



# The Impact of Olfactory Dysfunction on the Psychological Status and Quality of Life of Patients with Nasal Obstruction and Septal Deviation

Konstantinos Valsamidis<sup>1</sup> Athanasia Printza<sup>1</sup>  Jannis Constantinidis<sup>1</sup> Stefanos Triaridis<sup>1</sup>

<sup>1</sup> 1st Otolaryngology Department, Medical school, Aristotle University of Thessaloniki, AHEPA Hospital, 54124, Thessaloniki, Greece

Address for correspondence Stefanos Triaridis MD, MsC, PhD, 1st Otolaryngology Department, Medical school, Aristotle University of Thessaloniki, AHEPA Hospital, 54124, Thessaloniki, Greece (e-mail: triaridis@hotmail.com).

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## Abstract

**Introduction** Olfactory dysfunction may be present in patients with nasal obstruction and septal deviation. The impact of olfactory dysfunction on the psychological profile and quality of life (QoL) of these patients remains unexplored.

**Objective** The present study aimed to investigate the emotional status and QoL of patients with olfactory dysfunction and septal deviation and to identify predictors associated with clinically significant improvement of psychological status and QoL, focusing mainly on the role of olfactory recovery after septoplasty.

**Methods** The olfactory function was quantitatively assessed using the “Sniffin’ sticks” test (Burghart Messtechnik GmbH, Wedel, Germany) in 60 patients and 25 controls enrolled in this prospective study. The participants completed validated questionnaires specific for general health (Short Form-36), nasal-symptom related QoL (SinoNasal Outcome Test-22), olfaction-associated QoL (Questionnaire of Olfactory Deficits) and for assessing their psychological state (Short Anxiety Screening Test and Beck Depression Inventory) preoperatively and 6 months postoperatively. The patients used the Glasgow Benefit Inventory to evaluate their personal benefit after septoplasty with.

**Results** Septoplasty led to significantly improved olfactory function. Patients with olfactory impairment had significantly lower nasal-symptom related QoL, higher stress levels, and more depressive mood compared with normosmics and controls before and after septoplasty. Postoperatively, personal benefit from surgery was higher in normosmic patients. Improvement of nasal-symptom related QoL was significantly associated with higher likelihood of clinically significant improvement of patients’ psychological profile and more personal benefit from surgery. Olfactory dysfunction was negatively correlated with the emotional status of the patients.

**Conclusion** Olfactory dysfunction appears to significantly affect the psychological status of patients with nasal obstruction, and olfactory recovery improves the patients’ perception of personal benefit from septoplasty.

## Keywords

- ▶ olfactory dysfunction
- ▶ septoplasty
- ▶ anxiety
- ▶ emotional status
- ▶ quality of life
- ▶ olfaction test

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## Introduction

Olfactory dysfunction due to decreased nasal airflow is a common symptom among patients with nasal obstruction related to nasal septal deviation.<sup>1</sup> Olfactory disorders may have a significant negative impact on different areas of daily life, including food appreciation, safety (detection of environmental hazards, such as smoke, fire, gas, and spoiled food), personal hygiene, and social communication. Especially in the case of individuals whose professions depend on a well-functioning sense of smell, such as cooks, wine tasters, perfumers, or firemen, olfactory deficits can be catastrophic.<sup>2</sup> Therefore, olfactory impairment due to septal deviation, although underestimated by patients and overlooked by doctors,<sup>3</sup> may substantially affect the quality of life (QoL) of patients and potentially be associated to mental health.<sup>2,4-6</sup> Nasal septoplasty is the standard treatment of nasal septal deviation because it usually produces an improvement of nasal airflow and resolution of nasal obstruction symptoms.<sup>7-10</sup> To date, there are a few studies evaluating the effects of septal surgery on olfactory function.<sup>1,11-18</sup> However, the impact of olfactory impairment due to septal deviation on the nasal-symptom related and general QoL of the patients has not been adequately addressed in the literature. In addition, although there are studies investigating predictive factors for QoL outcomes after septoplasty,<sup>19-25</sup> there is no data available to the relevance of the olfactory function specifically to patients' psychological status (anxiety and depression symptoms) and its effect on their satisfaction with the surgical procedure and postoperative QoL recovery. The use of standardized olfactory tests, validated olfaction-specific questionnaires, and mental health psychometric instruments allows a clearer delineation of the psychological profile and evaluation of olfaction of the patients as a co-determinant for QoL and emotional status after septoplasty. The clinical importance is that these data may enable otorhinolaryngologists to better assess their patients and inform them about the anticipated benefit for their QoL after septoplasty.

The aim of the present prospective study was to assess the emotional status and QoL outcomes of patients with olfactory dysfunction and nasal obstruction symptoms who undergo septoplasty. Additionally, the study explored differences in QoL and psychological status between normosmic patients and those with olfactory deficits and investigated the prognostic value of demographic and clinical characteristics for clinically significant improvement of QoL, anxiety symptoms, and emotional status of patients with olfactory dysfunction.

