

One hundred years of external approach medialisation thyroplasty

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Abstract

It has been 100 years since Erwin Payr first developed an operation to improve the effects of a paralysed vocal fold, and operations based on this technique are still in use today. This technique, medialisation thyroplasty, aims to improve the symptoms caused by vocal fold palsy by realigning the lateralised vocal fold into the midline.

Whilst the effects of vocal fold palsy were recognised in antiquity, it was only with the development of indirect laryngoscopy in the late nineteenth century that the vocal fold paralysis could be identified as an aetiology for poor phonation and dysphagia. Payr, in 1915, was the first to perform a recognisable form of medialisation thyroplasty, which was further developed in the early twentieth century, but medialisation thyroplasty did not begin to be widely used until the development of the modern technique by Isshiki *et al.*, in 1974.

Since then, medialisation thyroplasty has continued to be developed and is currently the most widely used technique for correcting the effects of vocal fold palsy. However, a wide array of therapeutic options is now available for vocal fold palsy and it is impossible to say whether or not medialisation thyroplasty will still be used in another 100 years.

Key words: Laryngoplasty; Laryngoscopy; Otolaryngology; Vocal Cord Paralysis; Deglutition Disorders; Vocal Cords; Thyroid Cartilage; Larynx; Phonation; History; Inventions

Introduction

It has been 100 years since Erwin Payr first developed an operation to improve the effects of a paralysed vocal fold,¹ and operations based on this technique are still in use today. This technique, medialisation thyroplasty, aims to improve the symptoms caused by vocal fold palsy by realigning the lateralised vocal fold into the midline.² This allows the non-paralysed vocal fold to adduct fully against the paralysed vocal fold, permitting the vocal folds to return to their normal function of lower airway protection, respiration and phonation.³

Although relatively uncommon in the general population,^{4,5} vocal fold palsy can have a devastating effect on the basic functions of the larynx.^{6,7} It is not a disease *per se*⁸ and is rarely due to diseases of the larynx; rather, it is most commonly caused by lung and oesophageal cancers,^{9,10} trauma,⁸ and post-operative complications.¹¹ Some patients, especially those who are otherwise well, can compensate for a paralysed vocal fold by aligning the normal vocal fold across the midline.⁵ However, this can cause significant morbidity in the generally co-morbid patients most commonly affected by vocal fold palsy. In these patients, vocal fold palsy can lead to complications including

voice hoarseness, dysphagia, cough, sore throat, breathlessness, aspiration and stridor.^{5,12}

Historical vocal fold palsy treatments

The importance of the larynx and vocal folds in voice production was well understood by the ancient Greeks. The author of the Hippocratic work ‘On the Flesh’ first noted that patients with a severed larynx, for example due to attempted suicide, were left without a voice.¹³ Galen, in the second century AD, also noted the importance of the recurrent laryngeal nerves, and experimentally proved their importance in voice production.¹⁴ However, vocal fold palsy could not be formally diagnosed without the ability to view the vocal folds, which was impossible until the nineteenth century.

A Frenchman, Leveret, is credited with the first attempt to examine the living larynx, in 1743, with a bent mirror and a snare for removing laryngeal polyps,^{15,16} but his technique was not widely adopted. Both Bozzini in Germany, in 1807,¹⁶ and Babbington in England, in 1829,^{13,16} made further attempts to visualise the vocal folds, but Bozzini’s device was ignored. Babbington’s device was the first to be recognisable as a laryngoscope; however, he

never published details of his invention. It was not until 1854 that Manuel Garcia, a Spanish voice teacher, developed the first widely known laryngoscope.¹⁶ Ludwig Türck and Johann Czernak became the first physicians to be recognised for viewing the larynx of living patients in 1858,¹⁶ at which point the field of laryngology as a whole began to greatly expand.

By 1892, vocal fold paralysis was recognised as a neurological problem of the larynx, as discussed in a textbook written by Bosworth.¹⁷ However, treatment for vocal fold paralysis was slow to develop, with Jackson and Jackson's 1942 text on laryngology stating that treatment for vocal fold paralysis 'is chiefly the treatment of the basic disease causing the paralysis. Nothing is of any avail locally'.¹⁸ During this time, surgery for laryngeal cancers was beginning to develop, with Bilroth performing the first total laryngectomy in 1873.¹⁹

Brunnings, in 1911, was one of the first to document attempts to repair vocal fold palsy. He described a technique to medialise paralysed vocal folds by injecting the paralysed fold with paraffin.²⁰ This method proved to be highly successful;²¹ however, paraffin was found to cause severe local foreign body reactions, such as paraffinomas,²² so experiments with injection therapy continued with other materials.²⁰ Teflon was the most widely used material for injection therapy after its introduction by Arnold in 1962.^{20,23} Although effective at producing medialisation of the paralysed vocal fold, issues such as a relatively high rate of airway compromise,²⁴ the formation of Teflon granulomas²⁵ and formations of intra-thyroid masses mimicking thyroid carcinoma²⁶ led to a search for alternative methods for vocal fold medialisation.

