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Arytenoid Adduction Asymmetries in Persons with and without Voice Disorders

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Abstract

Asymmetry of the arytenoid complex is considered when evaluating a patient for a voice disorder. This study sought to determine if there were differences in the asymmetry in persons with and without voice disorders. Three aspects of arytenoid adduction asymmetry were judged from still frames of the arytenoids in the adducted position from stroboscopy recordings of 52 vocally-normal speakers and 54 persons with voice disorders. Asymmetry of the arytenoids was prevalent in both normophonic and dysphonic speakers. The lack of strong differences in the prevalence of arytenoid asymmetries in the adducted position between normophonic and dysphonic speakers suggests that caution should be taken when using these asymmetries as an indicator of or related to a voice disorders.

Keywords

voice disorders; symmetry; stroboscopy; arytenoids

INTRODUCTION

Arytenoid adduction plays a critical role in creating a normal voice[1]. It is necessary for the arytenoids to approximate each other pulling the vocal folds medially. If, in the case of unilateral or bilateral paralysis, the arytenoids are unable to rotate and medialize the vocal folds, a voice disorder results. Voice disorders can also result from arytenoid dislocation or fixation.

To create a normal voice, there needs to be a balance between the two vocal folds. This balance is made up of equality of tension/mass, sufficient combined midline placement to build up subglottal pressure, and of a similarity of vertical position. If one arytenoid is

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anterior to another in the adducted position, it is likely that the associated vocal fold will be shortened, having less tension and more pliable tissue. The vocal fold associated with the anteriorly positioned arytenoid cartilage may also be slightly inferior to the vocal fold on the side of the normally positioned arytenoid. This arytenoid posture will create disequilibrium between the vocal folds which may result in abnormal vocal fold vibration. Thus, arytenoid adduction is an important feature in the assessment of persons with voice complaints.

Laryngeal adduction asymmetries in the absence of voice complaints have been noted through laryngeal mirror, dissection, computer tomography, and endoscopy[2,3,4]. In the most recent study, 70% of normophonic speakers were found to exhibit laryngeal adduction asymmetries[4]. Sixty-six percent of persons exhibited asymmetry in the anterior-posterior position of the corniculate or cuneiform tubercles. Five types of asymmetry were investigated for frequency of occurrence, the results were: right cuneiform tubercle anterior to left 50%, right angle of aryepiglottic fold more acute than left 50%, right corniculate tuberculum overlapping left 17%, left corniculate tuberculum overlapping right 16%, and left cuneiform tubercle anterior to right 10%. Increased incidence of marked asymmetry was noted with age, for persons aged 20–39 years, 47% demonstrated asymmetries, while 73% of persons 60–81 were noted to have asymmetry. The increase in asymmetry with age likely coincides with known age-related anatomical changes of the larynx. In general, as we age, our cartilages and joints ossify and calcify, muscles atrophy, and the vocal fold epithelium thickens[5]. These laryngeal changes, in concert with decreased breath support that would relate to increased medial compression of the vocal folds, provide several reasons for an asymmetrical presentation of the arytenoid complexes of the larynx. Asymmetries were more frequent in singers than non-singers, stressing the point that asymmetries are common in persons, not only without a voice disorder, but also in persons with preferred vocal quality. There are no known studies on arytenoid adduction asymmetries in persons with voice disorders.

Arytenoid adduction asymmetries, in persons presenting to an otolaryngology or speech-language pathology voice clinic with a voice complaint, are frequently considered to be part of the pathology. In the cases of persons with paralysis/paresis, arytenoid dislocation and arytenoid fixation, this is true. However, since 70% of persons with normal voices have arytenoid adduction asymmetries, it can be suspected that in many cases the arytenoid adduction asymmetries visualized in persons with voice disorders have no influence on their presenting complaint. Thus, it seems important to investigate the prevalence of arytenoid adduction asymmetries in persons with voice disorders. Such an investigation would provide information that voice clinicians can use to weigh their decision of whether or not to include arytenoid adduction asymmetry as a component of the disorder in every case where it is present.

The purpose of this study was be to replicate the Lindestad, Hertegard, and Bjorck[4] study of arytenoid adduction asymmetries in persons without voice disorders and to apply this methodology to assessing arytenoid adduction asymmetry in persons with voice disorders. The specific research questions were:

1. What is the prevalence and type of arytenoid adduction asymmetry present in vocally-normal speakers as rated via static stroboscopy images? We hypothesized that the answer to this research question would be similar to that found in the study by Lindestad, Hertegard, and Bjorck[4], which this question sought to replicate. Thus, we expected that out of the 52 normophonic speakers, 70% would exhibit some type of arytenoid adduction asymmetry, while 66% of participants would exhibit asymmetry in the anterior-posterior position of the corniculate or cuneiform tubercles.

