

Research Article

Post-Operative Unilateral Vocal Fold Paralysis: A Proposal for a Therapeutic Algorithm

Molteni G¹, Alberici MP^{1*}, Mattioli F¹, Menichetti M¹, Luppi MP¹, Nizzoli F¹, Presutti L¹, Marchioni D² and Bergamini G¹

¹Department of Otolaryngology-Head and Neck Surgery, Azienda Ospedaliero-Universitaria Policlinico Modena, Modena, Italy

²Department of Otolaryngology, Azienda Ospedaliera Universitaria Integrata Verona, Verona, Italy

*Corresponding author: Alberici MP, Department of Otolaryngology-Head and Neck Surgery, Azienda Ospedaliero-Universitaria Policlinico Modena, via Del Pozzo 71, Modena, Italy

Received: July 29, 2016; Accepted: September 16, 2016; Published: September 19, 2016

Abstract

Introduction: Unilateral Vocal Fold Paralysis (UVFP) is a condition that is commonly met in clinical practice and presents as dysphonia with hoarseness and breathiness of voice, and occasionally also with dysphagia. Various approaches are used in the management of post-operative UVFP but there is no general agreement on the best approach in the international literature. Speech therapy after UVFP is not used widely and there are very few reports on its results. Injection laryngoplasty and medialization thyroplasty type I are the treatment techniques most widely used.

Materials and Methods: Based on our experience over the past 15 years, we propose a diagnostic-therapeutic algorithm for the management of post-operative UVFP, either reversible or permanent, from the immediate post-operative period until the time when the best vocal results are achieved.

Results: Early voice therapy followed by injection laryngoplasty gives successful results in patients with UVFP. In cases where the results of early speech therapy are not satisfactory, injection laryngoplasty is indicated. Speech therapy after injection laryngoplasty is always recommended to rehabilitate the voice with the new vocal fold position after surgery.

Conclusion: A practical algorithm for management of post-surgical UVFP is useful for ENT specialists. Many treatment options are available but early treatment and patient co-operation are fundamental for the best possible voice results no matter whether vocal fold motility will recover or not.

Keywords: Vocal fold paralysis; Thyroidectomy; Speech therapy; Injection laryngoplasty

Introduction

Unilateral Vocal Fold Paralysis (UVFP) is a condition that is commonly met in clinical practice, but the real incidence rate is unclear because sometimes this condition remains asymptomatic or dysphonia remains minimal and the patient does not visit a specialist. The main symptom is dysphonia with hoarseness and breathiness of voice, and sometimes it may also present with dysphagia due to inadequate airway protection or eventually with impairment of the superior laryngeal nerve.

In UVFP, the vocal fold can assume three different positions: median, paramedian/intermediate or lateral and these are usually correlated with a worsening of vocal performance from the median to lateral position [1].

It is also important to distinguish vocal fold mobility disorders due to neurological diseases such as vocal fold weakness, paresis, or paralysis which can be temporary or permanent, from disorders related to cricoarytenoid ankylosis [2].

Various approaches are used in the management of post-operative UVFP but there is no general agreement on the best approach in the international literature. Speech therapy after UVFP is not used widely and there are few reports about its results. Injection laryngoplasty and medialization thyroplasty type I are the surgical techniques most

widely used in the treatment of VFP [3].

In this paper, we propose a diagnostic-therapeutic algorithm for the management of post-operative UVFP, either reversible or permanent, starting from the immediate post-operative period until the best vocal results are achieved. The aim of our study is to propose an algorithm based on our experience with a multidisciplinary approach composed of a complete phoniatric evaluation, speech therapy, and surgical treatment if necessary.

Methods

This paper proposes an algorithm for the diagnosis and management of post-operative UVFP based on our broad experience gained over the last 15 years. This algorithm was developed by ENT and phoniatric specialists and speech therapists.

