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History of Rhinology: Anatomy of the paranasal sinuses

H. Stammberger

University E.N.T. Hospital, Graz, Austria

SUMMARY

The knowledge of the presence of the paranasal sinuses dates back to early mankind as well as attempts to treat their diseases. Apart from the sensory function of smell, however, little has been known about the function and especially the anatomy of the system till the end of the last century. Until the late middle ages sometimes obscure functions were attributed to the sinuses, like holding the "grease" for the movement of the eyeballs, or allowing the brain to "drain its bad spirits" to the outer world, bringing about names like "la cloaca del cerebro" by Sansovino in the 16th century. The old French expression of "rhume de cerveau" demonstrates these ideas having passed on into modern man's vocabulary. During the 17th and 18th century discussion was mainly about the function or purpose of the sinuses, and the rare anatomical studies were meant to support or prove one or the other "philosophies" (Figure 1).

Today's knowledge of the anatomy to a great deal goes back to the basic work of Emil Zuckerkandl of Austria, who starting from the 1870s described in subtile studies the anatomical and development details of the nose and the sinuses, opening an entire new field for scientific and surgical approach to the area. The decades around the turn of the century boost with studies on sectional and surgical anatomy, creating the speciality of rhinology and leading into our modern concepts of diagnosis and therapy of nasal and paranasal sinus diseases. Names like Grünwald, Onodi, Hajek and many others are closely linked with this creative period.

Radiology, especially the development of conventional and computed tomography during the last two decades helped to "rediscover" the fascinating details and complex connections of the paranasal sinus system. Together with the development of the operating microscope and the endoscope this helped to open new ways for functional approaches and less radical microsurgery.

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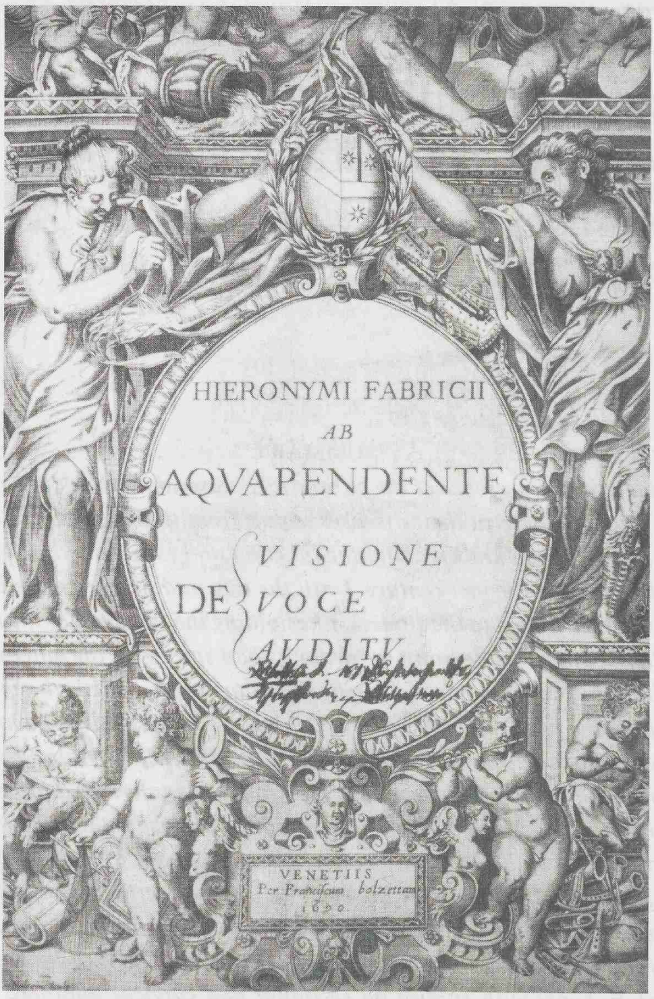


Figure 1. Original title page of H. Fabricius' book: "De visione, voce, auditu", published in Venice in 1600 and already contained some excellent drawings of the orbit and its contents. The sinuses, however, are very much neglected.

The knowledge of the existence of the paranasal sinuses (PNS) dates back to the earliest days of mankind. Prone to injury and trauma – as well as disease – they attracted the attention of those affected by a lesion and of those trying to apply some kind of treatment.

Detailed knowledge of the anatomy of the inner nose and its sinuses, however, took some millennia to occur, till the end of the 19th century, to be exact.

