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RHINOLOGY

Predictors of quality of life outcomes in chronic rhinosinusitis after sinus surgery

Michael Katotomichelakis · Efthimios Simopoulos · Gregory Tripsianis · Dimitrios Balatsouras · Gerasimos Danielides · Christos Kourousis · Miltos Livaditis · Vassilios Danielides

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Abstract The predictive value of olfaction for quality of life (QoL) recovery after endoscopic sinus surgery (ESS) in chronic rhinosinusitis (CRS) is still underestimated. The aim of this study was to explore the proportion of patients suffering from CRS who experience clinically significant QoL improvement after ESS and identify pre-operative clinical phenotypes that best predict surgical outcomes for QoL, focusing mainly on the role of patients' olfaction. One hundred eleven patients following ESS for CRS and 48 healthy subjects were studied. Olfactory function was expressed by the combined "Threshold Discrimination Identification" score using "Sniffin' sticks" test pre-treatment and 12 months after treatment. All subjects completed validated, widely used QoL questionnaires, specific for olfaction (Questionnaire of Olfactory Deficits: QOD), for assessing psychology (Beck Depression Inventory: BDI) and for general health (Short Form-36: SF-36). Statistically significant improvement of olfactory function by 41.8 % and of all QoL questionnaires scores (all $p < 0.001$) was observed on the 12-month follow-up examination. Clinically significant improvement for QoL was measured in a proportion of 56.8 % of patients on QOD, 64.9 % on SF-36 and 49.5 % on BDI scales results. Although olfactory dysfunction, nasal polyps, female gender, high socio-economic status and non-smoking habits were significantly associated with better QoL results, multivariate logistic regression analysis revealed that only olfactory dysfunction and nasal polyps were independent predictors significantly associated with higher likelihood of clinically significant improvement in all QoL questionnaire results. Olfactory dysfunction and nasal polyps were independent pre-operative predictors for surgical outcomes with regard to QoL results.

Keywords Olfactory dysfunction · Quality of life · Chronic rhinosinusitis · Nasal polyps · Endoscopic sinus surgery · Sniffin' sticks

Introduction

Olfactory loss is considered a defining symptom of chronic rhinosinusitis (CRS) [1, 2], closely related to mental health (MH) and quality of life (QoL) [3–6], although underestimated by patients and overlooked by doctors [7]. Endoscopic sinus surgery (ESS) has been described as the "gold" standard for the treatment of CRS [8–12] in several studies, because it is successful in obtaining symptom resolution, and furthermore it may improve olfactory function and QoL. However, the proportions of patients reporting clinically significant QoL improvement have not been adequately addressed in the literature [13]. In addition, although there are studies describing pre-operative predictors for QoL outcomes [13–22], there is no data available to the relevance of pre-operatively olfactory status to post-operative QoL recovery. The use of standardized olfactory tests and validated

M. Katotomichelakis · D. Balatsouras · G. Danielides · C. Kourousis · V. Danielides (✉)
Department of Otorhinolaryngology, Medical School, Democritus University of Thrace, Alexandroupolis, Greece
e-mail: vdanielidis@hotmail.com

E. Simopoulos · M. Livaditis
Department of Psychiatry, Medical School, Democritus University of Thrace, Alexandroupolis, Greece

G. Tripsianis
Department of Statistics, Medical School, Democritus University of Thrace, Alexandroupolis, Greece

specific for olfaction and mental health psychometric instruments provides new opportunities for assessing olfaction as a possible determinant for QoL after ESS. The clinical importance is that this data may enable otolaryngologists to better counsel their patients about the expected benefit for their QoL after ESS and how it is correlated to olfactory status. This may also support clinical decisions on the optimal management of patients suffering from chronic rhinosinusitis, facilitating case selections.

Accordingly, this study was aimed to prospectively evaluate the proportion of patients suffering from CRS, who experience clinically significant QoL improvement after ESS, related to their pre-operative characteristics, and to identify pre-operative clinical phenotypes that best predict surgical outcomes for QoL, focusing mainly on the impact of patients' olfactory status based on QoL results.

