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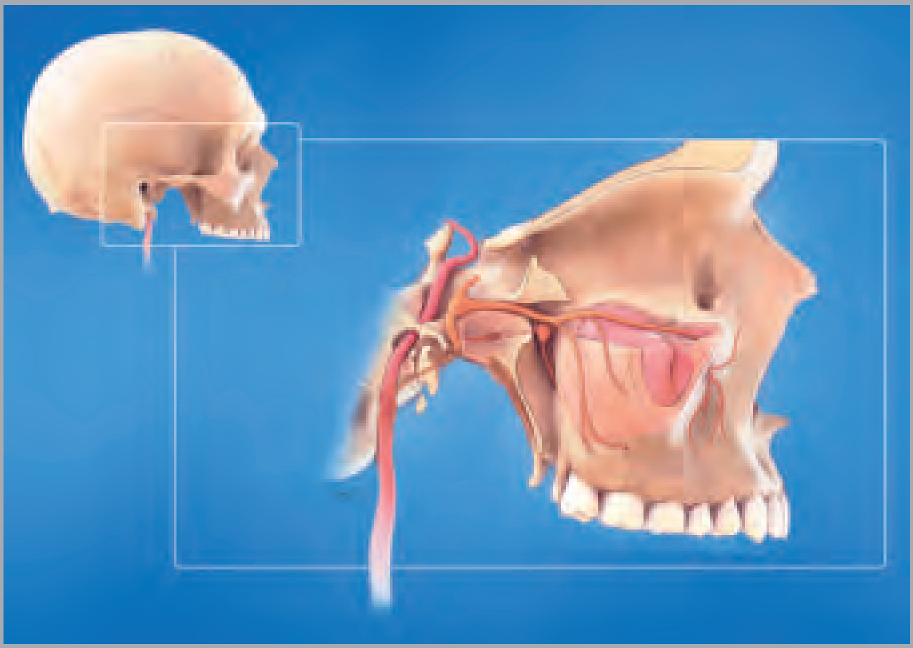
ENDOSCOPIC TRANSMAXILLARY APPROACHES TO THE SKULL BASE

Anatomy, Step-by-Step Guide, and Case Examples



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1 Introduction to Endoscopic Transmaxillary Approaches

1.1. Introduction

The endoscopic transmaxillary corridor is a versatile avenue to address diverse skull base pathology in challenging anatomical regions of the anterolateral skull base.[10] Because of enhanced collaboration with otolaryngology, improved endoscopy equipment and surgical instrumentation, and improved conceptual understanding of the relevant anatomical constraints, endoscopic transmaxillary approaches are increasingly being offered to patients as minimal access alternatives to open approaches. These robust approaches exploit the maxillary sinus, a large air-filed space adjacent to traditionally difficult-to-access anatomical regions, such as the pterygopalatine fossa, infratemporal fossa, cavernous sinus, and jugular fossa. Endoscopy can exploit this space to provide maneuverability and superior visualization that previously would have required more extensive surgical approaches and tissue destruction.[3] In general, endoscopic approaches through the maxillary sinus utilize the nasal cavity (i.e. endonasal transmaxillary approach) or direct anterior approach through a sublabial incision (i.e. sublabial transmaxillary approach). While each approach has its unique benefits and limitations, they have both been used to access neoplasms such as juvenile nasal angiofibromas, schwanommas, chordomas, spontaneous spinal fluid leaks, and meningoencephaloceles amongst other lesions.[1] In this reference manual, we will review the relevant anatomy of the region, provide a step-by-step guide to performing transmaxillary approaches, and describe illustrative case examples.

1.2. History and Evolution of Transmaxillary Approaches

Open, microsurgical transfacial or sublabial transmaxillary approaches to the anterolateral skull base have been utilized by otolaryngologists and neurosurgeons since the time of *Harvey Cushing.* Drs. *Caldwell* and *Luc* each approached the maxillary sinus in an open fashion via the sublabial approach that now bears their names in the last decade of the 1800s.[10] In the late 1960s, *Fisch et al.* described the infratemporal fossa approach for maxillary sinus lesions, which became a popular approach among open skull base surgeons.[9] For most of the 20th century, such approaches were performed using loupe magnification. The advent of the surgical microscope refined these approaches in the latter half of the 20th century.[5] The endoscopic transmaxillary approach has evolved in parallel to endonasal transsphenoidal endoscopy. Seminal work by teams in Pittsburgh, USA (Drs. *Jho, Carrau, Prevedello, Snyderman* and *Kassam*),[6,7] in Naples, Italy (Drs. *Cappabianca, de Divitiis* and *Cavallo*), and Bologna, Italy (Drs. *Frank* and *Pasquini*) expanded the use of skull base endoscopy beyond the sella and pituitary to include regions of the anterior skull base traditionally addressed through open approaches.[2] The endoscopic tranxmaxillary approach to the anterolateral skull base has been refined for the last two decades. A plethora of literature regarding all endoscopic approaches, including the transmaxillary approach, has dominated the publications of skull base surgery in the 21st century.

1.3. Surgical Indications

A wide area of the anterolateral cranial base can be accessed through a transmaxillary corridor. The main anatomical targets are the infratemporal fossa and pterygopalatine fossa, because they lie immediately posterior to the posterior wall of the maxillary sinus. In addition, surgeons are addressing deeper targets, including the middle cranial fossa, cavernous sinus, clivus, occipital condyle, and laterally to the zygomatic arch and medial mandible. Panel 1 lists the most common pathologies addressed and Panel 2 indicates the anatomical targets of these approaches.

Pathology addressed with transmaxillary endoscopic approach

- Cavernous sinus lesions (pituitary adenomas, meningiomas, schwanommas).
- Cholesterol granuloma.
- Chordoma.
- Chondrosarcoma.
- Espitaxis from posterior nasal cavity, ligation of internal maxillary artery.
- Juvenile nasal angiofibroma.
- Meningoencephalocele (lateral sphenoid sinus, foramen ovale).
- Schwanomma.
- Sinus carcinoma (squamous cell, adenoid cystic carcinoma).
- Sinus disease, mucocele.
- Medial and inferior orbital tumors (hemangiomas, metastasis).

Panel 1 Pathology addressed with transmaxillary endoscopic approach.

Anatomical targets addressed with the transmaxillary approach

- Cavernous sinus.
- Clivus.
- Infratemporal fossa.
- Maxillary antrum.
- Meckel's cave.
- Petrous apex (Meckel's cave).
- Pterygopalatine fossa (V_2, internal maxillary artery).
- Medial and inferior orbit.
- Occipital condyle and condylar joint.
- Jugular fossa.
- Sphenoid sinus, lateral aspect.

Panel 2 Anatomical targets addressed with the transmaxillary approach.

Approach	Strengths	Weaknesses
Endonasal Transmaxillary	■ Excellent for targets in pterygopalatine fossa and medial infratemporal fossa. ■ Avoids approach-related morbidity of sublabial transmaxillary approach.	■ For lateral lesions, requires use of angled instruments and endoscopes. ■ More surgical "struggle" for lateral lesions. ■ Nasal morbidity (crusting, septal perforation). ■ Narrow surgical corridor with limited surgical freedom, "swordfighting".
Sublabial Anterior Transmaxillary	■ Improved surgical freedom ■ Excellent lateral exposure without angled instruments.	■ Approach-related morbidity (teeth numbness, ora-antral fistula, facial bruising).

Table 1.1 Comparison of endoscopic transmaxillary approaches.

1.4. Clinical Evaluation

History and physical examination are important for determining the site of the lesion and its extent of involvement. Clinical presentation can provide clues as to the anatomical structures involved. For example, facial pain with trismus may indicate the presence of a lesion in the pterygopalatine fossa that invades the pterygoid musculature. Ocular symptoms such as stinging, tearing, lost corneal reflex, or diplopia, can also provide clues as to vidian nerve or pterygopalatine ganglion involvement, direct orbital involvement, or cavernous sinus involvement. Compressive lesions of the maxillary nerve, such as a chordoma or schwannomas, may lead to facial paresthesias. Epistaxis that does not respond to standard packing strategies is a common presentation of juvenile nasal angiofibromas. Extradural middle fossa tumors can present with symptoms of increased trigeminal pain, or localizing headaches to the region of the petrous apex.

1.5. Diagnostic Imaging

Detailed preoperative imaging is essential for choosing a surgical approach. Current imaging modalities provide complementary information. Coronal formatted CT scans of the paranasal sinuses provide a detailed view of the boney paranasal sinus anatomy, orbits, and skull base and the relationship of the target lesions to boney surgical landmarks (Fig. 1.1). Since the essence of endoscopic surgery is to exploit the air-filled paranasal sinuses, CT scans are helpful for deciding which paranasal sinus represents the key corridor. Thin slice CT scans can also be imported into the neuronavigation platform to assist with intraoperative decision-making. Contrasted MRI provides complementary information about the soft tissue extent of the tumor and the likelihood of achieving a gross total resection of the lesion. Vascular imaging, such as CT angiography, is especially helpful in cases where there is suspected involvement of the extradural carotid artery. We have found CT angiography particularly useful in extensive juvenile nasal angiofibromas to avoid carotid injury.