One of the earliest documented anatomy-related statements is found in the papyrus of Ebers and other Egyptian tomb inscripts, which date back to the

period of well before 1500 B.C. Here, we can read that when the brain was removed from a dead pharao's head for mummification purposes, this was achieved through the nose without a lesion to the face or the skull surface. So the topographic relation of the brain to the roof of the ethmoid and the cribriform plate must have been well known (Kassel, 1967).
The next three thousand years brought no significant increase in anatomical knowledge of this special region. Quite in contrast, the few details already discovered by some, tumbled into oblivion again. The "medical philosophers" had taken over the field, the main interest being the alledged purpose of the sinuses more than their anatomy. To prove their often strange, curious, mythologic and even obscure ideas on the sinuses, they frequently even deliberately "modified" the anatomy according to their needs, trying to make the anatomy match their philosophies – and not vice versa.
So there was the idea of a free passage between the nose and the cerebral ventricels to explain the mechanism of smell; only in 1655 when C. v. Schneider published his "Liber de osse cribriformi etc." in Wittenberg, Germany, this fantastic idea came to an end – the olfactory nerve, its fila and their penetration through the cribriform plate into the nasal mucosa were discovered. But it took two hundred more years, until these findings were widely accepted unanimously by the medical scientists and practitioners.

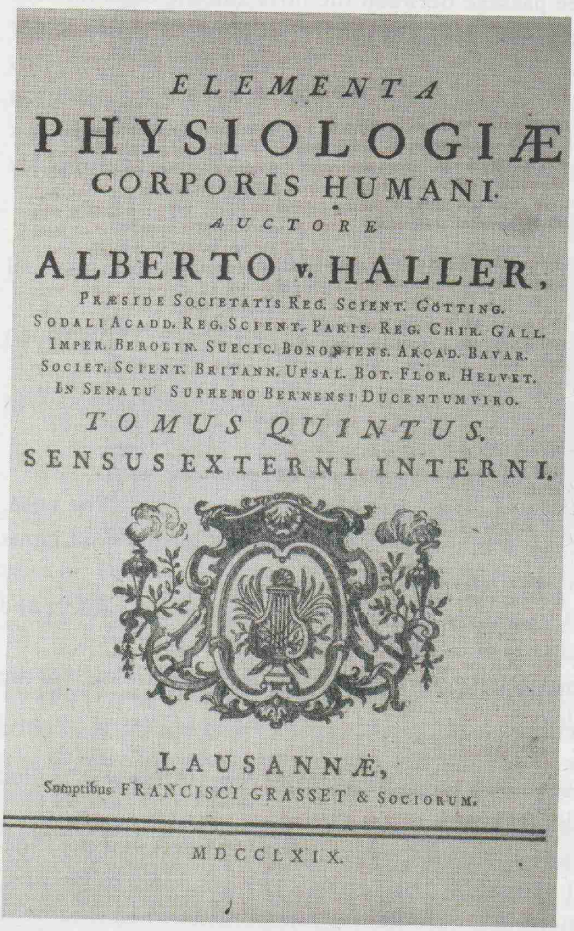
Over the centuries, the sinuses were attributed sometimes almost mystical properties:

- They were said to contain a "membrana viridans", a green membrane, which sometimes might turn whitish, too.
- They were said to "filter" the air on its way to the brain and to the ventricles, to create the "animus" or "spiritus vitae".
- They were said to contain medullary contents, similar to the brain.
- The brain was assumed to "drain its evil spirits" via the sinuses and the nose, especially the pituitary gland was thought to drain via the sphenoid sinus through the "pores" of the sphenoidal bone.
- The sinuses were thought to produce a medullary substance to protect the olfactory nerve and provide nutrition to the bone and the teeth.
- The sinuses – especially the frontal – were thought to hold the "grease" for the movement of the eye balls.

No wonder, that in 1550 Sansovino in his "L'edeficio del corpore humano" called the nasal cavity "la cloaca del cerebro".
This statement pretty clearly summoned the middle ages' ideas about the function of and the interest that should be paid to the inner nose and its sinuses.
Vesalius, Fallopia and Diemerbroek were the main opponents when it came to

decide whether the sinuses are empty – containing air – or filled with mucus or secretion from the brain or the hypophysis. Schneider, Valverda and Columbus fought for their concept of air containing sinuses. N. Highmore (Hagae Comitis, de corpore humano disquisitio anatomica, 1681) was a defendant of the pneumatisation concept, attributing a protective purpose for the eyeballs to the supraorbital protrusion of the frontal sinus as well as the principle of saving weight. Despite the fact of the maxillary sinus bearing his name today, in his original publications he neglected the fact of a communication between the maxillary sinus and the nose.

