# 100 Years of External Approach Medialization 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 cord, and operations based on this technique are still in use today. This technique, medialization thyroplasty, aims to improve the symptoms caused by vocal cord palsy by realigning the lateralized vocal cord into the midline.

Whilst the effects of vocal cord palsy were recognised in antiquity, it was only with the development of indirect laryngoscopy in the late 19th century that the vocal cord paralysis could be recognised as an aetiology for poor phonation and dysphagia. Payr in 1915 was the first to perform a recognizable form of medialization thyroplasty, which was further developed in the early 20th century; but medialization thyroplasty did not begin to be widely used until the development of the modern technique by Isshiki et al in 1974.

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

# Introduction

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

Although relatively uncommon in the general population[4][5], vocal cord 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, but is most commonly due to, lung and oesophageal cancers[9][10], trauma[8] and postoperative complications[11]. Some patients, especially those who are otherwise well, can compensate for a paralyzed vocal cord by aligning the normal vocal cord across the midline[5], but this can cause significant morbidity in the otherwise generally co-morbid patients most commonly affected by vocal cord palsy. In these patients, vocal cord palsy can lead to complications including voice hoarseness, dysphagia, cough, sore throat, breathlessness, aspiration and stridor[5][12].

# Historical Treatments for Vocal Cord Palsy

The importance of the larynx and vocal cords in voice production was well understood by the ancient Greeks, when 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 cord palsy could not be formally diagnosed without the ability to view the vocal cords, which was impossible until the 19th 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 Babington in England in 1829[13][16] made further attempts to visualise the vocal cords, 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 cord paralysis was recognised as a neurological problem of the larynx, as discussed in a textbook written by Bosworth[17]. However, treatment for vocal cord paralysis was slow to develop, with Jackson's 1941 text on laryngology stating that treatment for vocal cord 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]. One of the first documented attempts to solve vocal cord palsy was that of Brunnings in 1911, who described a technique to medialize paralysed vocal cords by injecting the paralysed cord 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 medialization of the paralyzed vocal cord, issues such as a relatively high rate of airway compromise[24], the formation of Teflon granulomas[25] and the formations of intra-thyroid masses mimicking thyroid carcinoma[26] led to a search for alternative methods for vocal cord medialization.

## Historical Methods of Medialization Thyroplasty

The first attempt at true medialization thyroplasty was 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 membrane and the Payr pylorus clamp all named after him[27]. He developed many novel surgical techniques and instruments during his career, with particular interests in joint disorders, vascular surgery and nerve surgery[28]. His interest in thyroid surgery in particular led him to work on an operation for vocal cord palsy; he noted that compression of the elastic thyroid cartilage significantly improved the voice of a young soldier with

dysphonia following a thyroidectomy[1][29]. In order to replicate this effect, Payr's operation involved a an 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 cord into the midline[1]. However, there were several disadvantages to this technique. Lack of safe anaesthesia, blood replacement and risk of infection[30] complicated all surgical techniques during this time period, but this operation was prone to postoperative infections and had 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 cord displacement and in fixing the cartilage in the desired position[33].

Local treatments for vocal cord paralysis were thought to be ineffective as late as 1941[34], but modifications to Erwin Payr's approach were made over the next few decades. One of the very earliest attempts was by Seiffert in 1942, who utilized a piece of cadaveric rib cartilage implanted through a hole in the thyroid cartilage to medialize the vocal cord[33]. Meurman published 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 to place a paralyzed vocal cord 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 cords in the inner perichondrium[36]; however, these techniques and others which involved direct intervention on the soft tissue

immediately lateral to the vocal cord led to post-operative oedema, which often required a tracheotomy[22].

Despite these early setbacks, the theory rang true and the search for better ways to surgically medialize paralysed vocal cords continued. Sawashima et al. in 1968 developed a method based on that of Meurmann 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 & Som in 1972 used a similar technique to place a piece of thyroid cartilage incised from its lower rim in patients after traumatic vocal cord 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, and inserting it into a pocket created between the inner perichondrium and the cartilage at the level of the vocal cords[39][40]. Kressner in 1953 devised a technique utilising two cartilage implants; one aimed to shift the paralyzed vocal cord medially while the other, smaller, piece was inserted into the cricoarytenoid joint space to lift the arytenoid and to further medialize the posterior part of the vocal cord[41], with the technique being 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 the cartilage wedge[43]. These techniques all relied on cartilage implants, and concerns about the long term durability of the implants limited the widespread application of these techniques.

Not all of these initial techniques utilized pieces of thyroid cartilage; Libersa in 1952 developed a technique similar to that of Meurmann, with the only significant difference being the use a piece of acryl as an implant instead of cartilage[44]. Morrison in 1948 described a technique to displace the arytenoid cartilage toward the midline along the (partially removed) posterior superior border of the cricoid cartilage to medialize the vocal cords, which is 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 due to their technical difficulty[22]. Bernstein and Holt in 1967 attempted to reposition the vocal cord in experimental animals by transposing the sternohyoid muscle between the thyroid cartilage and inner perichondrium[47]; whilst Mündnich in 1970 tensed and medically shifted the vocal cord by pulling and fixing the arytenoid towards the lower horn of the thyroid cartilage[48]. However, thyroplasty did not gain widespread acceptance[49] until the development of type I thyroplasty in 1974.

