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Mouth breathing – A predictor for patient satisfaction after nasal septoplasty?*

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Abstract

Background: No reliable marker exists to predict septoplasty outcome. Most patients suffering from nasal airway obstruction (NAO) caused by a deviation of the nasal septum report a bothersome mouth breathing and dryness. In this study our aim was to assess, whether mouth breathing could be objectified in these patients and whether mouth breathing could predict septoplasty outcome.

Methods: A monocentric, prospective case-control study of 21 patients was conducted. The proportion of mouth breathing was measured in a blinded manner. As a measurement of patient satisfaction, subjective symptoms pre- and postoperatively, were assessed by using VAS, NOSE and SNOT-20 score. In the patient group an additional acoustic rhinometry and a clinical examination of the nose were performed.

Results: With a mean of 25% (SD = 20%) the proportion of mouth breathing in patients with NAO did not differ significantly from the proportion in controls without NAO, with a mean of 27% (SD = 23%). Analysis of subjective scores revealed a significant reduction of subjective symptoms after septoplasty. A higher preoperative proportion of mouth breathing correlated with more remaining postoperative NAO.

Conclusions: The percentage of mouth breathing is no different in patients with symptomatic septal deviation than in control patients. Mouth breathing in patients with NAO, evaluated for septoplasty, could be a negative predictive factor for patient satisfaction after nasal septoplasty. Mouth breathing in these patients should be observed carefully because more preoperative mouth breathing should make one more hesitant to consider septoplasty.

Key words: deviated septum, mouth breathing, nasal airway obstruction, outcome, septoplasty

Introduction

Nasal airway obstruction (NAO) is a common symptom, affecting approximately one-third of the population [(1)]. NAO can be related to many etiologic factors, such as mucosal, anatomical or even psychological ones [(2)]. Apart from (allergic) rhinitis, one of the most frequent causes of NAO is a deviated nasal septum, often combined with a pathology of the turbinates [(3, 4)]. As a result, septoplasty with or without turbinoplasty, is a common therapeutic option to treat NAO.

Septoplasty with or without turbinoplasty is an effective method to treat NAO in patients with a deviated septum [(5)]. Although a lack of subjective NAO improvement after surgery can origin from unfavorable anatomical or mucosal conditions, the cause of low patient satisfaction after septoplasty often remains unclear. While several methods have been tested for a better selection of patients to undergo nasal septoplasty, no gold standard has been established yet to ensure higher levels of postoperative patient satisfaction [(6-8)].

Most patients suffering from NAO, due to a deviation of the nasal septum, report a large proportion of mouth breathing, along

with other problems, such as mouth dryness and a reduction in quality of life [9, 10], leading to the indication of septoplasty.
The aim of the study was to assess whether there is a difference in the proportion of mouth breathing between patients with reported NAO and controls without any nasal symptoms. Furthermore, the study aimed to evaluate whether the measured proportion of mouth breathing correlates with the subjective symptoms. Another aim was to assess whether the preoperative proportion of mouth breathing correlates with patient satisfaction after septoplasty. If so, mouth breathing could be a predictive factor for septoplasty outcome and could help to select patients with higher chances for postoperative satisfaction.

Materials and methods

Ethics

This study was approved by the Swiss Ethics Committee of research involving humans (No. KEK 2019-00010), and conducted with oral consent prior to and written informed consent after the video recording; when the patients were fully informed about the study goals. It was conducted in compliance with the permission of the independent ethical commission, the current Helsinki Declaration, as well as the Swiss law.

Study design and population

The project design was a monocentric, prospective case-control study of patients with NAO, undergoing septoplasty and was conducted at the Department of Otorhinolaryngology, Head and Neck Surgery at the University Hospital of Zurich. In total 20 patients with NAO and 15 control patients without any nasal symptoms were assessed. During the study eleven patients and three controls were excluded due to various reasons. Nine patients did not undergo septoplasty, one patient did not fill out the three months postoperative questionnaires and one patient underwent an adenotomy and turbinoplasty, without septoplasty. Two control patients did not fill out the questionnaires and one control patient's nose was decongested during the consultation, which could have had an impact on mouth breathing.
The study population finally consisted of nine patients presenting with NAO, suspected to be caused by a deviated nasal septum, who were assessed for primary septoplasty or functional septorhinoplasty with turbinoplasty. Other inclusion criteria were the possibility to give written consent and age between 18 and 99 years. Patients, who finally did not undergo septoplasty, were excluded from the study.
The control group finally consisted of twelve patients presenting with ear symptoms at the same department. Exclusion criterion for the control group was NAO, defined as a SNOT-20 score of ≥ 25, accepting only a mild nasal airway obstruction in control patients [11, 12].

