Plasticity of Voice Quality: A Prognostic Factor for Outcome of Voice Therapy?

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Summary: Plasticity of voice quality is defined here as the degree of improvement in deviant voice quality that can be achieved immediately or quasi-immediately by changing basic voicing conditions, posture, articulation or resonance, breathing mechanics, laryngeal position, or auditory feedback. Thirty-two adult patients with various benign organic voice pathologies, and who had a (preoperative) functional voice therapy, were scored before therapy using a weighted multidimensional Index of Voice Plasticity (IVP). The hypothesis is that IVP could be a predictor of the final outcome of functional voice therapy, and therefore a correlation with a comparable quantification of the actual results of the therapy was investigated. The IVP shows a satisfactory correlation (Spearman’s rho = 0.68) with the efficacy of (preoperative) voice therapy. The IVP also significantly differs between diagnostic categories. Although its predictive value remains limited, the Index of Voice Plasticity seems helpful in decision making for indication of (presurgical) voice therapy. Key words: Plasticity—Outcome—Voice therapy—Voice quality.

INTRODUCTION

Even in cases of clearly organic voice disorders, a functional, reactive component is also commonly observed, particularly in people whose voice is connected with their occupation; this component consists mainly of hypercompensation by abnormal muscle tension in extrinsic as well as intrinsic laryngeal muscles and may, in turn, show decompensation (“muscle tension disorder”). The importance of this functional, reactive component may vary considerably from subject to subject. Contrary to the organic component, the dyskinetic component is influenced by appropriate changes in voicing technique. In such cases, particularly when there are high (e.g., professional) demands on the voice, it may be useful to start the treatment with a short functional voice therapy before performing phonosurgery.¹

Plasticity of voice quality is defined here as the degree of improvement in voice quality that can be observed immediately or after a short time by changing basic voicing conditions (e.g., loudness, etc.), posture (e.g., adjusting the shoulders, etc.), articulation or resonance (e.g., hyperarticulation, etc.), breathing mechanics (e.g., changing lung volume, etc.), laryngeal position (e.g., lowering the larynx, etc.), or auditory control (e.g., Lombard-Tarneaud effect). Our hypothesis is that the degree of voice plasticity could predict the final outcome of functional voice therapy. To verify the hypothesis, this degree of plasticity must be assessed quantitatively and correlated with a
comparable quantitative assessment of the patient’s condition following therapy. In our research, a reasonable degree of correlation was found between two sets of results, allowing us to put a plasticity index into use to indicate presurgical voice therapy. Moreover, clear differences were observed in different diagnostic categories.

MATERIAL AND METHODS

Thirty-two adult patients with various kinds of organic benign voice pathologies [vocal fold nodule (9), vocal fold polyp (8), Reinke’s edema (6), unilateral paralysis (5), intracordial cyst/sulcus/scar (4)], and who had preoperative functional voice therapy, were initially scored using a weighted multidimensional Index of Voice Plasticity (IVP).

Pretherapeutic Evaluation of Plasticity

**Perception**

The G (grade, or overall voice quality), R (roughness component), and B (breathiness component) scores from the GRBAS scale were rated separately by two experienced raters (an ENT-phoniatrician and a speech therapist) using for each parameter a visual analog scale of 100 mm. For each patient, the rated material consisted of both conversational speech and sustained /a/’s (spontaneous voicing at comfortable pitch and loudness). The scores were from 0 (normal, no deviance) to 100 (maximal deviance in voice quality, extreme roughness, extreme breathiness). The scores of the two raters were averaged. Plasticity was evaluated by comparing the score of spontaneous voicing with the score (on the same protocol sheet) of the best sounds obtained during the different tests (changing voice conditions, articulation, breathing etc.). The result was scored as follows:

- No improvement at all or slight improvement (= a reduction of the score to a value higher than 67% of the original value): 0 (e.g., a G-score improving from 50 to 40)
- Moderate improvement (= a reduction of the score to a value between 50% and 66% of the original value): 1 (e.g., a G-score improving from 50 to 30)
- Large improvement (= a reduction to a value lower than 50% of the original value): 2 (e.g., a G-score improving from 50 to 10)

For evaluating this magnitude of improvement, the most sensitive parameter was chosen (G, R, or B), that is, the one showing the largest relative change.

**Acoustics**

Jitter %, shimmer %, and noise-to-harmonics ratio were computed by the Multidimensional Voice Program (MDVP) (Kay Elemetrics, Lincoln Park, NJ) on a /a:/ at spontaneous, comfortable pitch and loudness. The degree of plasticity was computed in the same way as for perception, that is, on the parameter showing the largest change.

**Videostroboscopy**

Glottal closure, regularity of vibration (as it appears with stroboscopic slow motion), and quality of mucosal wave were rated separately on three 100-mm visual analog scales by two experienced laryngologists: the ENT-phoniatrician performing the examination, and a colleague rating the video material afterward, with a sound track. The rating system was identical to that used in the perceptual evaluation: a score of 0 meant “normal, no deviance,” and a score of 100 meant “extremely deviant.” These three parameters may be considered as essential, and show sufficient reliability. The voice material was again sustained /a/’s, at comfortable pitch and loudness. To allow maximal possibilities for changing voicing conditions, we gave preference to a transnasal flexible endoscope. The values for the two raters were averaged. The degree of plasticity (no or slight improvement/moderate improvement/large improvement) was scored in the same way as for perception and acoustics, by considering the parameter (closure/regularity/mucosal wave) demonstrating the largest change. The IVP was then obtained by summing up the three values (minimum: 0; maximum: 6).

