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Olfactory function and disease severity in chronic rhinosinusitis

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Abstract

Background—Olfactory dysfunction is deemed to be a significant contributor to poor quality of life (QOL). However, little is known about the relationship of olfactory testing to other measures of disease burden in patients with chronic rhinosinusitis (CRS).

Objective—In this study, we examine the relationship of olfactory function to computed tomography (CT) scores, endoscopy scores, and QOL measures in patients with CRS.

Methods—A multi-institutional, cross-sectional analysis of 367 patients was performed. Several objective measures were collected: the Smell Identification Test, Lund-MacKay CT score, Lund-Kennedy endoscopy score, two validated disease-specific QOL instruments, the Rhinosinusitis Disability Index and the Chronic Sinusitis Survey, and a general health-related QOL instrument, the Medical Short Form-36. Analysis of variance was performed. Correlation coefficients were calculated.

Results—Patients with olfactory dysfunction had significantly worse mean endoscopy scores (normosmics: 4.16 ($\pm$ 3.97); hyposmics: 6.26 ($\pm$ 4.21); anosmics: 9.61 ($\pm$ 4.48); $p < 0.001$) and significantly worse CT scores (normosmics: 9.11 ($\pm$ 5.40); hyposmics: 11.16 ($\pm$ 5.96); anosmics: 17.62 ($\pm$ 5.37); $p < 0.001$). Endoscopy scores were moderately correlated with olfactory scores ($r = -0.46$, 95% CI -0.38, -0.54; $p < 0.001$). CT scores were moderately correlated with olfactory scores ($r = -0.53$, 95% CI -0.45, -0.60; $p < 0.001$). Olfactory function was not correlated with disease-specific or general health-related QOL measures.

Conclusions—Although previous studies have suggested that olfactory impairment is associated with poor QOL, this study found no such correlation. In contrast, olfaction scores correlated well with other objective measures of CRS, namely endoscopy and CT scores.

Keywords

chronic rhinosinusitis; olfaction disorders; sinusitis; smell; computed tomography; endoscopy; quality of life; anosmia

INTRODUCTION

Olfactory impairment is deemed a significant contributor to poor quality of life (QOL).¹⁻⁴ Patients with olfactory impairment frequently report difficulty cooking, mood changes, decreased appetite, and decreased perception of self-hygiene.² As much as 75% of patients report difficulty detecting spoiled foods.³ Patients are also at risk for being unable to detect

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other safety hazards such as smoke, gas leaks, cleaning solution vapors, chemicals and pesticides.³ Finally, for those whose occupation depends on good olfactory function such as chefs, firemen, plumbers, professional food and beverage tasters, chemists and industrial workers, olfactory impairment can be debilitating.¹ It is a common symptom affecting 61-83% of patients with chronic rhinosinusitis (CRS).⁵⁻⁸ Additionally, it is one of only four signs and symptoms included in the diagnostic criteria for CRS published in the new AAO-HNS Academy guidelines.⁹

Despite its importance to patients and its role in the diagnostic criteria, olfaction is understudied compared to other manifestations of CRS. While the relationships of CT and endoscopy to CRS disease-severity have been examined, little is known about the relationship of olfactory testing to other measures of disease burden in patients with CRS. Jiang et al. noted a small correlation between preoperative CT and olfaction ($r = -0.36$, $p = 0.003$), but the analysis was limited to primary surgical patients.¹⁰ Furthermore, olfaction is rarely reported as an objective measure either at presentation of illness or in outcomes studies following endoscopic sinus surgery. In this study, we examine the relationship of objective olfactory function to other measures of CRS disease-severity including computed tomography (CT) scores, endoscopy scores, and QOL measures in patients with CRS.

MATERIALS AND METHODS

Study Population and Data Collection

Study subjects were recruited from three tertiary care centers over a three-year period ($n = 396$) and have been reported elsewhere.⁷ All patients had a diagnosis of CRS based on the Rhinosinusitis Task Force criteria and endorsed by the American Academy of Otolaryngology - Head and Neck Surgery.¹¹ Adult (≥ 18 yrs old) patients were enrolled at the time they had failed maximum medical management and had elected to undergo sinus surgery. Subjects completed a medical history intake form and underwent a physical exam. Demographic and comorbidity data were documented by the physician during the interview and confirmed by physical exam and nasal endoscopy where appropriate. CT scans were evaluated. Patients with immunodeficiency ($n = 5$), autoimmune disease ($n = 8$), and/or cystic fibrosis ($n = 12$) were excluded from the study. Patients with olfactory test scores consistent with malingering (score ≤ 5) ($n = 4$) were also excluded. A total of 367 patients (93%) were available for analysis. All study protocols and informed consent were collected and approved by Institutional Review Boards at each study site. All data was collected prospectively.

