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Comparison of voice therapy and selective electrical stimulation of the larynx in early unilateral vocal fold paralysis after thyroid surgery: A retrospective data analysis

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Abstract

Objectives: The goal of the retrospective study was to investigate the 3-month-outcome after treatment of patients with early unilateral vocal fold paralysis (UVFP) with either standard voice therapy (VT) or selective electrical stimulation of the larynx (SES).

Design: Non-randomised retrospective study.

Setting: 1519 patients who underwent thyroid surgery between 2015 and 2018 were analysed according vocal fold mobility; UVFP patients were treated either by VT or SES.

Participants: 51 UVFP patients.

Main outcome measures: 51 UVFP patients have been advised regarding treatment options like either VT (group 1) or SES (group 2). The patients of group 1 (n = 26) and 2 (n = 25) were re-assessed up to 3 months post-operatively regarding UVFP persistence/recovery and perceptive voice sound quality. At follow-ups, perceptual analysis of voice sound (using roughness=R/breathiness=B/hoarseness=H scale) and endoscopic laryngoscopy have been performed. Position of immobile vocal fold, shape of glottal closure and RBH parameters have been considered for statistical analyses.

Results: Restitution of UVFP with regular respiratory vocal fold mobility of both vocal folds occurred in 53.8% of group 1 (VT), and in 40.0% of group 2 (SES) after 3 months of therapy between both groups. No difference could be seen for RBH, type of glottal closure and position of ailing vocal folds in patients with persisting UVFP within both groups and between the groups.

Conclusions: The study reveals that SES can achieve similar functional outcome in early UVFP. Thus, it should be considered as an equivalent therapy alternative to VT for treatment of early UVFP patients since no significant difference in vocal outcome and glottal configuration between the two groups could be demonstrated.

1 | INTRODUCTION

Injury of the recurrent laryngeal nerve (RLN) is a severe complication after thyroid surgery (TS).[1]

Due to the poor predictive value of recent diagnostic measures regarding outcome of unilateral vocal fold paralysis (UVFP), early therapeutic strategies encompass several causal and compensatory methods aiming to restore glottal closure for phonation and improve vocal function. Causal strategies include intraoperative non-steroidal medication, nerve reanastomosis and gene therapy. Compensatory strategies include mainly voice therapy (VT), vocal fold augmentation, external vocal fold medialisation thyroplasty, selective/non-selective reinnervation, and arytenoid adduction.[2] Meanwhile there is a tendency refrain from external vocal medialisation in the first six months after RLN injury because of high rates of therapy failures due to either physiological or synkinetic reinnervation.[3]

Selective electrical stimulation of the larynx (SES) is not yet routinely considered as standard therapy in early UVFP, although SES has been successfully applied in treatment of several other types of voice disorders like muscle tension disorders, benign focal fold lesion, and presbyphonia. For example, the increase in muscle volume by SES could be shown in elderly people with thyroarytenoid (TA) muscle atrophy.[4] The selective effect of SES of laryngeal muscles by endoscopic evaluation of adduction of the vocal folds have already been reported by Bidus et al. for innervated laryngeal muscles.[5] In UVFP, SES is considered to prevent atrophy of the paretic muscle and to speed up the regeneration process.[6] Only few studies reported on SES effectiveness for treatment in UVFP patients. Ptok et al included patients with UVFP onset (all etiologies) of at least 2 weeks and maximum 6 months prior to therapy and maintained that SES should be regarded as superior to VT. SES as an early treatment option of UVFP has received little research attention;[7,8] Thus, this non-randomised retrospective study investigated the 3-month-outcome after routine treatment of either VT or SES in patients with UVFP following TS specifically attending to recovery of RLN function.

Keypoints

- We aimed to investigate the effect of standard voice therapy vs selective electrical stimulation of the larynx in patients with early unilateral vocal fold paralysis.
- Selective electrical stimulation of the larynx can achieve similar functional outcome in early unilateral vocal fold paralysis patients compared to voice therapy.
- Restitution of unilateral vocal fold paralysis with regular respiratory vocal fold mobility of both vocal folds occurred in 40% in the selective electrical stimulation of the larynx group after 3 months of therapy.
- Selective electrical stimulation of the larynx is an alternative to standard voice therapy for treatment of early UVFP patients.