1.6. Surgical Planning and Approach Selection

Surgical approach selection depends on several factors (Table 1.1). First, the anatomical characteristics of the lesion are important. In our experience, the endonasal medial maxillectomy approach is excellent for lesions that are somewhat medially located, such as lesions of the maxillary sinus, pterygopalatine fossa, pterygoid plates, vidian canal, inferior orbit, and cavernous sinus, but is technically more challenging for laterally placed lesions, such as those in the lateral infratemporal fossa. The reason for this is that the piriform aperture limits the ability of the surgeon to turn the corner and reach laterally (Fig. 1.1b). To reach more lateral targets using this approach, such as lesions abutting the mandible ramus or in the lateral infratemporal fossa, requires the use of angled instruments and angled endoscopes which increases the surgical instrument conflict and surgeon frustration. Alternatively, resection of the bone at the piriform aperture (i.e., endoscopic Denkers approach) allows for more lateral access.[11] We have previously proposed a simple way to determine lateral extension in the surgical field that allows optimum surgical freedom without the use of angled instruments or angled endoscopes. We proposed drawing a straight line from the anterior nasal septum to the tumor passing through

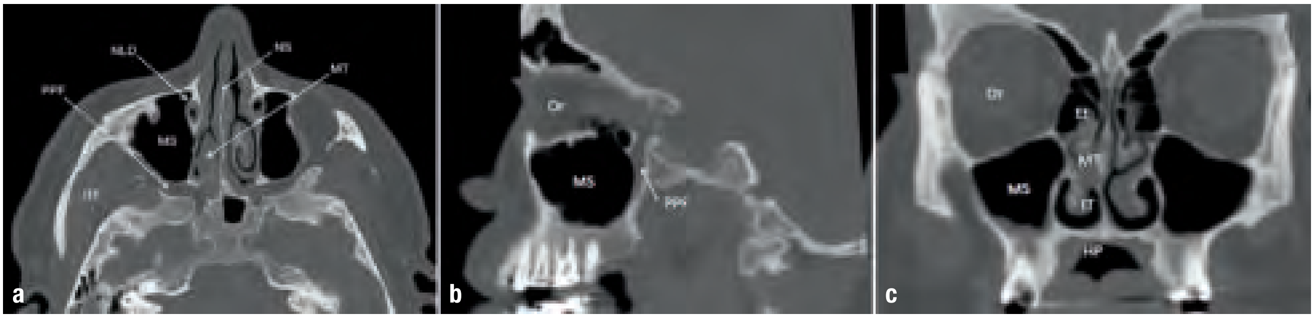

Fig. 1.1 Axial (**a**), sagittal (**b**), and coronal (**c**) CT scan reformats demonstrating the relationship of the maxillary sinus to the paranasal structures. Orbit (**Or**); pterygopalatine fossa (**PPT**); maxillary sinus (**MS**); nasolacrimal duct (**NLD**); infratemporal fossa (**ITF**); nasal septum (**NS**); inferior turbinate (**IT**); middle turbinate (**MT**); superior turbinate (**ST**); hard palate (**HP**); foramen rotundum (**FR**); ethmoids (**Et**).

the nasolacrimal duct on a pre-operative axial imaging. For lesions with an epicenter lateral to this line, we tend to favor the sublabial transmaxillary approach because of its direct anterior to posterior trajectory and improved lateral surgical freedom. To address this limitation of the endonasal approach, compensatory strategies have been developed including a contralateral transseptal approach and the endoscopic equivalent of the Denker's approach. For large lesions occupying medial and lateral anatomical compartments, we will often use a combined strategy with an endonasal approach and a sublabial approach. Second, approach selection also depends on the approach-related morbidity. Authors have noted that the sublabial approach can result in tooth numbness and rarely oro-antral fistula. On the other hand, the endonasal approach can result in increased nasal morbidity from direct nasal trauma. Third, surgeon experience also influences the decision. We have found that as we have gained more experience with these approaches that we have tended to use the endonasal strategy more as the collaboration with otolaryngology has grown and as our comfort with working with angled instrumentation has grown.

1.7. Endoscopic Instrumentation

These approaches require a standard endoscope set-up including endoscopes (0°, 30°, 70°), high definition cameras and monitors, digital recorder, and tailored surgical instruments. We also use irrigating sheath to keep the endoscope clean and improve surgical efficiency. In addition to standard nasal and sinus instruments, we use a mucosal debrider for the nasal exposure, irrigating transsphenoidal style drill with cutting and diamond burrs, and single-shafted bipolar cautery.

1.8. Operative Set-Up and Surgical Ergonomics

We prefer a two-surgeon, three-handed technique and therefore fashion the operative suite to suit this preference (Fig. 1.2). The two surgeons stand on the right side of the patient, with the endoscopist standing by the patient's right ear and the operative surgeon standing at the level of the patient's right shoulder. The patient's head is positioned with lateral flexion directed away from the surgeon so the surgeon does not have to lean over the patient. An alternative technique is to have the endoscopist standing on the left side of the patient. The main endoscopic tower is positioned directly in front of the operating surgeon's field of view, and the accessory monitor is placed about a meter away from the patient's left ear directly in the endoscopist's line of sight. The anesthesiologist and ventilator are on the left side of the patient at the level of the patient's knees. The surgical nurse is on the patient's right side at the level of the patient's knees. The stereotactic reference arc is positioned on the forehead if using and electromagnetic option or near the vertex if using a line-of-site system. The monitor for neuronavigation system is positioned to the side of the main endoscopic tower.

Fig. 1.2 Positioning of patient and instruments in the operating room. The head is laterally flexed with the vertex away from the surgeon in order to allow the surgeon to comfortably hold instruments within the endonasal corridor without having to lean over the patient. The anesthesia team and ventilator are placed left of the patient near the patient's feet. Two monitors are used: the main tower is placed directly in front of the surgeon unobstructed from view. The accessory monitor is placed to the patient's left, and is primarily used by the assistant surgeon holding the endoscope, approximately one meter away from the patient's left ear. The monitor for neuronavigation system is positioned to the side of the main endoscopic tower.

2 Anatomical Review

2.1. Nasal Cavity

The lateral wall of the nasal cavity is composed of six bones: lacrimal, maxillary, ethmoid, the vertical plate of the palatine, inferior nasal concha and sphenoid bones. A remarkable feature of this anatomical structure is pronounced rugged surface mainly shaped by the turbinates (Fig. 1.1). The turbinates, along with the perpendicular plate of the palatine bone, form the lateral wall of the nasal cavity and also the medial wall of the maxillary sinus. These structures are often transgressed in endonasal transmaxillary approaches. The anterior border of the nasal cavity is formed by lacrimal bone, which articulates with the maxilla. The lacrimal bone also helps form the lasolacrimal groove in which runs the nasolacrimal duct (Fig. 1.1). The nasolacrimal duct is another important endoscopic landmark for trans-maxillary approaches because it serves as the anterior limit of the middle meatal approach.[8] The nasolacrimal duct can be sectioned to achieve a more lateral surgical angle if needed.[8]

The turbinates and their relations to the paranasal sinuses are critical surgical anatomy to understand. The superior turbinate (concha) is the smallest turbinate. It is positioned posterior and superiorly to the middle turbinate. This structure is commonly lateralized or resected in approaches to the sphenoid sinus. The middle turbinate (concha) is a projection of the ethmoid bone, which forms the lateral nasal cavity. The ethmoids present a variable degree of pneumatization, creating an air-filled cavity inside the turbinate called “concha bullosa”. Depending on the size of the concha bullosa, the middle turbinate can bulge into the nasal cavity leading the obstruction of the middle meatus, and ventilation problems due to the narrow nasal space. Its lateral wall is articulated to the uncinate process. Lateral to the turbinates, the paranasal sinuses open into spaces called meati. The space lateral to the middle turbinate is the middle meatus, which is a key corridor for the transmaxillary approaches.

The uncinate process (UP) is a curved lamina located in the lateral nasal wall that attaches to lamina papyracea superiorly and articulates to the middle turbinate and the ethmoidal process of the inferior concha medially. The space between the lamina papyracea and the UP is called ethmoid infundibulum, usually posterior to the anterior surface of the ethmoidal bulla.

The ethmoidal bulla (EB) is described as the largest and most constant ethmoidal air cell, and usually compounds the middle group of ethmoidal cells (Fig. 3.1b). The degree of pneumatization is variable and the EB can also cause significant narrow of the middle meatus. If the EB is not pneumatized, the lamina papyracea can project toward the midline, leading to inadvertently orbital violation during endoscopic procedures. The ethmoid bulla is a helpful landmark for performing an ethmoidectomy.

Inferior nasal turbinate (concha) is a separate bone, and is the first structure recognized when the endoscope is introduced parallel to the floor of the nasal cavity. The inferior turbinate is largest turbinate, and is responsible for airflow direction, humidification, heating, and filtering.

The perpendicular plate of the palatine bone is a noteworthy structure for the transmaxillary approaches. From its two horizontal crests, conchal (lower) and