Measurement of Objective and QOL Data

Olfactory Testing—The Smell Identification Test (SIT) from Sensonics, Inc., an objective measure of olfactory dysfunction, was administered to patients by a trained research coordinator.^{12,13} The SIT is a validated 40 question forced-choice test (total score: 0-40). It has high test-retest reliability ($r > 0.90$) and is highly correlated with more sophisticated measures of olfactory dysfunction ($r > 0.80$).¹⁴⁻¹⁶ Absolute SIT scores are categorized into olfactory severity categories based on robust gender-adjusted normative data.¹² Men with SIT scores of 34-40 and women with SIT scores of 35-40 are normosmic, men with SIT scores of 19-33 and women with SIT scores of 19-34 are hyposmic or microsmic, and men and women with SIT scores of 6-18 are anosmic. Patients with SIT scores ≤ 5 are assumed to be malingering.

CT Scan and Endoscopy Measurements—All patients underwent CT scans in the coronal plane and were scored using the Lund-Mackay CT scoring system (range: 0-24).¹⁷ Rigid sinonasal endoscopy was performed and quantified using the Lund-Kennedy scoring system (range: 0-20).¹⁸

QOL Measurements—Two validated disease-specific and one general QOL instruments were administered in the presence of a trained research coordinator: the Rhinosinusitis Disability Index (RSDI), the Chronic Sinusitis Survey (CSS), and the Medical Outcomes Short Form (SF-36).¹⁹⁻²¹ The RSDI is a 30-question survey (range: 0-120) developed to predict rhinosinusitis specific health outcomes in three domains (physical, functional, and emotional).¹⁹ The physical subscale is constructed of 11 items (range: 0-44), the functional subscale consists of 9 items (range: 0-36), and the emotional subscale has 10 items (range: 0-40). Higher scores on the RSDI represent a higher level of disease impact and worse QOL status. The CSS is a valid, 6 item disease-specific questionnaire developed for assessing health status and treatment effectiveness in CRS. Higher total and subscale scores (range: 0-100) represent a lower impact of disease and better QOL status.²⁰ The SF-36 contains measures overall QOL status in eight individual domains: general health, physical functioning, physical role, bodily pain, vitality, social functioning, emotional role, and mental health.²¹⁻²² Higher subscale scores (range: 0-100) represent a lower impact of disease severity and better overall health. The clinician was blinded to all QOL responses for the duration of the investigation.

Statistical Analyses

Analyses were conducted using SPSS v16.0 statistical software (SPSS Inc., Chicago, IL). Demographic and clinical characteristics of study subjects were analyzed by olfactory severity category. Differences in the demographic data and clinical characteristics were assessed across the three olfactory severity categories using 2×3 contingency tables with Pearson's chi-square testing for dichotomous data and one-way analysis of variance (ANOVA) for continuous data. Differences in mean CT, endoscopy and QOL scores were analyzed using Kruskal-Wallis test for nonparametric data (CSS symptom subscale; physical functioning, physical role, and emotional role scores of the SF-36) and ANOVA for parametric data (CT, endoscopy, all other QOL measures). Mean and standard deviations ($\pm$ SD) were reported where appropriate. Pearson and Spearman two-tailed bivariate correlations were used to examine the relationship between SIT score and the following variables: CT, endoscopy, RSDI, CSS, and SF-36 scores. Pearson's correlation coefficients were calculated for parametric data and Spearman's correlation coefficients were calculated for nonparametric data. $P \leq 0.05$ was considered significant for all analyses.

RESULTS

Of 367 patients with CRS from three tertiary care centers, 33% of patients were normosmic (n=122), 45% were hyposmic (n=166), and 22% were anosmic (n=79). Baseline demographic and co-morbidity data are listed in Table I. Patients with olfactory impairment were more likely to have nasal polyposis ($p < 0.001$), asthma ($p < 0.001$), ASA intolerance ($p < 0.001$) and/or a history of prior sinus surgery ($p = 0.026$). Patients with severe olfactory impairment were less likely to have septal deviation ($p < 0.001$).

CT and Endoscopy Scores

Mean SIT scores, endoscopy scores and CT scores with SDs are described in Table II. The mean SIT score for patients with normosmia was 36.05 (± 1.40). For patients with hyposmia, the mean SIT score was 29.44 (± 4.04). Patients with anosmia had a mean SIT score of 11.17 (± 3.30) ($p < 0.001$). The mean endoscopy score was significantly higher (more abnormal) in patients with hyposmia (mean SIT: 6.26 (± 4.21)) or anosmia (mean SIT: 9.61 ($\pm$ SD 4.48)) than patients with normosmia (mean SIT: 4.16 (± 3.97); $p < 0.001$). The mean CT score was also significantly higher (more abnormal) in patients with hyposmia (mean SIT: 11.16 (± 5.96)) or anosmia (mean SIT: 17.62 (± 5.37)) than patients with normosmia (mean SIT: 9.11 (± 5.40); $p < 0.001$).

