Rhinology, 35, 28–32, 1997

Computerised tomography evaluation of the frontal recess in inflammatory diseases of the frontal sinus: Standardisation of a new technique*

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SUMMARY

The authors present a new investigation technique by means of CT of the frontal sinus drainage pathway, the frontal recess, which could be of considerable help in defining its potential role in determining a chronic or recurrent inflammatory process of this cavity. Among the main characteristics of this technique are: (1) a clear presentation of the course and conformation of the recess and its relations with surrounding structures; (2) speedy, and therefore economical, operation (12 min for a complete examination); and (3) tolerability, because this examination starts off with axial scans, which, compared to CT coronal projections and MRI scans, are less prone to defects and do not require strained postures. This this means that all kinds of patients can be assessed, which is a basic requirement for achieving standardisation. With axial scans the authors work from paraxial reconstructions (oblique sagittal) which, in their opinion, give the best definition of the frontal recess so far recorded.

Keywords: frontal recess, CT, frontal sinusitis, paraxial CT reconstructions, paranasal sinuses

INTRODUCTION

The improvement of CT imaging and the use of high-resolution programmes (HRTC) have led to considerable progress in the study of paranasal sinuses, allowing even the slightest differences of tissue density, both normal and pathological, to be shown.

We started from the premises of the study by Duvoisin and Schnyder (1992), in which, after establishing a clear correlation between inflammation of the frontal sinus and the presence of inflammatory stenosis or obstruction of its drainage pathway, a careful investigation of the frontal recess was suggested in cases of frontal sinusitis, whether in progress or recurrent. We aimed to standardise a simple and efficient radiological technique, which, through high-resolution computerised tomography, is able to show this structure and its relations with neighbouring ethmoidal cells.

In the terminology of this article we indicate the drainage pathway of the frontal sinus as frontal recess, following the indications of the *International Conference on Sinus Disease* held in Princeton (Stammberger and Kennedy, 1995), where it has been stated that as the bony walls of this structure, which leads to and communicates with the frontal sinus, are not truly its own – being defined exclusively in terms of its relations with adjacent structures (Stammberger, 1992) – calling it a duct, even if sometimes for its particularly small dimensions it can have a duct-like appearance, is not anatomically correct.

MATERIAL AND METHODS

Twenty-four adult patients, the majority of which were affected by non-polypoid, chronic sinus inflammatory pathology with no medical history of facial traumas or previous surgical operations on paranasal sinuses, were studied. They all underwent computerised tomography of their paranasal sinuses with a third-generation Siemens SOMATOM PLUS appliance, using high-space resolution scanning programmes on a 130×130mm field and a 512×512 matrix, at 130 kV and 100 mA. Since the course of the frontal recess does not develop on a single plane, but obliquely from the bottom of the frontal sinus in a cranio-caudal, latero-medial and postero-inferior direction, any kind of direct scanning can only show a part of it. We therefore considered it essential to carry out reconstructions in order to be able to follow its course and make a correct evaluation of the whole recess.

The volume required by the computer in association with the tomograph was provided by a series of direct scans, from which data was used to obtain reconstructed images on a paraxial plane (oblique sagittal), which, as will be described, is in our opinion the most suitable for a correct identification of the frontal recess.

* Received for publication April 23, 1996; accepted November 13, 1996

Axial scans

For axial projections the patient is in a supine position, with the head in any position, and held still by lateral, radiopaque supports. The scans and their inclinations are determined from a preliminary scout view, carried out from a lateral position using digital radiography, from which the scanning package is then programmed. Starting from the floor of the nasal cavities, scans were carried out in parallel from the bottom to the top, as far as a plane at a tangent to the roof of the orbit (Teatini et al., 1987). The scans were 2 mm thick and taken at 2-mm intervals, with a total number of approximately 35 and an operating time of approximately 10 min.

Scans were then divided into 5 groups, starting with the most cranial:

Group 1: The first scan at a tangent to the top of the orbit is still endocranial (Figure 1). Proceeding in an antero-posterior direction the pneumatised cavities of the frontal sinuses are singled out. The frontal sinus has two parts: a vertical and a horizontal which extend towards the top of the orbit, and two walls, one anterior and one posterior; as it is about 1 mm thick, the latter is a sound barrier against endocranial propagation of sinus inflammations. Behind the frontal sinus, on the median line, the *crista galli* appears. Posteriorly the upper part of the sphenoid sinus can be seen, and (in particularly in Figure 1) it is possible to make out the bulges of the optic nerves and the internal carotid arteries.

