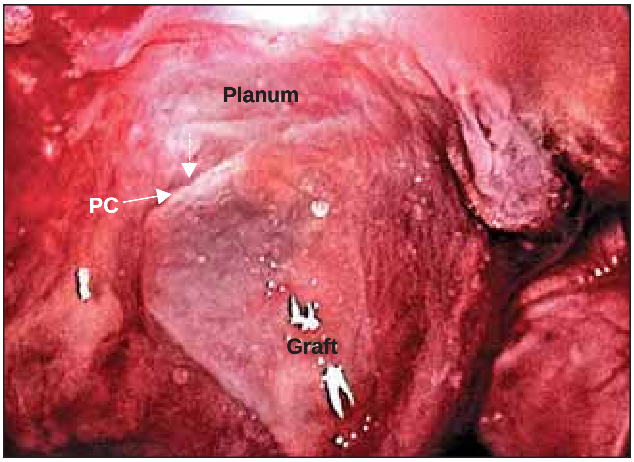

Fig. 45
In this patient with a postoperative cerebrospinal fluid (**CSF**) leak, there is migration of the acellular dermal graft with a persistent channel (**PC**) where the CSF is leaking through.

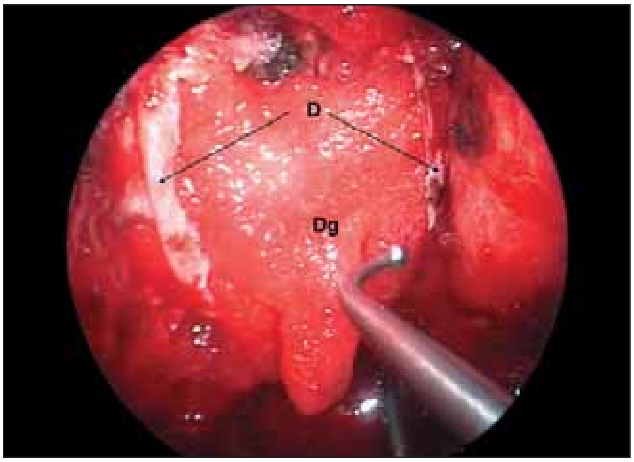

Fig. 46
An inlay Duragen graft (**Dg**) is placed between the brain and the dura (**D**).

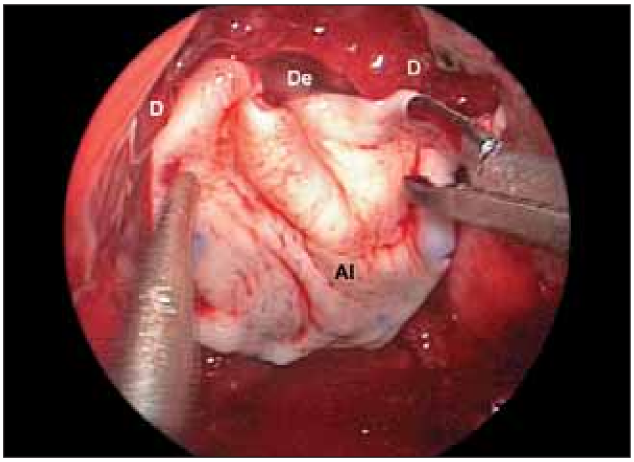

Fig. 47
An onlay Alloderm graft (**Al**) is placed extradurally and overlaps the bony defect (**De**). The dura mater of the edge of the defect is shown (**D**).

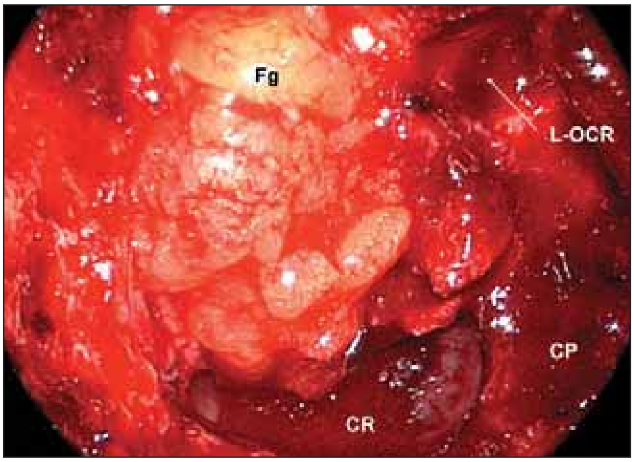

Fig. 48
A fat graft (**Fg**) harvested from the abdomen covers the extradural onlay graft and is contact with bone. The lateral optic-carotid recess (**L-OCR**) is shown in the left side. The clival recess (**CR**) is shown under the sella where the fat graft is positioned bounded by the carotid protuberance (**CP**) laterally.

We adopted the use of a collagen matrix graft (Duragen), which while easy to maneuver, is soft and pliable; thus, decreasing the risk of injuring any critical structure as we tuck the graft to overlap the surrounding dural edges of the defect. We eliminated the routine use of lumbar drains and reserved them for high-risk situations or secondary repairs. Acellular dermis was chosen as the onlay graft (off-label indication), as we found that it tends to revascularize faster than other tissues. A graft of moderate thickness (0.30–0.70 micron) seemed to offer the best combination of tissue handling and take. Whenever possible, the onlay graft is placed at a different orientation to the inlay graft (**Fig. 47**).

Then, we stopped using any type of sealant between the layers of the reconstruction. Biological sealants or glues are applied over the last graft only, i.e. the fat grafts (**Fig. 48**). In addition, we increased our vigilance during the placement of the fat and /or packing to avoid the accidental shifting of the underlying grafts. It is important that the fat grafts be in contact with bare bone (mucosa removed) to allow vascularization.

We were concerned that the nasal tampons may have caused the grafts to shift during their removal due to shearing forces or creation of a suction effect upon withdrawal. We also surmised that many leaks occurred early in the perioperative period due to transient spikes in CSF pressures due to patient activity or body habitus. In order to counteract this force, we adopted the use of a balloon catheter to provide an external counterforce. A 12–24 Fr Foley catheter is placed in the nasal cavity at the completion the procedure and inflated with 5–10 cc water to compress the fat grafts and is removed 4–7 days later (**Fig. 49**). It is critical to inflate and place the balloon under direct visualization.

It is critical to examine the patient immediately postoperatively to ensure that the balloon is not creating a neural compression syndrome. This will reduce the risk of placing the tip of the catheter through the grafts or overinflation of the balloon leading to compressive intracranial symptoms. We continued to experience an unacceptable incidence of CSF leaks, however some of which were still deemed to be caused by shifting of the grafts during the placement of the fat grafts or even the balloon inflation.

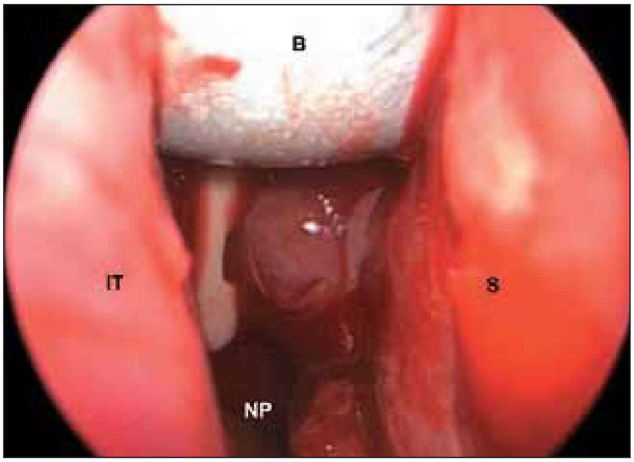

Fig. 49
A balloon catheter (**B**) is inflated intranasally to provide external support for the reconstruction during the early healing phase.
The nasal septum (**S**), the nasopharynx (**NP**), and the inferior turbinate (**IT**) are shown.

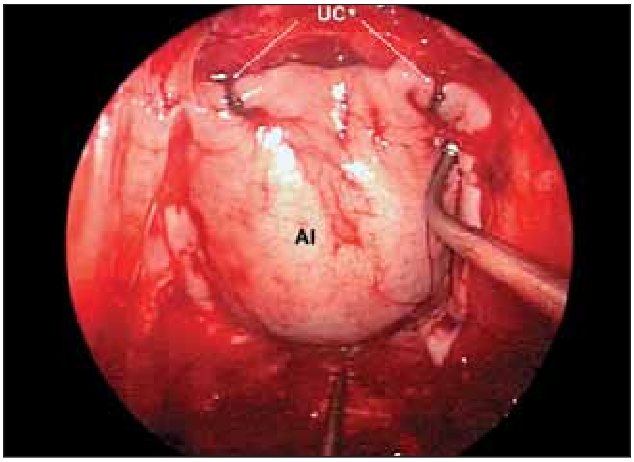

Fig. 50
The onlay Alloderm graft (**Al**) can be secured to the dural edge with sutures or nitinol U-clips (**UC**) to prevent graft migration.

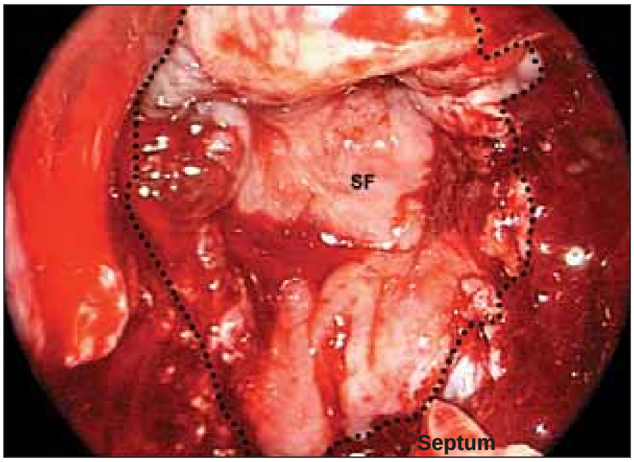

Fig. 51
A vascularized septal flap (**SF**) pedicled on the posterior nasal artery can be rotated to cover large clival and planum defects.

We started suturing the edges of the onlay fascial graft to the remaining dura, a technique that although effective, was technically challenging and cumbersome. This task became easier with the use of with nitinol rings (Medtronic U-clips, Memphis, TN off-label indication), which are self coiling "sutures" that were created for vascular anastomoses (**Fig. 50**). Our latest intervention to decrease the incidence of postoperative CSF leaks employs vascularized mucosal flaps. The use of vascularized tissue would be expected to hasten the healing process, especially in patients with prior radiation therapy, and make patients more suitable for early postoperative radiation therapy. Several mucoperiosteal flaps have been described and used with great success for the repair of CSF leaks. These flaps, however, were rotation flaps with a random blood supply that limited their surface area. Additionally, the septal flaps were based in such a way that the torsional forces of the tissue tended to pull the flap away from the defect. *Hadad* and *Bassagasteguy* from Argentina developed – that we subsequently modified for EEA, a nasoseptal flap – supplied by the posterior nasoseptal arteries, which are branches of the posterior nasal artery. The posterior nasoseptal arteries supply the entire septum anastomosing with the ethmoidal arteries superiorly, the greater palatine artery inferiorly and the facial artery anteriorly. A mucoperichondrial/ mucoperiosteal flap pedicled on the posterior nasal arteries provides a long flap that has a wide arc of rotation and a potential for area of coverage that is superior to any other flap previously described (**Fig. 51**). The flap may be harvested to cover the entire anterior skull base from the frontal sinus to the sella, or cover a clival defect from the sella to C2. Use of the flap needs to be anticipated in advance, however, since a posterior septectomy wide large sphenoidotomy, which is part of our basic approach, removes the vascular pedicle. This flap is very reliable and is typically positioned over a fascial graft or fat graft and held in place with fibrin glue and a balloon catheter. We have not observed any significant donor site morbidity with the use of this flap and the septum becomes remucosalized within several months of surgery.

In those cases where a mucoperiosteal flap is not available (revision surgeries or neoplastic involvement of the rostrum) and reconstruction with vascularized tissue is felt to be necessary (irradiated tissues), regional vascularized flaps have been used. A lateral temporoparietal fascial flap can be tunneled through a maxillary defect to provide wide coverage of the anterior cranial base. Similarly, an anteriorly base pericranial flap could be used in the absence of a frontal craniotomy but would require construction of a bony window for the vascular pedicle.

7.0 Post-Operative Management

Perioperative prophylactic antibiotics are administered until the packing is removed. Silastic splints, which are placed at the time of surgery, to prevent synechiae between the nasal septum and turbinates, are removed in general 5–21 days later. When a septal mucosal flap is used, the splints are retained for 2–3 weeks to facilitate healing of the donor site. Patients are instructed to use a saline nasal spray for nasal hygiene. They are strongly and repeatedly cautioned against any activity that may elevate the intracranial pressure or may stress the graft, such as nose blowing, physical exertion, or bending over. They are examined in the office every 2–4 weeks initially to debride nasal crusting until healing is complete. Any clear rhinorrhea is evaluated with endoscopic examination and testing of the fluid for beta-2 transferrin. Complete healing of fat grafts can be prolonged for several months while the non-viable part of the fat graft separates from the vascularized portion. Saline irrigations are instituted, if necessary, for nasal hygiene after the risk of a CSF leak has passed.

8.0 Equipment

Navigation Systems

Several considerations are critical when using an optical tracking surgical navigation device during EEAs. Maintaining a line of sight between the camera and the probe is challenging. Placing an endoscope in through the nares and a navigation probe beneath it often results in obstructing the path between the camera array and the light-emitting diodes on the probe. A bilateral transnarial approach partially compensates for this, as it increases the angle of visualization allowing the separation of scope and probe. A system with a wide range of camera coverage is preferable. It should be remembered that the accuracy at degrades proportionally to the distance to the surface registration points. These two issues are accentuated during EEAs that approach posterior, i.e. clival, lesions. Currently, we use a Stryker Navigation system (Stryker-Leibinger Co., Kalamazoo, Michigan, U.S.A.) that has been effective regarding all these issues.

Endoscopic Holder

We do not advocate the routine use of an endoscopic holder as we believe this significantly limits the potential for the superior visualization potential of the endoscope and hinders the surgeons flexibility. Our strong recommendation is to have a dedicated team comprised by a neurosurgeon experienced in microvascular techniques and an otolaryngologist experienced in sinonasal surgery. This 2 surgeons-4 hands technique that we have described allows for dynamic movement of the scope and instruments which is critical for maintaining visualization in tight spaces, minimizing the loss of visualization caused by the contact of the endoscope lens with mucosa, blood and other instruments. This dynamic interaction provides critical visual cues that help the surgeons to compensate for the loss of the depth perception. In addition, two experienced surgeons are better equipped to deal with hemorrhage or any other significant complication that requires continuous visualization.

Drills

We use a drill that was designed for endonasal work. An angled extended drill can be introduced endonasally and the extendable drill bit may be projected beyond the end of the shaft. This provides the visualization required for fine detailed drilling. A 3 mm diamond coarse bit provides an excellent combination of diamond and cutting characteristics. We use an extra long drill bit for the removal of the odontoid, which can be 13 cm from the nasal entrance.

Ultrasonic aspirator

A modified aspirator with an extended angled attachment and tip for endonasal application is effective for soft tissue removal and can be effectively used endonasally. The ultrasonic EEA aspirator (Integra Radionics, Burlington, Massachusetts, USA) is particularly effective for tissue in close contact to bone, and aids to maintain hemostasis, which makes it advantageous for the removal of pannus. New modifications allows the removal of even dense bone, such as the pterygoid plates.

Endoneurosurgical instrumentation

To facilitate our discussion we have divided the endoneurosurgical instrumentation according to surgical steps:

■ **Approach**

Most instruments are available in a standard paranasal sinus endoscopy tray. Some of these instruments will require a longer length to allow endoneurosurgical approaches. Modified instruments are available for this purpose. An endonasal drill is required during the approach.