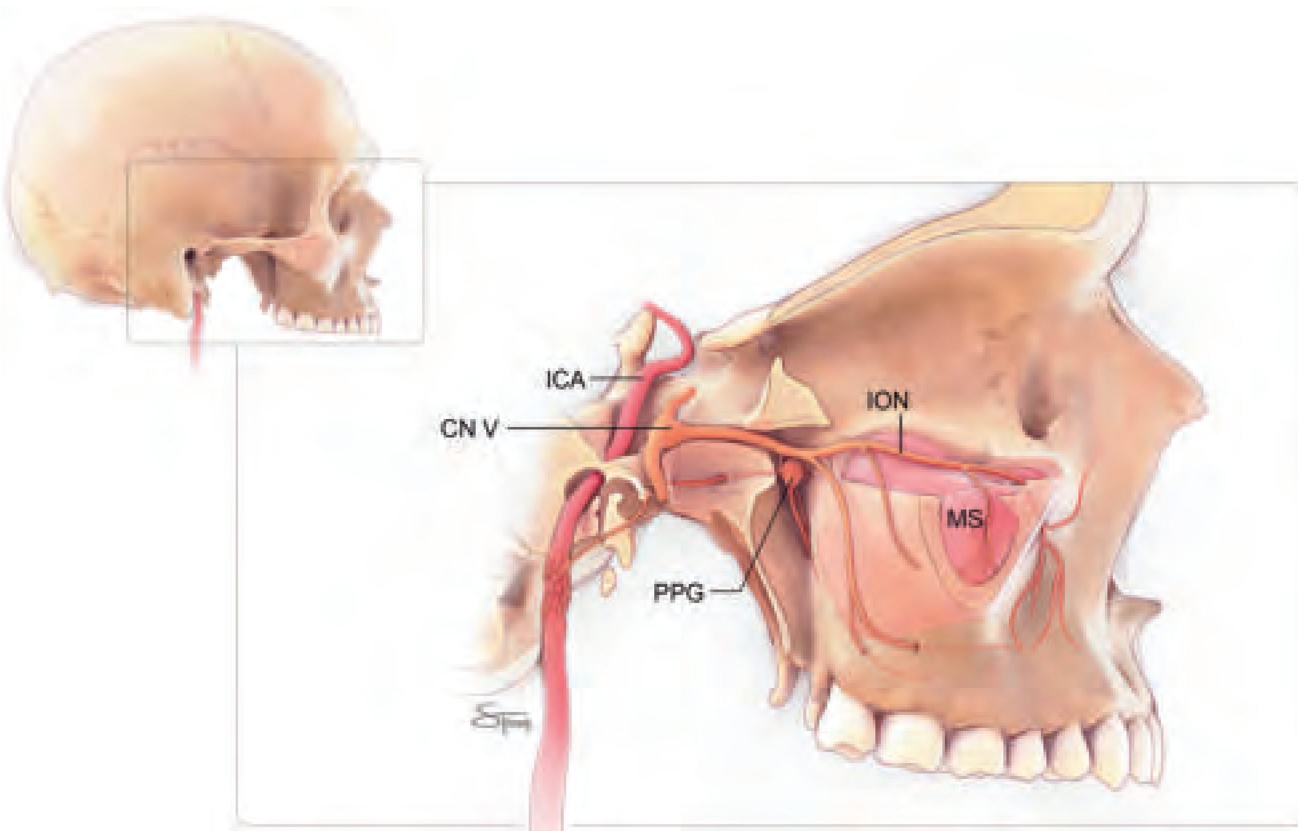

Fig. 2.1 Lateral view of the maxillary sinus, and posterior maxillary sinus structures. Internal carotid artery (**ICA**); cranial nerve V (**CN V**); pterygopalatine ganglion (**PPG**); infraorbital nerve (**ION**); maxillary sinus (**MS**).

ethmoid (upper) arise the inferior and middle turbinates, respectively. The perpendicular plate articulates with the sphenoid bone to form the sphenopalatine foramen, another relevant landmark during the transmaxillary approaches. The sphenopalatine foramen harbors the sphenopalatine vessels and posterior superior nasal nerves (Fig. 2.1). The sphenopalatine foramen is origination of juvenile nasal angiofibromas.

2.2. Maxillary Sinus

The maxillary sinus is the gateway to the transmaxillary approaches. The maxillary sinus is a pyramidal air space contained inside the maxillary body, which is physiologically connected to the nasal cavity through the middle meatus. It is anatomically related to the orbit in the roof, alveolar processes and the palatine recesses in the floor, to the face in the anterior wall, and to the pterygopalatine and infratemporal fossa through the posterior wall. As described previously, the medial cover of this space is the middle and inferior turbinates. Therefore, the base of pyramidal space is formed by the middle and inferior turbinates, and the apex points laterally to the zygomatic process. The infraorbital canal harboring the infraorbital nerve and vessels is a consistent landmark in the roof of the sinus that can be tracked posteriorly to find the maxillary nerve (Fig. 2.1). Moreover, the infraorbital nerve acts as an anatomical landmark to establish the surgical limit between pterygopalatine (medial) and infratemporal (lateral) fossae (Fig. 2.1). The posterior wall of maxillary sinus, usually formed by a thin lamina of bone, contains the alveolar canals that harbor posterior superior alveolar vessels and nerves to the molar teeth.

2.3. Sphenoid Sinus

The sphenoid sinus is a midline cavity in the sphenoid body and is an important natural corridor to the central skull base. It has an anatomic relationship with the pituitary gland, cavernous sinus, cavernous segment of internal carotid artery and extraocular nerves, as well as extracavernous structures such as with optic, maxillary, mandibular and vidian nerves, and petrous carotid artery (Fig. 2.2). It is important for endoscopic skull base surgery because it gives access to the anterior, middle and posterior skull base. The sinus contributes to the lateral nasal wall with the sphenoid concha and medial pterygoid plate. The sphenoid concha articulates with the sphenopalatine notch of the palatine bone to form the sphenopalatine foramen. The medial pterygoid plate of the sphenoid forms the lateral edge of the choana.

The anterior wall of the sphenoid sinus is divided in two parts: medial and lateral. The lateral part comprises the sphenoid conchae, and the posterior ethmoidal cells. The medial sphenoid sinus wall is closer to the sinus roof and harbors the sphenoid meatus at the level of the sphenoethmoidal recess. This orifice is a reliable surgical landmark that provides access to the sphenoid sinus. The sphenoid sinus cavity is usually divided by the sphenoid septum, which may be a major single septum in the majority of cases or may consist of multiple septae. The sphenoid septum is commonly placed off of midline and may project to the carotid prominence.[12] Carotid injury can occur from fracturing the sphenoid septum. Thus, a careful analysis of the bony CT scan is strongly recommended before a transsphenoidal approach.

Lesions in the lateral sphenoid sinus may be approached through a transpterygoid transmaxillary approach. Resection of the medial pterygoid plate provides access to the structures in the lateral sphenoid wall including the trigeminal nerve, optic canal, and carotid artery. The most common indications we use a transpterygoid approach for lateral sphenoid sinus lesions are spontaneous CSF leak and pituitary adenomas with either cavernous sinus extension or adenomas that grow into the lateral recesses of the sphenoid sinus.

The vidian canal is contained in the sphenoid sinus floor located in the line of fusion between the pterygoid process and body of the sphenoidal bone. The vidian canal contains the vidian nerve important in endoscopic transmaxillary approaches. The canal has been used as reliable landmark to track the anterior petrosal genu of the internal carotid artery. It opens anteriorly into the medial part of the posterior wall of the pterygopalatine fossa, and posteriorly into the upper part of the anterolateral edge to the foramen lacerum. The vidian nerve is placed below and laterally to the anterior genu of the petrous carotid.

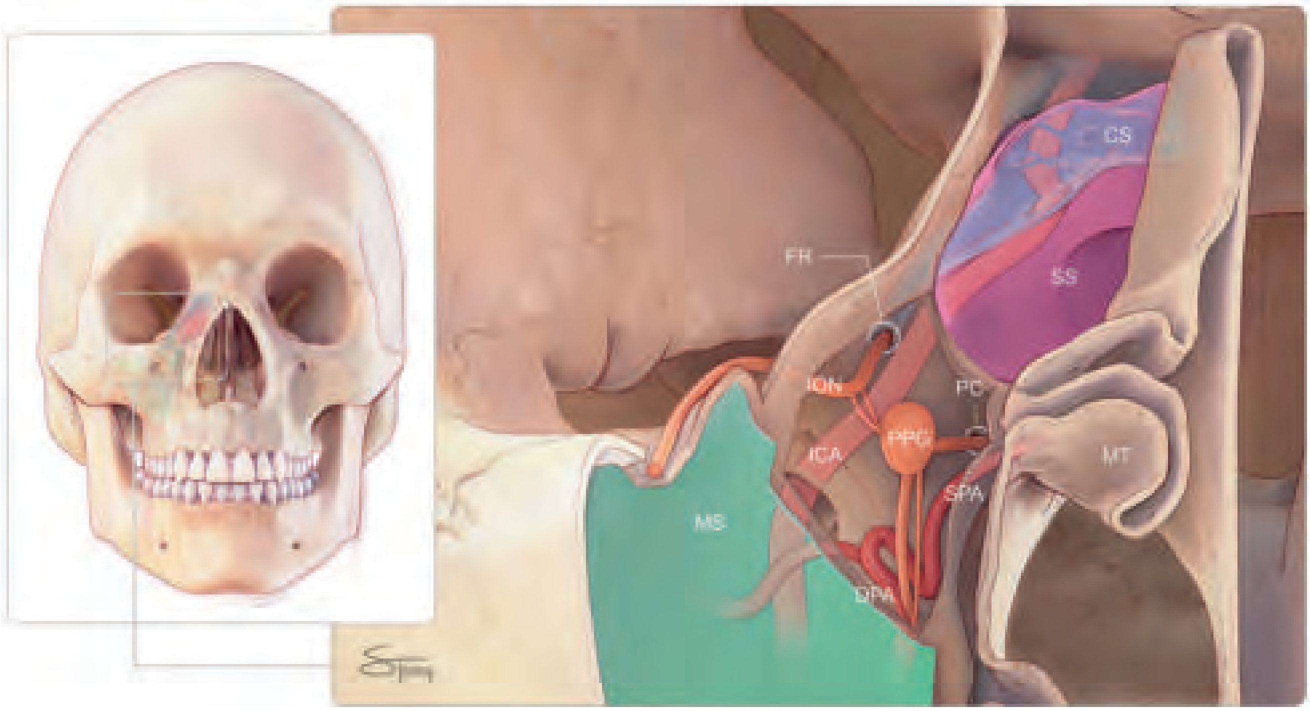

Fig. 2.2 Confrontational view of the posterior maxillary sinus. Foramen rotundum (**FR**); infraorbital nerve (**ION**); internal carotid artery (**ICA**); maxillary sinus (**MS**); cavernous sinus (**CS**); sphenoid sinus (**SS**); pterygoid canal (**PC**); pterygopalatine ganglion (**PPG**); sphenopalatine artery (**SPA**); middle turbinate (**MT**); orbit (**Or**).

2.4. Pterygopalatine Fossae

The pterygopalatine fossa (PPF) is a space located between the posterior wall of maxillary sinus and the base of the pterygoid process (Fig. 2.2). One surgical landmark that delineates the PPF from the infratemporal fossa laterally is the infraorbital nerve/V_2 (Fig. 2.1). PPF communicates with many adjacent anatomic compartments such as infratemporal fossa, middle cranial fossa, foramen lacerum, oral cavity, nasal cavity, and orbit. The PPF contains adipose tissue, sphenopalatine ganglion, vidian nerve, maxillary nerve (V_2), and the terminal segment of the internal maxillary artery. Commonly, the fat and vessels lie anteromedial to the neural structures. Therefore, when entering the PPF via transmaxillary approach, the IMA and fat are the first structures encountered (Fig. 2.2). The palatovaginal canal also opens into the PPF medial to the vidian canal and contains neural branches from the pterygopalatine ganglion, and can be used as a marker to determine the vidian canal position. The PPF has an inverted cone shape. The roof is composed of the sphenoid bone and orbital process of the palatine bone. The apex communicates to the oral cavity through the greater and lesser palatine foramina. The sphenopalatine foramen communicates the PPF to the nasal cavity. The sphenopalatine artery (SPA) arises from internal maxillary artery in the PPF and enters the sphenopalatine foramen with the posterior superior nasal nerves to enter into the nasal cavity (Fig. 2.2). In the nasal cavity, the SPA can be found superior and posterior to the tail of the middle turbinate.

