



LARYNGEAL PHONOMICROSURGERY FOR TREATMENT OF BENIGN VOCAL FOLD LESIONS

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Benign vocal fold lesions (BVFL) include a range of pathologies e.g. nodules, polyp(s), cyst(s), and Reinke's oedema/chronic polypoid corditis.¹ BVFLs represent a common cause of voice disorders, accounting for approximately 11-22% of patients presenting with dysphonia complaints.^{1,2}

This chapter summarises the clinical management of BVFLs, including relevant anatomy, pathophysiology, and an overview of appropriate phonosurgical techniques and postsurgical care.

Anatomy of vocal folds

The vocal fold consists of *squamous epithelium*, *lamina propria* and the *vocalis muscle* (Figure 1). The epithelium and superficial lamina propria form the *mucosal layer*. The intermediate and deep layers of the lamina propria blend into one another and form the *vocal ligament*.

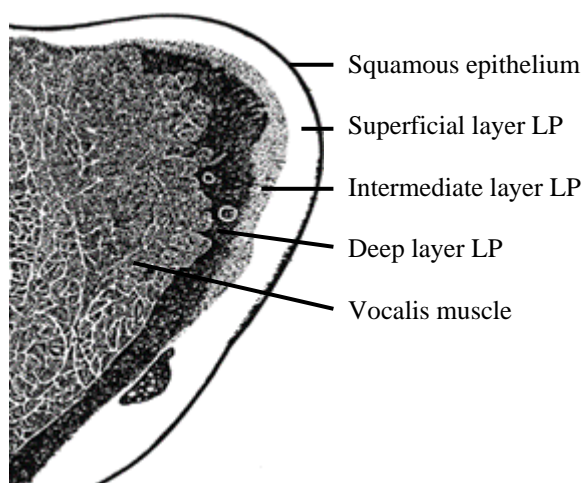


Figure 1: Anatomy of vocal fold (LP = lamina propria)

The *superficial lamina propria* is gelatinous in nature and comprised of water, collagen, and elastin.⁷ The *intermediate and deep*

layers of the lamina propria contain elastin and increasing density of collagen fibers. The intermediate layer is mainly comprised of collagen type III fibers whereas the deep layer is comprised of very dense collagen type I and III fibers whereas.⁶

When considering *vibration of the vocal folds*, it is important to appreciate that the epithelium and superficial lamina propria vibrate together over the underlying vocal ligament to generate sound. Changes to this microanatomy, secondary to laryngeal pathology, may result in decreased pliability and movement of the vocal folds, leading to dysphonia.⁸

Aetiology of BVFLs

Although the precise aetiology underlying the formation of specific types of BVFLs remains incompletely understood, phonotrauma resulting from vocal abuse, overuse, and/or misuse has been implicated as a primary risk factor.³ A growing body of evidence suggests that the combination of mechanical stress, tissue remodeling, and active inflammation within the vocal folds may underlie the formation of BVFLs.⁴ The central contribution of inflammation to the pathogenesis of BVFLs has been strengthened by several recent reports including studies demonstrating increased expression of the proteolytic enzyme pepsin in polyps relative to the posterior commissure of healthy control patients.⁵

Pathophysiology

Polyps

- Exophytic, translucent or haemorrhagic
- Generally unilateral, can be bilateral or with a contralateral reactive lesion
- May be pedunculated or sessile

- May have haemorrhagic or fibrous properties
- Characterised by abnormally thin overlying epithelium and unorganized gelatinous material in the subepithelial space

Nodules

- Always bilateral
- Result in incomplete vocal fold closure
- Normal or minimally impaired mucosal wave on stroboscopy
- Strong association with heavy voice use
- Respond very well to voice therapy and reduced voice use

Cysts

- Appear as a white or yellow mass beneath the vocal fold epithelium or near the vocal ligament (observed at surgery)
- Encapsulated mass in subepithelial space or near the vocal ligament
- Usually unilateral, but can be bilateral
- Most commonly in middle of vocal fold
- May be associated with reactive contralateral lesion
- Significant disruption of mucosal wave on stroboscopy

