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Perennial allergic rhinitis and chronic sinusitis: correlation with rhinologic risk factors

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Background: The reported association of allergy and sinusitis varies greatly between study, and the exact role of allergy in predisposing to sinusitis is not clear. We attempted to determine whether patients with perennial allergic rhinitis are at greater risk of developing sinusitis with respect to a control group, and to determine whether there is a correlation between rhinomanometry, endoscopy, and nasal swab, and computed tomography (CT) findings.

Methods: Forty adult patients with perennial allergic rhinitis underwent CT scans of the paranasal sinuses, and the results were then compared to CTs of the paranasal sinuses of 30 control subjects. All allergic patients underwent nasal endoscopy, nasal swab, and active anterior rhinomanometry, and the results were studied in relation to the CT findings.

Results: We found sinusitis in 67.5% of the allergic patients and in 33.4% of the controls, with a statistically significant difference between the two groups ($P=0.017$). Twenty-three patients had a positive nasal swab; 22 showed increased nasal resistance on rhinomanometry, and 36 had positive endoscopy, but the association of CT findings with endoscopy, rhinomanometry, or nasal swab was not statistically significant ($P=0.583$, $P=1.00$, $P=0.506$, respectively).

Conclusions: Allergic rhinitis is often associated with sinusitis, but the underlying mechanism has yet to be determined. Evidently, factors other than classical pathogen growth and mechanical factors, such as the association of the various factors and immunologic mechanisms, may contribute to the pathogenesis of chronic sinusitis in allergic patients.

Sinusitis is a common disorder occurring in both adults and children; its association with allergic rhinitis has been confirmed by some authors (1–7) but denied by others (8–12).

Table 1. CT staging. ^{a)} 0) no abnormalities, 1) partial opacification, 2) total opacification; ^{b)} 0) not occluded, 2) occluded (from Ref. 20)

Sinus system	Left	Right
Maxillary (0, 1, 2) ^a	–	–
Anterior ethmoid (0, 1, 2) ^a	–	–
Posterior ethmoid (0, 1, 2) ^a	–	–
Sphenoid (0, 1, 2) ^a	–	–
Frontal (0, 1, 2) ^a	–	–
Osteomeatal complex (0 or 2 only) ^b	–	–
Total points	–	–

The association of allergy and sinusitis reported in several studies has varied from 25% to 70% (10, 13), depending on the inclusion criteria and the study methods used. Nevertheless, the exact influence of allergy in predisposition to sinusitis is not clear. Allergy may be one of the underlying factors in acute and chronic sinusitis, since it alters the normal physiology of the paranasal sinuses. Inflamed nasal mucosa and damaged functioning of the ciliary apparatus in allergic patients can block ostial drainage from the sinus and cause stasis of secretions, with the consequent development of infection (13–17). These can take place especially in cases of perennial rhinitis, where the inflammatory stimulus is persistent. According to some studies, repercussions at the level of the sinuses seldom occur in seasonal allergic rhinitis (18). In these patients, the incidence of sinusitis does not seem to be greater than that in the general population (18).

The purpose of this study was to examine the prevalence of sinusitis in patients with perennial allergic rhinitis monosensitized to *Dermatophagoides*, compared with the general population, and to determine whether a cross-correlation between sinusitis and nasal bacteriology, endoscopy, and nasal resistance exists in allergic patients.

Material and methods

From November 1995 to December 1996, subjects were selected from a group of consenting adult patients who had experienced chronic nasal complaints for at least 6 months, and who had not received any medical therapy in the last 3 months or undergone surgery of the nose and paranasal sinuses. Patients with cystic fibrosis or immunodeficiencies were excluded; asthmatic patients were not excluded. Forty consecutive patients monosensitized to *Dermatophagoides* were enrolled in the study. The group comprised 15 males

Table 2. Endoscopic appearance score.