■ **Resection**

A series of microscissors, including a 45 degree rotatable scissors, is critical for endodissection. The rotatable scissors allow change in cutting direction without removal of the instrument from the surgical field. Fine cup forceps and fine cutting forceps are necessary for the removal of fibrous tumors. All instruments should have pistol grip activation. Malleable suctions tips are required for suctioning, retraction and dissection. Malleability allows for the custom design of the suction to reach the surgical target and avoid interference with the endoscope (KARL STORZ Tuttlingen, Germany). Fine extendable bayonet-shaped dissectors are used for capsular dissection. These instruments are extendable and can be adjusted to reach deeper targets. Their bayonet-shaped design allows them to be kept low along the nasal floor out of the way of the endoscope.

■ **Hemostasis**

Pistol grip bipolar electrocautery forceps are absolutely necessary. Our current choice of bipolars can rotate 360 degrees to allow reorientation of the tips. We use three types of tips: a large thirty-degree up-angled tip, a fine thirty-degree up-angled irrigating bipolar for extracapsular dissection, and fine parallel arrow tips (Kassam bipolars).

9.0 Discussion

Transnasal access to the ventral skull base was first proposed almost a century ago. Over this time period, significant advancements in biotechnology and improved understanding of the anatomic relationships from this vantage point have resulted in the development of the EEA. In our opinion, the EEA provides an anatomically intuitive approach to the ventral skull base and intracranial cavity. It is ideal for centrally located pathology where the lesion is surrounded by critical neurovascular structures located around the perimeter. The EEA allows for direct access, minimizing the need for manipulation of these structures.

We present our experience and operative techniques developed over the past decade; however, the reader needs to be aware that these techniques continue to evolve, as do the technology platforms that they are based on. The successful execution of the EEA is based on a series of key prerequisites. First and foremost are the intense collaborative efforts between neurosurgeons and otolaryngologists. Ten years ago we performed our first endoscopic pituitary surgery and it has taken us a decade to develop the skills and experience required for some of these complex procedures.

The next requisite is comfort with endoscopic anatomy. Our modular endoneurosurgical approaches are based on anatomical knowledge of the ventral skull as viewed endonasally. The sphenoid sinus is the epicenter and the starting point for most of these modules due to the concentration of critical structures around the periphery. Technological advances, including the development of new instruments designed for endoscopic use, have facilitated the development of these surgical techniques. It should be emphasized that the principles of endoscopic tumor dissection are no different than those espoused for open surgical approaches with microscopic assistance. Extracapsular dissection is performed with full visualization of important neurovascular structures. There is no pulling of tumor and the dissection is controlled and precise. Not adhering to this principle will inevitably lead to catastrophe as the margin for error is much less with EEA than conventional approaches.

Training in these techniques should be both incremental and standardized in order to avoid unnecessary morbidity. We have developed a training plan that is incremental and takes into account the technical difficulty, risk of neural or vascular injury, and type of pathology (**Tab. 3**). Endonasal cranial base surgery has a steep learning curve. The surgeries are technically challenging and the anatomy (from the endoscopic perspective) is unfamiliar to most traditional cranial base surgeons. Endoneurosurgical techniques require the acquisition of new surgical skills on the part of the neurosurgeon. These are best developed as a team of surgeons (preferably, neurosurgeon and otolaryngologist) working together. In fact, it is not possible for the advanced surgical procedures described here to be performed by a single surgeon safely. Advantages of having a skilled second surgeon providing endoscopic visualization include dynamic adjustment of the endoscope to provide the best possible picture and avoid contact interference of instruments, a second surgical opinion in complex anatomical areas, and perhaps most important, maintenance of an endoscopic view in case of a crisis such as a vascular injury. The surgical team must have adequate endoscopic skills to achieve hemostasis and deal with vascular emergencies. There is a significant risk of neural and vascular injury and reconstruction of dural defects is challenging. In our opinion, these surgeries should only be performed by a dedicated team of surgeons that are trained in both open and endoscopic techniques. In fact, as stated previously, we believe it is mandatory that the same team be able to perform both an open and endoscopic approach to the same location. This allows for the selection of the approach to be guided by the anatomy rather than the surgeon's bias.

Endoscopic anatomical dissections in the anatomy laboratory, attendance at dedicated courses and a progressive escalation of surgical case complexity tied to a mentorship program are the basic components for successful training that offers safety to our patients. Having already established the anatomical principles and instrumentation, the learning curve we faced can be greatly compressed for those wishing to commit the time and energy. Our personal experience with the EEA was that of incremental growth; specifically, progressive comfort with each module forming the foundation to proceed to the next. It is this incremental growth that will minimize complications during the learning curve (**Tab. 3**).

The level I procedures represent endoscopic sinonasal surgery and is exactly where the teamwork must start. Although the otolaryngologist could be performing these procedures independently, it is the best opportunity for both surgeons to learn how to work together and for the neurosurgeon to become accustomed to the sinonasal anatomy and the use of the endoscope. As they progress together to level II, they gradually form a work unit where one can predict the other's actions while repairing CSF leaks and removing pituitary adenomas. The understanding of the endoscopic ventral skull base anatomy is a primordial step in order to advance to extradural surgery at level III and beyond. At this point the surgeons must make a conscious decision as to whether they wish to dedicate additional time and training to proceed to the more complex levels. Level IV is intradural surgery and the likelihood of complications increases dramatically. All the experience collected during previous levels is extremely important in the incremental acquisition of skills. The knowledge of repairing CSF leaks at level II is applied to reconstruct the large defects that surgeries at level IV can proportionate. Any endoscopic procedure that extends beyond the carotid in the paramedian plane must be considered level V along with other vascular procedures. Dissecting and transposing the internal carotid arteries with the use of angled scopes is definitely a daunting maneuver that must be considered by surgeons only after mastering the previous levels. The endonasal endoscopic surgical principles for the treatment of aneurysms and vascular malformations has not been well established. If they are to be pursued, the surgeons must adhere to the general principles of open cerebrovascular surgery.

Once mastered, the entire ventral skull base can be accessed with the EEA. The EEA starts at the sphenoid sinus and extends rostrally and caudally in a modular fashion based on the anatomic location of the tumor.

There are two primary concerns that need to be addressed at the onset when considering the EEA. The first is the ability to maintain hemostasis through these relatively tight corridors. Obviously the primary strategy is avoidance of hemorrhage and the endoneurosurgical techniques described previously for intradural dissection will optimize this. Despite this, however, situations requiring vascular control will arise and if EEA is to be established as a safe and effective approach, the ability to secure hemostasis must be consistently proven. In this review we have provided our techniques to maintain both arterial and venous hemostasis. To this date, we have not encountered a situation in which we could not achieve hemostasis, even in the case of major arterial hemorrhage.

The other major concern is that of being able to effectively reconstruct the defects following EEA. This can be challenging as some of the defects can span the entire ventral skull base. As discussed, the EEA has been a progressive and incremental evolution. The early years focused on developing the technology and anatomical basis to access and resect these lesions. Currently, the focus has shifted to reconstructive techniques. Despite the early primitive reconstructive techniques, the incidence of bacterial meningitis was remarkably low (1.5%). During this period, a number of patients required staged reconstruction with secondary procedures to repair persistent CSF channels. Surprisingly, the relatively higher incidence of CSF leak was not a major source of long-term morbidity during this early experience. The addition of suturing techniques for dural grafts, the balloon stent, and the vascularized mucosal flap have proven to be sentinel events in reconstruction that have dramatically reduced the risk of CSF leaks. It is anticipated that with an increasing focus on reconstruction, improvements in biomaterials and new technologies will completely solve this problem.

With any new treatment, the indications and limitations of the techniques are not clearly defined during the development and early adaptation phases. Outcomes studies are needed to establish that endoscopic techniques provide tumor control equivalent to traditional open techniques with less morbidity. Although our initial experience suggests that this is the case, further validation and generalizability needs to be established. Finally, studies are necessary to confirm the potential benefits of endoscopic techniques (improved visualization and more complete tumor resection, decreased brain injury due to reduced need for retraction and manipulation, and improved preservation of neural function). The surgical community has an opportunity to collect this data prospectively given the relative early stage of EEA and must make this a priority.

10. Conclusions

The expanded endonasal approach to the ventral skull base provides endoscopic access from the frontal sinus to the second cervical vertebra in the sagittal plane and from the midline to the jugular foramen, IAC and lateral mass of C2 in the coronal plane. Anatomical modules can be combined to tailor the approach to the location and extent of the pathology. Potential advantages of the expanded endonasal approach not only includes improved cosmesis but more importantly, the potential for much less neurovascular manipulation in well selected cases. In pediatric patients, preservation of the facial skeleton avoids disruption of growth centers and development of facial asymmetry with further growth. In contrast to an intracranial approach, an endonasal approach avoids the need for any brain retraction and may result in less damage to nervous tissue. Improved visualization and better access to difficult to reach sites may result in improved oncological outcomes. Publication of outcomes studies is necessary to verify these potential benefits and this is underway.

Complications of the expanded endonasal approach are the same as open approaches: neural and vascular injury, infection, CSF leak. Neural and vascular injuries are fortunately rare. In our current series of 700 patients, the incidence is 1.0%. These can be avoided with attention to anatomical landmarks and proper dissection techniques. An experienced team can effectively control venous bleeding from the cavernous sinus or basilar plexus. Inadvertent laceration of a large arteriole can be catastrophic unless the team can maintain an endoscopic view and control the bleeding with bipolar electrocautery or focal packing. Injury to the internal carotid artery usually requires subsequent sacrifice using endovascular techniques. Despite bacterial contamination of the nasal portal, infectious complications are exceedingly rare. Perioperative antibiotic prophylaxis, multilayered repair of dural defects, and aggressive management of postoperative CSF leaks are contributing factors. One of the biggest remaining challenges is repair of large dural defects and prevention of postoperative CSF leaks. With the advent of the septal flap, the current experience suggests a rate of 6%. This will need to be defined further as experience with the flap continues to accrue. In all cases except two previously irradiated patients, we have successfully repaired leaks with additional endoscopic surgery. Developments that have decreased the incidence of postoperative CSF leaks include a multilayered closure, direct suturing of grafts to the dural edges, use of biological glues, coverage with a vascularized septal mucosal flap, and supporting the reconstruction with an intranasal balloon catheter.

The limits of endoscopic cranial base surgery have not been reached. Considerations include the ability to achieve a complete resection, the ability to deal with complications such as a vascular injury and reconstruct the dura, and the duration of surgery. Our guiding principle has been that the best approach is the one that minimizes the need for displacement of normal neural and vascular tissues. For many tumors involving the ventral skull base, the most direct approach is through the nasal cavity. Outcomes studies with adequate follow up are necessary to define the role of endoscopic techniques in the management of malignant neoplasms.

11. Training Program

At the University of Pittsburgh Medical Center, we are extremely committed to the systematic and incremental development of our trainees (**Tab. 3**). We believe that the foundation of this development is adequate exposure to the procedure, understanding each level. Toward this end, a detailed course has been developed at the University o Pittsburgh Medical Center. The course is organized based on the incremental levels of training. The first day of the course focuses on level I and II procedures and provides a general overview.

This is then followed by a live surgical procedure that specifically demonstrates the surgical technique in the operating room viaa case performed by the team. Next, a series of cadaveric dissections are done in the laboratory. Each station in the laboratory is organized in a manner that parallels the operating room with fresh cadaveric specimens, individual image-guidance systems and detailed endonasal equipment as outlined in the equipment section. This allows the participant to learn the surgical procedure in a proctored, systematic fashion and become familiar with the anatomical principles and equipment. At this point, once level I and II procedures are covered and performed, the hands-on course moves into levels III, IV and V with intradural dissections. A series of detailed anatomic lectures are given, followed by modular dissections in the cadaveric lab with individual proctoring.

We believe that once the attendees have developed a familiarity with this procedure via the course, they then should return to their home environments to perform level I and II procedures. As they gain increasing experience with level I and II procedures, they should then return for a problem-focused approach. This involves a second course focusing on the obstacles and barriers that they encountered during level I and II procedures. At this point, we believe that it is extremely advantageous for the individuals to undertake a 1–2 week, concentrated mini fellowship with our team. The participants are offered observation in the operating room for more advanced as well as basic cases. In addition, individualized proctored cadaveric dissections can be arranged. We believe that this is the most systematic way of gaining incremental experience with the procedure, minimizing the scope of the learning curve and maintaining patient safety.

The intense training required for levels IV and V involves a systematic commitment with complete immersion.

The existing cadaveric courses are used to augment the initial exposure but cannot be used in lieu of detailed immersion in the training program for the more advanced levels to follow.

The cadaveric courses are offered three times a year at the University of Pittsburgh Medical Center and the mini fellowships are offered throughout the year.

http://www.neurosurgery.pitt.edu/training/endoscopic_course.html

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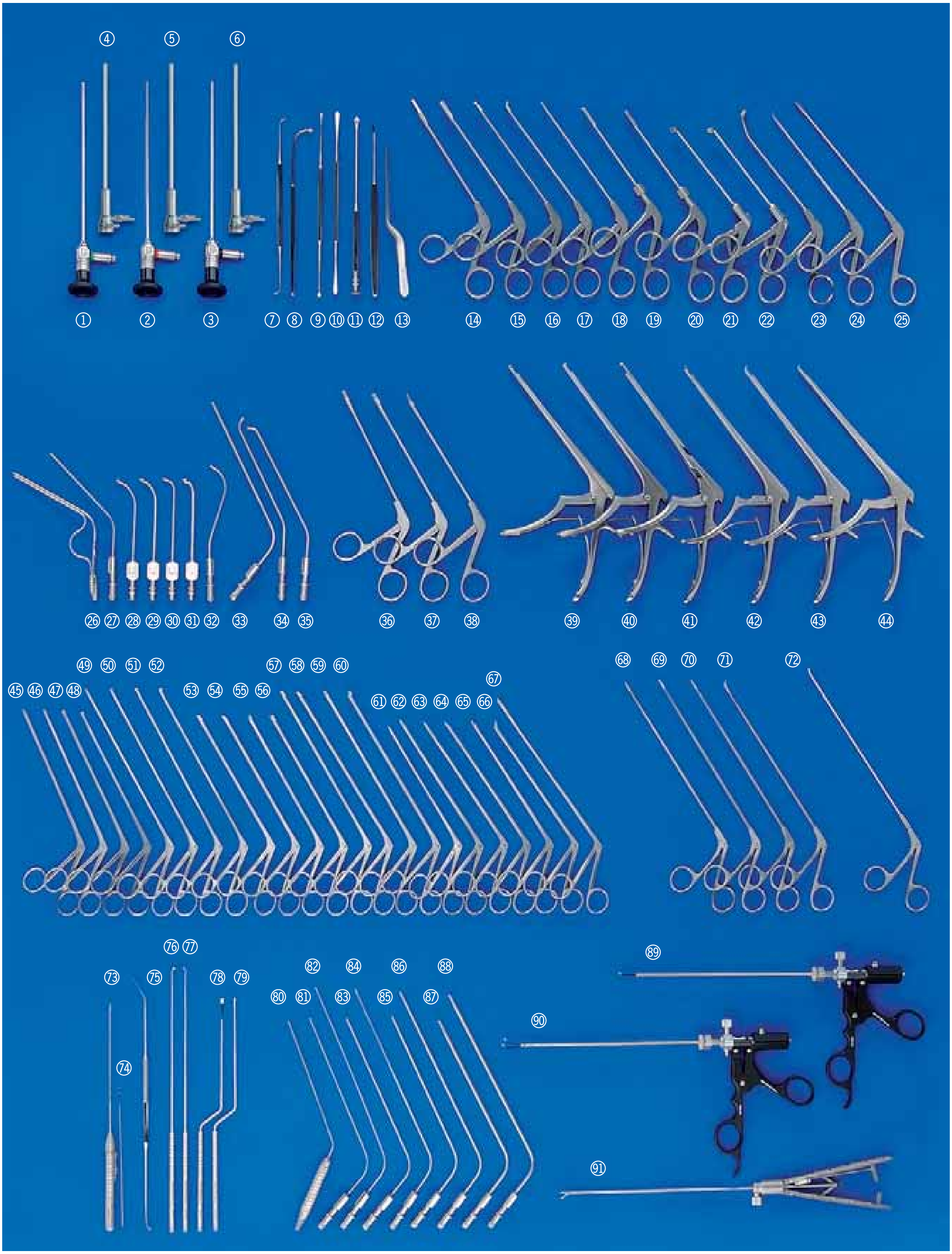