2 | PATIENTS AND METHODS

2.1 | Ethical considerations

This study is part of the registry on epidemiology and management of patients with UVFP, which has been approved by the Ethics Commission of the Medical University of Vienna (EK 1507/2019). According to the Austrian law and the guidelines of the research ethics committee, written informed consent was obtained from all patients.

2.2 | Patients

The data of 1519 patients who underwent TS at a tertiary hospital between 2015 and 2018 were reviewed. The patients had been endoscopically examined prior and up to two days after surgery regarding respiratory and phonatory vocal fold mobility. Patients with BVFP were excluded from this study. Immediately after surgery, UVFP was diagnosed in 97 patients and treatment with vitamin B1, B6 and B12 (Neurobion®), non-steroidal and/or steroidal antiphlogistic were administered. In 25/97 patients the respiratory vocal fold function recovered to normal within the first 2 post-operative weeks.

To the other 72 patients with persisting UVFP, either VT or SES was recommended. 26/72 patients opted for VT (Group 1) and 25/72 patients for SES (Group 2), whereas 21 patients did not remain in our medical care due to other medical reasons, distance to the hospital, or lack of therapy motivation.

Of the 51/72 UVFP patients remaining in therapy, 35 females and 16 males with mean age (±SD) age of 54 (±14) years. 33/51 patients had a left-sided and 18/51 patients a right-sided UVFP (Table 1).

2.3 | Otorhinolaryngological examination

The 51 patients of Group 1 and Group 2 were re-assessed in approximately monthly intervals up to 3 months post-operatively regarding persistence of UVFP.

At all follow-ups, perceptual analysis of voice sound (using roughness=R/breathiness=B/hoarseness=H scale) and endoscopic laryngoscopy were performed. Vocal fold immobility/position, shape of glottal closure and RBH scale were assessed and used for statistical analysis.

The documentation of perceptual voice sound analysis using RBH scale has already been in use for decades. It was introduced by Wendler et al considering “R”, “B” and “H”, in order to describe the acoustic voice quality in a semiquantitative way.[9] All parameters were rated on a 4-point severity scale: 0 = normal; 1 = mild deviance; 2 = moderate deviance; and 3 = severe deviance.

The laryngeal endoscopic examinations were performed using rigid or flexible endoscopes and the DiVAS documentation system by XION medical GmbH/Germany. From the laryngoscopic recordings, the following parameters were selected for evaluation (Figure 1):

- Position of ailing vocal fold using the Likert scale: 1 = median, 2 = paramedian, 3 = intermediate, 4 = lateral
- Glottal closure during phonation using the rating scale by Södersten et al. as demonstrated in Figure 1.[10]

2.4 | Treatment

2.4.1 | Voice therapy

Patients of Group 1 received weekly logopedic sessions of VT lasting 45 minutes each for up to 3 months and were given the task of daily repetition of exercises of at least 30 minutes. Therapy concepts focused on voice training based on Kruse[11] and Heptner,[12] accent method using Smith [13]and integrative VT by Evemarie Haupt.[14] Therapy concepts also aimed at improvement of posture, less breathy voice onset, prolonged maximum phonation time, breath control, compensatory muscle activity of the healthy vocal fold, and turning the head aside to the paralysed vocal fold during phonation.[15]

2.4.2 | Selective electrical stimulation of the larynx

Patients received SES by an external stimulation device (either Stimulette rx or Stimulette r2x by Schuhfried, Medizintechnik, GmbH, Austria) via surface electrodes (Pierenkemper GmbH, electrode 40 mm × 28 mm) with a biphasic pulse duration of 100 ms (Figure 2). The SES has been tested in clinical settings with flexible endoscopy of the larynx. SES aimed at adduction of both vocal folds, the healthy and ailing one. The current intensity (amplitude) was applied between sensitivity threshold value and values of non-selective side effects (activity of strap muscles, swallowing reflex and coughing reflex). Patients were advised to use the external stimulator twice a day for 25 minutes (3 × 5 minute stimulation interval with 2 × 5 minute breaks) in accordance with Martin et al.[16]