Lund-Kennedy endoscopy scores ($r = -0.46$, 95% CI $-0.38, -0.54$; $p < 0.001$) were moderately and inversely correlated with SIT scores (Figure 1). Lund-MacKay CT scores were also moderately and inversely correlated with SIT scores ($r = -0.53$, 95% CI $-0.45, -0.60$; $p < 0.001$) (Figure 2).

QOL Measures

Disease-specific QOL measure are described by olfactory status (Table III). There were no significant differences in the subscales or total RSDI or CSS scales by olfactory status (all $p > 0.05$). SIT scores were not correlated with either the RSDI or CSS ($-0.10 \leq r \leq 0.10$). Five domains of the SF-36 were not statistically different by olfactory status. Patients with normosmia scored statistically worse on three SF-36 domains: the physical role score ($p = 0.010$), pain score ($p = 0.004$), and vitality score ($p = 0.017$). However, all correlation coefficients for SF-36 domains were negligible ($-0.17 \leq r \leq +0.12$).²³⁻²⁴

DISCUSSION

In this study, we looked at an objective measure of olfactory impairment, a common symptom in patients with CRS. We examined the relationship of objective olfactory function with traditional measures of CRS disease-severity including CT and endoscopy scores as well as more contemporary measures of CRS disease-severity including disease-specific and general health-related QOL measures. Our results demonstrated that objective olfactory scores demonstrated moderate correlation with endoscopy scores and CT scores in an inverse fashion. As expected, patients with greater olfactory impairment had more severe disease evident on endoscopy and CT scan.

In striking contrast, objective olfactory testing was not correlated with two disease-specific QOL instruments, the RSDI and the CSS, nor was it correlated with general health-related QOL in any meaningful way. While a few of the mean SF-36 domain scores were statistically worse in patients with normosmia, the association was not meaningful as measured by the correlation coefficient ($-0.17 \leq r \leq +0.12$).²³⁻²⁴ While our large sample size is generally a strength of the study, it may have led to these spurious findings.²⁵

Our results are surprising in that others have documented that olfactory impairment has a negative impact on many aspects of daily life.¹⁻⁴ The majority of patients complain of difficulty cooking, eating, and detecting safety hazards such as smoke and gas leaks.²⁻³ They have difficulty with paid employment, housework, social life and family life.⁴ Patients with persistent olfactory impairment have reported higher levels of disability and lower levels of satisfaction with life than patients who recovered from olfactory loss.³ We suspect that the RSDI, CSS, SF-36 did not capture these aspects of olfactory impairment because of the limited nature of olfactory questions on these instruments: neither the CSS nor SF-36 had any specific questions regarding olfactory symptoms and only one question specifically addressed taste and smell on the RSDI. In general, olfaction has had limited representation in validated CRS disease-specific QOL instruments including the Sino-Nasal Outcome Test (SNOT-20), the Rhinosinusitis Outcome Measure (RSOM), and related allergic rhinitis instruments such as the Rhinoconjunctivitis QOL Questionnaire (RQLQ).²⁶⁻²⁸ The gap between patients' experiences with olfactory impairment and measurement on QOL instruments speaks to a need to measure olfaction directly in patients with CRS.

Olfaction may also play a role in the measurement of CRS disease-severity and disease-stratification. This may be significant for two reasons. First, if patients can be stratified by the extent of their disease, similar cohorts may be compared. Second, disease-stratification may allow for the prediction of post-surgical outcomes. Clinicians have previously attempted to stratify CRS disease-severity using other measures, the most common being the Lund-Mackay

CT scoring system.^{17,29} However, while CT has been useful in the diagnosis and stratification of disease, the ability of CT to correlate with patients' symptoms and predict surgical success has been limited.³⁰⁻³² Endoscopy scoring systems have also been developed to measure disease-severity, but their ability to correlate with symptoms and outcomes has also been limited.³¹⁻³³ Both the Lund-Kennedy endoscopy scoring system and the newly developed Perioperative Sinus Endoscopy scoring system correlated only weakly with patients' symptom scores and not at all with disease-specific QOL as measured by the CSS.³³ In our previous work, we demonstrated that endoscopy did not predict post-operative change in QOL outcomes.³¹ As no ideal measure exists, olfaction may complement other means to objectively measure and stratify disease at the time of presentation. It correlated with more traditional measures of CRS disease-severity while offering a different construct that measures aspects of disease not examined by endoscopy or CT scan. Ultimately, disease-stratification may allow olfaction to be examined as a potential predictor of post-surgical outcomes.