Surgical procedure

The surgeries were performed by different surgeons at the ENT department. Either by fully trained surgeons or by trainees with the supervision of a board-certified ENT surgeon trained at our institution.

Data collection

To measure the proportion of mouth breathing, the consultation of each participant was video recorded (Sony Cyber-Shot DSC-W530 14.1 MP Digital Camera, Japan) by a trained examiner (C.B.). The video was zoomed in as much as nothing but the face of the participant was visible. The video was never stopped until the end of the consultation. The examiner documented the whole "consultation time" using an electronic time clock and subtracted the "talking time" when the subject was talking to the doctor. The time during the clinical examination, when the patients had to open (examination of the oral cavity) or close their mouths (Valsalva during otoscopy) was also subtracted. The remaining time was divided into "mouth breathing" (mouth open) and "nose breathing" (mouth closed). The percentages mentioned, reflect "mouth breathing" divided by the sum of "mouth breathing and nose breathing". In a next step the videos were blinded by the first examiner (C.B.) and analyzed by a second examiner (N.B.). Videos with a proportion of mouth breathing time differing more than 10% between the two analyses (6/20 patients and 3/15 controls), were watched again by both of the examiners together and a consensus was found.
Subjective data was collected in the patient group preoperatively and three months after surgery, using VAS, the validated D-NOSE [13-16] and SNOT-20 GAV scores [12, 17].
The Sino-Nasal Outcome Test-20 German Adapted Version (SNOT-20 GAV) [12] is a 20-item measure to assess primary and secondary rhinological symptoms, as well as the quality of life. For each of the 20 questions participants had to provide a value between 0 (no problem) and 5 (problem as bad as it can be). The maximum attainable SNOT-20 GAV score is 100.
The Nasal Obstruction Symptom Evaluation scale in German language (D-NOSE) [14] is a 5-item measure to assess nasal airway obstruction, as well as restriction in quality of life due to nasal symptoms. For each of the 5 questions the participants had to provide a value between 0 (no problem) and 4 (severe problem). The maximum attainable D-NOSE score is 100.
As suggested by Ciprandi et al., we used the Visual Analog Scale (VAS) to additionally evaluate nasal airway obstruction [18]. Each participant had to provide a value between 0 (no nasal airway obstruction) and 10 (nasal airway obstruction couldn't be worse).
The scores were also assessed in the control group in order to exclude control patients with NAO, defined as a SNOT-20 score of ≥ 25, accepting a mild nasal airway obstruction in control patients [11].

Table 1. Demographic factors and mean values of objective and subjective data pre- and postoperatively within the groups.

Characteristics	Nasal airway obstruction group (n = 9)	Control group (n = 12)
Mean age (y)	37.56 ± 12.41	50.67 ± 16.00
Proportion of mouth breathing (mean ± SD)	0.25 ± 0.20	0.27 ± 0.23
VAS score preoperative (median, IQR)	7, 1	0, 0.75
NOSE score preoperative (median, IQR)	75, 20	0, 8.75
SNOT-20 score preoperative (median, IQR)	19, 25	11, 12.25
VAS score postoperative (median, IQR)	2, 1	
NOSE score postoperative (median, IQR)	40, 27.50	
SNOT 20 score postoperative (median, IQR)	11, 10	
Delta VAS score (median, IQR)	4, 1.50	
Delta NOSE score (median, IQR)	30, 15	
Delta SNOT-20 score (median, IQR)	10, 14.50	