Fibrous Mass

- Often pale or gray in colour
- Amorphous material within vocal fold
- Dense, fibrous lesion found in subepithelium or ligament
- Significant reduction in mucosal wave on stroboscopic exam

Pseudocyst

- Superficial lesion associated with glottic insufficiency
- Most often unilateral, but may be bilateral
- Frequently nonresponsive to treatment with voice therapy

- High recurrence rates if underlying glottic insufficiency is not treated
- Normal-to-minimal reduction in vibratory property of vocal folds with stroboscopy

Reactive lesions

- Occurs in response to presence of a lesion on the contralateral vocal fold e.g. polyp, cyst, fibrous mass
- Unilateral, as it occurs as a reaction to a contralateral lesion
- Normal-to-minimal reduction in vibratory property of vocal folds with stroboscopy
- Usually responds to voice therapy
- Variable size, but usually is smaller than the inciting lesion

Reinke's oedema (Chronic polypoid corditis)

- Oedematous process with gelatinous deposition in the subepithelial space
- Strong association with smoking, but may occur with voice misuse or severe reflux
- May be unilateral or bilateral and does not need to be symmetric in appearance
- Should remove inciting factor prior to consideration of surgical treatment

Surgical Management

Benign vocal fold lesions tend to be subepithelial in origin (~85%). These include vocal fold nodules, which are by definition bilateral, vocal fold polyps, vocal fold cysts, Reinke's edema, and fibrous masses¹. It is important to note that lesions, including cysts and fibrous masses, may also arise near the vocal ligament.¹⁻³

Phonemicsurgery refers to a variety of surgical techniques that involve precise removal of tissue. The goal of phonemicsurgery is to enhance vocal quality while

simultaneously preserving as much normal tissue as possible. Surgery is typically reserved for patients who fail voice therapy or is performed in conjunction with perioperative voice therapy.

It is desirable to *preserve mucosa* to optimize wound healing and to minimize disruption of the *mucosal wave* generated during phonation. The mucosal wave generated during phonation is reflected in Hirano's cover-body theory of vocal fold vibration, in which the epithelium and superficial lamina propria act as a "cover" which vibrates over the "body" designated by the deeper tissue layers of the vocal fold (intermediate and deep layers of the lamina propria and vocalis muscle). Vocal fold lesions can disrupt the mucosal wave by diminishing the free movement of this cover over the body of the vocal fold and result in dysphonia. It is theorised that remaining as superficial as possible in your dissection of the lesion will minimise scarring as there is a higher content of fibroblasts in the deeper aspect of the vocal fold.¹

Equipment

Surgical exposure is of paramount importance. The larger the laryngoscope that you use for exposure, the better your visualisation and working area.

Laryngoscopes can be considered in two functional categories: intubating or operating laryngoscopes. Anaesthesiologists often use curved (Macintosh) or straight (Miller) blades to displace the tongue and expose the glottis for the purpose of intubation (Figure 2).

Operating laryngoscopes, in contrast, must not only be able to expose the larynx, but also allow for surgical procedures.⁹ Laryngoscopes are used for diagnosis, microsurgery (including laser surgery), documentation, difficult airway exposure, and mana-

gement of an obstructed airway. Table 1 lists some common laryngoscopes and their potential uses based on the functional classes as described by Benjamin and Lindholm.⁹



Figure 2: Curved (Macintosh) and straight (Miller) intubating laryngoscope blades

Diagnosis	Microsurgery	Documentation	Difficult / Obstructed airway
Lindholm	Universal modular glottiscope	Lindholm	Benjamin Superslimline Adult
Dedo	Dedo	Dedo	Ossoff-Pilling (w/wo Garrett modification)
Jackson	Bouchayer adult	Kantor-Berci	Holinger anterior commissure
Kleinsasser	Benjamin-Parson's slotted		
	Jako		

Table 1: Potential operating laryngoscopes according to functional classification of uses. Adapted from article by Benjamin & Lindholm⁹

