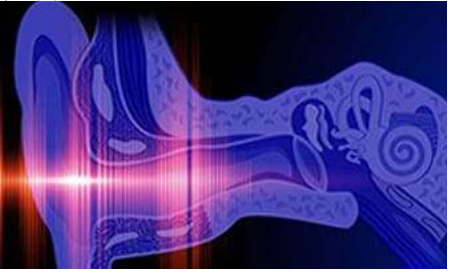


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## Medialization thyroplasty in patients with unilateral vocal fold paralysis

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### Abstract

Unilateral vocal fold paralysis (UVFP) is a common condition which has a variable personal and socioeconomic impacts on those affected, patients often present with dysphonia as a major complaint and sometimes aspiration. The most common etiologies usually following neck, thyroid, or chest surgery and idiopathic.

There are multiple procedures used for the management of UVFP; injection laryngoplasty (IL), medialization laryngoplasty (ML) with or without arytenoid adduction (AA) and laryngeal reinnervation.

Medialization laryngoplasty or type-1 thyroplasty initially described by Isshiki *et al.* in 1974 which consider now the most frequent used permanent procedure for UVFP by inserting autologous or synthetic material through the window of thyroid cartilage, to enhance vocal fold contact and enhance vibration necessary for phonation, it is necessary to medialize the afflicted vocal fold.

**Keywords:** Medialization thyroplasty, unilateral vocal fold paralysis

### Introduction

Payer (1915) was the first to introduce laryngeal framework procedure, but this technique failed to accomplish sufficient medialization of the vocal fold, prompting Isshiki *et al.* (1975)<sup>[14]</sup> to redefine the procedure and its implications. Koufrnan (1986) popularized the surgery in the United States. Isshiki and colleagues (1974) delineated four techniques referred to as LFS, which aim to modify the vocal folds' tension, mass, and position in order to impact vocal quality. Thyroplasty type I, also known as lateral compression, is a phonosurgical procedure primarily used to move a paralyzed vocal fold towards the middle. However, it can also be used for any laryngeal disease that causes incomplete closure of the vocal folds without swelling or a vocal fold tumor (Isshiki *et al.*, 1975)<sup>[14]</sup>. The next three laryngeal framework methods were developed with the aim of achieving lateral expansion, relaxation, and shortening of the vocal folds, as well as lengthening or stretching and are not typically utilized in unilateral vocal fold paralysis.

Currently, there are three methods of MT that can be employed for the treatment of laryngeal paresis and paralysis: (1) bilateral MT, (2) unilateral MT, and (3) Arytenoid adduction with MT. All of these surgical techniques has specific indications.

Arytenoid adduction is infrequently recommended as an independent surgery and is typically carried out in combination with MT.

Arytenoid adduction is specifically recommended for individuals who have innervated vocal folds and a laterally displaced arytenoid cartilage. Thus, it is advisable to consider arytenoid adduction as a treatment option for those with arytenoid dislocation or ankyloses, even in the absence of MT. The selection of the procedure for surgery is dependent on the surgeon's expertise, the patient's requirements, and the preoperative phonatory function and laryngoscopic assessment.

### Only Arytenoid adduction

- Lowers the vocal process' position.
- Positions the vocal fold and vocal process medially.
- Causes the arytenoid cartilage to rotate.

**Medialization laryngoplasty**

- Increases the thickness of the mid-membranous vocal fold.
- Enhances stiffness of the mid-membranous vocal fold.

**Utilizing both arytenoid adduction and medialization techniques concurrently**

- Moves the vocal fold medially.
- Seals the posterior gap.
- Causes the arytenoid cartilage to rotate.
- Increase the stiffness of the mid-membranous vocal fold.

**Contra-indications for medialization thyroplasty**

1. Patients with a hemorrhagic condition or weakened immune system. Individuals requiring chemotherapy may experience impaired wound healing and may not be suitable candidates.
2. Patients who have experienced a previous pneumonectomy and those with severe COPD will require a thorough evaluation of the impact of additional laryngeal surgeries and alterations in laryngeal resistance on their respiratory function.
3. In individuals with medical conditions, the presence of surgical complications that include temporary edema of the airway and hematoma may render even the most basic surgical operations unsuitable. Notwithstanding these precautions, the majority of those with vocal fold incompetence ought to be capable of enduring the brief MT operation under anesthesia without experiencing any negative consequences.

