The Journal of Laryngology & Otology, E8, 1 of 4.

doi:10.1017/S0022215107007967

Evaluation of mucosal surface reduction after ethmoidal surgery in nasal polyposis

P Bonfils, P Avan*, P Palimi†, D Malinvaud

Abstract

Objectives: To assess the reduction of mucosal surface after total sphenoethmoidectomy.

Study design: Prospective study.

Methods: Twelve normal, consecutive computed tomography scans were used. Computed tomography measurements were made at two different levels: the cribriform plate, and the upper level of the maxillary antrum. The length of the lateral wall of the ethmoid sinus and the perimeter of each ethmoid cell were measured at each level and on each side. The whole perimeter of the ethmoid sinus was evaluated for each CT scan level. For each side and each level, the ratio between the ethmoid sinus perimeter and the lateral ethmoid wall length was calculated.

Results: The mean length of the lateral ethmoid sinus wall was 61.7 ± 1.3 mm and 59.9 ± 1.6 mm at the upper and lower parts of the ethmoid sinus, respectively. The mean ethmoid sinus perimeter was 263.2 ± 11.5 mm and 250.4 ± 11.1 mm at the upper and lower parts of the ethmoid sinus, respectively. No significant statistical difference was observed between measurements as a function of side (right or left) or level (upper or lower). The mean ratio between the ethmoid sinus perimeter and the lateral ethmoid wall length was 4.2.

Conclusion: After total sphenoethmoidectomy, the mucosal surface of the ethmoid sinuses is reduced by a factor of 4.2; about 76 per cent of the mucosa is removed during total sphenoethmoidectomy.

Key words: Nasal Polyposis; Ethmoidectomy; CT Scan; Functional Endoscopic Sinus Surgery

Introduction

Nasal polyposis affects nearly 4 per cent of the total population in Western countries. It presents a real challenge to the physician because of its severity, chronicity and recurrence rate.[1] Combined surgery and corticosteroid therapy seem effective in the treatment of nasal polyposis, producing significant, long-term improvements in symptoms and nasal polyp size.[2] Functional endoscopic sinus surgery (FESS) techniques were developed in Europe by Messerklinger and Wigand. The extent of surgery required in nasal polyposis is controversial. Total sphenoethmoidectomy could be reserved for the patient with nasal polyposis extensively involving the bilateral paranasal sinuses. The purpose of complete ethmoidectomy is the creation of a unilocular ethmoid cavity with no party walls. The goal of these operations must be restitution of free aeration, drainage of the ethmoid cells, and increased steroid spray penetration.[3,4]

Moreover, endoscopic resection of all party walls of the ethmoid sinuses, with the creation of a large, unilocular ethmoid cavity, necessarily decreases the amount of ethmoid mucosa, and therefore the risk of nasal polyp formation. This consideration is probably one of the most important goals of FESS in patients with nasal polyposis. Nevertheless, this decrease of pathological mucosal surface in the ethmoid sinuses following FESS has never been evaluated in the literature. The aim of this paper was to evaluate mucosal surface reduction after resection of all party walls in ethmoid surgery.

Materials and methods

Principle

Endoscopic total sphenoethmoidectomy generally begins with the inferior resection of the middle turbinate. One-third of this structure is removed. Fenestration of the maxillary antrum is realised after resection of the uncinate process, with identification and widening of the maxillary ostium with retrograde forceps. Then, the posterior ethmoid cells are opened and their party walls are totally removed to the fovea ethmoidalis. The sphenoid ostium is located and opened. After completion of the sphenoidotomy, the anterior ethmoid cells are exenterated and the nasofrontal duct is identified.[4] Figure 1 shows a typical computed tomography (CT) scan after FESS in a patient with severe nasal polyposis. The purpose of complete, total sphenoethmoidectomy is the creation of a unilocular ethmoid cavity with no party walls.

It is not possible to measure the reduction in ethmoidal mucosal surface during ethmoidal surgery. Therefore, the aim of this study was to reproduce the effect of FESS on CT scans. We selected subjects without any nasosinusal pathology in order to clearly identify anatomical structures (i.e. to gain the best contrast between air and bone).

From the Departments of Oto-rhino-laryngology – Head Neck Surgery and †Radiology, European Hospital Georges Pompidou, Assistance Publique – Hôpitaux de Paris, Faculty of Medicine, University Paris-Descartes, Paris, the *Department of Biophysics and Biostatistics, EA2667, Faculty of Medicine, University of Auvergne, Clermont-Ferrand, France.
Accepted for publication: 1 February 2007.

