

Olfactory function after functional endoscopic sinus surgery for chronic sinusitis*

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SUMMARY

One hundred and fifteen patients suffering from chronic sinusitis were observed to analyse the prevalence of olfactory dysfunction and the influence of FESS. Pre-operative questionnaires were supplemented by examination of olfactory thresholds and discrimination. Pre-operatively, 58% of the collective were aware or complained of any olfactory deficit. However, the olfactory tests demonstrated that of the collective 52% were hyposmic and 31% anosmic. Eight per cent of the hyposmic patients presented with an isolated reduction of their ability to discriminate odours. Post-operative improvements were found in 70%. Normosmia was post-operatively achieved in 25% of the hyposmic patients, but only in 5% of the anosmic patients. Olfaction changed to the worse in 8% after FESS. Therefore, the prevalence of olfactory dysfunction in chronic sinusitis is pre-operatively higher, and the rate of improvement is lower than generally assumed. The extent of sinus disease as measured by the degree of intranasal polyposis correlates with olfactory dysfunction. Resections of the middle turbinate may have a negative effect on olfaction, due to damage to the olfactory fila or alteration of the normal aerodynamic pattern within the olfactory cleft. However, this hypothesis is based on a few observations and needs to be verified by further investigations.

Key words: chronic sinusitis, sinus surgery, olfaction

INTRODUCTION

More than 20% of all cases of olfactory disorders are associated to chronic sinusitis, which is therefore one of the most frequent causes of smell dysfunction (Henkin, 1981; Goodspeed et al., 1987; Seiden and Smith, 1988; Doty et al., 1991; Deems et al., 1991). Although the prevalence of chronic sinusitis is known to be high within the northern parts of Europe and the USA, the pathophysiological and epidemiological knowledge of the associated olfactory dysfunction is still limited. Most of the publications related to the clinical aspects of chronic sinusitis have focused on the respiratory complaints of the patients – i.e. nasal obstruction, hypersecretion, and craniofacial pain – while olfactory function obtained a minor degree of interest (Sogg, 1989; Loury and Kennedy, 1992). Moreover, the therapeutical efficacy of functional endoscopic sinus surgery (FESS) is usually evaluated by measuring the improvement of nasal respiratory function, whereas olfactory tests are optional and even rudimentary (Doty et al., 1991). Although a number of patients is said to be unaware of their sensory deficits, the sense of smell is often judged on the patient's reports and *a priori* assumptions (Doty et al., 1991). The primary purpose of this study is to ana-

lyse the characteristics of olfactory dysfunction in chronic sinus disease and the therapeutical influence of FESS.

PATIENTS AND METHODS

A total of 115 adults (63 males and 52 females) with chronic sinusitis was evaluated. The age ranged from 14 to 79 years with an average of 44 years. Patients having unilateral sinusitis and/or previous surgical treatments of the sinuses were excluded from the study. Moreover, patients with an established allergy or an history pointing to allergic rhinosinusitis were excluded. Additional adenotonsillectomy was not performed. All patients were examined by nasal endoscopy, cross-sectional CT scans (2 mm) and anterior rhinomanometry 10 min after application of 0.01% xylometazoline (Otriven®). According to the extent of the disease as determined by CT scan and rigid endoscopy the patients were classified into four groups. The classification considered both the radiological and mucosal appearance of the disease (Figure 1).

Olfactory tests were performed 1-4 days before and 67±16 days after the surgical treatment (FESS). The examination included a questionnaire on the patient's subjective abilities to smell and

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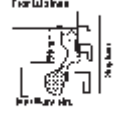

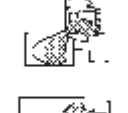

Group	CT-Scan	Endoscopy	No. of Patients	Characterization of the disease pattern
A	Thickened mucosa in the upper part of the nasal cavity swelling of the middle turbinate in the upper part of the nasal cavity	No endonasal polyps slightly hypertrophied inferior turbinate	25	
B	Supratentorial extension of the middle turbinate and the inferior turbinate in the upper part of the nasal cavity	Polyps restricted to the area between the middle turbinate and the lateral nasal wall	24	
C	Constriction between the septum and the middle turbinate in the upper part of the nasal cavity	Polyps with the middle turbinate	46	
D	Severe constriction of the middle turbinate	Subtotal nasal blockage in the upper part of the nasal cavity	20	

Figure 1. Classification of the collective of 115 patients according to the endoscopic and radiological (CT-scan) extent of chronic sinusitis.

