The Journal of Laryngology and Otology
February 1996, Vol. **110**, pp. 111–116

Review Article

Unilateral vocal fold paralysis: a review of the current methods of surgical rehabilitation

MEREDYDD LLOYD HARRIES B.Sc., F.R.C.S.

Abstract
This review article discusses the surgical treatment of patients suffering from unilateral vocal fold paralysis who have already been assessed and considered appropriate candidates for surgery. There are currently three main methods of surgical rehabilitation; injection medialisation; laryngeal framework surgery; re-innervation procedures.

Key words: Vocal fold paralysis; Surgery

1. Injection medialisation

This is still the commonest method used in the United Kingdom. There are a variety of injectable materials and methods currently available.

Selection of injecting material

Paraffin was the first material to be described in 1911 for injection into the vocal fold (Brunings, 1911) but was soon abandoned due to the complication of paraffinomas and distal spread of the paraffin (Von Leden, 1991). Since then a host of materials have been used and at present the following are in common usage:

Teflon.

First used in 1962 (Arnold, 1962) this remains the commonest vocal fold injection material world-wide. Teflon is a polymer of polytetrafluoroethylene (Ford, 1991) and is sold as a paste consisting of 50 per cent glycerine. This glycerine component is absorbed in the first few weeks (Lewy and Millet, 1978) and its volume is partially replaced initially by an acute inflammatory reaction and later by a localized chronic inflammatory response which encapsulates the remaining Teflon (Dedo and Carlsoo, 1982). This is in effect a localized granuloma, but the difference between the initial volume injected and the final space occupying lesion is unpredictable, both in size and state, and although it gives good results immediately these can deteriorate with time (Stone and Arnold, 1967). If the Teflon is incorrectly placed or migrates within the fold to a superficial level, erosion of overlying mucosa can lead to granulomas on the surface of the fold with further complications (Lewy, 1983). Studies on the complications of Teflon have shown that these increase with time as does the stiffness of the fold (i.e., reduced mucosal wave) and a 36 per cent incidence of superficial granuloma production has been reported (Gardener and Parnes, 1991). This may not be the experience of other authors but this can be explained by the short follow-up period due to the short life expectancy of some patients.

Teflon particle sizes in the paste are 50–100 microns and are too large for immediate lymphatic drainage (macrophage lymphatic cut off is 40 microns) (Boedts *et al.*, 1967). Studies on a commercial preparation of Teflon however have found particles of Teflon of 4–40 microns (Boedts *et al.*, 1967) which must lead to the question of distal spread. A study on relatively large volumes of Teflon injected into the peri-urethral area showed spread to both regional and distal organs (Malizia, 1984) but although local spread (to lymph nodes and to produce a cold nodule in the thyroid) has been described following laryngeal injection (Lewy, 1983) no distal spread has yet been documented.

Gelfoam powder.

Initially developed as a haemostatic material this has been used in a mixture with saline to augment the vocal fold (Schram *et al.*, 1978). It is a temporary material only lasting up to three months and is commonly used in conjunction with a re-innervation procedure to provide temporary improvement while

Accepted for publication: 22 July 1995.
From the The Voice Clinic, The Royal National Throat Nose and Ear Hospital, London, UK.

https://doi.org/10.1017/S0022215100132918 Published online by Cambridge University Press

neural regeneration occurs (Crumley, 1985). It can also be used repeatedly during the first 12 months in a patient with a paralysis of unknown aetiology but in whom vocal function is essential. Recently there has been difficulty obtaining gelfoam powder and its manufacture may be stopped in the near future due to its relatively small demand.

Fat.

This autogenous material is still in the early days of trials but has numerous advantages; it is easily harvested, readily available and does not give a foreign body reaction (Illouz, 1988). Although it can be harvested via liposuction, this can lead to up to 30 per cent cell destruction with later hypersensitivity reactions (Chajchir *et al.*, 1990) and fat harvested through a larger incision therefore has less tissue disruption. The fat can then be loaded into a Brunning's syringe and injected into the vocal fold. Results in both animals (Wexler *et al.*, 1989) and humans (Mikaelian *et al.*, 1991) are so far encouraging. Recent reports using centrifuged fat which contains less impurities, suggest that this autologous material is well tolerated by the laryngeal tissues although the final volume does decrease with time (Mikus *et al.*, 1995).

Collagen.