2.5. Infratemporal Fossa

Lesions of the infratemporal fossae (ITF) can also be addressed though a transmaxillary approach. The ITF is bounded anteriorly by the posterior maxillary sinus wall, laterally by the mandible and pterygoid muscles, medially by the infraorbital nerve/V_2, inferiorly by the alveolar border maxilla, and posteriorly by the articular tubercle of the temporal bone and spine of the sphenoid bone (Fig. 2.2). The posterior maxillary sinus wall is the anterior border of the ITF. The coronoid process, ramus of the mandible and pterygoid muscles are the lateral limit. The posterior border is formed by the articular tubercle of the temporal bone and the spine of the sphenoid bone. The ITF communicates with the middle temporal fossa by the foramen ovale and foramen spinosum.

2.6. Internal Maxillary Artery (IMA)

The IMA is a prominent vascular landmark in transmaxillary approaches. The IMA is a terminal branch of external carotid artery. It runs on the anterior edge of lateral pterygoid muscle and reaches the pterygopalatine fossa through the pterygomaxillary fissure. It has a tortuous and variable route, but is always in the anterior plane and respect the nerves inside the PPF (Fig. 2.2). It usually terminates in two main branches, the sphenopalatine and descending palatine arteries. Often, IMA needs to be sectioned or mobilized in transmaxillar approaches. There is no clinical consequence to sacrificing the artery. Most commonly, we will sacrifice it and reflect it laterally along with the contents of the PPF.

3 Endoscopic Transmaxillary Approaches and Variations

The two endoscopic transmaxillary approaches that we use are the endonasal medial maxillectomy transmaxillary approach and the sublabial anterior antrostomy transmaxillary approach. We will review the advantages and disadvantages of these complementary approaches and provide a step-by-step dissection guide. For large lesions occupying multiple compartments, we will often use the approaches together for additional surgical maneuverability. While the maxillary sinus represents the epicenter of these approaches, the sphenoid sinus and ethmoid sinuses are opened as needed to facilitate exposure and identify surgical landmarks.

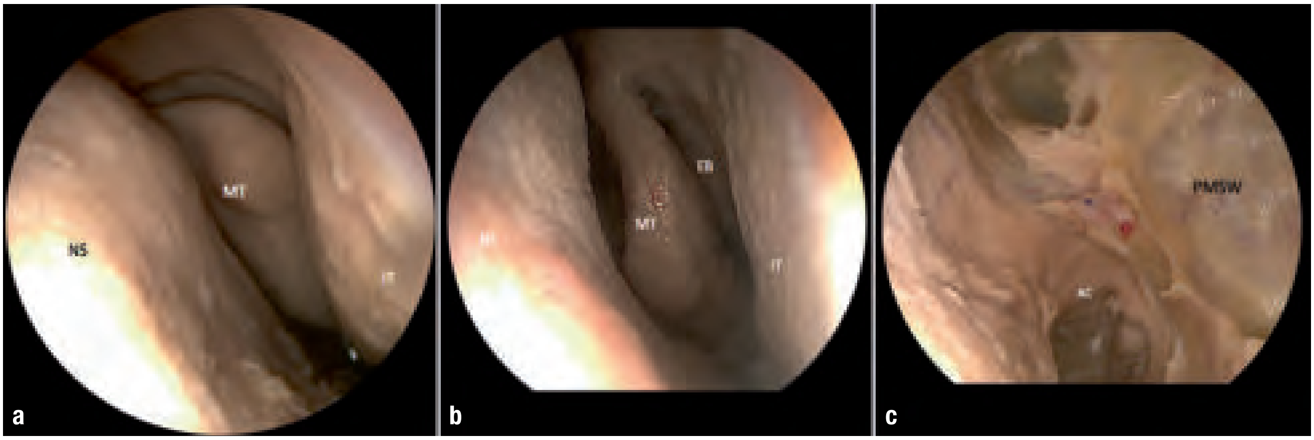

Fig. 3.1 Endonasal approach to the left maxillary sinus, cadaveric dissection. The nasal cavity is inspected with a 0-degree endoscope and the middle and inferior turbinates are identified (**a**). The ethmoid bullae is identified lateral to the middle turbinate (**b**). After resection of the middle turbinate and opening of the medial maxillary sinus wall, the posterior wall of the maxillary sinus is visible. The relationship of the maxillary sinus to the arch of the choana is visualized here (**c**). Middle turbinate (**MT**); inferior turbinate (**IT**); nasal septum (**NS**); ethmoid bullae (**EB**); posterior maxillary sinus wall (**PMSW**); arch of the choane (**AC**).

3.1. Endoscopic Endonasal Transmaxillary Approach

3.1.1. Nasal Stage

After administration of general anesthesia and intravenous antibiotics (1st or 2nd generation cephalosporin), the patient's nasal cavity is decongested. We generally use a combination of topical oxymetazoline-soaked pledgets placed on the middle and inferior turbinates and lidocaine with epinepherine injected submucosally in the septum and turbinates.

The nasal cavity is inspected with a 0°-endoscope and the middle and inferior turbinates are identified. A medial maxillectomy is sufficient in most cases, and so the middle turbinate is medialized and preserved and the maxillary sinus is opened by enlarging the sinus ostium and removing the uncinate process. The degree of additional exposure needed dictates the treatment of the inferior turbinate. One important dictum is that the degree of anterior boney removal limits the lateral extent of exposure once inside the maxillary sinus. For a wide medial maxillectomy, the inferior turbinate is removed to allow inferior and anterior access to the sinus antrum. We remove the medial maxillary sinus wall to the sphenopalatine foramen, which is at the posterior margin of the middle turbinate. A contralateral endonasal approach can be performed by removing the posterior nasal septum allowing for a binostril/bimanual technique.

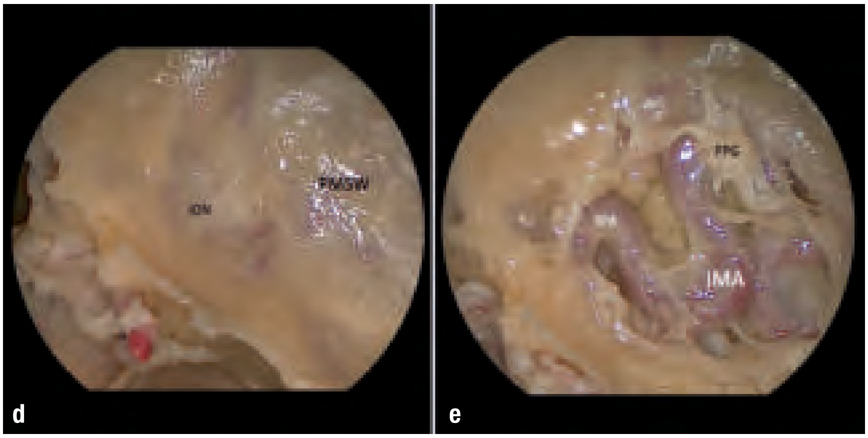

Fig. 3.1 A closer view of the posterior maxillary sinus wall (**d**). The infraorbital nerve is visible underneath the bone of the posterior maxillary sinus wall (**d**). After resection of the posterior maxillary sinus wall, the internal maxillary artery, sphenopalatine artery and pterygopalatine ganglion are visualized (**e**). Posterior maxillary sinus wall (**PMSW**); infraorbital nerve (**ION**); sphenopalatine artery (**SPA**); pterygopalatine ganglion (**PPG**); internal maxillary artery (**IMA**).

3.1.2. Maxillary Sinus Stage

Once the antrum is entered through the middle meatus, the next step is to identify the anatomical landmarks inside the sinus. The most useful surgical landmark is the infraorbital nerve, when it is visible. Often, one can see the groove of the nerve in the roof of the sinus and follow it posteriorly. The infraorbital nerve is a helpful landmark because it leads back to V_2, the cavernous sinus, and separates the pterygopalatine fossa from the infratemporal fossa. The posterior wall of the maxillary sinus is easily removed using punch to expose the contents of the infratemporal fossa including most notably the internal maxillary artery and its branches, V_2 and V_3. One constant relationship is that the internal maxillary artery and branches are superficial to the nervous structures. When possible, the contents of the pterygopalatine fossa are swept laterally in a subperiostial manner in order to maintain fascial integrity and prevent fat herniation into the field. This requires cautery and sectioning of the sphenopalatine artery. If more medial exposure is needed, the sphenopalatine artery is coagulated, and the sphenopalatine foramen is opened toward the orbital process of the palatine bone.

3.2. Endoscopic Sublabial Anterior Antrostomy Transmaxillary Approach

The chief advantages of this approach are the excellent surgical freedom, direct anterior-posterior operative trajectory, and antero-lateral exposure. The lateral exposure achieved by this approach is superior to the endonasal approach because it is not limited by the nasolacrimal duct and piriform aperture. We have been able to address lesions abutting the mandible and zygomatic arch through this approach. Most lesions can be removed using a 0°-endoscope and straight instruments, whereas an angled endoscope and angled instruments are often needed in the endonasal approach. The disadvantages are the approach-related morbidity such as tooth numbness. Further, it should not be performed in children prior to the arrival of permanent dentition.