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⑧ 628714 KUHN-BOLGER **Frontal Sinus Curette,** 90° curved, oval, forward cutting, length 19 cm

⑨ 479100 COTTLE **Elevator,** double-ended, semisharp and blunt, graduated, length 20 cm

⑩ 474000 FREER **Elevator,** double-ended, semisharp and blunt, length 20 cm

⑪ 474001 FREER **Suction Elevator,** with stylet, length 19 cm

⑫ 628001 **Sickle Knife,** pointed, length 19 cm

Forceps

⑬ 426516 JANSEN **Nasal Dressing Forceps,** bayonet-shaped, length 16.5 cm

⑭ 455010 STRUYCKEN **RHINOFORCE® II Nasal Cutting Forceps,** with cleaning connector, working length 13 cm

⑮ 455500 B TAKAHASHI **RHINOFORCE® Nasal Forceps,** straight, working length 13 cm

⑯ 451000 B GRÜNWALD-HENKE **RHINOFORCE® II Nasal Cutting Forceps,** straight, through-cutting, tissue-sparing, BLAKESLEY shape, size 0, width 3 mm, with cleaning connector, working length 13 cm

⑰ 451500 B GRÜNWALD-HENKE **RHINOFORCE® II Nasal Cutting Forceps,** 45° upturned, through-cutting, tissue-sparing, BLAKESLEY shape, size 0, width 3 mm, with cleaning connector, working length 13 cm

⑱ 456000 B BLAKESLEY **R HINOFORCE® II Nasal Forceps,** straight, size 0, with cleaning connector, working length 13 cm

⑲ 459016 STAMMBERGER **Antrum Punch,** backward cutting, sheath 360° rotatable, with fixing screw, dismantling, working length 10 cm, for use with Cleaning Adaptor 459015 LL

⑳ 459036 STAMMBERGER **Antrum Punch,** small pediatric size, slender, backward cutting, sheath 360° rotatable, with fixing screw, take apart, working length 10 cm

㉑ 459051 STAMMBERGER **Antrum Punch,** right side downward and forward cutting, with cleaning connector, working length 10 cm

㉒ 459052 **Same,** left side downward and forward cutting

㉓ 456511 B BLAKESLEY-CASTELNUOVO **RHINOFORCE® II Nasal Forceps,** end of sheath 25° upturned, jaws 45° angled upwards, width 3.5 mm, with cleaning connector, working length 13 cm

㉔ 452832 **RHINOFORCE® II Miniature Nasal Forceps,** with extra fine flat jaws, through-cutting, tissue-sparing, straight sheath, jaws 45° upturned, width of cut 1.5 mm, with cleaning connector, working length 13 cm

㉕ 649123 B TAKAHASHI **RHINOFORCE® II Ethmoid Forceps,** spoon size 4 x 10 mm, with cleaning connector, working length 17 cm

Cannulas

㉖	206600	FISCH **Suction and Irrigation Tube,** cylindrical, suction tube outer diameter 2.5 mm, irrigation tube outer diameter 2 mm, working length 9.5 cm
㉗	529207	FRAZIER **Suction Tube,** with cut-off hole and stylet, angled, outer diameter 7 Fr./2 mm, working length 10 cm, total length 17.5 cm
㉘	586026	v. EICKEN **Antrum Cannula,** LUER-Lock, with cut-off hole, long curve, outer diameter 2.5 mm, length 12.5 cm
㉙	586031	**Same,** outer diameter 3 mm
㉚	586226	v. EICKEN **Antrum Cannula,** LUER-Lock, with cut-off hole, short curve, outer diameter 2.5 mm, length 12.5 cm
㉛	586241	**Same,** outer diameter 4 mm
㉜	641625	**Suction Tube,** for frontal sinus, with cut-off hole, LUER, outer diameter 2.5 mm, length 14.5 cm
㉝	649183	FERGUSON **Suction Tube,** with cut-off hole and stylet, LUER, 10 Fr., working length 15 cm
㉞	662885	FRANK-PASQUINI **Suction Tube,** angular, tip curved upwards, ball end, with grip plate and cut-off hole, LUER, diameter 3 mm, working length 13 cm
㉟	662886	FRANK-PASQUINI **Suction Tube,** angular, tip curved downwards, ball end, with grip plate and cut-off hole, LUER, diameter 3 mm, working length 13 cm

Scissors

㊱	449201	**RHINOFORCE® II Nasal Scissors,** straight, with cleaning connector, working length 13 cm
㊲	449202	**Same,** curved to right
㊳	449203	**Same,** curved to left

KERRISON **Punches**

㊴	662101	KERRISON **Bone Punch,** detachable, rigid, 90° upbiting, not through-cutting, size 1 mm, working length 17 cm
㊵	662102	**Same,** size 2 mm
㊶	662112	KERRISON **Bone Punch,** detachable, rigid, 90° downbiting, not through-cutting, size 2 mm, working length 17 cm
㊷	28164 MKA	KERRISON **Bone Punch,** detachable, rigid, upbiting 60° forward, size 1 mm, working length 17 cm
㊸	28164 MKB	**Same,** size 2 mm
㊹	662120	KERRISON **Bone Punch,** detachable, rigid, upbiting 40° forward, size 0.7 mm, working length 17 cm

Resection Phase – Cupped Forceps

㊺	662202	**Forceps,** straight, extra delicate, oval cupped jaws, width 0.6 mm, working length 15 cm
㊻	662203	**Same,** curved to right
㊼	662204	**Same,** curved to left
㊽	662205	**Same,** 45° upturned
㊾	28164 TD	**Forceps,** round cupped jaws, diameter 0.6 mm, straight, extra delicate, working length 18 cm
㊿	28164 TE	**Forceps,** oval cupped jaws, diameter 0.6 mm, curved to right, extra delicate, working length 18 cm
51	28164 TF	**Same,** curved to left
52	28164 TA	**Same,** 45° curved upwards

Through-cutting Forceps “Gardeners“

53	662251	**Miniature Forceps,** straight, through-cutting, with fine flat jaws, width of cut 1 mm, working length 15 cm
54	662255	**Same,** curved to right
55	662256	**Same,** curved to left
56	662257	**Same,** curved upwards
57	28164 GS	**Miniature Forceps,** straight, through-cutting, with fine flat jaws, bite 1 mm, working length 18 cm
58	28164 GR	**Same,** curved to right
59	28164 GL	**Same,** curved to left
60	28164 GU	**Same,** curved upwards
61	662271	**Grasping Forceps,** straight, fine serrated, working length 15 cm

Scissors

62	662300	**Scissors,** straight, working length 15 cm
63	662301	**Scissors,** straight, extra delicate, working length 15 cm
64	662304	**Same,** curved to right
65	662305	**Same,** curved to left
66	662307	**Same,** 45° curved upwards
67	663300	**Scissors,** straight, working length 18 cm
68	28164 MZB	**Scissors,** straight, with small handle, with cleaning connector, working length 18 cm
69	28164 MZC	**Same,** curved to right
70	28164 MZD	**Same,** curved to left
71	28164 MZE	**Same,** curved upwards
72	28164 SAD	**Scissors, upturned 45°,** delicate, sheath 360° rotatable, with cleaning connector, working length 18 cm

Micro Raspatories, Elevators and Scalpel

⑦③ 28164 KK de DIVITIIS-CAPPABIANCA **Scalpel,** with retractable blade, length 23 cm, including:
Handle
Outer Sheath
Micro Knife, sickle-shaped

⑦④ 28164 MC **Micro Knife,** pointed, spare blade for de DIVITIIS-CAPPABIANCA Scalpel 28164 M

⑦⑤ 28164 EC CASTELNUOVO **Elevator,** double-ended, blunt end angled, semisharp end slightly curved, graduated, length 26 cm

⑦⑥ 28164 EL **Micro Raspatory,** single curved to left, width 2 mm, length 27 cm

⑦⑦ 28164 ER **Same,** single curved to right

⑦⑧ 28164 DR **Dissector,** bayonet-shaped, sharp, curved to right, length 24 cm

⑦⑨ 28164 DL **Same,** curved to left

Suction Tubes

⑧⓪ 663818 **Suction Tube,** angular, malleable, with round handle and cut-off hole, diameter 2 mm, working length 13 cm

⑧① 649179 B **Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 4 Fr., working length 15 cm

⑧② 649179 C **Same,** working length 18 cm

⑧③ 649180 B **Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 6 Fr., working length 15 cm

⑧④ 649180 C **Same,** working length 18 cm

⑧⑤ 649182 B **Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 8 Fr., working length 15 cm

⑧⑥ 649182 C **Same,** working length 18 cm

⑧⑦ 649183 B **Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 10 Fr., working length 15 cm

⑧⑧ 649183 C **Same,** working length 18 cm

Hemostasis

⑧⑨ 28164 BDL **TAKE-APART® Bipolar Forceps,** with fine jaws, width 1 mm, distally angled 45°, vertical closing, outer diameter 3.4 mm, working length 20 cm
including:
Bipolar Ring Handle
Outer Sheath
Inner Sheath
Forceps Insert

⑨⓪ 28164 BDM **TAKE-APART® Bipolar Forceps,** with fine jaws, width 1 mm, distally angled 45°, horizontal closing, outer diameter 3.4 mm, working length 20 cm
including:
Bipolar Ring Handle
Outer Sheath
Inner Sheath
Forceps Insert

28164 BDD **TAKE-APART® Bipolar Forceps,** width 2 mm, distally angled 45°, (not illustrated) horizontal closing, outer diameter 3.4 mm, working length 20 cm
including:
Bipolar Ring Handle
Outer Sheat
Inner Sheat
Forceps Insert

28164 BDG **TAKE-APART®** TAN **Bipolar Coagulation Forceps,** (not illustrated) size 3.4 mm, length 20 cm,
including:
Bipolar Ring Handle
Outer Sheath
Inner Sheath
Forceps Insert

26176 LA **Bipolar High Frequency Cord,** with 2x 4 mm banana plug for **KARL STORZ** Coagulator 26020 XA/XB and Valleylab, length 300 cm (not illustrated)

28164 BGK **Bipolar Forceps,** jaws curved upwards 45°, for bipolar coagulation in skull base and pituitary surgery, working length 18 cm, for use with Bipolar High Frequency Cords 847002 A/M/V (not illustrated)

847002 A **Bipolar High Frequency Cord,** with 2x 4 mm banana plug for **KARL STORZ** Coagulator 26020 XA/XB, length 450 cm (not illustrated)

452650 A MONTGOMERY-YOUNGS **RHINOFORCE® II Clip Applicator,** for endonasal endoscopic sphenopalatine artery ligature, with suction channel, handle with spring, straight, with cleaning connector, working length 13 cm, for use with Titanium Clips 8665 T (not illustrated)

⑨① 26167 FNS KOH **Ultramicro Needle Holder,** with tungsten carbide inserts, straight handle with ratchet, jaws slightly curved to left, size 3 mm, length 20 cm

39351 J **Plastic Container for Sterilization and Storage,** perforated, with transparent lid, for two-level storage, for use with forceps and instruments, external dimensions (w x d x h): 530 x 250 x 145 mm (not illustrated)

Expanded Endonasal Approach to the Ventral Skull Base NEW

Recommended Sets acc. to KASSAM-SNYDERMAN

Starter Set

Telescopes

①	28132 AA	**HOPKINS® Straight Forward Telescope 0°,** enlarged view, diameter 4 mm, length 18 cm, **autoclavable,** fiber optic light transmission incorporated, color code: green
②	28132 FVA	**HOPKINS® Forward-Oblique Telescope 45°,** enlarged view, diameter 4 mm, length 18 cm, **autoclavable,** connection for fiber optic light cable on upper side, fiber optic light transmission incorporated, color code: black
③	28132 CVA	**HOPKINS® Lateral Telescope 70°,** enlarged view, diameter 4 mm, length 18 cm, **autoclavable,** connection for fiber optic light cable on upper side, fiber optic light transmission incorporated, color code: yellow
	495 ND	**Fiber Optic Light Cable,** with straight connector, diameter 3.5 mm, length 300 cm (not illustrated)

KARL STORZ CLEARVISION® II System

	40 3341 01	**CLEARVISION® II,** irrigation pump for irrigation of the front lens, (not illustrated) power supply 100 – 240 VAC, 50/60 Hz including: **CLEARVISION® II** **Mains Cord** **One-Pedal Footswitch,** two-stage **Silicone Tubing Set,** for irrigation, sterilizable
④	28164 CBA	**Irrigation Sheath,** outer diameter 5 mm, working length 14 cm, for use with HOPKINS® Telescope 28132 AA and **KARL STORZ** lens irrigation system CLEARVISION® II
⑤	28164 CBF	**Irrigation Sheath,** outer diameter 5 mm, working length 14 cm, for use with HOPKINS® Telescope 28132 FA/FVA and **KARL STORZ** lens irrigation system CLEARVISION® II
⑥	28164 CBC	**Irrigation Sheath,** outer diameter 5 mm, working length 14 cm, for use with HOPKINS® Telescope 28132 CA/CVA and **KARL STORZ** Lens Irrigation System CLEARVISION® II

Approach Set – Probes, Elevators

⑦	629820	**Probe,** double-ended, maxillary sinus ostium seeker, ball-shaped ends diameter 1.2 and 2 mm, length 19 cm
⑧	628714	KUHN-BOLGER **Frontal Sinus Curette,** 90° curved, oval, forward cutting, length 19 cm
⑨	479100	COTTLE **Elevator,** double-ended, semisharp and blunt, graduated, length 20 cm
⑩	474000	FREER **Elevator,** double-ended, semisharp and blunt, length 20 cm
⑪	474001	FREER **Suction Elevator,** with stylet, length 19 cm
⑫	628001	**Sickle Knife,** pointed, length 19 cm

Forceps

⑬	426516	JANSEN **Nasal Dressing Forceps,** bayonet-shaped, length 16.5 cm
⑭	455010	STRUYCKEN **RHINOFORCE® II Nasal Cutting Forceps,** with cleaning connector, working length 13 cm
⑮	455500 B	TAKAHASHI **RHINOFORCE® Nasal Forceps,** straight, working length 13 cm
⑯	451000 B	GRÜNWALD-HENKE **RHINOFORCE® II Nasal Cutting Forceps,** straight, through-cutting, tissue-sparing, BLAKESLEY shape, size 0, width 3 mm, with cleaning connector, working length 13 cm
⑰	451500 B	GRÜNWALD-HENKE **RHINOFORCE® II Nasal Cutting Forceps,** 45° upturned, through-cutting, tissue-sparing, BLAKESLEY shape, size 0, width 3 mm, with cleaning connector, working length 13 cm
⑱	456000 B	BLAKESLEY **RHINOFORCE® II Nasal Forceps,** straight, size 0, with cleaning connector, working length 13 cm
⑲	459016	STAMMBERGER **Antrum Punch,** backward cutting, sheath 360° rotatable, with fixing screw, dismantling, working length 10 cm, for use with Cleaning Adaptor 459015 LL
⑳	459036	STAMMBERGER **Antrum Punch,** small pediatric size, slender, backward cutting, sheath 360° rotating, with fixing screw, dismantling, working length 10 cm, for use with Cleaning Adaptor 459015 LL
㉓	456511 B	BLAKESLEY-CASTELNUOVO **RHINOFORCE® II Nasal Forceps,** end of sheath 25° upturned, jaws 45° angled upwards, width 3.5 mm, with cleaning connector, working length 13 cm
㉔	452832	**RHINOFORCE® II Miniature Nasal Forceps,** with extra fine flat jaws, through-cutting, tissue-sparing, straight sheath, jaws 45° upturned, width of cut 1.5 mm, with cleaning connector, working length 13 cm
㉕	649123 B	TAKAHASHI **RHINOFORCE® II Ethmoid Forceps,** spoon size 4 x 10 mm, with cleaning connector, working length 17 cm