## Materials and Methods

This was a prospective observational study. Sixty adult patients with nasal obstruction due to nasal septal deviation were studied. The diagnosis of septal deviation was established based on clinical examination and nasal endoscopy. Twenty-five healthy individuals, who had neither nasal obstruction nor septal deviation, were recruited as controls. All the enrolled

participants signed the informed consent. The study protocol was performed according to the Declaration of Helsinki and was approved by the local institutional review board (decision no 3525/10.02.2016).

Adult patients younger than 65 years with nasal septal deviation, diagnosed by means of clinical examination and presence of symptoms of nasal obstruction for at least 6 months, were included in the study. Patients were excluded if they met any of the exclusion criteria, such as chronic rhinosinusitis, with or without nasal polyposis; allergic rhinitis; previous nasal surgical procedure; sinonasal malignancy; perforation of the nasal septum; nasal valve collapse; craniofacial syndrome; fracture or trauma of the nose during the last 3 months; pregnancy or cognitive impairment. Patients with a recent infection of the upper respiratory tract, a known hyposmia, patients exposed to chemicals or those suffering from any neurological or systematic diseases with potential impact on the olfactory function were not included in the study. Additionally, patients who underwent any other nasal surgical procedure, particularly rhinoplasty and sinus surgery concomitant to septoplasty, were also excluded.

All participants filled in a detailed health form, which included demographic information and presence of medical comorbidities, and focused on factors that might affect olfactory function, such as smoking habits, profession, medical treatment, and recreational activities. For recruitment to the study, in addition to anterior rhinoscopy and nasal endoscopy, participants underwent skin prick testing for atopy and sinus computed tomography scanning (when medically justified) for the identification of those who met the exclusion criteria.

The "Sniffin' sticks" test package (Burghart Messtechnik GmbH, Wedel, Germany), which includes specific tests for odor threshold (OT), odor discrimination (OD), and odor identification (OI)<sup>26-28</sup> was used for quantitative evaluation of the olfactory function of all participants. The results of each test were combined with an overall "Threshold Discrimination Identification (TDI) score"<sup>28,29</sup>. The TDI score ranges from 0 to 48. Values of 16 or less represent anosmia; values between 16.25 and 30.5 represent hyposmia; and values over 30.75 represent normosmia.<sup>28</sup> A six-point difference in the TDI score was considered a clinically significant change of olfactory function after surgery.<sup>30</sup>

The olfactory tests were performed preoperatively and 6 months after septoplasty. At these time points, the participants also filled in six widely used questionnaires, translated, and validated into the Greek language: the Nasal Obstruction Symptom Evaluation (NOSE) questionnaire, assessing the severity of nasal obstruction symptoms;<sup>31,32</sup> the SinoNasal Outcome Test-22 (SNOT-22), assessing nasal symptom-related QoL;<sup>33,34</sup> the Questionnaire of Olfactory Deficits (QOD), assessing olfaction-associated QoL;<sup>35,36</sup> the Short Anxiety Screening Test (SAST), evaluating anxiety symptoms;<sup>37,38</sup> the Beck Depression Inventory (BDI), evaluating the emotional status of the patients;<sup>39,40</sup> and the Short Form 36 (SF-36), assessing general QoL.<sup>41,42</sup> A postoperative general-health survey specific for patients' satisfaction with the surgical procedure, the Glasgow Benefit Inventory (GBI),<sup>43,44</sup> was completed at 6 months after septoplasty. The NOSE is a

questionnaire for the evaluation of nasal obstruction. It consists of five questions that are scored on a five-point Likert scale from zero to four. The final score ranges between 0 (no symptoms) and 100 (severe nasal obstruction). The SNOT-22 is a health-related questionnaire, in which patients grade 22 different symptoms related to both nasal and general health, physical and emotional status on a scale from 0 (no symptoms) to 5 (symptoms as severe as can be). The QOD is an olfaction-specific QoL questionnaire, which evaluates the effect of olfactory dysfunction on several areas of daily life. Patients answer to 25 4-point scale statements (17 “negative”, 2 “positive”, 6 “socially desired”). The maximum total score is 57, and high scores represent a high negative impact of olfactory disorders on QoL. The SAST consists of 10 questions related to somatic symptoms manifestations of anxiety. Each item is self-rated from 1 to 4, and the total score ranges between 10 and 40, with higher scores indicating a higher degree of anxiety. The BDI is a screening instrument for the evaluation of the psychological profile. It is a 21-item self-reporting questionnaire, and each item is graded from 0 to 3. A higher score is associated with higher levels of depressive mood. The SF-36 is an overall-health related survey assessing QoL in eight domains covering aspects from both physical and mental health from the perspective of patients suffering from chronic diseases. Scores range from 0 to 100, with a higher score indicating better general QoL. Finally, the GBI is a validated 18-item postintervention questionnaire measuring the patient's benefit, developed especially for surgical interventions. The total score ranges from +100 (maximum positive change) to -100 (maximum negative change).

