THE SINUS LIFT
Practical Interdisciplinary Guide with a Description of the Berlin Training Model

Steffen G. KÖHLER, Hans BEHRBOHM
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Basic Principles and Diagnostic Workup

1.1 Introduction
Today the sinus floor augmentation provides a safe and dependable treatment option within the field of implantology. It allows dental implants to be placed successfully in patients with significant vertical and horizontal bone loss.

The basic principle of this method has changed little since it was first described by H.O.Tatum (1977)4 and P.J.Boyne (1980).1 The procedure has been simplified by new technologies3 and new augmentation materials.2 It would exceed the scope of this monograph to describe all practical (and impractical) techniques of sinus floor augmentation. We are concerned mainly with the external sinus lift, as the indications for an internal lift are more limited due to the use of short implants.

This publication is based on our experience with over 1000 implantations in the lateral maxilla with sinus floor augmentation. Over time we have developed safe and dependable diagnostic and therapeutic protocols based on close cooperation with the allied specialty of otorhinolaryngology.

The authors wish to emphasize that every decision in maxillary sinus surgery should be preceded by a sound, optimum diagnostic workup and the reasonable consideration of alternative treatment options.

1.2 Diagnostic Workup
Implant-related issues that are noted on initial clinical inspection should first be investigated radiographically. Except for evaluations of individual teeth, the initial implant study of choice is the orthopantomogram (OPG), or dental panoramic radiograph. The OPG allows the clinician to make a preliminary decision that will direct all subsequent preoperative planning. The findings are reviewed in consultation with the patient so that all therapeutic options and risks can be discussed. If the bone volume in the lateral maxilla is significantly reduced and the patient desires a fixed restoration (including both cemented and telescopic bridges, for example), the diagnostic workup should be geared specifically toward the requirements of a sinus lift.

Although the success rates of lateral maxillary implantations with augmentation performed by experienced specialists are comparable to those of „ordinary“ implantations, it should still be noted that implantations with augmentation are associated with greater risks and potential complications.

In the chapters that follow, all the steps for a successful sinus lift are described in a logical sequence according to the motto:

What you should know before operating on the maxillary sinus.
1.2.1 History
A patient with normal sinus anatomy and physiology can be reasonably predicted to have high "sinus compliance," so that even partial injuries of the mucosa will not necessarily have serious sequelae. But if significant sinus pathology is present, it must be detected in advance because of its impact on the prognosis of a sinus floor augmentation.

When the history is taken, special attention should be given to any of the following signs and symptoms:

- Signs of recurrent or chronic rhinosinusitis (facial pain, nasal obstruction, hyposmia)
- Evidence of an allergic rhinopathy
- Non-steroidal anti-inflammatory drugs-exacerbated respiratory disease (NERD): NSAID hypersensitivity / intolerance, bronchial asthma, polyposis
- Hypo- or hypernasal speech
- Olfactory disturbances
- Nasal airway obstruction
- Unexplained pain symptoms

If any of these symptoms are present, the patient should be referred to an ENT specialist.

1.2.2 Diagnostic Imaging – Digital Volume Tomography (DVT)
Experience in three-dimensional diagnostics has confirmed that panoramic radiographs are not sufficient for a complete evaluation of the maxillary sinuses. Based on our experience in more than 3000 DVT examinations, 40% of the patients had maxillary sinus pathology that was not detected by OPG and was clinically asymptomatic. In all planned procedures involving the maxillary sinus, preoperative planning for maxillary sinus surgery should be based on DVT.

The series of images in the illustrative clinical cases (below) clearly show that a three-dimensional study is essential for a planned sinus floor augmentation. It should be reemphasized that a sufficiently large diagnostic window is needed to evaluate the ventilation status of the affected maxillary sinus.

**Figs. 1.3a, b** Determination of residual bone height at the implant site by DVT (a) and a dental film after the sinus lift (Ankylos implants).

**Fig. 1.4** OPG for treatment planning (patient M.A., age 61) shows apparent opacity of both maxillary sinuses.
Fig. 1.5  OPG after placement of three implants (Ankylos) in the second and third quadrants. The patient is asymptomatic and free of clinical complaints.

Fig. 1.6  DVT before implantation planning, first quadrant. The image shows complete opacity of the right maxillary sinus in an asymptomatic patient.

Fig. 1.7  Axial scan through both maxillary sinuses.
Fig. 1.8 Sagittal scan through the right maxillary sinus. Placement of an implant in the right maxilla must be preceded by correction of sinus pathology.

Fig. 1.9 Unchanged basal mucosal swelling in the left maxillary sinus after an internal sinus lift. The patient is clinically asymptomatic and the implant is bearing functional loads.

Fig. 1.10 Patient B. T. (age 46) before implant placement at position 16 (OPG). The maxillary sinuses cannot be evaluated in this radiograph.

Fig. 1.11 Basal opacity of both maxillary sinuses consistent with chronic dentogenic sinusitis.

Fig. 1.12 Dental film after implant placement at position 16 with a sinus lift.
Basic Principles and Diagnostic Workup

Fig. 1.13  OPG (patient B. B., age 57) before planned implantations in the right and left maxillae. The maxillary sinuses cannot be clearly evaluated.

Fig. 1.14  DVT shows clear maxillary sinuses with good ventilation.

Fig. 1.15  Postprocedure OPG after placement of six Camlog® implants and bilateral sinus lifts with Cerabone®.

Fig. 1.16  Postprocedure OPG after implant exposure. All the implants are stable and free of irritation. The maxillary sinuses appear unchanged.
1.3 References


2.1 Introduction

Endoscopes have revolutionized diagnosis and treatment in clinical medicine during the past century. They have allowed for increasingly smaller and less invasive surgical approaches while significantly improving exposure and level of detail.

This particularly applies to the treatment of paranasal sinus diseases.

The history of diagnostic endoscopy of the paranasal sinuses began over 110 years ago in Berlin. In 1901 the Berlin physician A. Hirschmann performed the first maxillary sinus endoscopies with a modified cystoscope. In 1903 he introduced a new diagnostic method in his article “On Endoscopy of the Nose and Paranasal Sinuses.” Hirschmann introduced his 5-mm-diameter cystoscope into the maxillary sinus through the alveolus of a previously extracted tooth. In this way he was able to take the first photographs of chronic maxillary sinusitis. At the time, Hirschmann saw only a diagnostic indication for endoscopy, which he also used to examine the nose, ear, and epipharynx. M. Reichert developed a similar instrument at approximately the same time. In 1902 he reported his experience in three endoscopic examinations of the maxillary sinus in patients with alveolar process fistulas. His 7-mm endoscope, which he called an “antroscope,” provided visual guidance for minor therapeutic procedures such as opening cysts, sinus irrigation, and the cautery of granulations. Wolfgang Draf (1978) reviewed the history of maxillary sinus endoscopy in his book Endoscopy of the Paranasal Sinuses. He cited a 1906 article in which Valentin used the Hirschmann cystoscope in the nasopharynx to observe the opening mechanism of the eustachian tube. He called this procedure “salpingoscopy.” A. Sargnon (1908) appears to have been the first surgeon to enter the maxillary sinus through its lateral wall. He used this approach to remove a foreign body from the maxillary sinus using a small tube.

In response to the technique described by Dennis and Mulin (1922) for opening and exploring the maxillary sinus through the lateral antral wall, W. Spielberg (1922) of the U.S. published an endoscopic alternative. He developed an antroscope which he introduced into the maxillary sinus through the inferior meatus of the nose. He demonstrated the clinical importance of maxillary sinus endoscopy in several publications.

The New York otolaryngologist M. Maltz (1925) designed an optically advanced endoscope based on his experience with maxillary sinus endoscopy, and he had the instrument fabricated at the Georg Wolf Company in Berlin, Germany (Fig. 2.2). He coined the term “sinoscopy” for diagnostic sinonasal endoscopy, which he performed through the inferior meatus as well as the canine fossa.

Publications in the years that followed contain references to the application and modification of maxillary sinus endoscopy in France by Portman (1926), in Spain by Botey (1927), and in England by Watson-Williams, who presented his instruments to the Royal Society of Medicine in London in 1926.

After decades of stagnation in endoscopic technique, the studies by von Riccabona (1955) sparked a renaissance
of maxillary sinus endoscopy in rhinology.\textsuperscript{22} Using a 70°
endoscope (3 mm in diameter) and microinstruments
(KARL STORZ Tuttlingen), he performed 100 endoscopic
examinations of the maxillary sinus. His endoscopic findings
were then checked by subsequent radical operations
on the maxillary sinus. Von Riccabona recognized the
unique value of the method, particularly in the atraumatic
detection and diagnosis of asymptomatic diseases.\textsuperscript{22} But
he also noted significant technical deficiencies including
the poor depth of field of endoscopes fitted with the lens
systems available at the time.

Indeed, a variety of technical shortcomings initially
prevented the widespread acceptance and use of maxillary
sinus endoscopy in clinical practice. W. Draf (1978)\textsuperscript{11}
cited three main reasons for this: poor depth of field with
conventional lens systems, inadequate illumination over
the whole field of view, and the difficulty of taking precision
biopsies under endoscopic guidance.