This is a natural protein that is a normal constituent of the lamina propria of the vocal fold (Ford, 1986). Widely used in dermal augmentation it has been popularized by Ford in the larynx (Ford *et al.*, 1992). Although rapidly absorbed by the skin, collagen lasts much longer in the vocal folds due to their poor lymphatic drainage, and times of up to three years post-injection have been reported (Remacle *et al.*, 1990). Using a purified bovine collagen with gluteraldehyde in phosphate buffered saline, it is therefore a bio-implant which does not simply displace the host tissues but becomes incorporated and even replaced by new host tissue (Ford and Bless, 1987). Collagen has been used to augment the paralysed and/or scarred vocal fold by injecting superficially (intra-cordal) into the vocal ligament i.e. much more superficial than Teflon which is injected deep and laterally. Problems include hypersensitivity reactions, that necessitate skin testing pre-operatively, and irregularity in its mode of absorption and replacement (Spiegel and Sataloff, 1987). Collagen is less dense than Teflon and considerably less pressure is required at injection which can be performed using a simple syringe instead of the Brunning's syringe.

Choice of method of injection

There are a variety of different approaches to vocal fold injection and these may be sub-divided as follows: (1) General anaesthesia: direct laryngoscopic method; (2) Local anaesthesia: direct laryngoscopic method; indirect laryngoscopic method; transcutaneous route through the thyroid cartilage; transcutaneous route through the cricothyroid membrane.

General anaesthesia is the commonest method in the UK. Drawbacks include visualization problems due to the anaesthetic tube or some other means of ventilation, the abnormal anatomical positioning of the neck, difficulty in gaining access to the larynx in patients with cervical spine problems or other anatomical factors preventing direct laryngoscopy, and most significantly lack of patient feedback via phonation during injection. This last factor plays an essential role in deciding the amount of material to inject at the time of surgery in patients undergoing procedures under local anaesthesia. Although jet ventilation may remove the problem of the anaesthetic tube, some patients may have an underlying aetiology of bronchial carcinoma and in these patients a general anaesthetic may carry a significant morbidity.

Direct laryngoscopy under local anaesthesia allows patient co-operation to adjust the amount of injected material but is technically demanding, requires the use of the operating theatre, and still has the head in an abnormal position.

The indirect laryngoscopic technique can be carried out as an outpatient procedure, therefore not requiring operating theatre time or the frequent delay in obtaining it. Although in expert hands it is reported to give excellent results many find the technique difficult to master. The head position is still abnormal and due to the length of the instruments it is difficult to assess the depth of penetration into the fold. Some needle tips have a side opening and/or a shield that prevents the tip from passing too deep although this does not guarantee correct positioning.

Transcutaneous techniques maintain the benefits of being procedures that can be carried out in the outpatient setting and have the great advantage in that the head can be placed in a neutral more anatomically correct position (Strasnick *et al.*, 1991; McCaffrey, 1993). Penetrating the cricothyroid membrane is becoming a more familiar technique now that botulinum toxin injections into the thyroarytenoid muscle for adductor spasmodic dysphonia are increasing. The injection needle can either pass directly into the fold without entering the laryngeal lumen or pass initially into the lumen and then across into the cord while being visualized via the nasendoscope. The visualization of the needle tip and its relative short distance compared to endoscopic instruments, increases the precision of the positioning of the injecting material.

With transcutaneous techniques through the thyroid cartilage, penetration is lateral through the inferior half of the thyroid cartilage, but difficulty can occur when the cartilage is ossified and the depth of the needle tip is not as accurately positioned compared with the method through the cricothyroid membrane.

There are therefore benefits and drawbacks for each technique and in many ways it is for the

https://doi.org/10.1017/S0022215100132918 Published online by Cambridge University Press

surgeon to use the technique that works best in his/her hands.

2. Laryngeal framework surgery

Payr in 1915 is credited with the first description of laryngeal framework surgery. This has been refined over many years by other surgeons including Meurman (1952), Opheim (1955) and Sawashima *et al.* (1968). Isshiki *et al.* (1974), however were the first to describe using an alloplastic material (silastic) and his name and the classification of laryngeal framework surgery, with four types of thyroplasty, remains.

Kaufman has done much to popularize the technique in America (Kaufman, 1986) and new modifications of the original technique are continuing to emerge: Cummings *et al.* (1993), Montgomery *et al.* (1993) and Netterville *et al.* (1993).