There is a wide variety of laryngoscopes available geared for particular applications and age groups (children vs adult). These laryngoscopes have a light source, a prism or a light clip / carrier (Figures 3a,b), a blade which may be a wide variety of shapes and sizes depending on the laryngoscope used (Figures 4-7), and a handle which allows for suspension of the larynx (Figure 8).⁹



Figure 3a: Light clip



Figure 3b: Light carrier



Figure 6: Dedo laryngoscope



Figure 4: Kleinsasser laryngoscope



Figure 7: Jackson laryngoscope



Figure 5: Lindholm laryngoscope



Figure 8: Laryngoscope holder to suspend the larynx

Phonicrosurgery instruments

In addition to specialised laryngoscopes, some of which are described above, certain instruments are essential for phonicrosurgery. These are listed below in *Figures 9a-c* (adapted from Rosen et al):⁷

- Microelevators
- Cup forceps
- Microscissors
- Curved alligators
- Small suctions (3, 5, and 7 Fr)
- Triangular (or Bouchayer) forceps (specialised laryngeal instruments created to aid with atraumatic grasping of microflaps)
- Suspension device – Gallows (Figure 1) or Rotation-Fulcrum Type
- Long Hopkin's rod telescopes (0, 30, and 70-degree)
- Microscope (lens with focal length of 400nm is typical for laryngeal procedures to allow for appropriate working distance and passage of instruments through the laryngoscope)

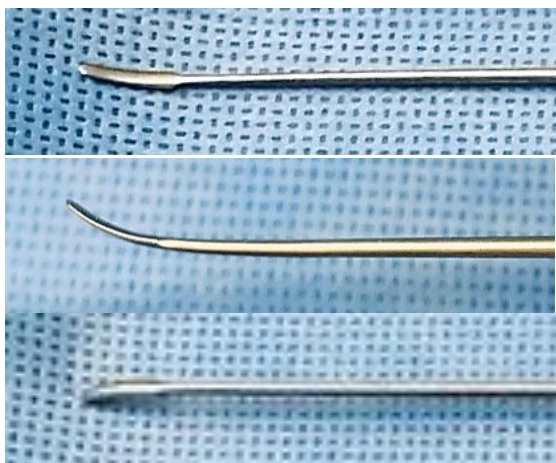


Figure 9a: Microelevators



Figure 9b: Triangle forceps



Figure 9c: Curved and up-microscissors

Anaesthesia considerations

Ventilation for laryngeal surgery is typically done with endotracheal intubation or jet ventilation. If intubating a patient is desired, it is important to use a small endotracheal tube (sizes 5.0 or 5.5). If there is concern that endotracheal intubation will obstruct visualisation of the vocal folds, jet ventilation or intermittent apnoea may be used.

In some circumstances, apnoeic methods may also be employed with intermittent periods of ventilation.^{10,11} This can be challenging as the amount of time apnea is tolerated can vary significantly from patient to patient depending on medical comorbidities and body habitus. High flow nasal cannula oxygen administration can be the primary method of ventilation for short cases or supplemental for apnea cases.

Preoperative administration of IV steroids is typically used in laryngeal surgery to minimize perioperative oedema (10-20 mg IV Decadron). The administration of glycopyrrolate is another common practice in patients with copious secretions limiting visualisation (unless medically contraindicated).

Positioning the patient

- The optimal position for phonosurgical procedures is with neck flexed and head extended (*Figure 10*).
- A shoulder roll is not recommended as this causes extension of the neck
- If the operating bed has an articulated head, the head of the bed can be adjusted to flex the neck
- Alternatively, pillows may be placed under the neck and head
- Head extension is typically achieved during laryngoscopy and suspension of the laryngoscope



Figure 10: Patient suspended in sniffing position (neck flexed, and head extended) using Gallows suspension

Introducing the laryngoscope

- Take care to avoid injury to the patient's teeth by placing a tooth guard over the upper teeth
- In edentulous patients, a wet folded gauze or high density foam¹² is placed along the superior alveolar ridge

