Walter Messerklinger

Endoscopy of the Nose

388 Figures
with
360 color
illustrations

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Schwarzenberg

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Preface

The task of investigating the normal and pathological functioning of the mucous membrane of the upper respiratory tract was assigned to me by my teacher, Prof. Dr. Dr. h. c. Gustav Hofer, Head of the University Ear, Nose and Throat Clinic in Graz from 1931 to 1959. For the last thirty years certain questions particular to this field of enquiry have deeply engaged my attention. Many of the experimental observations led to the expectation of new diagnostic and therapeutic possibilities. The first requirement, however, was to improve methods of examining the nose, in order that the best possible view into all the nasal passages, together with their orifices and clefts, could be obtained. The work on nasal endoscopy here laid before the reader is the result of my efforts in this direction. I would like to dedicate this book to the memory of the teacher who followed my early investigations with unfailing interest.

While carrying out this work I have received help from many different sources. The Sektion Steiermark der Österreichischen Krebsgesellschaft and its President, Prof. Dr. H. Moser, had constructed the first endoscopes in the expectation of improving the early detection of nasal tumors. The manufacturers of the endoscopes, Karl Storz of Tuttlingen, together with their Austrian representative in Vienna, Carl Reiner, have met every one of my special requirements. During my many investigations I was at all times most ably supported by my surgical nurses, Sisters Paula, Anni, Maria and Berta. Mr. Paul of the Graz Photographic Laboratory put his extensive skills at my disposal in order to obtain faithful color prints from the negatives. Mrs. J. Steel has supplied the English translation. Notwithstanding the many colored illustrations, the Publishers, Urban & Schwarzenberg, accepted the manuscript and provided a splendid and most experienced advisor in the person of Dr. E. Müller. I wish to thank all these people most sincerely for their help and their confidence.

Very special thanks are due to my collaborator of many years' standing, *K. W. Albegger* M. D. Having first of all read through the translation with a professional eye, since I speak no English myself, he undertook many arduous tasks essential to the completion of the book, including revision of the proofs and the compiling of the Index.

For my fellow workers as for myself, nasal endoscopy has for several years now been an indispensable part of diagnosis and treatment. I am certain that it will also prove its worth to others in the field and will eventually become a routine technique.

W. Messerklinger

Contents

Introduction and Historical Survey

From earliest times people have endeavored to find ways of examining the nasal cavity. "The head was tilted backwards a little and the tip of the nose raised. In exceptional cases a glimpse even deeper into the nose might have been vouchsafed, but the examination was not carried any further" *(Spiess)*. *Dionis* described a nasal speculum in 1714, but it was rarely used because of the absence of a suitable method of illumination and fell once more into oblivion. In 1858 *Czermak* was the first to succeed in viewing the nasopharynx by means of a small laryngeal mirror; he called this procedure "rhinoscopy". As an alternative means of examining the nose, he recommended inspection through the nostrils using a *Markusovsky* speculum. Until then, to the best of his knowledge, there had been "no similar general method of approach discovered". In the succeeding years, very different varieties of nasal speculum were developed. One of these merely dilated the nostril by direct contact, while with another the inferior concha was pressed to the side so that the region of the tubal orifice could be examined, as well as the nose.

Since rhinoscopy only allowed surfaces directly facing the eye to be examined, an attempt to view those surfaces turned away from the examiner by using a small mirror was obviously indicated. In the cadaver, *Czermak* succeeded in inserting a small mirror introduced into the nose by way of a speculum and observing a bristle which projected from the nasolacrimal duct. *Wertheim* (1868), using his "conchoscope" (a tube with an angled mirror at the front), attempted to identify the deeper parts of the inside of the nose more precisely. He termed this procedure "middle rhinoscopy" (rhinoscopia media). In 1893, *Rethi* recommended a small mirror, the angle of which could be varied by means of a wire rod, for the same purpose.

However, the discovery of cocaine, with its property of retracting mucous membrane had, according to *Spiess,* rendered all these instruments superfluous.

In order to be able to explore the middle meatus in greater detail, *Killian* in 1896 developed his "middle rhinoscopy" (rhinoscopia media), also termed "deep anterior rhinoscopy" (rhinoscopia anterior profunda). After applying cocaine, he penetrated into the middle meatus by feeling his way with the flat blades of his speculum extended to 5 cm and 7.5 cm and then gradually separating them.

The success of *Nitze's* cystoscopy (1879) naturally suggested that nasal endoscopy too should be attempted with this instrument. In 1901, *Hirschmann* was the first to introduce a cystoscope successfully into the middle meatus on several occasions, especially when there had previously been an operation on the middle concha or the ethmoid bone. However, these attempts apparently progressed no further, for in 1925 *Zarniko* wrote "I get from them more the impression of an interesting exercise than of indispensable methods of examination. I cannot cite a single result achieved by these methods that could not have been more simply achieved in other ways".

Valentin, in 1903, was the first to use a cystoscope for viewing the nasopharynx and inspecting the pharyngotympanic tube via the inferior meatus ("Salpingoscopia"). *Zöllner* improved this procedure to its present level.

Endoscopy of the maxillary antrum, also known as "highmoroscopy" *(Slobodnik)* or „sinuscopy," was first carried out by *Hirschmann,* who in 1901 introduced a cystoscope into the maxillary antrum through an enlarged tooth socket. *Bauer, Christensen, Draf, Grünberg, Herberhold, Hellmich, Illum and Jeppesen, Nehls, Pihrt, von Riccabona, Rosemann, Timm, Wodak,* by continual-

ly improving the endoscope, have brought this method of examination to its present-day perfection.

Zarniko's remark that direct examination of the lateral wall of the nose can only be an interesting exercise is surely incorrect. The lateral nasal wall, with its passages, fissures, and recesses, is certainly the key region in many diseases, and it is often from here that infection spreads to neighboring cavities. There is no substitute for being able to see and manipulate these structures directly. Today *Zarniko*'s utterance can only be interpreted as an admission that at that time no way was known of penetrating into the narrow bony-walled recesses in order to examine them and to perform operations.