Materials and methods

The prospective study was carried out in the University Department of Otorhinolaryngology of Democritus University of Thrace in Alexandroupolis/Greece, during a 4-year period from March 2008 to June 2012. One hundred eleven patients suffering from chronic rhinosinusitis (either with nasal polyps (NP): CRSwNP or without NP: CRSsNP) were studied. Forty-eight healthy subjects who visited our outpatient department for a routine health check-up were recruited as controls. Diagnosis was established based on history, clinical examination, nasal endoscopy, sinus computed tomography scanning, skin prick testing (SPT) for atopy, test of pulmonary function and olfactory testing. None of the subjects used oral or nasal corticosteroids and antibiotics 4 weeks prior to inclusion and oral antihistamines 1 week prior to SPT, according to our protocol for CRS patients. Patients with a history of previous sinus surgery, cystic fibrosis or any malignancy were excluded. All patients fulfilled the criteria of CRS according to the EPOS [1] guidelines. Only patients with resistant CRS to maximal medical therapy (antibiotics, oral and nasal steroids) over a 6-month period were subjected to surgery. All subjects underwent a brief psychiatric interview to exclude those with pre-existing major psychiatric disorder. ESS was conducted by a single surgeon following Messerklinger [23] technique according to the extent of the disease, with the use of microdebrider device. Septoplasty and inferior nasal turbinates (INT) volume reduction—by submucosal radiofrequency tissue ablation—were implemented whenever significant septal deviation or INT enlargement were observed. The frequency of each treatment protocol performed is shown in Table 1. Post-operative care included multiple visits at the outpatient clinic where nasal endoscopy and toilette as needed were performed. All patients were asked to rinse the nose with sodium chloride solution and nasal steroids. The study protocol was approved by the local Institutional Review Board. All subjects signed informed consent. The study was performed in accordance with the Declaration of Helsinki/Hong Kong.

Olfactory function of all patients and healthy controls was quantitatively evaluated using "Sniffin' sticks" test package (Burghart, Wedel, Germany) pre-treatment and 12 months after treatment, as it was an adequate time period for the healing process to be completed [24]. At these time points all subjects also filled in three validated, widely used questionnaires specific for olfaction-associated QoL (Questionnaire of Olfactory Deficits: QOD), for assessing psychology (Beck Depression Inventory: BDI) and a general-health survey (Short Form: SF-36).

"Sniffin' Sticks" test battery for olfaction included specific tests for odor threshold (OT), odor discrimination (OD), and odor identification (OI) [25]. Results of each one of the three tests were combined to a "Threshold Discrimination Identification (TDI) score" [25]. TDI score ranges from 0 to 48 (values of 15 or less represent anosmia, values between 16 and 34.5 represent hyposmia and values over 34.5 represent normosmia for the mild climate conditions in Greece) [26].

QOD represents an olfaction-specific questionnaire for QoL, translated and validated for the Greek population [27]. It consists of 25 4-scale statements (17 "negative", 2 "positive", 6 "socially desired") with a maximum score of 57 points [27]. High scores indicate a strong impairment in QoL. BDI was used for assessing QoL of patients detecting specifically their psychological profile [28]. BDI consists of 21 self-reporting items graded from 0 to 3, and a higher score indicates higher level of depression. Finally SF-36 is a widely used general-health related survey that assesses QoL in eight domains covering both physical and mental health from the patient's point of view with chronic diseases [29, 30]. Scores range from 0 to 100, with a higher score representing better functioning [29, 30].

Statistical analysis of the data was performed using the Statistical Package for the Social Sciences (SPSS), version 19.0 (IBM). The normality of quantitative variables was ascertained with Kolmogorov–Smirnov test. The Chi-square test and Student's t test were used to assess differences of demographic characteristics between patients and controls. The scores of olfactory function and all QoL questionnaires were expressed as the mean and standard deviation (SD). Differences in the scores of olfactory function and QoL questionnaires between (1) patients and controls and (2) pre- and post-treatment were assessed by

Student's t test for independent and related samples, respectively. Since the distribution of BDI score was skewed, the statistical analysis was performed on the log-transformed scores. The Chi-square test was used to evaluate any potential association between the incidence of clinically significant improvement for each QoL questionnaire with patients' demographics and clinical characteristics. Multivariate stepwise logistic regression analysis was constructed to explore the independent effect of patient's characteristics on clinically significant improvement. Odd ratios (OR) and 95 % confidence intervals (CI) were estimated as the measure of association between clinically significant improvement and all potential predictors. All tests were two tailed and statistical significance was considered for p values of less than 0.05.