Clinically, UVFP injury presents as a breathy voice; diplophonia, aspiration, and dysphagia symptoms may also occur. As reported in other guidelines [2-7], the surgeon should document any change of voice and/or swallowing disorder as soon as possible after any surgical procedure that involves thyroid, carotid, or cervical spine surgery or other neck/mediastinum structures. Primary in this surgery is an ENT evaluation before and after surgical practice with the aim to evaluate vocal fold motility.

Medical history and surgical description are important to

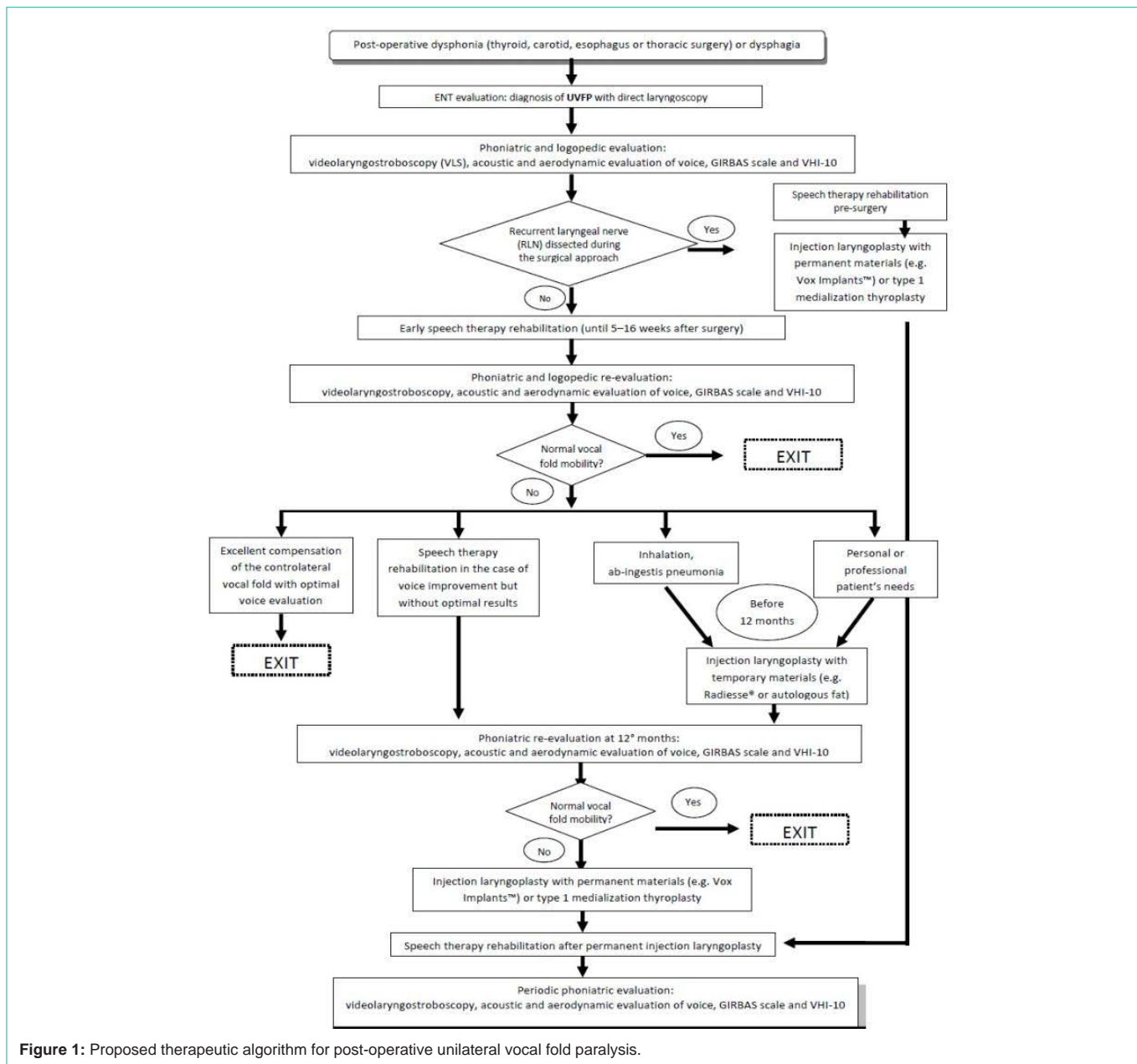


Figure 1: Proposed therapeutic algorithm for post-operative unilateral vocal fold paralysis.

establish whether the unilateral vocal fold paralysis is due to surgical treatment or to something else.