Instruments for Nasal Endoscopy

As well as the usual assortment of rhinological instruments such as speculum, spray, nasal probe, angled forceps, and cotton wool carrier (Fig. 1), endoscopes with different viewing angles are required to give the best possible vision into individual passages and cavities. I myself use a *Hopkins* endoscope (Fig. 2) with direct view and deflections of 30°, 70°, and 120°, all 18 cm long and 4 mm wide (Fig. 3). This length is necessary, since the endoscope has to project far enough during examination to allow space for the operation of a probe or sucker parallel to its shaft and guided by it. Endoscopes of 4 mm possess a range of vision which always allows adequate orientation. They are also small enough to enter into the nasal meatus of most patients. For particularly narrow places, however, there is an endoscope which is only 2.8 mm wide, but its range of vision is somewhat less and orientation is therefore sometimes more difficult.

With these endoscopes the nasopharynx also can be examined piecemeal. A good overall view of this region and the posterior part of the nose is obtained by placing a *Berci-Ward*'s modification of a *Hopkins* endoscope (Fig. 4) in the oropharynx. This endoscope has a viewing angle of 90°. In order to facilitate the examination, it is an advantage to pull the soft palate forward; for this purpose the soft palate retractor of *Hopmann* (in *Koopman*'s modification) has proved useful (Fig. 5).

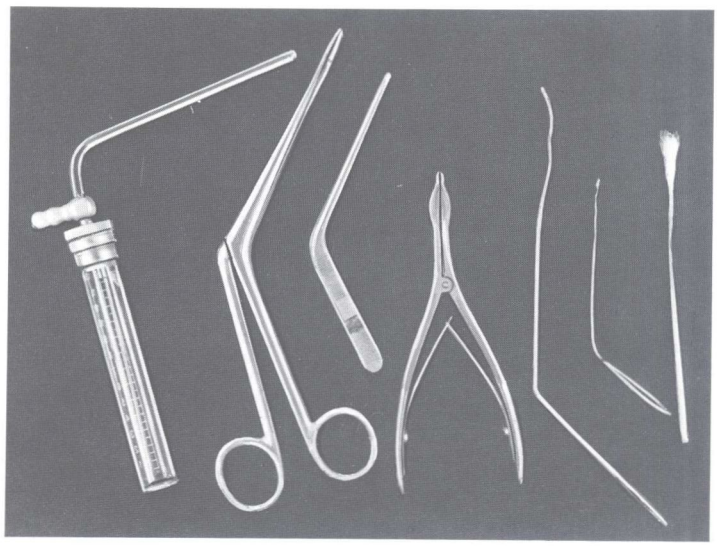

Fig. 1. General instruments for nasal endoscopy: Left to right: spray, *Hartmann*'s nasal swab forceps, angled forceps, nasal speculum, nasal probe, and cotton wool carrier.

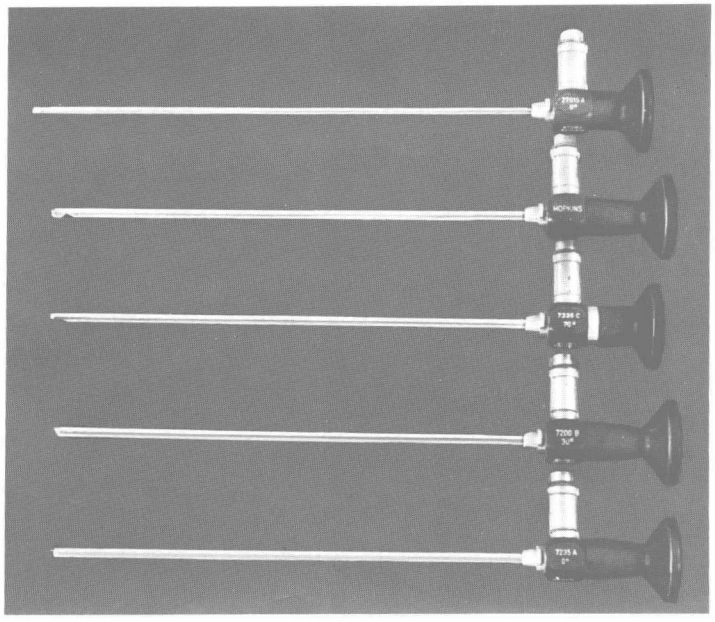

Fig. 2. *Hopkins*' nasal endoscopes. From above downward, 4 mm endoscopes: direct view, deflections of 30°, 70°, and 120° and 2.8 mm endoscope with deflection of 30°.

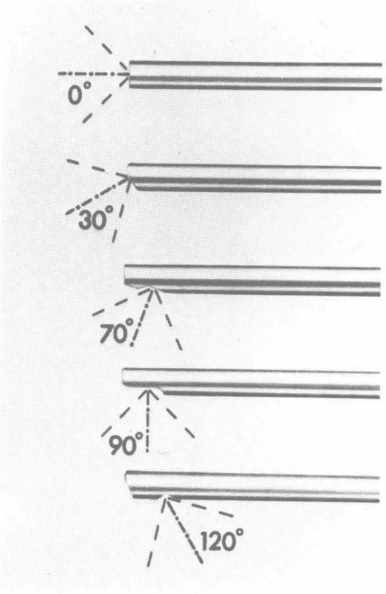

Fig. 3. Visual fields with various viewing angles.