Group 2: The scanning plane passes slightly above the roof of the ethmoid bone; all the paranasal sinus cavities can be viewed except for the maxillary sinus (Figure 2). Anteriorly one encounters the frontal sinuses, posteriorly the sphenoid cavity and between them are the ethmoidal cells, at the centre of which the cribriform plate and the *crista galli* can be seen. The cribriform plate separates the nasal cavities from the anterior cranial fossa and is positioned at a lower level than the top of the ethmoid bone. The ethmoidal cells are laterally bordered by the *lamina papyracea*, which separates them from the orbits.

Group 3: The scans show the floor of the frontal sinuses and the most cranial part of the nasal cavities. The intersinusal septum of the frontal sinus, when present, is usually off the median line. The nasal cavities, which are bordered at the walls by the turbinates' plate (Figure 2), appear as narrow parallel fissures, a few millimetres wide, on both sides of the nasal septum, which at this point is formed by the perpendicular plate of the ethmoid bone. Posteriorly, the nasal cavities tend to diverge, ending in correspondence with the anterior wall of the sphenoid sinuses where their ostia are situated. Continuing in a posterior direction, the last cavity is the sphenoid sinus, which is often divided into one or more septa that are normally asymmetrical; attention should be given to the course of these septa as they can deviate laterally and settle directly onto the internal carotid artery.

Group 4: The anterior contour of the root of the nose shows up thickened and continues posteriorly with the nasal septum. The floor of the frontal sinus becomes thinner antero-medially in the frontal recess which runs in a postero-inferior direction. The nasal cavities diverge to form the sphenoethmoidal recesses (Figure 2). The optic canal runs in a medial-lateral direction

Figure 1. Axial tomogram (*fs*: frontal sinus; arrow: apex of crista galli; *ss*: sphenoid sinus; *or*: orbit roof).

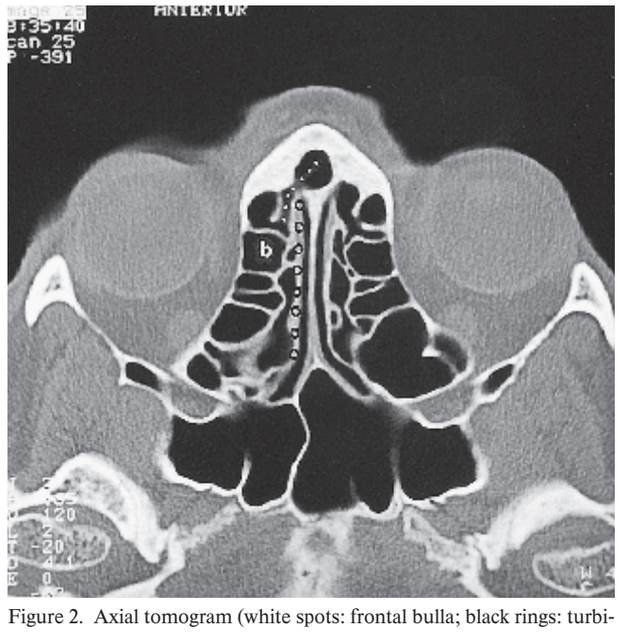

Figure 2. Axial tomogram (white spots: frontal bulla; black rings: turbinates' plate; *b*: bulla).

between the last posterior ethmoidal cell and the sphenoid sinus and goes inside the orbit.

Group 5: On the median line are the nasal bones, and to the sides of these, the rising branch of the maxillary bone. This continues posteriorly with the fine lacrimal bone plate which opens into a lateral, concave groove which receives the nearby portion of the nasolacrimal duct. At this height the maxillary sinuses appear. They are roughly triangular in shape with the upper part bending backwards. The anterior extremity of the middle turbinate separates the nasal cavity from the middle meatus, where the main structures are represented anteriorly by the uncinate process and posteriorly by the protuberance of the ethmoidal bulla. The fissure which occurs between these two formations is called the *hiatus semilunaris*. The ostium of maxillary sinuses,

which can be seen along the medial wall, appears as a bone-filling defect, and can be localised at various levels along the *hiatus semilunaris.*

Coronal scans

Coronal scans are carried out with the patient supine and the head hyper-extended. A lateral projection scout view is also carried out in this case. Direct coronal scans are carried out in parallel, with a thickness of 3 mm and taken at intervals of 4 mm, and go from the anterior wall of the frontal sinus to the posterior wall of the sphenoid sinus, with a total number of 20 and a total operating time of approximately 5 min.