**Anesthesia**

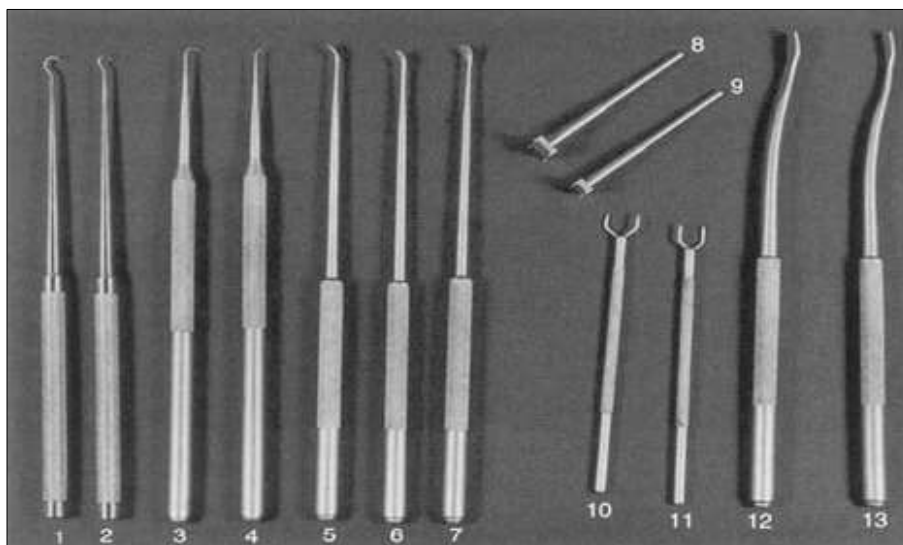
Medialization laryngoplasty is performed with local anesthetic. The patient's compliance is essential at specific intervals throughout the procedure. The administration of sedation, along with iv relaxation and narcotic pain medicine, is typically performed by the anesthesiologist. The titration of medicine for anxiety and pain managing must be carefully adjusted in order to preserve a balance

between the desire to produce vocal sounds and the preservation of reflexes that protect the airway. An iv mix of fentanyl and midazolam, or a short-acting narcotic, is commonly used to achieve sufficient sedation and pain relief during surgery, while also allowing the surgeon to assess the patient's vocal capabilities. Utilizing a combination of benzodiazepine agonist-antagonist (midazolam-flumazenil) gives the most favorable conditions for surgery and ensures patient comfort.

The administration of local anesthetic for MT involves injecting a solution of 1% lidocaine with 1:100,000 epinephrine directly into the thyroid cartilage. A midline injection measuring 3 cm by 3 cm is sufficient for MT. Subsequent injections are administered into the thyroid perichondrium at a greater depth following the initial superficial injection. Additional injections are administered on the sides of the thyroid alae for those who are receiving the arytenoid adduction - MT approach. In order to sufficiently anesthetize the larynx and pharynx for the combined arytenoid adduction -ML technique, injections are administered from the centerline to the inferior pharyngeal constrictors. It is important to be cautious in order to prevent the injection of local anaesthesia into the pyriform sinus area and the cricothyroid muscle. A suitable local anaesthesia should enable the surgeon to move the thyroid cartilage without causing any pain to the patient.

The administration of general anaesthesia for thyroplasty was accompanied with the placement of a laryngeal mask anesthetic, through which a fiber-optic bronchoscope was introduced. The use of continuous fiberoptic bronchoscopy allowed the surgeon to evaluate the optimal placement of the medialized vocal cord. General anaesthesia, utilizing a laryngeal mask anesthetic to evaluate the location of the voice cords during surgery, is a feasible option for conducting a thyroplasty.

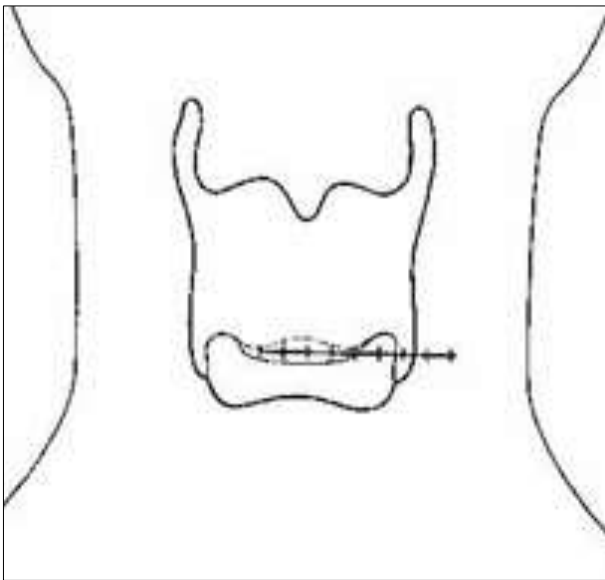
The utilization of superficial cervical nerve plexus block, when administered by a skilled anesthesiologist, is significant and enables the safe and efficient execution of medialization thyroplasty.



