Original Research Article

Effect of nasal obstruction in the acoustic analysis of voice

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ABSTRACT

Background: The voice is the main form of communication between humans and the nasal and sinusal cavity participates in the resonance process. An alteration in the nasal diameter can produce changes in the voice. The objective of this study was to relate the degree of nasal obstruction measured by the SNOT 20 questionnaire to the acoustic analysis of the voice.
Methods: 58 non-smoker volunteers without laryngeal pathology where included, 25 women (43%) and 33 men (57%). The average age was 22.1 years (±1.7). The laryngopharyngeal reflux and SNOT20 questionnaires were applied together with an acoustic analysis, we measured fundamental frequency, Jitter and Shimmer. The analysis was done separating in groups by sex and by SNOT score (less than 20 points and equal or higher than 20).
Results: The average of SNOT questionnaire was 15.06 (±11.8), we found no relation between the scores of the SNOT20 questionnaire with Jitter, fundamental frequency, Shimmer or voice intensity ($p \geq 0.01$). When separated by groups, the analysis by sex or by scores (SNOT > or < than 20 groups) did not show a statistically significant relationship.
Conclusions: In this study we did not find a relation between changes in acoustic analysis in Fundamental frequency, Jitter and Shimmer and the degree of nasal obstruction measured by SNOT 20. The groups of gender and severity of SNOT did not show relationship. More studies are necessary in order to evaluate the relation of nasal obstruction and the acoustic analysis of the voice.

Keywords: Voice analysis, SNOT 20 questionnaire, Nasal obstruction, Dysphonia

INTRODUCTION

The voice is the main form of communication between humans. It depends on organs that are voice activators such as the thoracic muscles, the larynx that is the voice generator, the oral cavity together with the tong and teeth that articulate the voice and the nasal cavity with the paranasal sinuses that participate in the resonance. This is the reason because nasal obstructive diseases such as acute rhinitis, septum deviation, turbine hypertrophy and nasal polyps decrease the nasal diameter, creating a change in the natural resonance of the voice. This is called hyponasal voice and can be objective or subjective.[1]

The tests that are used to measure the nasal resonance or nasality are the nasometer that measures the nasalance. The nasalance is the degree of the velopharyngeal opening during phonation; it is calculated by dividing the amplitude radius of the acoustic energy of the voice in the nostrils (An), by the acoustic energy of the voice in the oral cavity (Ao). Nasalance is usually referred to as the percentage of: An/Ao + An. Although a nasometer can confirm temporal patterns of nasalance, there are still controversies as to its use, results and interpretation.[2,3]

There are different tests to evaluate the voice such as the GRBAS scale, the voice handicap index (VHI) scale, and the acoustic analysis of the voice among others. In the

last decades the voice acoustic analysis has become essential in voice evaluation.[4] Among the acoustic phenomenon that are most used in the analysis of the voice is Jitter, the fundamental frequency (F0) and Shimer, they have been used to compare changes in different laryngeal pathologies and to evaluate treatment results.

The F0 is one of the most important parameters and it is determined by the number of vibrating cycles that vocal cords complete during phonation, it is measured in hertz (Hz) or cycles per second. The F0 differs among men and women; it is what gives each gender its characteristic voice.[5]

The importance of F0 in the acoustic analysis of the voice lies in that it can suffer important changes during the health-sickness process of the larynx; it is useful in order to establish a measurement of improvement or deterioration in the evolution of a clinical or surgical treatment.[5]

Jitter is the variation of frequency from one cycle to the next and it is calculated as the percentage of the absolute variability of frequency from one cycle to the next divided by the average frequency. Variations of Jitter can occur when vocal cords suffer alterations in their mass, as is the case when they increase or decrease their volume.[5]

Shimmer is the variation in the amplitude from one cycle to another and it is determined as the percentage of the absolute variability of amplitude from one cycle to another divided by the average amplitude.[6] Shimer can vary for two reasons, by changes in the muscular tone such as in neurological disorders or by aerodynamic alterations caused by bronco pulmonary disorders or defects in glottis closure. These two measures (Jitter and Shimmer) express the degree of stability or instability of the phonetic system during voice production.[5]

In voice analysis acoustic signals enter software which is capable of analysing qualitatively and quantitatively the physical dimensions of a sound wave and express the results in a graph with numerical parameters that are interpreted by the evaluator.[7]