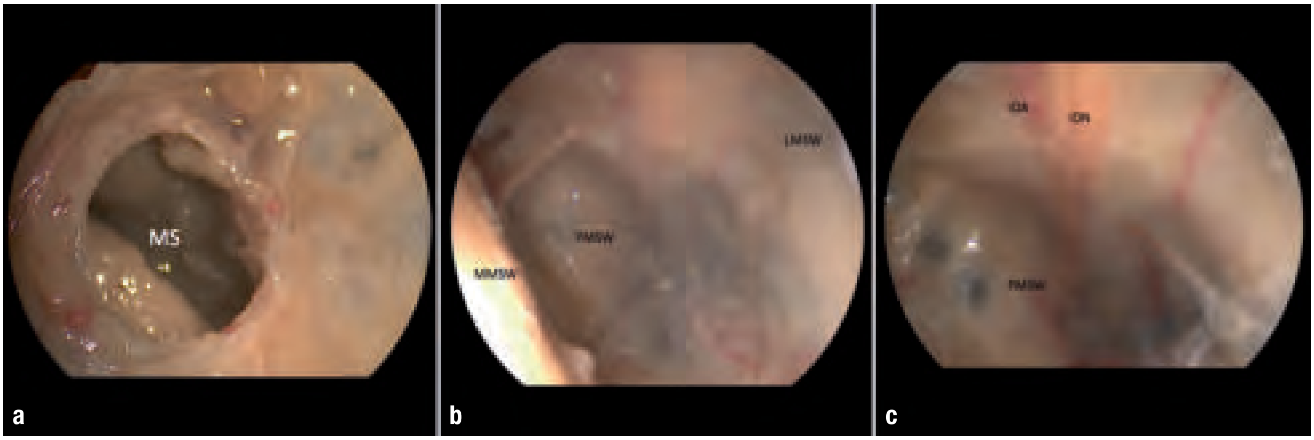

Fig. 3.2 Sublabial approach to the left maxillary sinus, cadaveric dissection. After performing an antrostomy of the anterior wall of the maxillary sinus from a sublabial approach (**a**), the posterior, lateral, medial and inferior maxillary sinus wall are identified (**b**). The infraorbital nerve and artery are visualized through the translucent bone of the superior maxillary sinus wall (**c**), and followed posteriorly as a landmark to the pterygopalatine ganglion. We use the ION as a waypoint for safe entry zones in transmaxillary approaches. Maxillary sinus (**MS**); medial maxillary sinus wall (**MMSW**); lateral maxillary sinus wall (**LMSW**); posterior maxillary sinus wall (**PMSW**); floor of maxillary sinus (**FMS**); infraorbital nerve (**ION**); infraorbital artery (**IOA**).

Fig. 3.2 Early in the dissection uncovering the posterior maxillary sinus wall, the sphenopalatine artery and internal maxillary artery are identified (**d**). Deeper dissection with removal of bone over the infraorbital nerve (**e**). The vascular structures are removed in this cadaveric specimen in order to better visualize the relationship of the infraorbital nerve as it joins the pterygopalatine ganglion (**f**). Infraorbital nerve (**ION**); infraorbital artery (**IOA**); nasal cavity (**NC**); sphenopalatine artery (**SPA**); internal maxillary artery (**IMA**); pterygopalatine ganglion (**PPG**).

3.2.1. Surgical Technique

Topical decongestants are administered as above and a sublabial incision in the buccogingival line is performed from the canine to the second molar tooth. An exposure of anterior wall of the maxilla along with the infraorbital nerve and artery is completed by making an incising through the submucosa and the periostium thus creating a sub-periosteal plane. An anterior maxillotomy is performed using an osteotome and punch. The size of the boney opening can be tailored to the amount of surgical freedom desired. Once inside the maxillary sinus, the dissection proceeds as would the endoscopic endonasal transmaxillary approach. These steps include removal of the posterior maxillary sinus wall, and identification of the infraorbital nerve and the internal maxillary artery. Often, we will enlarge the maxillary sinus ostium and perform a medial maxillectomy so as to better identify the surgical landmarks in the nasal cavity, such as the sphenopalatine foramen, vidian canal, and parasellar carotid artery. At the conclusion of the procedure, the gingiva is closed using a chromic suture.

3.2.2. Transpterygoid Extension

For more laterally located lesions, the pterygoid plates can be left intact. However, when the lesion occupies the pterygopalatine fossa, the lateral sphenoid sinus, or in cases whether one wishes to identify the petrous carotid such as in a transcavernous approach or approach to the middle fossa/petrous apex, the pterygoid plates can be removed using an irrigating drill. Exposure of the lateral sphenoid sinus for repair of an encephalocele often requires removal of the medial pterygoid process. The vidian nerve is an important anatomical landmark in this approach as it runs in the root of the pterygoid process. It can be found by first identifying the sphenopalatine foramen at the posterior edge of the middle tubinate and tracing the neurovascular bundle into the foramen. The vidian nerve may be traced posteriorly to the foramen lacerum in order to identify the petrous carotid artery. We drill the vidian canal using the technique of *Kassam et al.,* where the depth of the carotid is determined by drilling the medial and inferior aspects of the canal. Removal of the pterygoid plates also facilitates exposure of the foramen of rotundum and V_2. The infraorbital nerve can be followed posteriorly to the cavernous sinus. The bone between V_2 and the vidian canal can be drilled out toward the union between the horizontal segment of petrous carotid and its anterior genu exposing the cavernous sinus, petrous apex, and Meckel's cave.

3.3. Utility of Combined Surgical Approaches

We tend to use both a sublabial direct approach and an endonasal approach when targeting a large lesion that occupies multiple anatomical compartments. The other advantage of using two "portals" is that it limits "swordfighting" and increases surgical freedom. This is particularly useful in large vascular tumors such as juvenile nasal angiofibromas and hemangiopericytomas.

3.4. Surgical Pitfalls and Clinical Pearls

- Sufficient soft tissue removal to operate freely in the surgical corridor is essential. Prior to rushing towards the pathology of interest at the deep aspect of the field, the surgeon should ensure that the superficial approach trajectory (either endonasal or sublabial) is opened widely to both accommodate all necessary instruments and to be able to use them freely.
- Upon entering the maxillary sinus, the surgeon should identify the infraorbital nerve and infraorbital groove, as this will consistently lead to foramen rotundum.[4]
- The vidian nerve and its canal are helpful in locating the petrous internal carotid artery.
- Intraoperative image guidance is particularly useful for identifying the carotid artery and also identifying surgical anatomy that may be distorted by the tumor.

3.5. Postoperative Endoscopic Transmaxillary Approach Management

Standard sinus surgery precautions are utilized, with no straws or nose-blowing to prevent negative-pressure dislodgement of closure materials. Saline rinses may be used to irrigate the nasal cavity to reduce crusting. Diluted hydrogen peroxide may be used orally to debride the gingiva when a sublabial approach is used. Generally, hemostasis is sufficient at the conclusion of the operation to negate the use of routine nasal tampons or dense acking materials. Perioperative intravenous antibiotics with gram negative and gram positive coverage at meningitis dosing (e.g., ceftriaxone 2g BID) are continued for 24–48 hours for intradural procedures. The length of hospital stay varies upon the surgical pathology and overall health of the patient but averages two to three days postoperatively.

4 Case Examples

4.1. Case 1

50 year-old female with pain on swallowing. Imaging revealed an adenoid cystic carcinoma in the left fossa of Rosenmüller (Fig. 4.1). Endoscopic endonasal transmaxillary transpterygoid approach was undertaken for resection. The transpterygoid extension allowed for improved access to the lateral margin on the tumor.

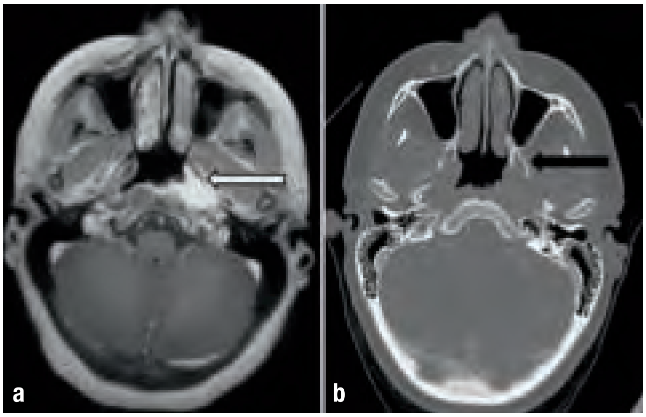

Fig. 4.1 50 year-old female with pain on swallowing. Axial T1-weighted MRI scan with contrast demonstrating an enhancing lesion in the left fossa of Rosenmuller (arrow) (**a**). Axial CT scan demonstrating the pterygoid plate (arrow) illustrating why the pterygoid plate should be removed to gain lateral access to the tumor (**b**).

4.2. Case 2

30 year-old female who presented with trismus. Imaging revealed a retromaxillary mass (Fig. 4.2). Because the mass was posterior to the maxillary sinus wall and bordered the mandibular ramus, we elected to perform a sublabial transmaxillary approach in order to insure we were able to address the lateral margin of the tumor.

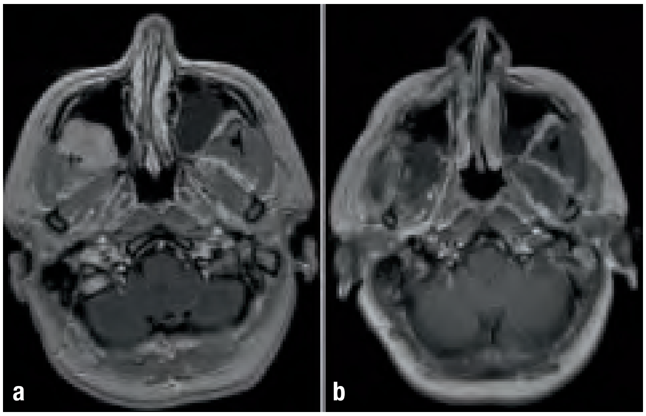

Fig. 4.2 30 year-old female who presented with trismus. Axial T1 gadolinium enhanced MRI demonstrating a retromaxillary mass on the right side (**a**). Postoperative axial T1 gadolinium enhanced images shows excellent resection of the mass (**b**).

