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Vocal Fold Mucus Aggregation in Persons with Voice Disorders

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Abstract

Mucus aggregation on the vocal folds is a common finding from laryngeal endoscopy. Patients with voice disorders report the presence of mucus aggregation. Patients also report that mucus aggregation causes them to clear their throat, a behavior believed to be harmful to vocal fold mucosa. Even though clinicians and patients report and discuss mucus aggregation, we have a limited understanding of mucus aggregation in persons with voice disorders. The primary goal of this study was to provide an initial assessment of the presence and features of mucus aggregation in persons with voice disorders. The secondary goal of this study was to determine if there are differences in mucus aggregation between persons with and without voice disorders. To address these goals, four features of mucus aggregation were judged from laryngeal endoscopy recordings from 54 speakers with voice disorders and compared to judgments of these same features in persons without voice disorders. The results from this study showed: (1) 100% of dysphonic speakers had visible mucus aggregation on their vocal folds. (2) Persons with hyperfunctional voice disorders had different mucus characteristics than persons with hypofunctional voice disorders ($p=0.002$). (3) Dysphonic speakers did not differ in frequency of mucus identified on the vocal folds than non-dysphonic speakers. However, the two groups had different mucus characteristics ($p=0.001$). Future studies are warranted to determine if these differences in mucus aggregation between persons with and without voice disorders relate to specific aspects of laryngeal pathology or patient characteristics, such as age and gender. Once we understand these relationships, we may be able to use this information to improve our diagnosis and treatment of patients with atypical laryngeal mucus aggregation.

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Keywords

Mucus; Voice Disorders; Throat Clear; Stroboscopy; Vocal Folds

1. Introduction

1.1 Laryngeal Mucus in the Clinic

Patients with voice disorders report feeling the presence of laryngeal mucus aggregation. Laryngeal mucus aggregation on the vocal folds is a common finding from laryngeal endoscopy of persons with voice disorders. This laryngeal mucus aggregation may cause a patient with a voice disorder to feel the need to clear their throat (Colton and Casper, 1996). In patients with voice disorders, even normal amounts of drainage can cause habitual throat clearing (Stemple, Glaze, and Klaben, 2000). Even brief mucus aggregation on the vocal folds may be enough to cause the sensation of needing to clear ones throat for a patient with a voice disorder (Colton and Casper, 1996). Laryngeal mucus and the associated clearing behavior may negatively impact voice quality (Colton and Casper, 1996; Ayache et al, 2004; Leydon et al, 2009). Coughing and throat clearing contribute to “vocal fold swelling or more serious vocal fold pathologies” (Stemple, Glaze, and Klaben, 2000) like vocal fold hemorrhages (Stemple, Glaze, and Klaben, 2000). Reducing habitual non-productive chronic coughing subsequently reduces the vibratory trauma to the vocal folds and improves voice quality and patient complaint of irritating laryngeal sensations (Stemple, 2000). It is important to understand laryngeal mucus aggregation as it is a common patient complaint and endoscopic finding, as well as a reported cause of throat clearing and coughing.

Clinicians who evaluate patients with voice disorders assess mucus aggregation and related clearing behaviors. The assessment of mucus and clearing behaviors generally includes: 1) asking the patient about globus sensations (feeling of a lump in the throat) (Stemple, Glaze, Klaben, 2000); 2) asking the patient about throat clearing and coughing behaviors (Stemple, Glaze, Klaben, 2000); 3) assessing the presence of laryngeal mucus from endoscopy (Stemple, 2000); and 4) assessing the frequency of throat clearing and coughing during the evaluation session (Stemple, 2000). While these are common clinical assessments, there is no protocol for these assessments or set thresholds to determine if the findings from the assessments are abnormal. This paper will focus on assessing the presence of laryngeal mucus from endoscopy.