Thyroplasty type 1 essentially involves medialization of the vocal cord by its inward displacement with an implant placed through a window in the thyroid cartilage. In the original description, the cartilage window was preserved but many now remove this island of cartilage believing it can be displaced or absorbed leading to later complications (Netterville *et al.*, 1993). Modifications include using a template to mark out the dimensions of the window (Cummings *et al.*, 1993), using an operating microscope or loupes (Netterville *et al.*, 1993) while cutting the window to improve preservation of the inner perichondrium, and using a diamond (non-cutting) drill burr to thin and make an initial opening in the inner plate of the thyroid cartilage followed by bone punches to remove the remaining cartilage (Cummings *et al.*, 1993). Although a recent paper (Netterville *et al.*, 1993) advocates incising the inner perichondrium and preserving the thyroarytenoid fascia, most are in agreement that preservation of the perichondrium is essential (Kaufman, 1986). This keeps the implant out of the body of the vocal fold which allows the fold to vibrate without altering its vibrating characteristics. This has been proven in stroboscopic studies (Sercarz *et al.*, 1992) and is an advantage over Teflon or any injected material which together with a later foreign body reaction at the site of injection i.e. medial to the perichondrium, will stiffen the fold. Studies looking specifically at the mucosal wave have shown this to be decreased following Teflon injection and the stiffness of the fold to increase with time (Gardener and Parnes, 1991). This suggests that laryngeal framework surgery may give better results for voice in the long term.

Design of the implant and the material used varies; silastic is the commonest, but others include cartilage (harvested from the superior half of the thyroid lamina), and more recently hydroxylapatite (Flint and Cummings, 1993). This last implant will be available commercially soon in a set which includes prefabricated dense hydroxylapatite implants with matched-sizing prosthesis templates that allow rapid determination of the correct implant position and size. Carved silastic implants are used in most centres and there is variation in design: some prefer to insert the implant in halves; others use partial incisions so that the implant will snap into place; and others have a long posterior flange in an attempt to close the posterior glottic chink (Kaufman, 1986). It is still not certain whether a posterior chink can be closed using this method and many now consider an arytenoid adduction necessary in such cases.

Proponents of the hydroxylapatite implant have looked at the reaction to both silastic and their implant. Silastic creates a capsule of thin fibrous tissue with minimal inflammatory response and no chronic fibrosis i.e. no granuloma formation (Isaacson *et al.*, 1990). Hydroxylapatite also gives a thin fibrous capsule but because the material is bio-integratable, osteo-neogenesis has been noted in the region of the thyroid cartilage fenestra which is suggested may stabilize the implant (Flint and Cummings, 1993). This is therefore unlikely to be a reversible operation but whether laryngeal framework surgery using silastic implants with a posterior flange to correct the posterior chink is reversible is also under debate (Kaufman, 1993).

The greatest advantage of thyroplasty is quoted to be its adjustability (Kaufman, 1986). Under local anaesthesia, using the patients' vocal feedback, the ideal size of the implant required can be determined. Local oedema can complicate the issue however, and is said to be an important factor if the procedure takes more than thirty minutes (Kaufman, 1993). This operative time can be reducd by using preformed implants (either silastic or hydroxylapatite), but the silastic implants can be finely adjusted with a scalpel for individual requirements which may be an advantage. The local oedema has led Isshiki to suggest that overmedialisation is recommended (Isshiki, 1989) although this has been known to lead to later airway compromise and emergency removal of the implant (Tucker, 1983).

Nasendoscopic control is useful during surgery as it can assist in the correct positioning of the implant but is not always used as some surgeons pay more emphasis to the voice quality produced rather than the anatomical position of the fold.

Medialisation laryngoplasty can be used in any patient with an unilateral vocal fold paralysis. Waiting 12 months in idiopathic cases with regular laryngeal electromyography is still recommended, although if there is severe aspiration or if in exceptional cases where the vocal needs of the patient require early intervention, surgery maybe carried out sooner as an alternative to repeated gelfoam injections. The reversibility and adjustability of medialization laryngoplasty is therefore a great advantage over Teflon injection in these cases and with the possible unavailabilty of gelfoam powder it may represent the only truly reversible method of treating a temporary paralysis.

Medialization laryngoplasty can also be used in cases of unilateral or bilateral bowed vocal folds caused by ageing or soft tissue defects in the vocal

https://doi.org/10.1017/S0022215100132918 Published online by Cambridge University Press

fold as a result of previous surgery such as laser removal of Teflon.