4.3. Case 3

18 year-old man with nasal congestion and epistaxis. Imaging revealed a nasal angiofibroma in the nasal cavity, pterygopalatine fossa, and eroding the middle cranial fossa (Radkowski grade 3A) (Fig. 4.3). The patient underwent embolization followed by combined endonasal and sublabial transmaxillary approaches. This case is a good example of using two endoscopic surgical corridors to improve access and is especially useful for large vascular lesions.

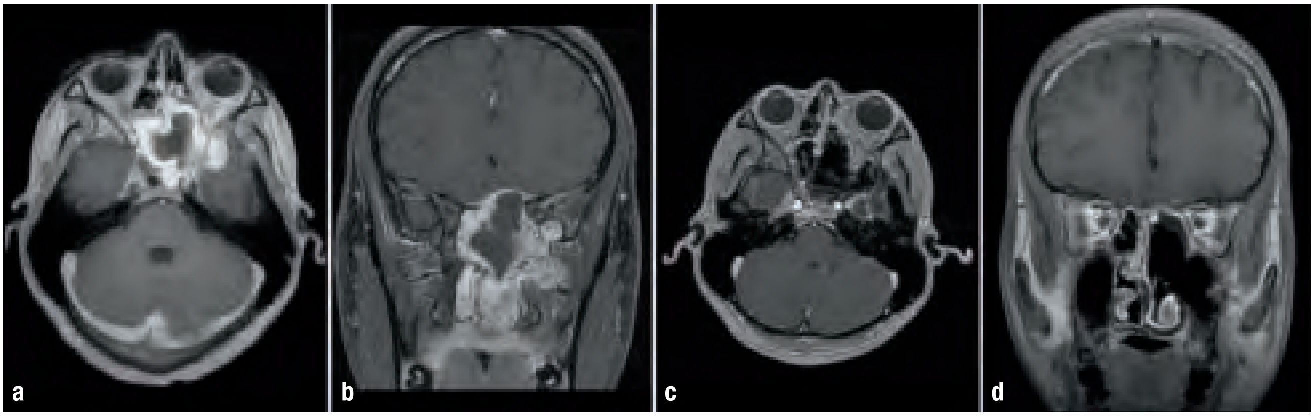

Fig. 4.3 18 year-old man with nasal congestion and epistaxis. Axial T1 gadolinium enhanced (**a**) and coronal T1 gadolinium enhanced (**b**) imaging revealed a nasal angiofibroma in the nasal cavity, pterygopalatine fossa, and eroding the middle cranial fossa (Radkowski grade 3A). The patient underwent embolization followed by combined endonasal and sublabial transmaxillary approaches. Postoperative Axial T1 gadolinium enhanced (**c**) and coronal T1 gadolinium enhanced (**d**) images show excellent resection of this mass. This case is a good example of using two endoscopic surgical corridors to improve access and is especially useful for large vascular lesions.

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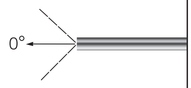
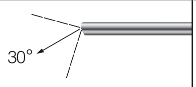
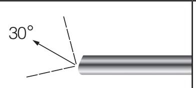
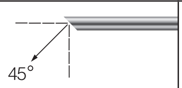
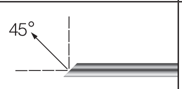
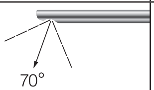
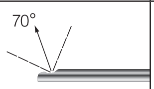
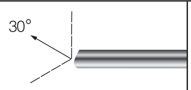
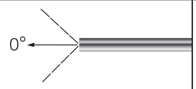
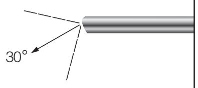
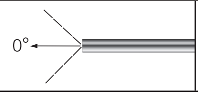
	28132 AA	4 mm	18 cm
	28132 BA		
	28132 BVA		
	28132 FA		
	28132 FVA		
	28132 CA		
	28132 CVA		
	28132 BWA		
	28164 AA		30 cm
	28164 BA		
	28018 AA	2.7 mm	18 cm

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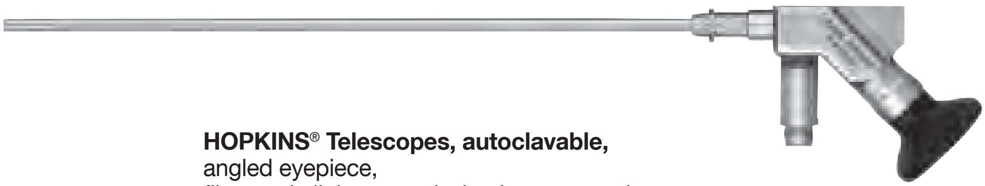

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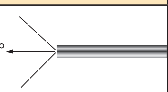
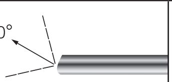
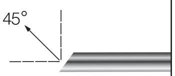
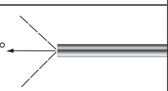
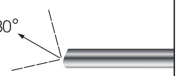
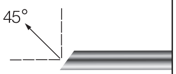
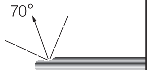
 0°	28162 AVA	4 mm	20 cm
 30°	28162 BVA		
 45°	28162 FVA		
 0°	28162 AKA	2.7 mm	
 30°	28162 BKA		
 45°	28162 FKA		
 70°	28162 CKA		

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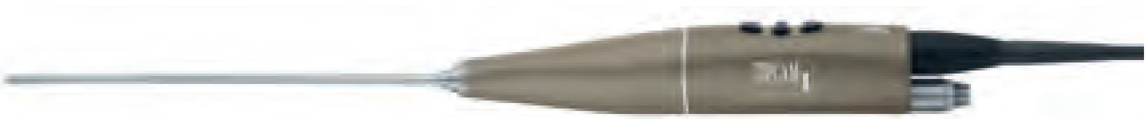

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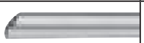	28164 CAF			7229 FA	45°		
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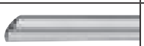
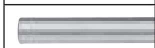
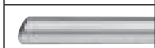
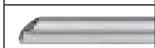
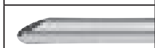
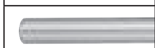
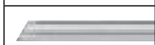
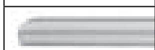
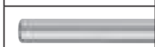
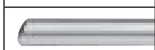
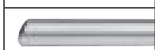
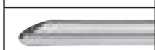
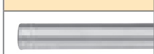
	28164 BSA			28164 BA	30°		
	28164 CBA		14 cm	28132 AA	0°		18 cm
	28164 CBB			28132 BA	30°		
	28164 CBF			28132 FA	45°		
	28164 CBC			28132 CA	70°		
	28162 AVS	5 mm	18 cm	28162 AVA	0°	4 mm	20 cm
	28162 BVS			28162 BVA	30°		
	28162 FVS			28162 FVA	45°		
	28164 CAK	3.8 mm	15 cm	28162 AKA	0°	2.7 mm	
	28164 CBK			28162 BKA	30°		
	28164 CFK			28162 FKA	45°		
	28164 CCK			28162 CKA	70°		

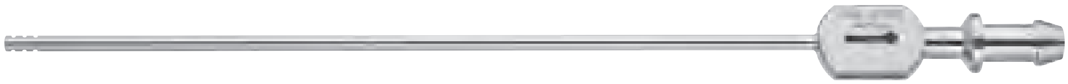
CLEARVISION® II Suction and Irrigation Sheath, for simultaneous intraoperative irrigation and suction of the telescope

Compatible HOPKINS® Telescopes

	Order No.	Outer Diameter	Working Length	Compatible Telescope	Direction of View	Outer Diameter	Length
	7230 AS	4.8 mm x 6 mm	14 cm	28132 AA	0°	4 mm	18 cm
	7230 BS			28132 BA	30°		
	7230 FS			28132 FA	45°		
	7230 CS			28132 CA	70°		

CLEARVISION® II Sheaths for use with CLEARVISION® II Set **40**334101

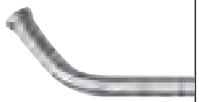
Suction Tubes



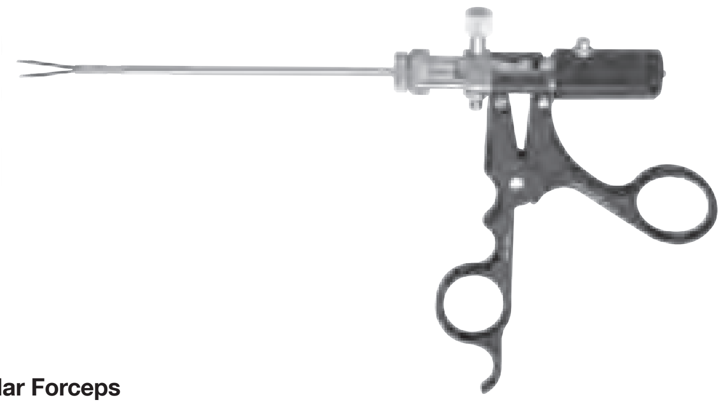
Suction Tube, with grip plate

	Order No.	Description	Diameter	Working Length
	28164 XG	**Suction Tube,** with grip plate, elongated cut-off hole, distal holes, LUER	9 Charr.	15 cm

Suction Tube, short curve, with olive

	Order No.	Description	Diameter	Working Length
	28164 XC	**Suction Tube,** with cut-off hole, drop-shaped, with distance markings, LUER, conical distal end, tip curved upwards, ball end	8 Charr.	15 cm

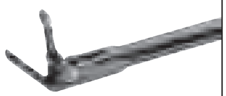
Coagulation



TAKE-APART® Bipolar Forceps

	Order No.	Description	Width of Jaws	Working Length
	28164 BDM	**TAKE-APART® Bipolar Forceps,** with fine jaws, distally angled 45°, horizontal closing, outer diameter 3.4 mm	1 mm	20 cm
	28164 BDD	**TAKE-APART® Bipolar Forceps,** distally angled 45°, horizontal closing, outer diameter 3.4 mm	2 mm	
	28164 BGS	**TAKE-APART® Bipolar Forceps**, with fine jaws, size 3 mm, distally angled 45°	2 mm	10 cm

Bipolar Forceps

	Order No.	Description	Width of Jaws	Working Length
	28164 BGK	**Bipolar Forceps,** jaws curved upwards 45°, for bipolar coagulation in skull base and pituitary surgery	–	18 cm

Monopolar Coagulation Ball Electrode*

	Order No.	Description	Diameter	Working Length
	28164 ED	**Coagulation Ball Electrode,** laterally curved	2 mm	13 cm

* Available Unipolar High Frequency Cords (26002 M, 26004 M, 26005 M, 26006 M) are selected in accordance with the generator used. Please refer to the KARL STORZ product catalog for more detailed information.