**Fig 1:** 1,2 curved hooks for traction on thyroid cartilage; 3,4 sharp hooks to elevate thyroid cartilage from thyroplasty window; 5,6 duckbill elevators to elevate inner perichondrium from thyroid cartilage; 7 chisel elevator used to separate inner perichondrium from thyroid cartilage; 8,9 window outline instrument, male and female; 10,11 window calipers, male (9mm) and female (7 mm); 12,13 implant insertors

### Surgical procedure

For exposure of the thyroid cartilage, a tiny incision should be made in the skin 1 cm paramedian on unaffected side 1 cm lateral from posterior margin of thyroid cartilage on the affected side. The dissection of the plane above the superficial layer of the deep cervical fascia is performed from below the cricoid cartilage to above the thyroid notch. The strap muscle is cut along the midline raphe and retracted to expose the thyroid cartilage. The outer perichondrium of the thyroid cartilage remains undisturbed while the thyrohyoid, sternohyoid, and sternothyroid muscles are moved to the side. Retractors are employed for retracting the strap muscles, as depicted in Figure 2. A solitary hook is positioned between the thyroid cartilage and the strap muscles, while anterior traction rolls are positioned in the thyroid cartilage' posterior superior cornu at the front. Next, the thyroid cartilage of the paralyzed larynx is carefully repositioned towards the center and brought into plain sight for the surgery. This procedure avoids the need for sectioning the strap muscles.



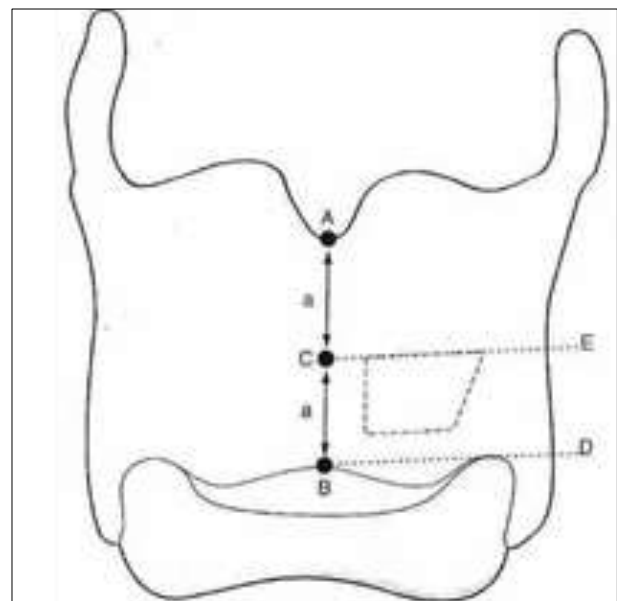
**Fig 2:** Skin incision for thyroplasty type 1

A broad, lower-positioned U-shaped perichondrial flap is subsequently formed above the thyroid cartilage. Once the perichondrial flap has been created and reflected, the next step is to identify the landmarks for the thyroplasty window. Accurate awareness of the position of the vocal fold as it appears on the external thyroid cartilage is crucial for the successful execution of type I thyroplasty. The upper boundary of the thyroid cartilage window ought to be created at the same level as the vocal folds. Various authors have examined the correlation between external anatomical landmarks of the larynx and the position of the vocal folds. The vocal fold posteriorly intersects with the meeting point of the upper two thirds and 49, 50 lower one third of the oblique line.

The main points of alignment are the central line of the thyroid cartilage, the lower edge of the thyroid notch, and the lower edge of the thyroid cartilage. The vocal folds are located in the lower portion of the thyroid cartilage. The "one half-one half" rule formula is universally suitable for larynges of all sizes. To begin, the caliper is used to determine the distance between the bottom of the thyroid notch and the lower border of the thyroid cartilage.

Generally, the average spacing is 16 to 20 mm for women and 20 to 24 mm for men. The distance from the thyroid notch to the inferior edge of the thyroid cartilage is halved to provide the upper boundary for the thyroplasty window. In males, the distance between the inferior border of the thyroid cartilage and the top of the thyroplasty window ranges from 10 to 12 mm. In females, the distance is between 8 and 10 mm. A line is drawn parallel to the lower edge of the thyroid cartilage over the thyroid cartilage, as shown in (Figure 3). The lower boundary of the thyroplasty window is located at a distance equal to half the distance from the upper margin of the thyroplasty window to the lower boundary of the thyroid cartilage.