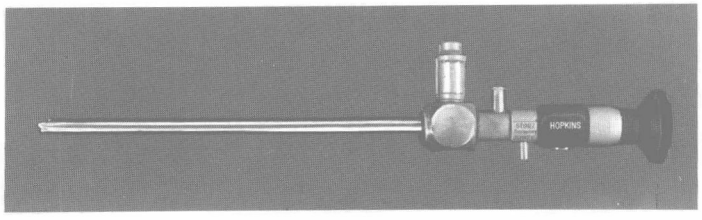

Fig. 4. *Berci-Ward*'s modification of *Hopkins*' endoscope for examining nasopharynx from the mesopharynx. Deflection 90°.

For sucking away secretions, soft polythene catheters are used; their front ends are easily bent by brief heating over a flame. These angled suction tubes may be rotated on their long axes so as to allow the point to be directed to the required position. If it is not possible to clean a small cavity with these, one can use a finer polythene catheter which runs in the adjustable guiding tube along the shaft of the endoscope and is controlled by it (Fig. 6).

For endoscopy of the maxillary antrum, the sinus is punctured with a trocar via the inferior meatus or the canine fossa. The trocar sheath must have an indentation in front in order to push aside bulging tissues for an unhindered view (Fig. 7).

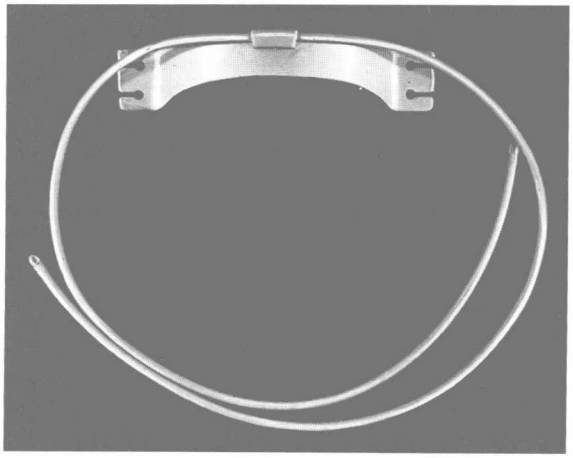

Fig. 5. *Koopman*'s modification of *Hopmann*'s soft palate retractor.

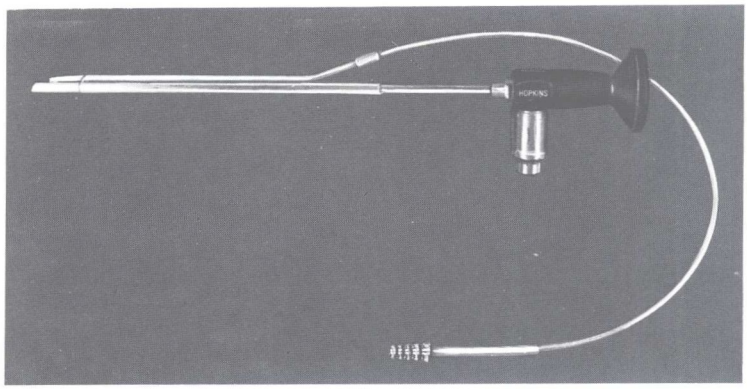

Fig. 6. *Hopkins'* 30° endoscope with small polythene suction tube attached.

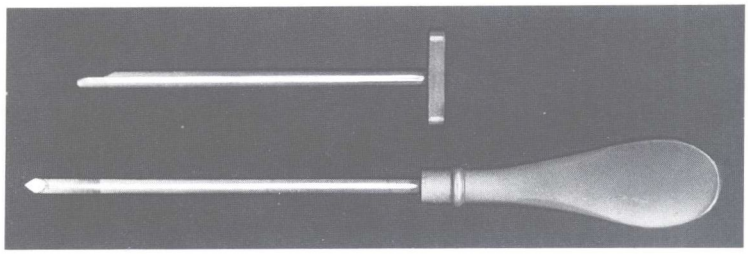

Fig. 7. Trocar for endoscopy of maxillary antrum.

Method of Examination

For nasal endoscopy the patient lies on his back on the operating table with his face turned towards the examiner. The latter sits beside him. The mucosa is anesthetized by spraying twice with a mixture of equal parts of 2% pantocaine and a mild vasoconstrictor. The examination may be commenced one or two minutes later. The 30° endoscope is guided, by means of the view through the instrument, across the floor of the nasal cavity as far as the choana. The endoscope is fixed immediately above the nostril by the thumb and forefinger of the left hand, while the right hand guides and rotates it. The left hand therefore rests upon the patient's face and is used to stabilize and control the head (Fig. 8). After inspection of the nasopharynx and tubal orifice, the endoscope is slowly withdrawn and directed backward into the meatus to be examined or into the spheno-ethmoidal recess. The meatuses are wider posteriorly than in front. At the back it is usually easy to introduce the endoscope tangentially (Fig. 9) and to examine them from behind forward, displacing the concha medially.

Contrary to what might be expected, the examination is generally successful even where there is a fairly marked septal deviation or where the nasal cavity is reduced in width owing to some anatomical variation. When it appears impossible because of narrowing, an attempt is nevertheless recommended; the endoscope, with constant gentle pressure, often slides past an apparently insuperable obstruction. Sometimes secretion from the mucosa at the side can be picked up by the endoscope; it may appear brightly illuminated in front of the objective lens. Since the sleeve of the endoscope projects a short way beyond the objective, withdrawing the instrument a little is usually sufficient to wipe away the secretion and restore the view. With a little practice, hemorrhage during this maneuver is rare.

It is also possible, of course, to examine the nasopharynx via the nose, and by bringing the

Fig. 8. Control of endoscope during nasal examination. The thumb and index finger of the left hand hold the endoscope immediately above the nostril, while the left hand is supported by the patient's face. The right hand guides and rotates the instrument.