FIG. 1

(a) Axial and (b) coronal computed tomography sections of the paranasal sinuses in a patient with nasal polyposis, following endoscopic complete sphenoethmoidectomy.

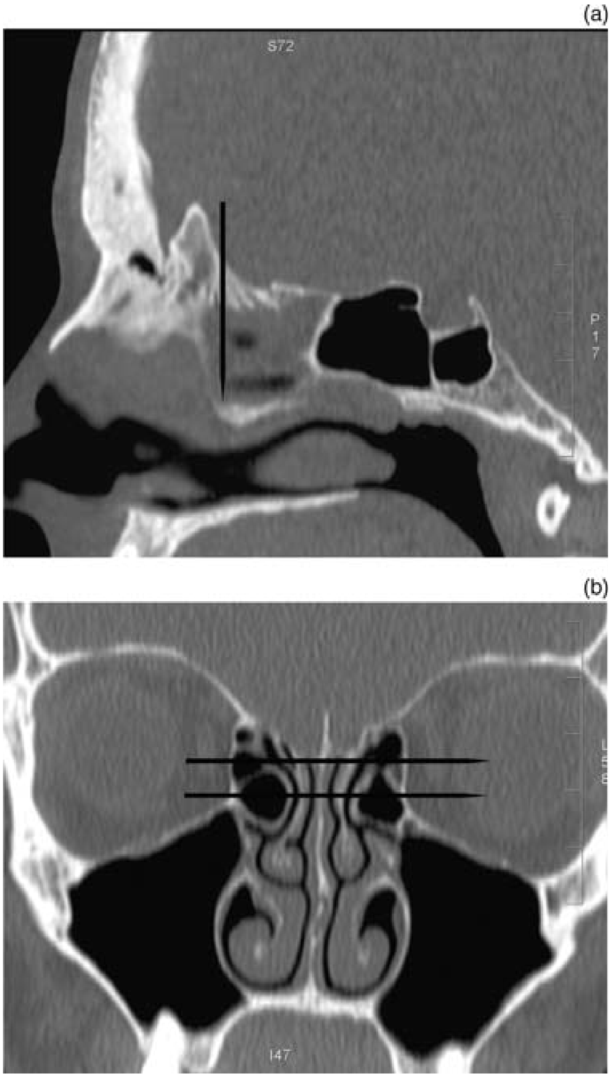

FIG. 2

Computed tomography scans. (a) Sagittal view; the anteroposterior level is defined by the posterior part of the crista galli. (b) Coronal view; the upper level is defined by the cribriform plate, while the lower level is defined by the upper part of the maxillary antrum.

Imaging technique and measurements

Twelve consecutive CT scans were taken in patients with no clinical and/or radiological sinus abnormalities (CT scans were taken for ophthalmological investigations). No subject had chronic rhinosinusitis symptoms. All CT scans showed normal nasal and paranasal sinus cavities.

Computed tomography measurements were performed using the following protocol. The CT scans were performed using a multislice CT machine (GE Lightspeed 64, General Electric Company, Fairfield, Connecticut, United States) with a 1.25 mm slice thickness (120 Kv, 20 mA). Acquisition data were treated on a GE ADW workstation (4.2 version, General Electric Health Care, Milwaukee, Wisconsin, USA), using the reformat tool of the volume viewer software.

From a coronal CT slice located on the posterior basal part of the crista galli, a midline, reformatted, sagittal view was selected (Figure 2a). Two axial slices were selected from this coronal view. The first was chosen at the level of the cribriform plate, passing through the upper part of the ethmoid labyrinth (designated the 'upper level'). The second was chosen at the upper level of the maxillary antrum, passing through the lower part of the ethmoid labyrinth (designated the 'lower level') (Figure 2b).