Table 1 Frequency of treatment procedures performed

Treatment procedure	No. of patients (%)
Maxillary antrostomy	111 (100.0)
Partial ethmoidectomy	88 (79.3)
Total ethmoidectomy	76 (68.5)
Sphenoidotomy	66 (59.5)
Frontal sinusotomy	62 (55.9)
Septoplasty	98 (88.3)
Radiofrequency ablation for inferior turbinates volume reduction	101 (91.0)

Results

One hundred eleven patients [59 (53.2 %) males, mean age: 44.74 ± 16.21 years] and 48 healthy subjects [25 (52.1 %) males, mean age: 40.15 ± 15.50 years] participated. Demographics and disease characteristics of all patients and controls are shown in detail in Table 2. The table reveals no statistically significant differences related to gender ($p = 0.901$), age ($p = 0.100$), socio-economic status ($p = 0.376$) and smoking habits ($p = 0.156$) between patients and controls. Quantitative assessment of subjects' olfactory function with the use of Sniffin' sticks test revealed patients to present statistically significant lower TDI score as compared to controls [23.15 ± 12.75 (range 2–38) vs. 38.88 ± 1.38 (range 37–41), $p < 0.001$]. Based on this score, 84 (75.7 %) patients presented olfactory dysfunction; 36 (32.4 %) were anosmics and 48 (43.3 %) were hyposmics. The duration of olfactory deficit of these patients ranged from 2 to 30 years, with a median duration of 8 years (interquartile range 5–15 years). All the subjects of the control group were normosmics. Among patients, higher frequency of anosmia was associated with female gender (44.2 vs. 22.0 %, $p = 0.013$; OR = 2.81, 95 %CI = 1.23–6.40), ages older than 55 years (68.2 vs. 9.0 %, $p < 0.001$; OR = 21.79, 95 %CI = 7.61–62.35), lower socio-economic status (75.0 vs. 29.1 % in medium and high social status, $p = 0.008$; OR = 7.30, 95 %CI = 1.39–38.23), non-smoking habits (46.0 vs. 14.6 %, $p < 0.001$; OR = 5.00, 95 %CI = 1.95–12.82), asthma history (88.2 vs. 22.3 %, $p < 0.001$; OR = 26.07,

Table 2 Demographics and disease characteristics of patients and healthy controls

	Control group ($n = 48$)	Patients ($n = 111$)	p value
Demographics [no (%)]			
Male gender [no (%)]	25 (52.1)	59 (53.2)	0.901
Age [years; mean (SD)]	40.15 (15.50)	44.74 (16.21)	0.100
Socio-economic status [no (%)]			0.376
Low	1 (2.1)	8 (7.2)	
Medium	21 (43.8)	51 (45.9)	
High	26 (54.2)	52 (46.8)	
Smoking [no (%)]	15 (31.3)	48 (43.2)	0.156
Disease characteristics [no (%)]			
Allergic Rhinitis [no (%)]	–	52 (46.8)	
Asthma presence [no (%)]	–	17 (15.3)	
Nasal polyps [no (%)]	–	54 (48.6)	
Aspirin intolerance [no (%)]		12 (10.8)	
TDI score [mean (SD)]	38.88 (1.38)	23.15 (12.75)	<0.001
Olfactory function [no (%)]			
Normosmics	48 (100.0)	27 (24.3)	
Hyposmics	–	48 (43.3)	
Anosmics	–	36 (32.4)	
Duration of olfactory dysfunction [years]	–	8 (5–15)	

Normally distributed quantitative variables were expressed as mean (standard deviation, SD); non-normally distributed quantitative variables were expressed as median (interquartile range, IQR); qualitative variables were expressed as frequencies (percentage, %)

95 %CI = 5.52–123.23), nasal polyps (51.9 vs. 14.0 %, $p < 0.001$; OR = 6.60, 95 %CI = 2.63–16.53) and aspirin intolerance (75.0 vs. 27.3 %, $p = 0.001$; OR = 8.00, 95 %CI = 2.01–31.78).