Johann Riolan (the Younger) in 1649 in his book "Encheiridium Anatomicum" was the first to see the paranasal sinuses as an entity: "Omnes sunt vacui, membrana tenui obducti" (All are empty, lined by a thin membrane). Again, C. v. Schneider demonstrated that when a correct dissection technique was used, the


ELEMENTA

PHYSIOLOGIÆ

CORPORIS HUMANI.

AUCTORE

ALBERTO v. HALLER,

PRÆSIDE SOCIETATIS REG. SCIENT. GÖTTING.
SODALI ACADD. REG. SCIENT. PARIS. REG. CHIR. GALL.
IMPER. BEROLIN. SUECIC. BONONIENS. ARCAD. BAVAR.
SOCIET. SCIENT. BRITANN. UPSAL. BOT. FLOR. HELVET.
IN SENATU SUPREMO BERNENSI DUCENTUMVIRO.

TOMUS QUINTUS.

SENSUS EXTERNI INTERNI.

LAUSANNÆ,
Sumptibus FRANCISCI GRASSET & SOCIORUM.

MDCCLXIX.

Figure 2a. Original title page of A. v. Haller's Book from 1769.

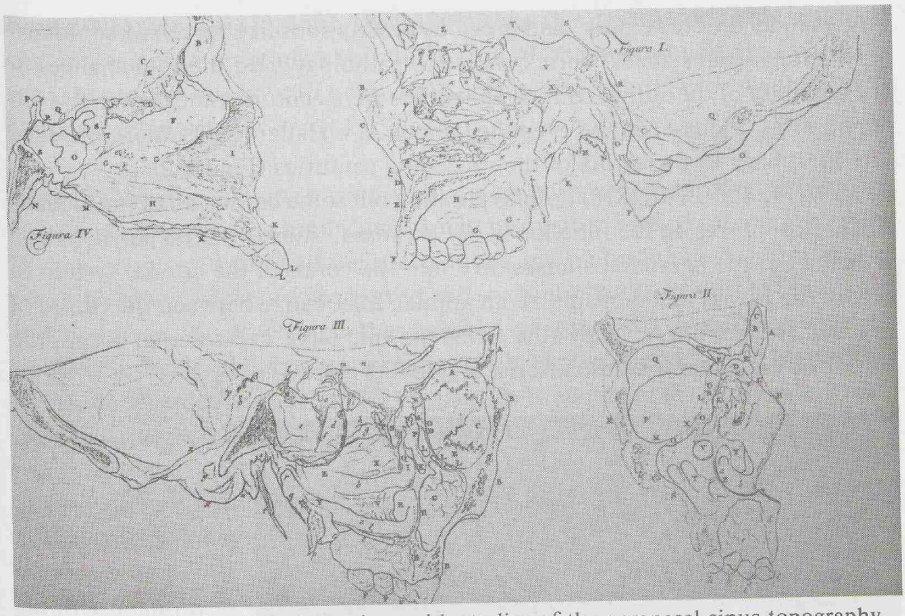


Figure 2b. Haller's original drawings with studies of the paranasal sinus topography.