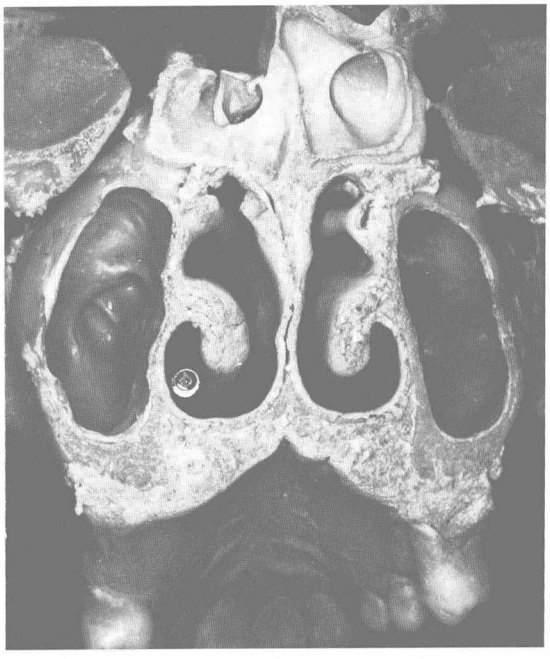

Fig. 9. Endoscope penetrating the left inferior meatus tangentially, as seen from choana.

Fig. 10. Endoscopy of the nasopharynx with *Berci-Ward*'s modification of the instrument. The soft palate is drawn forward by means of the catheters of the soft palate retractor; the endoscope at the same time serves as a tongue depressor.

endoscope closer parts of the wall can also be inspected under increased magnification. In this way, areas of the nasopharynx can be examined individually one after another. An overall view in a single visual field is only obtainable by more remote examination from the oropharynx, e. g., with the *Berci-Ward's* modification of the 90° *Hopkins* endoscope. To achieve this it is convenient to fix the soft palate forward. After the mucous membrane has been anesthetized, the catheters of the soft palate retractor (Fig. 5) are introduced into both nostrils right through into the oropharynx, drawn out through the mouth, and fastened under tension on to the holding-plate over the upper lip. Then the endoscope, which also serves as a tongue depressor, is brought up to a point close in front of the posterior pharyngeal wall. The nasopharynx and, through the choanae, the back of the nose are then examined (Fig. 10).

The maxillary antrum can be endoscoped via the inferior meatus (*Slobodnik; Bauer* and *Wodak; von Riccabona; Timm*) or via the canine fossa (*Link; Hellmich*). After the mucous membrane has been anesthetized, the trocar is introduced into the sinus through the inferior meatus (as in maxillary antrum puncture) or, after infiltration anesthesia, through the canine fossa. During this procedure, it is preferable to bore through the bony wall more by rotation of the trocar than by pressure. This way hemorrhage is less likely. After removal of the trocar, the straight or the 30° endoscope is first pushed through the guide tube in order to obtain information about the condition of the antrum and its contents. Then, if necessary, irrigation or suction alone can be carried out; then individual regions of the antrum are examined with the 30°, 70° and 120° endoscopes.

Endoscopy of the frontal or sphenoidal sinuses through their ostia is only possible in exceptional cases. So far I have twice succeeded, in the presence of pneumosinus dilatans, in passing a 2.8 mm endoscope through the opening of the frontal sinus, and I was once able to examine the sphenoidal sinus through a very large ostium. One can examine the frontal sinus, of course, by means of a burr-hole, in a manner similar to the drilling procedure of *Beck* (*Boenninghaus; Zippel*), or, after an intranasal resection of the anterior wall of the sphenoid *(Draf),* the sinuses there can be examined.

Endoscopy of the Healthy Nose (Normal Anatomy and Its Variations)

With anterior and posterior rhinoscopy only those structures can be seen which lie directly in the line of sight. The use of endoscopes with different viewing angles allows the observation of many details that could not be seen formerly in the living without surgical exposure, to say nothing of the consequent possibility of penetrating or looking into passages and clefts. Our anatomical understanding of areas hitherto rhinoscopically obscure was obtained from the study of sagittal and coronal sections and of macerated skulls. Endoscopic examination through the nostril allows much more to be seen than might have been expected. In addition, the numerous anatomical variations revealed constitute an extremely diverse spectrum, which sometimes makes the boundary between malformation and pathological change difficult to determine. If one is going to take full advantage of nasal endoscopy, it is imperative to study the structures of the healthy nose in their wide variety.

The *inferior meatal wall* is formed above and medially by the inferior turbinate bone; laterally, it consists of the nasal surface of the maxilla in front, to which are attached further back the maxillary process of the turbinate and the perpendicular plate of the palatine bone. The palatine process of the maxilla and the horizontal process of the palatine form the floor. This skeletal framework is covered by respiratory mucous membrane, which varies somewhat according to the region: over the hollow of the concha, it is

thin and sparsely supplied with glands; the adjacent mucosa covering the medial surface and free edge of the bone is rich in glands and contains powerful erectile bodies. The upper surface of the concha is characteristically formed with folds and papillae *(Grünwald)* (Plate 1, Fig. 1).

Sometimes one finds a sagittal groove on the medial surface of the concha, dividing it into upper and lower parts. This is a vestige of a type of concha with doubly convoluted laminae *(Zuckerkandl)* which project from the central conchal plate at a sharp angle upward and downward. Although the inferior concha of man is usually of the single variety, on rare occasions the rudiment of an upper lamella is present (Plate 1, Fig. 2).

The form and extent of the inferior meatus are variable, depending essentially on whether the concha has a well developed (Plate 1, Fig. 3) or virtually absent horizontal portion (Plate 1, Fig. 4) and on whether the origin of the concha in front is low (Plate 1, Fig. 4) or high up the lateral nasal wall (Plate 1, Fig. 3). The inferior meatus rises steeply anteriorly and slopes down again more slowly posteriorly, thus reaching its greatest height very near the front. Since in this anterior region the lateral wall of the nose is usually vertical and the concha is scarcely curved the passage is often narrow here. At about the point where the meatal height is maximal, the lateral wall becomes slightly concave. The concha either arises from the lateral wall of the nose with a more or less clearly defined horizontal portion, or it runs obliquely downward and medially (Plate 1, Fig. 4) with the vertical part bent a little toward the midline. Together the concave lateral surface of the concha and the usually outwardly deflected free margin of the bone form the conchal sinus *(Zuckerkandl)* (Plate 1, Fig. 5). Toward the back of the meatus, the height and projecting curvature of the concha steadily diminish.