The scores of olfactory function and QoL questionnaires of patients and controls are presented in Table 3. Patients' pre-treatment scores in all questionnaires were statistically significantly worse (all $p < 0.05$) compared to healthy controls. Throughout the 12-month follow-up time, it was observed a significant improvement of (1) all indices of olfactory function: odor threshold (OT) by 68.3 % ($p < 0.001$), odor discrimination (OD) by 33.2 % ($p < 0.001$), odor identification (OI) by 36.7 % ($p < 0.001$) and TDI score by 41.8 % ($p < 0.001$), and (2) the scores of all QoL questionnaires: QOD by −50.9 % ($p < 0.001$), QOD-NS by −85.2 % ($p < 0.001$), QOD-PS by 22.6 ($p < 0.001$), QOD-SD by −53.0 % ($p < 0.001$), SF-36 by 25.2 % ($p < 0.001$) and BDI by −31.5 % ($p < 0.001$) (Table 3). Clinically significant improvement was defined for each QoL questionnaire as a change of ≥1/2 SD of the pre-treatment score [31]. Using this criterion, improvement was defined as a decrease of 4.91 points for QOD and 4.33 for BDI and an increase of 7.65 points for SF-36. Among the entire cohort, clinically significant improvement was observed in 63 (56.8 %) patients for QOD, 72 (64.9 %) patients for SF-36 and 55 (49.5 %) patients for BDI. The incidence of clinically significant improvement of QOD, SF-36 and BDI in relation to patients' and disease characteristics was studied next (Tables 4, 5, and 6). In univariate statistical analysis, it was found that the likelihood of clinically significant improvement of (1) QOD was higher for patients with female gender (67.3 vs. 47.5 %, $p = 0.035$), medium or high socio-economic status (68.6 % and 50.0 vs. 25.0 %, $p = 0.028$), nasal polyps (66.7 vs. 47.4 %, $p = 0.040$), hyposmia or anosmia (64.6 % and 75.0 vs. 18.5 %, $p < 0.001$) and lower for smokers (45.8 vs. 65.1 %, $p = 0.043$), (2) SF-36 was higher for patients with nasal polyps (85.2 vs. 45.6 %, $p < 0.001$) and hyposmia or anosmia (60.4 % and 86.1 vs 44.4 %, $p = 0.002$), and (3) BDI was higher for patients with nasal polyps (63.0 vs. 36.8 %, $p = 0.006$) and hyposmia or anosmia (54.2 % and 61.1 vs. 25.9 %, $p = 0.015$).

Multivariate logistic regression analysis revealed that the following independent predictors were significantly associated with higher likelihood of clinically significant improvement: anosmia for all three questionnaires (QOD: aOR = 12.39, 95 %CI = 3.08–49.94, $p < 0.001$; SF-36: aOR = 4.92, 95 %CI = 1.11–21.80, $p = 0.036$; BDI: aOR = 7.68, 95 %CI = 2.16–27.40, $p = 0.002$), hyposmia for QOD and BDI (QOD: aOR = 8.55, 95 %CI = 2.65–27.52, $p < 0.001$; BDI: aOR = 3.97, 95 %CI = 1.31–12.02, $p = 0.015$), nasal polyps for all three questionnaires (QOD: aOR = 2.54, 95 %CI = 1.15–5.57, $p = 0.021$; SF-36: aOR = 6.14, 95 %CI = 2.03–18.56, $p = 0.013$; BDI: aOR = 3.31, 95 %CI = 1.52–7.25, $p = 0.046$) and medium or high social status for QOD (aOR = 8.92, 95 %CI = 1.43–55.70, $p = 0.019$); while smoking was an independent predictor significantly associated with lower likelihood of clinically significant improvement of BDI (aOR = 0.41, 95 % CI = 0.17–0.98, $p = 0.046$) (Table 7).

