The Impact of Phonation Mode and Vocal Technique on Vocal Fold Closure in Young Females With Normal Voice Quality

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Summary: Objective. Because voice quality depends substantially on vocal fold closure (VFC), voice therapists try to modify VFC by specific voice techniques or adjustments in phonation mode. This study demonstrates the impact of six different phonation modes on VFC in healthy subjects.

Methods. For this study, 21 female subjects with normal voice quality were selected. The impact of different phonation modes and voice techniques was examined by fiberoptic laryngovideoendoscopy during different modes of phonation: habitual phonation, high pitch, low pitch, resonance on /m/, Coblenzer's "abspannen," and chant talk. The video recordings were judged by three experienced professionals (two Speech and Language Pathologist and one laryngologist) by means of a visual analog scale.

Results. Statistical analysis showed that only resonance on /m/ significantly improved VFC compared with habitual phonation. All other phonation modes and techniques, except low-pitched phonation, led to a significant worse closure in comparison with the closure at normal pitch. The glottic closure observed by low-pitched phonation was not significantly different than the closure at habitual pitch. Interrater agreement was moderate to very good, depending on the mode of phonation.

Conclusions. The results of this study allow a better understanding of the impact of phonation mode and vocal therapy techniques on VFC in healthy subjects and give an indication about the impact of these methods to influence VFC.

Key Words: Vocal fold closure–Phonation mode–Vocal technique–Resonance.

INTRODUCTION

Glottic closure is an important point of interest in the evaluation and interpretation of voice quality and voice problems since videolaryngostroboscopy is systematically applied in voice assessment. Classification systems for vocal fold closure (VFC) are commonly used in stroboscopic protocols.[1,2] Linville[1] distinguished seven types of glottic closure: complete glottic closure, anterior gap, posterior gap, double gap, incomplete closure, longitudinal gap, and bowing.

Although complete glottic closure is generally regarded as the standard and incomplete VFC is frequently related with dysphonia, clinical observations show that a perceptual normal voice is possible with incomplete VFC.[3,4] Several studies show that glottic closure is influenced by several aspects as age, sex, vocal register, pitch, intensity, and way of examination. Posterior gaps are the most observed glottic closure type in women, whereas complete closure is the standard in men. Whereas posterior gaps are often observed in young[3,4] and adult women,[5] older women show more bowing and anterior gaps.[3]

Murry et al[6] found that glottic closure decreases in the falsetto register. Sulter et al[7] demonstrated significant effects of the factors pitch, sound intensity, and age on vocal fold appearance and glottal functioning. Also, Gelfer and Bultemeyer[8] found VFC to be influenced by pitch. They investigated glottic closure in five female students on both high and low pitch. Incomplete closure occurred in three subjects on high pitch and in two subjects on low pitch. Complete closure on both pitches was only observed in one subject, and only one subject had improved closure on high pitch.

Sodersten and Lindestad[9] showed that both the laryngeal examination procedure (fiberoptic or rigid telescopic) and loudness level have an impact on glottic closure. In their study, the degree of incomplete closure was significantly higher during rigid telescopy, especially in soft phonation, and the degree decreased significantly with increased loudness, regardless of the method.

Although not necessarily related with dysphonia, incomplete VFC, resulting in air leakage with breathiness and decreased loudness as a consequence, is often observed in functional and organic voice disorders.[10–12] In that case, voice quality is negatively affected by the inadequate VFC and voice therapists will try to improve glottic closure. To do so, they can rely on a number of specific techniques, for instance, pitch changes (habitual-high-low), traditional resonance exercises,[10,13] Coblenzer's "abspannen,"[14] and chant talk.[15,16] Most of these techniques have been clinically proven to be more or less successfully improving voice quality in general, but it is not clear to what extent they have an impact on glottic closure. In fact, voice therapists often try to modify voice quality by changes and adaptations

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in breathing and vocal tract proportions, but their empirical findings were never checked in a systematical and experimental investigation. This study was set up to evaluate the impact of phonation mode on VFC in subjects with normal voices.

