Acoustic Analysis Before and After Voice Therapy for Laryngeal Pathology.

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ABSTRACT

Background

Voice problems caused by pathologies in vocal folds are well known. Some types of laryngeal pathologies have certain acoustic characteristics. Objective evaluation helps characterize the voice and voice problems providing supporting evidences, severity of disorders. It helps assess the response to the treatment and measures the outcomes.

Objective

The objective of the study is to determine the effectiveness of the voice therapy and quantify the results objectively by voice parameters.

Method

Study includes 61 patients who presented with different types of laryngeal pathologies. Acoustic analyses and voice assessment was done with Dr. Speech ver 4 (Tiger DRS Inc.). Acoustic parameters including fundamental frequency, jitters, shimmers, Harmonic to noise ratio (HNR), Normalized noise energy (NNE) were analyzed before and after voice therapy.

Result

Bilateral vocal nodules were the most common pathologies comprising 44.26%. All acoustic parameters showed a significant difference after the therapy ($p<0.05$) except for NNE. Dysphonia due to vocal fold polyp showed no improvement even after voice therapy ($p>0.05$).

Conclusion

Acoustic analysis provides an objective, recordable data regarding the voice parameters and its pathologies. Though, few pathology require alternative therapy rather than voice therapy, overall it has a good effect on glottic closure. As the voice therapy can improve the different indices of voice, it can be viewed as imperative part of treatment and to monitor progression.

KEY WORDS

Acoustic analysis, objective evaluation, voice assessment, voice therapy

INTRODUCTION

Quality of sound depends on the nature of vocal cord adduction and regularity of the mucosal waves of the true vocal cord. Voice is the acoustic outputs that are characterized by their dependence on the vocal cord vibratory inputs.[1] Use of instrumentation in voice analysis and extraction of physical parameters of voice is known as acoustic analyses.

Vocal alteration can reveal itself at a very initial stage of the pathology. Attempts have been made to utilize vocal cues for the early detection of certain laryngeal pathologies. Whisper and breathy voice results from inadequate closure of the vocal cord while hoarseness occurs with aperiodic sounds produced due to irregularities of mucosal vibrations of the vocal cord.

Sound consists of fundamental frequency and harmonics along with non-harmonic noises. The rate of vibration of a vocal fold is the function of the vocal cord length, elasticity, tension and mass with subsequent resistance to the subglottic air pressure.[2]

The research using objective parameters focused on laryngeal pathologies and voice is scarce. These studies have been more or less subjective and resulted in confusions. Objective evaluation of the voices helps to characterize voice problems, measurement of severity and variances, outcome and responsiveness to treatment. Voice therapy is generally used to minimize the inimical vocal behavior that increases the stress at the mid membranous vocal folds.

The study focuses on the effectiveness of voice therapy and objective measures of the voice parameters using acoustic analysis for different laryngeal pathologies.

METHODS

This is a prospective, longitudinal study that includes patients with different voice disorders. Sixty one of them presented to the outpatient department of ENT-HNS, Kathmandu Medical College and Teaching Hospital, Sinamangal, Kathmandu, Nepal from April 2014 to April 2015. The Kathmandu Medical College Research and Ethical Committee approved ethical clearance.

Consecutive sampling methods were used and all the patients were examined by the otorhinolaryngologist (author) using mirror examination, flexible fiber-optic and videostroboscope. Acoustic analysis was done by speech and language pathologist.

Inclusion criteria:

1. Both sexes aged more than 16 years
2. Patients with laryngeal pathologies except for malignancies
3. Patients without previous surgical interventions
4. Informed consent given

Exclusion criteria:

1. Patient less than 16 years
2. Patients with acute laryngeal pathologies
3. Patients with previous vocal cord surgical interventions
4. Patients with laryngeal malignancies
5. Informed consent not given

The study was done individually with patient seated in a quiet room.