Table 3 Scores of olfactory function and quality of life (QoL) questionnaires pre-treatment and 12 months after treatment

	Olfactory and psychometric scores			% Change	*p* value
	Control group	Patients			
		Pre-treatment	Post-treatment		
Olfactory scores					
OT	8.10 (0.69)	4.07 (2.01)*	6.85 (4.03)*	68.3	<0.001
OD	15.61 (0.60)	10.31 (5.12)*	13.73 (2.99)*	33.2	<0.001
OI	15.17 (0.56)	9.50 (4.46)*	12.99 (2.93)*	36.7	<0.001
TDI	38.88 (1.38)	23.15 (12.74)*	32.82 (7.25)*	41.8	<0.001
Psychometric scales					
QOD	6.25 (0.76)	17.12 (9.82)*	8.41 (4.24)*	−50.9	<0.001
QOD-NS	0.00 (0.00)	9.67 (5.18)*	1.43 (3.26)*	−85.2	<0.001
QOD-PS	6.00 (0.00)	4.60 (1.32)*	5.64 (0.76)*	22.6	<0.001
QOD-SD	0.25 (0.21)	2.85 (1.64)*	1.34 (1.18)*	−53.0	<0.001
SF-36	86.59 (10.73)	68.20 (15.30)*	85.38 (9.92)	25.2	<0.001
Beck Depression Inventory	4.98 (3.48)	12.43 (8.66)*	8.51 (5.24)*	−31.5	<0.001

Data are expressed as mean values (standard deviation, SD)

* Statistically significant difference compared to control group, *p* values refer to comparison between pre- and post-treatment scores

Table 4 Clinically significant improvement of QOD (Questionnaire of Olfactory Deficits) questionnaire in relation to patients' and disease characteristics

	Clinically improved QOD	*p* value	OR (95 % CI)
Gender		0.035	
Males	28 (47.5)		Ref.
Females	35 (67.3)		2.28 (1.05–4.94)
Age		0.115	
≤55 years	34 (50.7)		Ref.
>55 years	29 (65.9)		1.88 (0.86–4.12)
Socio-economic status		0.028	
Low	2 (25.0)		Ref.
Medium	35 (68.6)		6.56 (1.19–36.14)
High	26 (50.0)		3.00 (0.55–16.26)
Smoking		0.043	
No	41 (65.1)		Ref.
Yes	22 (45.8)		0.45 (0.21–0.97)
Allergic rhinitis		0.561	
No	35 (59.3)		Ref.
Yes	28 (53.8)		0.80 (0.38–1.70)
Nasal polyps		0.040	
No	27 (47.4)		Ref.
Yes	36 (66.7)		2.22 (1.03–4.79)
Asthma		0.472	
No	52 (55.3)		Ref.
Yes	11 (64.7)		1.48 (0.51–4.34)
Aspirin intolerance		0.177	
No	54 (54.5)		Ref.
Yes	9 (75.0)		2.50 (0.64–9.79)
Olfactory function		<0.001	
Normosmia	5 (18.5)		Ref.
Hyposmia	31 (64.6)		8.02 (2.57–25.01)
Anosmia	27 (75.0)		13.19 (3.86–45.14)
Duration of olfactory dysfunction		0.388	
≤8 years	32 (78.0)		Ref.
>8 years	30 (69.8)		0.65 (0.24–1.74)

Discussion

Chronic rhinosinusitis is already known as a common chronic sinonasal disease that adversely affects the quality of life of most involved patients [13]. Although the main concern of any medical treatment for these patients should be the improvement of QoL, there is lack of studies analyzing in their outcomes clearly defined proportions of patients who experienced clinically significant improvement on their daily lives and not just providing general conclusions for patients' QoL. This study provides clinically relevant information for the individual patient and doctor, measuring the proportion of patients who experience a clinically significant improvement on QoL, related to their pre-operative clinical and demographic characteristics. In addition, although there are studies that highlight various demographic and clinical data and comorbidities that explain QoL outcomes after ESS [13–22], the importance of baseline olfactory status on QoL prediction is still worth pursuing and needs to be further explored, as olfactory loss is a major symptom in CRS directly affecting patients' QoL [1–6]. To achieve this, additionally we used a specific for olfaction-associated QoL psychometric questionnaire, as well as quantitative smell tests for the assessment of olfactory performance, providing, thus, objective data for the olfactory function and not self-reporting symptoms.