METHODS AND MATERIALS

A group of 21 female, first-year, speech therapy and audiology students with a mean age of 18 years (range, 17–19 years) participated in this study. All of them passed a voice assessment including a perceptual evaluation by means of the Grade, Roughness, Breathiness, Asthenia, Strain scale,[17] aerodynamic measures (maximum phonation time and vital capacity), voice range profile, acoustic analysis (*Multi-Dimensional Voice Program 5105*; Kay Elemetrics 4300B, Pine Brook, NJ), and Dysphonia Severity Index.[18] Only subjects with normal voice quality, normal hearing, and normal laryngoscopic findings, who received no voice training in the past, were included.

In advance to the actual test procedures, all subjects were individually instructed about the test procedures and the phonation modes they had to apply during the fiberoptic endoscopic examination. The following seven phonation modes were addressed: (1) habitual phonation, (2) phonation on high pitch, (3) phonation on low pitch, (4) resonance on /m/, (5) Coblenzer's abspannen (saying "hop" three times with abdominal breath support), and (6) chant talk on a Dutch sentence "Deze morgen ben ik naar de bakker geweest" ("I went to the bakery this morning"). The chant in therapy is characterized by an elevation of pitch, prolongation of vowels, lack of syllable stress, and an obvious softening of glottal attack.[16] In the technique of Coblenzer, the action of the abdominal muscles and the diaphragm results in a release of laryngeal tension and a comfortable inhalation. Each phonation mode was demonstrated by an experienced voice therapist and practiced by each subject until the subject completely understood the task and was capable to apply it on demand. Also during the actual endoscopic examination, the subjects were coached and instructed by the same speech therapist.

The endoscopic examination was completed about 30 minutes after the instruction session. All endoscopic examinations were done by the same experienced laryngologist using a flexible videoendoscopic system: Pentax VNL-1170K (KayPentax, Lincoln Park, NJ) or Olympus PEF VI (Tokyo, Japan). The recordings were transmitted on a VHS videocassette for further analysis by the judges. Each subject completed each phonation mode three times. Subjects were not allowed to observe the monitor during the examination to avoid adaptation mechanisms during the experiment.

Three judges—two experienced Speech and Language Pathologist with more than 15 years of experience in voice assessment and one laryngologist with specific training in phoniatrics—scored the randomized and anonymous recordings by means of a visual analog scale (VAS) from 0 to 100. The left extreme of the scale was defined as "no closure" and the right extreme as "complete closure." VFC was judged all along the vocal fold (membranous and cartilaginous part). To standardize the rating on a VAS, all three judges participated in a 1-hour training session, using video samples that were not included in the study.

During the actual scoring procedure, each judge scored strictly individually and there was no communication between the judges. The scores of the judges were registered in an *SPSS* software (INM, SPSS, Inc. Chicago, IL) datasheet for further analysis. Statistical analysis of the effect of phonation mode on VFC was based on the mean scores of the three judges and performed by means of a repeated measures analysis of variance and Bonferroni correction coefficient. The significance level was determined at $P < 0.05$.

For the analysis of the interrater agreement, the individual scores were used. Because the data are continuous, interrater agreement was determined by means of an intraclass correlation coefficient (ICC).[19]

RESULTS

Figure 1 shows the mean score and standard deviation (in millimeters on the VAS) per phonation mode for all subjects ($n = 21$). The best glottic closure is observed during resonance on /m/ and the worst in Coblenzer's abspannen. Compared with VFC for habitual phonation, all phonation modes, except resonance, resulted in decreased glottic closure. Table 1 shows the mean difference (and corresponding standard error) between VFC of each phonation mode and VFC of habitual phonation as well as the significance level of that difference. Except for low-pitched phonation, all differences are significant. Only resonance on /m/ leads to significantly increased VFC ($P < 0.05$). High-pitched phonation ($P < 0.05$), Coblenzer's abspannen ($P < 0.001$), and chant talk ($P < 0.001$) lead to a significantly decreased VFC compared with habitual phonation.

The ICC for each phonation mode is listed in Table 2. Interrater agreement is good for habitual pitch, low pitch, high pitch, Coblenzer's abspannen, and resonance on /m/ and is moderate for chant talk and glide low-high.