Arytenoid adduction

Many now recognize that the procedure of choice for a paralyzed fold at different vertical levels and with a large posterior chink is an arytenoid adduction. First described by Isshiki (1978) it has not gained as much popularity as other procedures possibly due to its greater technical requirements. It can be combined with a thyroplasty type 1 if there is bowing of the fold (Slavit and McCaffery,1991) or if the paralyzed fold's muscle is atrophic. Combining this with a thyroplasty type 1 for anterior medialisation, will give bulk to the paralyzed fold. Recent reports indicate this to be an excellent technique for suitable cases (Green *et al.*, 1991) which emphasizes the importance of accurate pre-operative assessment of both the horizontal and vertical position of the fold.

3. Re-innervation procedures

There is much in the current literature regarding re-innervation procedures either with a neuromuscular pedicle or by direct neural anastomosis with the ansa cervicalis nerve. Recurrent laryngeal nerve anastomosis was initially described in 1909 by Horsley, and further work by Lahey (1928) and Doyle (1968) suggested that this was a successful technique but with no objective evidence to support their conclusions. Recently, Crumley (1991) has popularized the technique of ansa cervicalis to recurrent laryngeal nerve anastomosis although with little objective evidence to support his results.

The recurrent laryngeal nerve is a mixed nerve containing afferent, sympathetic, parasympathetic and 500 to 1000 motor axons in an adductor to abductor ratio of 5:1 (Goding, 1991), but the ansa cervicalis contains efferent fibres from the first three cervical nerves to innervate the strap muscles. Whereas the intrinsic laryngeal muscles are controlled to contract at specific times e.g., thyroarytenoid contracts during phonation, the strap muscles have not been shown to have phasic action in the primate (Ellenbogen *et al.*, 1981).

Re-innervated muscle takes on the characteristics of its supplying nerve, however, and the selection of the donor nerve should take into account the muscle fibre composition of the muscle to be re-innervated (Buller *et al.*, 1987).

Muscle fibres can be divided into specific types based on their histochemical and contractile properties (Fata *et al.*, 1987). There are three basic groups: Type 1: slow contractile period and aerobic metabolism; Type 2B: fast contractile period and anaerobic metabolism; Type 2A: intermediate contractile period and both aerobic and anaerobic metabolism.

Muscles that produce low tension over a sustained time period will have a high concentration of type 1 muscle fibres. A high concentration of type 2B fibres will be seen in muscles that contract rapidly, generating high tension over a short time. The intrinsic muscles of the larynx differ in their constitution of muscle fibres but the thyroarytenoid muscle (part of which is the vocalis muscle of the vocal fold) has a fast contraction time (14 msec) and less than 36 per cent type 1 muscle fibres. The strap muscles however have a higher percentage of type 1 muscle fibres (almost 66 per cent) and a contraction time of 50 msecs (Kirchenberg and Shwatz, 1985). The distribution of neuro-muscular end plates in each of the intrinsic laryngeal muscles and the strap muscles are also different, with a diffuse pattern in the thyroarytenoid but a typical skeletal muscle distribution in the strap muscles where they form a narrow band at the midpoint (Rosen *et al.*, 1983).

This gross difference in the histochemical and contractile properties of these muscle groups and their nerve supply makes them poor recipients and donors for nerve transfer. It is said that, by removing the resting tone of sternothyroid during an ansa-recurrent laryngeal nerve transfer, the fold is medialized immediately due to the removal of the muscle's lateralizing effect and the procedure provides tone, bulk and tension to the intrinsic muscles (Crumley, 1991). It is proposed that the 'unfavourable' synkinesis that occurs in a damaged recurrent laryngeal nerve with mixed partial axonal regrowth,

TABLE I

THE THREE MOST COMMON PROCEDURES CURRENTLY USED FOR THE REHABILITATION OF A PATIENT WITH UNILATERAL VOCAL FOLD PARALYSIS

	Teflon injection	Laryngeal framework surgery	Re-innervation
Time taken for procedure	10–30 Minutes	35–75 Minutes	60–120 Minutes
Results	Immediate	Immediate	2–3 Months (+ Gelfoam injection)
Anaesthesia	Local/general	Local/general	General
Reversibility	No	Yes	Yes
Demand on technical skill	Moderate	Moderate	Most
Changes in vocal fold	Granuloma within body of fold (Non-vibratory)	Implant lateral to body of fold (Reduced mucosal wave)	Return of mucosal wave, but no vocal fold movement
Complications	1. Under-injection	1. Wound infection	1. Wound infection
	2. Over-injection	2. Haematoma	2. Haematoma
	3. Airway compromise	3. Airway compromise	3. Loss of abnormal synkinetic tone (Flaccid fold)
	4. Misplacement of Teflon	4. Mucosal perforation	
	5. Migration	5. Dislodgement and/or extrusion	
	6. Granuloma formation		
Cost	Cheapest	Operating theatre time	Operating theatre time

