A Case of Nervus Laryngeus Superior Paresis Treated With Novafon Local Vibration Voice Therapy

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Summary: Objective. The aim of the study is to present a case of chronic idiopathic superior laryngeal nerve paresis (SLNp) treated with a novel voice therapy approach called Novafon Local Vibration Voice Therapy (NLVVT).

Methods. Outcome measurements including acoustics, aerodynamics, and self-perception of voice handicap were acquired before intervention (i.e., NLVVT) and after intervention (i.e.,follow-up). The use of NLVVT was modified from previous reports of use in functional voice disorders for application to a neurological voice disorder (SLNp).

Results. The results showed that NLVVT had meaningful improvements in Voice Range Profile boundaries, an increase in speaking fundamental frequency, and improved acoustic indices of voice quality in a case of SLNp. The follow-up after NLVVT intervention revealed maintenance of the post-treatment improvements at a 1-month measurement interval.

Conclusion. The NLVVT program may have potential to improve voice quality and vocal function in a case of SLNp. Further research is necessary to test a potential effectiveness for NLVVT applied to vocal fold immobility due to paresis in both larger numbers of patients and more well-designed, controlled experiments.

Key Words: Novafon Local Vibration Voice Therapy−Dysphonia−Voice therapy−Superior laryngeal nerve paresis−Voice outcomes.

INTRODUCTION

The nervus laryngeus superior or superior laryngeal nerve (SLN) innervates the cricothyroid muscle, which is responsible for longitudinal tension of the vocal folds, and thus is active in the control of fundamental frequency (particularly, to reach higher frequencies).[1] A SLN paresis (SLNp) has a complex effect on voice resulting in a reduced physiological frequency range, reduced speaking fundamental frequency (SFF), reduced intonation contour in speaking, and increased phonatory instability measured by elevated frequency perturbation values.[1] The prognosis for recovery is difficult because no specific studies have determined the specific factors that influence rate of recovery.[1] The treatment of a SLNp has currently no standard due to several limitations, including difficulty in accurately diagnosing SLN injury and the variable effects of SLNp on different individuals. One common intervention for SLNp is voice therapy.[1] Unfortunately there is a lack of evidence-based information evaluating the effects of voice therapy for SLNp.[1] A relatively new approach utilizes localized vibration instruments to treat individuals with voice disorders and performers experiencing vocal fatigue or phonatory effort.[2-7] Novafon Local Vibration Voice Therapy (NLVVT) is a novel approach that combines vibratory therapy with voice exercises in hierarchic 5-week voice therapy program.[2] In recent studies patients with both organic and nonorganic voice disorders showed improvement in vocal function after NLVVT treatment.[2,3] The underlying theory for physiological effect of local vibration is that it stimulates stretch reflexes in fast-twitch muscle fibers, facilitating changes to neuromuscular control during intentional muscle contraction. This perturbation to muscle function during phonation could be utilized to break conditioned inefficient muscle use patterns and also facilitate learning of new patterns for muscle recruitment during voice production.[8,9] A high percentage of fast-twitch muscle fibers are present in cricothyroid muscle, which is impaired in cases of SLNp.[10] We hypothesized that the stimulation of external vibration during targeted vocal tasks which engage cricothyroid activity can facilitate neurorehabilitation of the SLN and functional recovery of cricothyroid function. The aim of this paper is to present a case of chronic idiopathic SLNp treated with the novel voice therapy approach NLVVT.[2,3] This research was approved by the ethical committee by the University of Jena (2019-1414-iH).

CASE PRESENTATION

A 61-year-old male was diagnosed with a functional dysphonia (e.g., nonphonotraumatic dysphonia) approximately 10 years prior to his current referral to a new voice treatment practice. He was treated for the past 5 years with voice therapy but without appreciable improvement. His main vocal symptoms were vocal fatigue, rough voice quality, decreased loudness (particularly in noisy rooms), and limitation of high pitch in falsetto.

Between September 2018 (i.e., baseline measurement) and January 2019 (i.e., intermediate measurement), he again received voice therapy at the recommendation of his

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otolaryngologist. The approaches utilized during that time were semi-occluded vocal tract exercises with and without a tube in water, manual circumlaryngeal therapy, and conversational therapy with the focus of stress-management. In February 2019 laryngeal electromyography confirmed a SLNp on the right side. After this new diagnosis, the treatment plan for voice therapy was changed.