The London physicist Harold Horace Hopkins (Fig. 2.3)
filed a patent application for the rod-lens system with
telescope attracted immediate attention when presented
at an optical trade fair in Cologne, Germany. The
endoscopist George Berci, originally from Hungary and
now residing in Los Angeles, informed Karl Storz (Fig. 2.4),
an instrument maker in Tuttlingen, Germany, about the
new system and urged him to contact Hopkins. Karl Storz
recognized the potential of this invention and contracted
with Hopkins to produce his new lenses, thus laying the
cornerstone for years of fruitful collaboration. (See pp.
21–22 for more details on the rod-lens system.).\textsuperscript{3,6}

Karl Storz began the serial production of a cold light
source in 1963. This device generated light with a greatly
reduced infrared component that was transmitted to the
endoscope through fiberoptic bundles to illuminate the
interior of a body cavity. A key step in this technology
was the development of fiberoptic light cables that could
transmit light with almost no energy loss, resulting in higher
light intensity at the target site.

The standard technique for maxillary sinus fenestration in
rhinosurgery, as it is the only technique that can improve
mucociliary transport.\textsuperscript{26,27} Nuclear medicine studies in
patients who had undergone previous inferior meatal
antrostomy confirmed its therapeutic efficacy.\textsuperscript{2,5,28}

2.2 The Maxillary Sinus – A Functionally Dependent Cavity

Since the studies by Walter Messerklinger (Fig. 2.5) on the
mucociliary apparatus of the paranasal sinuses (1966,
1967) and the role of the lateral nasal wall in the patho-
genesis of inflammatory sinus diseases, the maxillary sinus
has been viewed as a “functionally dependent” sinus.\textsuperscript{17–19}

This means that the anterior ethmoid cells largely
determine the drainage and ventilation of the maxillary
sinus. Both processes are essential for normal mucosal
function (Fig. 2.6). Messerklinger also showed in his studies
on mucociliary clearance that secretions always drain
from the maxillary sinus through its natural ostium, the
ethmoid infundibulum and semilunar hiatus. As a result
of this discovery, the supraturbinate antrostomy became
the standard technique for maxillary sinus fenestration in
rhinosurgery, as it is the only technique that can improve
mucociliary transport.\textsuperscript{26,27} Nuclear medicine studies in
patients who had undergone previous inferior meatal
antrostomy confirmed its therapeutic efficacy.\textsuperscript{2,5,28}
The middle meatal antrostomy can provide a drainage opening
of variable size. It also provides a viewing window into the
sinus and gives access for intracavitary manipulations such
as the removal of cysts and other pathology. Oblique endo-
scopes with viewing angles of 30°, 45° and 70° can be used
as well as the 0° forward-view scope. Since the publication
by M. Wigand and W. Steiner (1977) on endoscopic surgery
of the maxillary sinus, the endonasal route has become the
standard rhinosurgical approach to the maxillary sinus. Endonasal approaches for the treatment of maxillary sinus disease were described in the “pre-implant” era and were not designed to give optimum exposure of the alveolar recess. *W. Hosemann et al.* (2003) showed that the alveolar and prelacrimal recesses were endoscopic blind spots in the traditional supraturbinate approach to the maxillary sinus (Fig. 2.11). This prompted the authors of this publication to look for an access route that would provide the best optical control of these regions.

### 2.3 Endonasal Approaches to the Maxillary Sinus

In principle, three endonasal approaches to the maxillary sinus are currently available (Figs. 2.7a, b):

- Infundibulotomy with a supraturbinate approach
- Infraturbinate approach
- Prelacrimal approach

---

**Fig. 2.6** Mucociliary apparatus of the paranasal sinuses.

**Fig. 2.7** Structures of the maxillary sinus with the ethmoid infundibulum (a). Infratrochlear nerve (1), orbital floor (2), ostium of nasolacrimal duct (3), nasolacrimal canal (4), uncinate process (5), inferior turbinate (6), middle turbinate (7), nasal septum (8), ethmoid bulla (9), ethmoid infundibulum (10).

**Ethmoidal endonasal approaches to the maxillary sinus, projected onto the lateral nasal wall (b).**

- **Red** Supraturbinate approach
- **Yellow** Infraturbinate approach
- **Light green** Prelacrimal infraturbinate approach
- **Green** Prelacrimal approach
2.3.1 Infundibulotomy with a Supraturbinate Approach

Today the ethmoid infundibulotomy (Fig. 2.8) described by H. Stammberger\textsuperscript{27} has become the standard technique for opening the ethmoid bone.

**Principle:** The maxillary sinus contains respiratory mucosa with goblet cells and seromucous glands. They secrete a two-layer film that is transported by the mucociliary apparatus from the maxillary sinus to the mucosa of the lateral nasal wall. This takes place through a narrow funnel-shaped space at the upper end of the maxillary sinus: the ethmoid infundibulum. The infundibulum is bounded by the following structures: anteriorly by the agger nasi cells, posteriorly by the anterior wall of the ethmoid bulla, laterally by the lamina papyracea of the ethmoid bone, and medially by the uncinate process.

In the infundibulotomy, the medial wall of the ethmoid infundibulum is removed to create a broad opening between the maxillary sinus and nose (Fig. 2.9). This is done as atraumatically as possible, with maximum preservation of the mucosa in the middle meatus. The middle meatus is cranial to the inferior turbinate and lateral to the middle turbinate, which is why the approach is called “supraturbinate.” A supraturbinate window is created with a back-biting forceps or shaver. The interior of the maxillary sinus can be inspected with a 30°, 45° or 70° endoscope, and cysts, polyps, or fungal concretions can be removed. Note, however, that this approach gives poor endoscopic visualization of the alveolar and prelacrimal recesses.\textsuperscript{1,4,27}

![Fig. 2.8](image1.png) *The ethmoid infundibulotomy. Uncinate process (1), sickle knife (2), ethmoid bulla (3), semilunar hiatus (4), nasolacrimal duct (5), middle turbinate (6), nasal septum (7), agger nasi (8).*

![Fig. 2.9](image2.png) *Maxillary sinus empyema viewed through a large supraturbinate window.*

![Fig. 2.10](image3.png) *Endonasal approaches to the maxillary sinus with endoscopic blind spots (shaded).*
2.3.2 Infraturbinate Approach

The infraturbinate approach to the maxillary sinus was standard practice in the age of radical sinus surgery such as the Caldwell-Luc procedure. The main disadvantages are that the infraturbinate window has a strong tendency to become stenosed and that, even if it remains patent, mucociliary transport will still target the natural ostium via the ethmoid infundibulum. If ventilation and drainage of the maxillary sinus are obstructed at that level, chronic inflammatory sinus disease will persist despite the inferior antrostomy.

This approach is indicated for hard-to-reach cysts or antrochoanal polyps in the alveolar recess and would usually include a double antrostomy at both the supra- and infraturbinate levels.11

Fig. 2.11 View into the alveolar recess of the left maxillary sinus through an infraturbinate window.

Figs. 2.12a–d Infraturbinate antrostomy. Mucocele in the alveolar recess one year after implant placement in the right maxilla (a). Fenestration of the mucocele and maxillary sinus (b). View into the alveolar recess with inflammatory mucosal hyperplasia and osseointegrated implant (c, d).
2.3.3 Prelacrimal Approach

This is an elegant approach for performing an extended maxillotomy. Possible indications include papillomas or tumors of the maxillary sinus. The prelacrimal approach begins with a mucosal incision placed at a far anterior site over the dorsum of the inferior turbinate. A mucosal trapdoor flap is raised, and the relatively firm bone in front of the nasolacrimal canal is removed with a bur or osteotome. The nasolacrimal duct can be exposed or medialized. The advantage of this approach is that it allows complete visualization of all maxillary sinus recesses, even when a 0° endoscope is used. When the intracavitary surgical steps are completed, the mucosal flap can be reapproximated and fixed in its original position with a 4-0 Vicryl suture.1,12,23,24

![Image](image1.png)

**Fig. 2.13** Prelacrimal approach to the maxillary sinus.
Detail: A cyst in the alveolar recess is removed through this approach under visual guidance with a 0° endoscope.

![Image](image2.png)

**Figs. 2.14a–c** Left maxillary sinus viewed through a prelacrimal antrostomy with a 0° endoscope (!) one year after papilloma removal from the sinus.
Prelacrimal antrostomy ![image](image3.png) **(a).**
Lateral, medial and posterior walls of the maxillary sinus ![image](image4.png) **(b).**
Alveolar recess ![image](image5.png) **(c).**
2.4 References


Endoscopes are sophisticated optical instruments that provide doctors with fascinating views into hidden anatomic structures and cavities. This chapter offers practical tips and guidelines on the safest and most effective use of endoscopes.

### 3.1 Handling and Maneuvering the Endoscope

The operator can perform diagnostic and surgical endoscopy by viewing directly through the endoscopic eyepiece or by connecting a video camera to the endoscope and viewing the image on a monitor.

Which of these methods is used will naturally affect the handling of the endoscope, due in part to the different weight of the assembly.

When endoscopy is performed without a camera, the scope is held with the thumb and the index and middle fingers of the nondominant hand. The fingers are spaced slightly apart on the endoscope shaft to provide two-point fixation opposite the thumb. Sensory feedback allows for fine adjustments of the scope position and optical axis. Rigid endoscopes require a “paraendoscopic” working technique, i.e., the nondominant hand holds the endoscope while the dominant hand guides the instrument.

The instrument is introduced parallel to the scope, which provides visual control of instrument maneuvers.

The use of a video camera significantly alters the weight distribution and handling of the assembly. To maintain stable control, the operator must now hold the assembly by the camera head because it is heavier than the endoscope. The operator looks at the monitor while working.