TABLE 1 Patients characteristics

		Group 1 (VT[a])		Group 2 (SES[b])	
		(n)	(%)	(n)	(%)
Patients with UVFP 2 weeks after thyroid surgery	**Total**	**26**	**100**	**25**	**100**
Side of ailing vocal fold	Right	10	38.5	8	32.0
	Left	16	61.5	17	68.0
UVFP after up to 3 months after thyroid surgery	Recovery	14	53.8%	10	40.0%
	Persistence	12	46.2%	15	60.0%

Voice therapy and selective electrical stimulation of the larynx in UVFP as acute treatment after thyroid surgery.

[a]VT, voice therapy.

[b]SES, selective electrical stimulation of the larynx.

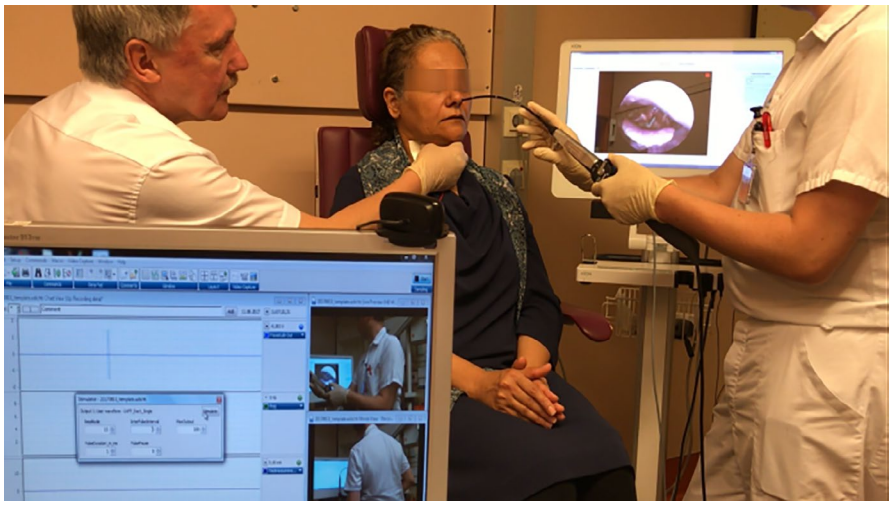

FIGURE 1 Clinical settings with flexible endoscopy of the larynx

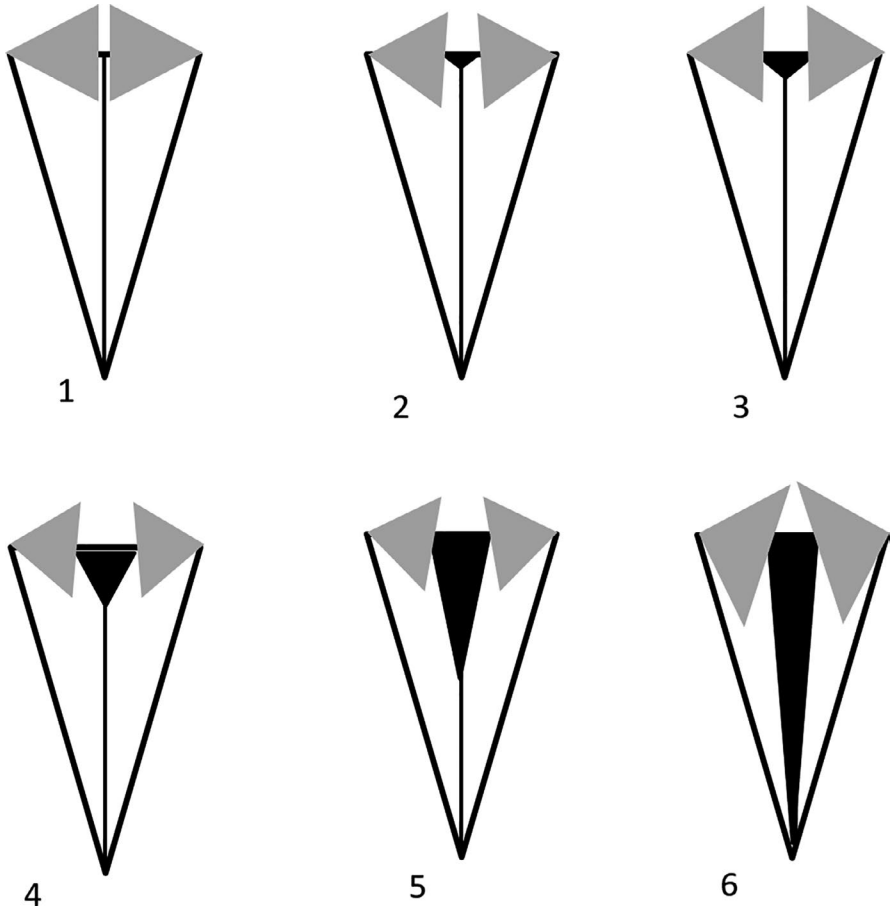

FIGURE 2 Glottal closure during phonation using the rating scale by Södersten et al

SES was not recommended in patients without recognisable selective activity of intrinsic laryngeal muscles.

2.5 | Statistics

Data were analysed using IBM SPSS 21 (Armonk). The primary outcome parameter "vocal fold mobility" at time point "2-week post-operative" was compared to "3 months post-operative" within the two groups using the McNemar test. The outcome parameters "R", "B", and "H," "vocal fold position" and "glottal closure" at time point "2-week post-operative" were compared to "3 months post-operative" within the two groups using the Wilcoxon-test. Results were considered statistically significant at a *P*-value beyond <.05.