1.2 Previous Studies

Three studies have used endoscopy to examine laryngeal mucus in persons with and without voice disorders (Hsiao, Liu, & Lin, 2002; Hsiung, 2004; Bonilha, Aikman, Hines, & Deliyski, 2008). The first study to report a visual rating schema for mucus aggregation was Hsiao, Liu, & Lin (2002). This study investigated the prevalence of an uneven mucus layer in persons with laryngeal tension-fatigue syndrome who had and did not have local anesthesia prior to the videostrobolaryngoscopic examination. This study also compared mucus aggregation of persons with laryngeal tension-fatigue syndrome to vocally-normal speakers. The authors define persons with laryngeal tension-fatigue syndrome as “chronic voice misusers and abusers who have dysphonia without overt macroscopic lesions on the vocal folds”. In this study, the variables of interest were presence of an uneven mucus layer and type of mucus. The authors characterized the mucus as Type 1, 2, or 3. Type 1 mucus was described as a rough mucus surface that was apparent during the open phase of vibration and sometimes forms bridging threads between the vocal folds. Type 2 mucus was described as “tiny mucus bubbles accumulating at the free margins of the vocal folds” during vibration, especially at the anterior commissure or at the junction between the

anterior one third and the posterior two thirds of the vocal folds”. Type 3 mucus was described as “mucus lumps found on the surface of the vocal folds before or during vibration”. Persons with voice disorders had a significantly higher incidence of visible mucus (83%) than persons without voice disorders (18.5%). The incidence of the three types of mucus was 7.4%, 11.1%, 0.0% for controls; 54.4%, 6.1%, 26.1% for patients with local anesthesia; and 44.6%, 12.4%, 20.7% for patients without local anesthesia for Type 1, Type 2, and Type 3, respectively. The authors posit that the uneven mucus layer seen in persons with voice disorders but not controls “alters the mechanical properties that contribute to the vibration of the cover of the vocal folds” and thus can “worsen the symptoms of dysphonia in patients with laryngeal tension-fatigue syndrome”. The authors cite two histological studies as evidence for the plausibility of vocal fold inflammation altering the components in mucus and causing mucus with increased viscosity (Nielsen, 1998; Sato & Hirano, 1998).

The second study to report a visual rating schema for mucus aggregation was Hsuing (2004). This study rated mucus aggregation prior to and after surgery to remove vocal fold nodules (Hsiung, 2004). In this study, the variables of interest were presence and location of mucus aggregation (anterior, medial, or posterior). Pre-operatively 55% of patients had a mucus layer while only 35% had a mucus layer post-operatively. Post-operatively, the mucus layer was visible more frequently in the anterior location (13% versus 27.5%), but less frequently in the other locations. The author posits that the sequela related to the nodules, “changes in the mechanical force on the vocal folds, alteration of the laryngeal secretory gland, and improper aerodynamic airflow”, caused the increased mucus aggregation and viscosity seen pre-operatively. The author interpreted the results as removal of the nodules and the related sequela decreased mucus aggregation and mucus viscosity.