Results

Therapeutic algorithm.

Patients with post-operative UVFP undergo a phoniatic evaluation after being evaluated by an ENT specialist. The therapeutic algorithm is shown in Figure 1.

The phoniatic evaluation consists of:

- Video Laryngo Stroboscopy (VLS): parameters measured are vocal fold position (median, intermediate or lateral), its profile (concave, rectilinear), glottic closure (complete, incomplete), vibratory behavior (wide, narrow, absent), mucosal wave (normal,

small, absent) and the different levels between vocal folds. The vibratory behavior of the paralyzed vocal fold is established compared to the mobile cord: a wide vibration is when it is almost the same in the two folds, whereas a narrow vibration is when it is reduced in relation to the normal fold;

- Acoustic analysis: spectrographic test with long or short window; fundamental frequency (fo) and voice amplitude with their trend over time (intonation and intensity curves); numerical parameters related to the fundamental period perturbation (jitter) and amplitude (shimmer), the spectral energy balance test (the relationship between the periodic component of the signal and the aperiodic one: Harmonics-to-Noise Ratio), diplophonia (simple or multiple), temporary arrests issue test (vocal breaks);

- Aerodynamic analyses: maximum phonation time (MPT)

with sustained vowel /a/;

- Perceptual evaluation with GIRBAS scale (Grade, Instability, Roughness, Breathiness, Asthenia, and Strain) [8];
- Self-assessment tools such as VHI (Voice Handicap Index)-10, Voice Outcome Survey, Voice-Related Quality of Life and Outcome Scale [9–12];
- Speech therapy evaluation [1,3].

It is important to know whether the Recurrent Laryngeal Nerve (RLN) was dissected during the initial surgery which led to UVFP. If it has been sacrificed, we can adopt an early definitive surgical procedure such as permanent injection laryngoplasty with a non-absorbable agent [1]. Meanwhile, there is also the option of speech therapy rehabilitation before the injection laryngoplasty; the goal of this early non-invasive treatment is to inhibit supraglottic compensation and to retain a more favorable vocal fold position. Laryngeal Electromyography (LEMG) can be useful for prognosis of vocal fold palsy: it is a good predictor of no recovery of vocal fold motion. LEMG identify normal innervation, absence of innervation, reinnervation, and even synkinesis by characteristic electrical signals [13]. We think that LEMG is mostly useful in long-term rehabilitation instead of early rehabilitation.

If the nerve has not been sacrificed, we can commence early voice therapy rehabilitation [5–16] weeks after the initial surgery which led to UVFP. In some reports, it was seen that early voice therapy seems to give a significant improvement in voice quality even though vocal fold palsy remains. During speech therapy, there are many cases of vocal fold motility recovery. This is due to functional recovery of the nerve but is also conditioned by the absence of cricoarytenoid articulation ankylosis which is prevented by passive arythenoid mobilization during laryngeal manipulation. Therefore, the main goal of voice therapy in UVFP is to achieve glottic closure during phonation, and also, in our opinion, to avoid cricoarytenoid joint ankylosis (especially in early treatment) [3,14].

Early (between 2 and 4 weeks after the causal event) voice therapy is based on forcible exercises (coughing attack, cough with vowel and vocal function exercises), posture (holding breath and pushing the chest and arms out), laryngeal manipulations and maneuvers pushing against resistance.