Historical medialisation thyroplasty methods

The first attempt at true medialisation thyroplasty was conducted in 1915, by a German surgeon called Erwin Payr.¹ Although probably best known for his work in neurosurgery, Payr had an interest in multiple areas of surgery, with Payr's disease, Payr's sign, Payr's membrane and the Payr pylorus clamp all named after him.²⁷ He developed many novel surgical techniques and instruments during his career, and had particular interests in joint disorders, vascular surgery and nerve surgery.²⁸

Payr's interest in thyroid surgery in particular led him to work on an operation for vocal fold palsy.^{1,29} He had noted that compression of the elastic thyroid cartilage significantly improved the voice of a young soldier with dysphonia following a thyroidectomy. In order to replicate this effect, Payr's operation involved a U-shaped incision through the thyroid cartilage, utilising an anteriorly pedicled flap of thyroid cartilage depressed inwards with a small wedge of cartilage to force the vocal fold into the midline.¹ However, there were several disadvantages to this technique. Lack of safe anaesthesia, blood replacement and risk of

infection³⁰ complicated all surgical techniques during this time period, but this particular operation was prone to post-operative infections and was associated with a high incidence of airway compromise.³¹ Complications specific to Payr's surgery included the unpredictable durability of the pedicle,³² especially when the thyroid cartilage was calcified,²¹ as well as difficulty in determining the degree of vocal fold displacement and in fixing the cartilage in the desired position.³³

Local treatments for vocal fold paralysis were thought to be ineffective as late as 1941,³⁴ but modifications to Payr's approach were made over the next few decades. A diagram illustrating some of the different external approaches to medialisation thyroplasty is shown in Figure 1. One of the very earliest attempts was by Seiffert in 1942, who utilised a piece of cadaveric rib cartilage implanted through a hole in the thyroid cartilage to medialise the vocal fold.³³ Meurman published on a series of 15 cases in 1952, where cartilage taken from the costal rib was implanted via an external approach between the thyroid cartilage and the inner perichondrium in order to place a paralysed vocal fold into a median position.³⁵ A similar technique was devised by Opheim in 1955, who instead used an incised piece of the thyroid cartilage itself, inserted via an external incision at the level of the vocal folds in the inner perichondrium.³⁶ However, these techniques and others that involved direct intervention on the soft tissue immediately lateral to the vocal fold led to post-operative oedema, which often required a tracheostomy.²²

Despite these early setbacks, the value of medialisation thyroplasty was evident and the search for better ways to surgically medialise paralysed vocal folds continued. Sawashima *et al.*, in 1968, developed a method based on that of Meurman and Opheim, which used an incised piece of thyroid cartilage placed between the ala of the thyroid cartilage and the inner perichondrium via an incision in the external thyroid cartilage.³⁷ Kamer and Som, in 1972, used a similar technique to place a piece of thyroid cartilage incised from its lower rim in patients after traumatic vocal fold paralysis.³⁸ Tucker in 1979 and 1983 further developed a similar technique, inserting a piece of thyroid cartilage from the ipsilateral upper margin of the ala into a pocket created between the inner perichondrium and the cartilage at the level of the vocal folds.^{39,40} Kressner, in 1953, devised a technique utilising two cartilage implants; one aimed to shift the paralysed vocal fold medially, whilst the other smaller piece was inserted into the cricoarytenoid joint space to lift the arytenoid and to further medialise the posterior part of the vocal fold.⁴¹ This technique was refined and used in a series of 12 patients by Westhues in 1973.⁴² Deneke, in 1964, used a wedge from the posterior edge of the thyroid, but kept this in place by dividing the cricoarytenoid tendon, medially displacing the arytenoid and suturing it against