^{a)} 0) absent, 1) catarrhal, 2) purulent; ^{b)} 0) absent, 1) not obstructive, 2) obstructive; ^{c)} 0) absent, 1) present

Secretion	(0, 1, 2) ^a
Polyps	(0, 1, 2) ^b
Inferior turbinate hypertrophy	(0, 1, 2) ^b
Septal deviation	(0, 1, 2) ^b
Paradoxical middle turbinate	(0, 1) ^c
Osteomeatal complex narrowing	(0, 1) ^c

and 25 females, ranging in age from 15 to 61 years (mean age 28.2 years).

All of the patients furnished a detailed medical history and underwent physical examination, nasal endoscopy, nasal swab for culture, active anterior rhinomanometry, and computed tomography (CT) of the paranasal sinuses.

The control group comprised 30 subjects (18 females and 12 males, mean age 30.1 years) who, due to complaints of dizziness, had undergone cranial CT extending to the paranasal sinuses. Therefore, data for comparison with the patient group consisted only of the CT scan; other tests, except for the allergy skin prick test, were not performed for logistic reasons.

Allergy skin tests

Skin prick tests were performed according to the EAACI guidelines (19) for the most common inhalant allergens in Italy, including house-dust mites, pollens, and fungi, with histamine and diluent controls (ALK Abell6). Wheal area was the indicator used to evaluate the skin prick test, and areas greater than 7 mm² (diameter >3 mm) were considered to be positive.

Computed tomography

CT imaging of the paranasal sinuses of allergic patients was carried out along the coronal and axial planes in contiguous 3–5-mm slices. Axial scans were performed from the hard palate to the frontal sinuses on the orbitomeatal plane. The coronal plane was considered to run parallel to the vertical portion of jaw, extending from the sphenoidal sinus to the nasal fossa.

The CT examination of the 30 healthy patients was carried out by axial scanning. Adjoining slices (3–5 mm) were obtained of the paranasal sinuses, including those between the hard palate and the frontal sinuses, oriented along the orbitomeatal plane. Where necessary, the examination was complemented by electronic reconstructions along the coronal and sagittal planes.

CT scans were obtained with soft and bony windows and were interpreted according to the assessment system proposed by the International Conference on Sinus Disease, July 1993 (20). The scans were also reviewed by one of the authors (A.A.), a neuroradiologist experienced in the interpretation of CT sinus scans, who was blinded to the patients' clinical characteristics. Staging was performed with only the axial scans to allow direct comparison of the two groups. Coronal scans in the allergic patients were studied to detect possible abnormalities necessitating surgery. Each sinus (maxillary, anterior ethmoid, posterior ethmoid, sphenoid, and frontal sinus) was graded as follows: 0 (no abnormality), 1 (partial opacification), and 2 (total opacification). The osteomeatal complex was scored as 0 (not occluded) or 2 (occluded) (Table 1). We considered the osteomeatal complex a functional entity comprising the maxillary sinus ostia, ethmoid infundibulum, hiatus semilunaris, and middle meatus.

Nasal endoscopy

A rigid fiberoptic endoscope (Storz, 4 mm, 0°) was used for endoscopic examination. The evaluation included the presence and type of secretions, the presence of nasal polyps, inferior turbinate hypertrophy and septal deviation (graded on a scale of 0–2), and paradoxical middle turbinate and osteomeatal complex narrowing (scored as 0 or 1) (Table 2).

Rhinomanometry

Nasal airflow resistance was measured by active anterior rhinomanometry with a Menfis rhinomanometer. After an acclimation period of about 30 min, the test was performed with the patient seated in a comfortable position. The pressure probe was attached to the nostril with adhesive tape, and a facial mask was worn. Unilateral nasal resistance was calculated according to the following formula: resistance (R) = pressure/flow. For each nostril, the mean flow was read at a pressure of 100 Pa, and the nasal resistance was measured in Pa/cc per s (21–23). Nasal resistance was considered to be normal if the values were less than 0.45 Pa/cc per s.

Bacteriology

Nasal secretions for bacteriologic study were obtained by passing a sterile cotton swab along the middle meatus, avoiding contact with the nasal vestibule. All specimens

were inoculated onto selective media under both aerobic and anaerobic conditions. After incubation at 37°C for 42–48 h, the organisms were identified macroscopically. The media kept under anaerobic conditions were examined 48 and 96 h later, and the thioglycolate medium was cultured for 5 days. All samples were Gram stained, and the bacterial agents were then identified by biochemical identification procedures (24).

