Phonomicrosurgical Treatment of Benign Lesions

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Laryngeal surgery is reemerging as a key surgical subspecialty similar to its stature in the 1800s because of the increasing importance of the human voice in communication-based societies. Laryngeal and voice problems are universal throughout the world irrespective of age, gender or social stratification and benign vocal edge lesions are the most common problem. In turn, phonomicrosurgery is enjoying tremendous growth and development due to unique collaborations between surgeons, scientists and engineers along with patient expectations. These successes have led to enthusiasm for future developments similar to the nascent era of Laryngology in the 19th century. Outstanding advancements have been achieved during the last 10 years and this progress should expand dramatically as biomaterials to replace the superficial lamina propria are developed.

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Background and Introduction

The term Phonomicrosurgery was introduced by the author in 19941-2) as a refinement of the 1960s term, phonosurgery (von Leden: personal communication) to differentiate these endoscopic vocal-fold procedures from laryngeal framework surgery3-5). Phonomicrosurgery requires maximally preserving the vocal fold’s layered microstructure; epithelium and laminae propria. Phonomicrosurgery is performed under general anesthesia and is generally done to improve the vibratory characteristics of the layered microstructure of the vocal fold. Every substantive innovation in phonomicrosurgery has improved precision. Shortly after the microscope was introduced to Laryngology, Jako6) and Kleinsasser7) designed hand instruments that were suitable for the magnified field. Subsequently, Jako8-9), Strong10), and Vaughan11) introduced the carbon dioxide (CO2) laser as a surgical instrument for excision of neoplastic soft tissue. Recently, new fiber-based angiolytic (i.e. 532nm pulsed-KTP Laser) lasers12-16) have become instruments of choice for the treatment of benign glottal lesions because of their ability to maximally preserve the delicate mucosal layered microstructure.

Optimal laryngeal sound production requires apposition of the vocal fold edges, which are driven by the sustained subglottal aero-dynamic pressure from the tracheo-bronchial tree. Lesions along the rima glottidis impair entrained oscillation by creating stiffness in the diseased vocal fold and by preventing smooth vocal-edge closure. These factors result in an aerodynamically inefficient glottal valve. Phonomicrosurgical procedures are designed to improve aerodynamic efficiency and vocal quality by creating a smooth vocal-fold edge that is not excavated with epithelium that is pliable17). Given the choice of sacrificing or disturbing normal superficial lamina propria [SLP] or normal epithelium, it is wiser to preserve normal SLP.

In our experience, there is little difficulty in the growth and regeneration of normal epithelium as is seen after a cordectomy that is left to heal secondarily. We have further noted that normal SLP does not typically regenerate if it has been removed. Our postoperative stroboscopic findings further reveal that if extensive dissection in normal SLP is performed to raise a wide microflap, mucosal stiffness will be noted in the field of dissection. Contrary to common belief, the location of epithelial incisions had no effect on postoperative mucosal wave pliability18). Impaired mucosal wave propagation was the result of dissection within the SLP. Pharyngeal epithelium is a delicate membrane, which encapsulates the tissues un-
derlying it, and reflects the viscoelastic properties, rheology, and vibration characteristics of the subepithelial soft tissues.

Preoperative discussion

The majority of endoscopic surgery in the glottis is done to treat benign processes. The most frequent presenting symptom for glottal disease is hoarseness. Benign lesions typically occur in vocal over-doers and seldom occur in individuals, who are reticent and shy. Many of these individuals will require preoperative and postoperative vocal therapy to unload habits that either predisposed to the original lesion and/or to remove compensatory strategies that developed as a result of the lesion(s). Since the timing and decision about surgery is frequently linked to the response to vocal therapy, the surgeon must know the speech language pathologist well in order to accurately assess the adequacy of therapy.

The patient must always be warned that it is possible for the voice to be worse subsequent to the surgery and the Laryngologist must have an accurate assessment of his/her surgical skills. Furthermore, it is very common for patients to have more pathology than can be appreciated even by stroboscopy. Examination in the operating room provides significantly greater magnification as well as the potential for use of telescopes to examine surfaces that are tangential and/or obscured in the clinic exam. Therefore, consent must be obtained to remove potential pathology, which may not be appreciated during the office examination including both folds. All patients should be prepared for the possibility of vocal deterioration after a phonomicrosurgical procedure.