Coronal scans, although important for viewing the components of the ostiomeatal unit (OMU; Figure 3), were deemed inappropriate in terms of our initial objectives, as they often manifest defects capable of masking important anatomical details.

These defects may be caused by brisk movements of the patient's head, due to the difficulty of holding an uncomfortable position for such a long period, or to the presence of amalgam and dentures which produce radial blurring. For these reasons coronal scans are, in our opinion, unsuitable for standardising a method of identification of the frontal recess, major target of our study, although they are necessary if one has to consider the anatomy of the anterior skull base, the roof of the ethmoid and the *lamina cribrosa.*

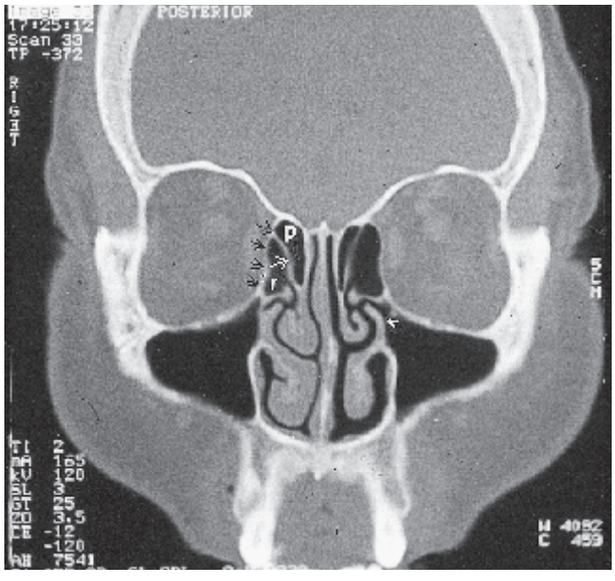

Figure 3. Coronal tomogram (thick arrow: maxillary sinus' ostium; *p*: posterior ethmoidal cell; *r*: retrobullar recess; white arrow: ground lamella; black arrows: lamina papyracea).

Paraxial reconstructions (oblique sagittal)

We therefore decided to use direct axial scans for the reconstructions, taking the scan at a tangent to the cribriform plate as a reference point (Figure 4). This scan gave a good view of the frontal sinuses, the ethmoidal cells and the sphenoid sinus. The reconstructions are 1 mm thick, ideal for definition of the recess, and were taken at intervals of 1 mm with a total number of 9, and a total reconstruction time of approximately 2 min.

To identify the frontal recess and its relations with the ethmoidal cells, the reconstructions were carried out in parallel, in a

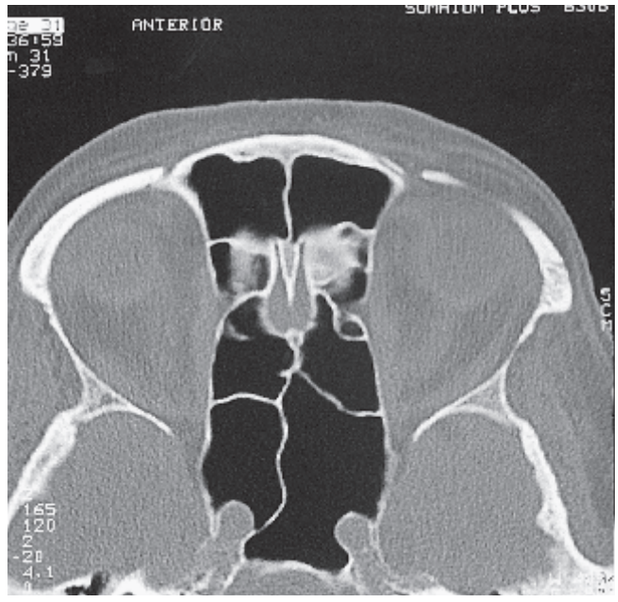

Figure 4. The scan taken at a tangent to the cribriform plate represents the reference point for the reconstructions.