The isolated organisms were classified as either classical or nonclassical pathogens, according to Doyle & Woodham (25). Classical pathogens are highly pathogenic with a marked potential for causing disease, while nonclassical pathogens are less pathogenic and may comprise part of the normal flora of the skin and respiratory mucous membranes.

Statistical analysis

The CT-scan results were compared in order to determine the incidence of sinus involvement in both the allergic patients and the controls. For allergic patients, these results were then compared with those of the endoscopy, the nasal swab, and rhinomanometry. All the data were analyzed by the chi-square test, and $P < 0.05$ was considered statistically significant.

Results

Skin prick test

The 40 allergic patients were positive only to *Dermatophagoides*. In the control group, two patients were positive to *Dermatophagoides*, one was positive to grass and olive pollens, and one was positive to grass pollens and *Dermatophagoides*.

Computed tomography

Of the 40 patients studied, 27 (67.5%) had sinus abnormalities with a score ranging from 1 to 17. The average score of the allergic patients with positive CT scans was 5.5. In five cases, the disease was present in a single sinus. In 22 patients, the disease was detected in multiple sinuses, of which 19 cases were bilateral. In 22 patients (81.48%), the disease occurred in the maxillary sinus; in 23 (85.19%), in the ethmoid sinus; in five (18.52%), in the sphenoid sinus; and in four (14.81%), in the frontal sinus. The osteomeatal complex was occluded

in 11 patients and in five of these, bilaterally; among these patients, only two had no abnormalities of the maxillary sinus. Of the 22 patients with abnormalities of the maxillary sinus, 13 were without obstruction of the osteomeatal complex.

The control group comprised 30 subjects, 20 (66.6%) of whom had CT scans of the paranasal sinuses showing no signs of disease (score=0). In 10 subjects (33.4%), there were signs of sinusitis: in six patients in a single sinus, and in four patients in multiple sinuses bilaterally. The average score for the CT scans of the positive control group was 2.5.

There was a statistically significant difference between the allergic patients and the control group ($P=0.017$) in the presence of CT signs of sinusitis (Fig. 1).

Endoscopy

Nasal endoscopy revealed nasal abnormalities in 36 cases; in 33 of these, bilaterally. The most frequent abnormalities were hypertrophy of the inferior turbinates (33 cases, of which 13 were obstructive and five bilateral) and nasal septal deviation (26 cases; in seven, obstructive). Nasal secretions were present in 13 patients; as catarrhal discharge in 11 and purulent discharge in two. In eight cases, there was narrowing of the osteomeatal complex. Four patients had nasal polyps, while none had paradoxical middle turbinate.

No significant correlation was found between the left or right CT and the homolateral endoscopy results ($P=1.00$) (Table 3). Among 69 nasal fossae with positive endoscopy, 40 had positive CT; of 11 nasal fossae with negative endoscopy, six had positive CT. Furthermore, when we examined only those nasal fossae with obstructive abnormalities (25/80), we still did not find a positive correlation with the CT scans ($P=0.583$) (Table 4).

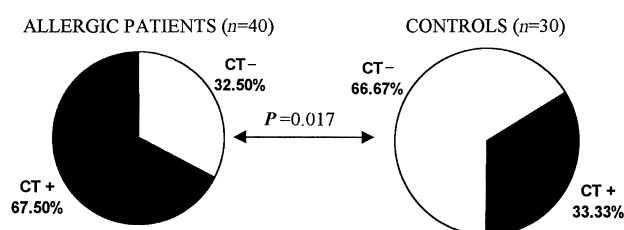


Figure 1. Results, expressed as absolute values and percentage, for CT scans in allergic patients and controls are compared (chi-square test). CT+: presence of paranasal disease; CT-: normal sinus.

