JITTER AND SHIMMER IN VOCAL FOLD NODULES, POLYPS AND EDEMAS BEFORE AND AFTER PHONOSURGERY

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ABSTRACT

Perturbation analysis in patientes suffering from nodules, polyps and Reinke's edemas are studied by means of acoustic (MC), electroglottographic (EGG, Lx) and flow glottographic (FGG) waves before and after microlaryngoscopic phonosurgery.

INTRODUCTION

According to the myoelastic theory, pressure below the vocal cords increases till the glottis opens setting the vocal folds in vibration. In the light of the source-filter theory of speech production, larynx is the source with the vocal folds chopping the column of exhaled air. In this way the "buzz" generated in the glottis, becomes audible as a vocal sound, outside the lips, by the action of the vocal tract, that behaves as a filter.

Vibratory pattern of the vocal folds is not always regular. **Perturbation** is the term applied to these deviations from regularity. Multiple indices for measuring perturbation have been developed. Most of them represent some sort of average of the difference between the periods (jitter) or amplitudes (shimmer) of succesive vocal cycles **[1]**.

Since the first attempts to create objective measures for perturbation analysis by Von Leden , research on this matter has generated numerous papers, a comprehensive overview of them can be found in Laver et al **[2]**.

Several factors have been suggested as posible contributors to irregularity in vocal fold vibration **[3]**: 1) unsteadiness in muscle contraction in the laryngeal and respiratory system; 2) turbulence in glottal air stream; 3) instability in the jet emerging from the glottis; 4) asymetry in the mechanical or geometrical properties of the two vocal folds; 5) nonlinearity in the mechanical properties of the vocal fold tissues; 6) changes in coupling between the vocal fold and the vocal tract and 7) mucus riding on the surface of the vocal folds.

If perturbations are present in normal phonation, it stands to reason that jitter and shimmer should be increased in the presence of vocal fold pathology. So perturbation could be employed to detect vocal fold pathology and to evaluate the resulting disordered voice.

Nodules, polyps and Reinke's edemas are common findings of ENT practice. Management of this vocal abuse pathology (VAP) includes voice therapy and surgery.

Phonosurgery (PS) refers to surgical techniques, designed to improove or restore the voice, based in the three layer structure of the vocal folds, .

The first purpose of the study was to establish the clinical usefullness of perturbation measures to follow patients that underwent phonosurgery. The second is to investigate the influence of the type of voice signal employed for perturbation calculus: microphonic (MC), laryngographic (Lx), inverse filtered (FGG). We studied RAP (relative average perturbation factor) **[4]** for frequency perturbation and shimmer in dB for amplitude perturbation **[5]**.

METHODS

1. **Signal acquisition hardware**. Signals

from a microphone (MC) (Shure Prologue), a Fourcin's Laryngograph (Lx) (Kay Elemetrics) and an inverse filtering system (FGG) provided with a Rothenberg mask (Glottal Enterprises) and a filtering system designed by the Tech. Dep. of Malmö General Hospital; were digitized two by two (MC, Lx) (FGG, Lx) on a CSL 4300 (Kay Elemetrics) data acqisition system provided with a 16 bits A/D converter, with a sampling rate 51200 Hz. using a 486, 8 Mb RAM PC.

2. **Test procedures**. All tests were carried out in three different moments: before surgery, 2 weeks and 1 month after surgery. a) Subjects. 52 patients (32 polyps, 11 Reinke's edemas and 9 nodules) were examined using laryngostroboscopy. Age ranged from 65 to 15, mean 40. Sex was 22 (M): 30(F).
b) Recording. Recordings made in a sound treated booth were stored in a rewritable optical disck 1.3 GB.
c) Voice tasks. The first task was to produce 2s of a sustained /a/ with Rothenberg mask and laryngographic electrodes in position, at a confortable pitch and loudness. Both signals (FGG,Lx) were simultaneously recorded. The second task was to produce 2s of a sustained /a/ at 5 cm mouth-to-microphone distance with laryngographic electrodes in position, at a confortable pitch and loudness, a simultaneous recording of both signals (MC, Lx) was made. This second task was performed twice (acoustic analysis II and III).
d) Analysis. analysis was based on sustained /a/ because formant configuration in this vowel was more suitable for inverse filtering proccedure.

Relative average perturbation (RAP) was used for jitter measures, and shimmer in dB for calculus of amplitude perturbation. Initial and terminal portion of phonation were excluded and only 2s of the remaining stable portion were used for analysis.

3. **Statistic analysis**. The first part of the analysis consists of descriptive statistics to obtain location measures (mean, S.D). The second part include U-Man-Whitney rank sum tests for ANOVA of unpaired data, and T-Wilcoxon tests for ANOVA of paired data.

RESULTS AND DISCUSSION

Table 1. Results: (MC.) acoustic wave; (Lx) Lx wave and (FGG) flow glottogram . Jitter(J) in %, shimmer (S) in dB. ; Pre- surgery(p) and 1month - Post-Surgery(m).