The third study to report a visual rating schema for mucus aggregation was Bonilha, Aikman, Hines, and Deliyski (2008). This study assessed the type, location, thickness, and pooling of vocal fold mucus aggregation of 52 non-dysphonic speakers. The type and location variables were measured according to the prior publications (Hsiao, Liu, & Lin, 2002; Hsiung, 2004). The novel thickness and pooling variables were rated on a four-point scale (no mucus, mild thickness or pooling, moderate thickness or pooling, and severe thickness or pooling). Mucus was judged as being mildly thick if it appeared light weight, separated easily, moved easily during vocal fold vibration, and was translucent. Mucus was judged as moderately thick if it appeared to be of medium weight, showed some resistance to separation, moved some during phonation, and was either translucent or opaque. Mucus was judged as severely thick if it appeared heavy, cohesive, did not move much during vocal fold vibration, or was opaque. Mild pooling was identified if the combined mucus covered up to a quarter of the vocal fold. Moderate pooling was identified if the combined mucus covered between a quarter and half of a vocal fold. Severe pooling was identified if the combined mucus covered more than half of a vocal fold. This study found that 97% of non-dysphonic speakers had visible mucus aggregation when rated via stroboscopy. The distribution of mucus type was: 82%, 36%, and 52% for Types 1, 2, and 3, respectively. The location of the mucus was 69%, 86%, and 85% for anterior, medial and posterior, respectively. Mucus thickness was rated mild in 46% of cases, moderate in 39% of cases and severe in 12% of cases. Mucus pooling was rated as mild in 58% of cases, moderate in 33% of cases, and severe in 6% of cases. The reliability in differentiating mild from moderate thickness or pooling and moderate from severe thickness or pooling was not sufficient. Therefore, the scale was revised to be three-levels (no mucus, mild, and severe) for these features to achieve sufficient reliability. Given the high incidence of visible mucus in vocally-normal speakers, the authors questioned the use of mucus presence as a clinically significant variable in the assessment and treatment of persons with voice disorders. The authors suggested that the features of the mucus (type, thickness, pooling, location) should

be assessed in persons with voice disorders to determine if they may have diagnostic significance.

1.3 The present study

The prevalence of laryngeal mucus aggregation in the general population (Bonilha, Aikman, Hines, & Deliyski, 2008), the severity of vocal fold tissue damage caused by its associated behaviors (Stemple, 2000; Stemple, Glaze, Klaben, 2000), the clinical importance of laryngeal mucus and mucus clearing (Colton and Casper, 1996; Stemple, 2000; Stemple, Glaze, Klaben, 2000; Ayache et al, 2004; Leydon et al, 2009), and the high reliability of our prior study to qualify mucus aggregation via endoscopy studies (Bonilha, Aikman, Hines, & Deliyski, 2008), demonstrated the importance of assessing vocal fold mucus aggregation in persons with voice disorders. Our intention for this study was to investigate whether a clinically useful differentiation of laryngeal mucus aggregation based on visually perceptible features between persons with and without voice disorders may be found. Such a differentiation may impact the evaluation and treatment of persons with voice disorders who present with abnormal mucus aggregation and its related clearing behaviors.

The primary goal of this study was to provide an initial assessment of the presence and features of mucus aggregation in persons with voice disorders. The secondary goal of this study was to determine if there are differences in mucus aggregation between persons with and without voice disorders. The specific research questions were as follows:

1. What is the prevalence and features of mucus aggregation in persons with voice disorders? This was answered by rating mucus type, thickness, pooling, and location from endoscopic recordings of persons with voice disorders.
2. Does the presence or features of mucus aggregation differ in patients with hypofunctional versus hyperfunctional voice disorders? This question was answered by comparing mucus aggregation features for these subsets of patients.
3. Does the presence of mucus aggregation features (type, thickness, pooling, and location) differ in persons with and without voice disorders? This question was answered by a direct comparison of the percent of cases for persons with and without voice disorders that were found to have mucus aggregation.

2. Method

2.1 Participants

The data collection, storage, and use were in accordance with human subjects regulations of the University of South Carolina and Presbyterian Hospital. The data for this study was recorded at Presbyterian Hospital's specialized voice center in Charlotte, NC. The speech-language pathologists involved with data collection were specifically trained in voice. Individuals exhibiting vocal pathology were recruited from Charlotte, NC via verbal request from the research team. Participants were also recruited upon arriving at the voice clinic for evaluation. The 54 participants with voice disorders consisted of 43 females and 11 males ranging in age from 18–88 with a mean age of 54. The participants completed a short medical history, a self-assessment of current or previous voice complaints, and a voice-related quality of life (V-RQOL) (Hogikyan & Sethuraman, 1999). Perceptual judgments were made to classify participants as dysphonic by judging voice quality as normal or abnormal. Visualization of laryngeal pathology (e.g. contact lesions, paralysis, etc.) upon endoscopy was a means to visually examine the vocal folds, confirm voice disorder status, and categorize patients as having a hyperfunctional or hypofunctional voice disorder.