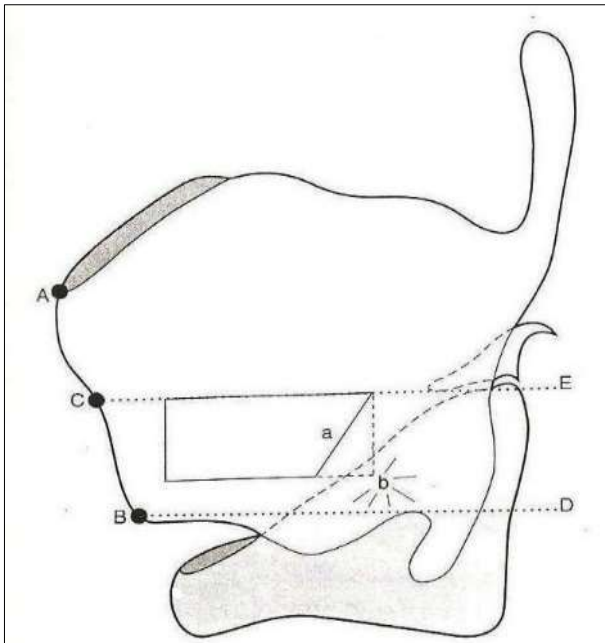
In order to prevent interference with the anterior commissure tendon, the window is positioned posteriorly, 5 mm in females and 7 mm in males, relative to the midline. Therefore, the dimensions of the window in women are normally 5 mm in height and 12 mm in width, whereas in males it is 6 mm in height and 14 mm in width. The key considerations for creating the window are as follows: (1) ensuring that the anterior incision is positioned at least 5 mm away from the midline, (2) centering the thyroplasty window with the limbs parallel to the lower edge of the thyroid cartilage, and (3) centering the window on the lower portion of the thyroid cartilage to prevent the false vocal folds medialization.



**Fig 3:** Landmarks for design of cartilage window of thyroplasty type 1. (A) thyroid notch; (B) midpoint lower margin thyroid ala; (C) midpoint between A and B, coinciding with anterior commissure; (D) line along upper parts of lower margin of thyroid ala; (E) line parallel to D through C coinciding with level of vocal fold

A quick thyroplasty window is created using a high-speed otologic drill equipped with a 3.0-mm cutting burr. While certain authors chose to retain the rectangular cartilage windows by the use of oscillating saws, others choose to extract the cartilage while keeping the inner perichondrium intact. As the cartilage is gradually removed through drilling, its color transitions from yellow to blue to pink. The presence of the pink inner perichondrium confirms that the thyroplasty window has been sufficiently removed. A little elevator or spatula is employed to delicately displace the inner perichondrium. Certain surgeons support the

practice of making an incision in the inner perichondrium, while others chose to keep the perichondrium undisturbed. When incising the perichondrium, it is recommended to perform the incision at the conclusion of the operation, (Figure 4).



**Fig 4:** Design of cartilage window of thyroplasty type 1. (a) Correctly designed cartilage window; (b) cartilage window too long in lower posterior corner. Medialization of window impeded by cricoid cartilage

Throughout the procedure, the TA muscle is tested by applying pressure using a depth gauge or elevator put through the window. The operator assesses the quality of the voice and links it to the level of medialization. Typically, a wedge-shaped implant is suitable. Occasionally, intraoperative testing reveals that the implants ought to have a greater size in the upper part compared to the lower part, or that a more optimal voice quality could be reached by adding a posterior extension to the implants. The surgeon shapes the implants to get the appropriate form throughout the implant-shaping stage. Intraoperative testing involves instructing patients to maintain a sustained vowel sound of "ee." Throughout the process of medialization, the surgeon can determine the size of the implants by using visual input from flexible laryngoscopy, auditory feedback, or a combination of both methods. The voice ought to have a proper pitch acoustically. The voice ought to be free from tension or breathiness and ought to offer a wide range of volume, from a quiet voice to a loud phonation. In order to minimize instances of dyspnea throughout phonation, it is preferable to have a phonation period that exceeds 8 seconds. Sustained vowels and running speech are used to measure both frequency range and dynamic range. After confirming that the voice is satisfactory with medialization alone, the implant is precisely shaped to match the defect.

### Implant Sizing

Multiple implant systems are currently available for commercial use. Medialization systems that can be adjusted are currently being developed. Hydroxyapatite and

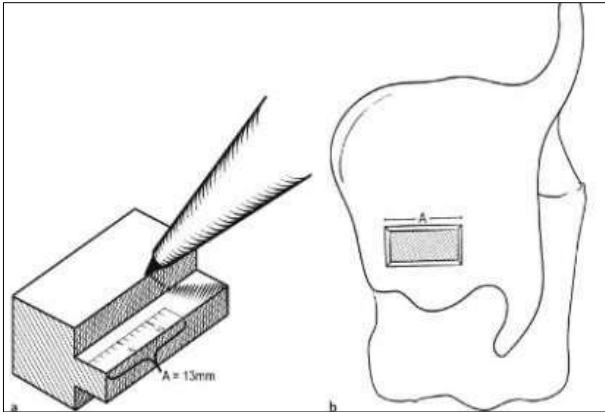
polymeric silicone (Silastic) manufactured implants are both utilized (Figures 5-11). These technologies are beneficial for surgeons who lack experience in sculpting implants. The key principles of implant design are as follows: (1) Ensuring secure fixation within the thyroplasty window so that migration isn't a problem, (2) Achieving medialization of the vocal fold while avoiding medialization of the false vocal fold or the anterior commissure, and (3) Ensuring that the implant conforms to the vocal folds in all three dimensions. The implant-shaping approach developed by Netterville *et al.* is frequently employed.