The clinician (first author) utilized the NLVVT program because positive evidence has been reported in previous studies when applying NLVVT to neurological voice disorders (e.g., cases of vocal fold paresis/paralysis).[2,3] For the NLVVT program, we used the Novafon classic sound wave appliance (Novafon GmbH, Weinstadt, Germany) with 100 Hz vibration. The outline of the NLVVT treatment protocol was identical to those described in previous studies.[2,3] However, according to the SLNp diagnosis, we modified the NLVVT program so that the cricothyroid muscle could be effected maximally based on the following three factors.

First, the vibration head of the Novafon sound wave appliance was exchanged for a magnetic attachment (see Figure 1). At the tip of the attachment is a magnet that is 3200 gauss strong. Magnetism is a noninvasive method for inducing cell and tissue modification, which is proven as safe clinical approach that have been successfully applied to treat resistant problems in the musculoskeletal system of the human body.[11] Furthermore, it has been posited that magnetic stimulation facilitates muscle regeneration, muscle hypertrophy, and increases metabolism and turnover of muscle without cause systemic or muscle damage.[12] Based on this evidence, our clinical hypothesis was that local vibration to the cricothyroid muscle and its nerve endings during voice exercises would improve functional neuromuscular control of the muscle.

Second, the placement of the Novafon sound wave appliance was applied laterally on the right cricothyroid muscle. This placement is necessary to achieve the maximal effect of vibration and magnetism because the cricothyroid muscle is outside the larynx with a superficial position under the skin. The patient could localize the muscle with his tip of the finger, which was trained earlier with a palpation technique by the clinician before the Novafon sound wave appliance was attached.

FIGURE 1. Novafon sound wave appliance with magnet attachment.

Third, cricothyroid contraction was targeted at the beginning of the treatment by using custom pitch glide exercises (e.g., vocalization imitation of a crowing cock) with closed lip humming.

All acoustic recordings were conducted using the Voice Profiler 5.0 (Alphatron Medical Systems, Rotterdam, The Netherlands). The recording system consisted of a dual microphone headset, and a calibrated soundcard by Alphatron.[13,14] The voice samples were digitized at 44,100 samples per second, saved as WAV file, and analyzed with the following computer programs: Voice Profiler,[13,14] Praat.[15]

Voice samples were obtained for subsequent voice quality analyses. At each evaluation time point, concatenation samples of the first 27 syllables of the German phonetically balanced text "The Northwind and the Sun" and three seconds sustained vowel [a:] without voice onset and voice offset were generated. To generate these, participants were asked to produce the connected speech sample and sustained vowel at comfortable pitch and loudness. The concatenated voice samples were analyzed using the Acoustic Voice Quality Index (AVQI) and Acoustic Breathiness Index (ABI) analyses in Praat.[16] The sustained vowel was also applied to narrowband spectrography analysis in Praat using the classification scheme for signal typing in voice by Sprecher et al.[17]

Auditory-perceptual judgments of voice quality were completed by a speech-language pathologist experienced in voice quality judgments for 10 years. The voice quality ratings were judged on the concatenated voice samples with one rating conducted on the baseline recordings and subsequent ratings and each post-treatment time point. The three dimensions of the GRBAS-scale[18] (i.e., GRB parameters) were used according to the ordinal four-point equal-appearing interval scale (0=normal, 1=slightly disordered, 2=moderately disordered, 3=severely disordered) as recommended by Wuyts et al.[19].

The assessment procedures of functional tests of voice production (i.e., voice range profile by the Voice Profiler, speech range profile by the Voice Profiler, and maximum phonation time in Praat) are based on the European Laryngological Society Protocol.[20] Additionally, the dysphonia severity index (DSI) was used to evaluate the dysphonia classification.[21] Finally, the German version of the Voice Handicap Index (VHI) was used as a questionnaire to quantify the impacts of voice problems.[22]