The non-dysphonic database used as controls for this study was also collected at Presbyterian Hospital's specialized voice center in Charlotte, NC in accordance with human subjects regulations as reported in Bonilha, Aikman, Hines, & Deliyski (2008). This database contains data from fifty-two participants: twenty-four male and twenty-eight female divided among three age ranges from 18–33, 34–49, and 50–65. Recruitment of participants included: a preliminary perceptual judgment of potential non-dysphonic participants, a short medical history and a self-assessment of current or previous voice complaints, and a voice-related quality of life (V-RQOL) (Hogikyan & Sethuraman, 1999). Speech-language pathologists used perceptual judgment to determine vocal normality. The medical history was to ensure that prior voice-related problems were identified. The self-assessment of current or previous complaints involved the participant answering that they had no such complaints. The V-RQOL was used to further ensure no current voice complaints. Visualization of laryngeal pathology (i.e. contact lesions, paralysis) upon endoscopy was also an exclusionary criterion. Fifty-five people were initially invited to participate in the study based on voice quality, history & V-RQOL. Three persons were later excluded based on frank vocal pathology on endoscopy: two persons had contact lesions and one person had paresis/paralysis. The instrumentation used for data collection of the non-dysphonic speaker database was the same as that used for this study of persons with voice disorders.

2.2 Data Collection and Instrumentation

Standard clinical procedures were utilized for endoscopy and stroboscopy. Positioning of the endoscope to place the image of the vocal folds in full view was accomplished with continuous light. One sustained phonation of the phoneme /i/ was recorded for each participant. Participants were instructed to phonate at habitual pitch and loudness levels. The duration of the sample was dependent on the ability of the participant to sustain phonation. A Digital Rhino-Laryngeal Stroboscopic System Model 9100B (KayPentax, Lincoln Park, NJ) coupled to a 70-degree rigid endoscope (KayPentax, Model 9106) was used along with a laryngeal contact microphone to track vocal fold vibratory frequency.

2.3 Procedures

The systematically collected database of stroboscopic recordings from 54 persons with voice disorders was randomized and visually rated by two naïve judges utilizing the ALVIN software (Hillenbrand & Gayvert, 2005). An example of a rating screen used in this experiment is displayed in Figure 1. Prior to rating mucus aggregation, both judges underwent training in the identification of the mucus aggregation features through didactic sessions and trial ratings with feedback on a subset of recordings not used in this study. Twenty percent of the recordings were randomly repeated to establish intra-rater reliability.

Mucus Aggregation Features—The judges rated the mucus aggregation features by type, thickness, pooling, and location. The categorization for type of mucus was the same as that in Hsiao, Lui, and Lin (2002), refer to Figure 2 for examples. Type 1 was defined by a rough surface of the vocal folds and by mucus threads between the vocal folds noted during open phase of vibration. Type 2 was identified as mucus bubbles visible upon phonation. Type 3 was distinguished by mucus lumps either prior to or during phonation along the edge and/or surface of the vocal folds. Mucus types were not an exclusionary category, thus it was possible for the same participant to present with multiple types of mucus. Thickness and pooling of mucus aggregation were visually rated on a three-point scale: no apparent mucus, mild, and severe. Mucus was judged as being mildly thick if it appeared light weight, separated easily, moved easily during vocal fold vibration, and was translucent. Mucus was judged as severely thick if it appeared heavy, cohesive, did not move much during vocal fold vibration, or was opaque. Refer to Figure 3 for examples of mucus thickness. Mild pooling