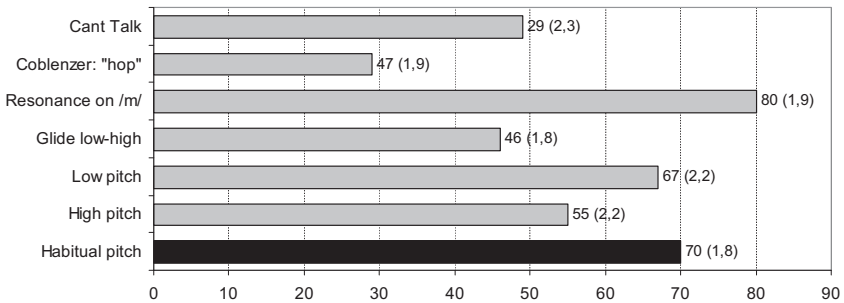

FIGURE 1. VFC per phonatory task: mean score and standard deviation (in millimeters) on VAS (0, no closure; 100, complete closure).

TABLE 1.
Mean Difference, Standard Error, and Significance Level of the Glottic Closure Between Habitual Phonation and the Other Phonatory Tasks

Factor 1*	Factor 2**	Mean Difference	Standard Error	Significance (*a*)
Habitual pitch	High pitch	1.531*	0.356	0.010*
	Low pitch	0.329	0.196	1.000
	Glide	2.437*	0.345	0.000**
	Resonance on /m/	−0.977*	0.197	0.002*
	Coblenzer "hop"	4.099*	0.620	0.000**
	Chant talk	2.084*	0.338	0.000**

*Significance level: $P < 0.05$.
**Significance level: $P < 0.001$.

DISCUSSION

The goal of this study was to evaluate the impact of phonation mode and vocal technique on VFC in subjects with normal voices. Five different commonly used voice techniques in voice therapy were compared with habitual phonation to determine the differences in VFC.

A first finding is that complete glottic closure is not the rule in young females. The average VAS score for VFC during phonation on habitual pitch is 70/100. This lends credence to the general opinion that complete VFC in young females is indeed rather exceptional.[3,4]

VFC increased in only one of the five phonation modes compared with VFC for habitual phonation. Resonance on /m/ results in a significantly better VFC ($P < 0.002$). This is in agreement with the clinical experience that resonance exercises lead to a better voice quality. All other phonation modes resulted in decreased glottic closure. However, the difference between habitual phonation and low pitch is not significant, which may be explained by the fact that low-pitched phonation is only three to four semitones below habitual pitch. The decrease of VFC on high pitch is not surprising and is in agreement with the findings of Murry et al[6] and Gelfer and Bultemeyer.[8] Coblenzer's abspannen and chant talk resulted in significantly decreased closure.

The authors are aware that there are a lot of influencing variables in this study. The use of a flexible videoendoscopic system to assess the impact of certain voice techniques can create unexpected laryngeal tension (as a compensatory behavior) or breath holding during phonation, consequently causing different laryngeal patterns like a decrease of VFCs.[20,21] Moreover the subjects were only trained briefly in applying all these techniques (one session of 45 minutes) in this procedure. In a routine voice therapy program, the techniques are frequently practiced while auditory, tactile, and proprioceptive feedback is provided by a voice therapist, which was not the case in this study. The lack of training can bias the results to some degree.

Whether the impact of these different phonation modes or techniques is different after a routine voice therapy approach is a subject of further research. In this study, the subjects had no opportunity to observe the glottis on the monitor during the recordings. The impact of biofeedback on VFC is as well an issue for future research.

Another source of bias may be scale effects. VASs are subjective of nature and have their inherent restrictions.[22]

The most important conclusions about this experiment are triple: (1) VFC in adult females with healthy voices is incomplete, (2) the mode of phonation does effectively have an impact on VFC, and (3) only one condition leads to an increased glottic closure, namely resonance on /m/ at least for normal young female subjects. Although these findings may not be generalized to predict voice therapy effects in dysphonic patients with incomplete VFC, at least they give an indication of what may be expected of particular phonation modes on VFC. Further research is necessary to determine the effect of these techniques on VFC in dysphonic patients with incomplete VFC and their relative therapeutic importance.

TABLE 2.
Interrater Agreement per Phonation Mode

Mode of Phonation	ICC
Habitual pitch	0.73
High pitch	0.56
Low pitch	0.68
Glide	0.39
Resonance on /m/	0.76
Coblenzer	0.50
Chant talk	0.37

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