Two measures were performed: (1) the distance between the anterior and the posterior insertion of the nasal middle turbinate (i.e. the mean length of the lateral wall of the ethmoid sinus) (Figure 3a); and (2) the perimeter of each ethmoid cell (Figure 3b). The perimeter of each ethmoid cell was measured by two methods, in order to take into account the following: (1) the cortical bone is a submillimetric structure; (2) the ethmoid mucosa is not directly visualised; and (3) the algorithmic reconstruction artificially widens the bony wall. These two methods were: delineation of the cell by using the apparent limit between air (black) and cortical bone (white) (performed by the first author); and delineation of the cell by directly following its bony wall (performed by the third author). The mean

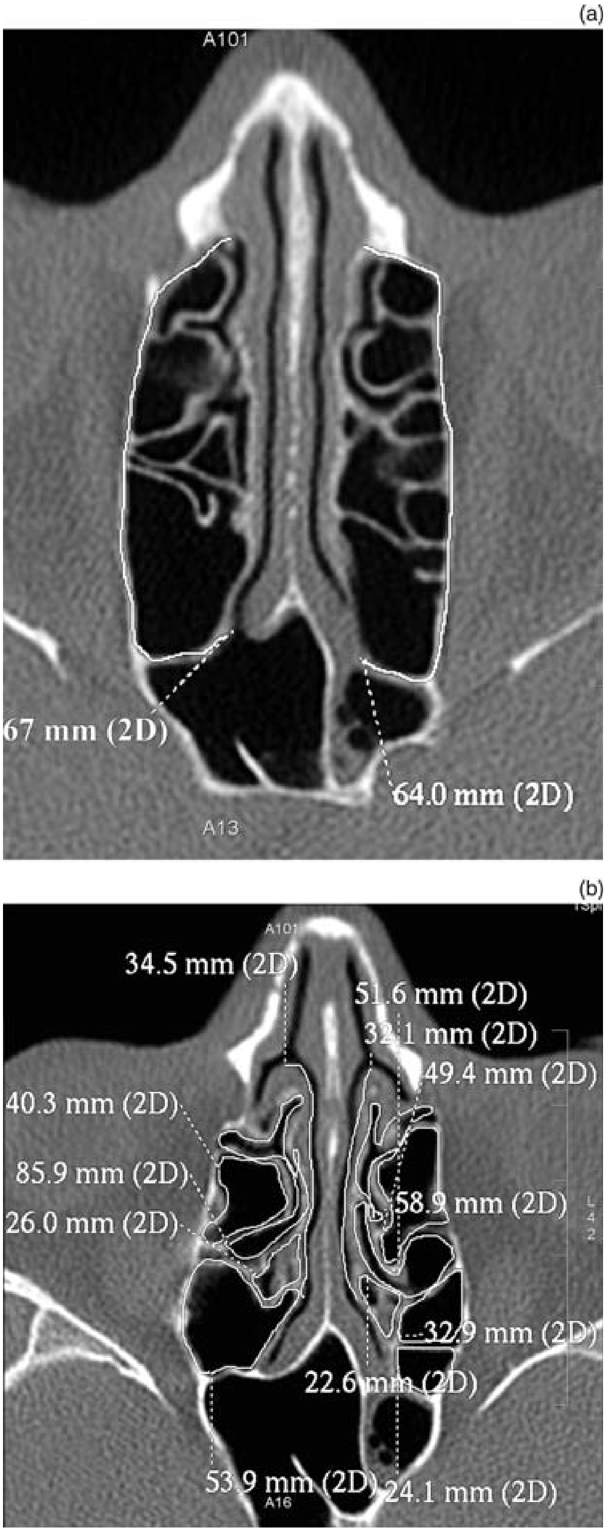

FIG. 3

Example of computed tomography scan measurements of (a) lateral ethmoid sinus wall length and (b) 'ethmoid sinus perimeter'.

perimeter of each ethmoid cell was calculated as the mean value between these two measurement methods. This average was designated the 'perimeter of the cell'. For example, in Figure 3(b), the perimeters of the right ethmoid cells were 34.5, 40.3, 85.9, 26 and 53.9 mm.

Then, for each side (right and left ethmoid sinus), and for each level (upper and lower levels), the sum of the perimeters of each ethmoid cell was calculated. This measure was designated the 'perimeter of the ethmoid sinus'. For example, in Figure 3(b), the perimeter of the ethmoid sinus was 240.6 mm (i.e. the sum of 34.5, 40.3, 85.9, 26 and 53.9 mm). Moreover, for each side and each level, the ratio between the ethmoid sinus perimeter and the lateral ethmoid wall length was calculated. For example, in Figure 3(a) and (b), the ratio between the ethmoid sinus perimeter (i.e. 240.6 mm) and the lateral ethmoid wall length (i.e. 67.7 mm) was 3.55.