In the patient group, an acoustic rhinometry and a clinical examination of the nose were performed additionally prior to septoplasty. Acoustic rhinometry was performed using Otopront (Germany) Rhino-Sys rhinometer and its software 2.81. The acoustic rhinometry was performed by trained nurses, according to instructions given by the manufacturer. We measured the minimal cross-sectional area 1 + 2 (MCA), and nasal volume 1 + 2 (Vol) for both sides of the nose. All of the measurements were performed prior to and after nasal decongestion. Nasal decongestion allowed us to evaluate structural, as well as mucosal components of nasal airway obstruction [19]. For statistical analysis only the values (MCA 1, MCA 2, Vol 1, Vol 2, total MCA (MCA 1 + 2) and total Vol (Vol 1 + 2)) after decongestion on the narrower side of the nose were used. Only decongested values were used in order to evaluate the structural, and not the mucosal component of acoustic rhinometry data. The study population for acoustic rhinometry data analyses slightly differed from the study population of the nine patients mentioned above. On one patient, who underwent septoplasty, no acoustic rhinometry was performed, so he or she could not be included in acoustic rhinometry analyses. On one patient, who did not undergo septoplasty and on one patient who did not reply to the questionnaires, an acoustic rhinometry was performed, so they could get included in the analyses. The study population for acoustic rhinometry analyses finally consisted of 10 patients.

The preoperative clinical examination of the nose was performed during the consultation by ENT consultants and ENT residents of the Department of Otorhinolaryngology, Head and Neck Surgery at the University Hospital of Zurich. The degree of septal deviation was categorized into 0 (none), 1 (mild), 2 (moderate) and 3 (severe). All of the 9 patients, who underwent septoplasty, suffered from an either moderate or severe deviation of the nasal septum.

Only after the end of the consultation, the video recording and the completion of the 3 questionnaires, patients and controls were informed of the hypothesis and the design of the study.

Statistical analysis

All statistical analyses were performed with an α-error of 5%, using the statistical software IBM SPSS Statistics Version 26 (Version 26.0.0.0 64-Bit, USA). All reported p-values are two-tailed. Graphic data presentation was performed using GraphPad Prism (Version 8.0.0 64-Bit, USA). The proportion of mouth breathing and data of acoustic rhinometry were considered as continuous variables and presented as mean ± SD. Subjective data, collected using VAS, NOSE and SNOT-20 scores and the results of the clinical nasal examination were considered as categorical variables and presented as median with interquartile range. The normality of distribution was tested by using the Shapiro-Wilk test. Comparisons of continuous variables with a normal distribution were performed, using a Student t-Test. Comparisons of continuous variables with a non-normal distribution and of non-normally distributed categorical data pre- and postoperatively were performed using a Wilcoxon signed-rank Test. Correlations between two continuous variables were calculated using a Pearson correlation. Correlations between continuous and categorical data were calculated using a Spearman rank correlation.

Results

In total, the study included nine patients with NAO, undergoing septoplasty/functional septorhinoplasty and twelve control patients, without nasal symptoms. The male to female ratio of the patients with NAO was 6:3, the ratio of the control patients was 7:5. The average age in the patient group was 37.56 ± 12.41 years and 50.67 ± 16.00 years in the control group. It was planned to include ten patients with NAO, undergoing septoplasty, but the situation due to the COVID-19 pandemic complicated

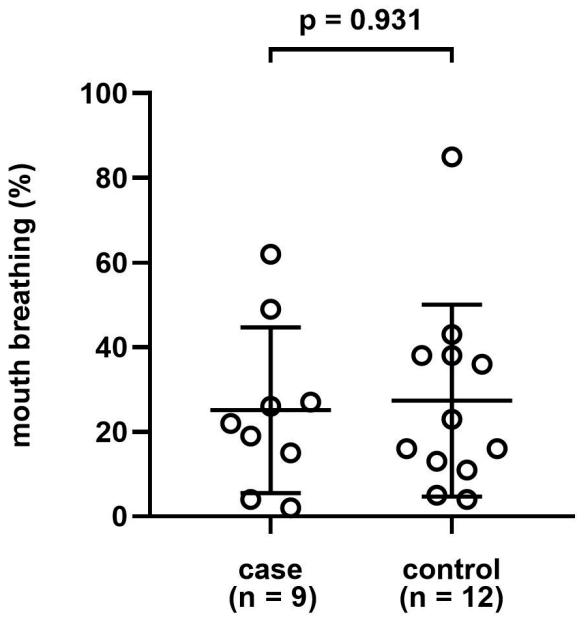

Figure 1. Comparison of mouth breathing in total breathing time in % between the patient and the control group.