At the end of this speech therapeutics' program, there is a new evaluation of the clinical condition with a new VLS study, acoustic and aerodynamic analyses (MPT), VHI and GIRBAS assessment scales. If the patient has normal vocal fold motility or there is excellent compensation of the contralateral vocal fold, voice rehabilitation ends; if UVFP with glottic insufficiency is still present at least 5 weeks after treatment, speech treatment continues until the 12th month after the initial surgery which led to UVFP. Patients with swallowing disorders (with ab ingestis pneumonia), or severe dysphonia, or with professional vocal needs, may be suitable for early injection laryngoplasty with absorbable materials such as Radiess[®], hyaluronic acid gels, autologous fat, or collagen.

In each case, the patient is followed in a close "follow-up voice program" with periodic evaluation of voice (VLS, acoustic and aerodynamic analyses, VHI and GIRBAS assessment scales).

Surgical treatments such as framework surgery or injection laryngoplasty with non-absorbable materials such as polydimethylsiloxane (VOX Implants) are usually proposed after a period of time not less than 12 months after initial surgery, which is generally considered to be the time period after which motility and fold arrangement (position and tropism) are permanent.

In our experience, we generally prefer injection laryngoplasty with polydimethylsiloxane, even in cases with a lateral vocal fold position, because we consider this surgical approach to be conceptually similar to type I thyroplasty. Both approaches showed very good results in reported series [1]. After this surgical treatment, post-operative speech therapy is recommended.

Discussion

Vocal fold paralysis is a condition with vocal fold immobility due to a neurologic injury. This condition is usually caused by surgical procedures in the neck and mediastinum regions usually after thyroid, esophagus, and mediastinum or neck metastasis surgery [2].

The etiology of UVFP can be subdivided into six groups: post-operative paralysis; direct nerve invasion by malignancy (thyroid, esophagus, mediastinum, neck metastasis); viral infections (HZV, HSV, CMV); metabolic or toxic pathologies; central nervous system disease, and idiopathic [15].

The prevalence of Recurrent Laryngeal Nerve (RLN) injury in anterior cervical spine surgery is the highest among all surgical procedures [16–17]. Based on the huge amount of procedures performed every year, an important role is also played by thyroid surgery. The real incidence is underestimated due to lack of routine post-operative laryngeal evaluation, but it is estimated to be between 2.3% and 4.9%, and increases to 6.9% in revision surgery [18–20].

Treatment of UVFP depends on the patient's condition and laryngeal status: in some cases, any intervention is indicated because the paralyzed fold is in a median position and the contralateral cord well compensates the gap. In all other situations, treatment is required and it can be rehabilitative or surgical. In our opinion, speech therapy is the preferable first and early approach in the case of UVFP. In the case of failure or unsatisfactory results, phonosurgery is required. In these cases, the aim of phonosurgery is medialization of the paralyzed cord and closure of the glottic gap [4]. Many surgical procedures have been described but basically three principal surgical approaches exist: injection laryngoplasty, framework surgery and reinnervation techniques [21].

Some authors use Laryngeal Electromyography (LEMG) to predict the prognosis in the UVFP. Wang et al. in a long-term prospective follow-up in UVFP say that for patients with positive LEMG findings, the chance of recovery of vocal fold motion will be very low. If LEMG is performed more than 2 months after the symptom onset, the positive predictive value could be improved from 93.0% to 97.9% [22].

LEMG is a good predictor of no recovery of vocal fold motion, but it seems not to be useful to predict recovery [23].

Injection laryngoplasty is a surgical procedure that consists of injecting material into the vocal cord to increase its volume and medialize the paralyzed fold. Injection may be done endoscopically

or by a transcutaneous approach using different materials which are temporary or permanent agents: temporary ones can be a means to support a patient during the healing period with improved laryngeal function and Quality Of Life (QOL) [24,25]. The purpose of injection laryngoplasty is to improve vocal fold position and bulk; it can be performed with a 1-day surgery under general or local anesthesia. The most commonly injected agents include hyaluronic acid gel, autologous fat, collagen, micronized human dermis, methylcellulose gel, calcium hydroxyapatite paste, dermal filler and PDMS (polydimethylsiloxane) [26]. The choice between temporary or permanent injection materials is based on the possibility of recovery of vocal cord motility.