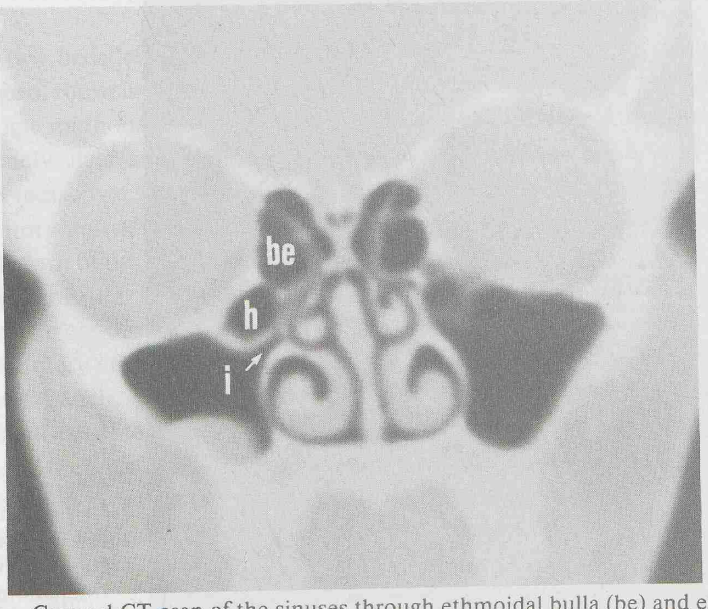
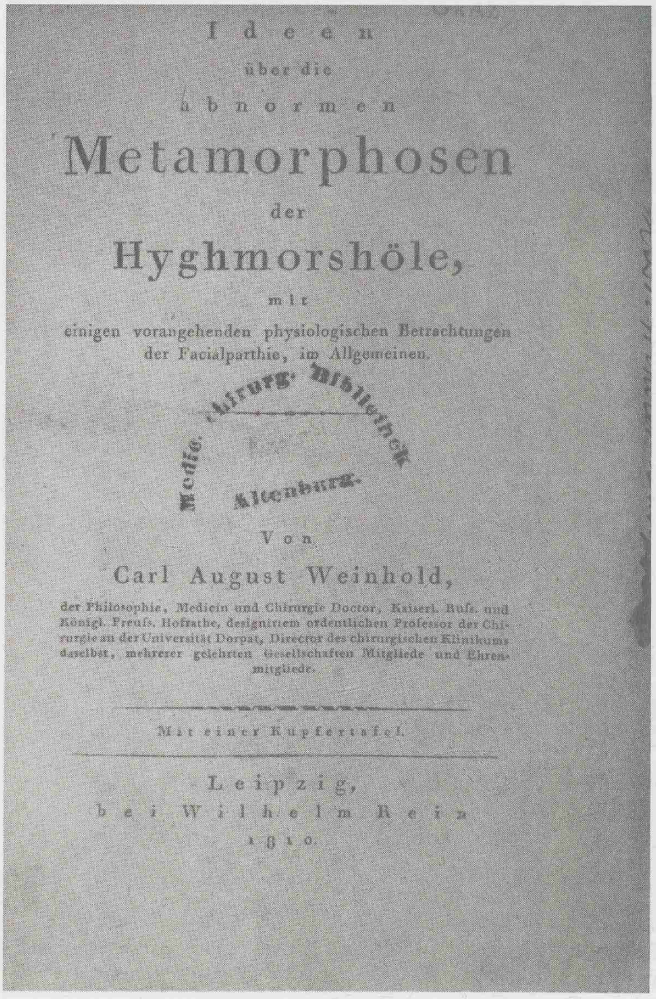


Figure 2c. Coronal CT-scan of the sinuses through ethmoidal bulla (be) and ethmoidal infundibulum (i), narrowed by a Haller's cell (h) on the right (side of the patient).

sinuses indeed were "empty" and previous descriptions like "green membranes" or "medullary substances" corresponded to pathology, post-mortem changes or just phantasy of the author. But he and others were centuries ahead of their contemporaries. Vieussenes and even the famous A. v. Haller (Lausanne, Göttingen 1769) fell back to the errors of the preceding centuries (Figure 2).

C. A. Weinhold (1810, 1818) despite pointing out some correct anatomical facts, still philosophizes on the function of the paranasal sinuses: "like a polyp, like an active organ the paranasal sinuses dive into the corals of the arterial system to absorb the access metabolism like an animal, to equalize between the centre of live and the periphery. They (the PNS) are one large excremental organ, the carrier of the equator of the arterial system" (Figure 3).


Ideen
über die
abnormen
Metamorphosen
der
Hyghmorshöle,
mit
einigen vorangehenden physiologischen Betrachtungen
der Facialparthie, im Allgemeinen.

Von
Carl August Weinhold,
der Philosophie, Medicin und Chirurgie Doctor, Kaiserl. Russ. und Königl. Preuss. Hofrathe, designirtem ordentlichen Professor der Chirurgie an der Universität Dorpat, Director des chirurgischen Klinikums daselbst, mehrerer gelehrten Gesellschaften Mitgliede und Ehrenmitgliede.
Mit einer Kupfertafel.
Leipzig,
bei Wilhelm Rein
1810.

Figure 3.
Original title page of C. A. Weinholds book on the "Metamorphoses of Hyghmor's Cavity" from 1810.

Emil Zuckerkandl (1875, 1882, 1884, 1887) gives this description in his first book and apologizes to his readers with the words: "I only mentioned this to demonstrate how much you have to suffer and tolerate on this earth, even if you are only a pneumatized cavity".