Each measure was derived three times in order to determine its variability. Evaluation procedures were performed during three test sessions, which were each separated by one day. For repeated measures, an analysis of variance was performed for the pooled (the three similar measurements) with time as the 'within' factor.

Statistical analysis

Statistical analysis was performed using Statview 5.0 software (Statview, SAS Institute Inc., Cary, North Carolina, USA). Applicable data were expressed as mean ± standard error of the mean. For continuous variables, Student's paired *t*-test was used to compare mean values of the items with standard normal distributions between patients.

Results

Test–retest reliability

The reliability of measurements between the three sessions was evaluated by repeated measures and analysis of variance. No statistically significant difference was noted between the three groups in terms of measures of the lateral ethmoid wall sinus ($p = 0.29$) and measures of the ethmoid sinus perimeter ($p = 0.89$). The mean measure of each structure was calculated as the mean of the three different measures performed.

Measurements of lateral ethmoid sinus wall

The length of the lateral wall of the ethmoid sinus varied, as a function of each CT scan, from 53.3 to 71.2 mm for the upper level, and from 48.5 to 72.3 mm for the lower level. Table I shows the mean length of the lateral wall as a function of level (i.e. upper or lower). The mean length of the lateral wall of the ethmoid sinus did not vary as a function of side (i.e. right or left) ($p = 0.40$ for upper level; $p = 0.38$ for lower level). The mean length, including the two sides, was calculated for the upper and lower levels. No statistically significant difference was observed between the measures as a function of level ($p = 0.40$).

TABLE I

MEAN LATERAL ETHMOID WALL LENGTH AND 'ETHMOID SINUS PERIMETER', BY SIDE AND LEVEL

Position	Lateral ethmoid wall length (mean ± SEM; mm)	'Ethmoid sinus perimeter' (mean ± SEM; mm)
Upper level		
Right side	62.6 ± 1.7	256.5 ± 10.8
Left side	63.8 ± 1.2	269.9 ± 14.6
Mean	61.7 ± 1.3	263.2 ± 11.5
Lower level		
Right side	61.2 ± 2.2	253.4 ± 10.3
Left side	58.7 ± 1.5	248.4 ± 13.4
Mean	59.9 ± 1.6	250.4 ± 11.1

SEM = standard error of the mean

https://doi.org/10.1017/S0022215107007967 Published online by Cambridge University Press

Measurement of ethmoid sinus perimeter

The perimeter of the ethmoid sinus varied, as a function of each CT scan, from 196.5 to 326.7 mm for the upper level, and from 165.7 to 313.8 mm for the lower level. Table I shows the perimeter of the ethmoid sinus as a function of level (i.e. upper or lower). The perimeter of the ethmoid sinus did not vary as a function of side (i.e. right or left) ($p = 0.46$ for upper level; $p = 0.81$ for lower level). The mean perimeter of the ethmoid sinus, including the two sides, was calculated for the upper and lower levels. No statistically significant difference was observed between the perimeters as a function of level ($p = 0.43$).

Evaluation of ethmoid sinus perimeter/lateral ethmoid wall length ratio

For each side and each level, the ratio between the ethmoid sinus perimeter and the lateral ethmoid wall length was calculated (Table II). No statistically significant difference was observed between the ratios as a function of side, either in the upper part ($p = 0.15$) or in the lower part of the ethmoid ($p = 0.75$). A mean ratio, including the two sides, was then calculated for the upper and lower levels. The mean ratio was 4.3 ± 0.1 for the upper level and 4.2 ± 0.1 for the lower level. No statistically significant difference was observed between the ratios as a function of level ($p = 0.69$). A mean ratio evaluated for all sides and all levels was calculated; this was 4.2. Therefore, after total sphenoethmoidectomy, the mucosal surface in the ethmoid sinuses is reduced by a factor of 4.2; that is, about 76 per cent of mucosa is removed during FESS.

Discussion

In the adult, the ethmoidal sinuses form a pyramid, the wider base being located posteriorly. The entire sinus measures 4 to 5 cm along its anteroposterior length. The roof of the sinus (the fovea ethmoidalis) extends an average of 2 to 3 mm above the more medial cribriform plate. The lateral wall is the lamina papyracea, which forms the most constant part of the ethmoid bone. The actual reported size of the sinus and the number of cells vary with each reported series, with one investigator examining 100 specimens and reporting a range of four to 17 cells per specimen, with an average of nine cells. The length of the floor of the nasal cavity in adults, measured between the subspinale and the staphylion, was 41 mm (range 33–57 mm), whereas the floor length between the anterior and posterior nasal spines measured 51.6 mm. This length also varied as a function of gender, being 42.6 mm in men and 40.1 mm in women. The mean length of the middle nasal concha was estimated at approximately 40.6 mm (range 30–54 mm), with a mean value of 40.4 mm in men and 41.2 mm in women.[5,6] All the measurements performed in the current study are in agreement with these previous anatomical data.