Moral and col. found an improvement in the fundamental frequency, the percentage of perturbations, in shimmer, noise- to harmonic- ratio and in the turbulence index of the voice one month after septumplasty. This suggests that in severe cases of septum deviation, provoked nasal obstruction affects the quality of the voice, although the results were not evaluated using a questionnaire that indicated nasal obstruction.[8]

Different questionnaires allow you to register the intensity of symptoms and quality of life. the sino nasal obstructive test questionnaire developed by Piccirillo stands out among them because it has more sensible and representative indicators than others such as Rhino QOL

and RSOM, which are longer and harder to interpret.[9,10] This questionnaire has been used to evaluate the responses to different medical and surgical treatments related to allergic sinusitis and rhinosinusitis.[11,12] It has also served to evaluate the impact of smoking on rhino sinus pathology.[13]

Changes in nasalance and in the acoustic phenomenon of the voice have been evaluated as well as their relation to nasal obstruction. However the relation between nasal obstruction questionnaires and changes in F0, jitter and shimmer, have not been evaluated. The objective of this study is to evaluate the correlation between the degree of severity of nasal obstruction, as evaluated by the SNOT 20 questionnaire in its Spanish version, with variations in elements of the acoustic analysis of the voice (perturbations, fundamental frequency, intensity and Shimmer).

METHODS

This is a cross sectional study. Volunteers were invited to participate, demographic data was collected, gender and age were registered; all volunteers answered the SNOT 20 questionnaire in its translated and validated version in Spanish as well as the Befalsky- Postma questionnaire for gastroesophageal reflux in its version in Spanish.[10,14] They were given all the time needed in order to answer these questionnaires and afterwards using the PRAAT (PRAAT Org version 5.4.08) program, in a quiet room, with the volunteer in a comfortable position, we recorded the volunteer pronouncing the vowel /a/, during at least three seconds, with record mono sound at 44,000 Hz, in three separate occasions.
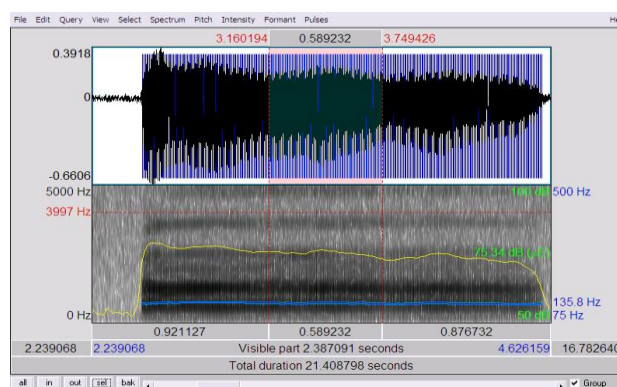

Figure 1: Shows the spectrogram and the acoustic analysis of the voice (PRAAT program), the blue line shows F0 (138.5Hz) and the yellow line shows intensity (75.34dB).

The acoustic analysis of the voice was carried out taking in to account the second intermediate of the recording of the vowel /a/. The percentage of perturbations, fundamental frequency and shimmer were analyzed. The researcher that carried out the acoustic analysis was blinded towards the result of the SNOT 20 questionnaire (Figure 1).

The study was performed in an adult volunteers, who accepted to participate in the study. Volunteers with known larynx pathology, history of laryngotracheal surgery, recent use of antihistamines, smokers and a Befalzky- Postma tests for gastroesophageal reflux higher than 15, were excluded from this study. An initial analysis was made comparing the results of the F0, Jitter and Shimmer with the SNOT 20 score.

After the volunteers were divided in to two groups, the first consisted of volunteers with a score of less than 20 in the SNOT 20 questionnaire and the second consisted of volunteers with a score equal or higher than 20 points. The variables F0, jitter and shimmer were compared to the score obtained in the SNOT 20 questionnaire

Finally volunteers were grouped according to gender; female and male were compared independently with the score obtained in SNOT 20. In both groups a regression analysis was carried out for each group.

The statistical analysis were used the statistical package R and R commander (version 3.1.2). We used descriptive statistics analysis for demographic data (means, range, standard deviation). Variables of interest were documented into sub-types of binary and continuous data. Continuous data included the age, jitter, F0, shimmer and the results of SNOT 20 and BF questionnaires. When we separate into two groups depending the SNOT 20 result (if was > o < than 20 points) we considered this variable like binary value. The variables were analyzed in a multivariate regression model to determine significance with a 95% confidence interval.