Cannulas

㉖ 206600 FISCH **Suction and Irrigation Tube,** cylindrical, suction tube outer diameter 2.5 mm, irrigation tube outer diameter 2 mm, working length 9.5 cm
㉗ 529207 FRAZIER **Suction Tube,** with cut-off hole and stylet, angled, outer diameter 7 Fr./2 mm, working length 10 cm, total length 17.5 cm
㉙ 586031 v. EICKEN **Antrum Cannula,** LUER-Lock, with cut-off hole, long curved, outer diameter 3 mm, length 12.5 cm
㉚ 586226 v. EICKEN **Antrum Cannula,** LUER-Lock, with cut-off hole, short curve, outer diameter 2.5 mm, length 12.5 cm
㉛ 586241 **Same,** outer diameter 4 mm
㉜ 641625 **Suction Tube,** for frontal sinus, with cut-off hole, LUER, outer diameter 2.5 mm, length 14.5 cm
㉝ 649183 FERGUSON **Suction Tube,** with cut-off hole and stylet, LUER, 10 Fr., working length 15 cm
㉞ 662885 FRANK-PASQUINI **Suction Tube,** angular, tip curved upwards, ball end, with grip plate and cut-off hole, LUER, diameter 3 mm, working length 13 cm
㉟ 662886 FRANK-PASQUINI **Suction Tube,** angular, tip curved downwards, ball end, with grip plate and cut-off hole, LUER, diameter 3 mm, working length 13 cm

Scissors

㊱ 449201 **RHINOFORCE® II Nasal Scissors,** straight, with cleaning connector, working length 13 cm
㊲ 449202 **Same,** curved to right
㊳ 449203 **Same,** curved to left

KERRISON **Punches**

㊴ 662101 KERRISON **Bone Punch,** detachable, rigid, 90° upbiting, not through-cutting, size 1 mm, working length 17 cm
㊵ 662102 **Same,** size 2 mm
㊶ 662112 KERRISON **Bone Punch,** detachable, rigid, 90° downbiting, not through-cutting, size 2 mm, working length 17 cm
㊷ 28164 MKA KERRISON **Bone Punch,** detachable, rigid, upbiting 60° forward, size 1 mm, working length 17 cm
㊸ 28164 MKB **Same,** size 2 mm
㊹ 662120 KERRISON **Bone Punch,** detachable, rigid, upbiting 40° forward, size 0.7 mm, working length 17 cm
651521 **Frontal Sinus Punch,** with link chain sheath 70° upturned, backward cutting, to reduce the spina nasalis superior, small, jaws 2.5 x 2 mm, working length 13 cm (not illustrated)
651522 **Same,** medium (standard size), jaws 3.5 x 3 mm (not illustrated)

Resection Phase – Cupped Forceps

㊺ 662202 **Forceps,** straight, extra delicate, oval cupped jaws, width 0.6 mm, working length 15 cm
㊽ 662205 **Same,** 45° upturned
㊾ 28164 TD **Forceps,** round cupped jaws, diameter 0.6 mm, straight, extra delicate, working length 18 cm

Through-cutting Forceps "Gardeners"

(53) 662251 **Miniature Forceps,** straight, through-cutting, with fine flat jaws, width of cut 1 mm, working length 15 cm
(56) 662257 **Same,** curved upwards
(61) 662271 **Grasping Forceps,** straight, fine serrated, working length 15 cm

Scissors

(68) 28164 MZB **Scissors,** straight, with small handle, with cleaning connector, working length 18 cm
(69) 28164 MZC **Same,** curved to right
(70) 28164 MZD **Same,** curved to left
(71) 28164 MZE **Same,** curved up
(72) 28164 SAD **Scissors,** upturned 45°, delicate, sheath 360° rotatable, with cleaning connector, working length 18 cm

Micro Raspatories, Elevators and Scalpel

(73) 28164 KK de DIVITIIS-CAPPABIANCA **Scalpel,** with retractable blade, length 23 cm, including:
Handle
Outer Sheath
Micro Knife, sickle-shaped
(74) 28164 MC **Micro Knife,** pointed, spare blade for de DIVITIIS-CAPPABIANCA Scalpel 28164 M
(75) 28164 EC CASTELNUOVO **Elevator,** double-ended, blunt end angled, semisharp end slightly curved, graduated, length 26 cm
(76) 28164 EL **Micro Raspatory,** single curved to left, width 2 mm, length 27 cm
(77) 28164 ER **Same,** single curved to right
(78) 28164 DR **Dissector,** bayonet-shaped, sharp, curved to right, length 11 cm
(79) 28164 DL **Same,** curved to left

Suction Tubes

⑧⓪	663818	**Suction Tube,** angular, malleable, with round handle and cut-off hole, diameter 2 mm, working length 13 cm
⑧①	649179 B	**Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 4 Fr., working length 15 cm
⑧③	649180 B	**Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 6 Fr., working length 15 cm
⑧⑤	649182 B	**Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 8 Fr., working length 15 cm
⑧⑦	649183 B	**Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 10 Fr., working length 15 cm

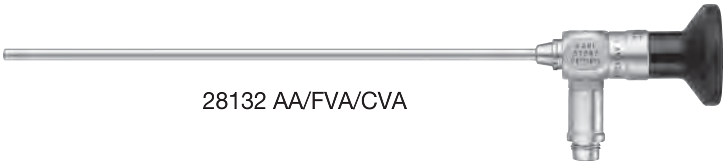
Hemostasis

⑧⑨	28164 BDL	**TAKE-APART® Bipolar Forceps,** with fine jaws, width 1 mm, distally angled 45°, vertical closing, outer diameter 3.4 mm, working length 20 cm including: **Bipolar Ring Handle** **Outer Sheath** **Inner Sheath** **Forceps Insert**
⑨⓪	28164 BDM	**TAKE-APART® Bipolar Forceps,** with fine jaws, width 1 mm, distally angled 45°, horizontal closing, outer diameter 3.4 mm, working length 20 cm including: **Bipolar Ring Handle** **Outer Sheath** **Inner Sheath** **Forceps Insert**
	28164 BDD	**TAKE-APART® Bipolar Forceps,** width 2 mm, distally angled 45°, (not illustrated) horizontal closing, outer diameter 3.4 mm, working length 20 cm including: **Bipolar Ring Handle** **Outer Sheath** **Inner Sheath** **Forceps Insert**
	28164 BDG	**TAKE-APART®** TAN **Bipolar Coagulation Forceps,** (not illustrated) size 3.4 mm, length 20 cm, including: **Bipolar Ring Handle** **Outer Sheath** **Inner Sheath** **Forceps Insert**
	26176 LA	**Bipolar High Frequency Cord,** with 2x 4 mm banana plug for **KARL STORZ** Coagulator 26020 XA/XB and Valleylab, length 300 cm (not illustrated)
	28164 BGK	**Bipolar Forceps,** jaws curved upwards 45°, for bipolar coagulation in skull base and pituitary surgery, working length 18 cm, for use with Bipolar High Frequency Cords 847002 A/M/V/U (not illustrated)
	847002 A	**Bipolar High Frequency Cord,** with 2x 4 mm banana plug for **KARL STORZ** Coagulator 26020 XA/XB, length 450 cm (not illustrated)
	452650 A	MONTGOMERY-YOUNGS **RHINOFORCE® II Clip Applicator,** for endonasal endoscopic sphenopalatine artery ligature, with suction channel, handle with spring, straight, with cleaning connector, working length 13 cm, for use with Titanium Clips 8665 T (not illustrated)
⑨①	26167 FNS	KOH **Ultramicro Needle Holder,** with tungsten carbide inserts, straight handle with ratchet, jaws slightly curved to left, size 3 mm, length 20 cm
	39351 J	**Plastic Container for Sterilizing and Storage,** perforated, with transparent lid, for two-level storage, Plastic Container for Sterilization and Storage, perforated, with transparent lid, for two-level storage, for use with forceps and instruments, external dimensions (w x d x h): 530 x 250 x 145 mm (not illustrated)

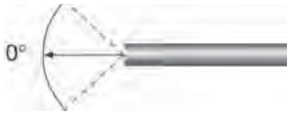
It is recommended to check the suitability of the product for the intended procedure prior to use.

Diagnostic Telescopes for Neuro-Endoscopes

HOPKINS® Telescopes, diameter 4 mm, length 18 cm



28132 AA/FVA/CVA



28132 AA **HOPKINS® Straight Forward Telescope 0°,**
enlarged view, diameter 4 mm, length 18 cm,
autoclavable,
fiber optic light transmission incorporated,
color code: green

28132 FVA **HOPKINS® Forward-Oblique-Telescope 45°,**
enlarged view, diameter 4 mm, length 18 cm,
autoclavable,
connection for fiber optic light cable on upper side,
fiber optic light transmission incorporated,
color code: black

28132 CVA **HOPKINS® Telescope 70°,**
enlarged view, diameter 4 mm, length 18 cm,
autoclavable,
connection for fiber optic light cable on upper side,
fiber optic light transmission incorporated,
color code: yellow

Protection Tube

723750 B

723750 B **Protection Tube,**
working length 19.7 cm,
for use with HOPKINS® telescopes
with length 18 cm

KARL STORZ CLEARVISION® II System

for intra-operative rinsing of the telescope lens

40 3341 01 **CLEARVISION® II,** irrigation pump
for irrigation of the front lens,
power supply 100 – 240 VAC, 50/60 Hz
including:
CLEARVISION® II
Mains Cord
One-Pedal Footswitch, two-stage
Silicone Tubing Set, for irrigation, sterilizable

Irrigation Sheaths

for use with KARL STORZ CLEARVISION® II System

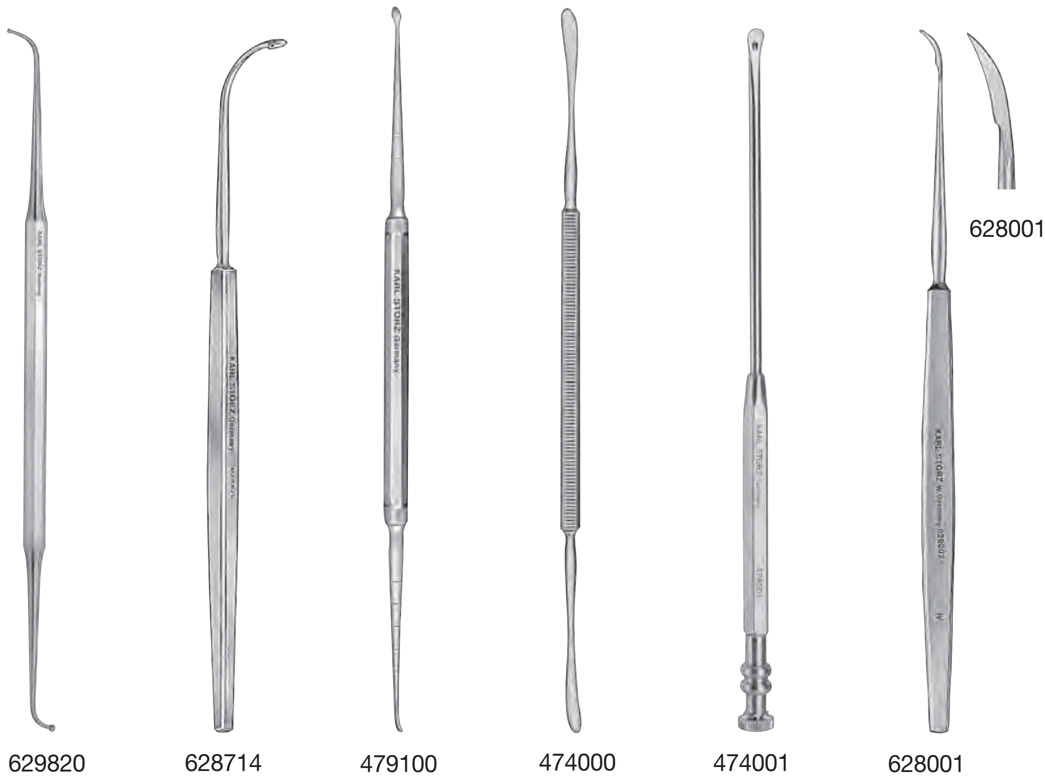
28164 CBF

28164 CBA **Irrigation Sheath,** outer diameter 5 mm, working length 14 cm, for use with HOPKINS® Telescope 28132 AA and **KARL STORZ** lens irrigation system CLEARVISION® II

28164 CBF **Irrigation Sheath,** outer diameter 5 mm, working length 14 cm, for use with HOPKINS® Telescope 28132 FA/FVA and **KARL STORZ** lens irrigation system CLEARVISION® II

28164 CBC **Irrigation Sheath,** outer diameter 5 mm, working length 14 cm, for use with HOPKINS® Telescope 28163 CA/CVA and **KARL STORZ** Lens Irrigation System CLEARVISION® II

Probes and Elevators



629820 **Probe,** double-ended, maxillary sinus ostium seeker, ball-shaped ends diameter 1.2 and 2 mm, length 19 cm

628714 KUHN-BOLGER **Frontal Sinus Curette,** 90° curved, oval, forward cutting, length 19 cm

479100 COTTLE **Elevator**, double-ended, semi-sharp and blunt, graduated, length 20 cm

474000 FREER **Elevator,** double-ended, semisharp and blunt, length 20 cm

474001 FREER **Suction Elevator,** with stylet, length 19 cm

628001 **Sickle Knife,** pointed, length 19 cm

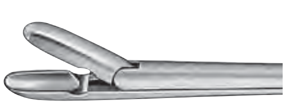
JANSEN **Nasal Dressing Forceps**

426516 JANSEN **Nasal Dressing Forceps,**
bayonet-shaped, length 16.5 cm

STRUYCKEN **RHINOFORCE® II Nasal Cutting Forceps**

455010 STRUYCKEN **RHINOFORCE® II Nasal Cutting Forceps,**
with cleaning connector, working length 13 cm

TAKAHASHI **RHINOFORCE® Nasal Forceps**



455500 B TAKAHASHI **RHINOFORCE® Nasal Forceps,**
straight, working length 13 cm

GRÜNWALD-HENKE **RHINOFORCE® II Nasal Cutting Forceps**

451000 B

451000 B GRÜNWALD-HENKE **RHINOFORCE® II Nasal Cutting Forceps,** straight, through-cutting, tissue-sparing, BLAKESLEY shape, size 0, width 3 mm, with cleaning connector, working length 13 cm

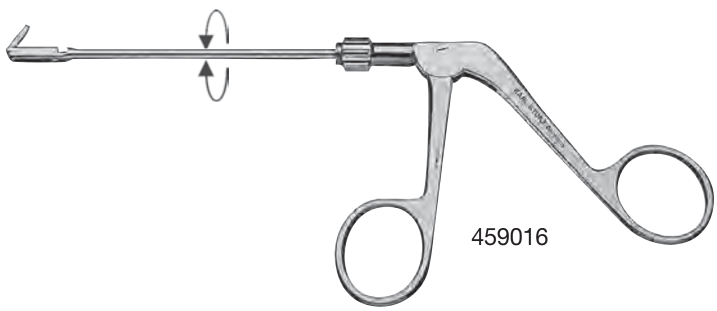
451500 B GRÜNWALD-HENKE **RHINOFORCE® II Nasal Cutting Forceps,** 45° upturned, through-cutting, tissue-sparing, BLAKESLEY shape, size 0, width 3 mm, with cleaning connector, working length 13 cm