Framework surgery usually gives long-term benefit to voice quality or permanent rehabilitation of UVFP. The first consists of mobilization of the hypo mobile vocal fold toward the midline with an implant (medialization thyroplasty or type I) 27 or by manipulation of the laryngeal cartilages (as in arytenoid adduction [28,29] or arytenoidpexy [30]). Laryngeal framework surgery, as described by Isshiki et al., [31] is one of the most commonly used surgical treatments for patients with permanent dysphonia due to UVFP. Medialization thyroplasty techniques offer reliable and immediate improvement in vocal quality, but they require external incision. Vocal fold augmentation by endoscopic injection is a minimally invasive, quick and relatively straightforward technique in skilled hands. Some authors practice this technique under local anesthesia with fiberoptic video laryngoscopic supervision [32].

Laryngeal reinnervation is performed with an anastomosis between the donor nerve (usually the ansa cervicalis) and the recipient RLN [33]. This procedure is less commonly performed than framework procedures or injection laryngoplasty, but it may potentially offer an improvement in vocal fold position and bulk, and may avoid long-term denervation atrophy of the laryngeal muscles [33,34]. We have no direct experience of RLN reinnervation techniques.

In our experience [3], early voice therapy followed by injection laryngoplasty gives successful results in patients with UVFP. The goal of early voice therapy is to achieve glottic closure during phonation, strengthen intrinsic muscles, develop abdominal support for breathing and avoid cricoarytenoid joint ankylosis (importance of early treatment).

A strategy, based on this principle, can be an energetic approach to avoid cricoarytenoid joint ankylosis, which may jeopardize the restoration of vocal fold motility, watching carefully to prevent supraglottic hyper functional compensation. An early (between 2 and 4 weeks after diagnosis and/or after the causal event) voice therapy based on forcible exercises (coughing attack, cough with vowel and vocal function exercises), posture (holding breath and pushing the chest and arms out), laryngeal manipulations and maneuvers against resistance promotes the restoration of laryngeal motility and improves glottic closure [3].

We published our experience of eleven years about the results of Early versus Intermediate or Delayed Voice Therapy in patients with UVFP: 171 patients were included in the study and they were divided into 3 groups (early, intermediate or delayed voice treatment

group). The 62% (106/171) recovered vocal fold mobility and the incidence was higher if the patient was in the first group (Early treatment); also there was a reduction of fundamental frequency (Fo) and improvement of the mean values of Jitter, Shimmer and noise-to-harmonic ratio [14].

When the results of early speech therapy are not satisfactory, injection laryngoplasty is indicated.

The first experience of injection laryngoplasty was reported by Brunings in 1911 using paraffin oil. After that, a variety of materials became available for vocal fold augmentation. Teflon was used in the period between 1960 and 1990 (Arnold in 1962) [35], and after that, soluble bovine collagen [36,37], which gave good results, but also gave resorption and hypersensitivity due to foreign protein reaction in 3% of patients; autologous fat and autologous fascia were introduced in 2000. The main problems with autologous fat and fascia were its very rapid resorption and also the harvesting incision. Acid and calcium hydroxyapatite were recently introduced in Laryngology. Hyalan B gel has good biocompatibility but is generally resorbed quickly [38,39], whereas calcium hydroxyapatite is supposed to be long lasting but no data are actually available. Sittel et al. first reported the safe use of textured Poly Dimethyl Siloxane (PDMS) in the human larynx for injection laryngoplasty in vocal cord paralysis [40].

Injection laryngoplasty can be performed with local anesthesia if a percutaneous approach is used along with absorbable materials or under anesthesia by microlaryngoscopy in 1-day surgery [41]. Commonly used injection materials include hyaluronic acid gels, autologous fat, collagen, micronized human dermis, methyl cellulose gel and calcium hydroxyapatite paste. The latter is considered to be an intermediate lasting agent as its effects may last for 18 months or longer [42]. Some of these materials are marketed as dermal fillers and used off-label in the larynx [43,44].