In our study we observed that olfactory function in CRS patients after ESS recovers and this is expressed by a significant improvement in the TDI and all separate tests (OT, OD, OI) score. Olfactory rehabilitation is followed by patients' QoL recovery as well, within 12 months post-

Table 5 Clinically significant improvement of SF-36 (Short Form-36) questionnaire in relation to patients' and disease characteristics

	Clinically improved SF-36	*p* value	OR (95 % CI)
Gender		0.059	
Males	43 (72.9)		2.13 (0.96–4.71)
Females	29 (55.8)		Ref.
Age		0.553	
≤55 years	42 (62.7)		Ref.
>55 years	30 (68.2)		1.28 (0.57–2.85)
Socio-economic status		0.337	
Low	7 (87.5)		Ref.
Medium	31 (60.8)		0.22 (0.03–1.94)
High	34 (65.4)		0.27 (0.03–2.37)
Smoking		0.208	
No	44 (69.8)		Ref.
Yes	28 (58.3)		0.61 (0.28–1.33)
Allergic rhinitis		0.914	
No	38 (64.4)		Ref.
Yes	34 (65.4)		1.04 (0.48–2.28)
Nasal polyps		<0.001	
No	26 (45.6)		Ref.
Yes	46 (85.2)		6.86 (2.75–17.10)
Asthma		0.276	
No	59 (62.8)		Ref.
Yes	13 (76.5)		1.93 (0.58–6.38)
Aspirin intolerance		0.156	
No	62 (62.6)		Ref.
Yes	10 (83.3)		2.98 (0.62–14.37)
Olfactory function		0.002	
Normosmia	12 (44.4)		Ref.
Hyposmia	29 (60.4)		1.91 (0.73–4.96)
Anosmia	31 (86.1)		7.74 (2.31–26.01)
Duration of olfactory dysfunction		0.269	
≤8 years	27 (65.9)		Ref.
>8 years	33 (76.7)		1.71 (0.66–4.46)

operatively, that is expressed by a significant improvement in the results of all questionnaires used for the assessment of patients' QoL. These results are in accordance with previous reports, in which positive effects of ESS on patients' QoL [10–20] were found. A basic limitation of former studies was the fact that the conclusions were difficult to be expressed into meaningful terms that patients can understand and doctors can integrate into shared decision making. This is the reason why we explored clinically significant improvement for patients' QoL, as defined by Norman et al. [31], adding new knowledge beyond what is already published on this topic in the literature. This definition is also clinically important as it permits us to build models to predict treatment outcomes. According to this criterion we observed that although all patients' QoL improved significantly after ESS, a 49.5–64.9 % of patients with CRS experienced clinically significant improvement according to the psychometric scales for QoL assessment used (QOD: 56.8 %, BDI: 49.5 %, SF-36: 64.9 %).

Additionally, it is clinically important to mention that we for the first time identified pre-operative clinical phenotypes that best predict surgical outcomes for clinically significant QoL recovery, focusing mainly on the impact of patients' baseline olfactory function on QoL results. After univariate screening of all possible clinical and demographic predictors we found that certain clinical phenotypes, such as CRS associated with anosmia or hyposmia, CRS associated with nasal polyps, CRS associated with non-smoking habits, and CRS in females and in medium or high socio-economic status patients were significant predictors of QoL outcomes; however, among these

Table 6 Clinically significant improvement of BDI (Beck Depression Inventory) in relation to patients' and disease characteristics

