AMERICAN ACADEMY OF OTOLARYNGOLOGY–HEAD AND NECK SURGERY FOUNDATION

OTO Open
2024, Vol. 8(1):e102

DOI: 10.1002/oto2.102
http://oto-open.org
WILEY

Influence of a Surgical Mask on Voice Analysis in Dysphonic Patients During the COVID-19 Pandemic

Rupal Mehta, MD[1], Quentin Mat, MD, PhD[1,2,3], Antonino Maniaci, MD, PhD[3,4], Christophe Lelubre, MD, PhD[2,5], and Jean-Pierre Duterme, MD[1]

Abstract

Objective. COVID-19 has radically changed medical practice. The main objective of this study was to assess the impact of surgical mask (SM) on voice quality analyzes in a group of patient with different common benign vocal organic pathologies.

Study Design. A cross-over study.

Setting. A group of 20 patients with different organic benign vocal pathologies was recruited from the ENT consultation of the University Hospital of Charleroi in Belgium.

Methods. On the day of the assessment, each subject underwent an endonasal laryngeal videostroboscopy followed by a voice analysis (VA) with and without a new SM. The following parameters were analyzed: fundamental frequency, maximum frequency, range in amplitude and frequency of the voice, jitter and maximum phonatory time.

Results. In this research, we showed that VA can be performed with an SM while not changing the measured vocal parameters. These results also suggest that for the same individual a VA performed before the pandemic without SM could be compared to one with a SM to follow the patient's evolution of his or her voice quality.

Conclusion. The wearing of an SM during VA should always be recommended in case of immunodeficiency, a contagious disease of the patient or during a (new) pandemic.

Keywords

COVID-19, surgical mask, vocal analysis, voice patients

Received July 15, 2023; accepted December 15, 2023.

COVID-19 has radically changed medical practice. To minimize the progression of this pandemic, only urgent cases were initially managed. The uncertainties of the beginning of the COVID pandemic have passed and hence the strict application of masking is no longer required as a standard. New pandemics can always occur in the future, but even patients that are immunodeficient or have a contagious disease require masking. The influence of an SM on voice quality analyses is thereby a current and pertinent topic to investigate.

Voice disorders are frequent and are responsible for a marked deterioration in the quality of life as well as significant absenteeism in certain professions (teachers, translators, lecturers, etc.).[1,2] They can also be the warning sign of laryngeal cancer[3] and must, therefore, be treated.

In this context, some studies carried out on healthy subjects have shown that wearing a surgical mask (SM) does not modify the most commonly analyzed vocal parameters.[4,5]

The main objective of this study was to assess the impact of SM on voice quality analyzes in a group of a patient with different common benign vocal organic pathologies.

Material and Methods

Ethical Approval

The study was carried out in accordance with the Code of Ethics of the institutional ethics committee (Comité d'Ethique Erasme-ULB. Reference Erasme: P2020/476. Reference CCB: B4062020000164). Each person included in the study received a detailed explanation of the process and the objectives of the study. It was made sure that the participants fully comprehend the study. No pressure was

[1]Department of Otorhinolaryngology, C.H.U. Charleroi, Charleroi, Belgium
[2]Faculty of Medicine and Pharmacy, University of Mons (UMons), Mons, Belgium
[3]COVID-19 Task Force of the Young Otolaryngologists of the International Federations of Oto-rhino-laryngological Society (YO-IFOS), Paris, France
[4]Faculty of Medicine and Surgery, University of Enna "Kore", Enna, Italy
[5]Department of Internal Medicine, C.H.U. Charleroi, Charleroi, Belgium

Corresponding Author:
Rupal Mehta, MD, Department of Otorhinolaryngology, Hôpital Civil Marie Curie, C.H.U. Charleroi, Chaussée de Bruxelles 140, 6042 Lodelinsart, Belgium.
Email: rupal.mehta@humani.be

exerted to include someone in the study and at any time participants were allowed to withdraw from the study without changing the relationship of trust that was developed between the participant and their physician and without prejudice. Oral and written informed consent was obtained from all participants. The data were anonymized.