2. What is the prevalence and type of arytenoid adduction asymmetry present in speakers with voice disorders as rated via static stroboscopy images? It was hypothesized that more than 70% of people with a voice disorder would exhibit adduction asymmetry due to the finding that 70% of people without a voice disorder exhibited adduction asymmetry[4]. This was especially expected because some of the voice disorders are defined by arytenoid posture irregularities, such as paresis and paralysis. Similarly, more than 66% of persons with voice disorders were expected to exhibit asymmetry in the anterior-posterior position of the corniculate or cuneiform tubercles.

METHOD

This study used two previously collected databases of stroboscopic images: one of vocally-normal speakers and one of speakers with vocal pathology. Participants were recruited from Columbia, S.C. and Charlotte, N.C. for the vocally-normal database and from Charlotte, NC only for the vocal pathology database. Data collection occurred at the Presbyterian Hospital's Specialized Voice Center by voice specialist Speech-Language Pathologists.

Participants

The normophonic speaker database is comprised of twenty-four males and twenty-eight females for a total of 52 participants ranging in age from 18–65 with a mean age of 41. Vocal normality was determined by case history, perceptual voice evaluation, V-RQOL, and a lack of apparent pathology upon stroboscopy. The normophonic speaker database was previously used and described in several studies aimed to answer different research questions[6,7,8,9]. The database of individuals exhibiting vocal pathology consists of eleven males and forty-three females for a total of 54 participants ranging in age from 18–88 with a mean age of 54. Persons with voice disorders were determined by presenting to a Voice Clinic with complaints and endoscopy consistent with a vocal pathology. Their distribution by predominant disorder is shown in Table 1. Participants with voice disorders were selected to be part of the study due to the fact that they were scheduled for a voice evaluation, thus type of disorder was not an exclusionary factor. During the recruitment process all participants were evaluated and provided with an informed consent detailing their level of participation and right to refuse to participate. Data collection, storage, and use were in accordance with human subjects regulations.

Instrumentation and Procedures

Endoscopy and stroboscopy—Standard clinical procedures were employed for endoscopy and stroboscopy. Continuous halogen light was used to locate the vocal folds and capture initial 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 in conjunction with a laryngeal contact microphone to track vocal fold vibratory frequency. Stroboscopy was used to capture habitual phonation (comfortable pitch and loudness).

Visual Perceptual Judgments—The digitally recorded images from the preexisting databases were visually rated to determine arytenoid adduction features from static stroboscopy images by two speech-language pathologists trained in voice. One static image of the arytenoids in the adducted position for each participant (106 images total) was carefully selected, extracted from the stroboscopic recording, and was judged for three features of arytenoid adduction (Figure 1). Still frames were chosen on the basis of 3 factors: 1) maximal adduction of arytenoid cartilages, 2) during comfortable pitch and loudness phonation, and 3) allowing for the least obstructed view of the features of interest

(cuneiform, corniculate, and aryepiglottic fold). The frames were taken from stroboscopic recordings with rigid endoscopes. The ALVIN program[10] was used to randomize and present the images to the raters. To obtain intra-rater reliability 20% of the images were randomly repeated. Therefore, a total of 128 images were rated from normophonic speakers and for persons with vocal pathology.

Arytenoid adduction postures were visually rated for asymmetry of the anatomical structures including: anterior position of the cuneiform tubercles, sharpness of the angle of the aryepiglottic folds, and overlapping posture of the corniculate tuberculum (Figure 2). The specific predefined arytenoid adduction postures that were judged include (Figure 3):

- Anterior posture of the cuneiform tubercle.
    - **a.** Left cuneiform tubercle anterior to the right cuneiform tubercle was rated mild, marked or absent.
    - **b.** Right cuneiform tubercle anterior to the left cuneiform tubercle was rated as mild, marked or absent.
- Overlapping posture of the corniculate tuberculum.
    - **a.** Left corniculate tuberculum overlapping the right corniculate tuberculum was rated as mild, marked or absent.
    - **b.** Right corniculate tuberculum overlapping the left corniculate tuberculum was rated as mild, marked or absent.
- Sharpness of the angle of the aryepiglottic fold.
    - **a.** Left aryepiglottic angle sharper than the right aryepiglottic angle was rated as either present or absent.
    - **b.** Right aryepiglottic angle sharper than the left aryepiglottic angle was rated as either present or absent.

