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RHINOLOGY

Sensibility, specificity, and accuracy of the Sinonasal Outcome Test 8 (SNOT-8) in patients with chronic rhinosinusitis (CRS): a cross-sectional cohort study

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Abstract

Purpose To analyze as the primary endpoint the accuracy, sensitivity, and specificity of the SNOT-22 assessing CRS severity and to compare the results with a version of the SNOT-8 obtained from the nasal domain items.

Methods Data were obtained from a prospective multicenter controlled study of dupilumab in adults with moderate–severe CRSwNP. EQUATOR and STROBE network guidelines were adopted. A multivariate logistic regression model was used to evaluate the accuracy of the model with the full (SNOT-22) and reduced (SNOT-8) item set to predict the severity outcome.

Results SNOT-22 demonstrated an AUC of 0.885 (95% CI 0.825, −0.945), and sensitivity and specificity of 91.49% (83.92–96.25%) and 69.23% (48.21–85.67%), respectively. Interestingly, after stepwise items elimination good outcomes were reported for SNOT-8, with an AUC of 0.818 (95% CI 0.744–0.892), achieving a sensitivity of 93.51% (85.49–97.86%) and specificity of 57.14% (40.96–72.28%).

Conclusion Psychometric analyses support the accuracy, sensitivity, and specificity of the nasal domains of SNOT-22 to assess the impact on HRQoL in patients with CRSwNP.

Keywords Chronic rhinosinusitis with nasal polyps · SNOT-22 · HRQoL · NPS

Introduction

Chronic rhinosinusitis (CRS) is a very common disease in the general population, with a prevalence of up to 5–15% [1]. CRS has significant impact on health-related quality of life (HRQoL) especially due to nasal obstruction, rhinorrhea, and olfactory impairments [2].

The use of HRQoL questionnaires improves patient care and demonstrates clinical and predictive efficacy in treatment [3–5]. Among the frequently used questionnaires in

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rhinology, the Sino-Nasal Outcome Test-22 (SNOT-22) is the most widely used and has proven to be the most suitable because of its reliability, validity, and ease of use [6].

The SNOT-22 has demonstrated its validity in also comparing therapeutic outcomes, both in the surgical approach to SRC and in the more recent use of biologic therapy [7]. However, to optimize the use of the questionnaire in patients with CRS, it is essential to use an HRQoL questionnaire that contains disease-specific domains, validating its predictivity against the original version. In this regard, a faster and more effective tool than SNOT-22 could be useful, removing confounding and not closely related items to nasal symptomatology [8].

To date, however, SNOT-22, although translated and validated in several languages, does not possess a validated reduced version presenting comparable accuracy and validity compared with SNOT-22 in patients with CRS.

We conducted this study to evaluate and validate the predictivity, sensitivity, and specificity of SNOT-8 in patients with CRS, showing its efficacy compared with SNOT-22 as diagnostic tool.

Methods

Study design and patients

We retrieved guidelines describing the design, conduct, and reporting of observational and clinical trials from the EQUATOR network (https://www.equator-network.org/). Additional searches of guideline references were conducted to identify relevant publications. We therefore selected and adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist [9].

A prospective controlled study was conducted, enrolling patients with severe CRSwNP at our tertiary ENT center from April 1, 2021, to November 1, 2022.

Patients aged 18 years or older with bilateral massive nasal polyps (NPS 5 out of a maximum of 8) [10] and symptoms of CRS despite intranasal steroids and/or short term of oral corticosteroids were recruited.

Nasal status was assessed via clinical and endoscopic examination to diagnose CRS according to the European position paper on rhinosinusitis and nasal polyps [11]. We excluded all patients with the following criteria: autoimmune diseases, genetic, congenital, or acquired immunodeficiencies, neoplasms or previous chemoradiation therapies, previous olfactory disorders, or other ongoing biologic therapies.

Additional inclusion criteria were that patients had to be able to understand and complete the questionnaire. If applicable, participants were informed about the study and completed the SNOT-22 questionnaire [12]. We then administered a second questionnaire (SNOT-8), consisting of the nasal domain items, to all subjects to complete after the first questionnaire obtained after backward elimination process to assess the significant correlation of each item with the established dependent variable.

