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Cross-sectional anatomy of the nose and paranasal sinuses. A correlative study of computer tomographic images and cryosections

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SUMMARY

Anatomic relations in the nose and paranasa! sinuses have been studied in computer tomographic images and CJyosections, to highlight some details that are of importancefor thefunctional nasal surgeon. From three heads the sections were obtained in three perpendicular planes (coronal, axial and sagittal).

The most interesting sections are depicted in three ways: a computer tomographic image, the swface photography of the tissue block in the microtome and a stained section of 20 microns.

A number of interesting relations that are clearly depicted are discussed.

INTRODUCTION

In view of the new developments in functional nasal and sinus surgery, detailed knowledge of the anatomy of the nose and sinuses has become of utmost importance. Cross-sections are an excellent tool to study the topographical relations in this area. Although cross-sections do not provide direct three-dimensional information, they have two advantages over the classical dissection.

In the first place the undisturbed relations of structures and tissues can be studied, while the problem of the reduction to two dimensions can be solved by studying series of cross-sections. This merit of cross-sections is well-known. Andreas Vesalius was the first to represent cross-sections in 1543 (Saunders and O'Malley, 1982). Nonetheless in this century the interest in gross-anatomical cross-sections gradually diminished until the seventh decade when CT and later MR entered the scene. The second advantage is a consequence of these developments. With the new imaging techniques the patient-specific anatomy can be assessed, including all possible variations. However, because of the indirect manner in which these cross-sections are reconstructed, correlations with direct cross-sections are imperative to avoid errors in the interpretations of the scans. The rapid reduction of the section thickness of these imaging modalities has induced new developments in the techniques of obtaining anatomical cross-sections. Large heavy duty microtomes have replaced the band saw. Rauschning (1979) recognized that photography of the surface of tissue block in the microtome could provide excellent cross-sectional images.

Weys and Hillen found in 1985 that fine structures such as vessels and nerves are often difficult to identify in photography, but in stained sections, using magnifications up to twenty times, they can easily be recognized.

Later Zonneveld (1987) collected tissue sections and put them in the same way through a staining procedure. He used this method for the study of CT-imaging of the temporal bone and the orbit and the correlations with anatomic cross-sections on which he published an excellent book. To avoid the freezing artifacts special plastic embedding techniques are under development (Huizing et al., 1985).

In this study we have used the techniques of cryosectioning and CT-scanning to obtain the cross-sections and illustrate some anatomical details from the nose and adnexa.

MATERIAL AND METHODS

Three human heads, obtained from normal dissecting-room material were used, one for each sectional plane: coronal (frontal), sagittal and axial (transverse). CT-scanning of these heads was performed in the Department of Radiodiagnosis, University Hospital Utrecht. The scans were not only used for the correlative study but were also helpful in determining the plane of sectioning of the specimens by marking the mounting plane and the first and last section of the series. The sectioning was done on a heavy duty cryomicrotome (**PMV** 450 **MP**) which was originally developed by Ullberg in 1977 for autoradiography and histochemistry in his toxicologic research. The procedure was as follows:

The specimen was embedded in carboxymethylcellulosis, placed on the mount and frozen to -20 °. Then the mount with the tissue specimen was fixed in the microtome. The chosen section thickness was 20 micrometer. A camera was placed over the microtome so that the surface of the tissue block could be photographed during the sectioning, at a certain interval, in t is case 0.5 mm. After taking a photograph, a section was taken with the so-called "on-tape" method. Recently this method is extensively reviewed by Van Leeuwen et al. (1990).

In short, an adhesive tape was fixed on the surface of the tissue block prior to sectioning. After sectioning a thin section (20 micrometer) of tissue stayed fixed on the tape and was stained with a modified Mallory-Cason procedure. Essentially this is the Mallory trichrome staining procedure, modified by Cason (1950).

Van Leeuwen et al. made adaptions to enhance the staining of the tissue and reduce the background staining on the tape. The dye bath was a solution of 0.5 g phosphotungstic acid, 0.1 g of orange G, 0.1 g aniline blue, 0.1 g of acid fuchsin in 100 ml of distilled water. After staining for two minutes the sections were differentiated in 70% ethanol and 95% ethanol respectively. The stained sections are mounted on cardboard.