With the Hopkins rod-lens system, conventional lenses are replaced by specially ground glass rods with optically processed ends. This offers significant advantages over a conventional lens system because the Hopkins rod-lens system produces images with higher resolution and better contrast fidelity. This results in an extremely clear and bright image in which the finest details are resolved throughout the field of view.
Wide-angle endoscopes have a large visual field that covers more peripheral points than can be seen with the unaided human eye. “Oblique” endoscopes have a viewing angle greater than 0°. They deflect the optical axis and enable surgeons to dissect “around the corner.” The surgeon can change from a survey view to a close-up view by moving the endoscope tip closer to the object of interest. This can be accomplished smoothly and, despite the different boundary conditions, can be done without loss of sharpness.

The farther the endoscope is from the target object, the smaller the risk of soiling the distal objective lens. Endoscopic surgery requires constant adjustments of the endoscope position to fully utilize wide-angle effects for orientation by surgical landmarks and magnification effects for the maximum recognition of details. The Clearvision® system (KARL STORZ Tuttlingen) also has the option of irrigating the distal lens if it becomes soiled by blood or mucus.

Endoscopes require sensitive handling in addition to special care and reprocessing to make them safe for reuse. Prying movements with the scope can bend the delicate shaft, damage or displace the rod lenses, or result in lens fracture. Strict care should be taken, therefore, that endoscopes for maxillary sinus endoscopy are always protected by a trocar.

Figs. 3.3a, b  Optical viewing effects, illustrated in a painting.7,12 The Grosse Gehege Near Dresden by Caspar David Friedrich (1774–1840). With this sweeping vista, the artist has created a “wide-angle view” that encompasses peripheral sites of interest (a). In panel b, our “scope” has been advanced toward the painting. This narrows the field of view but creates a magnification effect that brings out new details.

3.2 Maxillary Sinus Endoscopy via the Canine Fossa

Most issues that are addressed before a sinus lift are aimed at the investigation of mucosal diseases in the alveolar and lacrimal recesses. That is where the sinus membrane must be elevated to create a bony bed for placement of the dental implant.

Diseases of the maxillary sinus mucosa such as cysts, polyps or diffuse mucosal hyperplasia can hamper or jeopardize successful augmentation of the sinus floor while also posing an infection risk to the augmentation material and maxillary bone.3,4,9

Konrad Victor Schneider (1614–1680) described the structure and function of the respiratory mucosa of the nose and paranasal sinuses in his work Librum deca – tarrhis specialissimum. In it, Schneider refuted the theory of Galen that nasal secretions represented drainage from the brain. The maxillary sinus membrane is sometimes called the “Schneiderian membrane” in his honor.

Entering the maxillary sinus through the canine fossa provides the best endoscopic view for addressing maxillary sinus pathology.13–15 Hosemann et al. (2003) showed that the traditional rhinologic approaches to the maxillary sinus through a supraturbinate antrostomy created optical blind spots in the alveolar and prelacrimal recesses.17,18 This discovery redirected attention toward the time-honored but long-forgotten technique of maxillary sinus endoscopy through the canine fossa, now made more feasible by the use of thinner, high-performance HOPKINS® endoscopes.
With the availability of thin trocars, modern rod-lens endoscopes and compatible miniaturized instruments, we are embarking upon a new age of maxillary sinus endoscopy geared toward the correction of sinus pathology prior to augmentation and implant placement. No contact is made with the inferior third of the anterior maxillary sinus wall in the canine fossa approach.\(^1\)

### 3.2.1 Neo-Renaissance of Maxillary Sinus Endoscopy via the Canine Fossa

In this section we describe an endoscopic microsurgical technique that provides an optically safe, atraumatic, and direct route to the alveolar recess while also affording a view behind the sinus membrane. This approach should also prove a useful addition to the diagnostic and surgical repertoire of the implantologist. Simulated procedures on a training model are helpful for learning the technique (see Chapter 8).

**Evaluation of Optical Axes and Viewing Angles in the Maxillary Sinus with Thin Endoscopes in a Skull Preparation**

Tests were carried out in unfixed skull preparations from the Department of Anatomy at Berlin Charité Hospital. Four maxillary sinuses with varying degrees of pneumatization were each examined with a 0° endoscope 2.7 mm in diameter and a 30° endoscope 2.7 mm in diameter (KARL STORZ Tuttlingen). The purpose of the study was to determine whether all recesses of the maxillary sinus could be visualized and accessed with endoscopes introduced through two high punctures in the facial wall of the maxillary sinus. The study showed that all recesses could be accessed with no endoscopic blind spots. In particular, the alveolar and prelacrimal recesses were completely visualized and were fully accessible through the working channel.

**Optical Phenomena**

First the scope is advanced just a few millimeters past the end of the trocar to obtain a maximum peripheral view. This provides a survey view of the maxillary sinus that the endoscopist can thoroughly study and appreciate before proceeding to the closer inspection of specific areas. The farther the endoscope is from the target object, the more peripheral sites can be inspected. This allows for good orientation based on multiple endoscopic landmarks (e.g., the infraorbital canal and the vascular pattern of the mucosa).
Advancing the endoscope provides a more detailed, magnified view with a constant depth of field. The magnification effect allows the surgeon to evaluate fine details before turning to the sinus ostium and alveolar recess. It is helpful to learn endoscopic technique with rigid and flexible endoscopes, “paraendoscopic” dissection, and the technique of working from a video screen by training on a simulator or anatomic specimens under the supervision of a mentor.

Conclusion: Maxillary sinus endoscopy through the canine fossa using 2.7-mm endoscopes can provide complete optical control of the sinus interior. The double-puncture technique with two 3-mm trocars ensures access to all recesses in the maxillary sinus.

If necessary, the canine fossa approach can be combined with endonasal approaches at any time.

3.2.2 Technique of Maxillary Sinus Endoscopy via the Canine Fossa

The procedure can be performed under local anesthesia with the patient in a supine or reclined position.

The index finger is placed on the infraorbital nerve exit point, and the upper lip is raised with the thumb of the same hand. The infraorbital nerve is then infiltrated with a suitable anesthetic solution such as articaine or Xylocitin (lidocaine) 2% with epinephrine (0.001%). The index finger placed on the cheek controls the correct placement of the solution. Then the mucosa of the canine fossa is infiltrated with a small amount of the local anesthetic.1

After waiting several minutes, an assistant elevates the upper lip with two small LANGENBECK retractors. Three key landmarks are identified: The canine tooth bounds the canine fossa medially. The position of the infraorbital nerve is noted superiorly. Inferiorly, care is taken to spare the alveolar process with the dental roots and the region reserved for the sinus lift.

A medial opening is made in the lateral (facial) wall of the maxillary sinus using a 3-mm trocar with sheath. The instrument is inserted through the upper part of the lateral window with a twisting motion, approximately 4 mm below the exit point of the infraorbital nerve. It is unnecessary and undesirable to exert too much pressure on the trocar. After entering the sinus, the trocar is withdrawn and the sheath is advanced approximately 5 mm into the sinus cavity. The interior of the sinus is then examined with the 0° endoscope, proceeding systematically with the successive inspection of each region.

Evaluation of the maxillary sinus ostium is essential. If the ostium is fully patent, the endoscopic procedure itself represents definitive treatment. If the ostium is obstructed, further investigation by DVT or CT is necessary to assess the need for ethmoid surgery to enlarge the ethmoid infundibulum.

The trocar can be rotated somewhat at the perforation site so that even the 0° endoscope can provide an orientation view that covers almost all regions of the maxillary sinus. In a sinus with deep recesses or extensive pneumatization, blind spots can be visualized with a 30° or 45° endoscope. One opening is sufficient for minor endoscopic procedures such as checking the position of augmentation material and the sinus membrane.

The correction of maxillary sinus pathology prior to a sinus lift requires a second trephination to permit a bimanual operating technique. The second trephine opening serves as a working channel and employs a second 3-mm trocar with sheath, which is placed approximately 1 cm lateral to the first opening. This second portal provides access for dissection through the trocar sheath or through the opening itself. Cysts can be “harpooned” under visual control with a small sharp suction tube, aspirated, and then extracted with grasping or cutting instruments.

When endoscopy is completed, both openings are closed with a 3-0 or 4-0 Vicryl suture.
3.3 Endoscopic Anatomy of the Maxillary Sinus

Following trephination of the anterior maxillary sinus wall, the trocar is removed and the 0° endoscope 2.7 mm in diameter (KARL STORZ Tuttlingen) is advanced into the sinus. Spatial orientation within the pyramid-shaped maxillary sinus takes some practice because adjacent walls are not marked by well-defined corners or angles but appear to blend together. Below are some tips and guidelines for following a systematic endoscopic examination routine, illustrated for a right maxillary sinus.\(^1,2\)

![Image](image1)

**Figs. 3.8a–c** Endoscopic views of the right maxillary sinus. The first image (a) shows portions of the medial wall (mw), lateral wall (lw), posterior wall and roof (t). The ostium (om) is located at 1 o’clock. 0° endoscope, diameter 4 mm (KARL STORZ Tuttlingen). The next image (b) gives a view of the sinus ostium. Mucus tracks (→) on the mucosal lining can be seen converging toward the ostium. The ostium should be evaluated in every endoscopy, and if doubt exists, the patency of the infundibulum should be tested by irritation. 0° endoscope, diameter 4 mm (KARL STORZ Tuttlingen). The third view (c) is directed toward the roof of the maxillary sinus. The outline of the infraorbital canal (+) is clearly visible on the sinus roof. 30° endoscope, diameter 4 mm (KARL STORZ Tuttlingen).

