

Correlation between Pathological Voice Onset and Voice Quality Based on Vocal Attack Time(VAT) and Multidimensional Voice Program (MDVP).

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ABSTRACT

Correlation between pathological Voice Onset and Voice Quality of Chinese patients based on Vocal Attack Time(VAT) and Multidimensional Voice Program (MDVP) is discussed in this paper. The test subjects were divided into three groups, one is normal voice group and the other two are pathologic voice groups, namely, vocal cord polyps and non vocal cord polyps. We recorded the EGG signal for the above subjects and extracted the Jitter, Shimmer, HNR, NNE and VAT parameters by the relevant software. The VAT and other voice parameters at /a:/, /i:/ and /u:/ vowels were then compared and analyzed in different groups. The results showed that there was no significant difference in the VAT between the vocal polyp group and the non-vocal polyp group at /a:/, /i:/, and /u:/ vowels. In addition, the analysis of VAT changes in a patient with vocal cord polyps before and after surgery revealed that there was some difference in VAT, but neither the overall difference in vowels nor the difference in vocalization was significant.

KEYWORDS

Pathological Voice, Voice Onset, Voice Quality, Vocal Attack Time

1 Introduction

Electroglottography (EGG) is an established non-invasive method of detecting vocal cord vibration for the treatment of voice disorders. The EGG measures the vocal cord vibration and the vocal impedance signal through electrodes fixed on the larynx. Currently, a multidimensional voice parameter analysis method is used to evaluate the electroacoustic signal of the voice disorders,

*Article Title Footnote needs to be captured as Title Note

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where Jitter, Shimmer, HNR, NNE, and CQ are considered to be the key parameters. The reason for using multidimensional parameters is that there are many types of voice disorders, such as common unilateral/bilateral vocal polyps, vocal cysts, nodules, laryngitis, etc. The different voice disorders often result in multiple impairments of the voice, which can manifest as multidimensional changes in voice parameters. Therefore, it is difficult to reflect the full extent of voice pathology in a single parameter.

The vocal attack time, proposed by Baken and Orlikoff [1], is a parameter for the onset time of the voice by simultaneous processing of the sound pressure and EGG dual-channel sound signals. The vocal onset characteristics of normal and pathological voice have been investigated using VAT. Roark et al [2] set the threshold of FOM to be greater than or equal to 0.75 after observing 102 unqualified samples. Watson et al [3][4], Ma et al [5], Lee [6], Tam [7], and Zhang et al [8] reported normative VAT values for English, Cantonese, and Mandarin speakers, respectively. Liu Jinxuan [9] compared the VAT characteristics of normal Chinese voices with those of vocal polyps under different vowel sounds, tones, and consonants material, and concluded that there is a great difference between the consonants material VAT characteristics of vocal polyps group and normal voice group, especially consonant material under different manner of articulation by aspiration or not. In contrast, there are no significant differences in vowel and tonal materials. In addition, Liu Jinxuan discussed the correlation between VAT and voice quality parameters such as Jitter, Shimmer, and harmonic noise ratio (HNR) in Chinese normal voice and vocal cord polyps patients. Zhen Ren et al [10] analyzed the VAT of patients with cleft palate and showed that the VAT values were significantly shorter in patients with cleft palate who used glottal stop relative to patients without glottal stop as a compensatory articulation.

Although some results have been obtained, the correlation between voice onset and voice quality needs to be further explored. In particular, there is a need for research on other types of voice pathologies other than vocal polyps or cleft palate. It would be useful to have a direct comparison of the changes in

voice quality before and after the rehabilitation of the pathological voice. To this end, we have conducted the following studies.

2 MATERIALS AND METHODS

2.1 Subjects

A total of 39 patients with voice disorders were associated with data. These patients were clinically diagnosed as having unilateral/bilateral vocal polyps, vocal cysts, and vocal nodules. Since there have been studies on vocal polyps, the patients were divided into vocal polyps and non-vocal polyps groups to facilitate comparison with the results of existing studies. The vocal polyps group consisted of 12 patients, aged 18-71 years, and the non-vocal polyps group consisted of 27 patients, aged 15-76 years. In addition, an additional 13 normal-voiced adults, aged 23-52 years, served as a control group.