RESULTS

Some of the representative results obtained in the three specimens are presented in Figures 1-6 (figures 1-3: see pages 224 and 225, figures 4-6: see pages 228 and 229). Each of them is composed out of

a. a CT-scan
b. a surface photograph and
c. a cryosection.

The surface photograph and the cryosection are exactly at the same level. The latter shows a magnification of the most interesting part of the former.

1. *Coronal section at the level of the head of the inferior turbinate*

Figure 1 shows a coronal section at the level of the frontal sinuses, the eye lenses and the heads of the inferior turbinates.
In this section the joint between the cartilaginous septum and the premaxilla can be seen. Directly inferior to it, the left incisival canal is visible.
Note also the septal turbinate on both sides of the septum with its cavernous tissue in area 3, the so-called attic of the nasal cavity.

2. *Coronal section at the level of the ostiomeatal complex*

In Figure 2 a coronal section at the level of the ostiomeatal complex is presented. It is nicely shown how the middle turbinate is part of the ethmoid. Its lamella is attached to the skull base, laterally to the cribriform plate. In this specimen the roof of the ethmoid is about 5 mm cranially to the cribriform plate. This difference in level has to be taken into account in endonasal ethmoid surgery.
Both middle turbinates are well pneumatised showing a large bulla or sinus. Such a bulla can easily obstruct the infundibulum, thereby affecting the ventilation and the drainage of the maxillary sinus, the frontal sinus and the anterior ethmoidal cells. It may also produce referred pain when it is in contact with the septum and/or the ethmoid.
The section also shows the uncinate process and the ostium of the maxillary sinus on both sides. It is funnel-shaped and more a duct than an ostium.

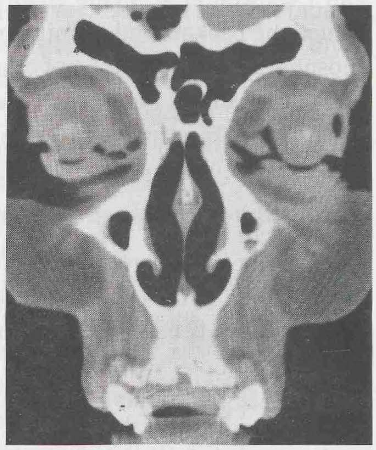


Figure 1 Coronal section at the level of the head of the inferior turbinate.

1. anterior attachment of the middle turbinate
2. lacrimal canaliculi
3. nasolacrimal duct
4. septa! turbinate
5. joint between septum and premaxilla
6. incisive canal

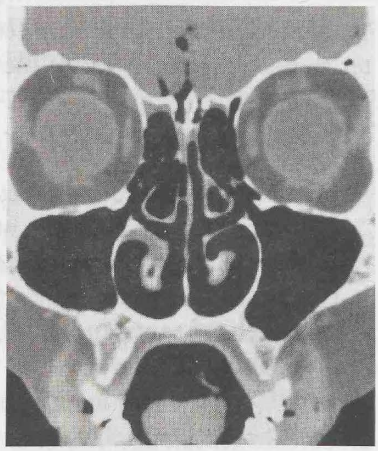


Figure 2 Coronal section at the level of the ostiomeatal complex.

1. superior oblique muscle
2. medial rectus muscle
3. roof of the ethmoid
4. Haller cell
5. uncinate process
6. roof of nasal cavity