Hyaluronic acid gel is not used for vocal fold medialization, but it can be used with Vox Implants to avoid vocal fold hypotrophy associated with paralysis in the case of lesion or cutting of the Recurrent Laryngeal Nerve (RLN) [45,46].

Speech therapy is always recommended after injection laryngoplasty to rehabilitate the voice with the new vocal fold position after surgery.

After these techniques (early voice therapy and injection laryngoplasty), periodic phoniatric evaluations with strobolaryngoscopy, acoustic and aerodynamic evaluation of the voice, GIRBAS scale and VHI-10 are needed to avoid late-onset vocal fold hypotrophy, which may require a new corrective injection laryngoplasty to give the best vocal result.

In this approach to UVFP, patient co-operation is really important, with motivation and understanding through educated participation in the voice restoration process. ENT specialists and speech therapists should strengthen the concept that patients with UVFP who follow correct therapeutic procedures have a good chance of considerably improving their voice quality even though there is no recovery of vocal fold motility. As mentioned earlier, in some cases, surgical treatment is unnecessary because of motility recovery or median position with good tropism and a regular profile of the paralyzed fold,

probably due to synkinetic re-innervation. Injection laryngoplasty or framework surgery is required in the case of persistence of paralysis 1 year after surgery and if speech therapy results are not satisfactory. In our experience, we prefer injection laryngoplasty using different materials based on the defect to be treated and the time elapsed from diagnosis of paralysis because we find this technique to be less invasive and gives the same results as framework surgery.

Conclusion

A practical and useful algorithm is presented for management of post-surgical UVFP based on the direct experience of the authors in this field. Many treatment options are available, but early treatment is fundamental for the best possible voice results no matter whether vocal fold motility will recover or not. Patients' co-operation is important because the therapeutic process is long-lasting and many interventions are generally required, but in the end, quality of life and vocal results are usually satisfactory. Constant follow-up evaluation, even after good results, is recommended to detect and promptly treat slight deterioration of the voice over time.