Table 3. Correlation between endoscopy and CT scan. Values and percentages (in relationship to total) for CT score and endoscopy results are shown (by chi-square test)

		Endoscopy		Total
		-	+	
CT	-	5 (6.25%)	29 (36.25%)	34
	+	6 (7.5%)	40 (50%)	46
	Total	11	69	80

$P=1.00$

Active anterior rhinomanometry

Bilateral normal nasal resistance was observed in 18 of the 40 patients studied. Increased nasal resistance was found in 22 cases, being bilateral in seven. The mean increased nasal resistance was 1.65 Pa/cc per s.

We examined the association of positive left or right CT with the results of rhinomanometry of the homolateral nasal fossae. Of 29 nasal fossae with increased nasal resistance on rhinomanometry, 17 (58.6%) had positive CT; of 51 nasal fossae with normal rhinomanometry, 29 (56.9%) had positive CT. The correlation between rhinomanometry results and the CT findings was not significant ($P=1.00$) (Table 5).

Bacteriology

A total of 40 nasal swabs was obtained. When cultured, those of 17 patients did not show pathogen growth, while 23 showed the growth of one or more aerobic organisms. The most common agents isolated were *Staphylococcus aureus* (12 cases), *Klebsiella pneumoniae* (five cases), and *Pseudomonas aeruginosa* (five cases). The other bacteria isolated were *Staphylococci coagulans negativi* (three cases) and

Table 4. Correlation between endoscopy (obstructive abnormalities) and CT scan. Values and percentages (in relationship to total) for CT score and examination for presence of obstructive abnormalities of nasal fossa are shown (P by chi-square test)

		Endoscopy		Total
		+	-	
CT	+	16 (20%)	30 (37.5%)	46
	-	9 (11.25%)	25 (31.25%)	34
	Total	25	55	80

$P=0.583$

Table 5. Correlation between rhinomanometry and CT scan. Values and percentages (in relationship to total) for CT score and nasal rhinomanometry are shown (*P* by chi-square test)

		Rhinomanometry		Total
		-	+	
CT	-	22 (27.5%)	12 (15%)	34
	+	29 (36.25%)	17 (31.25%)	46
	Total	51	29	80

P=1.00.

Proteus mirabilis (two cases). Anaerobic bacteria were not detected.

Of the 27 patients with positive CT, 17 had a positive nasal swab (62.96%); of the 13 patients with negative CT, six had a positive nasal swab (46.15%). The correlation between the results of the nasal swab and CT findings was not significant (*P*=0.506) (Table 6).

Discussion

Using various methods, many previous works have examined the association between atopy and sinusitis. Several of these reported that patients with sinusitis have a higher incidence of positive allergy skin tests than the normal population (4, 5). Other studies examined the incidence of sinusitis in allergic patients and concluded that chronic sinusitis could represent a complication of perennial allergic rhinitis (2, 3, 6). Hoover et al. (7) found a significant association between atopy, asthma, eosinophilia and extensive chronic sinusitis, with a particularly close correlation between eosinophilia and extensive sinusitis. They concluded that chronic sinusitis could be a disease arising from the immune activation of lymphocytes and suggested that the presence of atopy should be considered a risk factor for extensive sinusitis.

In other studies in which allergic patients were compared with nonatopic patients with nasal complaints, no correlation was found between allergic rhinitis and sinusitis (10, 11). These studies concluded that the presence of sinus disease is not determined by the presence of allergy, but by the existence of chronic nasal symptoms (allergic or nonallergic). Other authors agreed that allergic rhinitis is not a risk factor for sinusitis (8, 9, 12). In these studies, the results may be criticized because the control groups were made up of nonallergic patients with chronic nasal symptoms (10, 11) who probably were suffering from chronic

Table 6. Correlation between nasal swab and CT scan. Values and percentages (in relationship to total) for CT score and nasal swab result are shown (*P* by chi-square test)

		Nasal swab		Total
		+	-	
CT	+	17 (42.5%)	10 (25%)	27
	-	6 (15%)	7 (17.5%)	13
	Total	23	17	40

P=0.506.

infectious rhinitis, which can easily become complicated by sinus involvement. For this reason, a similar incidence of paranasal disease in the two groups would not be unexpected. Furthermore, it is important to determine whether the patients examined had perennial or seasonal allergic rhinitis, since it has been demonstrated that the latter does not predispose to sinusitis (18).