BLAKESLEY **RHINOFORCE® II Nasal Forceps**

456000 B

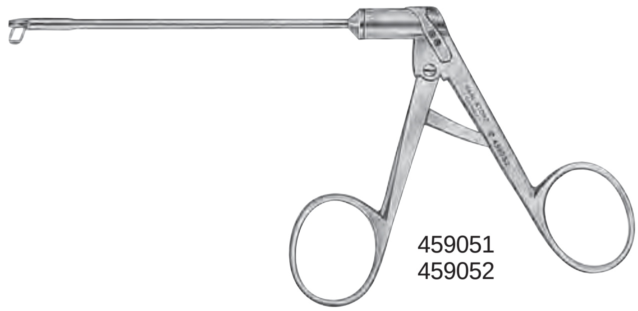
456000 B BLAKESLEY **RHINOFORCE® II Nasal Forceps,** straight, size 0, with cleaning connector, working length 13 cm

STAMMBERGER **Antrum Punch**



459016 STAMMBERGER **Antrum Punch,** backward cutting, sheath 360° rotatable, with fixing screw, dismantling, working length 10 cm, for use with Cleaning Adaptor 459015 LL

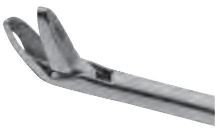
459036 STAMMBERGER **Antrum Punch,** small pediatric size, slender, backward cutting, sheath 360° rotating, with fixing screw, dismantling, working length 10 cm, for use with Cleaning Adaptor 459015 LL



459051 STAMMBERGER **Antrum Punch,** right side downward and forward cutting, with cleaning connector, working length 10 cm

459052 **Same,** left side downward and forward cutting

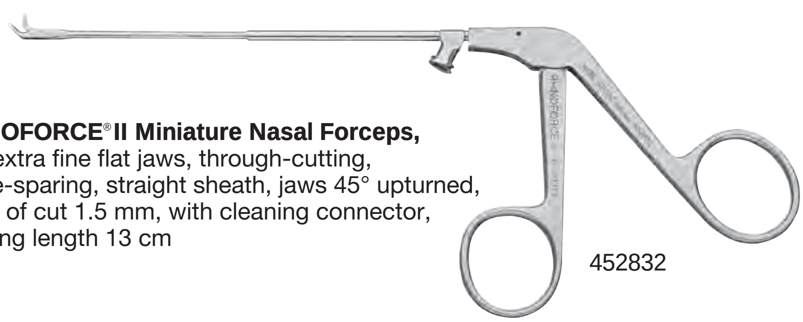
BLAKESLEY-CASTELNUOVO **RHINOFORCE® II Nasal Forceps**



456511 B

456511 B BLAKESLEY-CASTELNUOVO **RHINOFORCE® II Nasal Forceps,** end of sheath 25° upturned, jaws 45° angled upwards, width 3.5 mm, with cleaning connector, working length 13 cm

RHINOFORCE® II Miniature Nasal Forceps

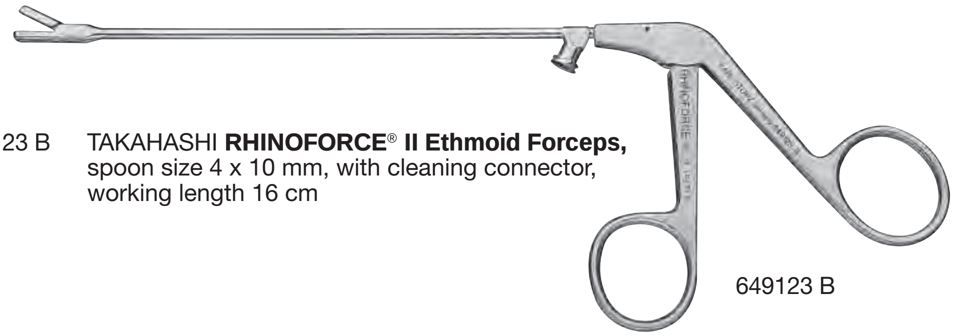


452832

452832 **RHINOFORCE® II Miniature Nasal Forceps,** with extra fine flat jaws, through-cutting, tissue-sparing, straight sheath, jaws 45° upturned, width of cut 1.5 mm, with cleaning connector, working length 13 cm

TAKAHASHI **RHINOFORCE® II Ethmoid Forceps**

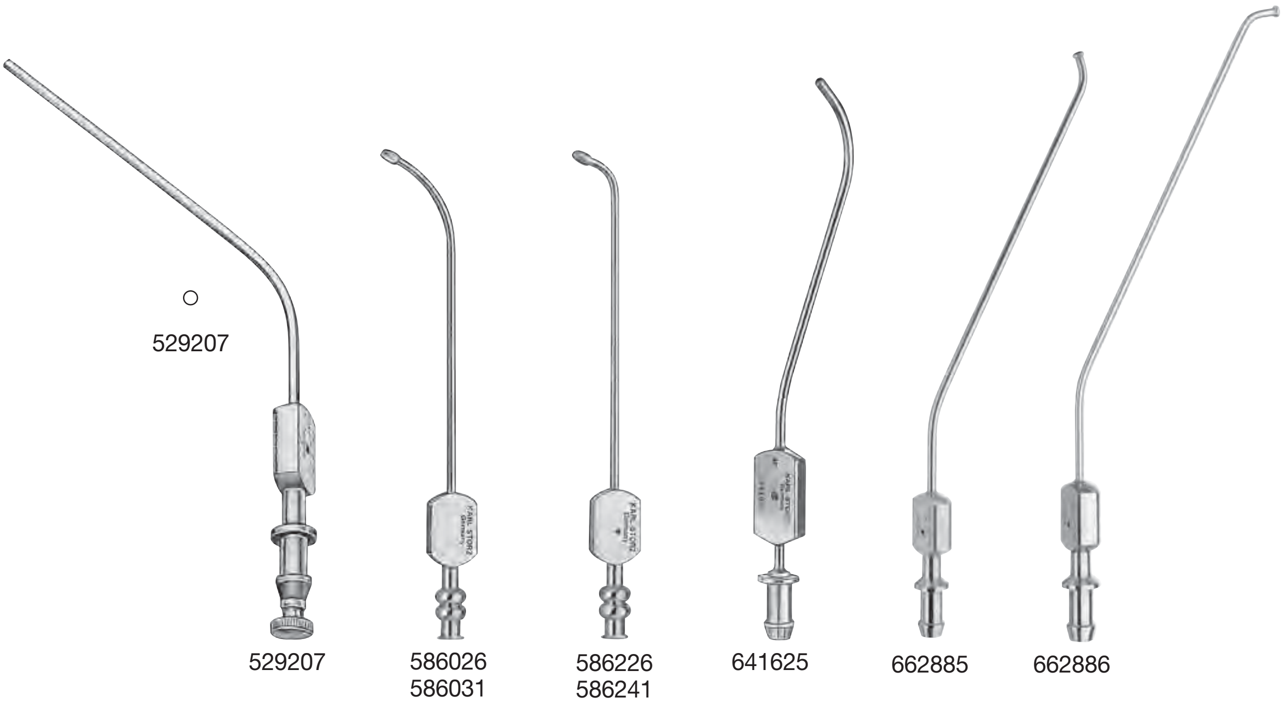
649123 B

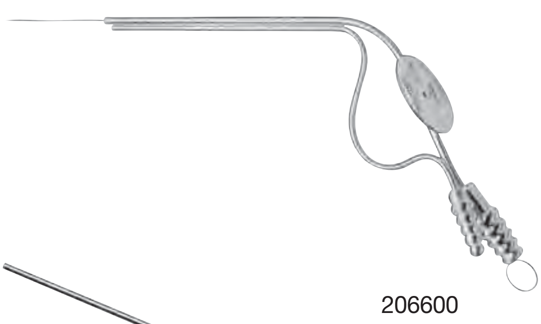


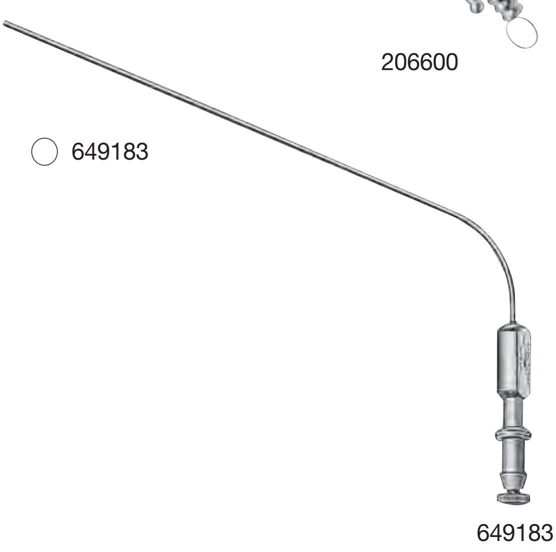
649123 B

649123 B TAKAHASHI **RHINOFORCE® II Ethmoid Forceps,** spoon size 4 x 10 mm, with cleaning connector, working length 16 cm

Suction Tubes and Antrum Cannulas







206600	FISCH **Suction and Irrigation Tube,** cylindrical, suction tube outer diameter 2.5 mm, irrigation tube outer diameter 2 mm, working length 9.5 cm
529207	FRAZIER **Suction Tube,** with cut-off hole and stylet, angled, outer diameter 7 Fr./2 mm, working length 10 cm, total length 17.5 cm
586026	v. EICKEN **Antrum Cannula,** LUER-Lock, with cut-off hole, long curve, outer diameter 2.5 mm, length 12.5 cm
586031	**Same,** outer diameter 3 mm
586226	v. EICKEN **Antrum Cannula,** LUER-Lock, with cut-off hole, short curve, outer diameter 2.5 mm, length 12.5 cm
586241	**Same,** outer diameter 4 mm
641625	**Suction Tube for Frontal Sinus,** with cut-off hole, LUER, outer diameter 2.5 mm, length 14.5 cm
649183	FERGUSON **Suction Tube,** with cut-off hole and stylet, LUER, working length 15 cm, 10 Fr.
662885	FRANK-PASQUINI **Suction Tube,** angular, tip curved upwards, ball end, with grip plate and cut-off hole, LUER, diameter 3 mm, working length 13 cm
662886	FRANK-PASQUINI **Suction Tube,** angular, tip curved downwards, ball end, with grip plate and cut-off hole, LUER, diameter 3 mm, working length 13 cm

RHINOFORCE® II Nasal Scissors

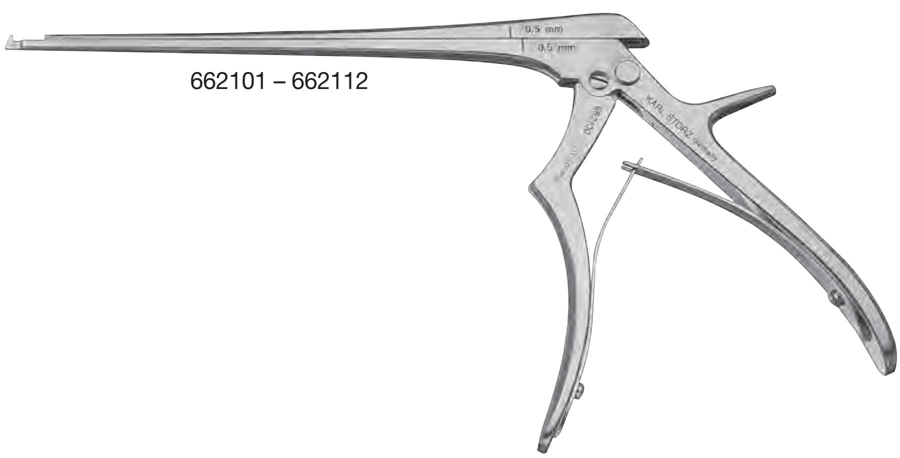
449201

449201 **RHINOFORCE® II Nasal Scissors,** straight, with cleaning connector, working length 13 cm

449202 **Same,** curved to right

449203 **Same,** curved to left

KERRISON **Bone Punches**



662101 – 662112

662101 KERRISON **Bone Punch,** detachable, rigid, 90° upbiting, not through-cutting, size 1 mm, working length 17 cm

662102 **Same,** size 2 mm

662112 KERRISON **Bone Punch,** detachable, rigid, 90° downbiting, not through-cutting, size 2 mm, working length 17 cm

KERRISON **Bone Punches**

28164 MKA/MKB

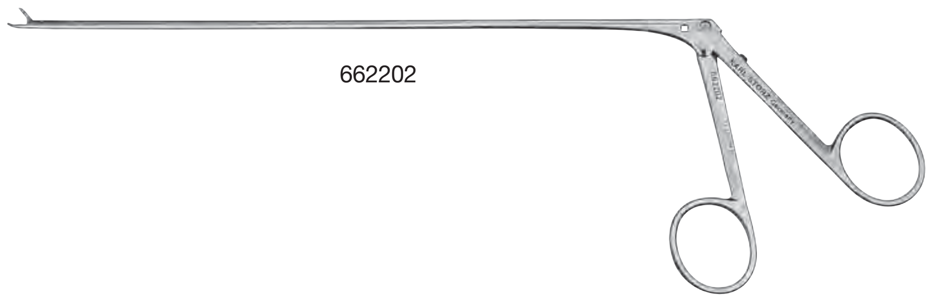
28164 MKA KERRISON **Bone Punch,** detachable, rigid, upbiting 60° forward, size 1 mm, working length 17 cm

28164 MKB **Same,** size 2 mm

662120 KERRISON **Bone Punch,** detachable, rigid, upbiting 40° forward, size 0.7 mm, working length 17 cm

Cupped Forceps

working length 15 cm / 18 cm

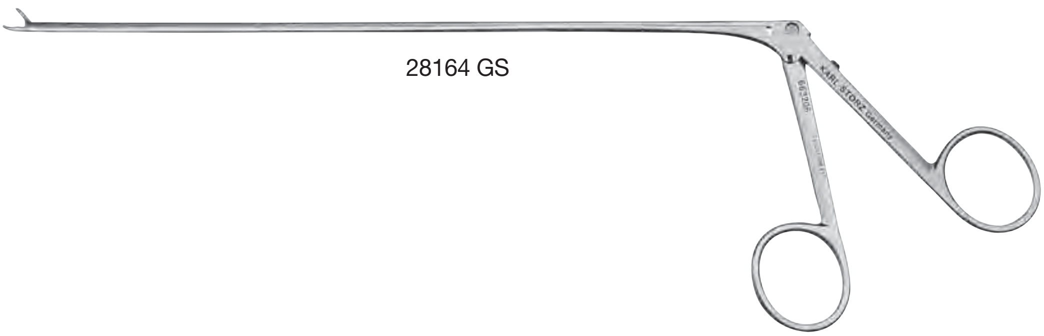


662202

	662202	**Forceps,** straight, extra delicate, oval cupped jaws, width 0.6 mm, working length 15 cm
	662203	**Same,** curved to right
	662204	**Same,** curved to left
	662205	**Same,** 45° upturned
	28164 TD	**Forceps,** round cupped jaws, diameter 0.6 mm, straight, extra delicate, working length 18 cm
	28164 TE	**Forceps,** oval cupped jaws, diameter 0.6 mm, curved to right, extra delicate, working length 18 cm
	28164 TF	**Same,** curved to left
	28164 TA	**Same,** 45° curved upwards