All patients underwent surgery under general anesthesia. The same consultant surgeon performed all the operations and did not participate in the questionnaires' collection and analysis of data. The standardized surgical procedure included partial resections and reshaping of the deviated areas of the septum and submucosal radiofrequency tissue ablation for volume reduction of the inferior nasal turbinates. The anterior nasal packings were removed 48 hours after surgery, and the silicone septal splints were removed on the 4<sup>th</sup> postoperative day. No major complication was encountered postoperatively.

### Statistical Analysis

The data were analyzed with IBM SPSS Statistics for Windows version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were obtained; quantitative variables are expressed as means with standard deviation (SD) while qualitative variables are presented as frequencies (percentages). The normality of the variables was ascertained with the Kolmogorov-Smirnov test. Differences between not normally distributed data were assessed with the use of the Mann-Whitney *U* test and Wilcoxon signed-rank test for independent and related samples respectively. For differences in qualitative parameters between groups, the Chi-square test was applied. Univariate linear regression analysis was used for the evaluation of any potential association between the likelihood of clinically significant improvement for each QoL questionnaire and patients' demographic and clinical characteristics. Clinically significant improvement for each QoL questionnaire was defined as a

change of  $\geq 1/2$  SD of the preoperative score.<sup>45</sup> Multivariate stepwise logistic regression analysis was performed to explore which of the studied patients' characteristics were independently associated with clinically significant improvement of each QoL questionnaire. Only variables with statistical significance during the univariate regression analysis were incorporated into the multiple regression analysis. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated as the measure of association between clinically significant improvement for each QoL questionnaire and all potential predictive factors. A *p*-value of less than 0.05 was considered as the statistical significance level.

### Results

The study cohort consisted of 60 patients (34 [56%] males - 26 [44%] females, mean age:  $32.98 \pm 11.98$  years) and 25 healthy control subjects (13 [52%] males - 12 [48%] females, mean age:  $29 \pm 8.87$  years). In the patients' subgroup, 20 participants were smokers (33.33%). Regarding the socioeconomic status, 14 (23%) had low, 24 (40%) had medium, and 22 (37%) had high socioeconomic status. In the controls' subgroup, 10 participants were smokers (40%). Regarding the socioeconomic status, 6 (25%) had low, 9 (35%) had medium, and 10 (40%) had high socioeconomic status. There were no statistically significant differences related to age ( $p = 0.151$  - Mann-Whitney *U* test), gender ( $p = 0.176$ ), smoking habits ( $p = 0.143$ ), or socio-economic status ( $p = 0.942$  - Chi-squared test for the 3 qualitative parameters) between the 2 groups.

Regarding the preoperative quantitative evaluation of the participants' olfactory function with the use of Sniffin' Sticks test, patients presented statistically significant lower olfactory scores (OT, OD, OI, TDI) compared with controls (Mann-Whitney *U* test,  $p < 0.001$  for all the variables). The olfactory scores of patients and controls are presented in ►Table 1. Six months after surgery, there was a statistically significant improvement in all olfactory scores (Wilcoxon signed-rank test,  $p < 0.001$  for OT, OI, TDI, and  $p = 0.008$  for OD). However, the OT, OD, and TDI scores remained statistically significantly lower compared with the scores of the control group (Mann-Whitney *U* test,  $p < 0.05$  for all parameters). Patients, as expected, had preoperatively statistically significant more severe nasal obstruction symptoms (NOSE scores). The patients' NOSE scores were significantly improved postoperatively but remained lower than the controls' scores.

Regarding QoL and psychological status assessment, there were no statistically significant differences both before and 6 months after surgery in olfaction-associated QoL (QOD scores), emotional status (BDI scores,) and general health status (SF-36 scores—only preoperative evaluation) between patients and controls (Mann-Whitney *U* test,  $p > 0.05$  for all parameters). The mean values are presented in ►Table 1. Preoperatively, the differences in SF-36 scores between patients and controls were minor; therefore, the questionnaire was not filled in by the participants 6 months after surgery. Patients had preoperatively statistically significantly worse nasal symptom-related QoL (SNOT-22 scores) and higher stress levels (SAST scores) than controls (Mann-Whitney *U* test,  $p < 0.001$

**Table 1** Olfactory function, questionnaires of quality of life and psychological status of the controls and the patient group (preoperatively and 6 months after surgery)