Evolution score

After the speech therapist completed the (presurgical) functional voice therapy, we performed a second evaluation using the same protocol as in the basic pretherapeutic situation: perceptual evaluation (G, R, B) of spontaneous voicing, acoustic measures on a sustained /a/ at comfortable pitch and loudness, and stroboscopic parameters (closure/regularity/mucosal wave). Once more, the evaluations were performed

separately by two experienced professionals: for perception a laryngologist and a speech therapist did the rating, and for laryngostroboscopy the examiner and a second ENT-phoniatrician, who rated the material afterward on a videotape recording, did the rating. The second ENT-phoniatrician was unaware of the fact that it concerned a posttherapeutic situation. The scores of the two raters were averaged. The findings of the posttherapeutic evaluation were compared with those of the pretherapeutic spontaneous voicing, to obtain an evolution score (ES); this was computed in the same way as for the initial scoring of the plasticity index (no or slight improvement/moderate improvement/large improvement). In this pre/post comparison, however, the possibility of worsening (−1) in the ratings was also included, for perception as well as for acoustics and for videostroboscopy. The ES was obtained by summing up the three values (minimum: −3; maximum: 6).

The duration of the voice therapy did not exceed 3 months, and comprised 4-19 sessions. An exhaustive medical report, including the mention of optional phonosurgery, was provided to the voice therapist in each case.

RESULTS

The reliability of perceptual evaluations was estimated by computing the Spearman’s correlation coefficients between the two judges: the global values were 0.77 for G, 0.71 for R, and 0.73 for B. For the laryngostroboscopic parameters, the interrater correlation coefficients were 0.65 for glottal closure, 0.61 for regularity, and 0.68 for mucosal wave. All these values are in agreement with previous findings.4,6

Figures 1 and 2 show the histograms of IVP and evolution score (ES); in both cases, a bimodal distribution is observed. Roughly, the plasticity of voice quality appears as either high scores (> 3) or low scores (< 3); similarly, the effect of treatment is either clear (scores > 1) or absent (scores < 1).

Figures 3 and 4 give the mean values of IVP and ES for each diagnostic category. A Kruskall-Wallis analysis of variance with diagnosis as a grouping variable demonstrates that both IVP and ES differ significantly between the different diagnostic categories (p < 0.03 in both cases). Reinke’s edema and vocal fold nodules are characterized by a high IVP. Nodules show the highest, and paralysis the lowest, ES scores.

The correlation between evolution after voice therapy and initial IVP is illustrated in Figure 5 (some...
FIGURE 2. Histogram of Evolution Score (ES), demonstrating a bimodal distribution: good/poor treatment efficacy.

FIGURE 3. Mean values of the IVP for each diagnostic category. Std. Dev. = standard deviation; Std. Err. = standard error.
points are superimposed): a satisfactory positive correlation is found between the two coordinates (Spearman's rho = 0.68; \( p < 0.001 \)).

**DISCUSSION**

If simple—although specific and well defined—changes in voicing technique are able to achieve a significant immediate improvement in the voice quality in a dysphonic patient, we may hypothesize that, after training these or similar conditions and making them habitual, voice therapy will be successful. This is a likely hypothesis if the basic anatomy of the vocal folds is unaltered, the limitation consisting then only in the learning and integration/habituation abilities of the patient.

This hypothesis is related to a second one: in case of organic changes of the vocal folds, the IVP is an estimate of the importance of the concomitant dysfunctional component. This point however requires a critical assessment. A previous study investigated the specific effect of a small increase in loudness on acoustical measurements in dysphonic patients (who merely had vocal fold lesions). The conclusion of that study was that in case of normal vocal fold anatomy or superficial vocal fold pathology (epithelium or Reinke's space), louder voicing (in the range of 2-3 dB) significantly reduces the perturbation parameters (jitter and shimmer), probably due to increase of the oscillating mass by larger involvement of normal deeper layers of the vocal fold. In contrast, when the pathology involves the deeper layers of the vocal fold (e.g., paralysis, cancer), louder voicing significantly enhances the irregularity of the vocal fold vibration period, as the recruited additional mass in the depth also alters mechanical characteristics.

Furthermore, when relevant, the functional treatment is orientated toward voice hygiene (avoiding overuse and inflammation of the upper airways, hyperhydration, etc.) rather than toward exercise therapy, which may also explain noticeable improvement.

Finally, some primary organic change may occur during the period of voice therapy, without relation to this treatment, but inducing either a favorable or an unfavorable effect of voice quality. This was the case in three patients in the present series, all of whom initially had unilateral vocal fold paralysis. In two cases, a partial reinnervation was objectivated by electromyography; in the third case, the paralyzed vocal fold became severely atrophic, with a clearly bowed edge.

All these effects (variation in learning capacity, diversity depending on the type of pathology, effect of

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**FIGURE 4.** Mean values of ES for each diagnostic category.
improved hygiene, effect of intercurrent organic change) probably limit the predictive value of the IVP. Nevertheless, in many cases, checking the plasticity of voice quality will certainly provide useful guidelines for the therapeutical approach.

**CONCLUSIONS**

1. In a variety of cases of benign organic voice pathology, the IVP, which is computed by quantifying the immediate improvement of voice quality and vocal fold vibration pattern due to changing the voicing technique, shows a satisfactory correlation with the efficacy of preoperative voice therapy.

2. For both the IVP and the ES (computed by quantifying the change in voice quality after voice therapy), a bimodal distribution is observed: roughly, the plasticity of voice quality appears as either high or low; similarly, the effect of treatment is either clear or absent.

3. The IVP, as well as the ES, significantly differs among diagnostic categories.

4. Although its predictive value remains limited, the IVP seems helpful in decision making for indication of presurgical voice therapy.

**REFERENCES**