Through-cutting Forceps "Gardeners"

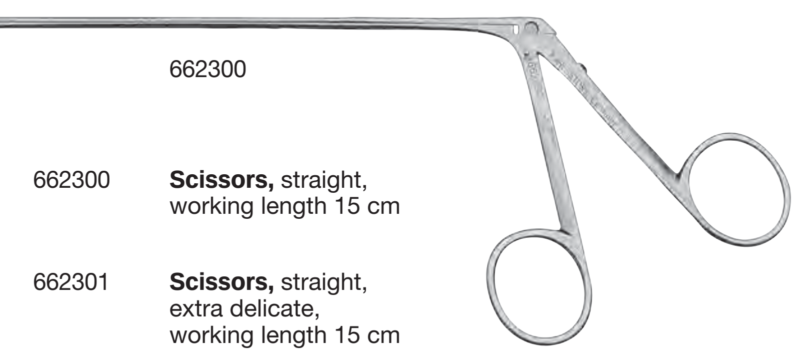
working length 15 cm / 18 cm



28164 GS

	662251	**Miniature Forceps,** straight, through-cutting, with fine flat jaws, width of cut 1 mm, working length 15 cm
	662255	**Same,** curved to right
	662256	**Same,** curved to left
	662257	**Same,** curved upwards
	662271	**Grasping Forceps,** straight, fine-serrated, working length 15 cm
	28164 GS	**Miniature Forceps,** straight, through-cutting, with fine flat jaws, bite 1 mm, working length 18 cm
	28164 GR	**Same,** curved to right
	28164 GL	**Same,** curved to left
	28164 GU	**Same,** curved upwards

Scissors



662300

662300 **Scissors,** straight, working length 15 cm

662301 **Scissors,** straight, extra delicate, working length 15 cm

662304 **Same,** curved to right

662305 **Same,** curved to left

662307 **Same,** 45° upwards curve

663300 **Scissors,** straight, working length 18 cm

28164 MZB

28164 MZB **Scissors,** straight, with small handle, with cleaning connector, working length 18 cm

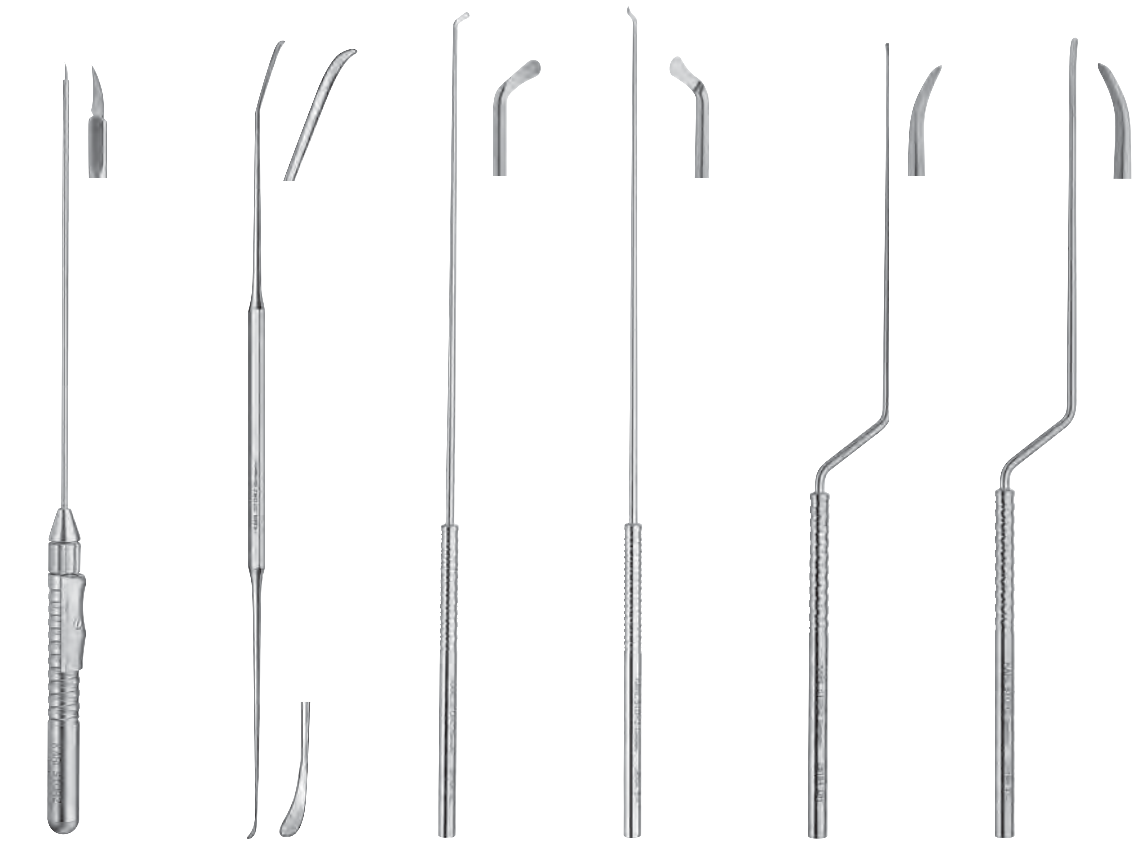
28164 MZC **Same,** curved right

28164 MZD **Same,** curved left

28164 MZE **Same,** curved up

28164 SAD **Scissors,** upturned 45°, delicate, sheath 360° rotatable, with cleaning connector, working length 18 cm

Micro Raspatory, Elevator, Scalpel and Dissector



28164 KK 28164 EC 28164 EL 28164 ER 28164 DR 28164 DL

28164 KK de DIVITIIS-CAPPABIANCA **Scalpel,** with retractable blade, length 23 cm, including:
Handle
Outer Sheath
Micro Knife, sickle-shaped

28164 EC CASTELNUOVO **Elevator,** double-ended, blunt end angled, semisharp end slightly curved, graduated, length 26 cm

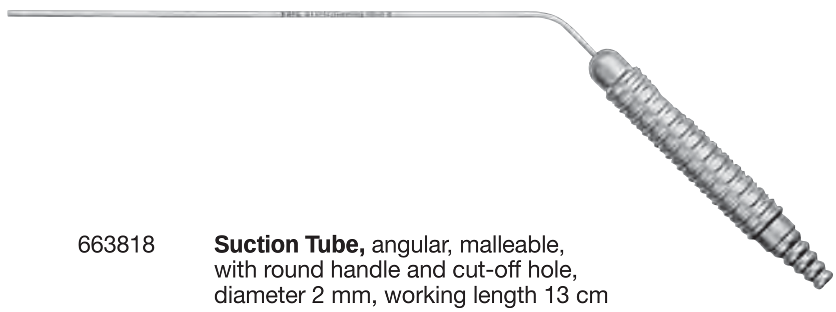
28164 EL **Micro Raspatory,** single curved to left, width 2 mm, length 27 cm

28164 ER **Same,** curved, right

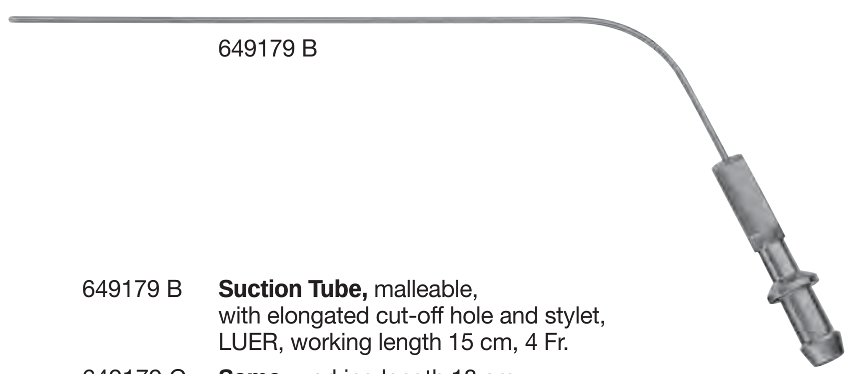
28164 DR **Dissector,** bayonet-shaped, sharp, curved to right, length 24 cm

28164 DL **Same,** curved left

Suction Tubes



663818 **Suction Tube,** angular, malleable, with round handle and cut-off hole, diameter 2 mm, working length 13 cm

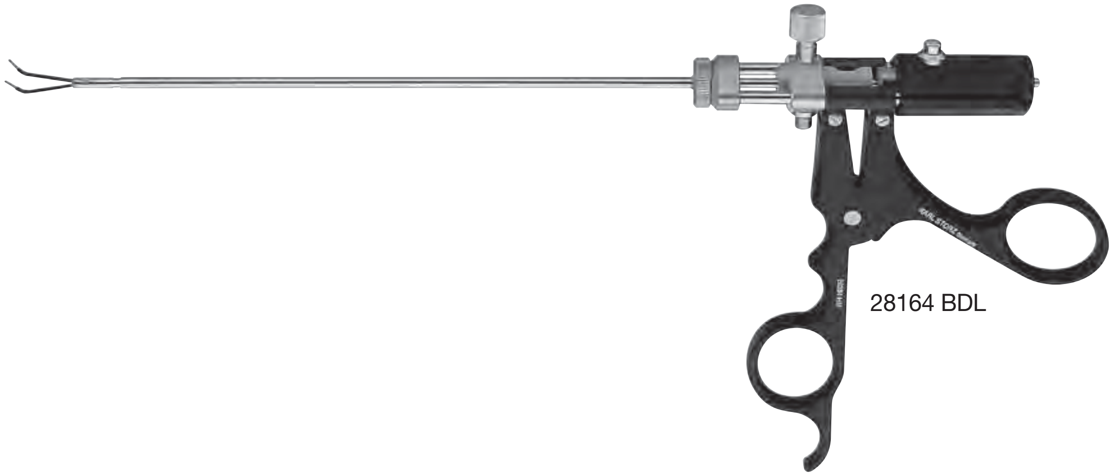


649179 B

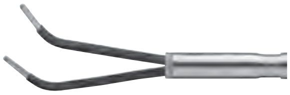
649179 B	**Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, working length 15 cm, 4 Fr.
649179 C	**Same,** working length 18 cm
649180 B	**Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 6 Fr., working length 15 cm
649180 C	**Same,** working length 18 cm
649182 B	**Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 8 Fr., working length 15 cm
649182 C	**Same,** working length 18 cm
649183 B	**Suction Tube,** malleable, with elongated cut-off hole and stylet, LUER, 10 Fr., working length 15 cm
649183 C	**Same,** working length 18 cm

TAKE-APART® Bipolar Forceps

bipolar



28164 BDL

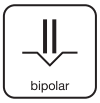


28164 BDL **TAKE-APART® Bipolar Forceps,**
with fine jaws, width 1 mm, distally angled 45°,
vertical closing, outer diameter 3.4 mm,
working length 20 cm,
including:
Bipolar Ring Handle
Outer Sheath
Inner Sheath
Forceps Insert

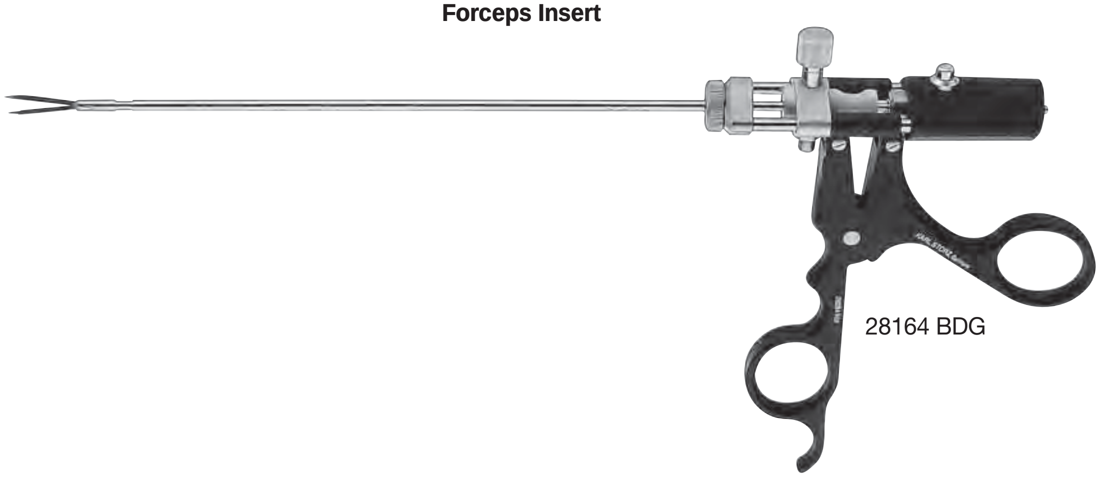
28164 BDM **TAKE-APART® Bipolar Forceps,**
with fine jaws, width 1 mm, distally angled 45°,
horizontal closing, outer diameter 3.4 mm,
working length 20 cm,
including:
Bipolar Ring Handle
Outer Sheath
Inner Sheath
Forceps Insert

28164 BDD **TAKE-APART® Bipolar Forceps,**
width 2 mm, distally angled 45°,
horizontal closing, outer diameter 3.4 mm,
working length 20 cm,
including:
Bipolar Ring Handle
Outer Sheath
Inner Sheath
Forceps Insert

TAKE-APART® Bipolar Forceps



28164 BDK **TAKE-APART® Bipolar Forceps,**
width 4 mm, distally angled 45°,
horizontal closing, outer diameter 3.4 mm,
working length 20 cm,
including:
Bipolar Ring Handle
Outer Sheath
Inner Sheath
Forceps Insert



28164 BDG **TAKE-APART®** TAN **Bipolar Coagulation Forceps,**
size 3.4 mm, length 20 cm,
including:
Bipolar Ring Handle
Outer Sheath
Inner Sheath
Forceps Insert

26176 LA **Bipolar High Frequency Cord,**
with 2x 4 mm banana plug for **KARL STORZ**
Coagulator 26020 XA/XB and Valleylab, length 300 cm

Bipolar Forceps

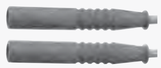
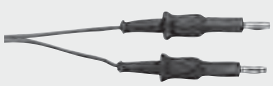
bipolar

28164 BGK **Bipolar Forceps,** jaws 45° upturned,
for bipolar coagulation in skull base and pituitary surgery,
working length 18 cm, for use with bipolar high frequency cable
847002 E or 847002 A/M/V/U

High Frequency Cords

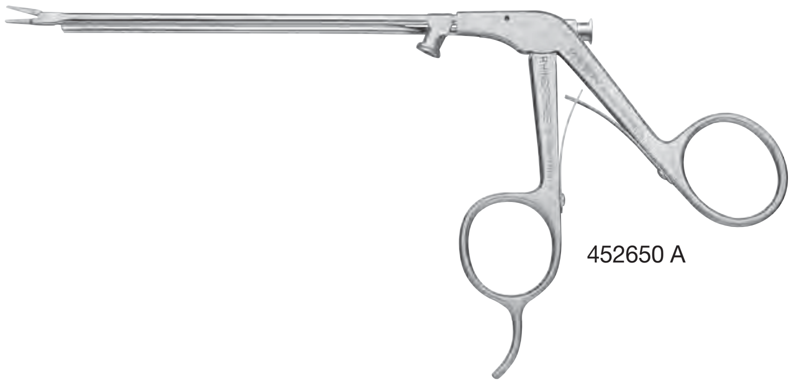
bipolar

Bipolar High Frequency Cords

KARL STORZ Instruments	High Frequency Electrosurgery Units		
		847002 A	**Bipolar High Frequency Cord,** with 2x 4 mm banana plug for **KARL STORZ** coagulator 26020 XA/XB, with two 2 mm cable sockets for **KARL STORZ** Bipolar Suction Forceps 461010, 461015 and Bipolar Forceps 8615 A/AS, 28164 BGK, length 450 cm

KARL STORZ Instruments	Standard Forceps Bipolar Cords		
		847002 U	**Bipolar Universal High Frequency Cord,** one side with two 2 mm cable sockets for **KARL STORZ** Bipolar Suction Forceps 461010, 461015 and Bipolar Forceps 8615 A/AS, 28164 BGK, other side with standard pin for connection to all current forceps bipolar cords, length 40 cm

MONTGOMERY-YOUNGS **RHINOFORCE® II Clip Applicator**



452650 A

452650 A MONTGOMERY-YOUNGS **RHINOFORCE® II Clip Applicator,** for endonasal endoscopic sphenopalatine artery ligature, with suction channel, handle with spring, straight, with cleaning connector, working length 13 cm, for use with Titanium Clips 8665 T

KOH **Ultramicro Needle Holders**

26167 FNS

26167 FNS KOH **Ultramicro Needle Holder,** with tungsten carbide inserts, straight handle with ratchet, jaws slightly curved to left, size 3 mm, length 20 cm, for use with suture material 7/0, 8/0 (Ethicon) and needle size BV 175-6

Plastic Container for Sterilizing and Storage

39351 J **Plastic Container for Sterilization and Storage,**
perforated, with transparent lid, for two-level storage,
for use with forceps and instruments,
external dimensions (w x d x h): 530 x 250 x 145 mm

EndoCAMeleon® NEURO HOPKINS® Telescope

The ENDOCAMELEON® is the newest member of the HOPKINS® family of rod-lens telescopes – and the most versatile.