3 | RESULTS

3.1 | Results of endoscopic laryngoscopy: recovery and persistence of vocal fold paralysis

After up to 3 months of therapy, a restitution of respiratory vocal fold mobility with symmetric ab- and adduction of both vocal folds occurred in 53.8% of Group 1 (VT), and in 40.0% of Group 2 (SES) without a statistically significant difference ($P > .005$).

14/26 patients of Group1 and 10/25 patients in Group 2 recovered within at least 3 months after surgery. UVFP persisted in 12/26 patients of Group 1 and 15/25 patients of Group 2 during the observation period of the study.

3.2 | Position of ailing vocal fold and glottal closure during phonation in all patients 2 weeks after surgery before VT or SES

Before treatment, patients of Group 1 presented with either median (1/26 = 3.8%), paramedian (16/26 = 61.5%), intermediary (8/26 = 30.8%) or lateral (1/26 = 3.8%) position of the ailing vocal fold. Patients of Group 2 had either paramedian (22/25 = 88%) or intermediary (3/25 = 12%) position of the ailing vocal fold.

3.3 | Position of ailing vocal fold and glottal closure during phonation in patients with persisting UVFP

After up to 3 months, patients with persistent UVFP still presented with either paramedian or intermediary position of the ailing vocal

TABLE 2 Type of glottal closure during phonation according to Södersten et al. in patients with recovery of respiratory vocal fold and in patients with UVFP