2.2 METHOD

In addition to electroglottograph (Model 6103, KayPENTAX, NJ), a series of equipment was used for voice signal acquisition, including laptop computer (Lenovo, V110, Lenovo, Beijing, China), external sound card (Sound Blaster X-Fi Surround 5.1

Pro, Creative Labs, Singapore), mixing console (Behringer XENYX502, MUSIC Group Macao Commercial Offshore Limited, Zhongshan, Guangdong, China), unidirectional collar clip microphone (ECM-44B, SONY, Tokyo, Japan), and recording software (Adobe Audition 3.0, Adobe Systems Incorporated, San Jose, CA, USA). Two metal electrodes were placed on the anterior third of the subject's neck below the thyroid cartilage plate on both sides of the subject's neck, roughly opposite to the glottis. The subjects were asked to pronounce the steady-state vowels /a:/, /i:/, /u:/ for 3-5 s, and each vowel was pronounced twice.

The basic parameters of voice quality are acquired from Mutispeech Model 3700 (KayPENTAX, NJ), a Multidimensional Voice Program. The following parameters are obtained: jitter, shimmer, NNE, HNR. (定义及生理意义)

The VAT data are extracted from the collected database using software developed by Roark et al. There are four main steps in the data analysis of this software. The first step is signal verification, where the original SP and EGG are audibly and visually verified. The second step is signal segmentation. A segment with a duration of 600ms is divided on the SP and EGG signals. The midpoint of this segment is the approximate time when the voice starts. The third step is F0-based frequency filtering and signal modeling. Obtain the instantaneous amplitude and frequency of the modeled SP and EGG to form a band-pass filter model. The last step is the extraction of VAT data. The SP and EGG signals after segmentation and filtering are analyzed

through the cross-correlation method to obtain the cross-correlation function curve. The phase difference between the maximum value of this curve and its midpoint is the value of VAT.

3 Results (再加一张堆积图)

Table 1 shows the relevant voice parameters of the vocal cord polyp group, the non-vocal cord polyp group and the normal adult as the control group. Compared with the control group, the stability of vocal cord vibration in both the vocal cord polyp group and the non-vocal cord polyp group decreased, the jitter, shimmer and nne increased, and the harmonic-to-noise ratio decreased. It can be seen from the results that parameters such as jitter, shimmer, HNR, and NNE can better reflect the significant difference between the diseased voice of the vocal cord polyp group and the non-vocal cord polyp group and the normal voice of the control group. This result is consistent with existing research.

	Jitter (%)	Shimmer (%)	HNR	NNE
Vocal cord polyp	0.41 ± 0.43	2.06 ± 1.81	27.86 ± 6.65	-11.67 ± 6.23
Non-vocal cord polyp	0.55 ± 0.79	2.18 ± 2.43	26.08 ± 7.68	-16.58 ± 8.81
Normal voice	0.32 ± 0.15	1.51 ± 0.38	29.09 ± 2.35	-18.21 ± 2.01

Table 1. Comparison of jitter, shimmer, HNR, NNE and other related values. Compared with the control group, the P values of jitter, shimmer, HNR, NNE and other parameters of the vocal cord polyp group and the non-vocal cord polyp group were all less than 0.05.

Table 2 shows the VAT values of different vowels in the vocal cord polyp group, the non-vocal cord polyp group and the normal adult as the control group. Compared with the control group, the VAT values of different vowels in the vocal cord polyp group and the non-vocal cord polyp group did not change significantly.

	a	i	u
Vocal cord polyp	-2.36 ± 7.63	1.31 ± 9.57	3.47 ± 8.89
Non-vocal cord polyp	-2.79 ± 9.24	1.48 ± 9.84	3.66 ± 8.27

Normal voice	-2.12 ± 7.29	1.01 ± 8.86	3.58 ± 9.02
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Table 2. Comparison of VAT values of different vowels, all VAT FOMs are greater than 0.75. Compared with normal voice, the P values of /a:/, /i:/, /u:/ trivowel VAT of the vocal cord polyp group and the non-vocal cord polyp group were less than 0.05.

4 Discussion

The correlations between the parameters such as jitter, shimmer, Hnr, NNE and the pathological voice have been clearly established, but it is still unclear whether the pathological voice causes specific changes in the VAT due to the special circumstances of the voice. Liu Jinxuan compared the VAT characteristics of normal Chinese voices with those of vocal polyps under different vowels, tones and consonants materials, and concluded that there is no significant difference in the vowel and tone materials of vocal polyps, but there is a big difference in the consonants material VAT characteristics of vocal polyps and normal patients. This study further illustrates that not only vocal cord polyp patients, but also other types of pathological voices, such as vocal cysts and vocal nodules, do not differ significantly from the normal group in terms of vowel and tonal voice material. More research is needed as to explore whether other types of pathological voice VAT can exhibit similar correlations in consonants material as in patients with vocal polyps.