Despite the surgery taking big innovative steps early in the 19th century already, anatomy had to wait for Emil Zuckerkandl of Austria, who lectured in Graz and Vienna, to put an end to all the speculations and philosophies. He brought the scientific sober aspect of a sharp eyed and sharp minded anatomist to the subject and within a decade created the standard anatomical knowledge about the sinuses. Such a level did he reach in his detailed knowledge and description, that he can be regarded as the founder of a scientific approach to sinus anatomy and even today there is little one could add to his descriptions, which therefore can be regarded the state of the art as far as sinus anatomy is concerned.
So clear were his studies, descriptions and drawings of all possible variations of normal and pathologic anatomy, that he enabled the foundation of modern sinus surgery with his first book in 1882. Before that, he already had published on comparative anatomy as well as reported on findings of different human races, when sailing around the world with the Austrian Vessel "Novara" in the 1870s (Zuckerkandl, 1884, 1887).
So great was his impact, that his descriptions influenced all other European and overseas literature right from the beginning (Moure, 1886).

The last two decades of the 19th century brought an explosion to mankind's knowledge of the anatomy, physiology and pathophysiology of sinuses. Advances in histologic methods, in embryology and surgical techniques summoned up to an extremely clear picture of the sinuses, their development and physiology. Facts we rediscover today - like the ethmoid being the centre of most of the inflammatory processes of the sinuses - were clearly pointed out at that time before the turn of our century already. When the analgetic potency of cocain was discovered by Koller in 1884 in Vienna, this meant another invaluable impetus to the field: The era of an effective and powerful anaesthetic for diagnostic evaluation and surgery of the nose and the sinuses (v. Eicken, 1951; Lesky, 1965, 1981; Spitzy and Lauch, 1982; Majer and Skopec, 1985). Now the descriptions of Zuckerkandl became even more valuable as they directly could be applied to patients and their problems: ostia could be palpated and probed for diagnosis and treatment, polyps be localized and removed and more sophisticated surgical techniques be applied with less discomfort for the patient.

The lucky coincidence of the right people being together at the right time and at the same place brought the Viennese School of Surgeons to a very high standard,

creating pioneers in almost every field of what would become otorhinolaryngology decades later (Majer and Skopec, 1985). Stimulated and excited by this pioneer period, many surgeons in various countries now dealt with anatomical studies of the nose and the sinuses. To all of them we owe much of our todays' knowledge.

To name only a few of them: Onodi from Budapest especially dealt with the topographic relation of the ethmoid and the optic nerve. His book of 1910 holds beautiful examples on how already posterior ethmoidal cells can have a close relation to the optic nerve. Posterior ethmoid cells which may extend superiorly or laterally to the sphenoid sinus – and thus mislead the surgeon when looking for the sphenoid at the posterior most wall of such a cell – may create there great danger of putting a lesion to the optic nerve. These cells therefore still today bear the name of Onodi.

Grünwald (1925) from Munich did many anatomical studies and described many topographical situations and ethmoid variations which today bear his name, like "hiatus semilunaris inferior and superior", "sinus lateralis", "interlamellar cell" = pneumatisation of the middle turbinate due to invagination of the superior nasal meatus into the middle turbinate.

Further names rank from Hajek (1926), the father of sinus surgery, via Killian (1903), Hofer (1931), Zarniko (1910), Denker (1925), Takahasi (1971) and many others into our days, where microsurgery with micro- or endoscope has renewed all the interest in the detailed anatomy of the sinuses.

The invention of the X-ray technique initially did not add much to the anatomical knowledge of the sinuses nor was it a big help accepted by all sinus surgeons right from the beginning (Zarniko, 1910; Hajek, 1926). We have the impression, that to some degree it is due to the development – and later on the widespread use of standard sinus X-rays – that the detailed knowledge about the anatomy of the ethmoid sinuses and their importance as the key position of pathology somewhat was "forgotten" in the decades to follow. Because suddenly, the surgeons got very clear images of pathology that was present in the larger sinuses like frontal and maxillary sinus. Standard X-rays were not able, however, to demonstrate disease very clearly in the delicate clefts of the (anterior) ethmoid. So the development of surgical techniques tended more and more with various approaches towards the maxillary and frontal sinuses, – somewhat neglecting the ethmoid, except in cases of complications of acute or chronic sinusitis.