taste as well as the duration of chemosensory dysfunctions. The olfactory tests were based on psychophysical methods and included both a quantitative and a qualitative olfactory examination. The initial evaluation of the tests was performed in a population of 100 healthy adults and were published *alio loco*. Polyethylene squeeze-bottles (volume: 200 ml) were used for the presentation of the odorants: Quantitative olfactory function was determined using six geometrically scaled dilutions of dimethyldisulfide (DMDS; foul smelling) and 2-phenylethanol (pleasant smelling). Scale 1 contained approximately 1:20 of the physiological threshold concentrations of DMDS and 2-phenylethanol, respectively. Scale 6 was equivalent to 1,000

ppm 2-phenylethanol and 200 ppm DMDS, which were supra-threshold concentrations. The test followed a triple forced-choice procedure. After standardization of the test in 100 healthy adults scales 3 and 2 were found to be normal thresholds for 2-phenylethanol and DMDS, respectively (Krugel, 1989). Hyposmia was diagnosed when the threshold of the individual corresponded to a higher scale, i.e. a higher concentration of the odorous substances.

The abilities of the patients to discriminate odours were examined using eight different substances of suprathreshold concentrations. The test consisted of eight steps with each of them containing the presentation of three bottles. Two of the bottles were filled with the same odorant, whereas the third bottle contained another one. The patients' exclusive task was to indicate the two bottles with the same smell. A verbal nomination and identification of the odours was not required. After standardization the olfactory discrimination was diagnosed to be pathological if the individual correctly discerned less than 6 out of 8 items (Krugel, 1989). Patients having a pathological olfactory discrimination were defined to be hyposmic.

The chemogustatory function was tested with solutions of 4% glucose, 1% citric acid, 2.5% saline and 0.075% quinine. The taste was found to be normal, if the terms "sweet", "sour", "salty" and "bitter" were correctly associated to the offered solutions.

All patients underwent bilateral FESS. The surgical technique was equivalent to the methods published by Wigand (1989). Deviations of the nasal septum and/or hypertrophies of the inferior conchae were surgically corrected in 35% of the patients. Post-operative care included subtle removal of crusts and secretions as well as the application of saline solution or lubricative nose drops for about three weeks.

Table 1. Results of the pre- and post-operative olfactory tests and of the pre-operative questionnaires in 115 patients with chronic sinusitis with regard to the extent of the disease (groups A-D).

	Total n=115	Preoperative Test Results											
		Normosmia 19 (=16%)				Hyposmia 60 (=52%)				Anosmia 36 (=31%)			
		A	B	C	D	A	B	C	D	A	B	C	D
Preoperative Self-Rating	normal 48 (=42%)	8	9	0	0	13	6	12	0	0	0	0	0
	reduced 39 (=34%)	1	1	0	0	2	4	21	1	0	3	4	2
	absent 28 (=24%)	0	0	0	0	0	0	0	1	2	6	9	10
Postoperative Test Results	Normosmia 36 (=31%)	8	8	0	0	11 2*	2 3*	5 15*	0	0	0	2	0
	Hyposmia 66 (=57%)	1	2	0	0	4	5	26	1	0	9	11	7
	Anosmia 13 (=11%)	0	0	0	0	0	3	2	1	2	0	0	5

*: Number of pre-operatively hyposmic patients showing post-operatively an improvement but not a normosmia.

RESULTS

Pre-operative olfactory tests

Pre-operative olfactory examination demonstrated anosmia in 31% (n=36), hyposmia in 52% (n=60) and normosmia in 17% (n=19) of the patients (Table 1). A more detailed analysis concerning the extent of sinus disease showed that the group-A and group-B patients (n=55) suffering from milder degrees of chronic sinusitis were normosmic in 35% (n=19), hyposmic in 45% (n=25) and anosmic in 20% (n=11). On the other hand, patients of groups C and D with signs of advanced sinus disease (n=60) expressed hyposmia in 58% (n=35) and anosmia in 42% (n=25). No patient of groups C and D was found to have a normal smell. Pre-operative normosmia was exclusively demonstrated in patients of groups A and B, whereas all of the others (groups C and D) expressed olfactory disorders of different degrees. Anosmia was demonstrated in 8% (2/26) of group A, 31% (9/29) of group B, 40% (13/33) of group C, and 86% (12/14) of group D.