![Image](image2)

**Figs. 3.9a–c** Image (a) is a laterally directed view into the zygomatic recess (rz) at 9 o’clock. 30° endoscope, diameter 4 mm (KARL STORZ Tuttlingen). A medially directed view (b) displays the medial wall of the maxillary sinus (mw). It typically appears as a flat prominence projecting into the maxillary sinus. The ostium is visible at 12 o’clock. 30° endoscope, diameter 4 mm (KARL STORZ Tuttlingen). In image (c), the alveolar recess (ra) has been displayed by rotating the endoscope downward. 30° endoscope, diameter 4 mm (KARL STORZ Tuttlingen).

![Image](image3)

**Figs. 3.10a, b** Dental roots protruding into the maxillary sinus form mounds in the alveolar recess.
3.4 Maxillary Sinus Endoscopy – Typical Findings

This section explores the most common, clinically relevant patterns of findings in the maxillary sinus prior to a sinus lift.

3.4.1 Diffuse Mucosal Swelling

Diffuse mucosal hyperplasia usually indicates that the ventilation of the maxillary sinus is impaired. There is variable thickening of the parietal mucosa, and the sinus lumen contains air. Some degree of hyperplasia is even desirable for augmentation of the sinus floor. The question of whether surgery to improve ventilation is indicated before a sinus lift is answered by the ethmoid bone itself. The maxillary sinus contains respiratory mucosa with goblet cells and seromucous glands. They produce secretions that are conveyed through the ethmoid infundibulum to the mucosa on the lateral nasal wall.6 (See p. 16 for infundibulotomy details.)

If pathology is found such as a large ethmoid bulla, orbital ethmoid cells that narrow the infundibulum ("Haller cells"), a long uncinate process, a pneumatized middle turbinate, or a deviated septum compressing the middle turbinate, the pathology should be corrected by endoscopic surgery prior to the sinus lift. The infundibulotomy, functional endoscopic sinus surgery, and septoplasty are all performed today using minimally invasive technique.2,10

Biostatic Surgery of the Ethmoid Bone

Biostatic ethmoid surgery is a very atraumatic technique that distinguishes between load-bearing ethmoid cells and cell walls that merely contribute to compartment formation. Biostatic surgery consists of an infundibulotomy with a supraturbinate antrostomy followed by any necessary correction of maxillary sinus pathology such as cysts, polyps, or fungal concretions. By leaving intact the basal lamella of the middle turbinate and the lamella of the ethmoid bulla, this technique will prevent postoperative atelectasis of the ethmoid bone and median displacement of the middle turbinate.5,8

Interval from Ethmoid/Maxillary Sinus Surgery to Sinus Lift

A frequently asked question is how long to wait after endoscopic surgery before proceeding with a sinus lift. A good rule of thumb is to allow 2 weeks for each 1 mm of mucosal regeneration. In the case of diffuse mucosal hyperplasia 3 mm thick, atraumatic surgery, and an optimum antrostomy window of 4–8 mm, a reasonable interval would be approximately 6 weeks based on our experience. Of course, the overall condition of the mucosa, its individual reparative capacity, a possible allergic disposition, and nicotine abuse will also play a role.

Flexible endoscopes, introduced into the sinus through a supraturbinate antrostomy or other suitable approach, are particularly useful for making a well-informed decision on the earliest possible timing of a sinus lift after maxillary sinus surgery.
3.4.2 Nasal and Sinus Polyps
Nasal polyps have a variable pathogenesis and are usually the “tip of the iceberg.” The most common form of polypoid rhinosinusitis results from eosinophilic inflammation. Nasal polyps almost never form in the nose but in the ethmoid bone and lead to polypoid hyperplasia of the maxillary sinus mucosa by inciting a mucosal reaction and by obstructing the sinus ostium.

Comorbid conditions such as bronchial asthma and analgesic intolerance are frequently present. This subset of patients constitute a high-risk group for sinus lift because the maxillary sinus mucosa is often colonized by problem organisms such as Staphylococcus aureus, Pseudomonas or Escherichia coli strains. The eradication of these organisms is essential. Surgery is just one aspect of the overall treatment plan, which should include the combined use of topical steroids, antihistamines or leukotriene receptor antagonists, as well as antibiotics in the case of bacterial inflammatory exacerbations. Given the immune predisposition of these diseases, hyperplasia of the parietal mucosa may well regress after surgery but will not resolve completely. The colonizing problem organisms should be eradicated by surgical treatment and specific antibiotic therapy.

3.4.3 Foreign Bodies and Empyema
Foreign bodies in the maxillary sinus are a common finding after endodontic treatments. Patients typically present in our office with maxillary complaints about 2 years after endodontic therapy. In most cases mucociliary transport has already moved the root filling material from the alveolar recess to the maxillary sinus ostium. There it incites a foreign-body reaction that obstructs the ostium, resulting in inflammatory hyperplasia of the sinus mucosa. We most commonly see unilateral involvement with radiopaque material within the sinus cavity. The differential diagnosis includes maxillary sinus fungal disease, a tooth erupting into the sinus, a displaced root after tooth extraction, or a windshield glass fragment from a motor vehicle accident.

Fungal diseases are pathognomonic findings. The fungus ball (mycetoma) usually occupies the center of the sinus cavity and has a shell-like appearance.

Evidence of foreign-body-induced sinusitis or a mycetoma is a definite indication for surgery. A distinction is made between invasive and noninvasive mycoses and between viable and nonviable fungi. The material removed from the maxillary sinus should be sent to a pathologist as well as a microbiologist. Invasive mycoses require a conscientious surgical treatment plan similar to that for a malignancy. The need for systemic antimycotic therapy is decided on a case-by-case basis. With noninvasive mycoses, treatment consists of complete removal of the fungus ball and adjacent mucosa.

Mycoses commonly occur in immunocompromised patients. Approximately 40% of new HIV cases present initially in the head and neck region. A fungal infection may be an early finding, and this possibility should always be considered.

“Chronic empyemas” of the maxillary sinus are still fairly common because maxillary sinus irrigation is rarely practiced today. They always constitute a local or focal indication for endoscopic surgery.
3.4.4 Cysts and Polyps

Behrbohm et al. (1991) conducted an experimental study to determine the smallest size at which solitary cysts and polyps in the maxillary sinus should be removed to preserve mucosal function. The authors found that lesions measuring 1.5 cm or larger interfered with mucociliary transport leading to clinical symptoms such as nasal airway obstruction. Smaller cysts and polyps are often an incidental finding. Cysts have a variable histology. They may be retention cysts, pseudocysts, or polyps that have undergone cystic degeneration. Cysts may be thick- or thin-walled, and their removal can present a variety of surgical challenges. Surgeons also have different philosophies when it comes to the treatment of maxillary sinus cysts. Options range from unroofing and marsupialization to complete removal. Mucoceles are by definition epithelial masses that transcend the boundaries of preformed anatomic cavities.

An important requirement of cyst removal before a sinus lift is to leave the sinus membrane intact, for any damage to the membrane would needlessly prolong the interval from sinus surgery to implant placement. If cyst removal is successful in this regard, augmentation can be performed within a few weeks.

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**Fig. 3.15** Fungus ball in the maxillary sinus.

**Figs. 3.16a–f** Removal of an extruded implant in the left maxillary sinus. Diffuse mucosal hyperplasia with a solitary cyst in the alveolar recess. Cysts in the left alveolar recess with an adjacent dental implant (a). The cysts are removed with a cyst forceps (KARL STORZ Tuttlingen) through an endonasal approach (b). At this point the implant is fully exposed (d, e). View into the alveolar recess at the end of the procedure (f).
3.5 References


4 Endoscopic Therapy

After the maxillary sinus was first described by Leonardo da Vinci in 1489 (Fig. 4.1), approximately 200 years passed until the first therapeutic intervention were performed by William Cowper (1666–1709). He was the first surgeon, in 1698, to remove a molar tooth in order to drain an inflamed maxillary sinus. Almost half a century passed until 1743, when Louis Lamorier (1696–1777) drilled through the zygomaticoalveolar crest to create the first non-natural route to the maxillary sinus, though it was not reported until 1768. A considerably easier approach via the canine fossa was first practiced by Pierre-Joseph Desault (1744–1795) (Fig. 4.2) and published by his pupil Marie François Bichat in 1789 (P.-J. Desault 1789).

George William Caldwell (1893) and Henri Luc (1897) independently described a similar maxillary sinus operation. After the sinus was opened through the oral vestibule, the sinus mucosa was radically removed and a drainage opening was created between the sinus and nasal cavity. This operation, called a “radical Caldwell-Luc antrostomy,” was widely implemented. It was not until the second half of the 20th century that the operation was criticized based on the analysis of its long-term results. The radical procedure sometimes caused massive scarring with associated severe neuralgiform and functional complaints (Lindorf 1979). The adverse outcome was sometimes described as a “maxillary sinus cripple.”

Lindorf developed a method in 1974 which avoided the above disadvantages of radical surgery while seeking to preserve the advantages of good exposure and a large access opening. He created a bone window in the anterolateral wall of the maxillary sinus. The saw-cut edges of the lateral window were beveled to allow precise replacement of the bone flap. Besides Lindorf, other authors also developed osteoplastic approaches with the same goal.