Participants

A group of 20 patients (9 men /11 women; median = 35.2 years, range = 21 – 74 years) with different organic benign vocal pathologies was recruited from the ENT consultation of the University Hospital of Charleroi in Belgium. All subjects did not report any voice training in the past. The benign lesions consisted of 1 unilateral nodule, 5 bilateral nodules, 1 contact ulcer, 4 unilateral cysts, 1 bilateral cyst, 1 Reinke edema, 1 unilateral granuloma, 1 combination of an unilateral polyp and granuloma, 1 acute glottic inflammation, 3 vocal polyps, and 1 exophytic vocal lesion. On the day of the assessment, each subject underwent an endonasal laryngeal videostroboscopy (Olympus ENF) followed by a voice analysis (VA) (DiVAS—Digital Video Archive software—Voice Diagnostics System from XION GmbH) with and without a new SM. Only 1 ENT specialist performed the videostroboscopy. Two speech-language pathologists executed the VA. For each participant, the running order of VA was randomized (with or without a mask). The following parameters were analyzed: fundamental frequency (*fo*), maximum frequency (Fmax), range in amplitude (RA) and frequency (RF) of the voice, jitter, and maximum phonatory time (MPT). All subjects were cued during each task for compliance. The recording was performed by reading a standard text 'L'hiver arrive avec son cortège' in French. The acoustic signal was trimmed to avoid onset/offset of phonation. *fo* was determined through a sustained vowel. To measure jitter-%, the vowel /a:/of each subject was recorded for 3 seconds. Afterward, 2 seconds of the midportion of the voice recording was marked for automated analysis by DiVAS. The Xion microphone with automatic calibration was placed at a constant distance of 30 cm (headset). The headset also incorporates automatic noise cancellation and provides a separate display of the ambient sound in the voice profile. All recordings were performed using the software DiVAS by XION medical, which is the standard software for voice diagnostics at the department of ENT of the University Hospital of Charleroi. All voices were recorded in a sound-treated chamber, which is used for routine voice diagnostics at the department. The same microphone was used during the pre-COVID and COVID-era.

All participants were submitted to a questionnaire for screening for COVID-19. The questionnaire was developed in the institution during the pandemic.

A subject was considered pathological if he or she considered his or her voice as abnormal for at least 1 week prior to the date of the examination and a benign organic laryngeal lesion was identified by videostroboscopy. The exclusion criteria were all malignant or neurological lesions.

Parameters

fo is defined as the average number of oscillations per second. It denotes the lowest frequency in a mixture of harmonic frequencies.

Fmax is the highest frequency during vocal speech.

Jitter is defined as the parameter of frequency variation from cycle to cycle.

MPT is the maximum amount of time a person can sustain the phonation of "ah."

RA and RF gives the vocal leeway in respectively dB and Hz of the given voice sample.

SM

The Kimberly-Clark Technol 49214 pleated SM (Kimberly-Clark), is a type of SM manufactured by Kimberly-Clark®, a company based in Irving, Texas. It is made up of 3 hydrophobic polypropylene layers. This particular mask was chosen for the study due to Kimberly-Clark's dominant market share in the United States for SMs in the health care sector.[6] The mask has also been used in previous experiments, which have shown its effectiveness in providing protection and physiological benefits.[7]

Statistical Analysis

Continuous variables were described using means and standard deviations or medians and interquartile ranges according to the normality of parent distributions. Normality was assessed using QQ plots and Shapiro-Wilk tests. Continuous variables were compared using nonparametric and parametric procedures for paired samples (Wilcoxon signed-rank tests and paired *t* tests). All tests were 2-sided with an α error level of .05. A $P < .05$ was considered significant. Statistical analyses were conducted using the software IBM SPSS Statistics version 23.0 (IBM).

Results

The data from 20 subjects was collected. **Table 1** showed that wearing a mask did not modify the studied parameters. In addition, paired *t* test did not find significant difference between mask conditions. Hence, we did not observe any modification of the recorded parameters according to the running order (**Table 2**).