The nasolacrimal duct opens into the meatus near where its height is greatest, generally 30 to 40 mm from the nostril *(Schaeffer)*, rarely further backward or forward *(Swerschewsky)*. If the ostium lies in the meatal vault, it is approximately round (Plate 1, Fig. 6); when it lies partially buried in the lateral nasal wall it is oval, (Plate 2, Fig. 7) or even slit-like, and may possibly reach the floor of the nose. The mouth of the duct is usually single, but it can on rare occasions be double (*Geddes; Schaeffer*), triple, or quadruple (Plate 2, Fig. 8). The size is variable, being anything from a mere groove to a canal (Plate 2, Fig. 9). *Onodi* found a maximum size of 10 mm. *Kuribayashi* observed the orifice to open and shut in conjunction with eyelid movement. If the duct and its orifice are wide, it is possible to see inside for a short distance using the angled endoscope; sometimes the opening of a small diverticulum (Plate 1, Fig. 6) or a thin oblique fold (which has been named after *Taillefer* and *Hyrtl*) can be seen.

Flecked deposits (Plate 2, Fig. 9) are occasionally seen in the mucosa of the duct and its orifice; they may correspond to dust particles which have been washed away by tears and laid down in the mucous membrane.

On rare occasions a congenital accessory opening can lead from the maxillary antrum into the inferior meatus (Plate 2, Fig. 10). This opening lies in the center of the meatus with its long axis

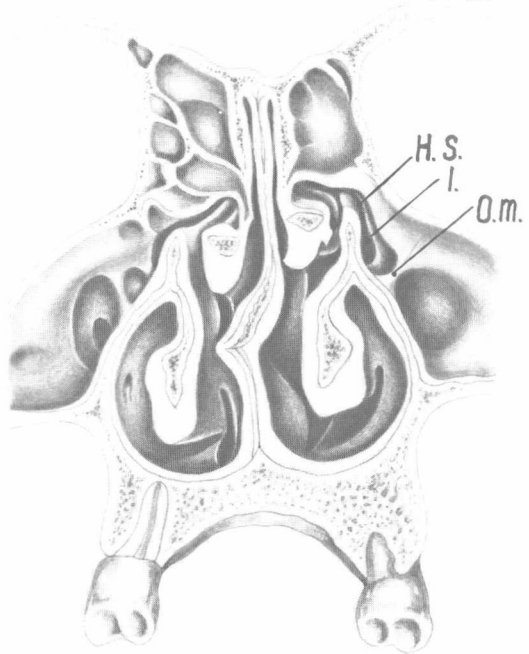

Fig. 11. Frontal section through nose at level of ostium of maxillary sinus, seen from behind. H. s. Hiatus semilunaris; I. Infundibulum; O. m. Ostium maxillare.

running obliquely downward and forward; it may therefore correspond to a fault between the maxillary process of the turbinate bone and the perpendicular plate of the palatine.

The infundibulum can reach from above and laterally almost as far as the vault of the inferior meatus and extend forward very nearly to the orifice of the nasolacrimal duct (Fig. 11). Because of this, diseases of the infundibulum and therefore of the front part of the ethmoid can cause irritation of the inferior meatal roof and the nasolacrimal duct.

In the front part of the nasal floor, close to the septum and only visible through the angled endoscope, can be seen the incisive or nasopalatine canal (Plate 2, Fig. 11). The *middle meatus* is bounded above and medially by the well-defined parts of the middle concha and laterally by the nasal wall with the uncinate process and the ethmoidal bulla. The front part is a multiple-coiled fissure and only becomes broader toward the back (Plate 2. Fig. 12). It receives the anterior group of ethmoidal air cells, the frontal and maxillary sinuses.

The middle concha (first ethmoturbinal) is, throughout its length, somewhat convex medially. Its free margin, especially in the middle and posterior third, is coiled laterally. Because of this there is found, toward the meatus, a conchal sinus *(Zuckerkandl)* which can be subdivided by fine vertical ridges into separate compartments (Plate 3, Fig. 13).

The anterior third of the concha has a slight medial convexity, or is even a flat plate, the origin of which is supported vertically. The anterior and horizontal margins meet at an oblique angle. This anatomical description by *Zuckerkandl,* who examined the region from the medial aspect, does not always correspond to the findings obtained by endoscopy. The endoscopic examination takes place from below and in front, with the anterior end of the concha close to the endoscope and its origin (from the lateral nasal wall) further away. Owing to the perspective and the downward continuation of a button-shaped operculum *(Zuckerkandl),* or lobulus *(Killian),* the concha appears to be lengthened anteriorly. For this reason the front end of the concha is conspicuous as the "conchal head" which arises with a "conchal neck" from the agger nasi (Plate 3, Fig. 14).

The relationship of the middle concha to the agger nasi determines the shape, position, and length of the conchal neck. Often the neck is vertical (Plate 3, Fig. 14); often it is slightly curved medially. Should the agger, owing to extensive pneumatization, bulge out markedly toward the midline, the conchal neck may be largely included in the anterior part of the curve (Plate 3, Fig. 15). In exceptional cases, the medial conchal surface is concave (Plate 3, Fig. 16); one variety of this "false curvature" includes nearly the whole extent of the concha and is always bilateral *(Zuckerkandl).* Another type, also rare, involves the triangular conchal head (Plate 3, Fig. 17). Here a more or less horizontal bony plate forms the free margin; it arises from the lower edge of the conchal head and then gradually spreads backward, merging into the former (Plate 3, Fig. 18). This plate encloses the adjacent parts of the lateral nasal wall, together with the uncinate process and ethmoidal bulla, like a bracket, producing a narrowing of the region. The conchal neck can extend even further in an antero-inferior direction and, like an accessory concha, can envelop a medially inclined uncinate process in the middle meatus (Plate 4, Fig. 19). Both elements may be extensively connected to one another, thereby reducing the opening of the meatus (Plate 4, Fig. 20).