was identified if the combined mucus covered up to a half of a vocal fold. Severe pooling was identified if the combined mucus covered more than half of a vocal fold. Refer to Figure 4 for examples of mucus pooling. These three-point scales for rating thickness and pooling were determined to provide sufficient reliability when used on recordings of non-dysphonic speakers (Bonilha, Aikman, Hines, & Deliyski, 2008). While thickness or viscosity can be directly measured, in this study we were interested in the perception of thickness as described from endoscopic recordings in the clinical evaluation of persons with voice disorders (Colton and Casper 1996, Stemple, 2000). When using the terms thick or thickness in this manuscript, we are referring to the perceived thickness and not a measure of mucus viscosity. Location of mucus aggregation was previously judged on the method of Hsiung (2004). Similar divisions of anterior, medial, and posterior were utilized in this study. Refer to Figure 5 for examples of mucus location. Mucus location was not an exclusionary category; that is, a participant could have mucus in the anterior, medial and posterior locations.

Rater Training and Agreement—Prior to judging features of mucus aggregation, the two judges underwent training and agreement sessions. The raters were trained by a voice specialist on how to identify the features of mucus, and agreement on a subset of data was established. Agreement was defined as the raters both identifying the same level of a mucus aggregation feature, such as both raters identifying a recording as having Type 1 mucus or mild pooling. The agreement was reviewed prior to each rating session. All judgments were completed in three sessions over a two-week period.

2.4 Analysis

Frequencies for each feature were reported from the compiled ratings. Inter- and intra-rater reliability were reported in percent agreement with 70% as high. Fisher's Exact Test was employed to determine statistically significant differences ($p=0.05$) in mucus aggregation features between persons with and without voice disorders and between persons with hypofunctional and hyperfunctional disorders.

3. Results

3.1 Frequency

All of the 54 dysphonic persons presented with apparent mucus as visualized by stroboscopy. The mean percent of cases judged for mucus type, thickness, pooling, and location, are presented in Table 1.

A one-tail Fisher Exact Test was performed to analyze differences between dysphonic and non-dysphonic data. Compared with non-dysphonic speakers, dysphonic speakers had significantly more Type 1, 2 and 3 mucus, more severely thick mucus, more severe pooling, and were more often seen to have mucus anteriorly, medially, and posteriorly located (Table 1).

A one-tail Fisher Exact Test was performed to analyze differences between hypo- and hyper-functional voice disorders. This was chosen based on the apriori hypothesis that persons with vocal fold inflammation would also have increased severity of mucus aggregation than persons without vocal fold inflammation. Statistically significantly more instances of Type 3 ($p=0.000$) and severely thick mucus ($p = 0.002$) were found in persons with hyperfunctional than hypofunctional voice disorders.

3.2 Inter- and Intra-rater Reliability

Inter- and intra-rater judgments were determined to be reliable if agreement was 70% or greater. Inter-rater average reliability was 90% ranging from 83% to 100%. Intra-rater reliability was an average of 98% for rater 1 and an average of 97% for rater 2. Judgments were reliable for all mucus features.

4. Discussion

4.1 Mucus Presence

All persons with voice disorders who participated in this study had apparent mucus aggregation. This is just slightly more than the number of non-dysphonic speakers with apparent mucus aggregation when analyzed via stroboscopy, 97% (Bonilha, Aikman, Hines, & Deliyiski, 2008). The large number of persons with and without voice disorders with mucus aggregation indicated that the presence of mucus aggregation is not a diagnostically significant factor. In clinical practice, it is often not the presence of a clinical feature, but rather its magnitude or severity that has diagnostic value. Our results found a smaller difference in the prevalence of mucus aggregation between persons with and without voice disorders than previously reported. Previously, Hsiao, Liu, and Lin reported that 83% of persons with laryngeal tension-fatigue syndrome studied had visible mucus aggregation, while only 18.5% of normophonic speakers had apparent mucus aggregation (2002). Further, mucus aggregation had been identified in 55% of patients studied with vocal fold nodules prior to surgery (Hsuing, 2004). The larger percentages of persons with mucus aggregation found in the current study were possibly due to differences in the stroboscopic instrumentation and/or in the sensitivity of the raters. An alternative reason for differences in findings may be inherent in the climate, geographic region, and population. The two previous studies of persons with voice disorders were conducted in Taiwan (Hsiao, Liu, & Lin, 2002; Hsiung, 2004), while this study population came from North Carolina. A larger study evaluating the differences in mucus aggregation between persons with and without voice disorders is needed to confirm these findings.