Voice recording was made with vocal assessment Dr. Speech ver. 4 software from Tiger DRS, Inc. Microphone was held eight cm away from the patient's mouth. The patients were instructed to attempt to sustain vowel /i:/ at optimal pitch levels several times and recording started. The amplitudes of sustained vowels were measured at the dominant amplitude that was picked up by a microphone. The median value being considered relevant for analysis, accordingly, voice parameters recorded and saved as a digital file.

Five acoustic parameters were measured: fundamental frequency (f_0), frequency perturbation measures or jitters (%), amplitude perturbation measures or shimmers (%), HNR (harmonic to noise ratio), NNE (normalized noise energy).

Voice of the patients with different laryngeal pathologies were grouped accordingly and evaluated before and after voice therapy. The patients underwent voice therapy for 1 to 3 months. Two sessions per week for 1st month then once a week from second month onwards. Each session lasted 30 minutes. Patients were also told to practice at home twice daily for 25-30 minutes. Altogether, patients underwent 16 sessions of supervised training. Patients were re-evaluated after completion of three months of voice therapy.

Statistical analysis was performed with SPSS ver. 17, Microsoft Excel. The parameters were analyzed with paired T test. Significant level was regarded as $p<0.05$.

RESULTS

Among the different laryngeal pathologies that patients presented with, bilateral true vocal cord nodules were the most common one followed by vocal cord polyp. Vocal cord nodules comprised 27 cases whereas polyp consisted about 11 cases. Number of patients presenting with other laryngeal pathologies are shown in figure 1. All the laryngeal pathologies show female preponderance with the ratio of 3.06:1. It was seen more commonly in patients in 2nd to 4th decade of life.

The acoustic analysis in these groups before and after the voice therapy was done which showed the following results.

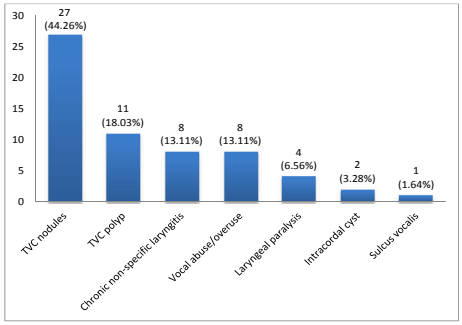

Figure 1. **Number of Benign Laryngeal pathologies.**

In patients with vocal cord nodules, the mean jitter values was 0.23%, shimmer = 1.35%, HNR = 29.49, NNE = -14.55 prior to the therapy. After the therapy, the parameters were, jitter = 0.17%, shimmers = 1.00%, HNR = 33.24, NNE = -9.95.

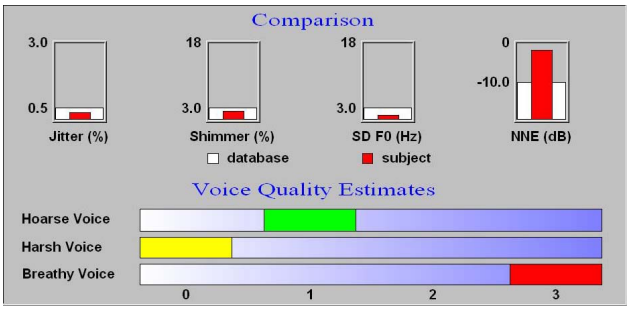

Figure 2. **Vocal assessment in a patient with bilateral vocal nodule before voice therapy.**

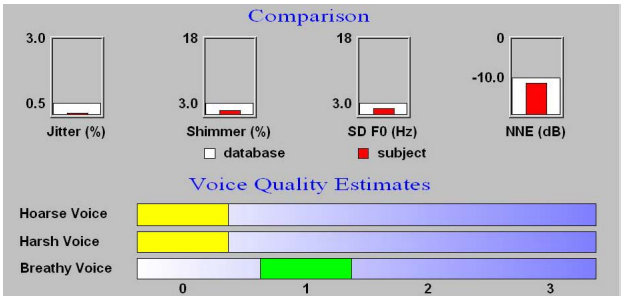

Figure 3. **Vocal assessment in a patient with bilateral vocal nodule after voice therapy.**

The differences of values were statistically significant for all parameters ($p<0.05$).