4.1 Diagnostic Endoscopy via the Canine Fossa Using One Approach

The procedure is generally performed under local anesthesia. Infiltration of articaine solution (4%) with 1:200,000 epinephrine or comparable agents at the puncture site is generally sufficient for the exploration. The finger is placed on the infraorbital rim, and the trocar is inserted with a twisting motion through the mucosa in the canine fossa, cranial to the fourth premolar, approximately 4 mm below the infraorbital foramen. The trocar should be “aimed” superomedially toward the largest presumed extent of the sinus (Fig. 4.3).

For orientation purposes, the maxillary sinus can be thought of as a pyramid lying on its side with its base on the medial sinus wall. An endoscope introduced through
the canine fossa can be rotated and swiveled to view all portions of the maxillary sinus (Fig. 4.4).

The sinus walls and recesses can be quickly and easily surveyed through this approach. Any pathology can be located and identified with a 0° or 30° HOPKINS® endoscope. While the lesion is fixed with the trocar (Fig. 4.5), a grasper can be introduced through the trocar to perform a blind forceps biopsy (Fig. 4.6). Smears or aspirates can be taken in a similar way. Afterward the sinus is reinspected with the endoscope.

The natural ostium should also be evaluated whenever possible. An ostium obstructed from the medial side should be referred to an ENT specialist for further investigation (CT, DVT) and any necessary treatment.

### 4.2 Endoscopic Treatment via the Canine Fossa Using Two Approaches

The procedure is generally performed under local anesthesia. Some patients will desire oral sedation, and midazolam has proven effective for this purpose owing to its short half-life and anterograde amnesia. Nerve block is produced by injection of articaine solution (4%) with 1:200,000 or 1:100,000 epinephrine at the infraorbital foramen. The first trocar is introduced as described above. With a finger placed on the infraorbital rim, a working trocar can then be introduced 1 cm lateral to the first trocar (Fig. 4.7).

An alternative is to dispense with a working trocar. In this case an approximately 1- to 2-cm mucosal incision is placed so that the tip of the LANGENBECK retractor has just enough room to engage the bone securely without crushing the soft tissues (Fig. 4.8).

The addition of a working canal allows instruments to be manipulated under vision. The use of separate, simultaneous suction makes the exploration considerably easier. A third sterile assistant is not essential but is often helpful.
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easier. The diameter of the trocar opening limits the size and type of pathology that can be removed, however. Solid lesions and larger foreign bodies are the wrong indication.

On the other hand, thin-walled mucosal retention cysts, even when of large volume (Fig. 4.9), can be treated by minimally invasive technique with predictable results. The thin-walled cyst lining can be visualized (Fig. 4.10a) and pierced with the suction tip.

As most of the debris is suctioned from the cyst, its lining will collapse. Then the pathology can be removed with a grasper. It may be somewhat cumbersome to use a working trocar at this stage. Often it is easier to deliver the cyst lining to the bony opening with the grasper (Fig. 4.10b) and fix it there with a larger forceps. The cyst can then be removed in toto with the larger grasper by performing a “delivery and regrasping” maneuver (Fig. 10c). The excised material is sent for histologic examination.

The procedure should conclude with reinspection of the natural ostium (Fig. 4.10d). If it is not clear but obstructed medially, the case should be referred to an ENT specialist for further evaluation (DVT, CT) and treatment.

**Fig. 4.8** Working through the bony opening without a trocar.

**Fig. 4.9** Axial DVT demonstrates a large mass of soft-tissue density in the right maxillary sinus. Residual lumen is noted past the rounded border of the mass. The left maxillary sinus appears normal.

**Figs. 4.10a–d** Rare interior view of a large mucous retention cyst in the maxillary sinus. The cyst was so large (see Fig. 4.9) and closely apposed to the facial sinus wall that the endoscope pierced and entered the cyst when introduced. Reflections from cholesterol crystals are visible in the deep part of the field (a). The cyst lining is exteriorized through the access opening, not through the trocar (b). At right center a small grasper is immobilizing the cyst while a larger forceps (with open jaws) is regrasping it for removal (c). The natural ostium should always be inspected. Here the endoscopist can see far into the nasal cavity through the ostium, which shows no evidence of obstruction. Clearance mechanisms are functioning normally, as shown by blood residues (left) tracking out of the sinus against the force of gravity (d).
4.3 Endoscopically Assisted Osteotomy Approach through the Canine Fossa

This approach can be used only after full eruption of the permanent dentition.

If the procedure is of short duration and no complications are expected, it can be performed under local anesthesia, preferably aided by midazolam sedation. But if it is reasonable to anticipate a longer procedure, difficult anatomy, or an increased bleeding risk, the surgery should be performed under general anesthesia using orotracheal intubation or nasotracheal intubation through the contralateral nostril. General anesthesia will facilitate an endonasal antrostomy, should it prove necessary. Nerve blocks are placed at the infraorbital, incisive and palatine foramina. Infiltration of the vestibular buccal mucosa is also advised.

A marginal or crestal incision is made from the canine region to the second molar, followed by a mesial and (if necessary) distal releasing incision into the vestibule (Fig. 4.11). A mucoperiosteal flap is developed as far as the infraorbital foramen.

Care is taken to preserve the infraorbital foramen. Surgery is aided by marking the area of the proposed bone window on the lateral sinus wall with a skin marker. A four-sided window is generally sufficient, although the approach through a very deep canine fossa can be facilitated by adding an osteotomy line in the upper part of the zygomaticoalveolar crest to create a five-sided bone flap (Fig. 4.12). Lindorf suggested beveling the flap edges. The osteotomy is performed with a thin diamond-coated disc, whose rotary axis is angled toward the center of the bone flap (Fig. 4.13).

The infraorbital nerve should be meticulously preserved. The osteotomy lines are carried into the thicker wall areas, piriform crest, and zygomaticoalveolar crest to allow for secure flap replacement. The bone flap and attached mucosa are mobilized with a slender instrument (scalpel blade or chisel) and placed in a gauze pad soaked in isotonic saline solution (Fig. 4.14).

Fig. 4.11 Incisions: marginal incision from the canine tooth to the second molar with mesial and distal releasing incisions.

Fig. 4.12 Five-sided osteotomy in the sinus wall. Two Langenbeck retractors are positioned anterior and posterior to the infraorbital foramen to prevent any pressure injury at that site.

Fig. 4.13 Placement of the beveled osteotomy lines (broken yellow lines). The rotary axis of the cutting disk (blue) is angled toward the center.

Fig. 4.14 Elevated bone flap with beveled edges.
The bone window is large enough to allow removal of foreign bodies, aspergillomas, a malpositioned tooth, or large polyps (Figs. 4.15–4.17).

If mandatory inspection of the natural ostium (Fig. 4.18) does not confirm good ventilation of the maxillary sinus, the placement of a temporary inferior meatal antrostomy should be considered.

Alternatively, this approach can be combined with an infundibulotomy when dealing with a stable obstruction.
Creating a permanent window to the inferior meatus (Fig. 4.19, different patient) with reflection of the nasal mucosa into the maxillary sinus is no longer favored today because the normal drainage of secretions is directed against gravity. An antrostomy in the inferior meatus may cause secretions to circulate between the natural ostium and inferior opening, as well as unphysiologic sinus ventilation. A polypoid reaction may result.

The bone flap is replaced after treatment. The beveled edges should ensure a snug fit (Fig. 4.20). Tapping the replaced bone flap lightly with the handle of a periosteal elevator or other instrument may help to secure it. With an extremely thin sinus wall or irregular osteotomy cuts, the bone flap may fall back into the sinus. In this case it should be "suspended" with absorbable sutures passed through drill holes in the flap and adjacent bone, as described by Feldmann in 1978. The sutures should provide the best possible support (Fig. 4.21).

4.4 References


Alternatives to the Sinus Lift

Despite the high success rate of implantations in the lateral maxilla, it is good practice to consider other alternatives. Although this pertains mainly to less experienced surgeons, even surgeons experienced in sinus lifts will want to avoid the risks of a larger operation in doubtful cases.\textsuperscript{1,5}

5.1 Alternatives

- Short implants
- Oblique implant placement
- Implant placement in the maxillary tuberosity
- Internal sinus lift

5.1.1 Short Implants

The use of short implants provides a simple and effective alternative. Anatomy permitting, successful rehabilitation can be accomplished with short implants (6–8 mm).\textsuperscript{4}

**Fig. 5.1** Follow-up OPG 18 years after implant placements (Branemark) in the lateral maxilla and mandible. Short implants (WP 6 mm) were used in the maxilla to eliminate the need for bone augmentation. The patient is a severe bruxer, as indicated by well-defined anterior wear facets.

**Fig. 5.2** Ankylos implants (after 7 years’ function). The distal implant is 5.5 mm in diameter and 8 mm long.

**Fig. 5.3** Branemark implants in the right maxilla. Short implants were used in accordance with available bone height. The implants were placed in 1994, and follow-up in 2009 showed no changes.
5.1.2 Oblique Implant Placement
Because only 3D imaging can define the true extent of the maxillary sinus, a narrow alveolar recess sometimes offers implant placement options that are not appreciated on panoramic radiographs.