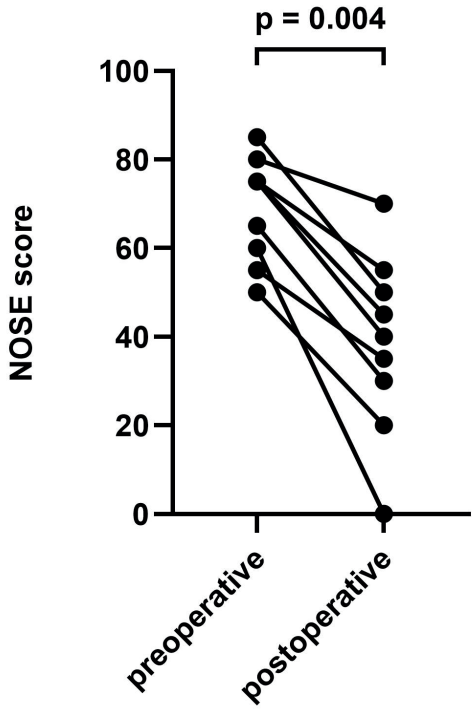

Figure 2. Comparison of pre- and postoperative NOSE score in the patient group.

the testing of additional patients. Table 1 summarizes demographic factors, as well as mean values of objective and subjective data pre- and postoperatively.

As Figure 1 demonstrates, there is no significant difference in the proportion of mouth breathing between the two groups, with a mean of 25% (±20%), in patients with NAO and a mean of 27% (±23%) in controls without NAO (Wilcoxon Test: p = 0.931).

All three scores measuring subjective symptoms showed a significant reduction postoperatively compared to preoperative values. The VAS score showed a median of 7.00 (IQR = 1) preoperatively and a median of 2.00 (IQR = 1) postoperatively (Wilcoxon test: p = 0.004). The NOSE score showed a median of 75.00 (IQR = 20) preoperatively and a median of 40.00 (IQR = 27.50) postoperatively (Wilcoxon test: p = 0.004), as demonstrated in Figure 2. The SNOT-20 score showed a median of 19.00 (IQR = 25) preoperatively and a median of 11.00 (IQR = 10) postoperatively (Wilcoxon Test: p = 0.005).

A significant correlation between the preoperative proportion of mouth breathing and postoperative NOSE score could be demonstrated (Spearman rank correlation: r = 0.77, p = 0.021), as shown in Figure 3. The correlation between the preoperative proportion of mouth breathing and the difference of the NOSE score pre- and postoperatively (delta NOSE), showed no statistical significance (Spearman rank correlation: r = -0.46, p = 0.211). Neither did the correlation between the proportion of mouth breathing and the degree of the septal deviation show any statistical significance (Spearman rank correlation: r = -0.31, p = 0.416).

All other correlations of subjective scores showed no statistical significance: between preoperative NOSE, VAS, SNOT-20 score and mouth breathing, between postoperative VAS, SNOT-20 score and mouth breathing and between the difference of VAS, SNOT-20 pre- and postoperatively and mouth breathing.

The measurement of minimal cross-sectional area (MCA) and nasal volume (Vol), using acoustic rhinometry showed no significant correlation with preoperative mouth breathing, with pre- and postoperative subjective scores and with the improvement of subjective scores pre- and postoperatively. As an example, Figure 4 demonstrates the correlation of mouth breathing and the total minimal cross-sectional area of the nose (MCA 1+2), which showed no statistical significance (Pearson correlation: r = -0.063, p = 0.863). The correlation between acoustic rhinometry measurements and the preoperative degree of septal deviation showed a significant result, correlating deviation with total volume (Vol 1+2) (Spearman rank correlation: r = -0.64, p = 0.046), total MCA (MCA 1+2) (Spearman rank correlation: r = -0.71, p = 0.021), Volume 1 (Spearman rank correlation: r = -0.64, p = 0.046) and with MCA 2 (Spearman rank correlation: r = -0.71, p = 0.021). In the end a Bonferroni procedure was used to minimize the risk of α-error accumulation, caused by multiple testing. Bonferroni procedure was used to adjust the significance level for the comparison of VAS, NOSE and SNOT-20 pre- and postoperatively and also for the correlation of mouth breathing and postoperative NOSE score. Even after the adjustment of the significance