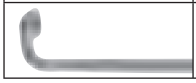
KERRISON **Bone Punches**

KERRISON **Bone Punches**

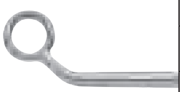
	Order No.	Description	Size	Working Length
	28164 MKA	**Bone Punch,** detachable, rigid, upbiting 60° forward	1 mm	17 cm
	28164 MKB		2 mm	
	28164 MKC		3 mm	
	28164 MKK		4 mm	
	28164 MKL		5 mm	
	28164 MKD	**Bone Punch,** detachable, rigid, downbiting 60° forward	1 mm	
	28164 MKE		2 mm	
	28164 MKF		3 mm	
	28164 MKO		4 mm	

Curettes, Dissectors, Hooks and Knives

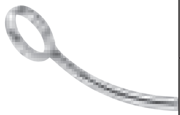
Curettes

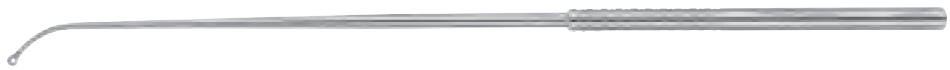
	Order No.	Description	Size	Working Length	Length
	28164 KA	**Curette,** round spoon, with round handle	1 mm	15 cm	25 cm
	28164 KB		2 mm		
	28164 KC		3 mm		
	28164 KF		2 mm		
	28164 KG		3 mm		
	28164 KLA	**Spoon Curette,** straight	1 mm	13 cm	23 cm
	28164 KLB	**Spoon Curette,** angled 45°			
	28164 KLC	**Spoon Curette,** angled 90°			
	28164 KLD	**Spoon Curette,** straight, round handle	0.8 mm		
	28164 KLE	**Spoon Curette,** angled 45°, round handle			
	28164 KLF	**Spoon Curette,** angled 90°, round handle			
	28164 KLG	**Spoon Curette,** straight	2 mm		
	28164 KLH	**Spoon Curette,** angled 45°			
	28164 KLI	**Spoon Curette,** angled 90°			

Ring Curettes

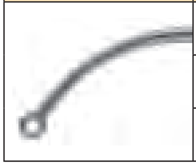
	Order No.	Description	Inner Diameter	Working Length	Length
	28164 RN	**Ring Curette,** with round wire, tip angled 45°, with round handle	3 mm	15 cm	25 cm
	28164 RO		5 mm		
	28164 RP		7 mm		
	28164 RE	**Ring Curette,** with round wire, malleable, tip angled 45°, with round handle	3 mm		
	28164 RJ		5 mm		
	28164 RK		7 mm		
	28164 RI	**Ring Curette,** with round wire, tip angled 90°, with round handle	3 mm		
	28164 RG		5 mm		
	28164 RH		7 mm		
	28164 RB	**Ring Curette,** with round wire, laterally curved sheath end, with round handle	3 mm		
	28164 RA		5 mm		
	28164 RC		7 mm		
	28164 RV	**Ring Curette,** with round wire, laterally curved sheath end 90°, with round handle	3 mm		
	28164 RD		5 mm		
	28164 RW		7 mm		

CAPPABIANCA-de DIVITIIS **Ring Curettes**

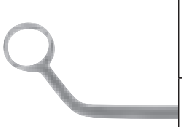
	Order No.	Description	Outer Diameter	Working Length	Length
	28164 RF	**Ring Curette,** with round wire, vertical, with round handle	5 mm	15 cm	25 cm
	28164 RFL		7 mm		
	28164 RM	**Ring Curette,** with round wire, horizontal, with round handle	5 mm		
	28164 RML		7 mm		



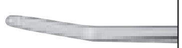
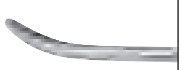
FRANK-PASQUINI **Ring Curettes**

	Order No.	Description	Outer Diameter	Working Length	Length
	28164 FRA	**Ring Curette,** distal end curved, vertical	2.6 mm	15 cm	25 cm
	28164 FRC		5 mm		
	28164 FRE		7 mm		

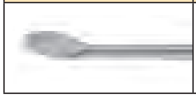
Ring Curettes, bayonet-shaped

	Order No.	Description	Outer Diameter	Working Length	Length
	28164 GGO	**Ring Curette,** bayonet-shaped, round wire, tip angled upwards 90°, with round handle	5 mm	17 cm	25 cm
	28164 GGU	**Ring Curette,** bayonet-shaped, round wire, tip angled downwards 90°, with round handle			
	28164 GKO	**Ring Curette,** bayonet-shaped, blunt, tip angled upwards 45°, with round handle	4 mm		
	28164 GKU	**Ring Curette,** bayonet-shaped, blunt, tip angled downwards 45°, with round handle			
	28164 GLL	**Ring Curette,** bayonet-shaped, blunt, tip angled to left 90°, with round handle	3.3 mm		
	28164 GLR	**Ring Curette,** bayonet-shaped, blunt, tip angled to right 90°, with round handle			

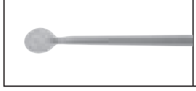
Dissectors

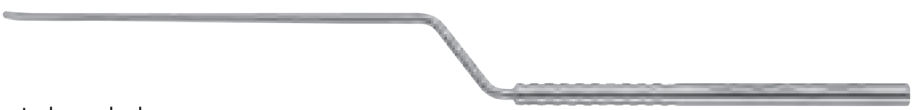
	Order No.	Description	Width	Working Length	Length
	28164 DA	**Dissector,** sharp, tip angled 45°, round spatula, with round handle	2 mm	15 cm	25 cm
	28164 DB		3 mm		
	28164 DF	**Dissector,** sharp, tip angled 15°, flat long spatula, with round handle	1.5 mm		
	28164 DG		2 mm		
	28164 DT	**Dissector,** semi sharp, slightly curved spatula, tip angled 15°, with round handle	1 mm		
	28164 DM	**Dissector,** sharp, slightly curved spatula, straight, with round handle	3 mm	13 cm	23 cm
	28164 DS	**Dissector,** sharp, tip angled 15°, with round handle	2 mm		
	28164 DLA	**Dissector,** tip angled 15°	1 mm		
	28164 DLB	**Dissector,** tip angled 45°			
	28164 DLC	**Dissector,** tip angled 90°			
	28164 DLD	**Dissector,** tip angled 15°	0.5 mm		
	28164 DLE	**Dissector,** tip angled 45°			
	28164 DLF	**Dissector,** tip angled 90°			

Double Elevator

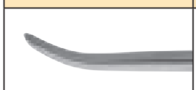
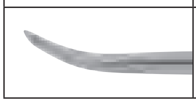
	Order No.	Description	Width	Length
	28164 EA	CASTELNUOVO **Double Elevator,** semisharp and blunt	2.2 mm / 3.0 mm	26 cm

Round Knive

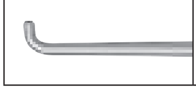
	Order No.	Description	Width	Working Length	Length
	28164 TLD	**Round Knive 0°**	2 mm	15 cm	25 cm



Dissector, bayonet-shaped, sharp

	Order No.	Description	Width	Working Length	Length
	28164 DL	**Dissector,** bayonet-shaped, sharp, curved to left	2 mm	13.5 cm	24 cm
	28164 DR	**Dissector,** bayonet-shaped, sharp, curved to right			

CASTELNUOVO **Hook**

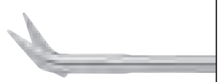
	Order No.	Description	Width	Working Length	Length
	28164 H	**Hook,** 90°, blunt, with round handle	0.6 mm	15 cm	25 cm

de DIVITIIS-CAPPABIANCA **Scalpel**

	Order No.	Description	Working Length	Length
	28164 M	de DIVITIIS-CAPPABIANCA **Scalpel,** with retractable blade	13 cm	23 cm

Scissors

Scissors

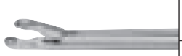
	Order No.	Description	Working Length
	28164 MZB	**Scissors,** straight, with small handle, with cleaning connector	18 cm
	28164 MZC	**Scissors,** curved to right, with small handle, with cleaning connector	
	28164 MZD	**Scissors,** curved to left, with small handle, with cleaning connector	
	28164 MZE	**Scissors,** angled upwards, with small handle, with cleaning connector	
	28164 SAD	**Scissors,** upturned 45°, delicate, sheath 360° rotatable, with cleaning connector	

SEPEHRNIA **Micro Scissors**

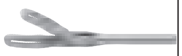
	Order No.	Description	Working Length
	28164 SBA	**Micro Scissors,** bayonet-shaped, sharp/sharp, straight	10 cm
	28164 SBB	**Micro Scissors,** bayonet-shaped, sharp/sharp, curved to left	

Forceps

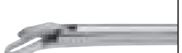
Double Spoon Miniature Forceps

	Order No.	Description	Spoon Diameter	Working Length
	28164 TD	**Forceps,** round cupped jaws, extra delicate, straight	0.6 mm	18 cm
	28164 T	**Forceps,** oval cupped jaws, extra delicate, straight	0.9 mm	
	28164 TA	**Forceps,** oval cupped jaws, extra delicate, upturned		

SEPEHRNIA **Grasping Forceps**

	Order No.	Description	Size	Working Length
	28164 PBC	**Micro Grasping Forceps,** bayonet-shaped, straight jaws, serrated	3 mm	10 cm

Miniature Forceps, through-cutting

	Order No.	Description	Bite	Working Length
	28164 GS	**Miniature Forceps,** straight, through-cutting, with fine flat jaws	1 mm	18 cm
	28164 GR	**Miniature Forceps,** curved to right, through-cutting, with fine flat jaws		
	28164 GL	**Miniature Forceps,** curved to left, through-cutting, with fine flat jaws		

RHINOFORCE® II Nasal Forceps, through-cutting

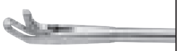
	Order No.	Description	Bite	Working Length
	28164 UA	**RHINOFORCE® II Nasal Forceps,** with extra fine flat jaws, through-cutting, tissue-sparing, straight sheath, straight jaws, with cleaning connector	1.5 mm	18 cm
	28164 UB	**RHINOFORCE® II Nasal Forceps,** with extra fine flat jaws, through-cutting, tissue-sparing, straight sheath, jaws angled upwards 45°, with cleaning connector		
	28164 UE	**RHINOFORCE® II Nasal Forceps,** with extra fine flat jaws, through-cutting, tissue-sparing, straight sheath, jaws angled downwards 45°, with cleaning connector		
	28164 UD	**RHINOFORCE® Nasal Forceps,** with extra fine, flat jaws, through-cutting, tissue-sparing, sheath end curved upwards 25°, jaws angled downwards 45°		

IMAGE1 S

As individual as your requirements

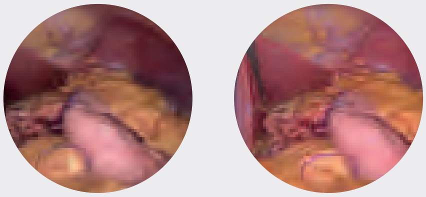
With the IMAGE1 S camera platform, KARL STORZ once again sets a new milestone in endoscopic imaging, consolidating their reputation as an innovative leader in minimally invasive surgery.