Only since 1967 we do have access to conventional tomography, and only since the midseventies CT is available. These now again make the relationship and the pathophysiologic dependence of the larger sinuses from the ethmoid very clear and todays microsurgical techniques more and more tend to apply again the knowledge which had been developed more than 100 years ago: Focusing on the

ethmoid - as its anatomy is such that disease in critical areas of the ethmoid sooner or later may bring about secondary disease of the frontal and the maxillary sinuses.

Comparisons of the high tech procedures like CT, MRI or even three dimensional reconstructions with the drawings and sketches of Onodi, Grünwald and especially Zuckerkandl demonstrate the incredible accuracy of these pioneers' knowledge (Figures 4 and 5).

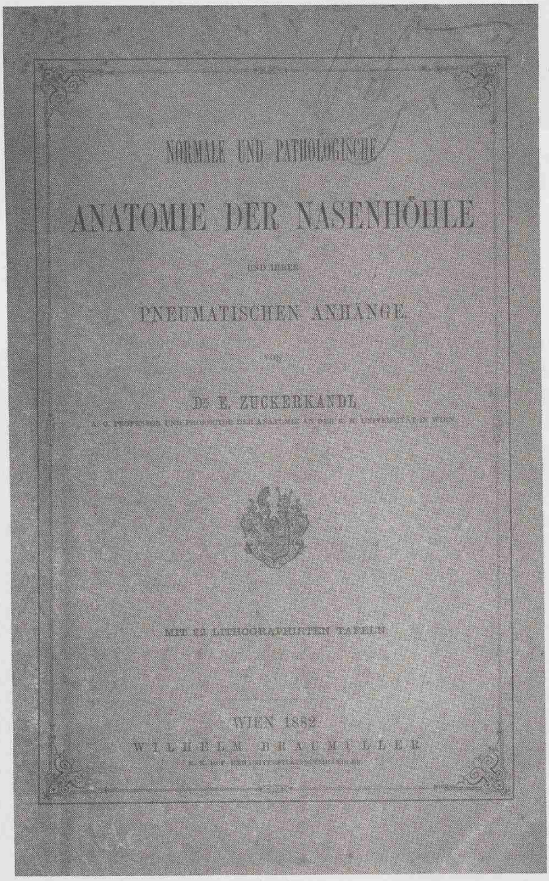


Figure 4a. Original title page of E. Zuckerkandl's first edition of "Normale und pathologische Anatomie der Nasenhöhle und ihrer pneumatischen Anhänge" from 1882.

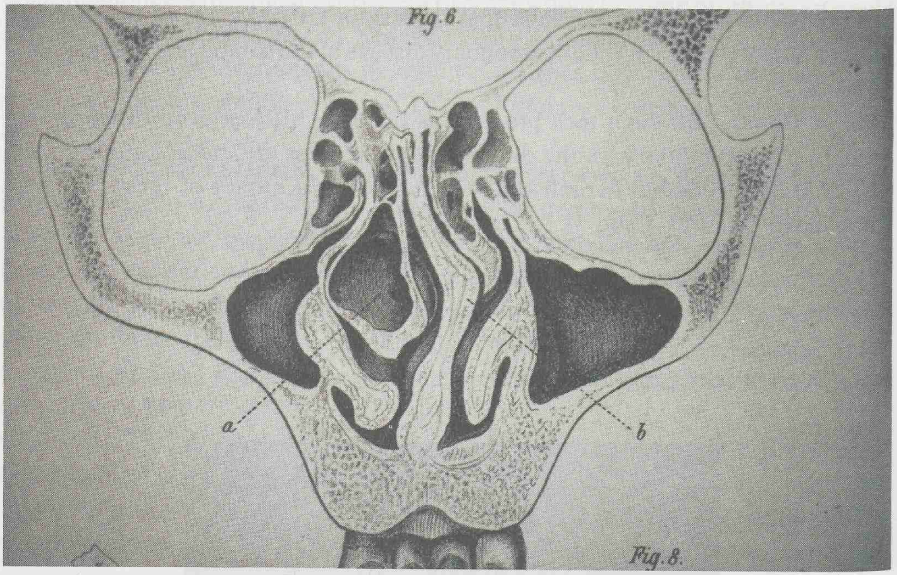


Figure 4b. Drawing of a right-sided concha bullosa of the middle turbinate in a coronal section from Zuckerkandl's book, 1882.