	All patients before treatment+		After up to 3 months: patients with recovery of respiratory vocal fold[b]		Patients after up to 3 months: patients with persistence of UVFP[c]	
	Group 1 (VT) (n) (%)	Group 2 (SES) (n) (%)	Group 1* (VT) (n) (%)	Group 2 (SES) (n) (%)	Group 1 (VT) (n) (%)	Group 2 (SES) (n) (%)
Complete closure all along the vocal folds	1 (4%)	0	2 (15.4%)	3 (30%)	1 (8.3%)	0
Indication of incomplete closure of the cartilaginous part	0	1 (4.2%)	2 (15.4%)	0	1 (8.3%)	0
Triangular incomplete closure reaching anterior to the vocal processes	4 (16%)	2 (8.3%)	4 (30.8%)	2 (20%)	4 (33.3%)	2 (14.3%)
Triangular incomplete closure of the posterior third of the folds	3 (12%)	5 (20.8%)	2 (15.4%)	1 (10%)	0	4 (28.6%)
incomplete closure of the posterior two-thirds of the folds	5 (20%)	5 (20.8%)	1 (7.7%)	1 (10%)	0	3 (21.4%)
incomplete closure all along the folds	9 (36%)	7 (29.2%)	0	0	5 (41.7%)	3 (21.4%)
spindle-shaped incomplete closure, closure at the vocal processes	1 (4%)	4 (16.7%)	0	3 (30%)	0	0
spindle-shaped incomplete closure at the anterior third of the folds, closure at the vocal processes	1 (4%)	0	1 (7.7)	0	1 (8.3%)	0
spindle-shaped incomplete closure at the posterior and the anterior thirds of the folds, closure at the vocal processes and at the middle of the membranous portion ("hourglass")	0	0	0	0	0	0
ventricular fold closure	1 (4%)	0	1 (7.7%)	0	0	1 (7.1%)
not defined	1 (4%)	1 (4%)	1 (7.7%)	0	0	2 (14.3%)

[a]VT = n = 26; SES = n25

[b]VT = n = 14; SES = n = 10

[c]VT = n = 12; SES = n = 15

fold. The paramedian position was diagnosed in Group 1 in 8/12 (=66.6%) cases and in Group 2 in 11/15 (=73.3%) cases. The other UVFP patients presented with intermediary position Group 1 4/12 (=33.7%) and in Group 2 4/15 (=26.7%) of the ailing vocal fold.

3.4 | Type of glottal closure during phonation in patients with persistent and recovered UVFP

Considering the influence of intensity and frequency on glottal closure configuration, the optimum glottal closure of each recording had been selected for evaluation.

An overview of glottal closure configuration and glottal closure competence for both groups before and after therapy is presented in Table 2.

No significant difference was found before or after therapy between both groups (Group 1 vs Group 2 before treatment $P = .398$; Group 1 vs Group 2 after treatment $P = .414$). Further, no significant difference was identified within each group (Group 1 before vs after treatment $P = .066$; Group 2 before vs after treatment $P = .558$).

3.5 | Type of glottal closure during phonation in patients with UVFP recovery

As expected, restituted patients showed an improvement of glottal closure and glottal competence (Table 2).

3.6 | Type of glottal closure during phonation in patients with persisting UVFP

The results of glottal closure of UVFP patients of Group 1 and Group 2 are presented in Table 2. The glottal closure configuration

and glottal closure competence improved in 4/12 in Group 1 and 4/15 in Group 2 in persisting UVFP patients. In the remaining patients, glottal closure configuration and glottal competence were not defined.

3.7 | Perceptual voice sound analysis using RBH scale in patients with persistent and recovered UVFP

"R" and "H" improved in patients with UVFP and recovered vocal fold (total study population) in Group 1, "R" and "H" (*P*-value .014, .024, respectively), whereas in Group 2 only "H" improved (*P*-value .046).

3.8 | Perceptual voice sound analysis using RBH scale in UVFP

In patients with persisting UVFP, the voice sound did not show any improvement or deterioration during therapy.

RBH did not change significantly before compared to after therapy in patients with UVFP. R before treatment vs R after treatment Group 1: 1.0 (1.0-1.5) vs 1.0 (0.5-1.0). Group 2: 2.0 (1-0-2.0) vs. 2.0 (1.0-2.0). B before treatment vs. B after treatment Group 1: 1.0 (1.0-2.0) vs. 1.5 (0.5-2.0). Group 2: 1.5 (1-0-3.0) vs. 1.0 (0.0-3.0). H before treatment vs. H after treatment Group 1: 2.0 (1.0-2.0) vs. 1.5 (0.5-2.0). Group 2: 2.0 (2.0-3.0) vs. 2.0 (1.0-3.0).