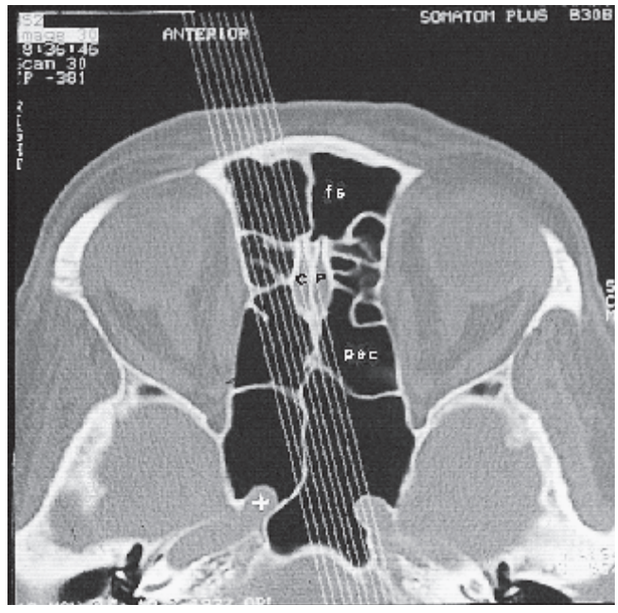

Figure 5. The figure shows the package of paraxial reconstructions (*fs*: frontal sinus; *pec*: posterior ethmoidal cell; *cp*: cribriform plate; +: internal carotid artery).

latero-medial direction starting from a plane at a tangent to the anterior half of the medial wall of the orbit and as far as the *crista galli* (Figure 5). The direction of the reconstruction *package* was dictated once again by the course of the recess, which is oblique with respect to the plane which passes through the median line; after various attempts we found that the ideal angle shot is always situated between 8° and 11° (Figure 6).

In successive scans it is essential to view the anterior uncinate process, as well as the posterior ethmoidal cells (Figure 7), bordering the *hiatus semilunaris* that communicates from above with the infundibulum.

The frontal sinus becomes thinner in the frontal recess which runs inferiorly and posteriorly, and is surrounded by ethmoidal

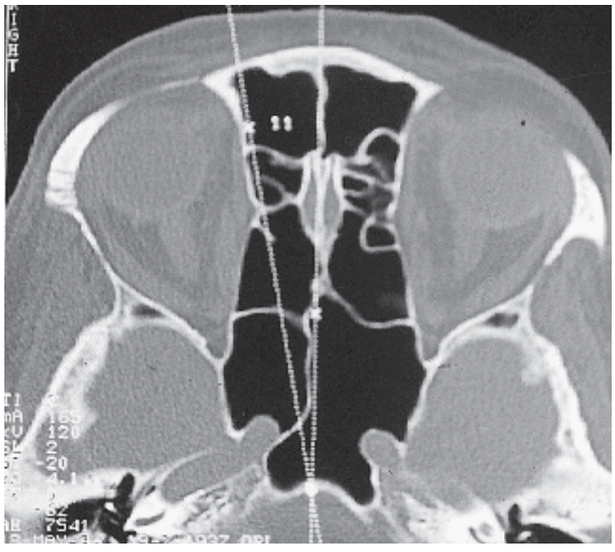

Figure 6. The ideal angle shot to identify the course of the frontonasal ducts between 8° and 11°.

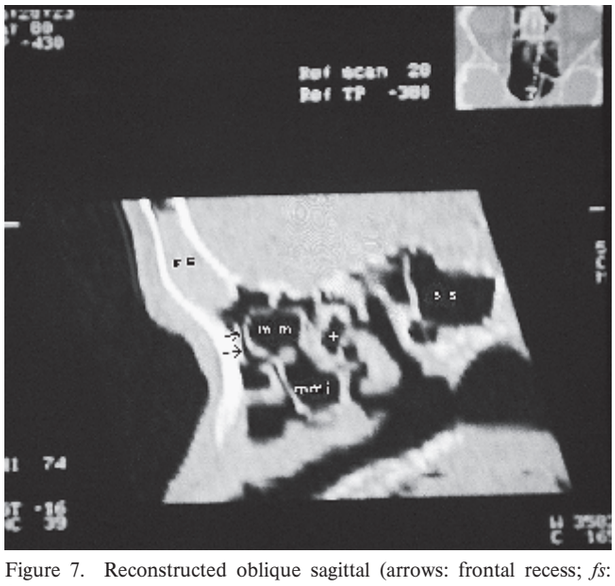

Figure 7. Reconstructed oblique sagittal (arrows: frontal recess; *fs*: frontal sinus; *mm*: middle meatus, superior portion; +: posterior ethmoidal cell; *mmi*: middle meatus; *ss*: sphenoid sinus).