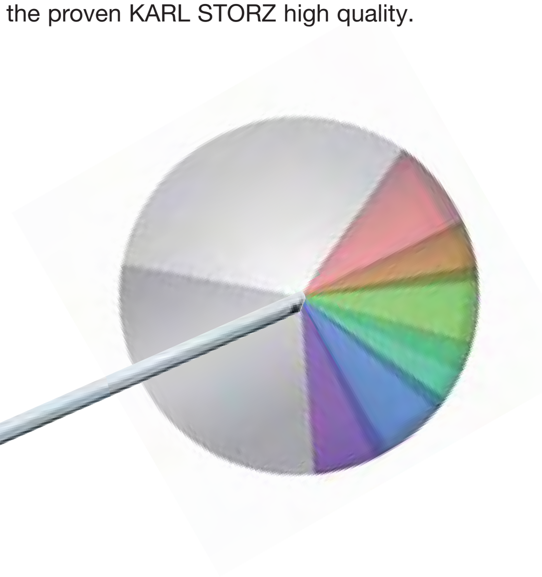
With a simple turn of the adjusting knob, ENDOCAMELEON® enables the user to select the direction of view between 15° and 90°. Consequently, the surgeon can quickly and easily select the desired direction of view for optimal orientation and control.

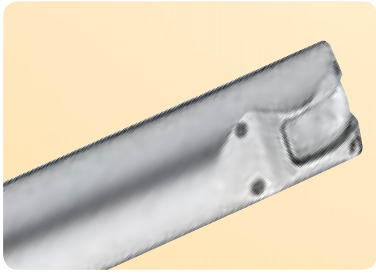
The ENDOCAMELEON® from KARL STORZ brings a new quality to endoscopy in the OR as it often enhances orientation during an operation without the time-consuming changeover of telescopes, thereby ensuring safe and smooth surgery.

The ENDOCAMELEON® combines the user comfort of the proven HOPKINS® endoscopes with unprecedented versatility – in the proven KARL STORZ high quality.

Special Features:

- Variable direction of view (15° to 90°)
- Easy-to-use adjusting knob selects the desired direction of view
- Lightweight construction and modern design
- HOPKINS® telescope with unique rod-lens system
- Diameter 4 mm, length 18 cm
- Standard eyepiece fits all camera heads





The familiar ergonomics and handling of conventional telescopes is enhanced with the additional convenience of a variable direction of view

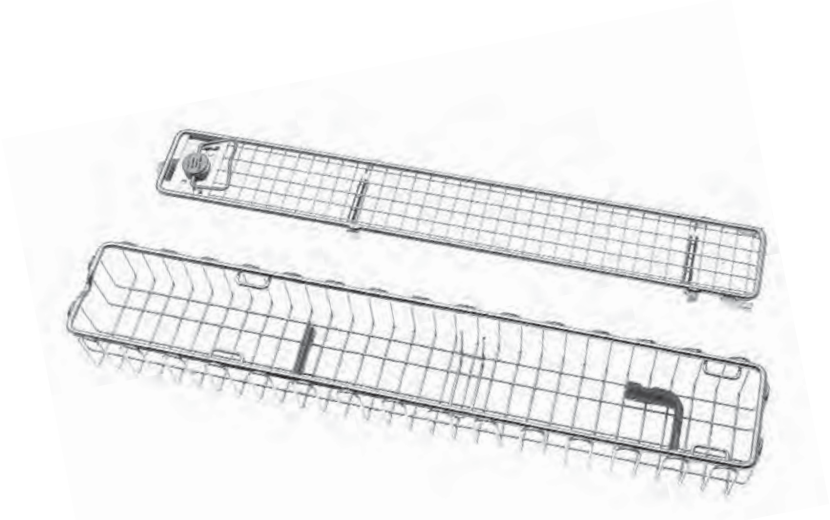
The direction of view is adjusted by a mere turn of the adjusting knob at the proximal end of the ENDOCAMELEON®

Telescope

28132 AE **ENDOCAMELEON® HOPKINS® Telescope,**
diameter 4 mm, length 18 cm, **autoclavable,**
variable direction of view from 15° to 90°,
adjustment knob for selecting the desired direction of view,
fiber optic light transmission incorporated,
color code: gold

7230 AES **Irrigation and Suction Sheath,**
outer diameter 4.8 x 6 mm, working length 14 cm,
for use with ENDOCAMELEON® ENT HOPKINS® Telescope 7230 AE
and KARL STORZ lens irrigation system CLEARVISION® II

Accessories



39501 A1 **Wire Tray for Cleaning, Sterilization and Storage**
of one rigid endoscope, including holder for light post adaptors,
silicone telescope holders and lid, external dimensions (w x d x h):
290 x 60 x 52 mm, for rigid endoscopes up to diameter 5 mm
and working length 20 cm

UNIDRIVE® S III NEURO SCB NEW

Special Features

UNIDRIVE® S III NEURO SCB

Special Features:

Straightforward function selection and optimized user control via touch screen
Choice of user languages
Operating elements are single and clear to read due to color display
One unit – six functions: Neurosurgery: – Craniotomes – Perforators – High-Speed Handpieces 100,000 rpm – High-Speed Handpieces 60,000 rpm ENT: – Shaver system for surgery of the paranasal sinuses and anterior skull base – INTRA Drills – Sinus Shavers – Micro Saws – STAMMBERGER-SACHSE Intranasal Drill – Dermatomes
Two motor outputs: Two motor outputs enable two motors to be connected simultaneously: for example, a high-speed handpiece and a shaver handpiece may be connected in parallel
Safe work due to rapid blade when the pedal is released
Integrated irrigation and coolant pump
Absolutely homogeneous, micro-processor controlled irrigation rate throughout the entire irrigation range. Quick and easy connection of the tubing set.
Easy program selection via automated motor recognition
Continuously adjustable revolution range
Maximum number of revolutions and motor torque: Microprocessor-controlled motor rotation speed. Therefore the preselected parameters are maintained throughout the drilling procedure.
Maximum number of evolutions can be preset
With connection possibilities to the KARL STORZ Communication Bus (KARL STORZ-SCB)
Irrigator rod included

UNIDRIVE® S III NEURO SCB *NEW*

Recommended Standard Set Configurations

SCB®

40 7017 01-1 **UNIDRIVE® S III NEURO SCB,** motor control unit with color display, touch screen, two motor outputs, integrated irrigation pump and integrated SCB module, power supply 100 – 240 VAC, 50/60 Hz

including:

Mains Cord

Irrigator Rod

Two-Pedal Footswitch, two-stage, with proportional function

Silicone Tubing Set, for irrigation, sterilizable

Clip Set, for use with tubing set

SCB Connecting Cable, length 100 cm

Single Use Tubing Set*, sterile, package of 3

Specifications:

Touch Screen	6.4"/300 cd/m²
Available languages:	English, French, German, Spanish, Italian, Portuguese, Greek, Turkish, Polish, Russian
Power supply	100–240 VAC, 50/60 Hz

Dimensions w x h x d	300 x 165 x 265 mm
Weight	5.2 kg
Certified to:	IEC 601-1, CE acc. to MDD

* mtp medical technical promotion gmbh,
Take-Off GewerbePark 46, 78579 Neuhausen ob Eck, Germany

UNIDRIVE® S III NEURO SCB *NEW*

High-Speed Micro Motor

Special Features:

- **Self-cooling and brushless high-speed micro motor**
- **Smallest possible dimensions**
- **Autoclavable**
- **Reprocessable in a cleaning machine**
- **Maximum torque 6 Ncm**
- **Number of revolutions continuously adjustable from 1000 – 60,000 rpm**
- **Possible to adjust the number of revolutions to 100,000 rpm with the appropriate handle**

20 7120 33

20 7120 33 **High-Speed Micro-Motor,** max. speed 60,000 rpm, including connecting cable, for use with UNIDRIVE® S III ENT/NEURO

Accessories:

280053 **Universal Spray,** 6x 500 ml bottles
– HAZARDOUS GOODS – UN 1950
including:
Spray Nozzle

031131-10* **Tubing Set,** for irrigation, for single use, sterile, package of 10

* mtp medical technical promotion gmbh,
Take-Off GewerbePark 46, 78579 Neuhausen ob Eck, Germany

UNIDRIVE® S III NEURO SCB *NEW*

System Components

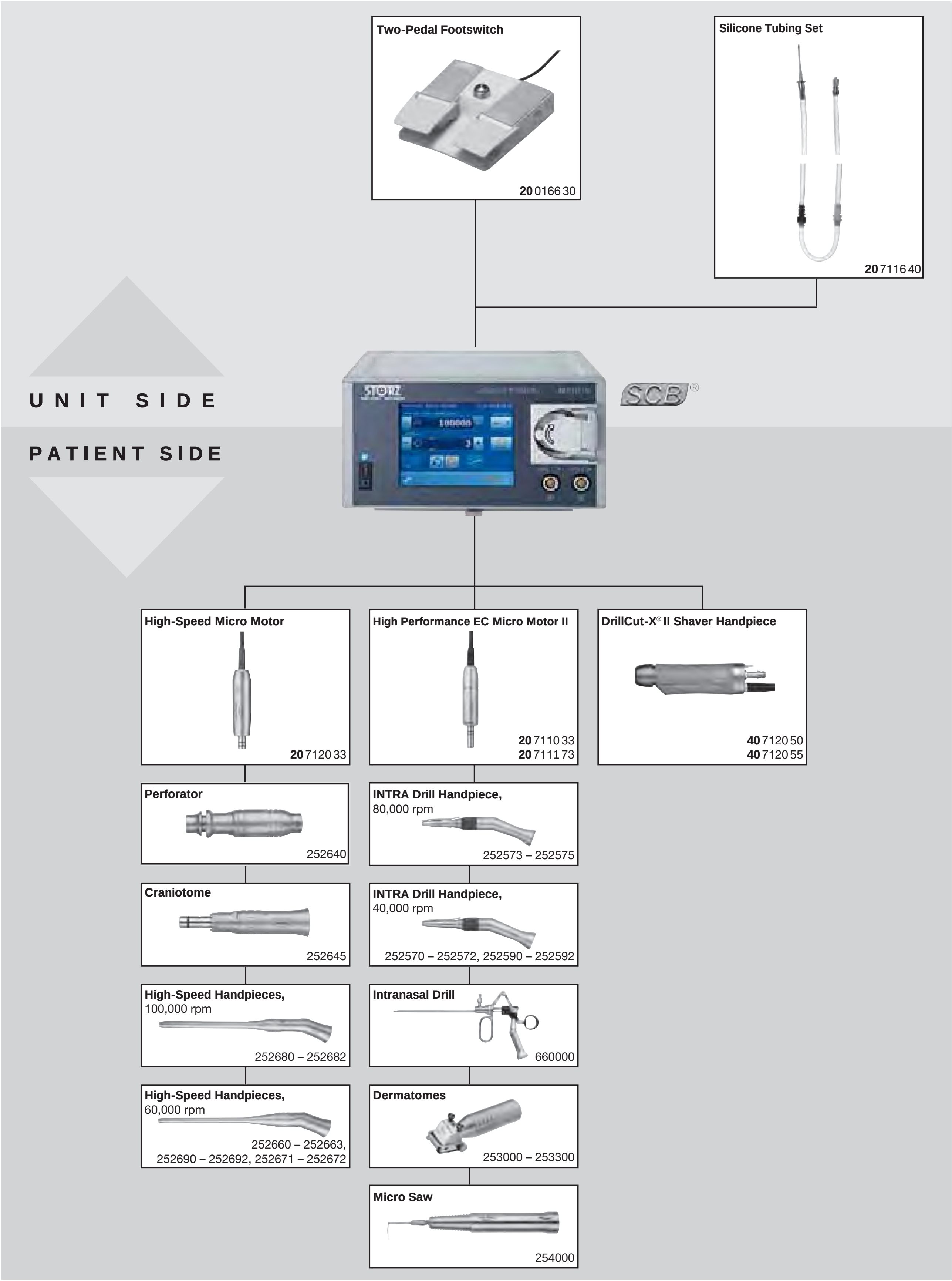


IMAGE1 S Camera System *NEW*

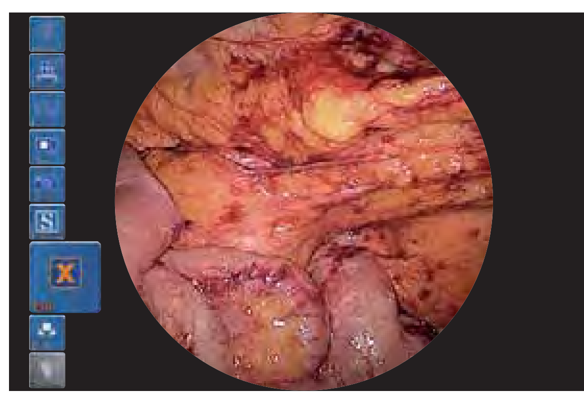
Economical and future-proof

- **Modular concept for flexible, rigid and 3D endoscopy as well as new technologies**
- **Forward and backward compatibility with video endoscopes and FULL HD camera heads**
- **Sustainable investment**
- **Compatible with all light sources**

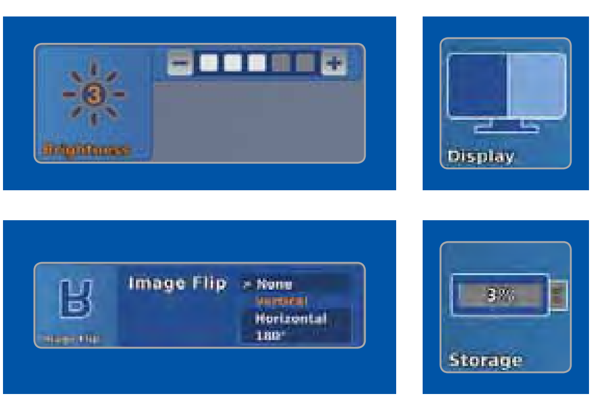
Innovative Design

- **Dashboard: Complete overview with intuitive menu guidance**
- **Live menu: User-friendly and customizable**
- **Intelligent icons: Graphic representation changes when settings of connected devices or the entire system are adjusted**
- **Automatic light source control**
- **Side-by-side view: Parallel display of standard image and the Visualization mode**
- **Multiple source control: IMAGE1 S allows the simultaneous display, processing and documentation of image information from two connected image sources, e.g., for hybrid operations**