A common implant utilized for women is a wedge-shaped implant measuring 6 mm in width, 14 mm in length, 4 mm in height, and 1 mm in thickness. A commonly utilized implant size for males is 8 mm in length, 16 mm in width, 5 mm in height, and 1 mm in thickness. The implant is sculpted to be larger compared to the thyroplasty window, and it has a window-lock extension that mimics the key and lock mechanism. This extension enables the implant to securely attach to the thyroplasty window, preventing any rotation or movement of the implant. Certain technological difficulties are pertinent. Throughout surgical procedures, it is possible for the voice to experience instability or become untestable. The most common cause of this issue is muscular edema or tissue hemorrhage. Hence, it is essential to refrain from frequent insertion and removal of implants, particularly those that are very large. One must be extremely careful to prevent any damage to the highly vascular inner perichondrium. Following the surgical procedure, a minor overcorrection of the defect by the implant is permissible, but it is crucial to ensure that the voice does not become too constricted, leading to breathing difficulties or abnormal breathing sounds known as stridor or dyspnea. If the voice quality remains unsatisfactory despite numerous efforts at medialization alone, fiberoptic laryngoscopy can be used to determine if the defect has been effectively closed with medialization. If the fault is not visible and there is a noticeable decline in voice quality, it is advisable to consider an AA operation.

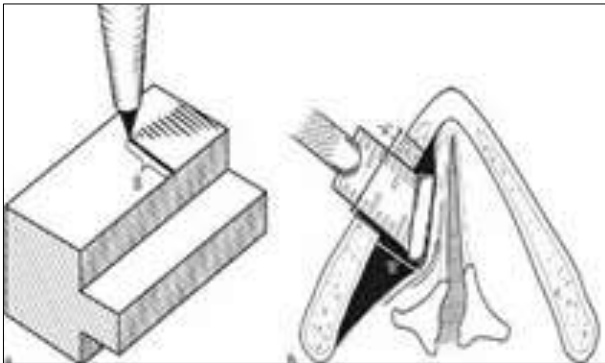
After the implant is positioned and the voice is considered satisfactory, the closure procedure is carried out. After closing the outside thyroid perichondrium, the strap muscles and the skin are next closed in layers. A miniature elastic drainage tube is retained overnight, and the individual is released on the first day following the surgical procedure. It is recommended to refrain from using your voice during the first week in order to allow the implant to settle undisturbed. Voicing is allowed after 1 week. Voice therapy is initiated 1 to 3 weeks post-surgery and is continued until the voice recovery reaches a plateau. The objectives of voice therapy are to broaden the vocal range and enhance vocalization with the newly implanted device. The objectives are: (2) to decrease excessive compensating, compression of the false vocal folds, and muscle tension; and (3) to integrate breath support and resonance for optimal voice quality.

### Silastic medialization laryngoplasty

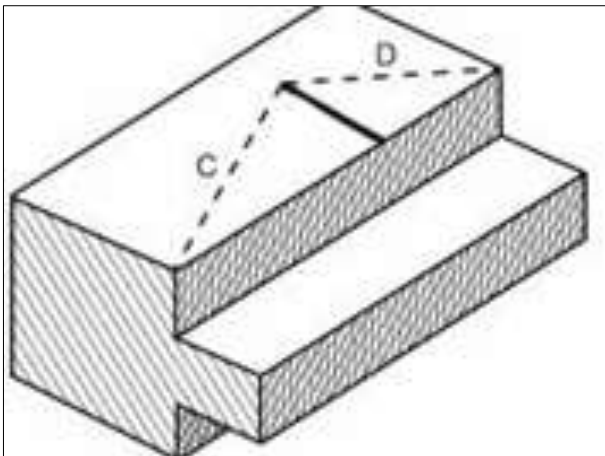
Silastic is an inert material which is well tolerated when implanted into the human body. Type 1 allergic reaction and granuloma almost always nonexistent, (Figures 5-11).