	Control (n = 25)	Patient group (n = 60)		p-value
		preop	postop	
Olfactory scores				
OT	9.2 (2.19)	<b>4.78 (2.88)</b>	<b>6.98 (3.03)</b>	< 0.001
OD	13.12 (1.67)	<b>9 (2.76)</b>	<b>11.35 (2.45)</b>	0.008
OI	13.32 (2.18)	<b>10.08 (1.69)</b>	12.08 (1.97)	< 0.001
TDI	35.64 (2.62)	<b>23.87 (4.28)</b>	<b>29.42 (4.72)</b>	< 0.001
QoL tools				
SF-36	83.48 (9.74)	80.20 (15.45)		
SNOT 22	12.9 (8.86)	<b>42.93 (19.57)</b>	<b>26.7 (18.9)</b>	< 0.001
QOD	6.92 (2.08)	8.85 (5.11)	7.91 (3.42)	0.25
Psychological tools				
SAST	11.7 (6.39)	<b>22.63 (7.94)</b>	<b>17.5 (4.4)</b>	0.05
BDI	6.85 (3.43)	7.53 (5.76)	7 (5.36)	0.08

Abbreviations: BDI, Beck depression inventory; OD, olfactory discrimination; OI, olfactory identification; OT, olfactory threshold; QOD, questionnaire of olfactory disorders; QoL, quality of life; SAST, short anxiety screening test; SF-36, short form – 36; SNOT 22, SinoNasal outcome test 22; TDI, threshold discrimination identification.

Bold: Statistically significant difference compared with the control group, p-values: pre and posttreatment scores comparisons for the patient group –Wilcoxon Signed-Rank test for paired samples.

Data are expressed as mean values (standard deviation), preop: preoperatively, postop: postoperatively.

for all parameters). Although these parameters were significantly improved postoperatively, they maintained their statistically significant difference between the patients and control groups (►Table 1).

We further investigated QoL and psychological implications in the subgroup of patients with olfactory dysfunction (according to TDI scores). The preoperative results are presented in ►Table 2 and the postoperative ones in ►Table 3. Preoperatively, patients with decreased olfactory function had worse nasal-symptom related and olfaction-associated QoL, higher stress levels, more depressive mood, and reduced general QoL than normosmic patients. However, only the differences in SNOT-22 and BDI scores reached statistical significance ( $p < 0.05$  for both). Six months after surgery, normosmic

patients had statistically significantly better nasal-symptom related QoL, lower stress levels, better emotional status and more personal benefit from the surgical procedure (GBI scores) than patients who reported olfactory deficits ( $p < 0.05$  for all parameters). Except for general QoL (SF-36 scores), both patients' groups (normosmics and patients with decreased olfactory status) had worse scores in all the above parameters preoperatively compared with controls. These differences were statistically significant for all scores between the patients with olfactory impairment and healthy controls. For normosmic patients, only differences in SNOT-22 and SAST scores reached statistical significance (Mann-Whitney  $U$  test,  $p < 0.001$  for both). Postoperatively, patients with decreased olfactory function had statistically significantly worse SNOT-22, SAST, and

**Table 2** Nasal symptom related quality of life (QoL), olfaction related QoL, stress levels, depressive mood and general health status of controls, patients with olfactory deficits and normosmic patients, preoperatively

	Controls (n = 25)	Patients with olfactory deficits (n = 50)	Normosmic Patients (n = 10)	p-value
SNOT 22	12.9 (8.86)	<b>57.7 (14.75)</b>	<b>38.8 (9.16)</b>	0.019
QOD	6.92 (2.08)	<b>10.94 (2.85)</b>	8.9 (2.75)	0.109
SAST	11.7 (6.39)	<b>23.62 (7.91)</b>	<b>20.4 (7.86)</b>	0.222
BDI	4.65 (2.08)	<b>8.26 (2.72)</b>	4.7 (2.7)	0.029
SF 36	83.48 (9.74)	77.65 (13.34)	81.2 (10.98)	0.086

Abbreviations: BDI, Beck depression inventory; QOD, questionnaire of olfactory disorders; QoL, Quality of life; SAST, short anxiety screening test; SF-36, Short Form – 36; SNOT 22, SinoNasal outcome test 22.

Bold: Statistically significant difference compared with control group, p value: comparisons between normosmics and patients with olfactory dysfunction, all groups comparisons: Mann-Whitney  $U$  test for independent samples.

Data are expressed as mean values (standard deviation). n: number of patients.

**Table 3** Nasal symptom-related quality of life (QoL), olfaction-related QoL, stress levels, depressive mood and patient's satisfaction with the surgical procedure of patients with olfactory deficits and normosmic patients, 6 months after surgery

	Controls ( <i>n</i> = 25)	Patients with olfactory deficits ( <i>n</i> = 41)	Normosmic patients ( <i>n</i> = 19)	<i>p</i> -value
SNOT 22	12.9 (8.86)	<b>30.97 (12.11)</b>	<b>22 (8.74)</b>	0.014
QOD	6.92 (2.08)	8.27 (4.33)	7.02 (3.4)	0.14
SAST	11.7 (6.39)	<b>20.58 (5.61)</b>	15.57 (5.76)	0.045
BDI	4.65 (2.08)	<b>8.09 (2.49)</b>	4.63 (0.61)	0.028
GBI		5.35 (2.18)	18.05 (3.51)	0.002

Abbreviations: BDI, Beck depression inventory; GBI, Glasgow benefit inventory; QOD, questionnaire of olfactory disorders; QoL, quality of life; SAST, short anxiety screening test; SNOT 22: SinoNasal outcome test 22.