The middle concha can contain one or more air cells, thus becoming a *concha bullosa.* The source of these cavities is quite variable and sometimes very complicated, as Fig. 12 indicates. The more anterior conchal air cell is in continuity with a large posterior ethmoidal air cell and has no connection with the middle meatus. The vertically disposed cells behind open into the middle meatus, or conchal sinus; the upper one opens through two ostia. There opens in front of the anterior ostium a large air cell, one of the posterior ethmoidal group, which extends into the upper part of the middle concha. It follows that conchal air cells can communicate, not only with the conchal sinus of the middle meatus and the recessus frontalis, but even with the cells of the posterior ethmoidal group. One of my own cases had an ostium in the undersurface of the conchal

1 = Inferior concha
2 = Middle concha
3 = Superior concha
4 = Concha suprema
5 = Conchal air cells from posterior ethmoidal group
6 = Conchal cells which open into the middle meatus
7 = Exposed "interlamellar cell"
8 = Sagittal cleft in middle concha
9 = Upper part of the ethmoidal bulla in exposed recessus frontalis
10 = "Sinus lateralis"
11 = Opening of frontal sinus
12 = Air cell of agger nasi

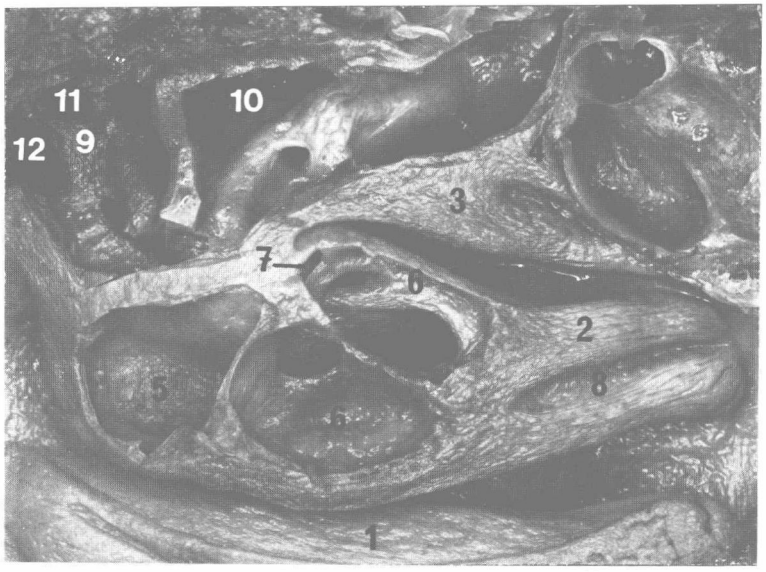

Fig. 12. Right nasal cavity. The middle concha contains four air cells and is divided posteriorly by a sagittal incisura. The most anterior conchal air cell has its origin in the posterior ethmoidal group. The two vertically disposed cavities behind it open into the middle meatus. A small "interlamellar cell" *(Grünwald)* opens above and in front of them. This reaches the medial surface of the middle concha and produces a bulge in the anterior part of the superior meatus.

head (Plate 4, Fig. 21) which would admit the endoscope into the air cell. In the posterior wall of this cell were two more openings which led into the conchal sinus (Plate 4, Fig. 22) through the larger and more medial of these ostia the ethmoidal bulla could be seen projecting a long way into the conchal sinus. Since there was no residual inflammatory process present, the opening in the conchal head could have been due to an unusual degree of pneumatization.

On endoscopy, a concha bullosa is often inconspicuous. Sometimes the conchal head and the free inferior border are somewhat broader and rounder. The condition can even make the lateral conchal surface expand into the front part of the middle meatus or cause the concha to bulge toward the septum; in the latter case, however, the conchal margin is not necessarily substantially broader if the lowest air cell does not reach it (Plate 4, Fig. 23). In a doubtful case a tomogram will settle the question (Fig. 13). Should the cell exceed a certain size, the conchal head is distended as if by a bubble (Plate 4, Fig. 21). In these circumstances the anterior curvature is not necessarily uniform; for example, the lateral wall can be balloon-shaped, the medial wall prominent only in a circumscribed region, with both coming together in front to form a narrow margin (Plate 4, Fig. 23). On rare occasions a structure like a large bony bladder can occupy the greater part of the front of the nasal cavity, obstructing entrance to the rima olfactoria, the recessus frontalis, and even to the ostium of the maxillary sinus.

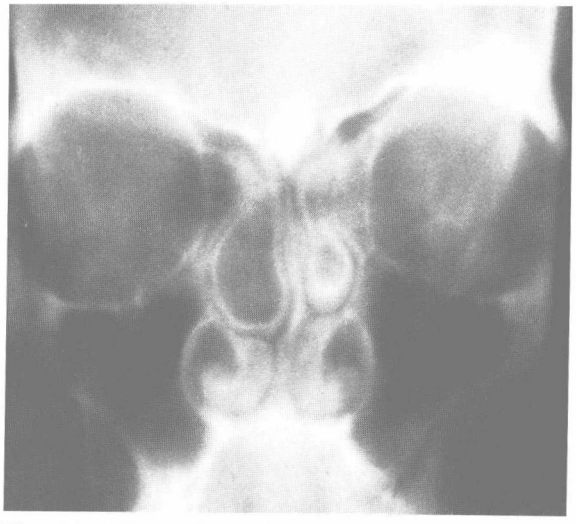

Fig. 13. Bilateral concha bullosa (Tomogram).