RESULTS

58 volunteers were included, 25 women and 33 men. The average age was 22.2 years ($\pm$1.7, with a minimum of 18 and maximum of 29). All had a Befalsky- Postma score with an average of 6.3, the SNOT 20 questionnaire score had an average of 15.8 points ($\pm$11.8, with a minimum of 0 and maximum of 57) (Table 1).

Table 1: Averages of age, Snot 20, BFI and voice analysis.

	Average	Standard deviation	Minimum-maximum
Age (in years)	22.2	±1.7	18-29
SNOT 20 score	15.8	±11.8	0-57
BFI	6.3	±6.5	4-27
Jitter	0.4	±0.2	0.1-0.4
Pitch	159.1	±54.9	139.4-293.2
Shimmer	6.9	±4.5	0.6-18.9
Intensity	75.1	±5.8	63.6-89.4

A first statistical analysis was carried out using linear regression with jitter, fundamental frequency and shimmer compared to the SNOT 20 questionnaire, the Befalsky–Postma index score and gender. We did not find a statistically significant difference among these variables ($p \geq 0.01$).

When volunteers were separated in two groups, the first with a score of less than 20 and the second with a score equal or higher than 20, using regression analysis to compare jitter, fundamental frequency and shimmer, we did not find a statistically significant difference between variables ($p \geq 0.01$). A variance analysis was carried out among the variables of the acoustic phenomenon and no statistically significant differences were found ($p \geq 0.01$).

When grouped by gender, we evaluated the relation between jitter, fundamental frequency and shimmer compared to the SNOT 20 questionnaire, the Befalsky–Postma index score and gender. No statistically significant differences were found between these variables ($p \geq 0.01$) (Table 2). These groups were subdivided according to a score of less than 10 or equal or higher than 10 in the Snot 20 questionnaire. Linear regression analysis was carried out comparing to jitter, fundamental frequency and shimmer and no statistically significant differences were found ($p \geq 0.01$).

Table 2: Averages of the results of voice analysis by gender and SNOT 20 groups.

	Number	F0 (sd)	JITTER (sd)	SHIMMER (sd)	SNOT 20 (sd)
Female	25(43%)	203.6	0.473	7.84	11.68
Male	33(57%)	125.7	0.591	6.37	17.59
SNOT<20	24	173.3 (60)	0.46 (0.25)	8.24 (4.54)	4.16 (3.38)
SNOT ≥20	34	148.9 (49)	0.59 (0.24)	5.97 (4.25)	22.7 (4.25)
Total	58(100%)	159 (54.9)	0.54 (0.77)	6.9	15.8

DISCUSSION

Nasal pathology has contributed to laryngeal manifestations. De Labio et al have found that 58% of pediatric patients with chronic nasal obstruction who have been evaluated using video laryngoscopy, have lesions such as swelling, thickening of the mucosa, nodules and cists in the larynx.[15]

Celik et al have found that in patients who have been operated of a rhinoseptoplasty and had "spreader" type grafts placed, have an improved voice perception when

measured using voice handicap index-10 (VH-10), although this hasn't demonstrated changes in the acoustic analysis of the voice.[16] A difference has also been found between patients with nasal obstruction and control patients, regarding voice onset time in the pronunciation of explosive vowels.[17] A relation has been found between an increase in the size of the maxillary sinus and its effect on the acoustic analysis of the voice.[18]

Something similar was found by Foroughian et al When comparing VHI-10 and acoustic analysis in patients before and after rhinoplasty. They found significant changes in VHI-10 and the acoustic analysis of the voice in vowels preceded and continued by a consonant and in nasal consonants.[19]

Notwithstanding Ozbal et al didn't find changes in the acoustic analysis of the voice when measuring disturbances, fundamental frequency and shimmer caused by septal deviation, in the vowels /a/ and in the nasal consonants /m/ y /n/.[20] We did not find gender to be a factor that could affect variables in acoustic analysis of the voice, when there were variations in the results of the SNOT 20 questionnaire.

Among the limitations of this study is that the highest score in the SNOT 20 questionnaire was 57 (when the highest limit is 100). It is possible that with higher scores in this questionnaire we could identify a relation. Another limitation is the lack of definition of the associated nasal problems, which englobe the differences in results of the SNOT 20 questionnaire.

More studies that include different groups of nasal pathologies and control groups should be carried out in order to evaluate differences in the SNOT 20 questionnaire and acoustic phenomenon in voice analysis, as well as studies that evaluate changes in acoustic phenomenon before and after corrections in nasal pathology, whether they are medical treatments such as for allergic rhinitis or surgical as is the case in septum deviations.

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