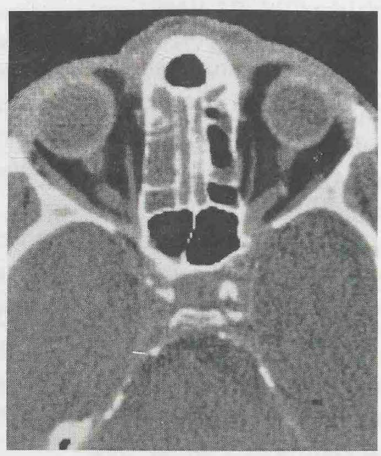
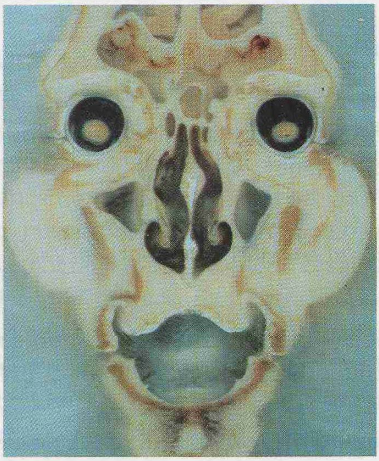


Figure 3 Axial section through the frontal, ethmoidal and sphenoidal sinuses.

1. angular artery
2. frontal sinus
3. nasal cavity
4. lamina papyracea
5. medial rectus muscle
6. carotid artery

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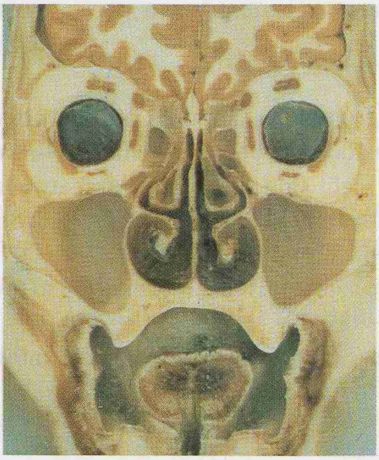

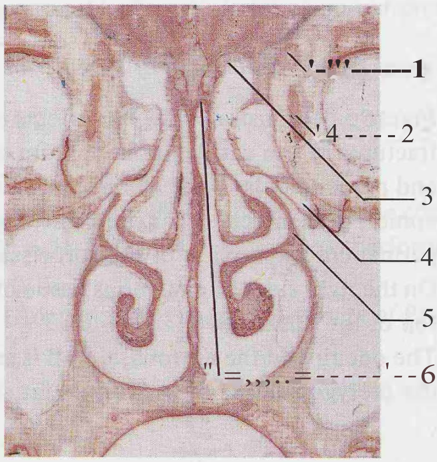
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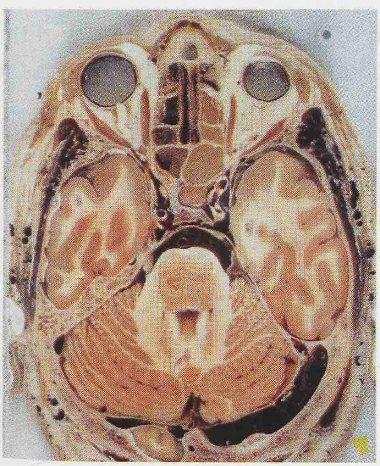

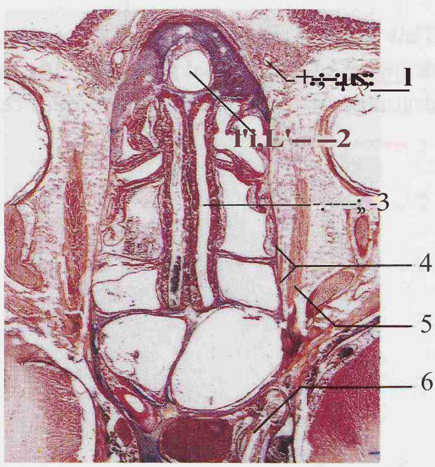
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3. Axial section through the frontal, ethmoidal and sphenoidal sinuses

This section (Figure 3) illustrates the relationship between the ethmoid and the orbital structures. It also shows the topography of the sphenoid, the carotid artery, the cavernous sinus and the pituitary gland.

4. Axial section through the ethmoidal-sphenoidal complex at the level of the superior turbinate

This section (Figure 4) illustrates the position of the agger cells, the ethmoidal bullae and the most cranial part of the infundibulum as well as the upper part of the antra.
The superior turbinates and their attachment to the medial wall of the posterior ethmoid and the anterior of the sphenoid are visible.