Bold: Statistically significant difference compared with control group, *p*-value: comparisons between normosmic patients and patients with olfactory dysfunction, all groups comparisons: Mann-Whitney *U* test for independent samples.

Data are expressed as mean values (standard deviation). *n*: number of patients.

BDI scores than controls (Mann-Whitney *U* test,  $p < 0.05$  for all). Normosmic patients showed, postoperatively, statistically significant differences from controls only in SNOT-22 scores (Mann-Whitney *U* test,  $p < 0.05$ ).

Among the patients' cohort, clinically significant improvement was observed in 22 patients (36.67%) for olfaction-associated QoL (QOD score), 32 (53.3%) for stress levels (SAST scores) and 18 (30%) for emotional health (BDI scores), while 32 patients (53.3%) reported a positive change of their general health status (GBI scores) after surgical procedure (► **Tables 4** and **5**). The incidence of clinically significant improvement of the QOD, SAST, BDI scores, and positive change of GBI scores in relation to the patients' demographics and disease characteristics was further analyzed (► **Tables 4** and **5**). In the univariate linear regression analysis (► **Table 4**), it was found that the likelihood of clinically significant improvement of the QOD score was higher for patients with clinically significant improvement of the NOSE and SNOT-22 scores and postoperative normal olfactory function ( $p < 0.05$  for all parameters). The incidence of positive change of GBI score was higher for patients with clinically significant improvement of the NOSE and SNOT-22 scores 6 months after surgery ( $p \leq 0.001$ —► **Table 4**). The likelihood of clinically significant improvement of the SAST score was higher for those patients who had clinically significant improvement of the NOSE and SNOT-22 scores ( $p < 0.05$  and  $p < 0.001$ , respectively—► **Table 5**). The likelihood of clinically significant improvement of the BDI score was higher for patients with clinically significant improvement of the NOSE and SNOT-22 scores and postoperative normal olfactory function ( $p < 0.05$  for all parameters—► **Table 5**).

The multivariate logistic regression analysis (► **Table 6**) revealed that the clinically significant improvement of the SNOT-22 score was an independent predictive factor significantly associated with higher likelihood of clinically significant improvement of all parameters (QOD score—OR: 3.79, 95%CI: 1.11–12.88,  $p < 0.05$ ; SAST score - OR: 6.14, 95%CI: 1.87–20.07,  $p < 0.05$ ; BDI score—OR: 5.61, 95%CI: 1.35–23.15,  $p < 0.05$ ) and higher incidence of positive GBI score (OR: 8.75, 95%CI: 2.07–36.93,  $p < 0.05$ ). Additionally, the clinically significant improvement of the NOSE score was statistically significantly associated with a higher likelihood of clinically significant improvement of the QOD (OR: 3.51, 95%CI: 1.02–12.04,  $p < 0.05$ ) and SAST scores

(OR: 3.82, 95%CI: 1.16–12.51,  $p < 0.05$ ) and higher incidence of positive GBI score (OR: 14, 95%CI: 3.32–58.95,  $p < 0.001$ —► **Table 6**). Furthermore, the presence of olfactory dysfunction was an independent predictive factor significantly associated with a lower likelihood of clinically significant improvement BDI score (OR: 0.56, 95%CI: 0.13–0.76,  $p < 0.05$ ).

## Discussion

Nasal septal deviation is a common nasal disease causing nasal obstruction symptoms and decreased olfactory function, which, in turn, affect the QoL of the patients.<sup>15,46</sup> Although there are previous reports on patients' satisfaction and the impact of septoplasty on the QoL of the patients,<sup>23,47–51</sup> there are no studies analyzing the impact of olfactory dysfunction on the emotional status and QoL in patients who had septoplasty. The present study assessed olfactory function as a potential predictor of patients' QoL and psychological status improvement, analyzing the correlations of demographic and clinical characteristics of the patients who experience a clinically significant improvement on the emotional status and QoL. The clinical importance of investigating the emotional status and QoL in this group of patients is related to the fact that nasal septal deviation is a common cause of olfactory impairment and nasal obstruction. Psychological status and QoL are likely to be affected due to the chronicity of symptoms, and it is a surgically treatable condition whose outcome measurement is essential to plan personalized patient care. Interesting findings regarding the correlations between patients' demographic and clinical characteristics and QoL, stress levels, depressive mood, and personal benefit from septoplasty were noted.