It is worth noting that in this study, a patient with vocal cord polyp diseased voice underwent surgery and returned to his normal voice. We recorded a complete voice material containing more than 60 syllables before and after his surgery. These syllables are mainly composed of non-aspirated stop sounds /p, t, k/, aspirated stop sounds /ph, th, kh/ and monophonic sounds /a,i,u / and four lexical tones in Mandarin. Although the overall sample size is relatively small, it provides a way to directly compare the VAT changes before and after rehabilitation of vocal cord polyp. It turns out that there are indeed certain differences in voice VAT before and after surgery, but neither the overall difference in consonants nor the differences in manner of articulation by aspiration or not are significant.

	Before surgery	After surgery
non-aspirated stop /p t k /	0.19 ± 4.86	-0.30 ± 5.59
aspirated stop /p ^h t ^h k ^h /	0.26 ± 4.02	-0.39 ± 4.68
Grand average	0.22 ± 4.43	-0.34 ± 5.14

Table 3. The VAT changes of a patient with vocal cord polyps before and after surgery. The patient's voice basically returned to normal after surgery. The p-values for the comparison of the two groups of VAT before and after surgery for The non-aspirated stop /p,t,k/, aspirated stop /p^h, t^h, k^h/ were all greater than 0.05 and were not significant.

The above data indicate that the VAT of pathological voice is relatively unstable between individuals and even individuals, which is inconsistent with Liu Jinxuan's research. Therefore, VAT is more suitable as a parameter in Multidimensional Voice Program (MDVP), reflecting that common voice disorders such as vocal cord polyps, vocal cord cysts, and vocal cord nodules may cause changes in the VAT value of the consonants material. It is not suitable as a specific indicator of certain types of voice disorders.

5 Conclusion

The VAT and other voice parameters were compared and analyzed for the three vowels /a:/, /i:/, and /u:/. It was found that there was no significant difference in VAT between the vocal polyps and non-vocal polyps groups when the vowels were pronounced in /a:/, /i:/, /u:/. This indicates that there is no significant difference on voice onset between the vocal polyps and non-vocal polyps groups. The analysis of the VAT changes in a patient with vocal cord polyps before and after surgery showed that there was some difference in VAT, but neither the overall difference in consonants nor the difference in manner of articulation was significant.

ACKNOWLEDGMENTS

This research has been supported by Major Projects of Ministry of Education of China. Project Name: Language Ontology Research based on Multi-Modal. Project No. 17JJD740001.

REFERENCES

- [1] Baken RJ, Orlikoff RF. 1998. Estimating vocal fold adduction time from EGG and acoustic records. In: Schutte HK, Dejonckere P, Leezenberg H, Mondelaers B, Peters HF, eds. Programme and Abstract Book: 24th IALP Congress, Amsterdam.
- [2] Roark RM, Watson BC, Baken RJ (2012). A figure of merit for vocal attack time measurement. *J Voice*. 26:8 - 11.
- [3] Watson BC, Baken RJ, Roark RM, et al. Effect of fundamental frequency at voice onset on vocal attack time. *J Voice*. 2013;27:273 - 277.
- [4] Watson BC, Baken RJ, Roark RM. Effect of voice onset type on vocal attack time. *J Voice*. 2016;30:11 - 14.
- [5] Ma EP, Baken RJ, Roark RM, et al. Effect of tones on vocal attack time in Cantonese speakers. *J Voice*. 2012;26:670.e1.
- [6] Lee T-YT. The effects of vocal intensity on vocal attack time (VAT). Pokfulam, Hong Kong: The University of Hong Kong. 2010 李芷茵.

- [7] Tam K-CB. Effects of straw phonation on vocal attack time in Cantonese speakers. Pokfulam, Hong Kong: The University of Hong Kong. 2013 譚家駿.
- [8] Zhang R, Baken RJ, Kong J. Vocal attack time of different pitch levels and vowels in Mandarin. *J Voice*. 2015;29:542 - 547.
- [9] Liu Jinxuan (2017), Research on the vocal onset characteristics of functional voice disorder based on VAT and the correlation between VAT and voice quality (Doctoral dissertation).
- [9] Zhen, R. , Xia, Z. , Lian, M. , & Jiangping, K. . (2019). Comparison study of vocal attack time in patients with cleft palate with and without glottal stop in mandarin. *Journal of Voice*, Vol. 33, No. 5,