5. Axial section at the level of the inferior turbinates

Figure 5 demonstrates the late effects of a frontal nasal trauma with multiple fractures of the cartilaginous septum, a dislocation between septal cartilage and perpendicular plate and a spur on the right side at the junction between vomer, perpendicular plate and cartilage. Note how the spur has produced a permanent impression of the soft tissues of the inferior turbinate.
On the right side the cavernous tissue of the septal turbinate extends up to the top of the nasal valve.
The opening in the antronasal wall is an accessory ostium. Note furthermore the pterygopalatine fossa with its fat and the maxillary artery.

6 Sagittal section at the level of the left fronto-ethmoidal complex

This section (Figure 6) shows the position of the bulla ethmoidalis and the drainage of the frontal sinus into the infundibulum. It also demonstrates the drainage of the posterior ethmoidal cells to the superior nasal meatus.

DISCUSSION

Series of cross-sections provide an excellent tool to study complex anatomical relationships and may be very helpful in studying the anatomy ofthe nose and the paranasal sinuses. The technique provides accurate correlative anatomy as it does not disturb the relation between the various tissues. Results can nicely be compared with those obtained by modern imaging techniques such as computer tomography and magnetic resonance.

Despite the accurate correlation a direct point to point comparison of small details may not always be possible since a CT-scan represents a slice of 1.5 mm thickness, whereas cryosections have virtually no thickness. In anatomically complicated areas like the ethmoidal complex more than one cryosection may therefore be needed for comparison to CT-scan.

Scans and sections in axial planes are generally less informative to the endoscopist than coronal ones because he is using vertical landmarks in his examination and surgery.

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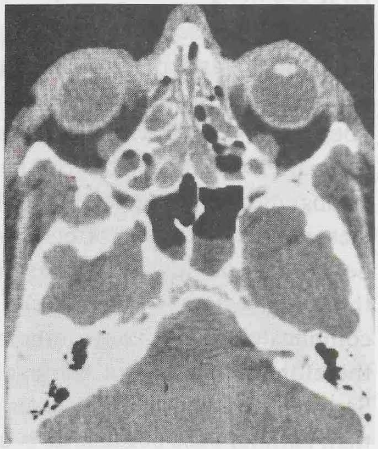


Figure 4 Axial section through the ethmoidal-sphenoidal complex at the level of the superior turbinate.

1. nasolacrimal duct
2. agger nasi cell
3. infundibulum
4. inferior rectus muscle
5. maxillary sinus
6. superior turbinate

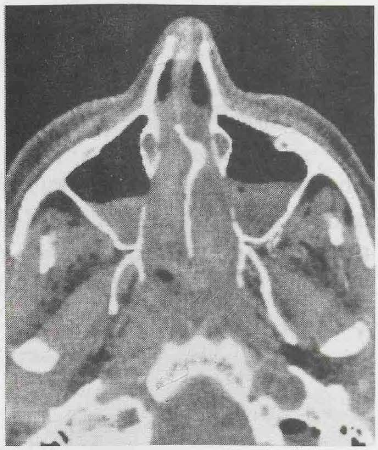


Figure 5 Axial section at the level of the inferior turbinate.

1. septolateral cartilage
2. perpendicular lamina
3. inferior meatus
4. vomer
5. accessory ostium
6. maxillary artery