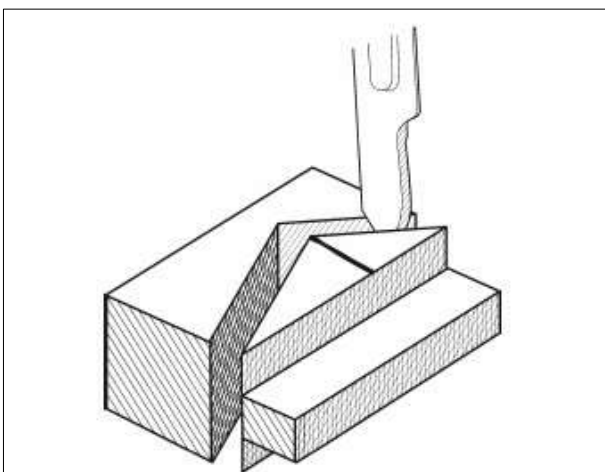
**Fig 5:** Measurement of anterior edge of thyrotomy window



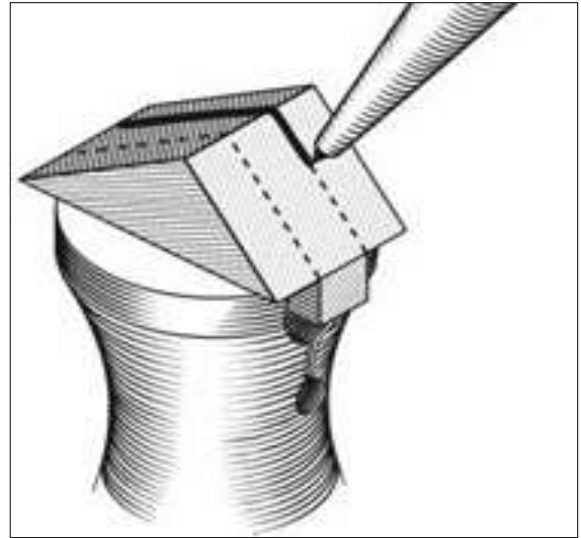
**Fig 6:** Measurement of the depth of medialization



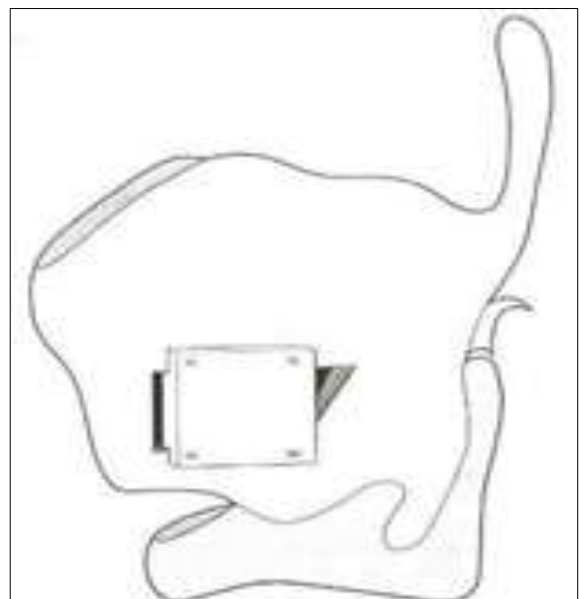
**Fig 7:** Lines C&D creating a triangular implant



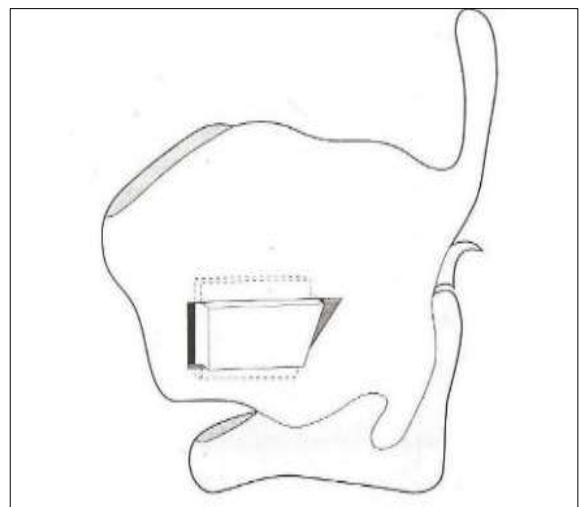
**Fig 8:** Trimming excess sialastic



**Fig 9:** Marking the plane of maximal medialization



**Fig 10:** Medialization by sialastic wedge. Wedge is self-retaining, kept in position by flangs medial to thyroid cartilage. Suitable for more than moderate medialization (3-5 mm)



**Fig 11:** Medialization of cartilage window by means of Sialastic blugs fixed by sutures suitable for moderate medialization (2-4 mm)