In yet other studies, the difference in results can be explained by the different methods used. For example, some authors used standard radiography to study the paranasal sinuses (2, 6), but it may be objected that radiographs of the paranasal sinuses are characterized by high false-positive and false-negative rates, especially in the diagnosis of chronic forms of disease (26–29). In our study, we used CT scans instead of plain radiographic films, because they allow a clearer evaluation of the paranasal sinuses, especially of the ethmoid sinuses and osteomeatal structures (14, 28). This is particularly important because the ethmoid sinus is the part most often involved in sinus infection, together with the maxillary sinus (10, 30–34).

Some authors maintain that magnetic resonance imaging (MRI) is more accurate than CT for soft-tissue analysis (35, 36). Nevertheless, the use of MRI to diagnose sinusitis has some drawbacks: its high cost, the need of sedation in patients with claustrophobia, and the lack of data on bone tissue (37).

Another important problem is that the results of the various studies are not easily comparable, since they are based on different examination methods. To define and stage the disease, we used the system proposed by the International Conference on Sinus Disease in July 1993 (20). This is a relatively simple and unambiguous assessment that can be used with equal facility by radiologists and otolaryngologists.

In our study, we attempted to determine whether patients with perennial allergic rhinitis are at greater risk of developing sinusitis than the general population as a control

group. We detected sinus involvement on CT scans in 67.5% of allergic patients and in 33.4% of a control group. This statistically significant difference ($P=0.017$) supports the hypothesis that there is an important association between allergic rhinitis and sinusitis. Furthermore, we observed that allergic patients exhibited more frequent bilateral or multiple involvement of the paranasal sinuses with a higher average CT score than the general population.

Most of our allergic patients showed positive endoscopy results (hypertrophy of the turbinates is very common in such patients), and for this reason no useful information could emerge from statistical analysis. Even when we examined only the subgroup of patients with obstructive abnormalities, no significant correlation with the CT results was found. Our findings agree with the data reported by Nguyen et al., who suggest that sinusitis is seldom associated with these obstructive abnormalities in children (11). Nasal obstruction due to mucosal edema is considered to be the *primum movens*, which, by blocking ostial drainage from the sinuses and causing the stasis of secretions, encourages the development of infection in allergic rhinitis (2, 14, 15). We therefore studied the possible correlation between increased nasal resistance in a single nasal fossa (employing active anterior rhinomanometry) and signs of sinusitis in CT, but we failed to find a positive association. Furthermore, we noted no correlation between a positive nasal swab and CT abnormalities of the paranasal sinuses. The latter result could be explained by the fact that apparently the culture of nasal swabs seldom corresponds to the culture of sinus specimens (2, 38–40). Therefore, the culture of nasal specimens has no predictive value for the

evaluation of bacteria in infected sinuses, but, unfortunately, the collection of sinus specimens is possible only during sinus surgery. However, Pelikan and Pelikan-Filipek (1) have suggested that the edema of sinus endothelium and opacification after antigen challenge may be due to mediator release rather than to infection.

Evidently, factors other than mechanical problems or classical pathogen growth, such as an immunologic mechanism or the association of the multiple factors, may contribute to the pathogenesis of sinusitis in allergic patients. Immunologic factors may play an important role, as suggested by studies that have demonstrated the accumulation in the sinus mucosa of activated eosinophils (41) and of cytokines (such as interleukin-3 and granulocyte-macrophage colony-stimulating factor) which promote eosinophil accumulation and activation (42). Through the release of their granules which contain toxic proteins such as eosinophil cationic protein and major basic protein, eosinophils may cause chronic inflammation of mucosa, even in the absence of microorganisms (42). In addition to immunologic factors, the patency of the ostia, the functioning of the ciliary apparatus, and the quality of the nasal secretions are important elements in the normal physiology of the paranasal sinuses, and these may be altered in allergic rhinitis.

In conclusion, our results suggest an association of perennial allergic rhinitis with chronic sinusitis; allergic patients exhibit more extensive sinusitis than the general population, but there are no correlations between positive CT findings and positive rhinomanometry, nasal swab, or endoscopy in allergic patients.