Pre-operative self-rating of olfaction

The self-ratings (Table 1) followed a diametrical trend: Pre-operatively, the patients estimated their smell sensitivity to be normal in 42% (n=48), reduced in 34% (n=39) and absent in 24% (n=28). Patients noticing olfactory dysfunction (n=67) dated back the onset of their complaints between 2 months and 4 years with an average of 10.5 months. The comparison between the self-ratings and the results of the olfactory tests showed a false-positive estimation of smell sensitivity in 40% (22/55) of the patients in groups A and B and in 30% (18/60) of the patients in groups C and D. Two per cent (3/115) of the collective complained of olfactory dysfunction in terms of a false-negative estimation. Only 28% of all patients estimated their pre-operative smell sensitivity correctly and in accordance to the olfactory tests.

The diagnosis of hyposmia was based on pathological olfactory thresholds in 52% (31/60). Both olfactory discrimination and thresholds were abnormal in 40% (24/60) of the hyposmic patients. Furthermore, it should be well noted that hyposmia was recognized in 8% (5/60) exclusively on decreased olfactory discrimination.

Post-operative olfactory tests

Post-operatively, anosmia was observed in 11% (n=13), hyposmia in 57% (n=66) and normosmia in 31% (n=36) of the collective (Table 1). After FESS improvements of the olfactory thresholds and/or the olfactory discrimination occurred in 70% (n=67) of the hyposmic or anosmic patients (n=96). Twenty-one per cent (n=20) achieved post-operative normosmia.

The most remarkable changes occurred in patients who suffered pre-operatively from anosmia: Olfaction improved in 80% (29/36) of them. However, normosmia was reached only in 5% (2/36) of these cases.

Hyposmic patients presented an increased smell sensitivity in 63% (38/60), but post-operative normosmia was merely seen in 25% (18/60) of them. A definite improvement was most evident in hyposmic patients of groups A and B, i.e. milder degrees of the sinus disease (n=25): 18 of them benefitted from the operation. Olfaction decreased post-operatively in 8% (9/115). In five of these worse cases, polyposis was limited and appropriate to group B. However, all of these cases showed major polypoid alterations of the middle turbinates requiring resections of more than the posterior one-third of them. Already 6 weeks after FESS, one of the patients sensed a new onset of nasal obstruction and a reduction of smell sensitivity which was initially undisturbed, i.e. normal after the operation. Despite subtle post-operative care polyps and granulations grew aggressively within the upper one-third of the nasal cave. Histopathological biopsies demonstrated the development of inverted papilloma, which was cured meanwhile by lateral rhinotomy. The post-operative decrease in olfactory function of the other patients in question is not clear until yet.

DISCUSSION

According to aetiological studies performed at different medical centres, more than 20% of all patients with olfactory impairment have chronic sinusitis (Henkin, 1981; Goodspeed et al., 1987; Seiden and Smith, 1988; Deems et al., 1991; Doty et al., 1991). The published incidence of smell dysfunction in chronic sinusitis lies in a wide range of 14-70% (Figures 2-3). The reports and questionnaires of the present study show that 58% of all patients noticed a pre-operative olfactory deficit, which was initially present, on average, 10.5 months (range: 2 months to 4 years)

Table 2. Pre- and post-operative olfactory function in patients with chronic sinusitis published in the literature (a: changes of the olfactory function registered in the early and late post-operative phase, respectively; b: a total of 220 patients).

Author	preoperative olfactory dysfunction (%)	postoperative improvement (%)	postoperative change to the worse (%)
Bagatella u. Mazzoni (1986)		41	
Flemming et al. (1967)	14	39-100 ^a	
Hosemann et al. (1993)	65	78	6
Jankowski (1991)	72	50	
Lildholdt et al. (1988)	42 (n=27)	67-73	0
Loury u. Kennedy (1991)	30		
Lund et al. (1991)	29 (n=7)	0	0
Thumfart u. Conrad (1986)	70	50-45 ^a	10-15 ^a
Wigand (1989)	40 (n=14)	84.9 ^b	6.9 ^b
Williams (1959)		40	
Yamagishi et al. (1989)		70-80	

before admission. However, 83% of the collective were identified to suffer from those deficits using detailed olfactory tests. This is the highest percentage published as yet (Table 2). With regards to the discrepancies between the self-rated and the proved olfactory functions we were not able to analyse precisely whether the duration of olfactory deficits correlated with their restitution after FESS or not. The hypothesis that long-standing anosmia would be more difficult to cure, can therefore only be verified by olfactory examinations performed months and years in advance of operative therapy, and should not be based on patients' reports.