4.2 Mucus Types

The results for type differed in magnitude but not trend from prior investigations. This study found 96%, 85%, and 91% of Type 1, 2, and 3 mucus aggregation, respectively. In comparison, 61%, 10%, and 29% of the dysphonic speakers studied by Hsiao, Liu, and Lin (2002) were found to exhibit type 1, 2, and 3 mucus aggregations, respectively. While a larger number of cases were found in the present study for each type, both studies shared the same trend of Type 1 being the most prevalent and Type 2 being the least prevalent. This trend was also seen in our previous study of non-dysphonic speakers. Different than our findings in non-dysphonic speakers, persons with voice disorders revealed a larger number of cases for each type of mucus aggregation. This finding supported the statement from Hsiao, Liu, and Lin (2002) supported by histological studies by Nielsen (1998) and Sato & Hirano (1998) that the vocal fold inflammation may alter the components in mucus. Future studies are warranted to evaluate the clinical significance of these differences.

4.3 Mucus Thickness and Pooling

Persons with voice disorders were found to have thicker appearing mucus aggregation and a greater amount of mucus aggregation than persons without voice disorders. This increase in mucus viscosity and abundance has been related to vocal fold tissue irritation and vocal strain (Hsuing, 2004). The thick mucus aggregation heightens the sensation of the need to clear ones throat, which presumably causes more forceful vocal fold contact (Colton and Casper, 1996). This forceful vocal fold contact appears to increase vocal fold tissue irritation

(Stemple, 2000). Future studies are warranted to evaluate the clinical significance of these differences.

4.4 Mucus Location

Mucus aggregation location was found to be primarily anterior and medial in patients before and after vocal nodule removal in a previous study by Hsuing (2004). In contrast, we found equal mucus aggregation across the locations in persons with voice disorders. In comparison the non-dysphonic speakers, the prevalence of mucus aggregation was greater at all locations for persons with voice disorders especially for the anterior location. However, it is unlikely that this difference will be a clinically useful specific indicator of laryngeal pathology.

4.5 Hypofunctional versus Hyperfunctional

Persons with hyperfunctional voice disorders were more likely to have Type 3 mucus and severely thick mucus aggregation. Since persons with hyperfunctional voice disorders are more likely to have vocal fold inflammation than persons with hypofunctional voice disorders, this finding supports Hsiao's hypothesis that vocal fold inflammation may alter the components of mucus (Hsiao, Liu, & Lin, 2002).

4.6 Limitations

There are three main limitations of this study that should be addressed in future research. The first limitation is that the patients were not grouped according to reflux status, tobacco or alcohol use, or laryngeal irritation. This limitation did not allow us to assess the interaction between these variables with mucus aggregation features. The second limitation is that the persons with and without vocal pathology were not age or gender-matched. This limitation did not allow us to assess the interaction between age and gender with mucus aggregation features. The third limitation is that the persons with voice disorders were not recruited in a stratified manner to provide a representative sample of different levels of dysphonia severity. This limitation did not allow us to assess the interaction between dysphonia severity and mucus aggregation features. All of these limitations are because we sought a non-biased view of laryngeal pathology and entered all persons presenting for voice evaluations into the study during the data collection period. Our goal was to provide initial data that could potentially warrant further studies addressing more specific questions toward refining our understanding of the relationships of mucus and voice disorders. Future research would benefit from specific methods that address these limitations.