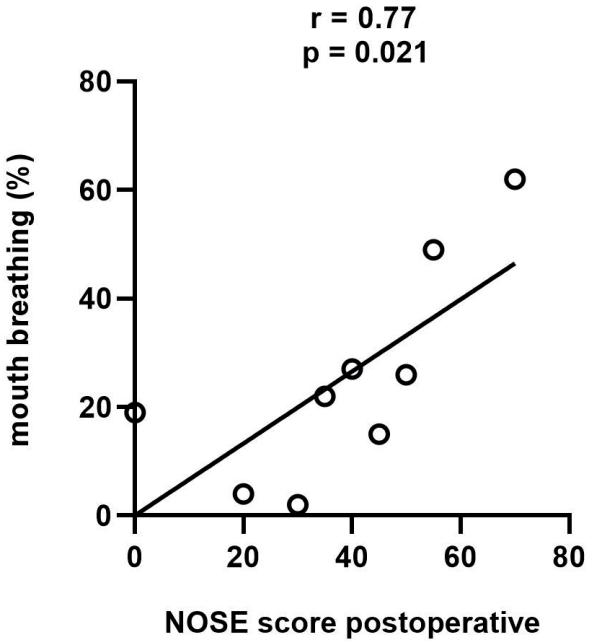

Figure 3. Correlation of preoperative mouth breathing in % and postoperative NOSE score in the patient group.

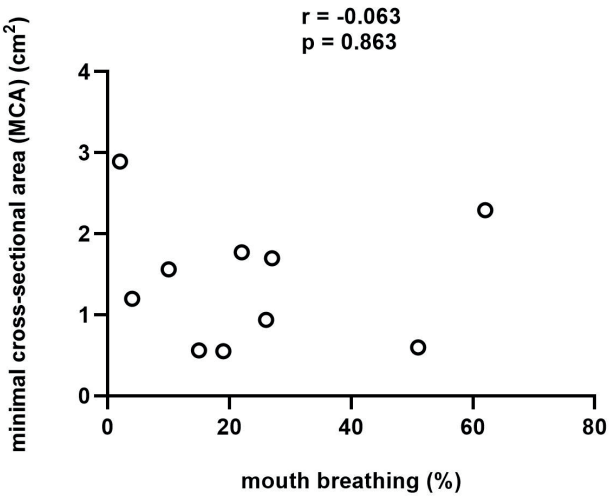

Figure 4. Correlation of total minimal cross-sectional area (MCA 1 + 2) in cm^2 and mouth breathing in %.

level, all of the significant results, mentioned above, still showed statistical significance.

Discussion

In this study, our aim was to investigate mouth breathing as an objective predictive factor for patient satisfaction after septoplasty. All of our patients showed a reduction of subjective symptoms post- compared to preoperatively. It could be demonstrated that there is no difference in mouth breathing between patients with or without nasal airway obstruction. Another main finding was that a higher percentage of preoperative mouth breathing correlated with more remaining nasal airway obstruction after septoplasty.

Mouth breathing is a common symptom reported by patients with nasal airway obstruction, suspected to be caused by a deviation of the nasal septum and is one reason to indicate a septoplasty. Previous studies have reported high patient satisfaction after septoplasty [20, 21]. In line with these results, a significant reduction of subjective symptoms three months postoperatively could be proven in our study. Even though several studies evaluating potential septoplasty outcome predictors have been conducted, there is still no reliable predictive factor for patient satisfaction after septoplasty [3]. Mouth breathing has never before been evaluated as a potential predictive factor for septoplasty outcome.

Van Egmond et al. demonstrated that septoplasty is an effective method to treat nasal airway obstruction, offering subjective and objective postoperative benefits to patients with a septal deviation [5]. As this previous study has shown, we could also observe a significant reduction of subjective symptoms (VAS, NOSE, and SNOT-20 score) post- compared to preoperatively, in all of our patients. In comparison to Tjahjono et al., our patients showed a higher absolute pre- and postoperative NOSE score, but the difference (deltaNOSE) was comparable to our results. Pre- and postoperative VAS score and consequentially also deltaVAS values showed equivalent results [22]. In comparison to Prus-Ostaszewska et al. SNOT-20 values pre- and postoperatively and deltaSNOT-20 were comparable to results of the present study [23]. Clinical examination of the nose postoperatively showed either a straight septum or a slight remaining nasal deviation in every patient and none of them had the intention to undergo revision surgery. All of these findings suggest that our surgical technique was adequate and effective.