	Clinically improved BDI	*p* value	OR (95 % CI)
Gender		0.771	
Males	30 (50.8)		Ref.
Females	25 (48.1)		0.90 (0.43–1.89)
Age		0.484	
≤55 years	35 (52.2)		Ref.
>55 years	20 (45.5)		0.76 (0.36–1.63)
Socio-economic status		0.331	
Low	5 (62.5)		Ref.
Medium	28 (54.9)		0.73 (0.16–3.39)
High	22 (42.3)		0.44 (0.10–2.04)
Smoking		0.067	
No	36 (57.1)		Ref.
Yes	19 (39.6)		0.49 (0.23–1.06)
Allergic rhinitis		0.219	
No	26 (44.1)		Ref.
Yes	29 (55.8)		1.60 (0.76–3.39)
Nasal polyps		0.006	
No	21 (36.8)		Ref.
Yes	34 (63.0)		2.91 (1.35–6.30)
Asthma		0.453	
No	48 (51.1)		Ref.
Yes	7 (41.2)		0.67 (0.24–1.91)
Aspirin intolerance		0.519	
No	48 (48.5)		Ref.
Yes	7 (58.3)		1.49 (0.44–5.00)
Olfactory function		0.015	
Normosmia	7 (25.9)		Ref.
Hyposmia	26 (54.2)		3.38 (1.20–9.47)
Anosmia	22 (61.1)		4.49 (1.51–13.36)
Duration of olfactory dysfunction		0.497	
≤8 years	24 (58.5)		Ref.
>8 years	22 (51.2)		0.74 (0.31–1.76)

phenotypes, baseline olfactory dysfunction, irrespective of its duration, and the presence of nasal polyps as well, appears to be independent clinical predictors when multiple risk factors were accounted for in the predictive model. We observed that hyposmic patients were 1.54 up to 8.55 times more likely to experience clinically significant improvement on QoL according to the psychometric scales used (QOD: 8.55, SF-36:1.54, BDI: 3.97), whereas the results for anosmics were even higher (SF-36:4.92, BDI: 7.68, QOD: 12.39). Also CRSwNP patients were better candidates for presenting clinically significant improvement for QoL after ESS, presenting 2.5- up to 6-fold more increase on QoL results on each occasion compared to CRSsNP patients (QOD: 2.54, SF-36: 6.14, BDI: 3.31). In addition, in our study certain potential determinants of outcomes of ESS on patients' QoL, including asthma [13], ASA intolerance [13, 15, 19], smoking [16, 21], nasal polyps [17], prior sinus surgery [13] as well as demographic factors including gender [13, 18, 20], socio-economic status [13], have been studied and described as important potential predictors of outcomes, although with occasionally conflicting results. However, to the best of our knowledge, this is the first study to address olfactory dysfunction as a significant predictor for QoL and psychological outcomes, using specific psychometric questionnaires as well as quantitative smell tests for the assessment of olfactory performance, providing, thus, objective data for olfactory function and not self-reporting symptoms.

In conclusion our results suggest that certain clinical phenotypes, such as CRS associated with anosmia and hyposmia, or with nasal polyps, or with non-smoking

Table 7 Results of multivariate logistic regression analysis between predictor variables and clinically significant improvement of QOD, SF-36 and BDI questionnaires in patients suffering from chronic rhinosinusitis, expressed as adjusted odds ratios (aOR) with their 95 % confidence intervals (CI)

	aOR	95 % CI	*p* value
QOD			
Olfactory function			
Normosmia	Ref.		
Hyposmia	8.55	2.65–27.52	<0.001
Anosmia	12.39	3.08–49.94	<0.001
Medium or high social status	8.92	1.43–55.70	0.019
Nasal polyps	2.54	1.15–5.57	0.021
SF-36			
Olfactory function			
Normosmia	Ref.		
Hyposmia	1.54	0.48–4.90	0.469
Anosmia	4.92	1.11–21.80	0.036
Nasal polyps	6.14	2.03–18.56	0.0013
BDI			
Olfactory function			
Normosmia	Ref.		
Hyposmia	3.97	1.31–12.02	0.015
Anosmia	7.68	2.16–27.40	0.002
Nasal polyps	3.31	1.52–7.25	0.001
Smoking	0.41	0.17–0.98	0.046

Only variables that maintained statistical significance are shown

habits, as well as CRS in females and in medium or high socio-economic status patients, are significantly associated to better QoL outcomes, 12 months post-operatively, after ESS. However, multivariate logistic regression analysis revealed that olfactory dysfunction (anosmia or hyposmia) and the presence of nasal polyps were independent pre-operative predictors associated with higher likelihood of clinically significant improvement on patients' QoL. This means that olfactory testing in CRS patients prior to surgery is of great clinical importance for appropriate case selection and consultation for treatment outcomes related to QoL results. This knowledge may further improve outcomes and patients' QoL.

Conflict of interest None.

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