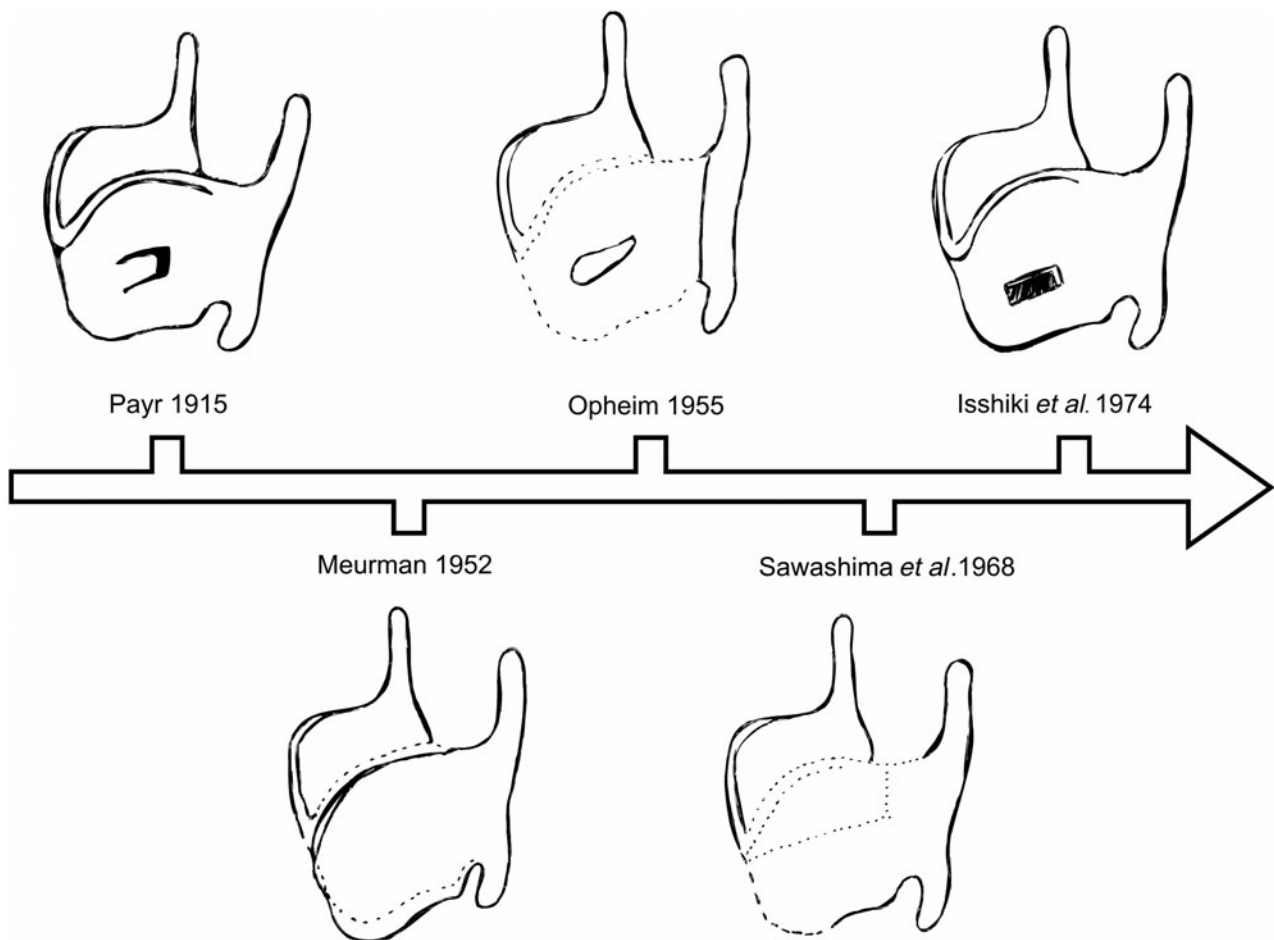


FIG. 1

A diagram illustrating some of the different external approaches to medialisation thyroplasty, from Payr¹ in 1915 to Isshiki *et al.*²² in 1974. Payr¹ (1915) described a U-shaped incision made in the thyroid cartilage at the level of the vocal folds, which is displaced inwards to medialise the underlying vocal fold. Meurman³⁵ (1952) reported splitting the anterior angle of the thyroid cartilage, avoiding damage to the perichondrium, and making a pocket for the cartilage implant between the perichondrium and the inner side of the thyroid ala. Opheim³⁶ (1955) described splitting the thyroid cartilage along the anterior midline using a small electric saw, avoiding damage to the inner perichondrium. A horizontal incision was made through the inner perichondrium at the level of the vocal folds, through which a small pouch was formed for the cartilage implant. Sawashima *et al.*³⁷ (1968) reported excising a cartilage implant from the upper part of the thyroid ala, contralateral to the paralysed vocal fold. An incision was then made through the anterior angle of the thyroid cartilage, avoiding damage to the underlying perichondrium, and a pocket was made between the thyroid cartilage and the perichondrium at the level of the vocal folds for insertion of the cartilage implant. Isshiki *et al.*²² (1974) described a rectangular incision made through the thyroid cartilage at the level of the vocal folds, and the insertion of a Silastic implant shaped to the size of the incision, abutting the laryngeal mucosa.

the cartilage wedge.⁴³ These techniques all relied on cartilage implants, and concerns about the long-term durability of the implants limited their widespread application.