RESULTS AND DISCUSSION

Outcome data associated with treatment is listed in Table 1 and Figure 2. Guideline references of thresholds from Table 1 can be found in previous NLVVT studies[2,3] and other published papers.[16,20] The results of the present single case treatment are comparable to other NLVVT studies,[2,3] in which NLVVT resulted in a positive increase in Voice Range Profile (VRP) boundaries, a consistent falsetto register, an increase in Speaking Fundamental Frequency (SFF) and DSI, and improved voice quality (i.e. G-scale, R-scale, AVQI, and narrowband spectrography). These improvements are based on

TABLE 1.
Outcome of the Voice Parameters Before, During and After the Modified NLVVT

Voice Parameter	Baseline (Sep 2018)	Intermediate Measurement (after 5 months traditional treatment)	Pre NLVVT (1 month break after traditional treatment)	NLVVT after 1 week	NLVVT after 2 weeks	NLVVT after 3 weeks	NLVVT after 4 weeks	NLVVT after 5 weeks	Follow-Up 1 week	Follow- Up 1 month
G-scale (Threshold < 1)	1	1	1	1	1	1	0	0	0	0
B-scale (Threshold < 1)	0	0	0	0	0	1	0	0	0	0
R-scale (Threshold < 1)	1	1	1	1	1	1	0	0	0	0
AVQI (Threshold < 1.85)	2.25	2.55	2.22	2.40	2.39	2.67	1.81	1.89	1.99	1.90
ABI (Threshold < 3.42)	2.89	3.15	2.98	2.81	2.90	3.36	2.59	2.56	2.69	2.92
DSI (Threshold > 3.0)	5.1	5.0	5.8	6.6	7.5	7.7	7.8	7.7	8.3	6.8
VRP- highest frequency in Hz (Threshold > 294 Hz)	284.60	338.98	319.40	379.84	379.84	379.84	404.54	427.47	481.08	451.70
VRP – lowest frequency in Hz (Threshold < 110 Hz)	101.00	89.22	85.04	79.85	85.04	75.57	79.22	84.38	88.46	84.38
VRP – maximal intensity in dB (Threshold > 90 dB)	91.44	95.41	94.61	100.89	93.79	97.61	98.43	93.52	97.61	93.52
VRP – minimal intensity in dB (Norm < 55dB)	48.06	52.48	45.73	42.18	41.37	40.00	40.00	43.82	40.00	45.46
SRP – SFF in Hz	125.16	124.55	121.41	124.58	120.50	127.69	126.31	127.99	130.02	135.38
SRP – mean intensity in dB	67.54	66.85	66.27	66.68	67.29	66.96	65.92	69.41	66.93	67.39
Narrowband Spectography (Threshold <2)	2	2	2	2	2	2	1	1	1	1
MPT in sek (Threshold > 15 sec)	32.03	35.16	31.02	31.71	34.54	33.38	30.81	36.59	31.29	32.84
VHI (Threshold < 25)	55	60	59	65	61	56	62	57	65	61

Abbreviation: NLVVT, Novafon Local Vibration Voice Therapy; G-scale, grade, perceived overall voice quality judgment; B-scale, perceived breathiness judgment; R-scale, perceived roughness judgment; AVQI, Acoustic Voice Quality Index; ABI, Acoustic Breathiness Index; DSI, Dysphonia Severity Index; VRP, Voice Range Profile, SRP, Speech Range Profile; SFF, Speaking Fundamental Frequency; MPT, Maximum Phonation Time; VHI, Voice Handicap Index.