Analysis—Percent agreement was employed for reliability analysis to establish intra-rater and inter-rater reliability. To determine the difference between types of arytenoid adduction postures present in vocally-normal speakers versus speakers with vocal pathology Fisher Exact test was conducted at an alpha level set to 0.05.

RESULTS

Overall, the majority of persons with and without voice disorders presented with arytenoid adduction asymmetries. The results are presented separately for the cuneiform cartilage, the corniculate cartilage and the aryepiglottic fold angle for both persons with and without voice disorders.

Cuneiform

When looking at the cuneiform alone, there is not much overall difference between the prevalence of asymmetry in persons with and without voice disorders (Table 2). The majority of cases from both groups revealed asymmetries. However, there were some significant differences between the persons with and without voice disorders. Persons without voice disorders had 50% of the asymmetries rated as mild and 37% as marked, while persons with voice disorders had 27% of asymmetries rated as mild and 58% rated as marked. There is also an interesting divergence in the data between persons with and without voice disorders related to side of asymmetry. Persons without voice disorders seem to have equal amounts of left (42%) and right (45%) cuneiform asymmetry, while persons

with voice disorders have double the cases of right (58%) than left (27%) cuneiform asymmetries.

Corniculate

Isolating our investigation to the corniculate, there appears to be a difference in prevalence of asymmetry between persons with and without voice disorders (Table 3). However, the presence of asymmetry in the corniculate does not signal a voice disorder as 76% of cases of persons without a voice disorder also revealed this asymmetry. Different than findings from the cuneiform, more mild (38%) than marked (48%) asymmetries were noted in persons with voice disorders, while the opposite was true of persons without voice disorders. There was no significant difference between the frequency of left and right corniculate asymmetries.

Aryepiglottic fold

The majority of persons with and without voice disorders had some asymmetry in the angle of the aryepiglottic fold. Thus, it seems that the sharpness of an angle of the aryepiglottic fold would not be a good diagnostic marker. There were twice as many cases of right-sided than left-sided increased angle acuity in persons with voice disorders, yet more left-sided than right-sided cases of increased angle acuity in persons without voice disorders (Table 4). The increased acuity of the right angle is in-line with the increased asymmetry in the right cuneiform cartilage (Table 2 and Table 4). A more anterior positioning of the cuneiform cartilage would decrease the space between the cartilage and the epiglottis creating a sharper angle.

DISCUSSION

Arytenoid adduction asymmetry in speakers without voice disorders

The results confirm that arytenoid adduction asymmetry is present in all normophonic speakers as visually evaluated through stroboscopic static images. Cuneiform, corniculate, and aryepiglottic angle asymmetry was found in 87%, 76%, and 91% of vocally-normal speakers, respectively. It was hypothesized that 70% of vocally-normal people would exhibit adduction asymmetry. This study found that 100% of vocally-normal speakers exhibited either corniculate, cuneiform, or aryepiglottic angle asymmetry. It was expected that 66% of vocally-normal speakers would exhibit asymmetry in the anterior-posterior position of the corniculate or cuneiform tubercles based on the previous research of Lindestad, Hertegard, and Bjorck[4]. The results of the current research were higher than expected with 100% normophonic speakers exhibiting anterior-posterior asymmetry of the corniculate or cuneiform tubercles. However, when excluding mild asymmetries, only 57% of vocally-normal speakers exhibited marked asymmetry. The increased occurrence could be due to a difference in the definition of asymmetry or related to the sensitivity of the raters participating in both studies, which strengthens the need for additional research to define the diagnostically significant parameters in normophonic speakers.

Arytenoid adduction asymmetry in speakers with voice disorders

The results confirm that an arytenoid adduction asymmetry is prevalent in individuals with vocal pathology as visually evaluated through stroboscopy static images. Cuneiform, corniculate, and aryepiglottic angle asymmetry was found in 85%, 86%, and 100% of persons with voice disorders, respectively. It was hypothesized that more than 70% of people with a voice disorder would exhibit adduction asymmetry. Some type of arytenoid adduction asymmetry was found in 100% of participants with voice disorders. Anterior-posterior asymmetry of the corniculate or cuneiform tubercles was visually rated in 98% of

individuals with vocal pathology, where 71% of the same individuals displayed marked asymmetry. This finding is inline with the expectation that persons with voice disorders would have arytenoid adduction asymmetry related to their laryngeal pathology.