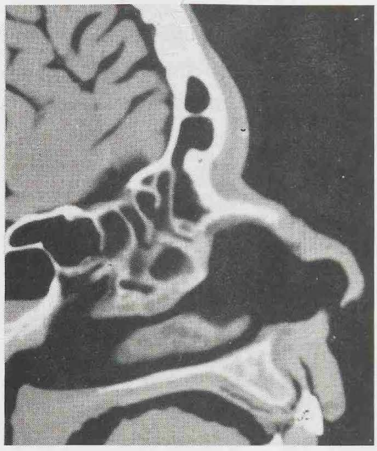
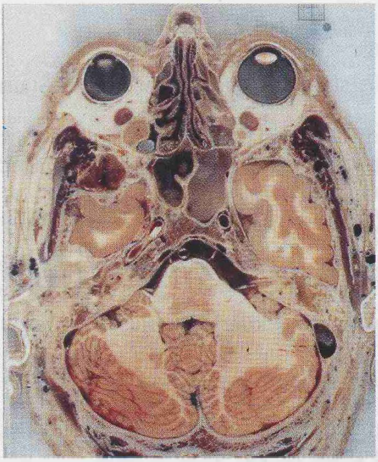
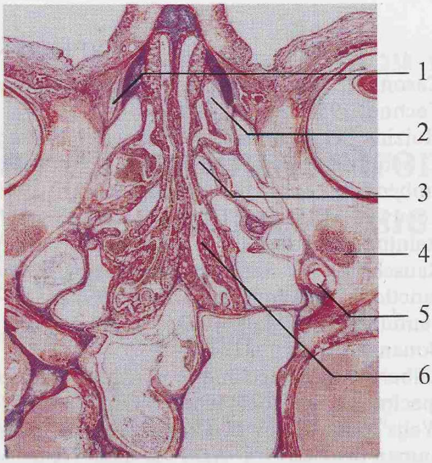


Figure 6 Sagittal section at the level of the left fronto-ethmoidal complex.

1. drainage of the posterior ethmoidal cells
2. ground lamella
3. infundibulum
4. ethmoidal bulla
5. middle turbinate

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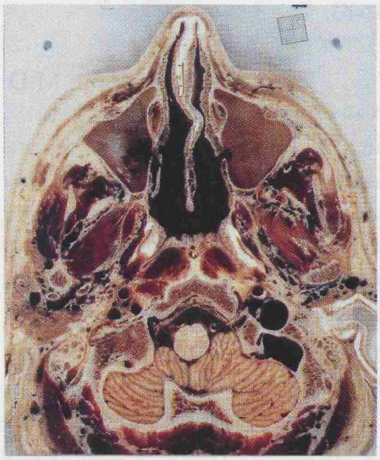

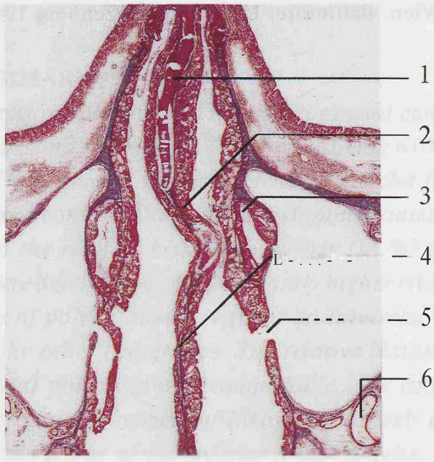
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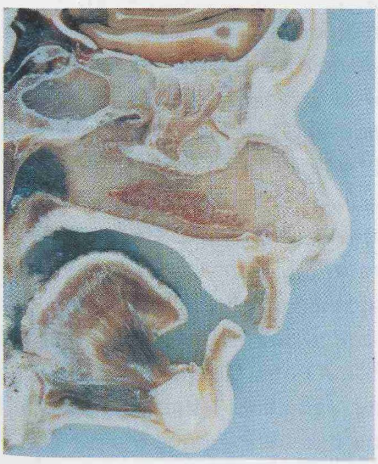

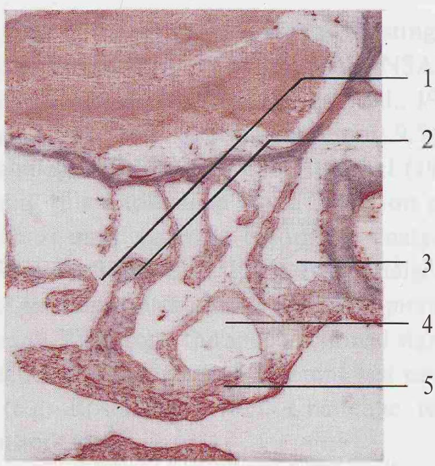
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