In summary, although previous studies have reported that olfactory impairment contributes to poor QOL, the current study found no such association in patients with CRS. Olfactory impairment may or may not be adequately measured by current disease-specific QOL instruments; this is worth further investigation in future studies. In contrast, olfaction was associated with other traditional measures of CRS disease-severity and potentially, may play a role in measuring disease-severity and disease-stratification. In the future, measuring olfactory function and the severity of impairment could serve multiple purposes: it may serve as a potential predictor of improvement after sinus surgery and could be used as a novel measure of post-operative outcomes.

CONCLUSION

Objective olfactory function moderately correlated with other traditional measures of disease-severity in CRS, including CT scan and endoscopy. However, in contrast to prior studies, olfactory function did not correlate with QOL measures and suggests a need for further exploration. Olfaction is not only an important factor at the presentation of illness but potentially, a novel outcome that, with further investigation, may help us to better understand who improves after sinus surgery.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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All study protocols and informed consent were approved by the Institutional Review Board.

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Figure 1.

Figure 2.

Table 1
Demographic and clinical characteristics of patients with normosmia, hyposmia, and anosmia

	Normosmic (n=122)		Hyposmic (n=166)		Anosmic (n=79)		p-value
	Mean ± SD	N (%)	Mean ± SD	N (%)	Mean ± SD	N (%)	
Age	43.81 ± 12.53		49.82 ± 13.60		49.43 ± 13.83		<0.001
Gender							
Male		61 (50.0)		81 (48.8)		44 (55.7)	
Female		61 (50.0)		85 (51.2)		35 (44.3)	0.590
Ethnicity							
White		113 (92.6)		137 (82.5)		66 (83.5)	
African-American		4 (3.3)		7 (4.2)		6 (7.6)	
Hispanic/Latino		1 (0.8)		6 (6.6)		0	
American Indian/Alaskan Native		1 (0.8)		3 (1.8)		0	
Asian		2 (1.6)		11 (6.6)		6 (7.6)	
Native Hawaiian/Pacific Islander		1 (0.8)		2 (1.2)		1 (1.3)	0.168
Clinical characteristics							
Septal deviation		38 (31.1)		47 (28.3)		6 (7.6)	<0.001
Nasal polyposis		22 (18.0)		56 (33.7)		59 (74.7)	<0.001
Asthma		36 (29.5)		55 (33.1)		55 (69.6)	<0.001
Allergic rhinitis		42 (34.4)		55 (33.1)		21 (26.6)	0.476
Revision surgery		57 (46.7)		94 (56.6)		52 (65.8)	0.026
Current smokers		7 (5.7)		14 (8.4)		6 (7.6)	0.684
ASA intolerance		5 (4.1)		12 (7.2)		19 (24.1)	<0.001
Turbinate hypertrophy		14 (11.5)		14 (7.2)		2 (2.5)	0.077

SD = standard deviation. ASA = acetylsalicylic acid. $p \leq 0.05$ is statistically significant

Table II

Means and standard deviations of the Smell Identification Test (SIT), Lund-Kennedy endoscopy score, and Lund-MacKay computed tomography (CT) score for patients with normosmia, hyposmia, and anosmia

	Normosmic (n=122)	Hyposmic (n=166)	Anosmic (n=79)	
	Mean ± SD	Mean ± SD	Mean ± SD	p-value
Objective Testing				
SIT score	36.05 ± 1.40	29.44 ± 4.04	11.17 ± 3.30	<0.001
Endoscopy score	4.16 ± 3.97	6.26 ± 4.21	9.61 ± 4.48	<0.001
CT score	9.11 ± 5.40	11.16 ± 5.96	17.62 ± 5.37	<0.001

SD = standard deviation. SIT = smell identification test. CT = computed tomography. $p \leq 0.05$ is statistically significant

Table III
Total and subscale disease-specific quality of life values for patients with normosmia, hyposmia, and anosmia

	Normosmic (n=122)		Hyposmic (n=166)		Anosmic (n=79)	
	Mean ± SD	N (%)	Mean ± SD	N (%)	Mean ± SD	N (%)
Quality-of-Life Measures						
RSDI total	46.97 ± 18.89		48.26 ± 21.76		46.00 ± 18.85	
Physical subscale	18.34 ± 7.16		18.92 ± 8.01		19.13 ± 7.20	
Emotional subscale	13.30 ± 7.24		13.57 ± 8.63		11.81 ± 7.84	
Functional subscale	15.32 ± 6.63		15.78 ± 7.57		15.06 ± 7.14	
CSS total	39.99 ± 20.56		39.51 ± 20.58		36.82 ± 19.75	
Symptom subscale	29.92 ± 26.13		31.33 ± 26.80		26.90 ± 25.87	
Medication subscale	50.07 ± 25.90		47.94 ± 26.53		46.73 ± 27.59	

SD = standard deviation. RSDI = Rhinosinusitis Disability Index. CSS = Chronic Sinusitis Survey p ≤ 0.05 is statistically significant