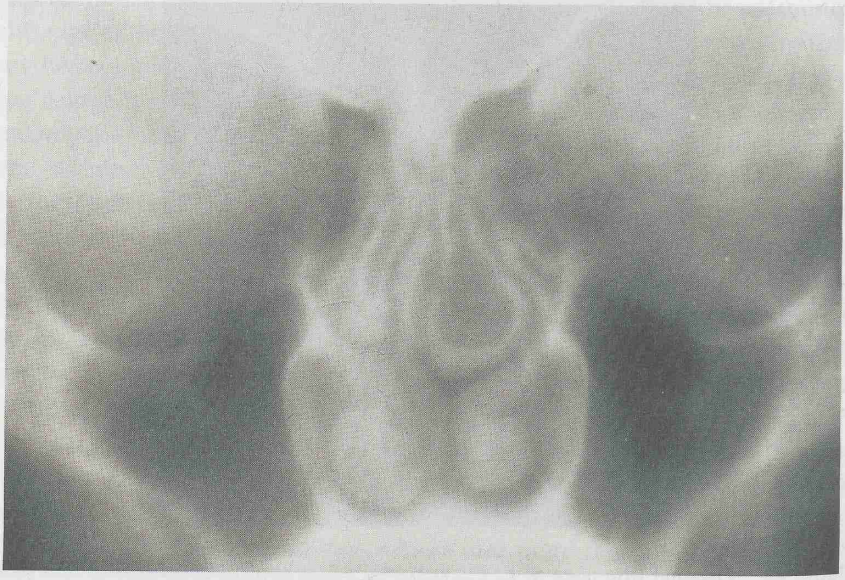


Figure 4c. Coronal tomography of concha bullosa of middle turbinate, 1988.

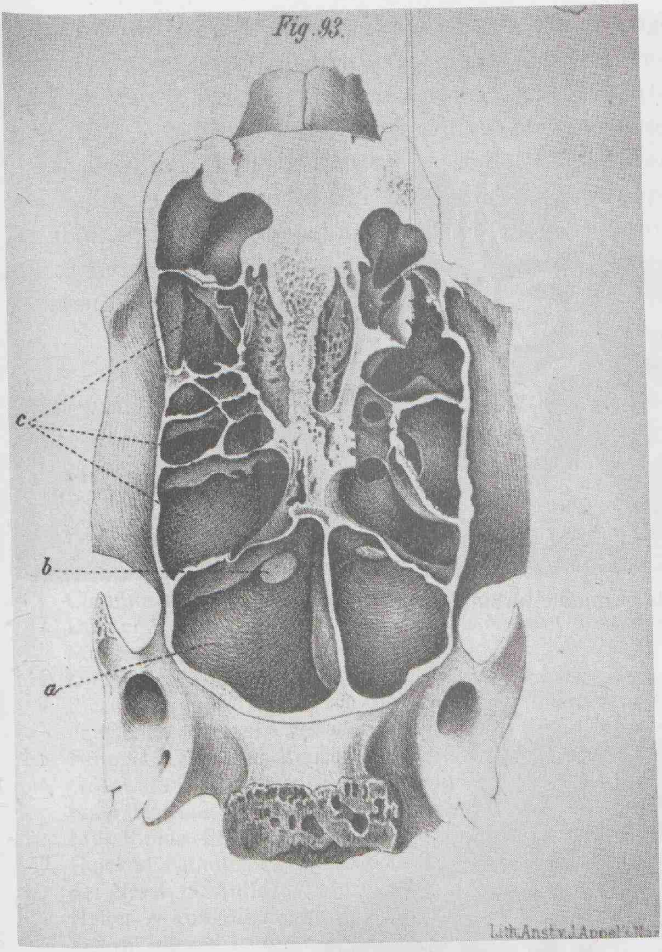


Figure 4d.
Longitudinal section through ethmoid and sphenoid sinuses. Zuckerkandl, 1882.

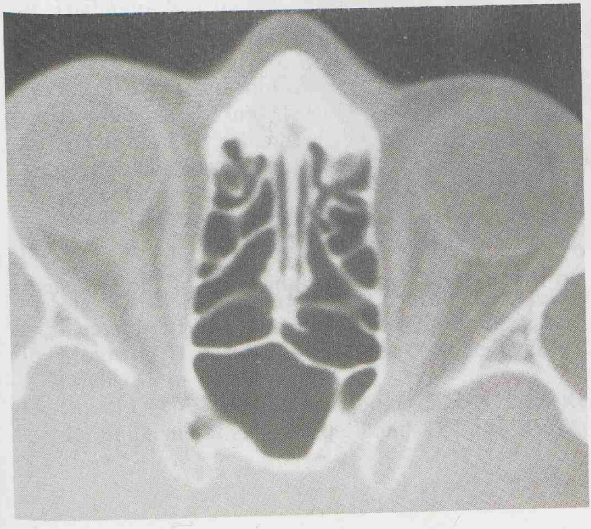


Figure 4e.
Axial CT-scan of same area, 1988.