- Introduce the laryngoscope into the mouth by gliding it over the ventral tongue surface
- Sweep the tongue over to the left side as the laryngoscope is advanced towards the base of the tongue

Laryngeal exposure

- As the laryngoscope is advanced past the oropharynx, a variety of methods can be employed to visualise the glottis
- Exposing the larynx can be made challenging by a tendency of the epiglottis to fold inward
- The most direct method for exposing the glottis is to advance the laryngoscope to the epiglottis and attempt to slide the laryngoscope underneath its laryngeal surface. If an endotracheal tube is present, the endotracheal tube may be followed and hugged by the laryngoscope until the epiglottis is encountered
- If the epiglottis keeps folding inwards, an alternate approach can be employed that involves using a large cup forceps to mechanically retract the epiglottis anteriorly to allow for passing of the laryngoscope
- Rarely, a traction suture (typically 4-0 or 3-0 silk suture) may be passed through the superior epiglottis. The laryngoscope is then removed, and the epiglottis is retraced anteriorly while the laryngoscope is reintroduced with the stitch remaining outside of the laryngoscope
- A less traumatic approach involves passing the laryngoscope between the endotracheal tube and the posterior pharyngeal wall until the endolarynx is exposed. The endotracheal tube will be located anterior to the laryngoscope and can be carefully repositioned using your fingers to position it behind the laryngoscope.

Laryngeal suspension

The goal is to suspend the larynx with upward and anterior pressure to allow for optimal visualisation of the larynx while being as atraumatic as possible.

A *Gallows suspension device* (Figure 10) is the preferred method of suspension. More commonly, a *fulcrum or rotation suspension device* is available (Figure 8). This type of suspension is typically done with the suspension device resting on a Mayo stand or on the patient's chest (protected with towels or foam). This is, in fact, not true suspension because for every degree of upward/anterior force applied, an equal downward/posterior force is also applied. Accordingly, special care must be paid to the maxillary dentition to ensure that no injury results.

In some cases, *external pressure* placed against the anterior laryngeal or tracheal surface can facilitate visualisation of the anterior glottis. This can be done by placing a piece of folded gauze over the skin and using one-inch silk tape to apply pressure to the anterior surface of the thyroid cartilage. The edges of the tape can then be taped to the sides of the operating room bed. If a patient begins to move, this needs to be removed immediately followed by removal of the laryngoscope and suspension.

Visualisation of endolarynx

Visualisation of the endolarynx is typically done using a combination of 0, 30, and 70-degree long *Hopkin's rod telescopes*. This allows for documentation of the pathology, while also facilitating surgical planning. These endoscopes also allow for better visualisation of the anterior and posterior commissures, ventricles, and the subglottis.

The remainder of the procedure is performed with the highest quality *microscope*

equipped with a 400mm lens. The microscope should contain multiple articulated angles which can be controlled by the surgeon to optimize visualisation and ergonomics.

Surgeon's ergonomics and positioning

Stability of the hands can be achieved by resting the forearms on a chair with arm rests. If this is not available, a Mayo stand may be placed between the surgeon and the patient's head to allow the surgeon to support the elbows and improve stability. Positioning the surgeon's elbow and forearms as low as possible improves surgeon ergonomics and can often be facilitated by placing the patient in a reverse Trendelenburg position.¹³

A 2010 study by Statham, *et al.*, reported on high-risk and ideal posturing for the laryngologist which may reduce occupationally related musculoskeletal pain and improvement of fine motor control.¹⁴ In their study, a simulated microlaryngology model was used to assess a variety of parameters including capturing full body postural data and using the validated *Rapid Upper Limb Assessment Scale* to calculate the risk of ergonomically unfavourable positions. Higher risk positions were when arms were not appropriately supported. Although risk decreased with use of a Mayo stand, optimal positioning was obtained using a chair with an articulated arm and the laryngoscope placed at an angle of 40degrees from the floor. Most laryngeal procedures are performed with the microscope at its highest magnification. Failure to adjust the microscope eyepieces was also associated with higher-risk positioning.¹⁴