Figure 2 and 3 shows improved voice quality in a patient with bilateral true vocal cord nodule before and after the voice therapy.

In patients with vocal cord polyp, analysis showed jitters = 0.43%, shimmers = 1.78%, HNR = 28.40, NNE = -8.59 before the therapy. After the therapy, jitters = 0.18%, shimmers = 1.12%, HNR = 31.18 and NNE = -13.63. The result was not statistically significant ($p>0.05$).

The mean acoustic voice parameters before and after the voice therapy for other laryngeal pathologies are given in table 1 among which Laryngeal paralysis, Intracordal cyst, sulcus vocalis was not statistically significant due to inadequate number of patients.

Table 1. **Mean acoustic voice parameters before and after voice therapy for laryngeal pathologies.**

Pathology	Mean Parameters	Pre - assessment	Post - assessment	Value of t	p value
TVC nodules	Jitters %	0.23	0.17	-2.619	0.0145
	Shimmers%	1.35	1.00	-2.681	0.0125
	HNR	29.49	33.24	4.797	0.000057
	NNE	-14.55	-9.95	0.8	0.406
Polyp	Jitters%	0.43	0.18	-1.15	0.274
	Shimmers%	1.78	1.12	-1.24	0.243
	HNR	28.40	31.18	1.61	0.136
	NNE	-8.59	-13.63	-2.14	0.057
Chronic non-specific Laryngitis	Jitters%	0.33	0.14	-3.04	0.018
	Shimmers%	2.16	0.85	-2.89	0.023
	HNR	26.34	34.42	6.98	0.000215
	NNE	-8.83	-13.38	-3.32	0.012
Vocal abuse/ Overuse	Jitters%	0.24	0.18	-0.87	0.412
	Shimmers%	1.28	1.52	0.74	0.478
	HNR	29.59	27.84	-0.68	0.512
	NNE	-11.41	-11.56	-0.12	0.9

Patients suffering from chronic non-specific laryngitis showed statistically significant improvement with $p<0.05$ after voice therapy. Jitters improved from 0.33% to 0.14%, shimmers from 2.16% to 0.85%, HNR from 26.34 to 34.42 and NNE from -8.83 to -13.38. Unfortunately, patients with vocal abuse or overuse showed no significant difference before and after the voice therapy ($p>0.05$). Analysis showed changes in jitters from 0.24% to 0.18%, shimmers from 1.28% to 1.52%, HNR from 29.59 to 27.84 and NNE from -11.41 to -11.56.

DISCUSSION

Phonation depends on the mechanism of voice production. Pathological phonation is associated with the imbalance of normal vibratory characteristics of the vocal folds.

The purpose of the study is to determine the effectiveness of the voice therapy and quantify the results objectively by voice parameters.

Previous high hopes that acoustic spectrums would provide a non-invasive means of diagnosing voice condition have not been realized. Attempts have been made to set standards for measurements and assessments.[3] Loudness and quality of voice are relative in nature and controversy exists among researchers regarding their measurements.

Measurement of jitter/shimmer indicates instability in the phonatory mechanism and is a useful index of dysphonia. Harmonic to noise ratio measures dysphonic severity and voice quality during treatment.[4] Normalized noise energy is the turbulence noise caused by the adduction insufficiency of glottis during phonation.