In the present study as well as in previous researches,<sup>52</sup> it was observed that patients with septal deviation had impaired olfactory function (lower OT, OD, OI and TDI scores), more severe nasal obstruction symptoms and reduced nasal-symptom related QoL than healthy controls. Furthermore, patients with olfactory deficits due to septal deviation had reduced nasal-symptom related and olfaction-associated QoL compared with normosmic patients and healthy controls. Normosmic patients had less impact on olfaction-associated QoL than patients with impaired olfactory function compared with healthy controls. Six months after septoplasty, probably due

**Table 4** Clinically significant improvement of questionnaire of olfactory disorders and positive change of Glasgow benefit inventory in relation to the demographic and clinical characteristics of the patients

	Clinically improved QOD (n, %)	OR (95% CI)	p-value	Positive change GBI (n, %)	OR (95% CI)	p-value
<b>Age</b>			0.39			0.55
≤ 30 years	9 (30%)	Ref.		15 (50%)	Ref.	
> 30 years	13 (43.3%)	1.02 (0.97–1.06)		17 (56.7%)	1.01 (0.97–1.05)	
<b>Sex</b>			0.429			0.944
Males	12 (35.2%)	Ref.		18 (52.9%)	Ref.	
Females	10 (38.4%)	1.53 (0.53–4.42)		14 (53.8%)	1.03 (0.37–2.88)	
<b>Smoking</b>			0.85			0.855
No	15(37.5%)	Ref.		22 (55%)	Ref.	
Yes	7 (35%)	0.46 (0.36–1.21)		10 (50%)	0.9 (0.3–2.65)	
<b>Socio-economic status</b>			0.285			0.804
Low	4 (28.5%)	Ref.		7 (50%)	Ref.	
Medium	8 (33.3%)	1.26 (0.56–2.07)		13 (54.1%)	1.02 (0.66–2.25)	
High	10 (45.4%)	1.47 (0.72–2.98)		12 (54.5%)	1.08 (0.56–2.11)	
<b>Clinically improved NOSE</b>			0.009			< 0.001
No	9 (20%)	Ref.		4 (9%)	Ref.	
Yes	13 (63.3%)	4.57 (1.45–14.38)		28 (88%)	11 (3.29–36.75)	
<b>Clinically improved SNOT-22</b>			0.022			0.001
No	7 (22.5%)	Ref.		10 (26.2%)	Ref.	
Yes	15 (51.7%)	3.67 (1.2–11.18)		22 (81.3%)	6.6 (2.12–20.55)	
<b>Olfactory dysfunction postoperatively<sup>a</sup></b>			0.024			0.302
No	17 (46.3%)	Ref.		22 (53.6%)	Ref.	
Yes	5 (26.3%)	0.27 (0.18–0.96)		10 (52.6%)	0.97 (0.6–2.29)	

Abbreviations: CI, confidence intervals; GBI, Glasgow benefit inventory; NOSE, nasal obstruction symptom evaluation; OR, odds ratio; p-values, univariate linear regression; QOD, questionnaire of olfactory disorders; SNOT 22, SinoNasal outcome test 22.

Data are expressed as number of patients (n) and percentages (%).

<sup>a</sup>Based on TDI score.

to increased intranasal airflow, an improvement of olfactory function was observed and this was expressed by a significant improvement of TDI scores and all separate olfactory (OT, OD, OI) scores. Previous reports demonstrated similar results.<sup>1,11,13–15,46,53</sup> Postoperatively, olfaction-associated QoL did not differ significantly between the three groups. Olfaction-related QoL was improved for both normosmic patients and those with olfactory dysfunction. Specifically, the mean value of the QOD score for the group of patients with olfactory deficits postoperatively reached the preoperative mean value of the normosmic patients. The QOD is a symptom-specific (olfaction) QoL measure but is possibly also affected by other nasal symptoms. The effects of other nasal symptoms might have a more prominent negative impact on QoL of patients with olfactory dysfunction because nasal symptoms coexist with impairment in areas such as food enjoyment, harm avoidance, and socializing.<sup>2</sup> According to the results of the present study, septoplasty leads to olfaction recovery and increase in the number of patients with normal olfactory function. Additionally, it contributes to nasal-symp-

tom related and olfaction-associated QoL improvement in patients with olfactory dysfunction and septal deviation, through nasal symptoms resolution and improvement of olfactory status.

Another important finding of the present study was that although in univariate analysis, the presence of postoperative olfactory dysfunction was significantly negatively correlated with clinically significant improvement of QOD, this association became non-significant in multivariate analysis. After screening of all potential demographic and clinical predictors, it was found that clinically significant improvement of nasal obstruction symptom severity (NOSE scores) and nasal-symptom related QoL (SNOT-22 scores) were the only parameters highly associated with an increased likelihood of clinically significant improvement of olfaction-associated QoL (QOD scores). These results support the opinion that there seems to be a disconnection between quantitative assessment of olfactory function and subjective experience of olfactory impairment and that olfactory-specific QoL is affected by additional factors beyond olfactory status.