5. Conclusion

This study investigated the presence and characteristics of mucus in persons with dysphonia and compared the mucus features between dysphonic and non-dysphonic speakers. All dysphonic speakers were found to have vocal fold mucus aggregation. Persons with hyperfunctional voice disorders had more mucus lumps (Type 3) and severely thick mucus aggregation than persons with hypofunctional voice disorders. Dysphonic speakers exhibit more of all types of mucus and have more severely thick mucus and significantly more pooling of mucus than non-dysphonic speakers. Future studies are warranted to determine if these differences in mucus aggregation between persons with and without voice disorders relate to specific aspects of laryngeal pathology or patient characteristics (such as age). Understanding these relationships will help improve our methods for diagnosis and treatment of patients with atypical laryngeal mucus aggregation.

Learning outcomes: Readers will be able to: (1) describe why mucus aggregation may be an important feature to understand in persons with voice disorders, (2) describe the

features of mucus aggregation that can be visually rated, and (3) explain the similarities and differences in mucus aggregation for persons with and without voice disorders.

Highlights

- Persons with voice disorders frequently present to clinic with complaints of laryngeal mucus.
- We examined mucus aggregation in persons with voice disorders and compared it with prior findings in persons without voice disorders.
- A large percentage of dysphonic speakers have mucus aggregation on their vocal folds.
- Persons with hyperfunctional voice disorders have more type 3 mucus and more severely thick mucus than persons with hypofunctional voice disorders.
- Dysphonic speakers have more severely thick mucus and significantly more mucus pooling than normophonic speakers.

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Appendix A. Continuing education

1. What is a common reason patient's give for chronic non-productive coughing and throat clearing?
 - a. choking
 - b. mucus aggregation
 - c. warm air
 - d. pneumonia
2. What is one way that speech-language pathologists commonly assess mucus aggregation?
 - a. hydration monitoring
 - b. visually analyzing and rating visible features of mucus aggregation
 - c. hydration testing
 - d. asking patients about throat clearing and coughing frequency
3. What features of mucus aggregation can be examined via endoscopy?
 - a. type of mucus
 - b. thickness of mucus
 - c. location of mucus

- d. all of the above
- 4. Presence of laryngeal mucus aggregation a good indicator of a voice disorder.
True / False
- 5. What features of mucus aggregation appear most sensitive to differentiating persons with and without voice disorders?
 - a. type and thickness
 - b. location and presence
 - c. type and location
 - d. presence and thickness

Answers

- 1. b
- 2. d
- 3. d
- 4. False
- 5. a

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Figure 1.
An example of the ALVIN software used to rate mucus aggregation from stroboscopy.

Figure 2.
Examples of Type 1 (A), Type 2 (B), and Type 3 (C) mucus aggregation from stroboscopy.

Figure 3.
Examples of mildly thick (A) and severely thick (B) mucus aggregation from stroboscopy.

Figure 4.
Examples of mild pooling (A) and severe pooling (B) of mucus from stroboscopy.

Figure 5.
Examples of anterior (A), medial (B), and posterior (C) locations of mucus aggregation from stroboscopy.

Table 1

Frequency in percent of mucus type, thickness, pooling and location as rated via stroboscopy from persons with voice disorders. The same data is displayed for persons without voice disorders from our prior study. The p-values from the Fisher's exact test comparing the data for persons with and without voice disorders are shown demonstrating whether ratings were statistically significantly different, for each type of mucus.

Parameter	Dysphonic	Normophonic	P-Value
TYPE			
Type 1	96	82	0.001 *
Type 2	85	36	0.000 *
Type 3	91	52	0.000 *
THICKNESS			
NA	0	3	0.123
Mild	8	75	0.000 *
Severe	92	12	0.000 *
POOLING			
NA	0	3	0.123
Mild	9	91	0.000 *
Severe	91	6	0.000 *
LOCATION			
Anterior	93	69	0.000 *
Medial	94	86	0.000 *
Posterior	93	85	0.000 *

Statistically significant p-values are marked by an asterisk.