Jitter is one of the measures to identify the instability in the vocal cord vibration.[5]

Growths on vocal cords may influence jitter. Jitter increase as control over laryngeal muscle tone becomes coarser.[6]

Shimmer increases with poor and inconsistent contact between the vocal edges. Incomplete closure of the glottis leads to air leakage, which is acoustically characterized as noise.[6]

In a study done by Van Houtte E et al. functional voice disorder was most frequently diagnosed (30%), followed by vocal nodules (15%).[7] Whereas significant vocal cord edema, or paralysis/paresis was identified in 52.3%.[8] In our study, bilateral vocal cord nodule was the most common laryngeal pathology. Vocal nodules can be treated both non-surgically and surgically. Non-surgical treatments are based on behavioral modifications.[9]

The results obtained from objective acoustic analysis confirm the beneficial effects of vocal treatment on hyperfunctional dysphonia with prenodular and nodular lesions. Statistically significant difference (p=0.025) was registered for all parameter values except for jitter%.[10] In a non randomized clinical trial done by McCrory of 26 vocal nodules,[11] results demonstrate elimination and or reduction of vocal fold nodules in over 70% of patients. Post therapy, over 80% of patients presented with either a normal voice quality or a mild degree of dysphonia.

Similarly, Amir et al. came to the conclusion that after a voice course for vocal nodules and incomplete adduction of the glottis,[12] most acoustic measures improved, whereas no significant effect is found for any of the perceptual scale.

In our study also there was significant difference in all acoustic parameters except for NNE (p=0.406). Jitters% (p=0.0145), Shimmers% (p=0.0125) and HNR (p=0.00005) were noted.

Unfortunately, vocal polyp showed no improvement after the therapy alone. None of the parameter differences were significant. Similarly, Mirjana Petrovic-Lazic et al. demonstrates significant benefit only after phonomicrosurgical treatment with statistically significant differences between the indices as measured from preoperative to postoperative performance.[13]

It is possible that if voice therapy is provided as an initial treatment, it may lead to an improvement in perceived voice quality in patients with benign vocal fold lesions despite persistence of polyp or cyst. Clear and significant improvement in the mean values of jitter% (p=0.04) and HNR (p=0.04) was visible.[14]

Similarly, chronic non-specific laryngitis also improved with voice therapy. In a study by Damborenea et al. with Dr Speech Science 3.0 software,[15] the mean fundamental frequency (F_0) was lower, and jitter (%) and shimmer (%) were higher in smokers than in non-smokers. The other two parameters, HNR and NNE did not differ significantly. In a study by Bassiouny for nonorganic dysphonia, minimal associated pathological lesions,[16] the difference in improvement for most of the parameters after therapy is generally significant. The improvement in the pretest to midtest to posttest values follows a linear tendency.

Gordon et al. studied 143 dysphonia resulting from vocal misuse or abuse with a variety of secondary pathologies.[17] Successful resolution of the problem was seen in only 41.5% and 35% with therapy and monitoring program, relaxing exercises respectively.

Patients presenting with vocal abuse/overuse showed no improvement in all the acoustic parameter. Jitters% (p=0.412), shimmers% (p=0.478), HNR (p=0.512) and NNE (p=0.9).

Ptok and Strack found that in 24 unilateral vocal fold paresis,[18] only 58% and 69% of patients of traditional voice therapy and electro stimulation voice exercises respectively, show an obvious improvement. Statistical analysis indicates slight though not significant differences between both groups favoring electrostimulation supported exercise.

Though the study shows promising results in few pathologies, the results of other pathologies cannot be generalized due to the inadequate number of sample. Should a further study be considered, sample size should be increased. Structured data recording and parameters can be affected by the quality of instruments used resulting in sampling bias so a precise set of instruments and protocol should be followed.

CONCLUSION

Voice therapy has good effect on glottal closure as reflected by different voice parameters during acoustic analysis. Among all the parameters, Harmonic to noise ratio (HNR) was seen as more reliable parameter. It has promising results incases of hyper-functional voice disorders like vocal nodules and chronic non-specific laryngitis. Unfortunately, dysphonic voices due to vocal polyp and voice abuse showed no compelling effects and an alternative regime should be sought.

The study determines that acoustic analysis quantifies the results objectively and provides an effectual way of evaluation of voice therapy in terms of voice quality, voice status and function.

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