References

1. Pelikan Z, Pelikan-Filipek M. Role of nasal allergy in chronic maxillary sinusitis – diagnostic value of nasal challenge with allergen. *J Allergy Clin Immunol* 1990;**86**:484–491.
2. Rachelefsky GS, Katz RM, Siegel SC. Chronic sinusitis in the allergic child. *Pediatr Allergic Dis* 1988;**35**:1091–1101.
3. Sacha RF, Trembray NF, Jacobs RL. Chronic cough, sinusitis and hyperreactive airways in children: an overlooked association. *Ann Allergy* 1985;**54**:195–198.
4. Savolainen S. Allergy in patients with acute maxillary sinusitis. *Allergy* 1989;**44**:116–122.
5. Rachelefsky GS, Siegel SC, Katz RM, Spector MD, Rohr AS. Chronic sinusitis in children [Abstract]. *J Allergy Clin Immunol* 1991;**87**:219.
6. Furukawa CT. The role of allergy in sinusitis in children. *J Allergy Clin Immunol* 1992;**90**:515–517.
7. Hoover GE, Newman LJ, Platts-Mills TAE, Philips CD, Gross CW, Wheatley LM. Chronic sinusitis: risk factors for extensive disease. *J Allergy Clin Immunol* 1997;**100**:185–191.
8. Clement PAR, Bijloos J, Kaufman L, et al. Incidence and etiology of rhinosinusitis in children. *Acta Otorhinolaryngol Belg* 1989;**43**:523–543.
9. Kennedy DW. Medical management of sinusitis: educational goals and management guidelines. *Ann Otol Rhinol Laryngol* 1995;**104 Suppl 167**:22–31.
10. Iwens P, Clement PAR. Sinusitis in allergic patients. *Rhinology* 1994;**32**:65–67.
11. Nguyen KL, Corbett ML, Garcia DP, et al. Chronic sinusitis among pediatric patients with chronic respiratory complaints. *J Allergy Clin Immunol* 1993;**92**:824–830.
12. van der Veken PJV, Clement PAR, Buisseret TH, Desprechins B, Kaufman L, Derde MP. CT scan study of the incidence of sinus involvement and nasal anatomic variations in 196 children. *Rhinology* 1990;**28**:177–184.
13. Furukawa CT, Sharpe M, Bierman CW, et al. Allergic patients have more frequent sinus infections than non-allergic patients [Abstract]. *J Allergy Clin Immunol* 1992;**89**:332.
14. Calhoun K. Diagnosis and management of sinusitis in the allergic patient. *Otolaryngol Head Neck Surg* 1992;**107**:850–854.
15. Reilly JS. The sinusitis cycle. *Otolaryngol Head Neck Surg* 1990;**103**:856–862.