https://doi.org/10.1017/S0022215100132918 Published online by Cambridge University Press

is replaced by a more 'favourable' synkinesis from the ansa cervicalis, where the rate of neural impulses is said to be more physiological (Crumley, 1988).

Muscle-nerve pedicle re-innervation has also been described (May and Barry, 1986; Tucker, 1987) using a block of omohyoid with its branch from the ansa, although some surgeons are now combining neural anastomosis with laryngeal framework surgery as it appears that neural anastomosis alone does not give a good result in a lateralized fold.

In the author's opinion, there is currently no convincing clinical or scientific evidence that re-innervation techniques give better or equal results to either injection medialization or laryngeal framework surgery in the management of a unilateral vocal fold paralysis.

Table I shows the advantages and disadvantages of the three most common procedures currently used for the rehabilitation of a patient with an unilateral vocal fold paralysis.

Personal choice

I use injection medialisation via the transcutaneous technique, through the cricothyroid membrane with nasendoscopic and television monitoring. Injection medialisation is only used in patients with a unilateral vocal fold paralysis due to widespread malignant disease and who have a short life expectancy. These patients require a competent larynx and a reasonable voice immediately to improve the quality of their remaining brief life. I initially used Teflon but have changed to collagen which I find easier to use since it requires less pressure at injection due to its decreased viscosity.

Laryngeal framework surgery is used for patients where the paralyzed vocal fold lies on the same vertical level as the normal fold and there is not a large posterior chink. For these patients with a higher fold I use an arytenoid adduction procedure to lower the paralyzed fold and close the posterior chink.

A range of surgical procedures therefore exist which includes transcutaneous injection, laryngeal framework surgery and arytenoid adduction. The choice of procedure involves accurate pre-operative patient assessment which at this voice clinic includes stroboscopy, laryngeal EMG and assessment of the vertical level of the paralyzed fold.

References

Arnold, G. (1962) Vocal rehabilitation of paralytic dysphonia. IX. Technique of intracordal injection. *Archives of Otolaryngology* **76:** 358–368.

Boedts, D., Roels, H., Kluyskens, P. (1967) Laryngeal tissue responses to Teflon. *Archives of Otolaryngology* **86:** 562–567.

Brunings, W. (1911) Uber eine neue Behandlungsmethode der Rekurrslahmung. 18. *Verhandlungen der Deutscher Laryngology* **93:** 151.

Buller, A., Kean, C., Ranatunga, K. (1987) Transformation of contraction speed in muscle following cross reinnervation: Dependence on muscle size. *Journal of Muscle Research and Cell Motility* **8:** 504–516.

Chajchir, A., Beuzaquen, I., Wexler, E. (1990) Fat injection. *Aesthetic Plastic Surgery* **14:** 127–136.

Crumley, R. (1985) Update of laryngeal reinnervation concepts and options. In *Surgery of the Larynx* (Bailey, B., Biller, H., eds.) W. Saunders, Philadelphia, pp 135–147.

Crumley, R. (1988) Laryngeal synkinesis: its significance to the laryngologist. *Annals of Otology, Rhinology and Laryngology* **97:** 87–92.

Crumley, R. (1991) Update: ansa cervicalis to recurrent laryngeal nerve anastomosis for unilateral paralysis. *Laryngoscope* **101:** 344–348.

Crumley, R., Izdebski, K. (1986) Voice quality following re-innervation by ansa hypoglossi transfer. *Laryngoscope* **6:** 342–346.

Cummings, C., Purcell, L., Flint, P. (1993) Hydroxylapatite laryngeal implants for medialization preliminary report. *Annals of Otology, Rhinology and Laryngology* **102:** 843–851.

Dedo, H., Carlsoo, B. (1982) Histological evaluation of Teflon granulomas of human vocal cords. *Acta Otolaryngology* **85:** 47–56.