The IMAGE1 S camera platform offers surgeons a single system for all applications. As a modular camera platform, IMAGE1 S combines various technologies (e.g., rigid, flexible and 3D endoscopy) in one system and can therefore be adapted to individual customer needs. Furthermore, near infrared (NIR/ICG) for fluorescence imaging, the integration of operating microscopes and the use of VITOM® 3D exoscopes is possible via the camera platform.

Brilliant imaging

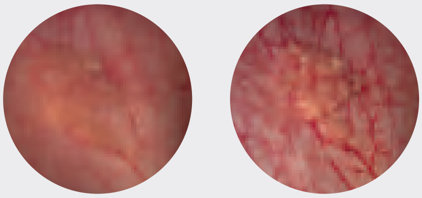
- Versatile visualization options for diagnosis and therapy
- Innovative S-Technologies for easy differentiation of tissue structures
- Clear and razor-sharp imaging
- Natural color rendition
- Automatic light source control

CLARA: Homogeneous illumination



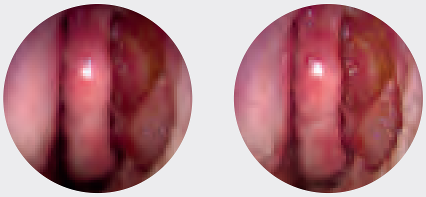
Standard Image CLARA

CHROMA: Contrast enhancement



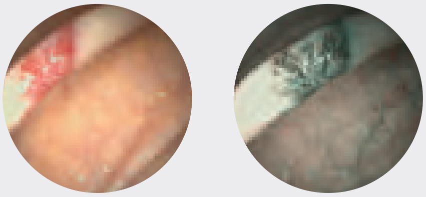
Standard Image CHROMA

CLARA + CHROMA: Homogeneous illumination + contrast enhancement



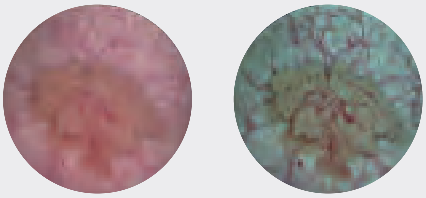
Standard Image CLARA + CHROMA

***SPECTRA A:** Color hue shift and exchange (filtering reds)



Standard Image *SPECTRA A

***SPECTRA B:** Spectral color shift (intensification of greens and blues)

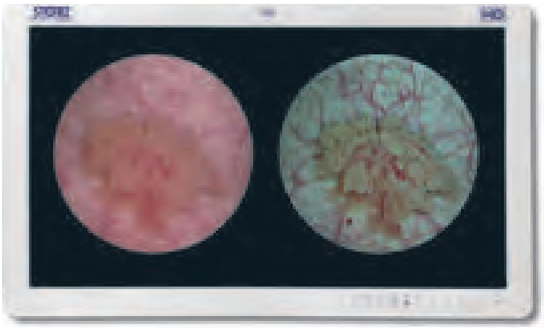


Standard Image *SPECTRA B

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

IMAGE1 S

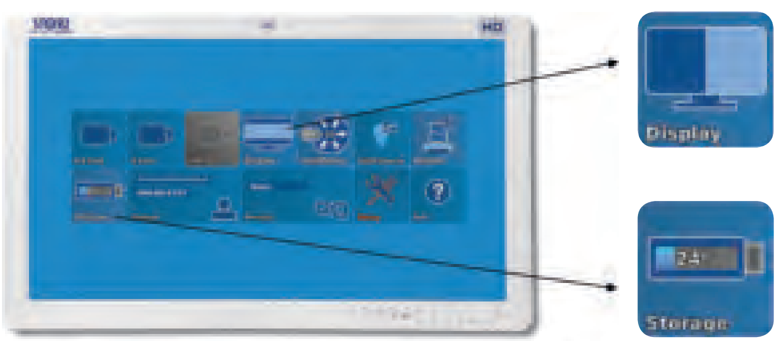
As individual as your requirements



Side-by-side View:
Parallel display of standard image and *SPECTRA B

Innovative Design

- Side-by-side View: Parallel display of standard image and visualization mode possible
- Multiple source management: Simultaneous control, display and documentation of two image sources possible (e.g., hybrid procedures)
- Intuitive user guidance (dashboard, live menu and setup menu)
- Intelligent icons display settings and status
- Individual presets possible
- 50 patient data records can be archived



Status indication icons

Dashboard

Economical and futureproof

- Modular platform: Rigid, flexible and 3D technology can be selected according to individual preferences
- Easy integration of new technologies
- Forward and backward compatibility
- No additional equipment (e.g., special light sources) required for S-Technologies

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

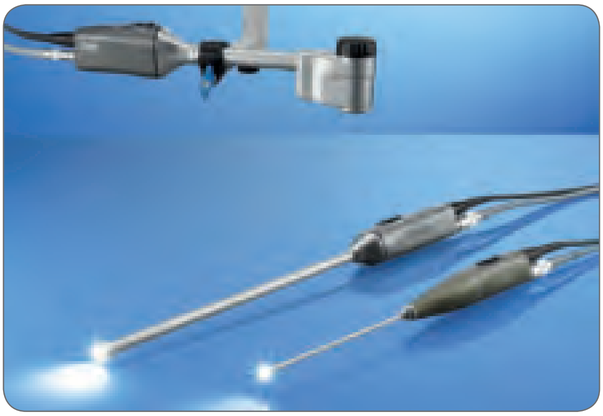
IMAGE1 S

As individual as your requirements

IMAGE1 S

IMAGE1 S 3D

IMAGE1 S 3D is a further component in the IMAGE1 S camera platform. The 3D system provides surgeons with excellent depth perception. Furthermore, the 3D stereoscopic imaging system is particularly valuable for activities that demand a high degree of spatial perception. The 3D camera platform from KARL STORZ impresses with its wide range of applications – from laparoscopy, gynecology, ENT to microsurgical interventions.

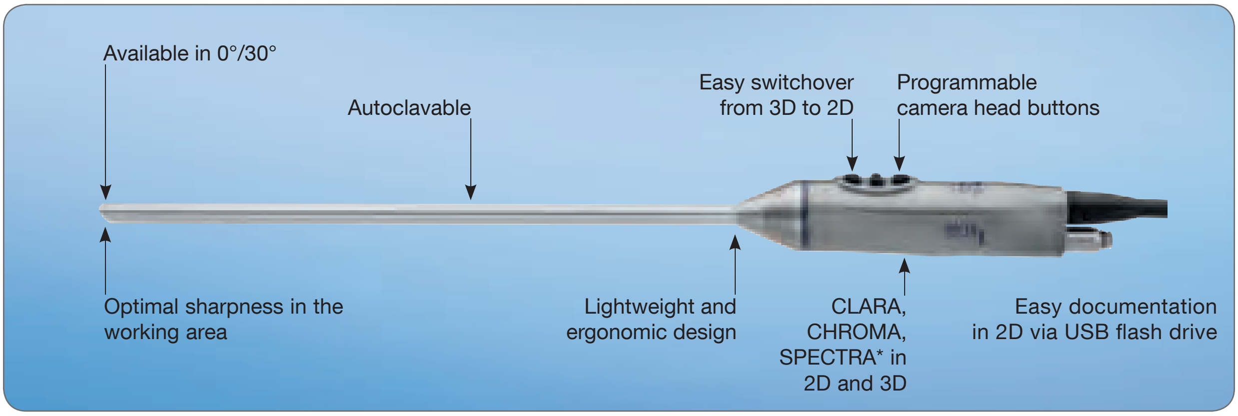


Benefits of IMAGE1 S 3D

- Brilliant and razor-sharp imaging in 2D and 3D
- Switchover from 3D to 2D at the touch of a button
- Easy integration into the IMAGE1 S platform
- CLARA, CHROMA, SPECTRA* in 2D and 3D
- 3D system with video endoscopes with diameters of 10 mm and 4 mm as well as VITOM® 3D

Benefits of 3D integration into the IMAGE1 S camera platform

- Communication between all units
- One system for multiple applications
- Reduced space requirements
- One user interface for all applications
- Synergy effects between the OR workflow and financing



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

IMAGE1 S Camera System

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

For use with IMAGE1 S CONNECT Module TC 200EN

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

TC 302 **IMAGE1 S D3-LINK,** link module, for use with 3D TIPCAM, 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

IMAGE1 S Camera Heads

IMAGE1 S

For use with IMAGE1 S Camera System
IMAGE1 S CONNECT Module TC 200EN, IMAGE1 S H3-LINK Module TC 300
and with all IMAGE 1 HUB™ HD Camera Control Units

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 IMAGE 1 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 **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 IMAGE 1 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