Discussion

The way medicine was performed before and after the start of the COVID-19 pandemic has completely changed. Face masks, gloves, protecting shields, more rigorous disinfection procedures… the list is long. Indeed, our way of doing medicine has forever changed. The effect of these

Table 1. Descriptive Data of the Studied Vocal Parameters and Statistical Comparisons of These According to the Wearing of the Mask or Not (SM+/SM−)

Voice parameter	SM	Median	Q1–Q3	*P* value
fo (Hz)	SM+	158	132.5–195	.325
fo (Hz)	SM−	149.5	126.5–183.25	
Fmax (Hz)	SM+	324.5	254.5–387	.872
Fmax (Hz)	SM−	324	263.5–385.25	
Jitter (%)	SM+	56	42–77	.422
Jitter (%)	SM−	57.5	41–79	
RF (Hz)	SM+	188	147.75–273	.668
RF (Hz)	SM−	206	152–251.75	
RA (dB)	SM+	34	28–39.25	.154
RA (dB)	SM−	32	24.25–36.75	
MPT (s)	SM+	10.9	6.6–15.275	.304
MPT (s)	SM−	10.25	6.55–14.1	

Abbreviations: Fmax, maximum frequency; *fo*, fundamental frequency; MPT, maximum phonation time; Q, quartile; RA, range in amplitude of the voice sample; RF, range in frequency of the voice sample; SM, surgical mask.

Table 2. Descriptive Data of the Studied Vocal Parameters and Statistical Comparisons of These According to the Running Order

Voice parameter	Running order	Median	Q1–Q3	*P* value
fo (Hz)	1	141.5	126.5–194.25	.490
fo (Hz)	2	161.5	141–199.75	
Fmax (Hz)	1	324	271–387	.219
Fmax (Hz)	2	324.5	249.25–385.25	
Jitter (%)	1	49.5	39–81.75	.444
Jitter (%)	2	60.5	42.75–74	
RF (Hz)	1	206	156.5–273	.135
RF (Hz)	2	188	144.75–253.25	
RA (dB)	1	35	28–39.25	.309
RA (dB)	2	32.5	28–36.75	
MPT (s)	1	10.9	6.725–14.15	.107
MPT (s)	2	9.3	6.425–14.85	

Abbreviations: Fmax, maximum frequency; *fo*, fundamental frequency; MPT, maximum phonation time; Q, quartile; RA, range in amplitude of the voice sample; RF, range in frequency of the voice sample; SM, surgical mask.

changes on known parameters has not all been investigated rigorously.

Voice quality evaluation is a widely used examination by voice specialists. This evaluation method is favored due to its low costs, noninvasive nature, and ease of application.[8,9] In 2001, the European Laryngeal Society summited a basic protocol for functional assessment of voice pathology, which include objective voice quality evaluations as an essential component.[9] Given the importance of objective voice quality evaluations in assessing voice pathology, it was reasonable to explore whether the use of an SM could impact acoustic measurements in a specific group of patients with benign vocal lesions. The purpose of this investigation would be to determine if wearing an SM has any effect on the objective measurements of voice quality in individuals with benign vocal lesions.

The use of face masks by the general public is ubiquitously appraised to be of high value in minimizing community transmission during the pandemic.[10] Previous studies have shown that wearing an SM use for a duration of 1 hour at a low-moderate work rate does not have any clinically significant physiological impact or significant subjective perceptions of exertion or heat.[7] In addition, other studies have shown that wearing an SM did not alter the vocal parameters analyzed in groups of healthy adults.[4,5] However the impact of an SM on VA has not yet been studied in a group of patients with different common benign vocal organic pathologies. This study is essential to be able to confidently assess the voice parameters recorded by voice patients when asked to wear an SM for the procedure. The aim of this study was to determine if wearing an SM could influence the various parameters recorded with a microphone during a standard VA. Indeed, in current practice, the removal of the mask by the patient during this examination could contribute to contaminating the medical equipment, the examiner or a (another) patient.