Not all of the early techniques utilised pieces of thyroid cartilage. Libersa, in 1952, developed a technique similar to that of Meurman, with the only significant difference being the use of a piece of acrylic as an implant instead of cartilage.⁴⁴ Morrison, in 1948, described a technique to displace the arytenoid cartilage towards the midline along the (partially removed) posterior superior border of the cricoid cartilage in order to medialise the vocal folds, which was the first attempt at correcting arytenoid displacement,⁴⁵ whereas Montgomery, in 1966, fixed the arytenoid cartilage to the cricoid cartilage in a new position with a pin.⁴⁶ However, neither of these methods gained much popularity because of their technical difficulty.²²

Bernstein and Holt, in 1967, attempted to reposition the vocal fold in experimental animals by transposing the sternohyoid muscle between the thyroid cartilage and inner perichondrium,⁴⁷ whilst Mündnich, in 1970, tensed and medially shifted the vocal fold by pulling and fixing the arytenoid towards the lower horn of the thyroid cartilage.⁴⁸ However, thyroplasty did not gain widespread acceptance⁴⁹ until the development of type I thyroplasty in 1974.

Modern medialisation thyroplasty

Isshiki and his team at Kyoto University first described the technique now known as type I thyroplasty in 1974, in a paper describing a series of operations on dogs. Instead of operating directly on the vocal folds, which caused mucosal scarring, reducing vocal fold compliance and hindering vibration,⁵⁰ they instead aimed to alter the position and physical property of

the vocal fold by actively changing the cartilaginous framework on which the vocal folds were suspended.²² As discussed above, this was not an entirely novel idea, and shared the same basic principle as Payr's initial 1915 operation.

Type I thyroplasty involves creating a window into the anterior thyroid cartilage ala under local anaesthesia, with or without sedation, and inserting a prosthesis, which was initially made from Silastic (a type of hardened silicone⁵¹).²² This pushes the paralysed vocal fold medially, allowing it to make contact with a non-paralysed vocal fold on the opposite side and restoring its function.³ Being able to carry out this procedure under local anaesthesia is a major benefit, as this not only enables patients otherwise unfit for general anaesthesia to undergo the procedure, but also allows for auditory feedback from the patient's own voice to ensure the best possible vocal result.³ It is also a much simpler surgical procedure than those developed before it, taking around 30 minutes to complete in an uncomplicated case.³

However, type I thyroplasty was not immediately widely used. Koufman noted in 1986 that Teflon injection was still the most common therapy for vocal fold palsy, despite its drawbacks.²³ Koufman's 1986 paper described a slightly modified version of Isshiki's technique, wherein a Silastic implant is inserted through a window in the thyroid cartilage, and the best possible improvement in voice and glottic closure is ensured by asking the patient to phonate during the procedure and by viewing the vocal fold intra-operatively under fibre-optic examination.²³

Koufman's post-operative outcomes were very good, supporting the more widespread use of medialisation thyroplasty.²³ Thyroplasty started to become much more widely utilised after this review, as discussed by Netterville *et al.* in 1993.²⁴ Netterville *et al.* reviewed a series of 116 medialisation thyroplasty operations performed on 100 patients from 1987 to 1992, and observed both the results and complication rates of the surgery. These authors found that deglutition and aspiration were universally improved, and the voices of a vast majority of patients were significantly better. The ability to adjust or reverse the procedure (by moving or removing the implant) represented a significant improvement over Teflon injections. The authors also found that it was much easier to train junior doctors to perform medialisation thyroplasty.²⁴ In addition, the complication rate was very low, with no patients having extrusion of their implant, although one implant needed to be removed because of post-irradiation laryngocutaneous fistula formation.²⁴

Thyroplasty started to become more widespread over the next few years, quickly becoming the treatment modality of choice in some centres,⁵² particularly when it was shown that medialisation thyroplasty led to an improved vocal result when compared to Teflon injections.²⁰ A review of 84 patients by Flint *et al.* showed that medialisation thyroplasty improved

dysphagia and reduced aspiration rates, improving outcomes when compared to conservative management alone.⁶ Isshiki's technique has continued to be used and modified over the two decades following its initial development,^{31,50,53–55} and was considered the 'gold standard' treatment by 1999.³¹