4 | DISCUSSION

This study focuses on the 3-month-outcome after either VT or SES in patients with early UVFP following TS as an alternative and equivalent acute therapy. In other forms of peripheral nerve damage, like in upper and lower limb damages, neuromuscular electrical stimulation is an accepted therapeutic strategy for muscle strengthening, maintenance of muscle mass and strength during prolonged periods of immobilisation, selective muscle retraining, and the control of oedema.[17] The data on SES in early UVFP to date, is sparse.

4.1 | Comparisons with other studies

Very mild forms of RLN damage (eg neuropraxia) can usually recover within few days after surgery as it could be seen in 25/97 UVFP patients of our study. In potential neuropraxia, nerve injuries of the axons can be remyelinated by Schwann cells and restored between 2 weeks and 6 weeks post-operatively.[18] In more severe cases of RLN damage (eg axonotmesis und neurotmesis), an axonal re-growth of 1-1.5 mm per day[19] can be seen resulting in reinnervation, either physiological or synkinetic.[20] Until reinnervation, the denervated muscles typically lose shape, volume and tension.[2] Therefore, non-invasive methods should focus on maintaining muscle volume and tension of the TA muscle in particular for providing optimum vocal fold vibration. Further, tension and functioning of abductor and adductor muscles need to be stimulated in order to optimise vocal fold position and mobility. Thus far, VT has been considered to be the only gold standard of conservative treatment next to laryngoplasty injection and reinnervation techniques in acute UVFP treatment.[2,21,22]

VT concepts focus on abdominal support for breathing and improving intrinsic muscle strength and agility.[23] In UVFP, VT is usually recommended in the first 1-3 months after onset of paralysis. The VT concept focuses on compensatory strategies and is still questionable in denervated muscles, as it can improve the activity of the healthy vocal fold by improving muscle strength, agility, and coordination.[23,24] VT (2 to 6 weeks after onset) in acute UVFP should improve glottal closure even without restitution of respiratory vocal fold mobility. VT limitations include content, timing, duration and frequency.[25] VT in early UVFP alone may lead to positive results, yet whether there is a therapeutic effect beyond spontaneous regeneration remains unclear.[5]

4.2 | Synopsis of key/new findings

Therefore, the outcome after SES in patients with acute UVFP after TS was investigated in comparison to standard VT in a non-randomised retrospective study design.

In this three-year study, after up to 3 months of therapy, the UVFP restitution and the functional voice outcome following SES or VT were comparable. The recovery rate was statistically similar in both groups. The restitution of UVFP occurred in 53.8 % of Group 1, and in 40.0% of Group 2 with restitution of symmetric respiratory vocal fold mobility. With restitution of vocal mobility, the glottal closure improved to almost normal functioning after RLN restitution with statistically significant improvement of voice sound. In patients with persisting UVFP, the ailing vocal fold rested mostly in the paramedian position and a bowing could be prevented.

The evaluation of glottal closure during phonation showed a tendency of improvement in both therapy groups. SES may allow a better closure in the anterior two-thirds of the glottis. With VT, a better posterior closure seems to be achieved and the development of pathological compensations could occur less frequently. This result also seems logical since surface stimulation certainly does not reach the posterior laryngeal sections very well (Table 2). Further, after the therapy period of up to 3 months, the vocal fold position of ailing vocal fold did not deteriorate in both groups. These findings support the assumption that both therapy types maintain or even improve mass, tension and volume of intrinsic laryngeal muscles.

This positive effect could be supported by the vocal outcome by evaluating the perceptual voice sound parameters. The parameters "H" and "R" improved significantly in Group 1 receiving VT. Also, in Group 2 (SES), a significant improvement of "H" could be achieved through therapy. The low degree of perceptive voice sound parameters before and after therapy might be explained by the timing of examination: before any possible atrophy of the vocal fold can effect

voice represented by both "R" and "B", and thus the degree of "H", and by a positive therapy effect.