In such cases it should be determined whether a sinus lift can be avoided by angling the implants in a way that conforms to available bone volume and is consistent with prosthetic requirements. Increasingly, navigated implantology and variable prosthetic designs are enabling a very oblique implant placement that can avoid a sinus lift.2

5.1.3 Implant Placement in the Maxillary Tuberosity
Another option is to use the maxillary tuberosity as an implant bed (Fig. 5.6). Generally this region is clearly definable by OPG and is suitable for implantation, although the bone quality of the maxillary tuberosity is usually in the D4 class.

Fig. 5.4 Transaxial scans clearly demonstrate bone structures not visible in the OPG.

Fig. 5.5 The lateral maxillary implants were placed obliquely to eliminate the need for a sinus lift.
5.1.4 Internal Sinus Lift

As mentioned earlier, the internal sinus lift has become a less important solution. A variety of descriptions have been published for this procedure, and opinions differ regarding the use of synthetic bone substitute. We believe that an internal sinus lift increases the risk of an undetected membrane perforation.3

In our view, augmentation is not strictly necessary for an internal sinus lift. An important prerequisite is preservation of the sinus membrane. Figure 5.9a illustrates a case from 1993 in which an external sinus lift would be performed today.
5.2 References


6 Sinus Lift Techniques

6.1 Procedures and Instruments

Although the basic procedure for a sinus lift has changed little over the years, the approaches and instrument techniques have seen numerous modifications. Besides the tried-and-true use of a diamond-coated round bur or disc, we have also tried various other solutions in our patients. The guiding principle is always to use the least traumatic technique that will preserve the delicate maxillary sinus membrane.

Authors have described bone preparation techniques using the piezotome and erbium-YAG laser. Both methods are technically feasible but, in the authors’ view, do not improve protection of the sinus membrane. They also require considerable experience and a longer operating time. This probably applies to the “balloon technique” as well. Basically all current techniques can be performed under endoscopic control. At our center the endoscope is used chiefly for the correction of maxillary sinus pathology prior to implantation.

Below we will describe the classic sinus lift procedure as well as the technique that we consider to be the safest, fastest, and easiest.
Aside from using the classic sinus lift approach of bone flap elevation, in the author's clinical practice, an even simpler and safer technique has recommended itself as method of first choice. The use of diamond-coated burs (Dentium) in this operative procedure offers the advantage of minimal trauma.

Figs. 6.6 Diagrammatic representation of bone augmentation and implant placement (one-stage procedure) using the bone flap technique.

Fig. 6.7 Special diamond-coated burs from the Dentium set.

Figs. 6.8a–d Diagrammatic representation of the surgical technique (a). Clinical view of one-stage trephination with simultaneous implant placement (b). Appearance after trephination. A depth stop on the trephine bur protects against membrane injury (c). Dissection of the sinus membrane (d).

Figs. 6.9a, b Diagrammatic representation of sinus membrane elevation (a). The bone substitute (here: Bio-Oss®) is prepared for placement (b).
6.2 Augmentation Materials

A variety of materials are currently available for sinus floor augmentation.⁴,⁵,⁹,¹³ They include autologous bone (with associated problems of donor site morbidity), processed (demineralized) human or bovine materials, and synthetic materials (most based on tricalcium phosphates). We prefer bovine material for most cases owing to its availability and high success rates. This material has an interconnecting pore system that is highly receptive to vascular ingrowth. Drilling debris from the area around the surgical site can be added to the bovine material to accelerate osseointegration. The material is mixed with the patient’s own blood and placed without extremely dense packing.

Bone augmentation material placed on the sinus floor becomes vascularized by extraosseous and intraosseous anastomoses from the posterior superior alveolar artery, which in turn is supplied by the maxillary artery.¹⁰

Osteogenesis begins on the bony walls in a process that was first described by Boyne and James (1980)¹ and Misch (1993).⁶,⁷ Conditions must be favorable for capillary ingrowth from the maxillary sinus walls, which should encompass even the more distant, internal portions of the augmentation material.

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Figs. 6.10a–c The bone substitute is introduced into the palatal region with an auxiliary instrument (a). Following placement of the material, the implants are inserted (b). The defect is grafted with Cerabone® after implant placement (c).

Figs. 6.11a, b Diagrammatic representation of the final appearance after implant placement (a). Post-implantation radiograph (b).

Figs. 6.12a–c Freeing the membrane from the window margin (a). The membrane is mobilized all around the window circumference (b). It is then elevated in the palatal direction (c).
The defect provides a source of blood and bone debris (from the drill hole or its surroundings) that, when added to the bone substitute, will loosen its particulate structure and make it more receptive to vascular ingrowth. This can occur only if the material is in a stable position. For this reason, we prefer a one-stage procedure even in patients with very little bone volume because the implant will stabilize the augmentation material while also functioning as a place-holder for an extended period. A one-stage procedure is possible only if good primary stability of the implant (> 5 N) is achieved.

6.3 Clinical Examples

Figs. 6.13a, b Cerabone® in its applicator (a). Easy-graft® in situ (b).

Fig. 6.14 Implants in the left maxilla and mandible have been in place for 4 years. Sinus lift at 26 appears free of irritation.

Figs. 6.15a, b Implant placement in the right maxilla with a sinus lift. Left maxilla: 28 months after implant placement with sinus floor augmentation, both maxillary sinuses appear free of irritation.
The case in Fig. 6.18 involves the planned extraction of tooth 14 with immediate implant placement plus implantation at position 16 with a sinus lift.

**Fig. 6.16** DVT before implant placement in the right maxilla. The radiograph shows a healthy-appearing maxillary sinus.

**Fig. 6.17** Bone height at position 16 is approximately 4 mm.

**Figs. 6.18a,b** Dental radiograph after implant placement at position 14 with sulcus former (a). Radiograph after implant exposure (b).

**Figs. 6.19a–c** Large bone defect at position 15 with greatly reduced bone volume (a). Condition after implant placement with an internal sinus lift and bone augmentation with Easy-graft® (b). Condition after exposure (3 months after implant placement); Ankylos implant (c).
Figs. 6.20a, b  DVT after a failed augmentation at position 26. The maxillary sinus is free of irritation. A bone defect is noted in the area of the old window on the vestibular side. Bone height is approximately 4 mm. The maxillary sinus is well ventilated.

Figs. 6.21a, b  OPG after sinus floor augmentation and implant placement (a). Radiograph at implant exposure (b). The implant is completely free of irritation.

Fig. 6.22  Single missing tooth at position 15 in 3D view.
Figs. 6.23a, b  Healthy maxillary sinus with bone height less than 4 mm at position 15 (a). Condition after simultaneous augmentation and implant placement (b).

Figs. 6.24a–c  Planned implant placement at position 26. Maxillary sinus is well ventilated and free of irritation. Bone height is less than 4 mm with low bone density (a). Dental radiograph after implant placement (b). Radiograph after exposure (c).

Figs. 6.25a–c  Planned augmentation and implant placement at positions 25 and 26 in the left maxilla. The maxillary sinus is free of irritation and well ventilated. Bone height at position 26 is less than 2 mm (a). Radiograph after sinus floor augmentation with Cerabone® and implant placement (Camlog®) (b). Radiograph at implant exposure 4 months later. The implants are stable and free of irritation (c).
Figs. 6.26a, b  DVT for treatment planning. Pronounced osteolysis is noted at positions 26 and 46, with very dense opacity of the left maxillary sinus. The treatment plan is to remove teeth 46 and 26, allow 3 months for healing, and place implants at positions 15, 16, 26, 36, 37, and 46, 47 (a). Massive osteolysis is noted at position 26 with maxillary sinus opacity. Suspected oroantral fistula (b).

Figs. 6.27a, b  OPG after implant placement (Camlog®) at positions 15 and 16 (sinus lift with Cerabone®) and at 36, 37 and 46, 47. Prosthetic restoration was done 4 months later. Region 26 was only augmented with Cerabone®/autologous bone and a Jason membrane (a). An 8-month period was allowed for augmentation healing before an implant was placed at position 26. A membrane fixation pin is still visible. The bone augmentation was stable and free of irritation (b).

Figs. 6.28a, b  OPG for treatment planning. Implant placements are planned for regions 14, 15, 17 and 11 (a). Maxillary sinus in region 17 is well ventilated and completely free of irritation. Residual bone height is approximately 2 mm (b).
Fig. 6.29 OPG after implant placement (Camlog®) and selective sinus lift at position 17.

Fig. 6.30 OPG for treatment planning. The patient desires a fixed restoration. Note extreme expansion of the maxillary sinuses.

Figs. 6.31a, b DVT shows a healthy right maxillary sinus (a) and a healthy left maxillary sinus (b).

Fig. 6.32 The maxillary sinus is well ventilated. Residual bone height is less than 2 mm.
Fig. 6.33  OPG after implant placement (Camlog®) at positions 16 and 26 with a sinus lift; at positions 24, 36, 44, 46, and an immediate placement at position 34.

Fig. 6.34  OPG after implant exposure (3 months after placement).