The comparison of mouth breathing between patients and controls did not show any difference. Patients without nasal airway obstruction even had a slightly higher mean proportion of mouth breathing than patients with relevant nasal airway obstruction. In other words, mouth breathing is an inadequate marker to discriminate between patients with nasal airway obstruction and patients without nasal symptoms.

A possible explanation for our findings could be an impaired endonasal trigeminal perception, causing the sensation of nasal airway obstruction, a finding Saliba et al. has demonstrated for patients with chronic rhinosinusitis [24]. We demonstrated recently [25] that better endonasal trigeminal perception is directly linked to higher postoperative patient satisfaction after septoplasty. An acoustic rhinometry measurement of our control patients would have been an interesting addition to our present measurements. Acoustic rhinometry measurements of control patients with comparable values to measurements of patients

with NAO, could have been another evidence for impaired endonasal trigeminal perception in patients with NAO. No correlation could be found between the extent of the deviation of the nasal septum and the proportion of mouth breathing; another finding supporting the hypothesis of an impaired perception causing sensation of nasal airway obstruction. Another possible explanation for our findings could be a co-existence of an inflammatory pathology, not visible upon clinical examination, with the nasal septum deviation causing or exacerbating NAO and mouth breathing and leading to a lower satisfaction after septoplasty.
In comparison to Kjaergaard et al. [26], no association of the subjective sense of nasal obstruction and acoustic rhinometry measurements could be found in the present study. Although the degree of septal deviation correlated with acoustic rhinometry findings, acoustic rhinometry does not seem to be an appropriate objective measure to predict nasal airway obstruction and patient satisfaction after septoplasty.
In contrast to our expectations, a significant correlation of preoperative mouth breathing and postoperative patient satisfaction in patients with NAO, measured using NOSE score, was found. More preoperative mouth breathing correlated with a higher postoperative NOSE score, more remaining postoperative nasal airway obstruction and less patient satisfaction.
According to Chambers et al., nasal valve dysfunction can be an indicator for insufficient improvement of nasal airway obstruction after septoplasty [27]. In the present study the nasal valve was carefully assessed preoperatively but we cannot exclude effects of a potential nasal valve dysfunction on the outcome.
Overall, it could be suggested that mouth breathing is an inappropriate indicator of nasal airway obstruction and the degree of septal deviation, as no correlation could be found with objective measures. However, it could help to appropriately select patients suffering from NAO with a lower chance of postoperative satisfaction after septoplasty. Potentially, these patients "neglect" to use their noses to breathe through. We believe that patients with more preoperative mouth breathing either have an altered perception of their noses´ patency and overestimate the contribution of septal deviation and turbinate pathology to their quality of life or suffer from co-existing inflammatory pathology along with nasal septum deviation. Surgery could be less likely to resolve symptoms in these patients and they could be informed about their decreased chances of symptom improvement after surgery, especially when the septal deviation is moderate. As a consequence, more mouth breathing preoperatively should incentivize ENT surgeons to search for other reasons causing nasal airway obstruction and make them more hesitant to consider septoplasty.

Conclusion

This is the first study to investigate prediction of septoplasty outcome using mouth breathing measurements. Despite the small study population, we were able to demonstrate that more mouth breathing in patients with nasal airway obstruction can indicate to an altered nasal trigeminal perception or a co-existing inflammatory pathology and can predict poorer septoplasty outcome. We suggest a close observation of mouth breathing in these patients during consultations and further investigations regarding the cause of nasal airway obstruction besides nasal septum deviation. Mouth breathing could help to select patients more appropriately for nasal surgery and inform them about their chances of postoperative improvement of nasal airway obstruction.

List of abbreviations

MCA: minimal cross-sectional area; NAO: nasal airway obstruction; NOSE-D: Nasal Obstruction Symptom Evaluation scale in German language; SNOT-20 GAV: Sino-Nasal Outcome Test-20 German Adapted Version; VAS: Visual Analog Scale; VOL: nasal volume

Authorship contribution

CB recruited the patients, collected subjective and objective data, performed statistical testing and wrote the manuscript. NB planned and structured the study, conducted the second, blinded video analysis, collected the acoustic rhinometry data and reviewed the manuscript. MBS planned, designed and supervised the study and reviewed the manuscript.

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Ethics approval and consent to participate

No approval or consent needed as only publicly available data was used.

Consent for publication

Not applicable.

Availability of data and materials

Not applicable.

Conflict of interest

The authors declare that they have no competing interests.

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