## Modern Medialization Thyroplasty

Issihiki and his team at Kyoto University first described the technique now known as type I thyroplasty in 1974, with a paper describing a series of operations on dogs. Instead of operating directly on the vocal cords, which caused scarring of the mucosa, reducing vocal cord compliance and hindering vibration[50], he instead aimed to change the position and physical property of the vocal cord by actively changing the cartilaginous framework on which the

vocal cords 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 anaesthetic with or without sedation, and inserting a prosthesis, which was initially made from Silastic (a type of hardened silicone[51])[22]. This pushed the paralyzed vocal cord medially, allowing it to make contact with a non paralyzed vocal cord on the opposite side and restoring its function[3]. Being able to carry out this procedure under local anaesthetic is a major benefit, as this not only allows patients otherwise unfit for general anaesthetic 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 that those developed before it, taking around 30 minutes to complete in an uncomplicated patient[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 cord palsy, despite its drawbacks[23]. However, Koufman's1986 paper described slightly modified version of Isshiki's technique in was  in, wherein a silastic implant  is implanted 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 as well as viewing the vocal cord using intra-operative fibre-optic examination[23].

Koufman's post-operative outcomes were very good, and suggested that medialization thyroplasty may be used more widely in the future[23].

Thyroplasty started to become much more widely used after this review, as discussed by Netterville et al. in 1993[24]. He reviewed a series of 116 medialization thyroplasty operations on 100 patients from 1987 to 1992, and observed both the results and complication rates of the surgery. He found that deglutition and aspiration were universally improved, and the voices of a vast majority of patients were significantly improved. The ability to adjust or reverse the technique (by moving or removing the implant) was a significant improvement over Teflon injections, and he found that it was much easier to train his juniors to perform medialization thyroplasty[24]. The complication rate was also very low, with no patients extruding their implant, although one needed to be removed due to a post-irradiation laryngo-cutaneous 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 medialization thyroplasty caused an improved vocal result when compared to Teflon injections[20]. A review of 84 patients by Flint et al. showed that medialization 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][54][55], and was considered gold standard treatment by 1999[31].

Currently, medialization thyroplasty is still the gold standard and most widely used surgical technique for vocal cord medialization. The technique continues

to be modified[56], with the most commonly used modification exchanging a folded piece of Gore-Tex for the silastic implant[57], which allows the degree of medialization 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]. Medialization 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 cords, which further improves(60) the changes in voice seen after medialization thyroplasty[4][56][61].

As with all surgical procedures, medialization thyroplasty is by no means perfect. The surgery is often carried out under local anaesthetic, 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 cords 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 medialization thyroplasty is extrusion of the implant, with an estimated incidence of 0.8% to 9.8%[64][65],and generally noted by the patient as increasing dysphonia[64]. Fortunately, one of the advantages of medialization thyroplasty is its potential reversibility, and an extruded implant is generally very straightforward to remove by either an open on endoscopic approach[4][62][63][64], and it is possible for a patient to undergo a revision thyroplasty to replace a mal-positioned or extruded implant[66][67].

## Conclusion

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

Vocal cord injection with Teflon was the most commonly used technique for several decades; but problems with vocal cord granuloma formation, lack of reversibility and over-reliance on an individual surgeon's skill made this technique fall into disuse[20][23][25]. Injection therapy using other materials has been developed, with common 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 medialization thyroplasty unless the cause of the vocal cord palsy resolves. This is an advantage in patients where fast, temporary intervention is needed, so injection therapies are still in widespread use[12][74]. Research into injection therapy for vocal cord palsy is ongoing, and some research shows long-term improvement after autologous fascia transplantation[75]; possibly due to the transfer of tissue stem cells and the regeneration of damaged tissues in the vocal cords[70][76]. Injection medialization is currently undergoing a resurgence in popularity due to the ability to perform the procedure in the office under

local anaesthetic. There is ongoing evidence that early injection for unilateral vocal cord 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, cardiothoracic, cervical spinal or skull base surgery.

Another alternative approach is that of re-innervation of the paralyzed vocal cord. Medialization thyroplasty minimises the effect of vocal cord palsy without treating the underlying paralysis of the vocal cord; re-innervating the cord 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][81][82][83]. This technique is often carried out in combination with either injection therapy or laryngeal framework surgery, as there is a significant delay before the full improvements to the voice are seen, as it takes time for the anastomosed nerve to regenerate[26][79][84][85].