Figs. 6.35a, b  DVT for planning implant placements in the left maxilla (a). The maxillary sinus is clear and well ventilated. Residual bone volume is extremely small. Implant placement (Camlog®) was planned at positions 14, 25, 26, 27. A one-stage procedure is desired (b).
Figs. 6.36a–i Marking the implant positions and creating the lateral window with a diamond bur. The sinus membrane is extremely thin (a). The membrane is freed all around the window circumference (b). The sinus membrane is elevated in the mesial, palatal and distal directions (c). Deeper dissection is done with a broader elevator (less injury risk than with slender instruments) (d). Due to the extremely thin sinus mucosa, a Jason membrane is inserted. There is very little bone at positions 26, 27. Bone density class is D2 (e). Bone substitute (here: Cerabone®) is applied in the palatal direction (f). Implants are placed at positions 25, 26 and 27. Primary stability at 26 and 27 is > 5 N (g). The defects are repaired with bone substitute (h). The Jason membrane in the maxillary sinus is placed over the augmentation material (i).

Fig. 6.37 Postprocedure OPG after implant placement and bone augmentation.
6.4 References


7 Problems and Treatment Options in the Sinus Lift

7.1 Complications

Despite experience and an atraumatic surgical technique, there is always a chance that difficulties and complications may arise.\textsuperscript{1-4}

7.1.1 Individual Anatomy

Besides occasional difficulties relating to a very distal location or limited mouth opening, variable bone thicknesses and septa may be encountered, especially in the region of the zygomaticoalveolar crest. These atypias can generally be appreciated in three-dimensional views of the jaws and dentition. DVT may also demonstrate vascular channels in the vestibular wall. They are an important indicator of the arterial vessels that are always encountered there. The vessel coursing on the inner wall or within the lateral maxillary bone originates from the posterior superior alveolar artery. Elian et al. (2005) found that the average distance of the artery from the alveolar crest was 16–19 mm. Besides atrophy of the alveolar process, we find that encountering this vessel in the area of the proposed lateral window is a significant risk factor. It may be a source of heavy intraoperative bleeding in response to a lateral osteotomy or membrane tears. If the vessel courses on the inside of the maxillary sinus, hemostasis may be difficult and sometimes requires electrocautery. In this case it is difficult to avoid membrane tears.

7.1.2 Injuries to the Sinus Membrane

If DVT demonstrates a fully healthy maxillary sinus, it may be assumed that the sinus mucosa is highly susceptible to injury. If the mucosa is dissected with faulty technique, it is likely to undergo complete retraction. We do not feel that this condition is reparable. We discontinue the procedure or use the opportunity to harvest an autologous bone graft. The defect is closed with the intact mucoperiosteal flap. The maxillary sinus mucosa is given time to regenerate, and a second procedure should be scheduled at least 12 weeks later.

If a partial tear of the sinus membrane occurs, the defect can be covered with collagen membrane (Geistlich Bio-Gide\textsuperscript{®}, Jason membrane, etc.). The success rates are comparable to those in uncomplicated procedures. It is helpful to fix the membrane to the facial wall of the maxillary sinus with pins.

7.2 Postoperative Complications

Besides intraoperative complications, it is sometimes necessary to deal with immediate, delayed or late postoperative complications. While the majority of complications arise during the first 2 weeks after surgery, there are rare instances of late problems that are directly related to the operation.

The following complications may arise:

- Bleeding and hematoma formation.
- Wound dehiscence with loss of the augmentation material
- Fistula formation
- Infection of the augmentation material
- Acute sinusitis with progression to chronic sinusitis
- Implant loss or displacement
- Abscess formation
- Resorption of the bony framework of the maxillary sinus
**Fig. 7.2** The implant was displaced into the maxillary sinus during exposure. Status post-bilateral sinus lifts. The right sinus lift has been bearing occlusal loads for 2 years.

**Fig. 7.3** Displaced augmentation material.

**Fig. 7.4** Nonvisualization of the lateral wall of the right maxillary sinus. Suspicious for a destructive process.

**Fig. 7.5** Atrophy of the right maxillary sinus after multiple failed augmentation attempts.
The proper use of digital volume tomography (DVT) requires a detailed knowledge of anatomy and interpretation of the whole image, not just the region of interest.

When it comes to sinus floor augmentation (sinus lift), we feel that a three-dimensional study with a large window is essential, if only to disclose situations or conditions that would contraindicate a sinus lift.

### 7.3 Contraindications

Despite the very high success rates, it should be recognized that the maxillary sinus is not just a cavity and that disturbances of sinus physiology may lead to complications. There are cases in which dental surgery in the maxillary sinus region is contraindicated.

The following contraindications would necessitate treatment prior to a sinus lift:

- Acute and chronic rhinosinusitis
- Maxillary sinus cysts, polyps and mycoliths in the alveolar recess
- Fungal diseases of the maxillary sinus
- Papillomas of the maxillary sinus
- Severe posttraumatic and postoperative deformities of the maxillary cavity
- Systemic diseases with immunodeficiency (e.g., AIDS)
- Maxillary sinus malignancies

Once a preexisting disease or condition has been properly treated, it may be possible schedule a sinus lift at a later time. As a rule, decisions on this matter should be made on an interdisciplinary basis.

Significant obstructions of drainage and ventilation should be treated as a prelude to sinus lift surgery. Of course, all dentogenic problems involving the lateral maxilla should also be eliminated.

### 7.4 References

The Berlin Training Model

8.1 Background and Planning Concept

The goal of our task group in Berlin was to design a surgical training model that would be suitable for interdisciplinary use by dentists, implantologists, ENT physicians, and maxillofacial surgeons and would help trainees gain a fundamentally new understanding of specialized procedures on the maxillary sinus.

In cooperation with the PHACON company (Leipzig, Germany), we used the PHACON Sinus System – which is based on 3D data from cranial CT scans – as the starting point for creating a training model that would simulate the topographic anatomy of the maxilla, the mucosa-lined maxillary sinus with all adjacent structures, and the morphology of an atrophic alveolar ridge following tooth loss in the maxillary premolar and molar region. Through the analysis of patient data and constant advances based on surgical experience, it was possible to create a model that realistically simulated all conditions encountered by a dentist or physician working in the maxillary region.

Points of special emphasis in the design process were to reproduce the characteristics of the “bone” and accurately simulate the color and feel of the maxillary sinus mucosa with a layer of silicone rubber.

The “bony” portion of the model is a mineral composite made from a mixture of plaster and composite bonding material. It is fabricated with 3D printer technology. The physical properties of the material have been tailored to produce a realistic bone thickness and strength. The “mucosa” is composed of molded silicone rubber dyed with pigments.

The result is a model that provides an effective alternative to human specimens.

By training on the model, young dentists and aspiring implantologists can deepen their knowledge of the complex topographic anatomy of the pneumatized facial skeleton and gain a fuller understanding of the relationship of the alveolar ridge to the maxillary sinus recesses.

Trainees can playfully cross specialty boundaries and explore the indications and techniques of maxillary sinus endoscopy through various endonasal approaches, while also practicing the use of miniature endoscopes introduced through the canine fossa.

Residents receiving specialty training in otorhinolaryngology can practice techniques of paranasal sinus surgery and experience some of the problems involved in dental implantology.

This kind of work promotes an interdisciplinary understanding of the indications, techniques, complications, and principal questions that arise in modern interdisciplinary dialogue.

The following diagnostic and dissection exercises can be performed on the model:

- Implant placement in the edentulous maxillary alveolar process.
- Performing an internal or external sinus lift on both sides.
- Systematic nasal endoscopy.
- Maxillary sinus endoscopy via the canine fossa and endoscopic control of the sinus lift.
- Bimanual cyst removal through various approaches.
- Dissection on the orbital floor and lamina papyracea, steps in reconstructive surgery (blow-out fracture).
- Studying topographic anatomy by opening a preformed window in the maxillary sinus, even without an endoscope.

The individual training steps can be done consecutively according to a fixed algorithm or in a modified sequence. For practical reasons, we recommend the routine described in the sections below.
8.2 Practical Use of the Training Model

The first step is to inspect the model and recapitulate the topographic anatomy of the facial skeleton based on key landmarks: the maxillary bone with the canine fossa, the infraorbital foramen, the orbit with the lamina papyracea and orbital floor (infraorbital canal), the optic canal, pterygopalatine fossa, pterygoid process, the hard palate with the greater and lesser palatine foramina, the incisive foramen, choana, vomer, nasal septum, the dentulous alveolar process, and the partially edentulous alveolar process and its relation to the maxillary sinus.

Figs. 8.2a–d The Berlin training model viewed from various aspects.
Anterior view (a) facial skeleton, orbit, supraorbital foramen, optic nerve, infraorbital foramen, bony nasal septum, anterior nasal spine, alveolar eminences, and canine fossa.
Right lateral view (b) with atrophic alveolar ridge in region 14–17, zygomatic arch, lamina papyracea, and pterygoid process.
Posterolateral view (c) looking into the retromaxillary fossa, pterygopalatine fossa, maxillary tuberosity, neurocranium, and anterior skull base (internal carotid artery, optic nerve and sella turcica). Retromaxillary region: removable bone flap allows the maxillary sinus to be viewed from the posterior side.
Inferior view (d), maxilla with anterior teeth and atrophic alveolar ridge, hard palate, greater and lesser palatine foramina, posterior nasal spine, incisive foramen, pterygoid process with medial and lateral laminae, pterygoid hamulus, choana and vomer.

8.2.1 Implant Placement in the Edentulous Maxillary Alveolar Process

Today the placement of dental implants has become a routine procedure for many dentists. But variations in individual anatomy and available bone volume constantly pose new challenges, even for experienced surgeons. Every implantation should be thoroughly planned and considered based on the evaluation of clinical findings and radiographs as well as 3D data sets if required.