Circumscribed bulges of the anteromedial conchal surface can be associated with the following conditions and are therefore to be taken into consideration in making a differential diagnosis: an expansion of the frontal part of the conchal sinus (the "tuberculum ethmoidale anticum" of *Zuckerkandl*) (Plate 4, Fig. 24); an anterior recess of the superior nasal meatus, which can extend deeply downward and forward into the medial wall of the concha (Plate 40, Fig. 236); and a part of the concha separated by a sagittal fissure of the medial conchal surface, which may also correspond to a superior concha (Plate 11, Figs. 62, 63, 64). In all these cases, however, there is no bulging of the lateral conchal surface into the middle meatus.

Congenital clefts and fissures can occur in the middle concha and are found more often during endoscopy than in anatomical preparations. Since quite similar appearances can be caused by disease, it is necessary to be able to differentiate one from the other.

According to their direction, sagittal and frontal clefts can be distinguished. In practice, the *sagittal cleft* always begins behind the conchal head. From there it usually runs directly backward in the medial wall of the concha just above its free border and fades out after a greater or lesser distance (Plate 5, Fig. 25). On rare occasions, it can lie in the free border. Sometimes clefts even reach the end of the concha and divide it like the tail of a swallow (Plate 5, Fig. 26). Other congenital sagittal clefts are convex or concave superiorly and give rise to various differences in the structure. In practice, they also always begin behind the conchal head. The fully developed cleft with an upward convexity separates off laterally a partial concha from the main middle concha; this gives rise to a thin bony lamella appearing in the lateral conchal wall (Plate 5, Fig. 27). In contrast to this, a cleft which is concave upward produces a partial concha arising out of the medial conchal surface and giving an appearance resembling a conchal head of double origin (Plate 5, Fig. 28). In addition, the partial concha can contain a conchal air cell (as in the case shown).

Embryologically, the sagittal clefts are "subsidiary clefts" in the developing ethmoid. *Grünwald* found such clefts in the first ethmoturbinal in 59% of 5-month embryos, but in only 6% of adults. According to my endoscopic observations, however, they occur considerably more frequently.

The *frontal cleft* runs immediately behind the conchal head and across the free margin, which it notches (Plate 5, Fig. 29). The ontogeny of this incisura can only be explained by assuming that a downgrowth from the rudimentary nasoturbinal contributes to the formation of the conchal head. *Richter* and *Spuler* are convinced that the downwardly directed front end of the middle concha contains an element from the nasoturbinal.

Sagittal and frontal clefts may be present together. In these circumstances a sagittal incisura can extend forward and downward over the front of the concha like the trunk of an elephant (Plate 5, Fig. 30).

Of the arrangements resulting from the multiple combinations which can occur, only the case of a concha divided into four sections will be mentioned. In this instance, the head of the concha was separated by a frontal incisura; behind this, the body of the concha was bifid posteriorly, that is to say, divided by an angular indentation into a medial and a lateral partial concha, the latter running backward and upward to end in the middle meatus. In addition to this, a cleft with an upward concavity cut off yet another segment from the medial partial concha (Plate 6, Fig. 31).

The *agger nasi* extends toward the nostril from the front end of the middle concha as a small bulging projection which slowly fades away into the lateral nasal wall. The *uncinate process* sweeps downward and backward as a long thin bony plate, lateral to and hidden by the middle concha. It articulates postero-superiorly with the upper part of the wall of the maxillary antrum through its maxillary process and below with the inferior concha by means of its turbinate process. Posteriorly it either has a free border or articulates with the perpendicular plate of the palatine (Fig. 14). The shape, development, and number of these processes can vary.

The agger nasi and uncinate process are vestiges of an ethmoidal concha, the nasoturbinal. The agger may be homologous with its free (pars

libera) components and the uncinate process with its covered (pars tecta) components *(Zuckerkandl)*. *Peter, Grosser,* and *Richter* discovered a transient conchal swelling in the human fetus which corresponds to the nasoturbinal of other mammals. *Richter,* however, did not consider it to be identifiable with the agger. He once observed in an adult a well developed nasoturbinal, which was remarkable for its characteristic position above the anterior end of the inferior concha, and also for its conchal shape and the smoothness of its mucous membrane covering.

During endoscopy, a structure corresponding to a vestige of the nasoturbinal is sometimes encountered. It runs along the lateral nasal wall from just above the beginning of the inferior concha to the origin of the middle concha and can be curved medially to produce the suggestion of a meatus. If one looks up through this groove, one sees right through to the head of the middle concha (Plate 6, Fig. 32). One also runs across various remnants which, in the least marked cases, show themselves as little more than a swelling of the beginning of the inferior concha and which might be taken for a reduplication of this part.

Because of pneumatization from the recessus frontalis, or even from the infundibulum, the agger nasi can be more strongly arched toward the midline (Plate 3, Fig. 15). A cavity corresponding to the position of the frontal process of the maxilla and confluent with that under the agger can also occur *(Zuckerkandl)*.