Currently, medialisation thyroplasty is still the gold standard and most widely used surgical technique for vocal fold medialisation. The technique continues to be modified.⁵⁶ The most commonly used modification involves the use of a folded piece of Gore-Tex rather than a Silastic implant,⁵⁷ which allows the degree of medialisation to be fine-tuned without having to remove and re-carve the entire implant,⁵⁸ and is now becoming the most commonly used implant.⁵¹ Medialisation thyroplasty is also increasingly being combined with a similar surgery, arytenoid adduction, in which the arytenoid muscle is pulled across anteriorly by a suture until it is almost parallel to the lateral cricothyroid muscle.⁵⁹ This is particularly helpful in closing posterior gaps between adducted vocal folds, which further improves⁶⁰ the changes in voice seen after medialisation thyroplasty.^{4,56,61}

As with all surgical procedures, medialisation thyroplasty is by no means perfect. The surgery is often carried out under local anaesthesia, is of short duration and involves little risk of significant blood loss,⁶² allowing this operation to be carried out in frail patients with significant co-morbidities such as multiple cranial neuropathies and terminal cancer. Post-operative haemorrhage into the vocal folds can cause airway obstruction requiring tracheostomy,⁶² although this complication has become less common as the original technique has been refined over time.^{4,63} A much more common complication of medialisation thyroplasty is implant extrusion, with an estimated incidence of 0.8–9.8 per cent,^{64,65} which generally presents as increasing dysphonia.⁶⁴ Fortunately, one of the advantages of medialisation thyroplasty is its potential reversibility. An extruded implant is generally very straightforward to remove by either an open or endoscopic approach,^{4,62–64} and it is possible for a patient to undergo revision thyroplasty to replace a malpositioned or extruded implant.^{66,67}

Conclusion

External approach medialisation thyroplasty was not the only surgical technique developed over the last 100 years to repair vocal fold palsy.⁶⁸ Voice therapy together with surgical techniques can improve phonation,⁶⁹ but the two main surgical alternatives to medialisation thyroplasty are vocal fold injection and vocal fold re-innervation.⁷

Vocal fold injection with Teflon was the most commonly used technique for several decades, but problems with vocal fold granuloma formation, lack of reversibility and over-reliance on an individual surgeon's skill decreased the popularity of this technique.^{20,23,25} Injection therapy has been employed

using other materials, including collagen (autologous or from animal sources^{12,70}), autologous fat^{71,72} or Gelfoam.⁷³ However, most of the new materials used for injection therapy are reabsorbed, meaning that patients will often need either repeat injections or further intervention with medialisation thyroplasty unless the vocal fold palsy resolves. This is an advantage in patients where fast, temporary intervention is needed; hence, injection therapies are still in widespread use.^{12,74} Research into injection therapy for vocal fold palsy is ongoing. Some research shows long-term improvement after autologous fascia transplantation,⁷⁵ possibly because of the transfer of tissue stem cells and the regeneration of damaged tissues in the vocal folds.^{70,76} Injection medialisation is currently undergoing a resurgence in popularity because the procedure can be performed in the office under local anaesthesia. There is ongoing evidence that early injection for unilateral vocal fold palsy gives a good voice outcome.^{74,77} This procedure is being adopted in many units where the nature of surgery exposes the recurrent laryngeal nerve, such as head and neck dissection, and cardiothoracic, cervical spinal or skull base surgery.

Another alternative approach is that of paralysed vocal fold re-innervation. Medialisation thyroplasty minimises the effect of vocal fold palsy without treating the underlying paralysis of the vocal fold; re-innervating the fold should, in theory, recreate its normal mass and tension.²⁶ Initial operations aimed to anastomose the ansa hypoglossi to the recurrent laryngeal nerve,^{26,78,79} but the most common technique used in re-innervation is to anastomose the ansa cervicalis and the recurrent laryngeal nerve.^{80–83} This technique is often carried out in combination with either injection therapy or laryngeal framework surgery because there is a significant delay before full improvements to the voice are seen, as it takes time for the anastomosed nerve to regenerate.^{26,79,84,85}

One hundred years after the first operation, medialisation thyroplasty remains the method of choice for treating vocal fold palsy,⁸⁶ with significant benefits to both vocal performance and quality of life in the patients on whom it is performed.^{87,88} However, with experimental advances, the rise of re-innervation and resurgence of injection medialisation, it is impossible to say whether it will remain the gold standard in another 100 years. Whatever the future holds, it will be a very interesting journey.

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