Figs. 8.3a–d DVT of the Berlin training model.
3D reconstruction (a), coronal view (b) and sagittal view (c).
The Berlin Training Model

Dentists at all levels of experience and physicians in continuing education can use this model to practice and develop their skills in implant placement and anatomic orientation. Implant placement in the model employs the same basic technique as in patients, depending on the type of system used. All established systems can be used and implants can be inserted.

**Figs. 8.3a–d** (continued) DVT of the Berlin training model. Multiple views are displayed with the Galileos Implant Viewer (Sirona Dental Systems GmbH, Bensheim, Germany).

**Figs. 8.4a–d** Implant placement in regions 15, 16 (Camlog® implant system). Axial alignment of the pilot drill and orientation by anatomic landmarks (a). Drilling the pilot hole (b, c). Paralleling posts with depth markings are used to check implant position (d).
8.2.2 Performing an Internal or External Sinus Lift on Both Sides

An analysis of clinical and radiographic findings will often show that residual bone height in the lateral maxilla is insufficient for a primary stable implant placement. Years of atrophy and increasing pneumatization of the alveolar process lead to a steady decline in bone volume. Depending on the residual bone height, the placement of a dental implant and the creation of a suitable implant bed will require vertical augmentation with sinus floor elevation by means of an internal or external sinus lift. Both procedures can be trained realistically on the Berlin model. The manual skills required for trephination of the lateral sinus wall and elevating the maxillary sinus membrane from the sinus floor can be learned and improved, which is of key importance for a successful operation.

Figs. 8.5a–f  External sinus lift with the DASK Drill Stopper Kit. The anterior wall of the maxillary sinus is carefully opened with a dome-shaped diamond bur, and a lateral bone window is created (a, b). The sinus membrane is carefully freed with the elevator (c). Mobilization and elevation of the sinus membrane is continued with the elevator to create sufficient space for the augmentation material (bone substitute) (d, e). Placement of the augmentation material (f).

Fig. 8.6  View into the right nasal cavity, showing structures of the lateral nasal wall: nasal septum, inferior turbinate, middle turbinate, and choana (0° endoscope, diameter 2.7 mm, KARL STORZ Tuttlingen).
8.2.3 Systematic Nasal Endoscopy

Nasal Endoscopy with the 0° Scope

Inferior Meatus
Endoscopy of the nasal cavity begins with a 0° endoscope (diameter 2.7 mm, KARL STORZ Tuttlingen). The endoscope is advanced over the nasal floor toward the choana. We begin on the right side of the “patient,” passing the inferior turbinate medially. Beneath the inferior turbinate is the orifice of the nasolacrimal duct. Endoscopy is continued back to the choana. Behind the choana is the nasopharynx with the pharyngeal openings of the eustachian tubes.2

Middle Meatus
Next the endoscope is retracted and trained on the middle turbinate, which is an important landmark. The olfactory groove can be identified medial to the middle turbinate.

The middle meatus is located above the dorsum of the inferior turbinate. It is bounded medially by the middle turbinate. The endoscope is advanced to the level of the head of the middle turbinate.

Lateral Nasal Wall
With the 0° endoscope positioned anterior to the middle meatus, the following key landmarks can be identified: the anterior wall of the ethmoid bulla, the prominence of the uncinate process, and the agger nasi laterally. The entrance to the semilunar hiatus lies between the anterior wall of the ethmoid bulla and the posterior free edge of the uncinate process. The hiatus is the two-dimensional “gateway” into which the ethmoid infundibulum opens.

The ethmoid infundibulum is a three-dimensional space that runs backward and upward when viewed in the sagittal plane. It is a funnel-shaped tube through which the maxillary sinus communicates with the nose. An infundibulotomy is performed by cutting around the uncinate process to remove the medial wall of the ethmoid infundibulum. This creates a broad communication with the maxillary sinus.3

Nasal Endoscopy with the 30° Scope

Once we have become familiar with endoscope handling and optical effects, we change to the 30° endoscope (diameter 2.7 mm). The viewing angle is directed upward. Because the instrument is a wide-angle scope, the view is directed forward and also “around the corner.” First we insert the endoscope (viewing upward) into the nose and advance it over the nasal floor to the choana, passing beneath the middle turbinate. The sphenoethmoid recess runs upward in front of the anterior wall of the sphenoid sinus. This sinus has its own ostium that opens into the sphenoethmoid recess.

Figs. 8.9a, b View upward from the nasal floor (30° endoscope, diameter 2.7 mm, KARL STORZ Tuttlingen). Right: view into the middle meatus. Left: view into the sphenoethmoid recess (a). View into the sphenoethmoid recess with the sphenoid sinus ostium (30° endoscope, diameter 2.7 mm, KARL STORZ Tuttlingen) (b).
8.2.4 Maxillary Sinus Endoscopy via the Canine Fossa and Endoscopic Control of the Sinus Lift

We perform maxillary sinus endoscopy to monitor the location and volume of the augmentation material placed beneath the sinus membrane. The first step is to identify the canine tooth. The canine fossa is located just lateral to the canine tooth and forms a palpable concavity.

Another landmark is the infraorbital foramen, which marks the exit point of the infraorbital branch of the trigeminal nerve. Trephination of the anterior maxillary sinus wall is performed with a 3-mm trocar and sheath at a relatively high level, approximately 4 mm below the infraorbital foramen. The trocar is “twisted” through the bone with light pressure and constant rotary movements. This step is more accurately described as a drilling maneuver than a perforation. A sudden drop in resistance signals that the trocar has entered the sinus cavity. At that point the trocar is withdrawn and the 0° endoscope (diameter 2.7 mm) is introduced through the sheath.

The interior of the maxillary sinus is viewed to establish orientation.1

Figs. 8.10a–c Endoscopic anatomy of the right maxillary sinus in the training model (0° endoscope, diameter 2.7 mm, KARL STORZ Tuttlingen). Survey view (a) displays portions of the posterior sinus wall (with the outline of the bone flap), the lateral and medial walls, and the upper part of the alveolar recess. Maxillary sinus roof and ostium (b). Alveolar recess (c).

For comparison: Views of the maxillary sinus with the 30° endoscope (diameter 2.7 mm, KARL STORZ Tuttlingen).

Figs. 8.11a–c Endoscopic anatomy of the maxillary sinus in the training model (30° endoscope, diameter 2.7 mm, KARL STORZ Tuttlingen). Posterior sinus wall, roof, and lateral wall (a). Medial wall with ostium, view directed 30° upward (b). Alveolar recess with tooth root, view directed 30° downward (c).
8.2.5 Bimanual Cyst Removal through Various Approaches

**Approach through the Canine Fossa of a Left Maxillary Sinus**

Colored modeling clay is shaped into a ball 7 mm in diameter. The ball is placed in the alveolar recess through the opened window in the posterior wall. Next a second opening is made in the anterior wall of the maxillary sinus with the 3-mm trocar. The simulated cyst is dissected with a micro-grasper using bimanual technique.

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**Figs. 8.12a–c** The lateral sinus wall is opened at a typical site in the canine fossa with the 3-mm trocar and sheath.

**Figs. 8.13a, b** View with the 0° endoscope (diameter 2.7 mm, KARL STORZ Tuttlingen) into the alveolar recess after membrane elevation for a sinus lift (a). Appearance after implant placement with elevation of the mucosa (b).

**Figs. 8.14a–c** Bimanual removal of a maxillary sinus cyst via the canine fossa. Maxillary sinus cyst in the alveolar recess (30° endoscope, diameter 2.7 mm, KARL STORZ Tuttlingen) (a). Bimanual removal of the cyst through the canine fossa (b) (30° endoscope, diameter 2.7 mm, KARL STORZ Tuttlingen). View is directed downward, grasper was introduced through an infraturbinate window. Same exercise as in (b) (30° endoscope, diameter 2.7 mm, KARL STORZ Tuttlingen), downward view. The cyst is removed through a second trephine opening in the canine fossa (c).
Supraturbinate Approach to the Maxillary Sinus
The middle meatus is visualized with the 0° endoscope. The mucosa over the contour of the uncinate process is incised circumferentially to expose the natural ostium of the maxillary sinus, which opens into the lower part of the ethmoid infundibulum. The ostium is enlarged by 1 cm with a back-biting forceps. The supraturbinate window provides access for maxillary sinus endoscopy.

Infraturbinate Approach
The head of the inferior turbinate is identified, and the turbinate is slightly medialized. The 3-mm trocar is advanced to bone contact with the medial wall of the maxillary sinus. The trocar is carefully twisted to perforate the medial wall. The small grasping forceps is introduced, and the cyst is dissected under visual guidance with the 0° or 30° endoscope passed through the canine fossa.

Prelacrimal Approach to the Maxillary Sinus
The head of the inferior turbinate is identified. A vertical incision is made in the mucosa, and a mucosal flap is raised. The bone is burried down to the nasolacrimal canal. The interior of the maxillary sinus is inspected with the 0° endoscope, followed by bimeatal intracavitary dissection. The mucosal flap is replaced.

8.2.6 Studying Topographic Anatomy by Opening a Preformed Window in the Maxillary Sinus, Even Without an Endoscope
The model has a removable plate measuring approximately 2 x 2 cm in the posterior wall of the maxillary sinus. This “bone flap” is held in place only by its silicone coating. It is easily raised to expose the sinus interior, allowing the endoscopist to inspect all recesses and all “surgical steps” that have been completed thus far.
8.3 References