We analyzed as primary endpoints the changes of sensibility, specificity, and accuracy of SNOT-22 at baseline and after stepwise items backword elimination discriminating CRSwNP severity according to total NPS score. In contrast, the secondary efficacy endpoints were the correlation between SNOT-22 full questionnaire and reduced (SNOT-8) and other baseline features as VAS for Nasal Obstruction, Rhinorrhea and Headache.

The study was approved by the University's Human Medical Research and Ethics Committee and was conducted in accordance with the Declaration of Helsinki (code 24121-21/05/2021).

Subjective questionnaire

The SNOT-22 has items scored on a scale of 0 to 5 with 0 meaning absence of symptoms, while 5 is the worst possible. The sum of each item results in a minimum score of 0 and a maximum score of 110, with worse symptomatology for higher scores. Two main categories comprise the questions: domain on physical symptoms (12 items) covering rhinological, auricular, and facial symptoms, while ten questions on general health and quality of life also cover sleep function and psychological.

The eight items constituting the reduced SNOT model are summarized in Fig. 1.

Patient assessment and outcomes

Patients were evaluated at baseline, assessing symptoms based on the visual analog scale (VAS), with 0 representing no symptoms and 10 representing the most severe symptoms, for nasal obstruction, rhinorrhea, and headache. CRS was assessed endoscopically with a 2.7-mm flexible endoscope at 0° degrees (Olympus, Germany), evaluating the

Item	
1	Need to blow nose
2	Sneezing
3	Runny nose
4	Cough
5	Post-nasal discharge
6	Thick nasal drainage
7	Sense of taste/smell
8	Blockage/congestion of nose

Fig. 1 SNOT-8 items

presence of nasal polyp score (NPS) for each nostril [16]. The sum of the scores obtained for the right and left nostrils has a range from 0 to 8, with higher scores indicating a worse state.

Statistical analysis

We used standard descriptive statistics, reporting mean and standard deviation for continuous variables and percentages for categorical variables. We used the independent *t* test for normally distributed values, while the Mann–Whitney *U* test was performed for non-normally distributed values. We used the Chi-square test to test the difference between the observed and expected data. A p value < 0.05 was considered statistically significant.

The predictive role of each independent variable assessed was evaluated via a multiple linear regression.

Logistic regression predictive models were used to evaluate and compare sensibility, specificity, and accuracy of the full and reduced SNOT questionnaire administrated. We used Receiver-Operating Characteristic (ROC) curves to assess the ability of the logistic regression models to identify disease severity. Results were reported in terms of area under the curve (AUC) and 95% Confidence Interval (95% CI). A first multivariate logistic regression model was used to evaluate the model accuracy in outcome prediction with the complete set of variables (SNOT-22). A second multivariate logistic model was the result of a backward stepwise elimination for the eight selected features, assessing the effect of the dependent variables to predict the severity outcome.

All analyses were performed using the statistical program for the social sciences (IBM SPSS Statistics for Windows, IBM Corp. Released 2017, Version 25.0 Armonk, NY: IBM Corp).

Results

Patients' features

After selection, a total of 120 participants with an age of 52,35 ± 2,15 years were included in the study, of which 77/120 (64.16%) were male vs. 43 (35.83%) female (Table 1).

Among other primary endpoints analyzed, the most severe disorder reported among preoperative symptoms was nasal obstruction, rhinorrhea, and smell with a mean severe VAS score at baseline of 8.26 ± 2.80, 6.87 ± 2.79, and 8.89 ± 0.91, respectively.

At multiple linear regression for independent predictive factors, preoperative NPS, VAS obstruction, Rhinorrhea, and Smell demonstrated a correlation and statistical significance for SNOT 22, while VAS Rhinorrhea, although correlated was not significant. Instead, SNOT 8 reached statistical correlation with the baseline outcome.