The uncertainties of the beginning of the COVID-19 pandemic have passed and hence the strict application of masking is currently no longer required as a standard. New pandemics can always occur in the future. Indeed, a new analysis of novel disease outbreaks of infectious illnesses over the past 400 years in the Proceedings of the National Academy of Sciences[11] suggests that statistically extreme events are not as rare as we may think. Together with recent estimates of increasing rates of disease emergence from animal reservoirs associated with environmental change, this finding suggests a high probability of observing pandemics similar to COVID-19 (probability of experiencing it in one's lifetime currently about 38%), which may double in coming decades. The influence of an SM on voice quality analyses is thereby a current and pertinent topic to investigate.

The type of microphone may impact the voice quality measurement results.[12,13] In this study, a Xion microphone with automatic calibration placed at a constant distance of 30 cm (headset) was utilized. As a result, the distance between the patient's mouth and the microphone and the positioning remain constant at all times. When the patient moves his head, the microphone moves along, which ensures stable recording. The headset's built-in electronics ensures automatic calibration of the microphone. The headset also incorporates automatic noise cancellation and provides a separate display of the ambient sound in the voice profile. These features enhance the reliability of the measurements by reducing background noise and allowing a better analysis of the patient's voice. The obtained results are, therefore, reliable and reproducible.

A previous study worked with a speech production dummy model and prerecorded human audio voice samples instead of human speakers.[14] The limitation of this study is

that no speech movements were involved and the effects of SM on speech behaviors and intentions to move articulators while wearing an SM were not investigated.

In this research, we showed that VA can be performed with an SM while not changing the measured vocal parameters. These results also suggest that for the same individual a VA performed before the pandemic without SM could be compared to one with a SM to follow the patient's evolution of his or her voice quality.

A study by Ribeiro et al indicates that a face mask increases the perception of vocal symptoms and discomfort.[15] To avoid any voice fatigability effect in our study a randomization process was implemented to the order of testing with and without an SM. Indeed by randomly assigning, the potential impact of voice fatigue on the measurements can be distributed evenly across the study group. This approach ensured that the order of testing was assigned in a way that did not introduce bias or additional discomfort for the participants.

Furthermore, we also showed that the running order did not have any influence to the measured vocal parameters and therefore, there does not seem to be any recorded vocal fatigue for the number of parameters that we tested. Each participant was also provided with a new SM out of the same box, which was kept at the department. This ensures that the type and condition of the SM did not vary among the patients, avoiding the potential for the mask itself to influence the recorded parameters.

Although these results are encouraging to confidently analyze the voice parameters of our voice patients, further studies on larger numbers are needed to confirm these results. The inclusion of subjects with only benign lesions is also a limitation of this study. A new study with the same set up in patients with vocal fold immobility (vocal fold paralysis, vocal fold paresis, vocal fold atrophy) or even more irregular tissue deformities (malignant lesions) is needed. It would also be interesting to assess how an FFP2 or FFP3 mask or even a facial screen could influence voice parameters in healthy and pathological voice subjects.

Conclusion

This study seeks to assess the potential effects of wearing an SM on VA parameters and determine if patients can wear masks during the examination without compromising the accuracy of the results or posing a risk of contamination.

Our study showed that the wearing of an SM did not influence voice parameters during VA in a group with a patient with benign vocal lesions. The wearing of an SM during VA should hence always be recommended in case of immunodeficiency or contagious disease of the patient or during a (new) pandemic.

Author Contributions

Authorship statement using ICJME criteria and author initials: ABC designed the work; ABC acquired and analyzed data; ABC drafted, revised, and approved the manuscript; ABC agreed to be accountable for all aspects of the work. **Rupal Mehta**, designed the work; acquired and analyzed data; drafted, revised, and approved the manuscript and agrees to be accountable for all aspects of the work; **Quentin Mat**, analyzed data, drafted, revised, and approved the manuscript and agreed to be accountable for all aspects of the work; **Antonino Maniaci**, revised and approved the manuscript; **Christophe Lelubre**, revised and approved the manuscript; **Jean-Pierre Duterme**, revised and approved the manuscript and agrees to be accountable for all aspects of the work.

Disclosures

Competing interests: None.