References

- Bergamini G, Alicandri-Ciuffelli M, Molteni G, Villari D, Luppi MP, Genovese E, et al. Therapy of unilateral vocal fold paralysis with polydimethylsiloxane injection laryngoplasty: Our experience. *J Voice*. 2010; 24: 119-125.
- Chandrasekhar SS, Randolph GW, Seidman MD, Rosenfeld RM, Angelos P, Barkmeier-Kraemer J, et al. Clinical practice guideline: Improving voice outcomes after thyroid surgery. *Otolaryngol Head Neck Surg*. 2013; 148: 1-37.
- Mattioli F, Bergamini G, Alicandri-Ciuffelli M, Molteni G, Luppi MP, Nizzoli F, et al. The role of early voice therapy in the incidence of motility recovery in unilateral vocal fold paralysis. *Logoped Phoniatr Vocol*. 2011; 36: 40-47.
- Kim SW, Kim ST, Park HS, Lee HS, Hong JC, Kwon SB, et al. Voice examination in patients with decreased high pitch after thyroidectomy. *Indian J Otolaryngol Head Neck Surg*. 2012; 64: 120-130.
- Baujat B, Delbove H, Wagner I, Fugain C, de Corbière S, Chabolle F. Laryngeal immobility after thyroidectomy (article in French). *Ann Chir*. 2001; 126: 104-110.
- Meek P, Carding PN, Howard DH, Lennard TW. Voice change following thyroid and parathyroid surgery. *J Voice*. 2008; 22: 765-772.
- Roh JL, Yoon YH, Park CI. Recurrent laryngeal nerve paralysis in patients with papillary thyroid carcinomas: evaluation and management of resulting vocal dysfunction. *Am J Surg*. 2009; 197: 459-465.
- Morsomme D, Jamart J, Wéry C, Giovanni A, Remacle M. Comparison between the GIRBAS scale and the acoustic and aerodynamic measures provided by EVA for the assessment of dysphonia following unilateral vocal fold paralysis. *Folia Phoniatr Logop*. 2001; 53: 317-325.
- Jacobson BH, Johnson A, Grywalski C, Silbergleit A, Jacobson GP, Benninger MS, et al. The Voice Handicap Index (VHI): Development and validation. *Am J Speech-Lang Pathol*. 1997; 6: 66-70.
- Glicklich RE, Glovsky RM, Montgomery WW. Validation of a voice outcome survey for unilateral vocal cord paralysis. *Otolaryngol Head Neck Surg*. 1999; 120: 153-158.
- Hogikyan NN, Sethuraman G. Validation of an instrument to measure voice-related quality of life (V-RQL). *J Voice*. 1999; 13: 557-569.
- Casper JK. Treatment outcomes in occupational voice disorders. In: Dejonckere PH, ed. *Occupational Voice: Care and Cure*. The Hague, The Netherlands: Kugler Publications. 2001; 187-199.
- Pardo-Maza A, García-Lopez I, Santiago-Pérez S, Gavilán J. Laryngeal Electromyography for Prognosis of Vocal Fold Paralysis. *J Voice*. 2016.
- Mattioli F, Menichetti M, Bergamini G, Molteni G, Alberici MP, Luppi MP, et al. Results of early versus intermediate or delayed voice therapy in patients with unilateral vocal fold paralysis: Our experience in 171 patients. *J Voice*. 2015; 29: 455-458.
- Ward PH, Berci G. Observations on so-called idiopathic vocal cord paralysis. *Ann Otol Rhinol Laryngol*. 1982; 91: 558-563.
- Rosenthal LHS, Benninger MS, Deeb RH. Vocal fold immobility: a longitudinal analysis of etiology over 20 years. *Laryngoscope*. 2007; 117: 1864-1870.
- Merati AL, Shemirani N, Smith TL, Toohill RJ. Changing trends in the nature of vocal fold motion impairment. *Am J Otolaryngol*. 2006; 27: 106-108.
- Scott-Coombes D. *The British Association of Endocrine and Thyroid Surgeons—Third National Audit Report*. Henley-on-Thames, UK: Dendrite Clinical Systems Ltd. 2009.
- de Pedro Netto I, Fae A, Vartanian JG, Barros AP, Correia LM, Toledo RN, et al. Voice and vocal self assessment after thyroidectomy. *Head Neck*. 2006; 28: 1106-1114.
- Bergenfelz A, Jansson S, Kristoffersson A, Mårtensson H, Reihner E, Wallin G, et al. Complications to thyroid surgery: results as reported in a database from a multicenter audit comprising 3,660 patients. *Langenbecks Arch Surg*. 2008; 393: 667-673.
- Harries ML. Unilateral vocal fold paralysis: a review of the current methods of surgical rehabilitation. *J Laryngol Otol*. 1996; 110: 111-116.
- Wang CC, Chang MH, De Virgilio A, Jiang RS, Lai HC, Wang CP, et al. Laryngeal electromyography and prognosis of unilateral vocal fold paralysis—a long-term prospective study. *Laryngoscope*. 2015; 125: 898-903.
- Rickert SM, Childs LF, Carey BT, Murry T, Sulica L. Laryngeal electromyography for prognosis of vocal fold palsy: a meta-analysis. *Laryngoscope*. 2012; 122: 158-161.
- Yung KC, Likhterov I, Courey MS. Effect of temporary vocal fold injection medialization on the rate of permanent medialization laryngoplasty in unilateral vocal fold paralysis patients. *Laryngoscope*. 2011; 121: 2191-2194.
- Graboyes EM, Bradley JP, Meyers BF, Nussenbaum B. Efficacy and safety of acute injection laryngoplasty for vocal cord paralysis following thoracic surgery. *Laryngoscope*. 2011; 121: 2406-2410.
- Carroll TL, Rosen CA. Long-term results of calcium hydroxylapatite for vocal fold augmentation. *Laryngoscope*. 2011; 121: 313-319.
- Isshiki N, Okamura H, Ishikawa T. Thyroplasty type I (lateral compression) for dysphonia due to vocal cord paralysis or atrophy. *Acta Otolaryngol*. 1975; 80: 465-473.
- Isshiki N, Tanabe M, Sawada M. Arytenoid adduction for unilateral vocal cord paralysis. *Arch Otolaryngol*. 1978; 104: 555-558.
- Kraus DH, Orlikoff RF, Rizk SS, Rosenberg DB. Arytenoid adduction as an adjunct to type I thyroplasty for unilateral vocal cord paralysis. *Head Neck*. 1999; 21: 52-59.
- Zeitels SM, Mauri M, Dailey SH. Adduction arytenopexy for vocal fold paralysis: indications and technique. *J Laryngol Otol*. 2004; 118: 508-516.
- Isshiki N, Morita H, Okamura H, Hiramoto M. Thyroplasty as a new phonosurgical technique. *Acta Otolaryngol*. 1974; 78: 451-457.
- Birkent H, Sardesai M, Hu A, Merati AL. Prospective study of voice outcomes and patient tolerance of in-office percutaneous injection laryngoplasty. *Laryngoscope*. 2013; 123: 1759-1762.
- Aynehchi BB, McCoul ED, Sundaram K. Systematic review of laryngeal reinnervation techniques. *Otolaryngol Head Neck Surg*. 2010; 143: 749-759.
- Paniello RC, Edgar JD, Kallogjeri D, Piccirillo JF. Medialization versus reinnervation for unilateral vocal fold paralysis: a multicenter randomized clinical trial. *Laryngoscope*. 2011; 121: 2172-2179.
- Arnold GE. Vocal rehabilitation of paralytic dysphonia. *Arch Otolaryngol*. 1962; 76: 358-368.