## Medialization laryngoplasty using Montgomery thyroplasty system

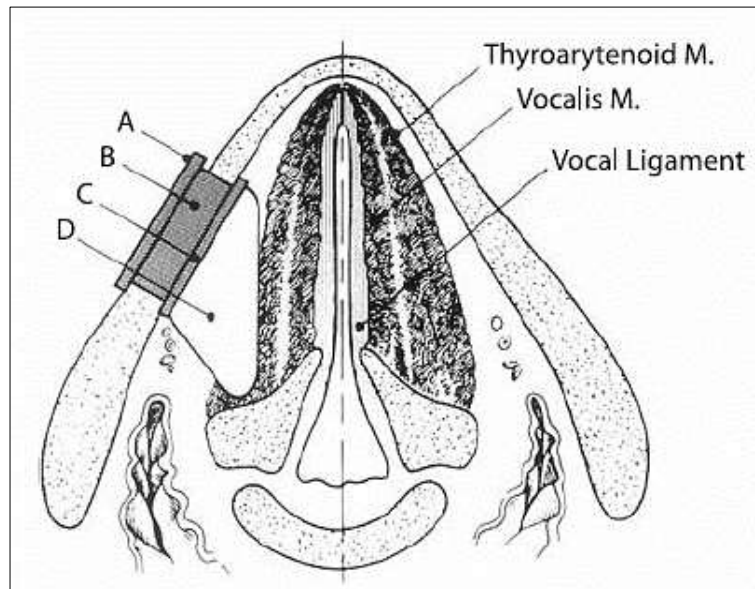
### Advantages

- A readily available implant in varying sizes.
- Specifically built measurement instruments to aid in the positioning of the thyroid cartilage.
- A snap-on implant design that can be securely attached without the need for sutures and with minimal danger of displacement.
- Can be readily removed if necessary.

- A design for an implant that will move the vocal process medially.

### Thyroplasty prosthesis design

Consisting of two components, the outer part functions to secure the prosthesis within the opening created in the thyroid lamina. The primary function of the inner section is to move the vocal fold and vocal process of the arytenoid medially, (Figure 12).



**Fig 12:** Thyroplasty implant. The outer section of the implant is composed of three layers. (A) The lateral plate stays positioned outside the thyroid cartilage, so preventing any medial displacement. (B) The middle plate serves to support the implant and has the same dimensions as the thyroid lamina window

(C) The medial plate is positioned within the thyroid lamina to avoid any outward displacements. The external part of the implant is identical in size for both male and female implants. (D) The triangular intralaryngeal component of the implant is specifically designed to move the vocal fold medially. The height of this section fluctuates according to the dimensions of the implant, with females having options of 6, 7, 8, 9, and 10mm, and males having options of 8, 9, 10, 11, and 12mm. The tip of the implant extends towards the back and reaches the vocal process of the arytenoid, allowing for posterior medialization.

## Medialization thyroplasty utilising the VoCoM vocal cord medialization system

### Advantages

Less edema due to short operative time and minimal manipulation.

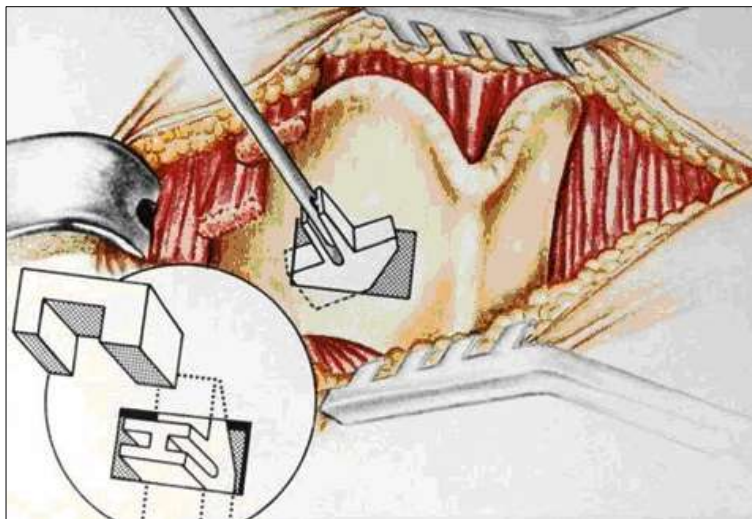
- A specially designed instrument to facilitate placement of window, determination of implant size and optimal location and insertion of the implant, (Figures 13 & 14).
- Implant made of hydroxylapatite that generate thin fibrous encapsulation.
- Minimal risk of displacement.

### Disadvantages

- Firm nature of the implant prevents further carving, so modification of the shape done with drill.
- Osteointegration in the area of thyroid lamina may make the procedure less easily reversible.
- Complications such as airway compromise, perforation of endolaryngeal mucosa, implant migration, or chondritis.