Funding source: None.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID iD

Rupal Mehta http://orcid.org/0000-0001-5514-5491
Quentin Mat https://orcid.org/0000-0001-5545-6927
Antonino Maniaci https://orcid.org/0000-0002-1251-0185
Christophe Lelubre https://orcid.org/0000-0002-7319-661X
Jean-Pierre Duterme http://orcid.org/0000-0002-5252-8849

References

1. Titze IR, Lemke J, Montequin D. Populations in the U.S. workforce who rely on voice as a primary tool of trade: a preliminary report. *J Voice*. 1997;11(3):254-259. doi:10.1016/s0892-1997(97)80002-1
2. Vilkman E. Occupational safety and health aspects of voice and speech professions. *Folia Phoniatr Logop*. 2004;56(4):220-253. doi:10.1159/000078344
3. Cohen SM, Kim J, Roy N, Asche C, Courey M. Prevalence and causes of dysphonia in a large treatment-seeking population. *Laryngoscope*. 2012;122(2):343-348. doi:10.1002/lary.22426
4. Mehta R, Mat Q, Lelubre C, Lechien JR, Duterme JP. Influence of a surgical mask on voice analysis in healthy subjects in the COVID-19 pandemic: a cross-over study. *Clin Otolaryngol*. 2022;47(6):692-695. doi:10.1111/coa.13964
5. Fiorella ML, Cavallaro G, Di Nicola V, Quaranta N. Voice differences when wearing and not wearing a surgical mask. *J Voice*. 2023;37(3):467.e1-467.e7. doi:10.1016/j.jvoice.2021.01.026
6. Kimberly-Clark. *Kimberly-Clark to acquire Safeskin in tax-free transaction*. 1999. Available from: http://investor.kimberly-clark.com/ReleaseDetail.cfm?releaseid=35603
7. Roberge RJ, Kim JH, Benson SM. Absence of consequential changes in physiological, thermal and subjective responses from wearing a surgical mask. *Respir Physiol Neurobiol*. 2012;181(1):29-35. doi:10.1016/j.resp.2012.01.010
8. Parsa V, Jamieson DG. Acoustic discrimination of pathological voice: sustained vowels versus continuous speech. *J Speech Lang Hear Res*. 2001;44(2):327-339. doi:10.1044/1092-4388(2001/027)
9. Dejonckere PH, Bradley P, Clemente P, et al. A basic protocol for functional assessment of voice pathology, especially for

investigating the efficacy of (phonosurgical) treatments and evaluating new assessment techniques. Guideline elaborated by the Committee on Phoniatrics of the European Laryngological Society (ELS). *Eur Arch Otorhinolaryngol*. 2001;258(2):77-82. doi:10.1007/s004050000299

10. Eikenberry SE, Mancuso M, Iboi E, et al. To mask or not to mask: modeling the potential for face mask use by the general public to curtail the COVID-19 pandemic. *Infect Dis Model*. 2020;5:293-308. doi:10.1016/j.idm.2020.04.001
11. Marani M, Katul GG, Pan WK, Parolari AJ. Intensity and frequency of extreme novel epidemics. *Proc Natl Acad Sci USA*. 2021;118(35):e2105482118. doi:10.1073/pnas.2105482118
12. Deliyski DD, Evans MK, Shaw HS. Influence of data acquisition environment on accuracy of acoustic voice quality measurements. *J Voice*. 2005;19(2):176-186. doi:10.1016/j.jvoice.2004.07.012
13. Lechien JR, Huet K, Finck C, et al. Are the acoustic measurements reliable in the assessment of voice quality? a methodological prospective study. *J Voice*. 2021;35(2):203-215. doi:10.1016/j.jvoice.2019.08.022
14. Maryn Y, Wuyts FL, Zarowski A. Are acoustic markers of voice and speech signals affected by nose-and-mouth-covering respiratory protective masks? *J Voice*. 2023;37(3):468.e1-468.e12. doi:10.1016/j.jvoice.2021.01.013
15. Ribeiro VV, Dassie-Leite AP, Pereira EC, Santos ADN, Martins P, Irineu RA. Effect of wearing a face mask on vocal self-perception during a pandemic. *J Voice*. 2022;36(6):878.e1-878.e7. doi:10.1016/j.jvoice.2020.09.006