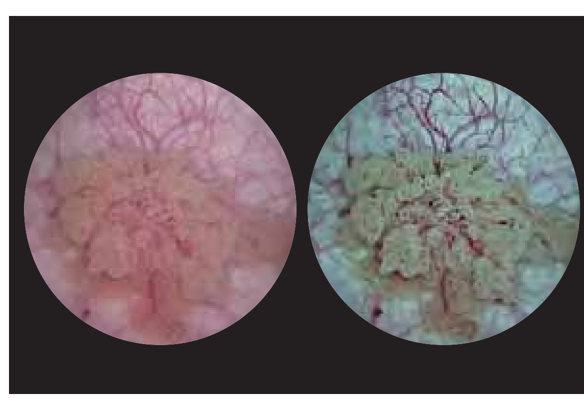
Dashboard



Live menu



Intelligent icons



Side-by-side view: Parallel display of standard image and Visualization mode

IMAGE1 S Camera System *NEW*

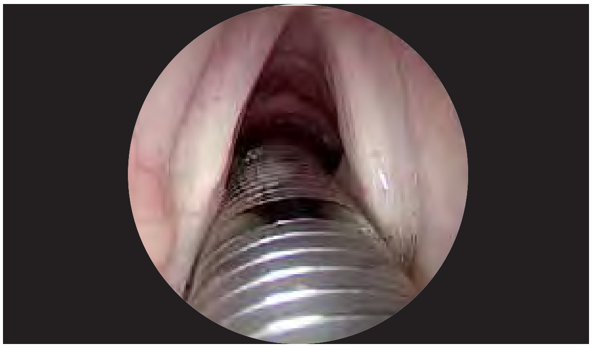
IMAGE1 S

Brillant Imaging

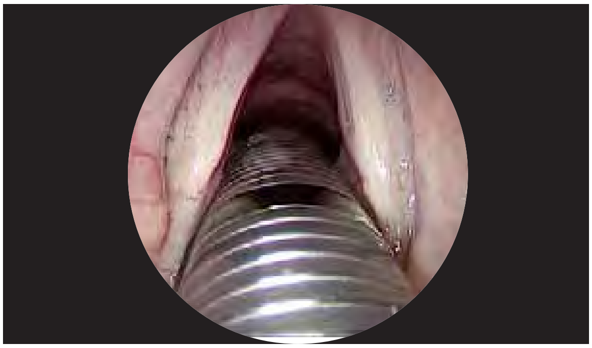
- **Clear and razor-sharp endoscopic images in FULL HD**
- **Natural color rendition**
- **Reflection is minimized**
- **Multiple IMAGE1 S technologies for homogeneous illumination, contrast enhancement and color shifting**

FULL HD image

CLARA



FULL HD image



CHROMA

FULL HD image

*SPECTRA A**

FULL HD image

*SPECTRA B***

* *SPECTRA A:* **Not for sale in the U.S.**
** *SPECTRA B:* **Not for sale in the U.S.**

IMAGE1 S Camera System *NEW*

IMAGE1 S

TC 200EN

TC 200EN* **IMAGE1 S CONNECT**, connect module, for use with up to 3 link modules, resolution 1920 x 1080 pixels, with integrated KARL STORZ-SCB and digital Image Processing Module, power supply 100–120 VAC/200–240 VAC, 50/60 Hz
including:
Mains Cord, length 300 cm
DVI-D Connecting Cable, length 300 cm
SCB Connecting Cable, length 100 cm
USB Flash Drive, 32 GB, USB silicone keyboard, with touchpad, US

***Available in the following languages:** DE, ES, FR, IT, PT, RU

Specifications:

HD video outputs	- 2x DVI-D - 1x 3G-SDI
Format signal outputs	1920 x 1080p, 50/60 Hz
LINK video inputs	3x
USB interface SCB interface	4x USB, (2x front, 2x rear) 2x 6-pin mini-DIN

Power supply	100–120 VAC/200–240 VAC
Power frequency	50/60 Hz
Protection class	I, CF-Defib
Dimensions w x h x d	305 x 54 x 320 mm
Weight	2.1 kg

For use with IMAGE1 S
IMAGE1 S CONNECT Module TC 200EN

TC 300

TC 300 **IMAGE1 S H3-LINK,** link module, for use with IMAGE1 FULL HD three-chip camera heads, power supply 100–120 VAC/200–240 VAC, 50/60 Hz,
for use with IMAGE1 S CONNECT TC 200EN
including:
Mains Cord, length 300 cm
Link Cable, length 20 cm

Specifications:

Camera System	**TC 300 (H3-Link)**
Supported camera heads/video endoscopes	TH 100, TH 101, TH 102, TH 103, TH 104, TH 106 (fully compatible with IMAGE1 S) **22** 2200 55-3, **22** 2200 56-3, **22** 2200 53-3, **22** 2200 60-3, **22** 2200 61-3, **22** 2200 54-3, **22** 2200 85-3 (compatible without IMAGE1 S technologies CLARA, CHROMA, SPECTRA*)
LINK video outputs	1x
Power supply	100–120 VAC/200–240 VAC
Power frequency	50/60 Hz
Protection class	I, CF-Defib
Dimensions w x h x d	305 x 54 x 320 mm
Weight	1.86 kg

* *SPECTRA A:* **Not for sale in the U.S.**
** *SPECTRA B:* **Not for sale in the U.S.**

IMAGE1 S Camera Heads *NEW*

For use with IMAGE1 S Camera System
IMAGE1 S CONNECT Module TC 200EN, IMAGE1 S H3-LINK Module TC 300
and with all IMAGE1 HUB™ HD Camera Control Units


TH 100

TH 100 **IMAGE1 S H3-Z Three-Chip FULL HD Camera Head,**
50/60 Hz, IMAGE1 S compatible, progressive scan,
soakable, gas- and plasma-sterilizable, with integrated
Parfocal Zoom Lens, focal length f = 15–31 mm (2x),
2 freely programmable camera head buttons,
for use with IMAGE1 S and IMAGE1 HUB™ HD/HD

Specifications:

IMAGE1 FULL HD Camera Heads	IMAGE1 S H3-Z
Product no.	TH 100
Image sensor	3x ⅓" CCD chip
Dimensions w x h x d	39 x 49 x 114 mm
Weight	270 g
Optical interface	integrated Parfocal Zoom Lens, f = 15–31 mm (2x)
Min. sensitivity	F 1.4/1.17 Lux
Grip mechanism	standard eyepiece adaptor
Cable	non-detachable
Cable length	300 cm


TH 104

TH 104 **IMAGE1 S H3-ZA Three-Chip FULL HD Camera Head,**
50/60 Hz, IMAGE1 S compatible, **autoclavable,**
progressive scan, soakable, gas- and plasma-sterilizable,
with integrated Parfocal Zoom Lens, focal length
f = 15–31 mm (2x), 2 freely programmable camera head
buttons, for use with IMAGE1 S and IMAGE1 HUB™ HD/HD

Specifications:

IMAGE1 FULL HD Camera Heads	IMAGE1 S H3-ZA
Product no.	TH 104
Image sensor	3x ⅓" CCD chip
Dimensions w x h x d	39 x 49 x 100 mm
Weight	299 g
Optical interface	integrated Parfocal Zoom Lens, f = 15–31 mm (2x)
Min. sensitivity	F 1.4/1.17 Lux
Grip mechanism	standard eyepiece adaptor
Cable	non-detachable
Cable length	300 cm

Monitors

9619 NB

9619 NB

19" HD Monitor,
color systems **PAL/NTSC,** max. screen resolution 1280 x 1024, image format 4:3, power supply 100–240 VAC, 50/60 Hz, wall-mounted with VESA 100 adaption,
including:
External 24 VDC Power Supply
Mains Cord

9826 NB

9826 NB

26" FULL HD Monitor,
wall-mounted with VESA 100 adaption,
color systems **PAL/NTSC,**
max. screen resolution 1920 x 1080,
image fomat 16:9,
power supply 100–240 VAC, 50/60 Hz
including:
External 24 VDC Power Supply
Mains Cord

Monitors

KARL STORZ HD and FULL HD Monitors	19"	26"
Wall-mounted with VESA 100 adaption	9619 NB	9826 NB
Inputs:		
DVI-D	●	●
Fibre Optic	–	–
3G-SDI	–	●
RGBS (VGA)	●	●
S-Video	●	●
Composite/FBAS	●	●
Outputs:		
DVI-D	●	●
S-Video	●	–
Composite/FBAS	●	●
RGBS (VGA)	●	–
3G-SDI	–	●
Signal Format Display:		
4:3	●	●
5:4	●	●
16:9	●	●
Picture-in-Picture	●	●
PAL/NTSC compatible	●	●

Optional accessories:

9826 SF **Pedestal,** for monitor 9826 NB
9626 SF **Pedestal,** for monitor 9619 NB

Specifications:

KARL STORZ HD and FULL HD Monitors	19"	26"
Desktop with pedestal	optional	optional
Product no.	9619 NB	9826 NB
Brightness	200 cd/m² (typ)	500 cd/m² (typ)
Max. viewing angle	178° vertical	178° vertical
Pixel distance	0.29 mm	0.3 mm
Reaction time	5 ms	8 ms
Contrast ratio	700:1	1400:1
Mount	100 mm VESA	100 mm VESA
Weight	7.6 kg	7.7 kg
Rated power	28 W	72 W
Operating conditions	0–40°C	5–35°C
Storage	-20–60°C	-20–60°C
Rel. humidity	max. 85%	max. 85%
Dimensions w x h x d	469.5 x 416 x 75.5 mm	643 x 396 x 87 mm
Power supply	100–240 VAC	100–240 VAC
Certified to	EN 60601-1, protection class IPX0	EN 60601-1, UL 60601-1, MDD93/42/EEC, protection class IPX2

Accessories for Video Documentation

495 NL **Fiber Optic Light Cable,**
with straight connector,
diameter 3.5 mm, length 180 cm

495 NA **Same,** length 230 cm

Cold Light Fountain XENON 300 SCB

20133101-1 **Cold Light Fountain XENON 300 SCB**
with built-in antifog air-pump, and integrated KARL STORZ Communication Bus System SCB
power supply:
100–125 VAC/220–240 VAC, 50/60 Hz
including:
Mains Cord
SCB Connecting Cord, length 100 cm

20133027 **Spare Lamp Module XENON**
with heat sink, 300 watt, 15 volt

20133028 **XENON Spare Lamp,** only,
300 watt, 15 volt

Cold Light Fountain XENON NOVA® 300

20134001 **Cold Light Fountain XENON NOVA® 300,**
power supply:
100–125 VCA/220–240 VAC, 50/60 Hz
including:
Mains Cord

20132028 **XENON Spare Lamp,** only,
300 watt, 15 volt

Data Management and Documentation

KARL STORZ AIDA® – Exceptional documentation

The name AIDA stands for the comprehensive implementation of all documentation requirements arising in surgical procedures: A tailored solution that flexibly adapts to the needs of every specialty and thereby allows for the greatest degree of customization.

This customization is achieved in accordance with existing clinical standards to guarantee a reliable and safe solution. Proven functionalities merge with the latest trends and developments in medicine to create a fully new documentation experience – AIDA.

AIDA seamlessly integrates into existing infrastructures and exchanges data with other systems using common standard interfaces.

WD 200-XX* **AIDA Documentation System,**
for recording still images and videos,
dual channel up to FULL HD, 2D/3D,
power supply 100-240 VAC, 50/60 Hz

including:
USB Silicone Keyboard, with touchpad
ACC Connecting Cable
DVI Connecting Cable, length 200 cm
HDMI-DVI Cable, length 200 cm
Mains Cord, length 300 cm

WD 250-XX* **AIDA Documentation System,**
for recording still images and videos,
dual channel up to FULL HD, 2D/3D,
including SMARTSCREEN® (touch screen),
power supply 100-240 VAC, 50/60 Hz

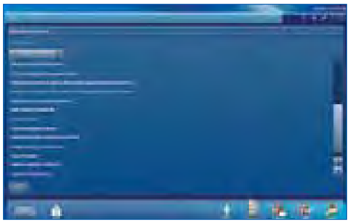
including:
USB Silicone Keyboard, with touchpad
ACC Connecting Cable
DVI Connecting Cable, length 200 cm
HDMI-DVI Cable, length 200 cm
Mains Cord, length 300 cm

*XX Please indicate the relevant country code
(DE, EN, ES, FR, IT, PT, RU) when placing your order.

Workflow-oriented use

Patient

Entering patient data has never been this easy. AIDA seamlessly integrates into the existing infrastructure such as HIS and PACS. Data can be entered manually or via a DICOM worklist.
All important patient information is just a click away.



Checklist

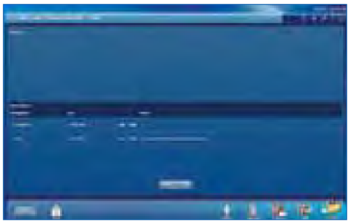
Central administration and documentation of time-out. The checklist simplifies the documentation of all critical steps in accordance with clinical standards. All checklists can be adapted to individual needs for sustainably increasing patient safety.

Record

High-quality documentation, with still images and videos being recorded in FULL HD and 3D. The Dual Capture function allows for the parallel (synchronous or independent) recording of two sources. All recorded media can be marked for further processing with just one click.

Edit

With the Edit module, simple adjustments to recorded still images and videos can be very rapidly completed. Recordings can be quickly optimized and then directly placed in the report.
In addition, freeze frames can be cut out of videos and edited and saved. Existing markings from the Record module can be used for quick selection.



Complete

Completing a procedure has never been easier. AIDA offers a large selection of storage locations. The data exported to each storage location can be defined. The Intelligent Export Manager (IEM) then carries out the export in the background. To prevent data loss, the system keeps the data until they have been successfully exported.

Reference

All important patient information is always available and easy to access. Completed procedures including all information, still images, videos, and the checklist report can be easily retrieved from the Reference module.

Equipment Cart

UG 220

UG 220 **Equipment Cart**
wide, high, rides on 4 antistatic dual wheels
equipped with locking brakes 3 shelves,
mains switch on top cover,
central beam with integrated electrical subdistributors
with 12 sockets, holder for power supplies,
potential earth connectors and cable winding
on the outside,

Dimensions:
Equipment cart: 830 x 1474 x 730 mm (w x h x d),
shelf: 630 x 510 mm (w x d),
caster diameter: 150 mm

inluding:

Base module equipment cart, wide
Cover equipment, equipment cart wide
Beam package equipment, equipment cart high
3x **Shelf,** wide
Drawer unit with lock, wide
2x **Equipment rail,** long
Camera holder

UG 540

UG 540 **Monitor Swifel Arm,**
height and side adjustable,
can be turned to the left or the right side,
swivel range 180°, overhang 780 mm,
overhang from centre 1170 mm,
load capacity max. 15 kg,
with monitor fixation VESA 5/100,
for usage with equipment carts UG xxx

Recommended Accessories for Equipment Cart

UG 310

UG 310 **Isolation Transformer,**
200 V–240 V; 2000 VA with 3 special mains socket,
expulsion fuses, 3 grounding plugs,
dimensions: 330 x 90 x 495 mm (w x h x d),
for usage with equipment carts UG xxx

UG 410

UG 410 **Earth Leakage Monitor,**
200 V–240 V, for mounting at equipment cart,
control panel dimensions: 44 x 80 x 29 mm (w x h x d),
for usage with isolation transformer UG 310

UG 510

UG 510 **Monitor Holding Arm,**
height adjustable, inclinable,
mountable on left or right,
turning radius approx. 320°, overhang 530 mm,
load capacity max. 15 kg,
monitor fixation VESA 75/100,
for usage with equipment carts UG xxx