Differences in arytenoid adduction asymmetries between vocally-normal speakers and speakers with voice disorders

A larger percentage of arytenoid adduction asymmetry was hypothesized to be present in persons with voice disorders than persons without voice disorders. The division in results between persons with and without voice disorders is not strong enough to allow for ease of clinical decision making. That is, one cannot conclude from these findings that all persons with substantial arytenoid adduction asymmetry have vocal pathology. Thus, even in the case of visible marked arytenoid adduction asymmetry, the asymmetry may not play a significant role in the voice disorder.

Finding that persons with voice disorders had more right-sided than left-sided asymmetries compared to persons without voice disorders was unexpected. While we know that the recurrent laryngeal nerve has a different path on the right than the left side, the left side of the nerve is typically believed to be more prone to damage than the right due to its longer path. Whether there is a true difference in the prevalence of right and left side asymmetries remains to be determined. Even if there is a true difference between the prevalence of asymmetries on the right versus left side of the larynx, the clinical implications of this are unclear. If this finding is maintained in further investigations, it may be used to indicate cases of pathological versus normal asymmetry.

CONCLUSION

This study sought to replicate the Lindestad, Hertegard, and Bjorck[4] study on arytenoid adduction asymmetry in persons without voice disorders and to extend it to include persons with voice disorders. The study found more cases of asymmetry in persons without voice disorders than predicted from the previous study. Findings from this study indicate a difference between persons with and without voice disorders particularly between instances of mild and marked asymmetries. These differences between persons with and without voice disorders are not clear enough to determine that arytenoid adduction asymmetries are clinically relevant in the majority of cases. Findings from this study suggest that voice clinicians need a strong knowledge of the prevalence of different types of arytenoid asymmetries to correctly determine an optimal diagnosis and treatment plan. A logical future extension of this work will be to compare arytenoid adduction asymmetries with vocal fold vibratory asymmetries.

Acknowledgments

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Figure 1.
Implementation of the *Alvin* program for visual perceptual judgments of the asymmetries of the cuneiform, corniculate, and aryepiglottic fold angle.

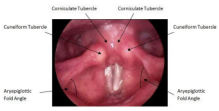

Figure 2.
Image of the larynx with points of interest labeled.

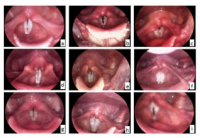

Figure 3.
Examples of the features and categories of arytenoid adduction asymmetry: a. symmetrical cuneiforms; b. mildly asymmetrical cuneiforms; c. markedly asymmetrical cuneiforms; d. symmetrical/non-overlapping corniculates; e. mildly overlapping corniculate; f. markedly overlapping corniculate; g. equal angles of the aryepiglottic folds; h. right angle of aryepiglottic folds is more acute; i. left angle of the aryepiglottic folds is more acute.

Table 1

Distribution of participants with voice disorders by predominant disorder.

Type of Disorder	# of cases
Vocal fold atrophy	11
Nodules	7
Post-lesion removal	6
Generalized edema	5
Spasmodic dysphonia (all types)	5
Polyp (with or without reactive nodule)	4
Vocal fold bowing	3
Unilateral paralysis	2
Cyst with reactive nodule	2
Bilateral paresis	1
Hemorrhage	2
Unilateral weakness	2
Unilateral paralysis post-arytenoid relocation	1
Leukoplakia	1
Scar	1
Muscle tension dysphonia	1
Total # cases	54

Table 2

Percent of cuneiform asymmetries in persons with and without voice disorders. Pvalues from the Fisher's Exact tests to determine statistically significant difference are noted.

Cuneiform	**Normophonic**		**Dysphonic**		**P-Values**
Left Markedly Anterior to Right	13	42	21	27	0.09
Left Mildly Anterior to the Right	29		6		0.00*
Right Markedly Anterior to the Left	24	45	37	58	0.04*
Right Mildly Anterior to the Left	21		21		0.56
Equal	13		15		0.27

Table 3

Percent of corniculate asymmetries in persons with and without voice disorders. P-values from the Fisher's Exact tests to determine statistically significant difference are noted.

Corniculate	**Normophonic**		**Dysphonic**		**P-Values**
Left Markedly Overlaps Right	28	40	20	43	0.15
Left Mildly Overlaps Right	12		23		0.03*
Right Markedly Overlaps Left	15	36	18	43	0.35
Right Mildly Overlaps Left	21		25		0.30
Equal	24		14		0.05*

Table 4

Percent of aryepiglottic fold angle asymmetries in persons with and without voice disorders. P-values from the Fisher's Exact tests to determine statistically significant difference are noted.

Aryepiglottic fold angle	Normophonic	Dysphonic	P-Values
Left Sharper	48	29	0.00*
Right Sharper	43	71	0.00*
Equal	9	0	0.00*