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Research Article

LOCALISATION OF VOCAL FOLD MASS WITH VARIATION OF ACOUSTIC PARAMETERS

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A B S T R A C T

Voice pathology detection has been studied intensively in the signal processing research community using various digital signal processing methods. It is now possible to detect & compare different pathologies of the vocal cords in individuals by comparing the acoustical analysis data of patients. The present study was undertaken aiming to find & analyse acoustical features of voice with intracordal vocal fold lesion & lesions located on vibratory margins of vocal fold. And to set out the management/ rehabilitation protocol in both the case scenarios. Out of 300 patients with dysphonia, total of 60 patients(30 with intracordal pathology and 30 with vibratory margins of vocal fold pathology) were selected for the study based upon the set inclusion & exclusion criterias. Acoustical voice analysis was done based upon parameters like fundamental frequency, jitter (frequency perturbation), shimmer (amplitude perturbation), HNR ratio & MPD & physiological dynamics with the help of PRAAT- Voice analysis software & Stroboscope at ENT Department at CNMC&H & Equilibrium Audio-Vestibular & Voice Clinic, Hoogly. The study demonstrated acoustic parameters varying with location of pathology as well as dynamics of vibration. Acoustic parameters are seen to be affected more in case of pathology on vibratory margin rather than intracordal pathology. Maximum phonation time (MPT) was affected more in case of vibratory margin pathology. Shimmer was also found to be high in case of vibratory margin lesions. Jitter was the only parameter which is more affected in intracordal lesion. HNR was higher in vibratory margin pathology, while, fundamental frequency was reduced in case of intracordal pathlogies.

The quality of voice was observed good with smooth margin, while intracordal pathology had more hoarseness but less breathiness and vice versa with vibratory margin pathology. The hoarseness of intracordal pathology persisted more than pathology on vibratory margin. The rehabilitation and treatment protocol differs drastically in both the conditions.

INTRODUCTION

Voice is dynamic and complex, while speech can be done in different languages, intonations and with different emotions. In the last few years, voice pathology detection has been studied intensively in the signal processing research community using various digital signal processing methods. Because of this, the reliability of the developed software which is currently being used to automatically detect pathology in the vocal folds and the underlying variability of speech has increased. It depends on the language analysed and the kind of pathologies and techniques used in the analysis. In speech clinical practice, the patient's voice quality is assessed using sustained vowel phonations and/or conversational speech. In order to make quantitative voice evaluation, acoustic, aerodynamic, endoscopic, perceptual or patient-self assessment examination may be needed. If the diagnosis is not ambiguous, the methods can be combined.

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1. There are different acoustic features being analysed, with a different focus.
2. That differs with the type of pathology & dynamics of vibrations.

The most commonly used measures are fundamental frequency, jitter (frequency perturbation), shimmer (amplitude perturbation), HNR ratio & MPD. Based on these, a lot of information can be extracted regarding differences between both pathology on Intracordal & that on vibratory margin of vocal cord.

Aims and Objective

1. To find & analyse acoustical features of voice with intracordal Vocal fold lesion & lesions located on vibratory margins of vocal fold.
2. To set out the management/ rehabilitation protocol in both the case scenarios.

MATERIAL AND METHODS

Study Area

ENT Department at CNMC&H & Equilibrium Audio-Vestibular & Voice Clinic, Hoogly.

Study Population

Patients attending Outpatient of ENT department. CNMC&H with dysphonia, requiring stroboscopic examination.

Study Period – 1 year
Sample Size – 60
Study Type- Prospective

Inclusion Critaria

Dysphonia patients due to Intracordal or vibratory margin lesion between age group of 25-45 years. Dysphonia of minimum 6 months duration.

Exclusion Critaria

Vocal Cord Paralysis, Functional dysphonia, Laryngopharyngeal Reflux disease, Induced dysphagia, Post radiotherapy, Neurology Patients, Post radiotherapy patients.
300 patients with dysphonia were analysed with stroboscopy. 60 patients were taken in the study, 30 with intracordal pathology and 30 with pathology on vibratory margins of vocal fold.