**Table 5** Clinically significant improvement of short anxiety screening test and Beck depression inventory in relation to the demographic and clinical characteristics of the patients

	Clinically improved SAST (n, %)	OR (95% CI)	p-value	Clinically improved BDI (n, %)	OR (95% CI)	p-value
<b>Age</b>			0.143			0.114
≤ 30 years	17 (56.7%)	Ref.		10 (33.3%)	Ref.	
> 30 years	15 (50%)	0.33 (0.18–1.08)		8 (26.7%)	0.87 (0.69–1.08)	
<b>Gender</b>			0.944			0.309
Male	17 (50%)	Ref.		11 (32.3%)	Ref.	
Female	15 (58%)	1.76 (0.34–2.68)		7 (27%)	0.55 (0.17–1.74)	
<b>Smoking</b>			0.204			0.238
No	20 (50%)	Ref.		7 (35%)	Ref.	
Yes	12 (45%)	0.25 (0.17–2.32)		11 (27.5%)	0.24 (0.17–4.7)	
<b>Socioeconomic status</b>			0.443			0.825
Low	7 (50%)	Ref.		5 (21.7%)	Ref.	
Medium	13 (54.1%)	1.02 (0.43–2.12)		7 (25.1%)	1.03 (0.24–1.98)	
High	12 (54.5%)	1.3 (0.66–2.54)		6 (29.2%)	1.08 (0.52–2.24)	
<b>Clinically improved NOSE</b>			0.011			0.029
No	7 (23.3%)	Ref.		6 (24%)	Ref.	
Yes	25 (83.3%)	4.03 (1.37–11.83)		12 (68%)	3.82 (1.15–12.71)	
<b>Clinically improved SNOT-22</b>			0.001			0.019
No	9 (15%)	Ref.		5 (21.3%)	Ref.	
Yes	23 (79.3%)	6.39 (2.07–19.68)		13 (72.4%)	4.22 (1.26–14.09)	
<b>Olfactory dysfunction postoperatively<sup>a</sup></b>			0.941			0.012
No	22 (53.6%)	Ref.		12 (65.7%)	Ref.	
Yes	10 (52.6%)	0.94 (0.35–3.1)		6 (17.2%)	0.28 (0.14–0.68)	

Abbreviations: BDI, Beck depression inventory; CI, confidence intervals; NOSE, nasal obstruction symptom evaluation; OR, odds ratio; p-values, univariate linear regression; SAST, short anxiety screening test; SNOT 22, SinoNasal outcome test 22.

Data are expressed as number of patients (n) and percentages (%).

<sup>a</sup>Based on TDI score.

In the present study, it was found that the whole patient group had higher stress levels (SAST values) than healthy individuals. Patients with olfactory deficits had more anxiety symptoms than patients with normal smell and healthy controls. Stress levels were reduced for the whole patient group after nasal septoplasty, in accordance with the results reported by Hong et al.<sup>24</sup> However, 6 months after surgery, only patients with normal olfactory function had stress levels that presented no significant differences from healthy controls. Furthermore, clinically significant improvement of nasal obstruction symptom severity (NOSE scores) and nasal-symptom related QoL (SNOT-22 scores), but not the presence of normal olfaction, were highly associated with an increased likelihood of clinically significant improvement of anxiety symptoms (SAST scores). Specifically, patients with clinically significant improvement of nasal obstruction symptom severity and nasal-symptom related QoL were 3.82 and 6.14 times more likely to experience clinically significant improvement of anxiety symptoms

(SAST scores), respectively. These results suggest that the levels of stress in patients treated for septal deviation are less affected by olfactory impairment than what has been reported for patients with other sinonasal diseases, such as chronic rhinosinusitis with or without nasal polyposis.<sup>54–56</sup> Although patients with olfactory deficits present higher stress levels than normosmic patients, nasal obstruction symptoms appear to be the main factor inducing anxiety symptoms in patients with septal deviation. This finding seems reasonable because nasal obstruction can be connected with symptoms such as insomnia/sleep disturbances and headaches, which are assessed with the use of the SAST questionnaire.

Regarding the emotional status, patients with olfactory deficits had more depressive mood (BDI scores) compared with patients with normal olfactory function and healthy controls, both before and 6 months after surgery. Previous studies evaluating the impact of olfactory disorders, due to various causes, on the QoL of patients<sup>2,4–6</sup> demonstrated that

**Table 6** Multivariate logistic regression analysis between predictor variables and clinically significant improvement of QOD, SAST and BDI scores and positive change of GBI scores

	OR (95% CI)	p-value
<b>QOD</b>		
Clinically improved NOSE	3.51 (1.02–12.04)	0.046
Clinically improved SNOT-22	3.79 (1.11–12.88)	0.033
Olfactory Dysfunction postoperatively	0.23 (0.16–1.8)	0.204
<b>SAST</b>		
Clinically improved NOSE	3.82 (1.16–12.51)	0.027
Clinically improved SNOT-22	6.14 (1.87–20.07)	0.003
<b>BDI</b>		
Clinically improved NOSE	2.67 (0.69–10.39)	0.154
Clinically improved SNOT 22	5.61 (1.35–23.15)	0.017
Olfactory Dysfunction postoperatively	0.56 (0.13–0.76)	0.021
<b>GBI</b>		
Clinically improved NOSE	14 (3.32–58.95)	< 0.001
Clinically improved SNOT-22	8.75 (2.07–36.93)	0.003

Abbreviations: BDI, Beck depression inventory; GBI, Glasgow benefit inventory; NOSE, nasal obstruction symptom evaluation; QOD, questionnaire of olfactory disorders; SAST, short anxiety screening test; SNOT-22, SinoNasal outcome test-22.