	Mean	S.D.	Mean.	S.D.	
MCJp	2.075	1.170	1.904	1.791	MCJp
MCJm	0 460	0.543	0.510	0.301	MCJm
MCSp	0 575	o 390	0 566	0 307	MCSp
MCSm	0 257	0 092	0.354	0 107	MCSm
LxJp	0.892	0.840	1.320	1.369	LxJp
LxJm	0.364	0.193	0.418	0 301	LxJm
LxSp	0.454	0.453	0.536	0 392	LxSp
LxSm	0.217	0.135	0.208	0.168	LxSm
FGJp	2.046	2 167	1 904	1 791	FGJp
FGJm	0 769	0 428	0.510	0 301	FGJm
FGSp	0 775	0 967	0.568	0 307	FGSp
FGSm	0.255	0.137	0.354	0.107	FGSm
	POLYPS n= 32		EDEMAS n=11		p < 0 05

Increased perturbation in voice may result from unsuitable patterns of vocal fold vibration, induced by the presence of pathology. Attempts of objective evaluation of voice in patients were restricted to medical research voice labs. Recent computer development has made this attempt in the clinic reasonable.

We evaluated the effect of nodules, polyps and edemas in the capacity for regular vibrations of the vocal folds. A nonparametric ANOVA test (T-Wilcoxon) for paired data was used to establish the influence of choosing a determined production of the vowel /a/ of the different possible trials. There were no significant differences in jitter and shimmer values, supposed the same type of voice signal was employed (MC, Lx or FGG).

The same test showed significant differences ($p<0.05$) for jitter and shimmer depending on the type of wave used for perturbation calculus. Our results are opposite to those found in other articles [6] where these differences proved erratic. According to our results FGG-jitter values were always higher than Lx-Jitter ($p<0.05$). Differences could be owed to the manual process for filtering the flow glottographic signal, paricularly before PS when the register was more irregular and a correct filtration specially difficult to achieve. Despite this we think differences are basically due to the distinct nature of the phenomena represented by both waves.

Patients with polyps showed before PS superior values of shimmer computed on FGG basis than Lx basis. But two weeks and one month after PS Lx-shimmer was superior to FGG-shimmer. A possible explanation for this is that once the lesion is excised, the small volumes of air liberated with each vocal cycle, represented by the peaks of the FGG, should be more uniform, as the glottal closure inproves and mechanical balance of vocal folds is restored. In the case of Lx wave peaks could be contaminated with artefacts. These artefacts, even present before PS, are probably masked by the superior grade of variation due to the lesion presence.

Patients with Reinke's edema showed before PS higher values for FGG-shimmer than Lx-shimmer. One month after PS again FGG-shimmer is greater than Lx-shimmer. The latest statements seem in contradiction with the reasons argued in the preceding discussion in patients with polyps and have difficult explanation. In their interpretation the different performance of polyps and edemas showed by stroboscopy should play a role . One month after PS, stroboscopy proved that: free margens of the vocal folds were more irregular, glottic closure was more incomplete and the presence of inflamatory signs were more evident in the case of edemas than in the case of polyps.

MC-Jitter was superior to Lx-Jitter independently of the type of lesion present in the vocal fold, before and after PS ($p<0.05$). A posible reason for this is that the acoustic wave is more complex than the Lx wave. Presumably multiple deflections of the MC-wave involves a major difficulty for pitch extraction algorithm, to identify the peak on which to calculate the period than in the case of the Lx wave, with a single deflection. Superiority of Lx wave above acoustic wave for pitch extraction has been mentioned by other authors [7].

A U-Mann-Whitney test for unpaired data showed no significant differences between different pathologies. Our findings are in agreement with previous studies [6,8,9] supporting that perturbation cannot be used to distinguish among several pathologies.

We have not found differences between men and women in perturbation values. Our results differ from others that find greater jitter values in women [10,11]. We agree with others who find relations between amount of jitter and gender somewhat equivocal [12].

Data presented show an appreciable difference between perturbations found before PS and jitter and shimmer found in normal speakers, when the same algorithms were used, either in the case of shimmer [5,13,] or in the case of jitter [6,13] . When the lesion is present , mechanics of the two folds are different and more irregular vibrations are the result. Added to this is the incomplete closure of the glottis due to the presence of the lesion.

Data presented support that jitter and shimmer values were clearly inferior after PS. ANOVA tests for paired data (T-Wilcoxon) proved this significant ($p<0.05$). This downward shift could be expected and if we take into account that pathologic voices have an increased amount of perturbations , it's obvious from our data that voice quality of our patients clearly improved. So primary intention of phonosurgery was achieved. The fact that published normal values of jitter and shimmer are similar and even superior to the values obtained in our study, provide more evidence for definite voice quality inprovement in our patients.

For a correct interpretation of our results it should be noticed certain differences of our study with refered works. For analysis we employed a sustained /a/ while others used the vowel /i/ [6,15] and with older subjects than our patients (mean age 40).

CONCLUSIONS

1.- Jitter and shimmer are increased in nodules, polyps and edemas no matter the type of wave used for the analysis (MC, Lx or FGG).

2.-Perturbation analysis does not make differential diagnosis among different pathologies.

3.- Perturbation values do not depend on the trial chosen for analysis (supposed the same evolution moment of the study is compared), but depends on the type of wave used.

4.- Perturbation analysis is a usefull method to evaluate results in phonosurgery.

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