Parameters Used

Acoustic Parameters

1. MPD in Sec
2. Fundamental Frequency (F0)
3. Shimmer (%)
4. Jitter (%)
5. HNR Ratio

Physiological Dynamics

1. Anatomy/Localisation of lesion (Intracordal or Superficial)
2. Mucosal wave pattern
3. Phase asymmetry
4. Pattern of phonatory gap

Tools

All patients were subjected to detailed history taking and examination. Voice recording and analysis (Speech samples and vowels) were also done along with stroboscopic examination.

All the data were analysed statistically

1. Software
2. PRAAT- Voice analysis software.
3. Stroboscope- Inventis- invisio (HR Strobe light and Maxer ICCD-1500 camera)
4. 70 degree,8 mm scope
5. Calibrated microphone.

Signal Record

The signal that is intended to be analyzed corresponds to a continuous and sustained pronunciation of one vowel. For this work the subjects reproduced the vowel /a/. Initially, the record consisted in a 3-4 seconds of sustained sound of the vowel /a/ for each speaker, with a minimum duration of 2 seconds. The record was performed using the Praat program and digitally recorded in the .wav format. The signal record was performed inside a laboratory with minimal acoustic conditions. In this room, each speaker sat comfortably and with a microphone (Sony ECM - MS907) 10cm away from the mouth. The sampling frequency used for recording these signals was 22.05 kHz, with 16 bit resolution and mono. It should be noted that the laboratory did not have the ideal characteristics, however, took up all the necessary precautions so that the signals were collected in an environment as good as possible.

RESULTS AND DISSCUSSION

Determination of jitter

Teixeira *et al* [1] in their study used algorithm to determine this parameter, their reflects the variation of the successive periods. There algorithm started to implement a function that detects the timing of the fundamental period. The output vector of the function contains the peak levels corresponding to the beginning of the glottal pulse signal. This means that this function returns a vector of the same size but only with the peaks. This function removes the linear trends of the signal and then uses a moving average with length corresponding to about 10 ms (a length similar to one glottal period). Then the peak is searched as the maximum of the acoustic signal under a window of 15 samples before and 15 samples after the index of the maximum of the moving average. Analyzing the results of the algorithm, the peaks are correctly extracted except when the maximum is a negative peak, as can be seen in figure 2. Therefore, as one can ascertain, the function of this timing does not detected the true maximum absolute peaks, because the positive peak are detect when it should detect the negative peak because it presents a higher magnitude compared to the positive peak. This situation was corrected using the module of the input signal.

After the determination of the onset time of the glottal pulses, the jitter can be determined for its several measures by shapes given by the formulas shown below (Boersma [2]; Teixeira *et al*. [3]). Jitter (local, absolute): Represents the average absolute difference between two consecutive periods and is known as jitta. The threshold value to detect pathologies in adults is 83.2 μs as reported by Guimarães [4].

Jitter (local): Represents the average absolute difference between two consecutive periods, divided by the average period. It is known as jitt and has 1.04% as the threshold limit for detecting pathologies.

Jitter (rap): Represents the average for the disturbance, i.e., the average absolute difference of one period and the average of the period with its two neighbors, divided by the average period. The threshold value to detect pathologies is 0.68%.

Jitter (ppq5): Represents the ratio of disturbance within five periods, i.e., the average absolute difference between a period and the average containing its four nearest neighbor periods, i.e. two previous and two subsequent periods, divided by average period.

Despite the same formulas used by different algorithm authors, the usage of the formulas can vary in the algorithms implementation considering different length of the used signal segment or even using several small segments and averaging its parameters for the whole signal. Besides, there are differences in the determination of the onset time of the glottal pulses.

Determination of Shimmer

The methods used for determining the Shimmer are identical to jitter. The main difference is that the jitter considers periods and shimmer takes into account the maximum peak amplitude of the signal. Teixeira *et al* [1] in their study to determine the Shimmer parameters, used the same methods as jitter. The algorithm began by determining the onset time of the glottal pulses of the signal and the respective magnitude of the signal at that sample. Then the algorithm was applied to determine the values of each parameter of Shimmer similarly as for the jitter. The shimmer parameters are given by following expressions (Boersma [1]; Teixeira *et al*. [2]).