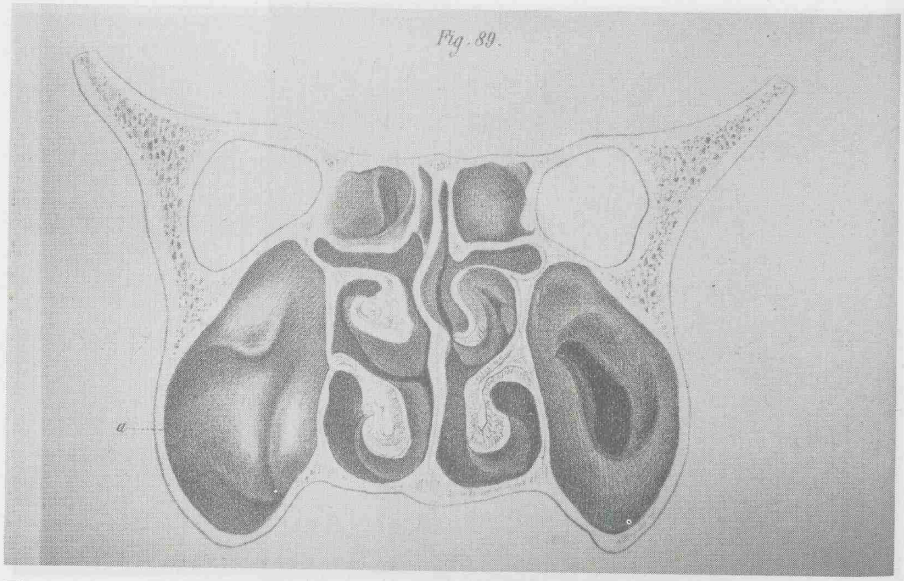


Figure 5a. Basal lamella of middle turbinate. Zuckerkandl, 1882.

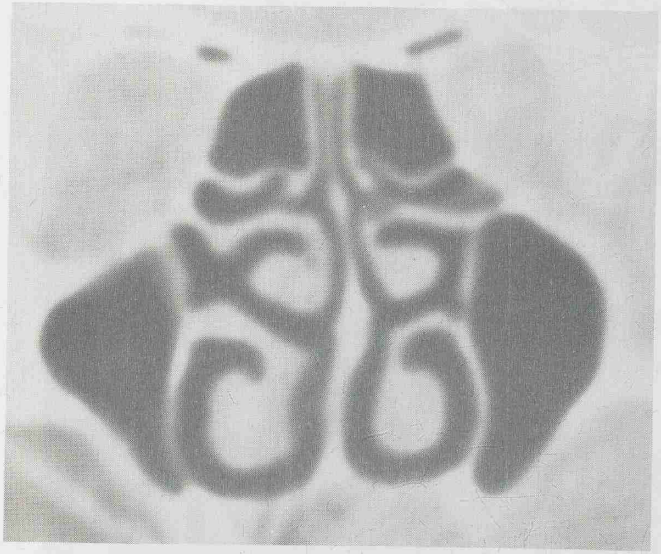


Figure 5b.
CT-scan of same area, 1988.

So is there anything left to do for us today as far as anatomy of the sinuses is concerned?
A lot, probably.

First we owe to these pioneers to preserve their knowledge, acquire and teach it to our students, as today surgical techniques make this knowledge more important than ever to avoid complications which can be fatal in this area. Furthermore, there is still a considerable confusion in the nomenclature of especially the ethmoid area among surgeons, anatomists and teachers in various countries. These discrepancies in nomenclature should be erased to make people speak about one structure with the same anatomical name. This will help to facilitate communication among colleagues and to compare results, effectiveness and hazards of different surgical approaches.

This paper is dedicated to Professor Walter Thiel, Head of the Institute of Anatomy of the Karl Franzens University Graz, on the occasion of his 70th birthday.

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Heinz Stammberger, M.D.
Professor of Otorhinolaryngology
University-ENT-Hospital
A-8036 Graz
Auenbruggerplatz 20
Austria