It is very important to endoscopically evaluate the SES effect in a UVFP patient and to adapt the current intensity for optimum SES of the larynx. This has already been reported by Bidus et al for innervated laryngeal muscles.[5] Surface stimulation of the larynx can induce vocal fold closure.

The limitations of this study include the retrospective non-randomised study design and the low number of patients. We were able to compare the outcomes within groups during course of therapy, but not reliably between groups due to statistical reasons. Thus, it cannot be concluded that recovery rate occurred due to VT, SES or spontaneous recovery.

4.3 | Strengths of the study

Nevertheless, results of this study suggest, that VT and SES are functionally equivalent non-invasive therapy options in very early UVFP patients, despite other studies maintaining the superiority of SES in comparison to VT. However, not only patients with early, but also with longer lasting UVFP were included in this study.

4.4 | Clinical applicability of the study

Clinical experience shows that VT is not always accepted by patients due to medical reasons, immobility, limited capacity of VT, and other reasons. SES should be incorporated into standard protocols for voice treatment in early UVFP to restore vocal fold mobility, prevent atrophy and improve voice outcomes. The benefit of the personal contact between a patient and a therapist is the personalised therapy, including a variety of speech concepts and later to the practicability and comfort of each therapy. The SES therapy requires a correct initial placement of the electrodes, the adjustment of the stimulator settings, and the most important endoscopic laryngeal evaluation of the vocal folds activity during stimulation. After the first initial fitting of SES, the patients can apply the SES alone at home without taking up the time and expertise of therapists.

As no standard protocols on current parameters for SES exist, future studies should focus on more extended current parameters, as in this study only current duration of 100 msec with varying current intensity was used.

5 | CONCLUSION

In early UVFP patients, SES can be recommended as an equivalent therapy to VT since no significant difference in vocal outcome and glottal configuration between the two groups could be demonstrated. One of the benefits of SES is the flexible home training after individual device fitting parameter setting, whereas standard VT is more bound to therapy availability, time and place.

6 | INFORMED CONSENT

According to the Austrian law and the guidelines of the research ethics committee, written informed consent was obtained from all patients.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

AUTHOR CONTRIBUTIONS

AK: data analysis, literature research, preparation of the manuscript. ML: performing SES, education of the patients about the treatment, videolaryngoscopy examination. DM D-L: education of the patients about the treatment, videolaryngoscopy examination. WM: technical and advise support for SES, advise for electrode placement. IK: speech therapeutic treatment, education of the patients about the operation of the device. BS-S: performing SES, education of the patients about the treatment, videolaryngoscopy examination, literature research, study supervision

COMPLIANCE WITH ETHICAL STANDARDS

This study is part of the registry on epidemiology and management of patients with UVFP, which has been approved by the Ethics Commission of the Medical University of Vienna (EK 1507/2019).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. Steurer M, Passler C, Denk DM, Schneider B, Niederle B, Bigenzahn W. Advantages of recurrent laryngeal nerve identification in thyroidectomy and parathyroidectomy and the importance of preoperative and postoperative laryngoscopic examination in more than 1000 nerves at risk. *Laryngoscope*. 2002;112(1):124-133.
2. Benninger MS, Crumley RL, Ford CN, et al. Evaluation and treatment of the unilateral paralyzed vocal fold. Otolaryngology–head and neck surgery : official journal of American Academy of Otolaryngology-Head and Neck. *Surgery*. 1994;111(4):497-508.
3. Crumley RL. Laryngeal synkinesis revisited. *Ann Otol Rhinol Laryngol*. 2000;109(4):365-371.
4. Gugatschka M, Jarvis JC, Perkins JD, et al. Functional Electrical Stimulation Leads to Increased Volume of the Aged Thyroarytenoid Muscle. *Laryngoscope*. 2018;128(12):2852-2857.
5. Bidus KA, Thomas GR, Ludlow CL. Effects of adductor muscle stimulation on speech in abductor spasmodic dysphonia. *Laryngoscope*. 2000;110(11):1943-1949.