Table 1 Main demographic features at baseline

	Subjects ($n = 120$)
Age	51.92 ± 12.37
Sex	M77(64.16%) vs. F43 (35.83%)
BMI	24.93 ± 8.92
Smoke status	16/120 (%)
Comorbidities	
Atopy	82/120 (%)
Asthma	70/120 (%)
Lund–Mackay score	
NPS	5.58 ± 1.05
SNOT 22	58.46 ± 20.28
SNOT 8	2.43 ± 7.16
NCS	2.39 ± 0.53
SSIT score	3.47 ± 2.74
VAS obstruction	8.26 ± 2.80
VAS rhinorrea	6.87 ± 2.79
VAS headache	5.16 ± 3.51
VAS smell	8.89 ± 0.91
ACT score (asthma)	22.65 ± 3.27

Logistic regression analysis, and full and reduced SNOT models

Through the traditional statistical analysis, the SNOT-22 (full model) demonstrated an ROC curve with an AUC of 0.885 (95% CI 0.825–0.945) and 86.67% accuracy (79.25–92.18%).

Moreover, a sensitivity and specificity of the regression to distinguish among CRS severity were 91.49% (83.92–96.25%) and 69.23% (48.21–85.67%), respectively (Fig. 2).

The consequent features' selection using the backward stepwise elimination demonstrated for the SNOT-8 (reduced model) an AUC of 0.818 (95% CI 0.744–0.892) (%–%) and an accuracy of 80.67% (72.42–87.34%).

Moreover, the model reached a sensitivity of 93.51 (85.49–97.86%) and a specificity of 57.14% (40.96–72.28%) (Fig. 3).

Discussion

The HRQOL is a frequently used measure in studies evaluating response to certain therapies, providing a useful alternative, through validated questionnaires, instrumental or laboratory outcomes [13–16].

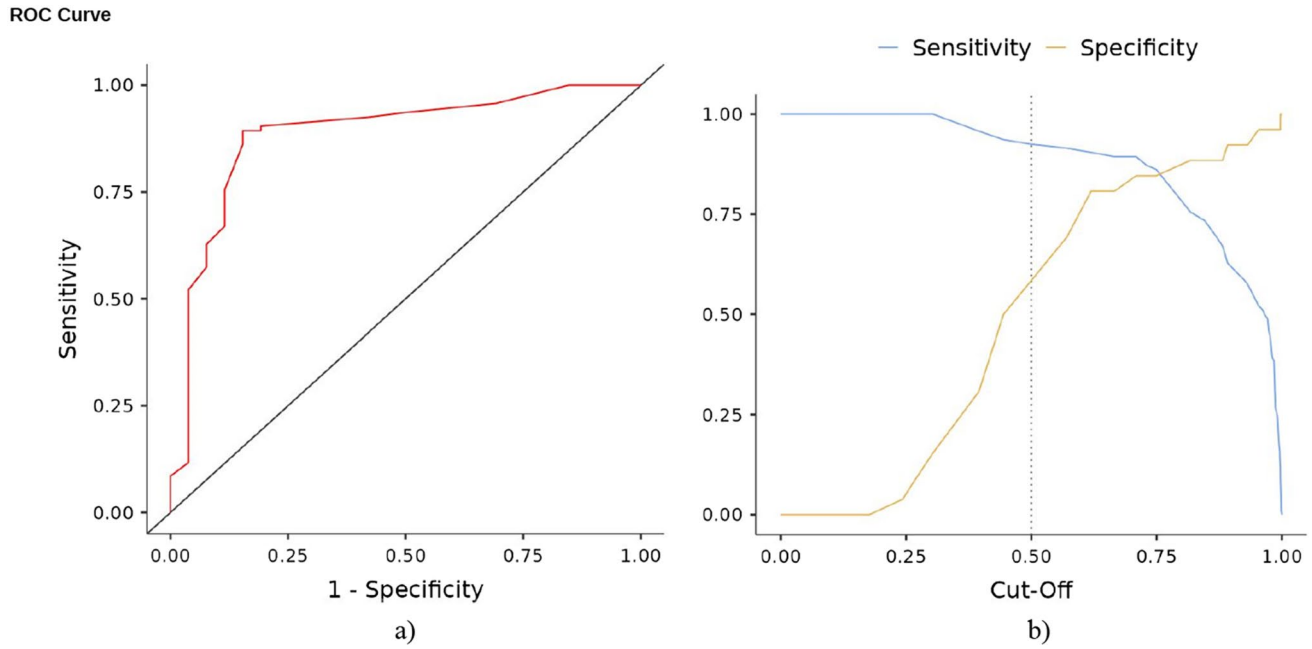

Fig. 2 SNOT-22 regression analysis: **a** ROC; **b** sensitivity and specificity curves