The ideal posture was reported as having the arms and feet were appropriately supported, and shoulders in a neutral, unraised anatomic position. The ideal angles for upper and lower arms were 20-45 degrees and

60-100 degrees from the torso respectively, with the wrists angled at 15 degrees or less.¹⁴

A follow-up 2015 prospective study by Smith, *et al.*, demonstrated decreased muscle fatigue and operator reported pain when adopting a more ergonomic position during microsurgery.¹³

Microflap approach for BVFLs

- Prior to removal of a BVFL, palpate the lesion(s) and fully assess the surface of the vocal folds in an atraumatic manner (*Figures 11, 12*)
- The *microflap* is a surgical approach for subepithelial pathology, which is the most common location of BVFLs
- For this reason, it is important to remain as superficial as possible with the dissection to minimise scarring
- To achieve hydrodissection and to aid with haemostasis, diluted epinephrine (1:10,000) is often injected prior to making an incision
- The incision is typically made using a sickle knife placed immediately lateral to, or directly over, the area of pathology

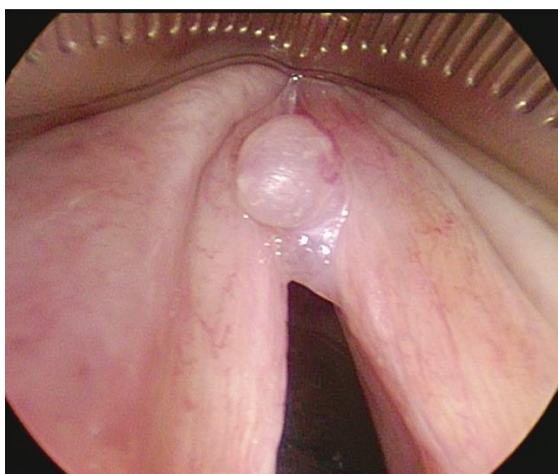


Figure 11: Right vocal fold polyp



Figures 12a,b: Palpate the vocal folds with microelevators to identify contralateral reactive lesions or a scar/sulcus which may not be readily identified on office laryngoscopy

- Alternatively, a fine microscissor may be used to enter the submucosal plane
- Take care to avoid disrupting normal tissues in your dissection
- If using a sickle knife, the tip of the sickle knife can enter the submucosal plane and then be used to raise the mucosa superiorly to prevent accidental injury to deeper layers
- Following the incision, a blunt curved elevator can be used to dissect between the epithelium and the location of the subepithelial pathology (*Figure 13*)

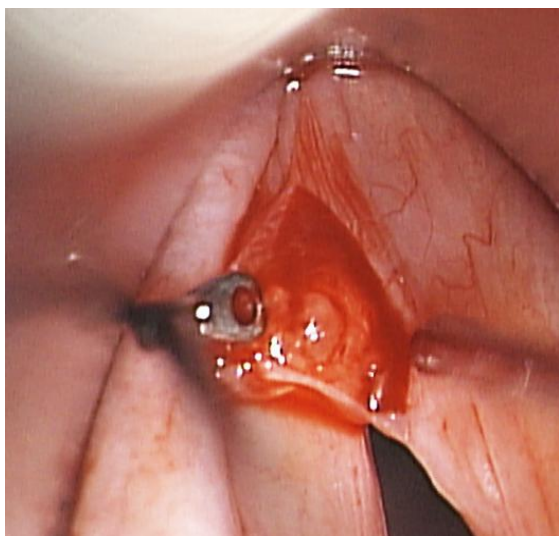


Figure 13: After the mucosal incision is made, the microflap is pulled medially along the plane of the vocal fold, like opening the pages of a book. Contents of the polyp are removed using blunt and sharp dissection