cells (Figure 8). According to Murai (1937) the most frequent position of these cells is along the dorsal wall of the recess (89%). In 34% of the cases the presence of a cell positioned to the side of the recess has also been noted; the presence of a medial and an anterior cell has been found in 22% and 26% of the cases, respectively. Both the relations and dimensions of this structure have proved to be more controversial. According to Reesvkoyi (1967) the frontal recess has an average length of 12.75 mm, with limits which range from 2 to 20 mm (Martinez Vidal, 1980). Rarely, it ends in the superior portion of the infundibulum (34% and 30% of the cases), inside the infundibulum (4% and 15%), in the bulla (7%), and in the *hiatus semilunaris* (2% and 1%; Kasper, 1936; Van Alyea, 1946); sometimes, a double recess is found (Laszlo, 1973). More recently, other authors (Bagatella, 1988; Stammberger, 1992; Stammberger and Kennedy, 1995) have questioned its structural autonomy, recog-

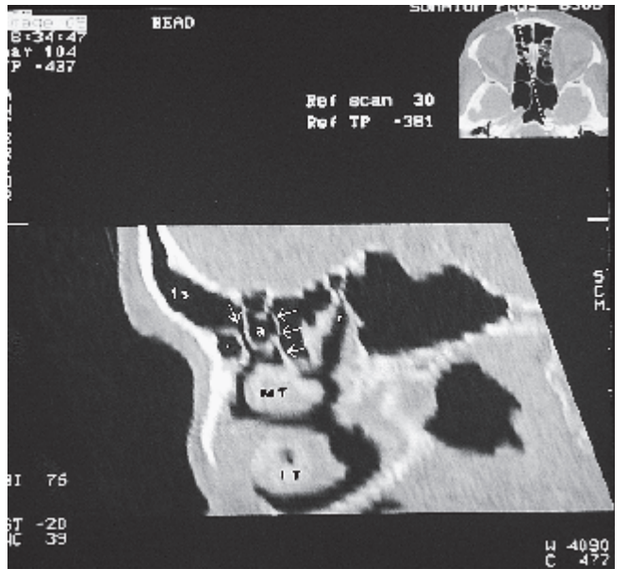

Figure 8. Reconstructed oblique sagittal (*fs*: frontal sinus; +: agger nasi cell; arrow: frontal recess; *a*: anterior ethmoidal cell; *r*: sphenoethmoidal recess; *mt*: middle turbinate; *it*: inferior turbinate; arrows: basal plate).

nising the definition only thanks to the juxtaposition of contiguous formations.

Going posteriorly along the frontal recess, at the top one finds the anterior ethmoidal cells, and at the bottom the bulla, and behind that the posterior ethmoidal cells separated from the anterior ones by the ground lamella (Figure 8). At the rear extremity is the sphenoid sinus and, between this and the posterior ethmoidal cells, the sphenoethmoidal recess.

RESULTS

The frontal recess, studied on one side only, was identified in 21 out of 24 patients. The frontal sinus and the frontal recess of 6 out of these patients were found to be free of disease (Figures 8-9); 9 patients had a recess obstructed by mucus but a frontal sinus almost completely free (Figure 11), in 3 patients the recess was completely obstructed with signs of inflammation in the frontal sinus (Figure 10), and 1 patient, affected by a mucocele,

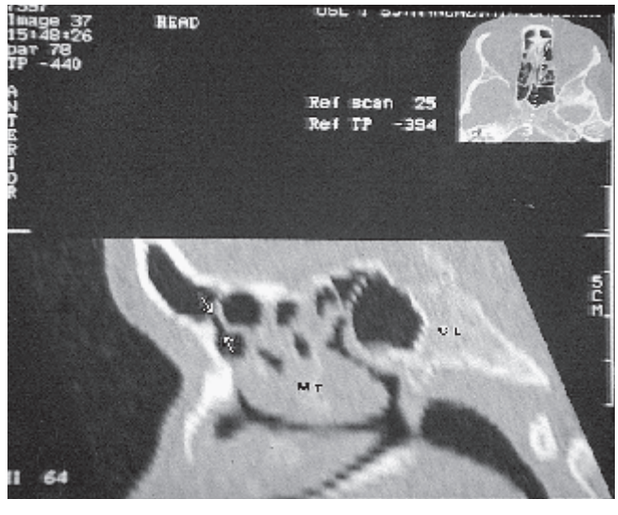

Figure 9. Reconstructed oblique sagittal (*cl*: clivus; *mt*: middle turbinate; arrows: frontal recess).