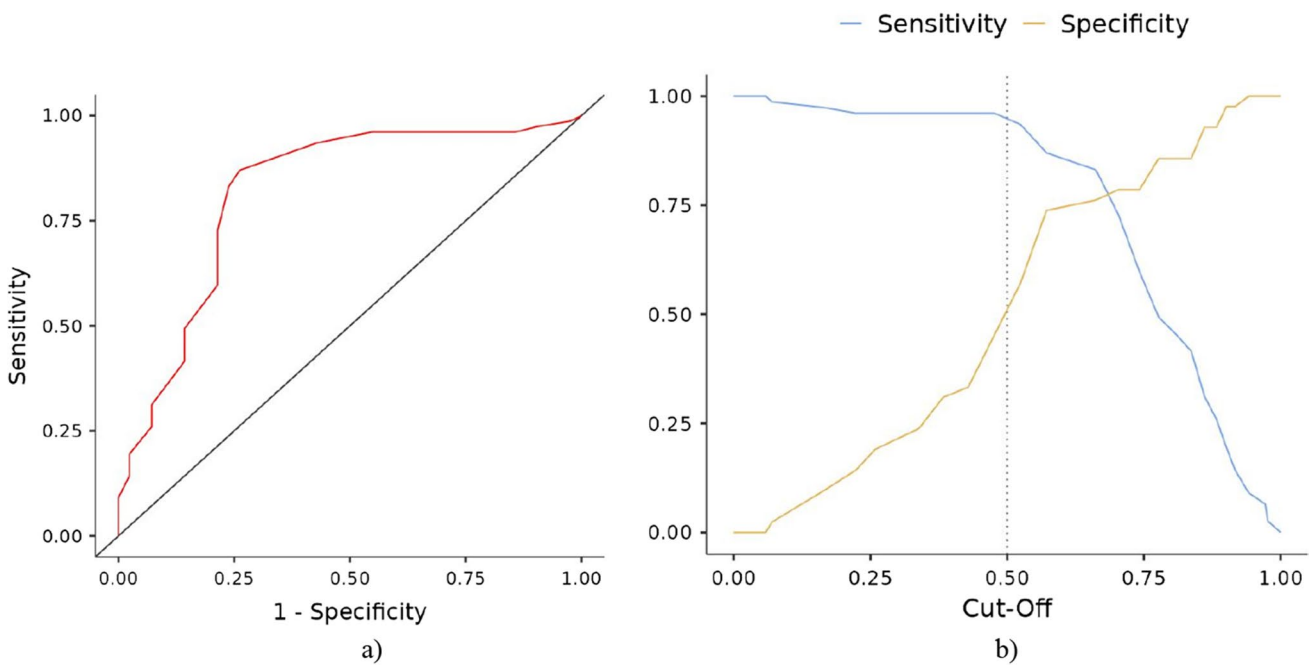

Fig. 3 SNOT-8 regression analysis: **a** ROC; **b** sensitivity and specificity curves

In particular, chronic rhinosinusitis is a condition characterized by a prominent subjective component, with symptoms and general sense of well-being severely impacting the patient's quality of life.

Koskinen et al. demonstrated a good validity of The Finnish SNOT-22 questionnaire, significantly differentiating patients with the sinonasal disease and healthy controls [17]. The authors reported good internal consistency scores for all items and ICC of 0.879 reflecting the correlation between test–retest scores.

Asiri et al. also confirmed the good internal consistency in the Arabic SNOT-2, reporting a Cronbach's alpha result

of the initial examination of 0.803 and 0.803 for the retest examination [18].

Our study confirmed how SNOT-22 demonstrated an ROC curve with an AUC of 0.885 (95% CI 0.825, − 0.945) and good sensitivity (91.49%) and specificity (69.23%) to distinguish SRC severity.