Shimmer (local): Represents the average absolute difference between the amplitudes of two consecutive periods, divided by the average amplitude. It's called a shim and this parameter was 3.81% as the limit for detecting pathologies.

Shimmer (local, dB): Represents the average absolute difference of the base 10 logarithm of the difference between two consecutive periods and it is called ShdB. The limit to detect pathologies is 0.350 Db.

Shimmer (apq3): represents the quotient of amplitude disturbance within three periods, in other words, the average absolute difference between the amplitude of a period and the mean amplitudes of its two neighbors, divided by the average amplitude.

Shimmer (apq5): Represents the ratio of perturbation amplitude of five periods, in other words, the average absolute difference between the amplitude of a period and the mean amplitudes of it and its four nearest neighbors, divided by the average amplitude. Fig.1 shows Jitter & Shimmer perturbation measures on an analysed voice.

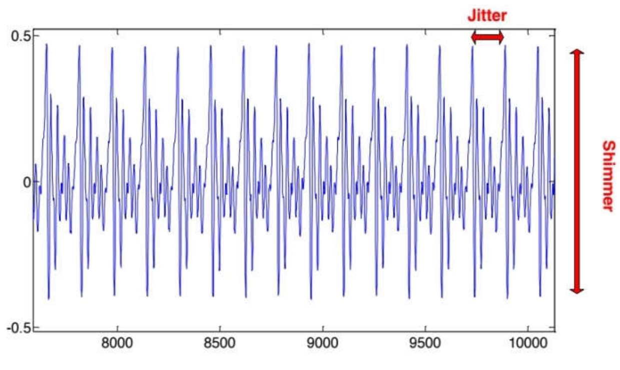

Fig.1. Jitter and Shimmer perturbation measures in speech signal [6].

Determination of HNR

The implementation of the harmonic to noise ratio was based on the mathematical fundaments presented by Boersma [1]. It started by the detection of the autocorrelation function of the voice signal, as the example displayed in figure . Taking into account the set value for the fundamental frequency (for women of 200 to 300Hz in the case of Man between 80 and 200 Hz) for the first index (fs/F0max) and the second index (fs/F0min). After determining the indices, the local maximum is found within the first and second index, finding their respective amplitude. Then applying the following formula, the value of HNR is found.

Despite the usage of the same mathematical formula, the algorithms are different because of the length of used segments or even because of the usage of several segments.

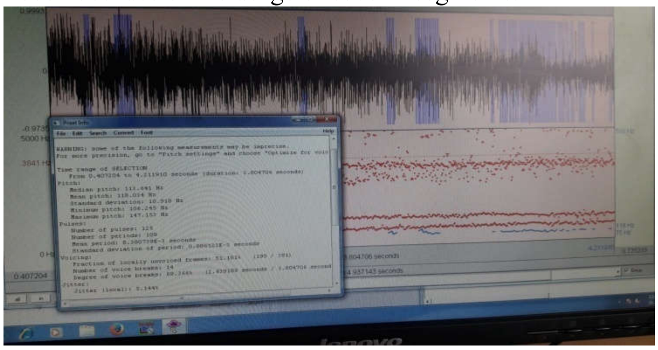

Fig 2 shows various acoustic data analysis by PRAAT software.

Presentation and Discussion of Results

The study showed us that acoustic parameters vary with location of pathology as well as dynamics of vibration [2]. Acoustic parameters are seen to be affected more in case of pathology on vibratory margin rather than intracordal pathology.

a. MPT – Is affected more in case of vibratory margin pathology.
b. Shimmer is also high in case of vibratory margin lesions.
c. Jitter is only parameter which is more affected in intracordal lesion.
d. HNR is also higher in vibratory margin pathology.
e. Fundamental frequency is reduced in case of intracordal pathlogies.