Total sphenoethmoidectomy is reserved for the patient with severe rhinosinusitis, or severe nasal polyposis extensively involving the ipsilateral or bilateral paranasal sinuses. Functional endoscopic sinus surgery is especially intended to permit the surgeon to exenterate the ethmoid sinus, using the fovea ethmoidalis as the superior boundary of the dissection.[7] The goal of such operations must be restitution of free aeration, drainage of the ethmoid cells, and decrease of the pathological mucosal surface area. The middle nasal turbinate is a key landmark of ethmoidectomy. It may be partially or completely removed, depending on the extent of the disease with respect to the olfactory cleft. The purpose of complete ethmoidectomy is the creation of a unilocular ethmoid cavity with no party walls.

It is very difficult to evaluate the mucosal reduction achieved during total sphenoethmoidectomy. Such evaluation is not possible during surgery. Anatomical studies may be possible, but there are important technical difficulties. Therefore, the aim of this study was to reproduce the effects of total sphenoethmoidectomy on CT images, and to calculate the reduction of the mucosal surface following FESS. For this purpose, measurements were taken in patients without any sinusal pathology, in order to clearly identify anatomical structures. It was very technically difficult to measure the real surface area of each ethmoid cell and the real surface area of the lateral wall of the ethmoid. Therefore, we calculated an approximate surface area, derived from perimeter measurements for each structure at different levels (i.e. upper and lower) and alternate sides (i.e. right and left). The ratio between the perimeter of the ethmoid sinus and the lateral ethmoid wall length, calculated in this study, represents the mean percentage of mucosal reduction as a result of endoscopic total sphenoethmoidectomy. The reduction of mucosal surface can be estimated at 75 per cent. No previous publication has suggested similar results.

TABLE II

MEAN VALUES FOR RATIO BETWEEN LATERAL ETHMOID WALL LENGTH AND 'ETHMOID SINUS PERIMETER', BY SIDE AND LEVEL

Position	Ratio (mean ± SEM)		p
	Upper level	Lower level	
Right side	4.1 ± 0.1	4.1 ± 0.1	NS
Left side	4.4 ± 0.2	4.2 ± 0.2	NS
Mean	4.3 ± 0.1	4.2 ± 0.1	NS

SEM = standard error of the mean; NS = not significant

Conclusion

Total endoscopic sphenoethmoidectomy reduces the mucosal surface of the ethmoid sinuses by an approximate factor of four.

References

1 Mygind N. Advances in the medical treatment of nasal polyps. *Allergy* 1999;**54**(suppl 53):12–16
2 Bikhazi NB. Contemporary management of nasal polyps. *Otolaryngol Clin North Am* 2004;**37**:327–37
3 Dalziel K, Stein K, Round A, Garside R, Royle P. Systematic review of endoscopic sinus surgery for nasal polyps. *Health Technol Assess* 2003;**7**:1–172
4 Wigand ME. *Endoscopic Surgery of the Paranasal Sinuses and Anterior Skull Base*. New York: Thieme, 1990;101–17
5 Lang J. *Clinical Anatomy of the Nose, Nasal Cavity and Paranasal Sinuses*. New York: Thieme, 1989;56–102
6 Bodino C, Jankowski R, Grignon B, Jimenez-Chobillon A, Braun M. Surgical anatomy of the turbinal wall of the ethmoid labyrinth. *Rhinology* 2004;**42**:73–80
7 Rice DH, Schaefer SD. *Endoscopic Paranasal Sinus Surgery*, 2nd edn. New York: Raven Press, 1993;187–210

Address for correspondence:
Professor Pierre Bonfils,
Otorhinolaryngology,
European Hospital Georges Pompidou,
20 rue Leblanc,
F-75015 Paris, France.

Fax: 33 1 56 09 34 36
E-mail: pierre.bonfils@egp.aphp.fr

Professor P Bonfils takes responsibility for the integrity of the content of the paper.
Competing interests: None declared