However, as a CRS tool, SNOT-22 has some deficiencies, requiring a lot of time and concentration for successful completion. In addition, the SNOT-22 includes items on sleep and psychological function associated with several confounding factors, such as OSA and mood disorders [19–22].

Chowdhury et al. in a multi-institutional observational cohort study of 276 patients with drug-refractory CRS evaluated the accuracy of SNOT-22 in targeting therapy [23]. Although the SNOT-22 and its domain scores were appropriate measures of disease-specific symptom severity, the authors reported poor diagnostic accuracy of the AUC analysis not necessarily predicting overall health well (ROC ≤ 0.71).

In addition, the presence of domains not specific to nasal symptoms but inherent to quality of life or quality of sleep at night exposes the questionnaire to numerous confounding factors, such as reduced well-being due to sleep or mood disorders.

Therefore, the selection of only sinonasal-specific items could increase its effectiveness in the management of conditions such as CRS and facilitate its use selecting patients for surgery or biologic treatment.

Speth et al. in 2018 examined the predictive role of the questionnaire to determine whether CRS symptom severity, endoscopic examination findings, and frequency of acute exacerbations [24]. After a 3-month follow-up, the authors stated that an SNOT-22 score ≥ 30 could predict at least 1 sinus infection (AUC) = 0.727; $p < 0.001$), antibiotic use (AUC = 0.691; $p < 0.001$), or oral corticosteroid treatment (AUC = 0.655; $p < 0.001$).

Our reduced model, although containing fewer questions on quality of life, demonstrated at the backward stepwise elimination a significant sensitivity of 93.51%, specificity of 57.14%, and an accuracy of 80.67% in identifying patients with more severe symptomatology.

The close association between severity of nasal symptoms and reduced quality of life is known in the literature, with a correlation between greater symptoms and lower patient QoL.

Gray et al. evaluated the patient-reported control of CRS symptoms and the impact on quality of life. The authors demonstrated how a score above 0.5 (AUC 0.843; 95% CI, 0.789 to 0.898; $p < 0.001$) maximized sensitivity (71.4%) and specificity (85.5%) in identifying the 35 patients with poor symptom control [25].

Our study confirmed the association between SNOT-22 and SNOT-8 scores and symptoms severity, demonstrating at multiple linear regression the significant correlation with VAS obstruction, Rhinorrhea, and Smell. SNOT 8 demonstrated a greater statistical correlation for the Rhinorrhea, a symptom frequently complained by the patient.

Strengths and limitations of the study

The sample size provided and the prospective study design that allowed evaluation of the ability to detect parameter change and proper patient selection strengths of this study include independence.

In addition, because the study was conducted at the multicenter level and the respective culturally and linguistically validated questionnaires were administered, the scores or domains of both the SNOT-22 and the SNOT-8 did not report significant variation. Yet, our study had some fundamental limitations. In fact, patients with moderate or severe CRSwNP were enrolled, while patients with mild CRSwNP were excluded, resulting in lower external validity of the results, since patients with less severe disease were not present.

Moreover, both our models presented a false-positive rate greater than 30% due to sample bias. Indeed, our analysis reported 78% of severe cases (positive outcome) for SNOT-22, while 65% for SNOT-8, thus leading to an unbalanced outcome variable. However, despite higher bias found for the SNOT-22, the full-based model resulted more accurate and with a lower false-positive rate than the reduced SNOT-8 (31% vs 43%).

On the other hand, as for SNOT-8, the higher rate of false positives certainly requires the inclusion of a larger and balanced sample to improve the performance of the proposed model.

Finally, although we selected items based on the clinical relevance of the domains in the questionnaire and eliminated those related to confounding factors such as the presence of concomitant mood or respiratory disorders, further input with careful selection of participants by comorbidities would be necessary to demonstrate their actual relevance.

Despite these limitations, our psychometric analyses support the validity, sensitivity, and specificity of the SNOT-8 (nasal domain) in assessing the symptoms and impact of CRSwNP.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00405-023-07855-8.

Availability of data and materials Data available on request due to privacy/ethical restrictions.

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