The uncinate process forms all or most of the medial wall of the infundibulum, while its border limits the hiatus semilunaris medially. It usually lies in the vertical plane (Plate 2, Fig. 12), but is sometimes inclined medially throughout (Plate 5, Fig. 29); it can, however, be curved medially like a hat-brim and make contact with the lateral surface of the concha (Plate 6, Fig. 33). Sometimes the turbinate process of the uncinate process is more strongly developed and, like a vertical ledge sticking out from the lateral nasal wall, obstructs the middle meatus immediately behind the conchal head (Plate 6, Fig. 34). It can be folded over on itself antero-superiorly and reach as far as the origin of the concha, even articulating with its head and neck (Plate 4, Fig. 20). If

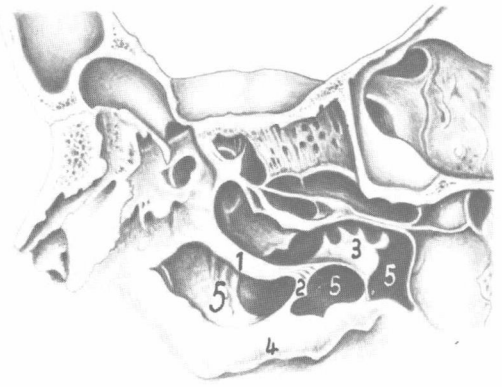

Fig. 14. Skeletal structure of the lateral nasal wall.
1 = Uncinate process
2 = Turbinate process of uncinate process
3 = Maxillary process of uncinate process
4 = Inferior turbinate bone
5 = Nasal fontanelle.

the middle concha arises more deeply and further forward, which it is particularly liable to do in cases of cleft palate, a curved uncinate process can lie in the middle meatus like an accessory concha (Plate 4, Fig. 19). The uncinate process can also on occasion be very thin, in which case the entrance into the middle meatus is wide, and the opening into the recessus frontalis can reach as far as a point just in front of the root of the middle concha. The contour of the uncinate process fades into the lateral nasal wall at the limit of the hiatus semilunaris; rarely, a fine horizontal bony ledge runs as far as the perpendicular plate of the palatine (Plate 6, Fig. 35).

In the medial infundibular wall, in the region below the uncinate process, one or two ostia may be present, connecting the infundibulum with the nasal cavity (Plate 6, Fig. 36). One of these openings can be so large that the infundibulum can be endoscoped; in these circumstances, the ethmoidal bulla and, below and further back, the ostium of the maxillary sinus can be seen (Plate 7, Fig. 37).

Between the projecting parts of the uncinate process and the inferior concha (that is to say, the ethmoidal process of the turbinate bone), and between the hinder end of the uncinate process and the perpendicular plate of the palatine, the bony wall is absent in varying degrees. *Zuckerkandl* has called these places, where the

mucous membranes of the nose and of the maxillary antrum are in direct contact, the "nasal fontanelles". That lying below the uncinate process he has called the inferior fontanelle; the other is the posterior fontanelle (Fig. 14).

The central structure of a fontanelle is formed from a network of fibers continuous with those of the periosteum underlying the mucous membrane of the nasal cavity and antrum. Immediately superficial to this fibrous network, tissue with cavernous spaces and thick unmyelinated nerve fibers is found on both sides.

Whether or not a function should be ascribed to these normally occurring fontanelles (of varying sizes) has not yet been decided. During endoscopy I have seen slight inward and outward movements of healthy fontanelles with forced nasal breathing. It is almost as if they, together with the ostium itself, play a similar part to that of the pressure-regulating section of a *Wilson*'s chamber.

The extent of a fontanelle cannot ordinarily be judged on endoscopy. However, if the membranous framework is thin, it will be translucent and conspicuous by reason of its coloration, which varies from bluish grey to light grey (Plate 7, Fig. 38).

Not infrequently (in 10% of cases, according to *Zuckerkandl*) the fontanelle contains an ostium (Plate 7, Fig. 39) which, in the overwhelming majority of cases, is an accessory entrance to the maxillary antrum. From time to time, however, an ostium is found connecting a deep infundibulum with the nasal cavity (Plate 6, Fig. 36). There is sharp controversy about whether these ostia are naturally present or occur only as a consequence of disease; their greater frequency in the elderly tends to support the latter conclusion. While this question cannot be definitely decided, it should be observed that there are regions of the fontanelles which, although having the appearance of a preformed ostium, are apparently sealed by a thin mucous membrane (Plate 7, Fig. 40).

Like the membranous parts of the lateral nasal wall, the fontanelles react rapidly and completely to slight inflammation of the nose or maxillary antrum. For this reason, their examination should play an important part in diagnostic endoscopy.

Constantly present above the uncinate process is a hollow bony protuberance, the *bulla ethmoidalis,* which is convex toward the middle meatus and covered by the middle concha, and is attached to the orbital plate of the ethmoid along its entire extent. *Zuckerkandl,* who named it, recognized several important variations, among them a small ledge-shaped bulla which does not project but is hidden away in the meatal depths (Plate 7, Fig. 41). Sometimes a bulla, without passing substantially beyond the margin of the hiatus semilunaris in a medial direction, extends so far downward that it almost touches the free border of the uncinate process (Plate 2, Fig. 12). A not uncommon variety of this can be so large that it expands across the middle meatus to reach into the conchal sinus (Plate 4, Fig. 22 and Plate 7, Fig. 42). In extreme cases, it can become so big that it appears through a deficiency in the vertical portion of the concha, as through a window, to reach almost to the nasal septum (Plate 8, Fig. 43). A bulla can also arise like a mushroom from the lateral wall and project downward below the uncinate process (Plate 7, Fig. 42), or reach down as far as the conchal margin to become visible between the concha and an uncinate process which is folded back on itself (Plate 8, Fig. 44). A further variety of bulla can project forward out of the middle meatus (Plate 20, Fig. 118) and even conceal most of the conchal head.

According to *Zuckerkandl,* the opening into the ethmoidal bulla is usually posterior. In my own cases, it was often situated superiorly, sometimes antero-superiorly (Plate 8, Fig. 45). On rare occasions it lies in the medial wall of the bulla and reveals, by means of septa immediately lateral to the orifice, that several cavities have here a common opening.

The bulla ethmoidalis and uncinate process define the *hiatus semilunaris (inferior) (Grünwald)* (Fig. 17). This forms the outlet for an antero-inferiorly directed recess of the lateral nasal wall, the infundibulum (Fig. 18 and Plate 7, Fig. 41). Normally the hiatus semilunaris extends from the postero-inferior border of the curved bulla and arches upward and forward around it. It can reach as far as the level of the cranial base. On occasion the bulla and the uncinate process may