- While starting with dissecting the lesion from the deeper structures may be tempting, this should be avoided as the epithelium is often attenuated and can be perforated if there is inadequate countertraction
- Sometimes it may be necessary to use a fine laryngeal microscissor to free the submucosal pathology from fibrous attachments in the submucosal plane and the deeper layers
- Haemostasis can be achieved during the procedure by using epinephrine- or oxymetazoline-soaked pledgets
- When suctioning in the submucosal or deeper planes, it is recommended that a 3 Fr suction be used with the finger off the suction hole to minimise trauma
- Dissection must be completed in a meticulous manner as the flap may tear easily
- At the conclusion of the procedure, re-drape the microflap over the surface of the vocal fold (*Figure 14*)
- Trim excess mucosa, if necessary

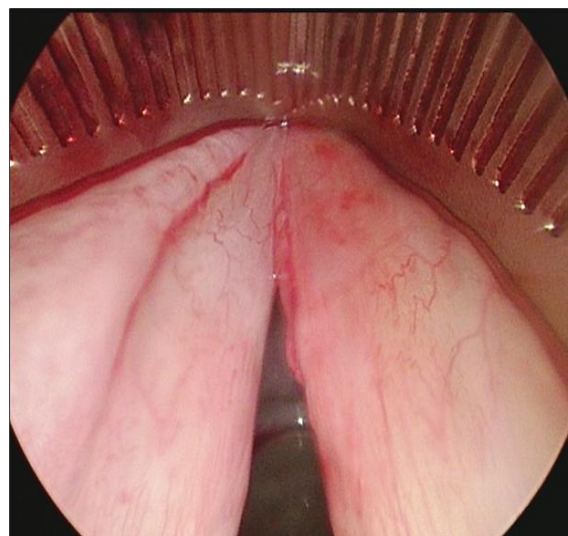


Figure 14: The mucosal flap is draped back down and excess epithelium is trimmed with an upward curved microscissor

- It is again important to again palpate the vocal folds to ensure that residual pathologic tissue does not remain in the sub-mucosal plane
- The microflap should have a straight edge when it is re-draped. If this is not the case, one must consider the possibility of there being remaining submucosal pathology
- Overly aggressive removal of this microflap tissue increases the risk of scarring which may impair the mucosal wave and affect voice quality
- The surgical bed may then be injected with steroids (dexamethasone 10mg/dL)
- Prior to removal of the laryngoscope, 2-3ml of 4% topical lidocaine can be applied via needleless syringe for additional anesthesia to minimize laryngeal stimulation and cough post-extubation

BVFL at anterior commissure

Vocal fold lesions involving the anterior commissure deserve special attention. When approaching the anterior commissure, care must be taken to avoid mucosal trauma of the contralateral vocal fold as this

can lead to an anterior web and poor voice outcomes.

Reinke's oedema

Behavioural modification with smoking cessation, control of laryngopharyngeal reflux and addressing vocal abuse/overuse should be implemented prior to consideration of surgery. Continued smoking is a relative contraindication to surgery as the lesions will recur. This should be taken on a case by case basis as airway compromise from large lesions or associated leukoplakia concerning for malignancy supersede this relative contraindication. Surgical options include "cold-knife" techniques including lateral microflap approach similar to that described above and microdebridement. Photoangiolytic laser therapy has gained recent popularity. Potassium titanyl phosphate (KTP) and pulse dye lasers (PDL) have been demonstrated to be safe and effective. For the appropriately selected patient, the added benefit of these procedures is that they can be performed in the office, awake, with the use of topical anesthesia.¹⁸

Postoperative care

- **Voice rest:** There is consensus that patients should be on voice rest to minimize postoperative phonotrauma. However, the optimal duration is not known and is a subject of active investigation. An average of 5-7 days of voice rest is typically recommended based on survey studies.^{15,16} However, a 2017 prospective study by Kaneko *et al.*, suggests that 3 days' voice rest in conjunction with voice therapy may lead to better wound healing than 7 days of postoperative voice rest.¹⁷
- **Voice therapy:** As misuse/overuse is a common cause of BVFL, optimising laryngeal mechanics and improving vocal hygiene are important perioperative

therapies to minimize the chance of recurrence.^{3,17}

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