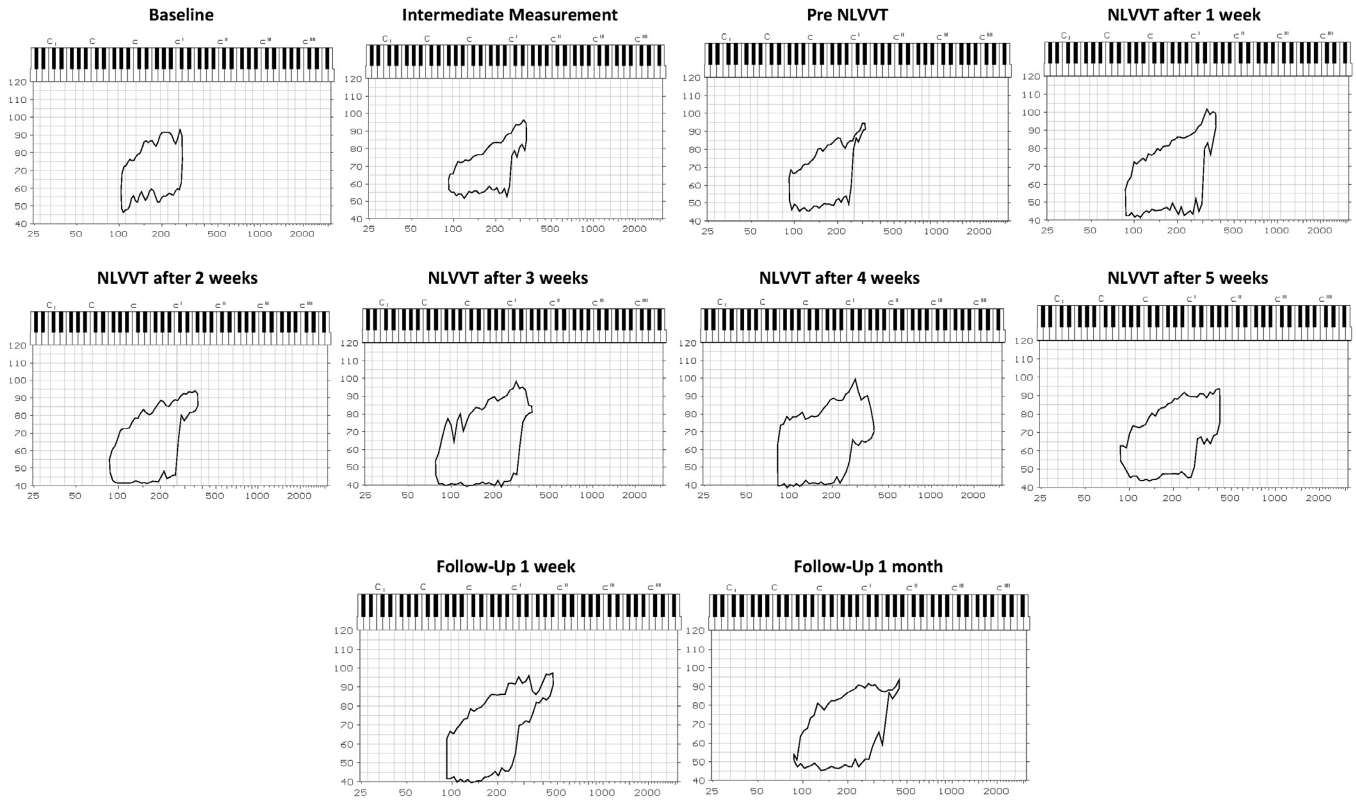

FIGURE 2. Sequence of plotted Voice Range Profiles of the subject by illustrating the process before during and after the modified NLVVT.

(a) approximating clinical thresholds of a normal voice (e.g., AVQI, narrowband spectrography, G-scale, B-scale, and a consistent falsetto register) and/or (b) alignment with results from previous literature that reported significant improvements/changes relating to intra-individual differences (e.g., VRP boundaries,[14] increasing in SFF[23] and DSI[24]).

These improvements were not realized in this patient subsequent to the previous traditional voice therapy they received in the five months prior to implementation of NLVVT. Follow-up measurements at one-month post-treatment revealed maintenance of the improvements for the parameters of perceptual voice quality ratings of the G-scale and R-scale, narrowband spectrography, AVQI, SFF, falsetto register, and highest frequency of the VRP. In summary, acoustic voice parameters improved through the application of modified NLVVT and supported the utilization of NLVVT for SLNp in this case study.

CONCLUSION

The modified NLVVT program of this single case report resulting in positive clinical outcomes associated with functional, perceptual, and acoustic outcomes. NLVVT may be a potential improvement or adjunct to existing treatments for SLNp. However, further research is necessary to test this hypothesis in both larger numbers of patients and well-designed, controlled experiments. This preliminary study of a single case report showed only the potential of the modified NLVVT treatment in one case of SLNp. Larger sample sizes would have allowed the use of more powerful parametric statistics to analyze a potential effect or benefit in comparison to traditional approaches. Future study designs which incorporate randomized clinical trials of NLVVT treatment compared to traditional approaches and/or placebo treatment in patients with SLNp would allow for inference of causality for the effectiveness of the modified NLVVT approach for treating SLNp.

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