6. Ptok M, Strack D. Electrical stimulation-supported voice exercises are superior to voice exercise therapy alone in patients with unilateral recurrent laryngeal nerve paresis: results from a prospective, randomized clinical trial. *Muscle Nerve*. 2008;38(2):1005-1011.
7. Ptok M, Strack D. Voice exercise therapy versus electrostimulation therapy in patients with unilateral vocal fold paralysis. *Hno*. 2005;53(12):1092-1097.
8. Garcia Perez A, Hernandez Lopez X, Valadez Jimenez VM, Minor Martinez A, Ysunza PA. Synchronous electrical stimulation of laryngeal muscles: an alternative for enhancing recovery of unilateral recurrent laryngeal nerve paralysis. *J Voice*. 2014;28(4):524;e521–527.
9. Nawka T. Die auditive Beurteilung heiserer Stimmen nach dem. RBH-System. 1994.
10. Sodersten M, Lindestad PA. Glottal closure and perceived breathiness during phonation in normally speaking subjects. *J Speech Hear Res*. 1990;33(3):601–611.
11. Kruse E. Gestörte stimme konservative verfahren. *Laryngorhinootologie*. 2005;84:192–203.
12. Heptner. https://www.Heptner. org/page/die-Heptner. methode. php.
13. Smith S, Thyme K. Statistic research on changes in speech due to pedagogic treatment (the accent method). *Folia phoniatrica*. 1976;28(2):98–103.
14. Haupt EM. http://www.integrative-stimmtherapie.eu/.
15. Schneider B, Bigenzahn W. How we do it: voice therapy to improve vocal constitution and endurance in female student teachers. Clinical otolaryngology : official journal of ENT-UK; official journal of Netherlands Society for Oto-Rhino-Laryngology & Cervico-Facial. *Surgery*. 2005;30(1):66–71.
16. Martin F, Witt TN. Elektrodiagnostische und histometrische Untersuchungen über den Einfluß von Reizstrom auf die Atrophie der denervierten Kehlkopfmuskulatur im Tierexperiment. *Laryngo-Rhino-Otologie*. 1983;62(12):590–596.
17. Lake DA. Neuromuscular electrical stimulation. An overview and its application in the treatment of sports injuries. *Sports Med*. 1992;13(5):320–336.
18. Dagum AB. Peripheral nerve regeneration, repair, and grafting. *J Hand Therapy*. 1998;11(2):111–117.
19. Seddon HJ, Medawar PB, Smith H. Rate of regeneration of peripheral nerves in man. *J Physiol*. 1943;102(2):191–215.
20. Crumley RL. Laryngeal synkinesis: its significance to the laryngologist. *Ann Otol Rhinol Laryngol*. 1989;98(2):87–92.
21. Busto-Crespo O, Uzcanga-Lacabe M, Abad-Marco A, et al. Longitudinal Voice Outcomes After Voice Therapy in Unilateral Vocal Fold Paralysis. *J Voice*. 2016;30(6):767. e769–767;e715.
22. Marie JP, Dehesdin D, Ducastelle T, Senant J. Selective reinnervation of the abductor and adductor muscles of the canine larynx after recurrent nerve paralysis. *Ann Otol Rhinol Laryngol*. 1989;98(7 Pt 1):530–536.
23. Miller S. Voice therapy for vocal fold paralysis. *Otolaryngol Clin North Am*. 2004;37(1):105–119.
24. Daniero JJ, Garrett CG, Francis DO. Framework surgery for treatment of unilateral vocal fold paralysis. *Cur Otorhinolaryngol Rep*. 2014;2(2):119–130.
25. Walton C, Carding P, Flanagan K. Perspectives on voice treatment for unilateral vocal fold paralysis. *Current Opin Otolaryngol Head Neck Surg*. 2018;26(3):157–161.

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