Doyle, P. (1968) Indications and contraindications for recurrent laryngeal nerve repair. *Transactions of the Pacific Coast Oto-Ophthalmological Society* **50:** 354–357.

Ellenbogen, B., Gerber, T., Coon, R., Tool, R. (1981) Accessory muscle activity and respiration. *Otolaryngology-Head and Neck Surgery* **89:** 370–375.

Fata, J., Malmgren, L., Gacek, R., Dum, R., Woo, P. (1987) Histochemical study of the posterior cricoarytenoid muscle reinnervation by a nerve-muscle pedicle in the cat. *Annals of Otology, Rhinology and Laryngology* **96:** 479–487.

Flint, P., Cummings, C. (1993) Phonosurgical procedures. In *Otolaryngology, Head and Neck Surgery*. (Cummings, C., ed.). 2nd Edition, Vol. 3, C. V. Mosby Co., St Louis. pp 2072–2109.

Ford, C. (1986) Histological studies on the fate of soluble collagen injected into canine vocal folds. *Laryngoscope* **96:** 1248–1257.

Ford, C. (1991) Laryngeal injection techniques. In *Phonosurgery: Assessment and Surgical Management of Voice Disorders.* Raven Press Ltd., New York, pp 123–141.

Ford, C., Bless, D. (1987) Collagen injection in the scarred vocal fold. *Journal of Voice* **1:** 116–118.

Ford, C., Bless, D., Loftus, J. (1992). Role of collagen in the treatment of glottic insufficiency: A study of 119 patients. *Annals of Otology, Rhinology and Laryngology* **101:** 237–247.

Gardener, G., Parnes, S. (1991) Status of the mucosal wave post vocal cord injection versus thyroplasty. *Journal of Voice* **5:** 64–73.

Goding, Jr. G. (1991) Nerve-muscle pedicle re-innervation of the vocal cord. *Otolaryngology Clinics of North America* **24:** 115–128.

Green, D., Berke, G., Ward, P. (1991) Vocal fold medialization by surgical augmentation versus arytenoid adduction in the *in vivo* canine model. *Annals of Otology, Rhinology and Laryngology* **100:** 280–287.

Horsley, J. (1909) Suture of the recurrent laryngeal nerve with report of a case. *Transactions of the Southern Surgical Gynecological Association* **22:** 161–170.

Illouz, Y. (1988) Present results of fat injection. *Aesthetic Plastic Surgery* **12:** 175–181.

Isaacson, G., Kim, J., Kirchner, J., Kirchner, J. (1990) Histology of Isshiki Thyroplasty Type 1. *Annals of Otology, Rhinology and Laryngology* **99:** 42–45.

Isshiki, N. (1989) *Phonosurgery; Theory and Practice.* Springer-Verlag, Tokyo Chapter 3: 23–33.

Isshiki, N., Morita, H., Okamura, H., Hiramoto, M. (1974) Thyroplasty as a new phonosurgical technique. *Acta Otolaryngology* **78:** 451–457.

Isshiki, N., Tanbe, M., Sawada, M. (1978) Arytenoid adduction for unilateral vocal cord paralysis. *Archives of Otolaryngology* **104:** 555–558.

Kaufman, J. (1986) Laryngoplasty for vocal cord medialization: an alternative to Teflon. *Larynoscope* **96:** 726–731.

Kaufman, J. (1993) Management of vocal fold paralysis. The Centre for voice disorders of Wake University, Winston Salem, *The Visible Voice.* Vol. 2, Number 3: 50–71.

https://doi.org/10.1017/S0022215100132918 Published online by Cambridge University Press