Data are expressed as odds ratios (OR) with their 95% confidence intervals (CI). Only variables with statistical significance during univariate linear regression analysis are included. *p*values: Multivariate logistic regression analysis.

individuals with olfactory dysfunction experience reduced food enjoyment, problems related to personal hygiene (insecurity about personal body odor), reduced participation in social life and limitations with sensing warning signals (gas/smoke). It can be assumed that the aforementioned daily life restrictions may impair QoL and impact the emotional status of patients with olfactory deficits related to septal deviation. The negative impact of olfactory dysfunction on patients' emotional status could also be related to the connection between olfactory system and structures of the limbic system like the amygdala and orbitofrontal cortex,<sup>57</sup> which mainly contribute to the development of depressive symptoms.<sup>58</sup> It is noteworthy that, clinically significant improvement of nasal-symptom related QoL (SNOT-22 scores) was associated with an increased likelihood of clinically significant improvement of depressive mood (BDI scores). Patients with clinically significantly improved SNOT-22 scores were 5.61 times more likely to experience clinically significant improvement in levels of depression. In contrast, impaired olfaction postoperatively was correlated with reduced incidence of improved BDI scores. Normosmic patients were 4.37 times more likely to experience clinically significant improvement of depressive mood (BDI scores) than patients with olfactory deficits. These findings indicate that olfactory impairment due to septal deviation appears to have a negative effect on patients' emotional profile.

According to the results of the present study, olfactory impairment had a negative impact on patient-reported benefit from surgery, as patients with impaired smell appeared less satisfied than normosmic patients. However, olfactory status was not found to have a significant impact on the likelihood of personal benefit from septoplasty. Similarly, none of the patients' demographics affected the subjective evaluation of surgical outcome, in agreement with previous studies which examined age, gender, smoking<sup>19,21,24,25,48</sup> and socio-economic status.<sup>19</sup> Clinically significant improvement of nasal obstruction and nasal-symptom related QoL were the only predictive factors significantly associated with subjective surgical outcome. Specifically, patients with clinically significant nasal obstruction symptom resolution and nasal-symptom related QoL improvement were 14 and 8.75 times more likely to experience higher personal benefit from surgery, respectively. This finding is in accordance with other reports, which demonstrated that patients with more severe nasal symptoms preoperatively had more potential of improvement of their health status after septoplasty and were more satisfied with surgical outcome.<sup>19,21,23,24,49</sup> Thus, it seems that personal benefit from septoplasty is mainly affected by nasal symptom resolution rather than improvement of olfactory function.

An interesting finding of the present study was that there were no significant differences between general QoL (SF-36 scores) of healthy controls and patients with septal deviation, either with olfactory deficits or normosmics. Probably, nasal obstruction and olfactory impairment related to septal deviation do not cause a deterioration of health status significant enough to be depicted in this general-health status questionnaire.<sup>50,51</sup> In contrast, the SNOT-22 is a specific nasal-symptom related QoL questionnaire, and it covers the effects of physical health, functional limitations, and emotional aspects of QoL related to the nasal functions, including olfaction. That explains why, according to the results of the present study, clinically significant improvement of the SNOT-22 score was an independent predictor highly associated with clinically significant improvement of olfaction-associated QoL, psychological status (anxiety symptoms and depressive mood), and a higher likelihood of patients-reported benefit from the surgical procedure.

To the best of our knowledge, this is the first study to address the association of olfactory function with clinically significant improvement of QoL and psychological outcomes of patients who undergo septoplasty. In the present study, validated tools were used to measure general, disease-specific and olfaction-specific QoL, emotional status, and patient outcome satisfaction and comparisons with healthy controls were performed. Additionally, quantitative smell tests for the measurement of olfactory performance were utilized, providing clinically important data for the olfactory function in patients treated with septoplasty. Future studies may provide useful knowledge on the clinical importance of olfactory testing prior to surgery for appropriate consultation of patients.



## Conclusion

Nasal septoplasty leads to better olfactory function along with nasal obstruction resolution and improvement of nasal symptom-related QOL. Olfactory impairment related to septal deviation has a negative impact on psychological status and disease-specific QoL. Although improvement of nasal obstruction and nasal-symptom related QoL were the only factors significantly associated with patients' evaluation of surgical outcome, patients with olfactory deficits were less satisfied with the surgical procedure than normosmics and experienced greater stress and depressive mood. Quantitative evaluation of the olfactory status of patients treated for septal deviation is important for optimal assessment of the patients and consultation regarding the anticipated septoplasty outcomes.

### Conflict of Interests

The authors have no conflict of interests to declare.

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