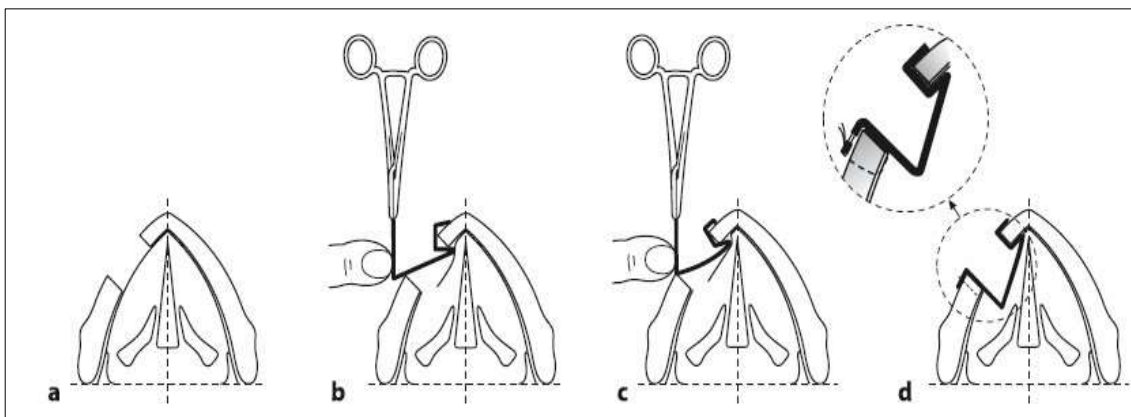
**Fig 13:** Trial implant tools along sides the corresponding final implants



**Fig 14:** The VoCoM vocal cord medialization system

**Titanium Medialization implants**  
**Advantages**

- a) Extremely low toxicity.
- b) Well tolerated by bone and soft tissues.
- c) Histological no cellular changes adjacent to titanium implants.
- d) Nonmagnetic so not interfere with MRI or CT, (Figures 15 & 16).



**Fig 15:** Principles of external vocal fold medialization using a titanium implant



**Fig 16:** Titanium implant placed in cadaver larynx. Note how it interlocks with the cartilage and extends anteriorly beyond the anterior margin of the window

**Gore-Tex medialization laryngoplasty**

Semiporous implant material (Polytetrafluoroethylene) which allows for limited vascular ingrowth without significant inflammatory response.

**Advantages**

- a) Simple surgical technique.
- b) It is easily combined with arytenoids adduction for closure of posterior glottic gap, (Figure 17).
- c) It is reversible and revisable. Gore-tex is a distinctive choice for medialization material due to its ability to be easily modified, changed, or removed in most surgical situations, in case a revision procedure is required.



**Fig 17:** A thin layer of Gore-Tex is applied gradually to provide support for the flaccid and denervated muscles

## Conclusion

Unilateral vocal fold paralysis (UVFP) significantly impacts patients, primarily causing dysphonia and occasionally aspiration. The primary etiologies include post-surgical complications (neck, thyroid, or chest surgeries) and idiopathic origins. Several procedures are available for managing UVFP, such as injection laryngoplasty (IL), medialization laryngoplasty (ML) with or without arytenoid adduction (AA), and laryngeal reinnervation. Among these, medialization laryngoplasty (ML), also known as type-1 thyroplasty, is the most frequently utilized permanent procedure.

Initially described by Isshiki *et al.* in 1974, ML enhances vocal fold contact and vibration necessary for phonation by medializing the affected vocal fold using autologous or synthetic materials. The procedure has evolved to include different techniques such as bilateral MT, unilateral MT, and arytenoid adduction combined with MT, each with specific indications. Arytenoid adduction alone is rarely performed but is essential for cases involving a laterally displaced arytenoid cartilage.

Contraindications for medialization thyroplasty include patients with hemorrhagic conditions, weakened immune systems, severe COPD, or those who have undergone previous pneumonectomy. The procedure requires precise anesthesia management, often involving local anesthetic with sedation, to allow intraoperative vocal assessment.

The surgical procedure for ML involves careful exposure and dissection around the thyroid cartilage, precise creation of a thyroplasty window, and insertion of a custom-shaped implant to medialize the vocal fold. Various implant materials are used, including silastic, hydroxyapatite, titanium, and Gore-Tex, each with unique advantages and potential complications. Post-surgical care involves a brief period of voice rest followed by voice therapy to maximize the benefits of the surgery. The goal is to achieve a balance between improving vocal quality and minimizing complications such as dyspnea or voice instability.

In conclusion, medialization laryngoplasty remains a cornerstone in the surgical management of UVFP, providing significant improvements in vocal function and quality of life for affected patients. The choice of technique and materials, along with careful perioperative management, are crucial for successful outcomes.

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**Author's Contribution:** Not available.

**Conflict of Interest:** Not available.

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