Kirchenberg, M., Shwatz, I. (1985) Excitation and contraction of skeletal muscle. In *Best and Taylor's Physiological Basis of Medical Practice* (West, J. ed.), Williams and Wilkins, Baltimore, pp 58–106.
Lahey, F. (1928) Suture of the recurrent laryngeal nerve for bilateral abductory paralysis. *Annals of Surgery* **87:** 481–484.
Lewy, R. (1983) Teflon injection of the vocal cord: Complications, errors, and precautions. *Annals of Otology, Rhinology and Laryngology* **92:** 473–474.
Lewy, R., Millet, D. (1978) Immediate local tissue reactions to Teflon vocal cord implants. *Laryngoscope* **88:** 1339–1342.
Malizia, A. (1984) Migration and granulomatous reaction after periurethral injection of Polytef {Teflon}. *Journal of the American Medical Association* **251:** 3277–3281.
May, M., Barry, Q. (1986) Muscle-nerve pedicle reinnervation. *Laryngoscope* **96:** 1196–1200.
McCaffrey, T. (1993) Transcutaneous teflon injection for vocal cord paralysis. *Otolaryngology–Head and Neck Surgery* **109:** 54–59.
Meurman, Y. (1952) Operative mediofixation of the vocal cord in complete unilateral paralysis. *Archives of Otolaryngology* **55:** 544–553.
Mikaelian, D., Lowry, L., Sataloff, R. (1991) Lipoinjection for unilateral vocal cord paralysis. *Laryngoscope* **101:** 465–468.
Mikus, J., Kaufman, J., Kilpatrick, S. (1995) Fate of liposuctioned and purified autologous fat injections in the canine vocal fold. *Laryngoscope* **105:** 17–22.
Montgomery, W., Blaugrund, S., Varvares, M. (1993) Thyroplasty: a new approach. *Annals of Otology, Rhinology and Laryngology* **102:** 571–579.
Netterville, J., Stone, R., Luken, E., Civantos, F., Ossoff, R. (1993) Silastic medialization and arytenoid adduction: The Vanderbilt experience. *Annals of Otology, Rhinology and Laryngology* **102:** 413–424.
Opheim, O. (1955) Unilateral paralysis of the vocal cord. Operative treatment. *Annals of Otolaryngology* **45:** 226–230.
Payr, E. (1915) Plastik am Schildknorpel zur Behebung Folgen einsteiner Stimmbandlahmung. *Deutsche medizinische Wochenschrift* **43:** 1265–1270.
Remacle, M., Hamoir, M., Etienne, M. (1990) Gax-collagen injection to correct aspiration problems after subtotal laryngectomy. *Laryngoscope* **100:** 663–669.
Rosen, M., Malmgren, L., Gacek, R. (1983) Three-dimensional computer reconstruction of the distribution of neuromuscular junctions in the thyroarytenoid muscle. *Annals of Otology, Rhinology and Laryngology* **92:** 424–429.
Sawashima, M., Totsuka, G., Kobayashi, T. (1968) Surgery for hoarseness due to unilateral vocal cord paralysis. *Archives of Otolaryngology* **87:** 289–294.
Schram, V., May, M., Lavorato, A. (1978) Gelfoam paste injection for vocal cord paralysis: Temporary rehabilitation of glottic incompetence. *Laryngoscope* **88:** 1268.
Sercarz, J., Berke, G., Gerratt, B., Ming, Y., Natividad, M. (1992) Videostroboscopy of human vocal fold paralysis. *Annals of Otology, Rhinology and Laryngology* **101:** 567–577.
Slavit, D., McCaffery, T. (1991) Regulation of phonatory efficiency by vocal fold tension and glottic width in the excised canine larynx. *Annals of Otology, Rhinology and Laryngology* **100:** 668–677.
Spiegel, J., Sataloff, R. (1987) The treatment of vocal fold paralysis with injectable collagen: clinical concerns. *Journal of Voice* **1:** 119–121.
Stone, J., Arnold, G. (1967) Human larynx injected with Teflon paste. *Archives of Otolaryngology* **86:** 550–561.
Strasnick, B., Berke, G., Ward, P. (1991) Transcutaneous teflon injection for unilateral vocal cord paralysis: An update. *Laryngoscope* **101:** 785–787.
Tucker, H. (1983) Complications after surgical management of the paralysed larynx. *Laryngoscope* **93:** 295–298.
Tucker, H. (1987) In *The Larynx*. 1st edition. Thieme Medical Publishers Inc., New York, pp 235–258.
Von Leden, H. (1991) The history of phonosurgery. In *Phonosurgery: Assessment and Surgical Management of Voice Disorders.* (Ford, C., Bless, D., eds.), Raven Press Ltd., New York, pp 3–23.
Wexler, D., Gray, S., Jiang, J., Titze, I. (1989) Phonosurgical studies: Fat-graft reconstruction of injured canine vocal cords. *Annals of Otology, Rhinology and Laryngology* **98:** 668–672.

Address for correspondence:
Meredydd Lloyd Harries,
The Voice Clinic,
The Royal National Throat Nose and Ear Hospital,
Grays Inn Road,
London WC1X 8DA.

https://doi.org/10.1017/S0022215100132918 Published online by Cambridge University Press