36. Ford CN, Bless DM. A preliminary study of injectable collagen in human vocal fold augmentation. *Otolaryngol Head Neck Surg.* 1986; 94: 104–112.
37. Remacle M, Marbaix E, Hamoir M, Bertrand B, van den Eeckhaut J. Correction of glottic insufficiency by collagen injection. *Ann Otol Rhinol Laryngol.* 1990; 99: 438–444.
38. Reiter R, Brosch S. Laryngoplasty with hyaluronic acid in patients with unilateral vocal fold paralysis. *J Voice.* 2012; 26: 785–791.
39. Szkielkowska A, Miaśkiewicz B, Remacle M, Krasnodębska P, Skarżyński H. Quality of the voice after injection of hyaluronic acid into the vocal fold. *Med Sci Monit.* 2013; 19: 276–282.
40. Sittel C, Echternach M, Federspil PA, Plinkert PK. Polydimethylsiloxane particles for permanent injection laryngoplasty. *Ann Otol Rhinol Laryngol.* 2006; 115: 103–109.
41. Sulica L, Rosen CA, Postma GN, Simpson B, Amin M, Courey M, et al. Current practice in injection augmentation of the vocal folds: indications, treatment principles, techniques, and complications. *Laryngoscope.* 2010; 120: 319–325.
42. Carroll TL, Rosen CA. Long-term results of calcium hydroxylapatite for vocal fold augmentation. *Laryngoscope.* 2011; 121: 313–319.
43. Ford CN. Paradigms and progress in vocal fold restoration. *Laryngoscope.* 2008; 118: 1709–1713.
44. Rosen CA. Phonosurgical vocal fold injection: procedures and materials. *Otolaryngol Clin North Am.* 2000; 33: 1087–1096.
45. Hallen L, Johansson C, Laurent C. Cross-linked hyaluronan (Hyalan B gel): a new injectable remedy for treatment of vocal fold insufficiency – an animal study. *Acta Otolaryngol (Stockh).* 1999; 119: 107–111.
46. Molteni G, Bergamini G, Ricci-Maccarini A, Marchese C, Ghidini A, Alicandri-Ciufelli M, et al. Auto-crosslinked hyaluronan gel injections in phonosurgery. *Otolaryngol Head Neck Surg.* 2010; 142: 547–553.