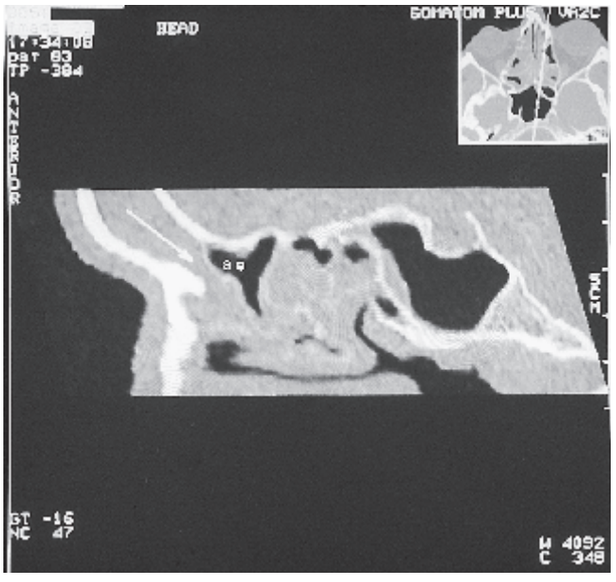

Figure 10. Reconstructed oblique sagittal (*ae*: anterior ethmoidal cell; arrow: obstructed frontal recess).

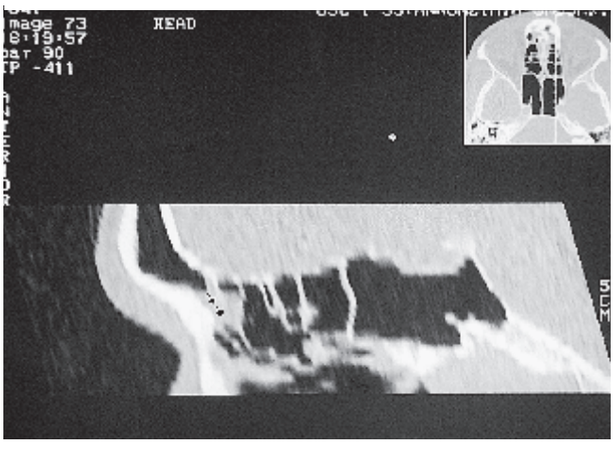

Figure 11. Reconstructed oblique sagittal (arrows: frontal recess obstructed by mucus).

(Figure 7), had the lower part of the sinus and the recess free of pathological processes. In 3 out of 24 patients the frontal recess was not detected, because movement blurs in one case and numerous ethmoidal multiple cavities in the other two patients impeded a correct anatomical evaluation.

DISCUSSION

Due to its sensitivity, CT with paraxial reconstructions (oblique sagittal) obtained from direct axial scans of the frontal sinus and the frontal recess gives accurate diagnostic assistance, allowing one to decide, when confronted with recurrent frontal sinusitis, what is the most suitable treatment to use. The images obtained with the technique described give an exact view of the anatomy of the frontal sinus, the frontal recess and its anterior and posterior relations, which, as is well known, may be subject to individual variations (Bagatella, 1988).

Standard CT examination using direct coronal and axial scans with a thickness of 3 mm and intervals of 4-5 mm is able to recognise the presence of pathological processes within the frontal sinus. The information obtained by this method is insufficient for an exact evaluation of the frontal recess. It is however possible, as we believe we have demonstrated, to represent it through oblique sagittal reconstructions obtained from axial scans, which unlike those used for the standard study of paranasal cavities, have reduced thicknesses from 3 mm to 2 mm and intervals from 4-5 mm to 2 mm. In this way a precise evaluation of the recess is obtained, which, in the light of data observed by Duvoisin and Schnyder (1992), can prevent two opposed but equally erroneous practices: on the one hand, superfluous surgery in treating a recess which has reduced dimensions but is unobstructed, and on the other hand, prolonged medical treatment, which with regard to a recess obstructed by a pathological process can only turn out to be ineffective.

This rapid and simple diagnostic technique, which clearly shows both the morphology and any pathological alterations of the recess, puts one in the ideal position of being able to decide which treatment to use with regard to the frontal sinus' only drainage pathway, whenever it is affected by an acute inflammatory process, either recurrent or chronic.

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