Acoustical Data Analysis

For Intracordal Pathology

MPT	HNR	SHIMMER	JITTER	FO-MALE	FO-FEMALE
5.7 secs Ref .- M-13-30 sec F- 15-30 sec	17.65 Ref.- 12	5.3 Ref.- 0.3 to 3.0 %	3.3 Ref.- 0.3 to 3.0 %	83 Hz Ref.- 18- 180 Hz	101 Hz Ref.- 165 – 225 Hz

For Vibratory Margin Pathology

MPT	HNR	SHIMMER	JITTER	FO-MALE	FO-FEMALE
4.3 secs Ref .- M-13-30 sec F- 15-30 sec	18.7 Ref.- 12	6.9 Ref.- 0.3 to 3.0 %	2.3 Ref.- 0.3 to 3.0 %	113 Hz Ref.- 18- 180 Hz	293 Hz Ref.- 165 – 225 Hz

1. Acoustic parameter vary with location of pathology as well as dynamics of vibration.
2. Acoustic parameter is more affected in case of pathology on vibratory margin rather than intracordal pathology.
3. Persistence of Hoarseness is more in intracordal pathology than pathology on vibratory margin.

Graphical comparison of acoustic data for both intracordal & vibratory margin leions has been shown in figure 3 & 4.

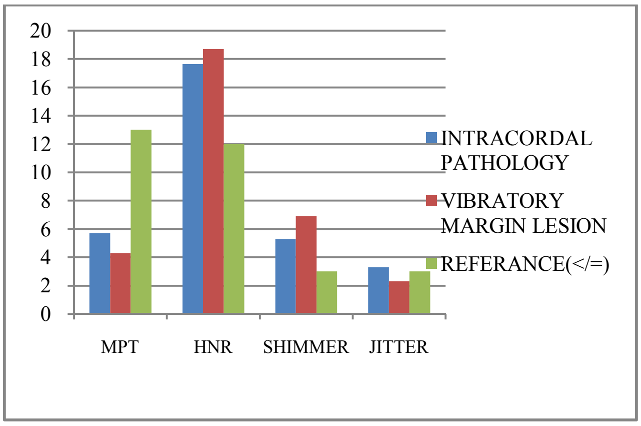

Fig 3 Graphical Comparison of Acoustic Data

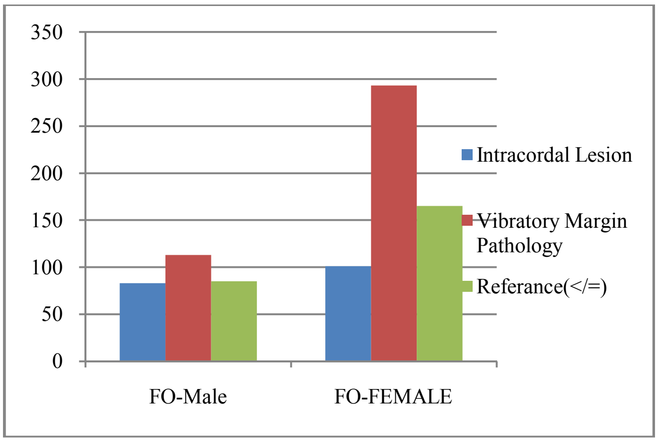

Fig 4 Graphical Comparison of Fundamental Frequency (FO)

CONCLUSION

The previously used subjective assessment technique were leading to lack of consensus among professionals, mostly due to, due to different results depending on the experience of the practitioner involved. Therefore it became necessary to search for an objective assessment, in which the voices were analyzed by devices which are capable of measuring several acoustic parameters, such as Almeida [5]. The study upon assessment by stroboscope & PRAAT- Voice analysis software, found

1. Smooth regular vibratory margin contributed more to the normal voice rather than intracordal pathology. The quality of voice was good with smooth margin. Intracordal pathology had more hoarseness but less breathiness and vice versa with vibratory margin pathology.
2. Hoarseness of intracordal pathology persisted for longer duration than pathology on vibratory margin.
3. The rehabilitation and treatment protocol were observed to differ drastically in both the conditions.

The guidelines for management & rehabilitation of these patients were also depending upon the nature of pathology. Soft lesions of vocal fold were considered for conservative management rather than immidiate surgery, while for, for hard lesions went towards surgical management, followed by voice rest. Post treatment prognosis of vibratory margin lesion were seen better than intracordal pathology. Time span of recovery was also seen less in case of vibratory margin lesions. Rehabilitation procedures like voice rest played more important role in vibratory margin lesions. While rehabilitation maneuvers for intracordal pathology were focussed over stretching of fold, those. Those for pathology on vibratory margins were focused over elevating the pitch.

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