No patient with intranasal polyposis of marked size (groups C and D) was found to be normosmic. Eighty-six per cent of the cases with severe polyposis (group D) pre-operatively had a complete loss of smell. Pre-operative normosmia was only present in 35% of the cases with no intranasal polyposis (group A), i.e. 17% of the total collective.

The results clearly demonstrate a correlation between the dimension of intranasal polyposis and the severity of olfactory dysfunction, as it was proposed by other authors before (Coward et al., 1993). The major aetiological factor for loss of smell in chronic sinusitis is supposed to be mechanical blockage of the upper nasal airway by polyps. Additionally, inflammatory damage to the neuroepithelium and alterations of the olfactory mucosal membrane may be other important causative factors (Aiba and Nakai, 1991; Egawa, 1995). These assumptions can be clinically supported by the fact that 8% of the anosmic patients had no intranasal polyposis (group A) and 14% of the patients with near-complete polypoid obstruction of the nasal cavity (group D) have been found to have a residual smell function.

It should be emphasized that 30-40% of all patients with chronic sinusitis presented with a false-positive estimation of their smell abilities, i.e. they were not aware of their smell deficits. No patient has reported smell dysfunction, which is not detectable by detailed olfactory examination. These observations are in contrast to some parts of the literature: Hosemann et al. (1993), for example, have suggested that more than 90% of the patients with evident olfactory dysfunction should be well aware of their deficits. Other authors have found that a large number of patients inadvertently attribute symptoms of flavour loss to taste dysfunction and do not realize the presence of olfactory disorders (Doty et al., 1991). Whatever the right view, the published data (including ours) point to the high risk of disagreement between patients and rhinosurgeon when olfactory function is judged solely by *a priori* assumptions and patients' reports. Therefore, the present data stress the necessity of olfactory examination in order to prevent those discrepancies.

Examination of integrative olfactory functions, such as the memory, identification and discrimination of odours, is a well-established method in neuropsychology (Krugger, 1989; Doty et al., 1991). The integrity of the central parts of the olfactory system, especially parts of the limbic system and Ammon's horn, are basically required for higher olfactory function. However, damage or blockage of the peripheral olfactory region located within the upper nose leads also to a restriction of those differentiated processes. Even in patients with chronic sinusitis (and

other diseases possibly causing damage to the peripheral olfactory structures) olfactory threshold tests should be combined with discrimination tests, as is demonstrated by the present results: Hyposmia was mono-symptomatically expressed as a reduced ability to discern odours in 8% of the collective, whereas the olfactory thresholds were normal. Therefore, it should be mentioned that the examination of olfactory discrimination can be a sensitive tool for the detection of slight olfactory dysfunction, even in chronic sinusitis.

Post-operative improvement of olfactory function has been found in 70% and normosmia is reached by 21% of the patients. Previous studies have shown better results with somewhat higher percentages of post-operative improvement (Flemming et al., 1967; Lildholdt et al., 1988; Wigand, 1989; Yamagishi et al., 1989; Hosemann et al., 1993). This may be due to different methods and time of olfactory testing, different degrees of sinus disease of the included patients. Despite those differences the prevalence of both pre- and post-operative olfactory dysfunction is supposedly higher than usually assumed.

FESS is most effective in cases of pre-operative anosmia (80% improvement). The chance to benefit from the operation increases with the extent of endonasal polyposis. Significant olfactory improvement has also been determined after resections of very different types of intranasal space-occupying lesions, i.e. polyposis, hypertrophied conchae and septal deviations. This supports the idea that mechanical obstruction of the olfactory cleft is the main causative factor for anosmia associated with chronic sinusitis (Wigand, 1989; Loury and Kennedy, 1991; Hosemann et al., 1993). Improvement of endonasal airflow is generally accepted to be essential for olfactory function. However, there is no consensus about the role of the middle turbinate: Most of the established techniques of endoscopic sinus surgery spare the middle turbinate in order to preserve the olfactory neuroepithelium, which may be present within the middle concha (Wigand, 1989; Lund et al., 1991; Loury and Kennedy, 1991). On the other hand, some studies suggest that partial resections of the middle turbinate could have either a positive or no effect at all on olfaction (Leopold, 1988; Friedman et al., 1996). We favour the preservation of the middle turbinate. Actually, resection of the middle turbinate might be a hypothetical cause for post-operative worsening of smell: five out of our nine cases with post-operative decrease of olfactory acuity underwent inevitable resections of the middle turbinate. However, it should be mentioned that the small group (5/9) does not lead to a significant conclusion with regard to the nocivity of total or partial resection of the middle turbinate.

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