100 years after the first operation, medialization thyroplasty remains the method of choice for treating vocal cord 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 the number of experimental advances, the rise of re-innervation and the resurgence of injection medialization, 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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## Summary

- 100 years since the first medialization thyroplasty operation, carried out in 1915 by Erwin Payr
- Development of indirect laryngoscopy in the late 19th century led to the recognition of vocal cord palsy as a medical condition
- Many operations to correct vocal cord palsy were developed between 1915 and 1974, but were not widely used
- Isshiki et al. type I medialization thyroplasty, developed in 1974, soon became the gold standard therapy for correcting vocal cord palsy
- Medialization thyroplasty continues to be improved, but alternatives such as injection therapies and re-innervation are also being developed

# Figures

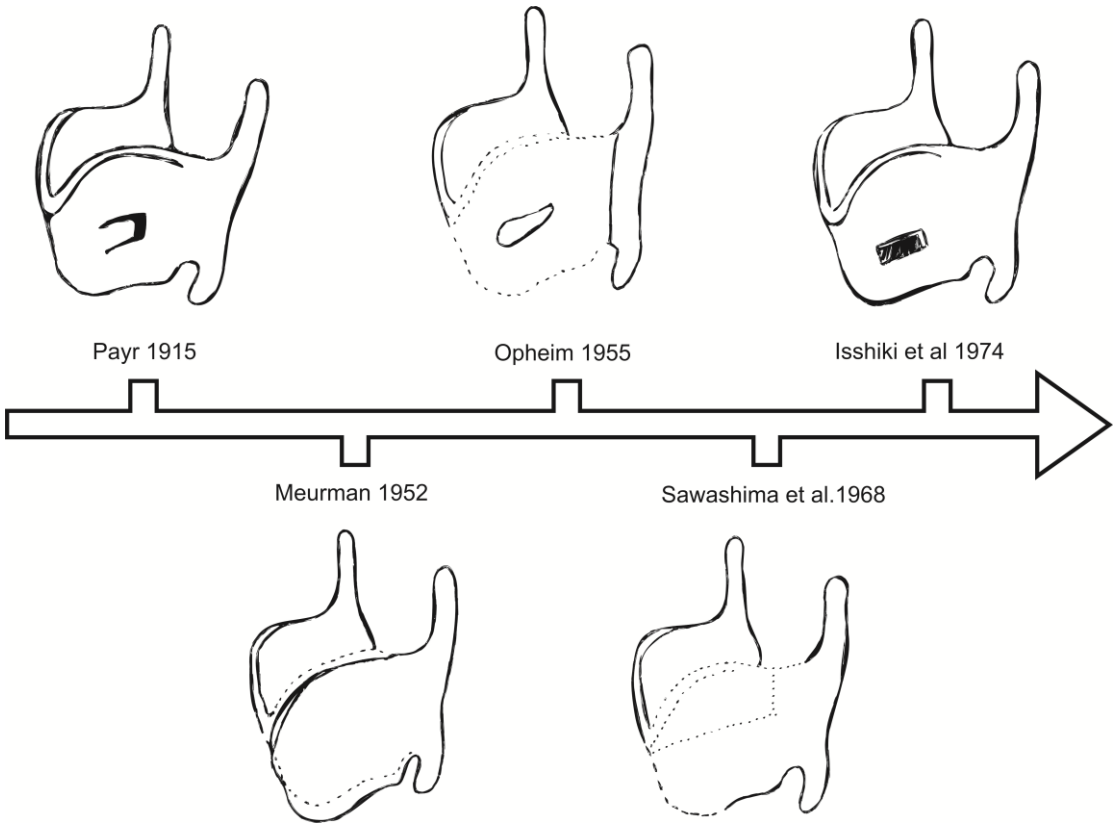


**Figure 1:** A diagram illustrating some of the different external approaches to medialization thyroplasty from Payr in 1915 to Isshiki et al. in 1974.

Payr 1915: A U-shaped incision is made in the thyroid cartilage at the level of the vocal cords, which is displaced inwards to medialize the underlying vocal cord.

Meurman 1952: The anterior angle of the thyroid cartilage is split, avoiding damage to the perichondrium, and a pocket is made for the cartilage implant between the perichondrium and the inner side of the thyroid ala.

Opheim 1955: The thyroid cartilage is split along the anterior midline using a small electric saw, avoiding damage to the inner perichondrium. A horizontal incision is made through the inner perichondrium at the level of the vocal cords, through which a small pouch is formed for the cartilage implant.

Sawashima et al. 1968: A cartilage implant is excised from the upper part of the thyroid ala, contralateral to the paralysed vocal cord. An incision is then made through the anterior angle of the thyroid cartilage, avoiding damage to the underlying perichondrium, and a pocket is made between the thyroid cartilage and the perichondrium at the level of the vocal cords for insertion of the cartilage implant.

Isshiki et al. 1974: A rectangular incision is made through the thyroid cartilage at the level of the vocal cords, and a Silastic implant shaped to the size of the incision is inserted, abutting the laryngeal mucosa.