16. Slavin RG. Sinusitis in adults and its relation to allergic rhinitis, asthma, and nasal polyps. *J Allergy Clin Immunol* 1988;**82**:950–956.
17. Mabry RL. Allergic and infective rhinosinusitis: differential diagnosis and interrelationship. *Otolaryngol Head Neck Surg* 1994;**111**:335–339.
18. Melen I, Ivarsson A, Schrewelius C. Ostial function in allergic rhinitis. *Acta Otolaryngol (Stockh)* 1992;**Suppl 492**:82–85.
19. EAACI Subcommittee on Skin Tests. Dreborg S, Frew A, editors. Position paper. Allergen standardization and skin tests. *Allergy* 1993;**48 Suppl 14**:49–61.
20. Lund VJ, Kennedy DW. Quantification for staging sinusitis. *Ann Otol Rhinol Laryngol* 1995;**104 Suppl 167**:17–21.
21. Clement PAR. Committee report on standardization of rhinomanometry. *Rhinology* 1984;**22**:151–155.
22. Cole P. Rhinomanometry 1988; practice and trends. *Laryngoscope* 1989;**99**:311–315.
23. Jones AS, Lancer JM, Stevens JC, Phil D, Beckingham E. Nasal resistance to airflow (its measurement, reproducibility and normal parameters). *J Laryngol Otol* 1987;**101**:800–808.
24. D'Amato RF, Baron EJ, Johnson RC, Murray PR, Rodgers FG, Graeventg A. Bacteria. In: Balows A, Hawsher WJ, Herman KL, Isenberg HD, Shadony HJ, editors. *Manual of clinical microbiology*. Washington, DC: American Society for Microbiology, 1991:209–572.
25. Doyle PW, Woodham JD. Evaluation of the microbiology of chronic ethmoid sinusitis. *J Clin Microbiol* 1991;**29**:2396–2400.
26. Zinreich SJ, Kennedy DW, Rosenbaum AE, Gayler BW, Kumar AJ, Stammberger H. Paranasal sinuses: CT imaging requirements for endoscopic surgery. *Radiology* 1987;**163**:769–775.
27. Carter BL, Runge US. Imaging modalities for the study of the paranasal sinuses and nasopharynx. *Otolaryngol Clin North Am* 1988;**21**:395–420.
28. Zinreich SJ. Paranasal sinus imaging. *Otolaryngol Head Neck Surg* 1990;**103**:863–869.
29. Lusk RP, Rande HL, Muntz HR. The diagnosis and treatment of recurrent and chronic sinusitis in children. *Pediatr Clin North Am* 1989;**36**:1411–1421.
30. Gordts F, Clement PAR, Buisseret Th. Prevalence of paranasal sinus abnormalities on MRI in a non-ENT population. *Acta Otorhinolaryngol Belg* 1996;**50**:167–170.
31. Patel K, Chavda SV, Violaris N, Pahor AL. Incidental paranasal sinus inflammatory changes in a British population. *J Laryngol Otol* 1996;**110**:649–651.
32. Cooke LD, Hadley DM. MRI of the paranasal sinuses: incidental abnormalities and their relationship to symptoms. *J Laryngol Otol* 1991;**105**:278–281.
33. Lloyd GAS. CT of the paranasal sinuses: study of a control series in relation to endoscopic sinus surgery. *J Laryngol Otol* 1990;**104**:477–481.
34. Havas TE, Motbey JA, Gullane PJ. Prevalence of incidental abnormalities on computed tomographic scans of the paranasal sinuses. *Arch Otolaryngol Head Neck Surg* 1988;**114**:856–859.
35. Katz RM, Friedman S, Diamant M, et al. A comparison of imaging techniques in patients with chronic sinusitis (X-ray, MRI, A-mode ultrasound). *Allergy Proc* 1995;**16**:123–127.
36. Moore J, Potchen M, Waldenmaier N, Sierra A, Potchen EJ. High field magnetic resonance imaging of paranasal sinus inflammatory disease. *Laryngoscope* 1986;**96**:267–271.
37. Zinreich SJ, Kennedy DW, Kumar AJ, Rosenbaum AE, Arlington JA, Johns ME. MR imaging of normal nasal cycle: comparison with sinus pathology. *J Comput Assist Tomogr* 1988;**12**:1014–1019.
38. Sener B, Hascelik G, Onerci M, Tunckanat F. Evaluation of the microbiology of chronic sinusitis. *J Laryngol Otol* 1996;**110**:547–550.
39. Almadori G, Bastianini L, Bistoni F, et al. Microbial flora of nose and paranasal sinuses in chronic maxillary sinusitis. *Rhinology* 1986;**24**:257–264.
40. Orobello PW, Park RI, Belcher LJ, et al. Microbiology of chronic sinusitis in children. *Arch Otolaryngol Head Neck Surg* 1991;**117**:980–983.
41. Harlin SL, Ansel DG, Lane SR, Meijers J, Kephart GM, Gleich GJ. A clinical and pathologic study of chronic sinusitis: the role of eosinophils. *J Allergy Clin Immunol* 1988;**81**:867–875.
42. Hamilos DL, Leung DYM, Wood R, et al. Chronic hyperplastic sinusitis: association of tissue eosinophilia with mRNA expression of granulocyte-macrophage colony-stimulating factor and interleukin-3. *J Allergy Clin Immunol* 1993;**92**:39–48.