After vocal-fold surgery that requires dissection in phonatory mucosa, complete voice rest is often advised for a minimum of 10 days after the surgery and modified voice use for 2 weeks. Atrophy or significant rest-induced hypo/hyper-function has not been observed. It is not unusual for patients to have temporary tongue numbness and/or dysgeusia in the region of the laryngoscope placement. We have not seen this as a permanent problem in over 5,000 cases. After 10 days, if postoperative stroboscopy revealed no significant or unexpected findings, the patient is allowed gradual resumption of voice use under the guidance of a speech pathologist. Patients typically have a preoperative and postoperative appointment for objective voice assessment and vocal hygiene discussion. For-

mal voice therapy is administered as is necessary.

Position of the patient for phonomicrosurgery

The supine sniffing (Jackson) position\(^{19}\) is comprised of extension of the head in relation to the cervical spine and flexion of the neck in relation to the chest and provides optimal exposure of the vocal folds for phonomicrosurgery\(^{1, 20–24}\). A true suspension gallows (Endocraft LLC) provides for true elevated-vector suspension\(^{20, 24}\). External counter-pressure is applied with one-inch silk tape and gauze\(^{5, 22, 23}\) or a laryngeal cushion. The angle of the tape alters the vector force of the counter-pressure and should be individualized for optimal exposure of the anterior glottis.

The flexion-flexion\(^{21, 22}\) head and neck position provides excellent exposure of the vocal folds for a difficult intubation, however, the laryngoscope is placed vertically, perpendicular to the operating table. This position is unsuitable for microlaryngoscopy since it would require that the surgeon be situated above the patient. It must be clearly understood that torsion-fulcrum laryngoscope holders utilize the laryngoscope tube as a lever and the maxilla as a fulcrum to expose the anterior glottis. It is analogous to an oar in a rowboat where the oar is the laryngoscope examining spatula/tube and the oarlock is the maxilla. Irrespective of a cushion being placed under the head and/or shoulder, which visually simulate the sniffing position, the forces are disposed incorrectly to the maxilla rather than the mandible, tongue, and anterior pharyngeal tissues.

The laryngoscope and true suspension

Laryngoscope is a generic term for an instrument that provides endoscopic exposure of the larynx and it is sensible to specify laryngoscopes by the anatomic site that they are best suited to expose. Although the terms subglottiscope and supraglottiscope have been utilized, until recently, glottiscope\(^{25, 26}\) had not been employed since 1829\(^{27}\).

A glottiscope should be appropriately shaped to the conformation of the glottal introitus without distortion of the anatomy. This is comprised of an isosceles triangle and not a circle or an oval. Internal distension of the supraglottal tissues facilitates maximal exposure of the superior surface of the vocal folds. Jackson et al\(^{20}\) first described lateral distraction of the vestibular folds (1925) and referred to this as laryngostasis. Ideally, a glottiscope should be
intercalated between the endotracheal tube and the infrapetiole region of the supraglottis as well as between the vestibular folds, which provides for complete internal distension of the supraglottal structures.

In recent years, a patent has been obtained for a universal modular (UM) glottiscope system (Fig. 1) (Endocraft LLC) which is comprised of a spectrum of different-sized spatulas and tubes. The examining tubes have an isosceles triangular shape with arcuate sides to facilitate exposure of the ventricular surface of the vocal folds and the superior surface of the anterior commissure. The examining tubes attach to a modular universal titanium handle, which can be joined with suspension gallows as well as fulcrum laryngoscope holders. Ideally, a laryngoscope for vocal-fold surgery should not be positioned above the vestibular folds since a significant portion of the superior surface of the vocal folds may be obscured. The triangular lumen of the UM glottiscope tubes vary in height and width to conform to gender, age, and anatomical variations. The UM glottiscope has bilateral lateral slots proximally to facilitate angulation of hand instrumentation and is a complete tube distally to allow for internal distension. Therefore it optimizes the functional advantages of a bivalved laryngoscope proximally and a tubular laryngoscope distally. The detachable light and suction are contained within the wall of the planar base and therefore do not obscure visualization of the intralumenal operative field.

The patient is placed in the classic Jackson position with the neck flexed and the head extended at the atlanto-occipital joint; and the position is maintained with a modified Killian gallows [Pilling Co, Endocraft LLC] in true elevated-vector suspension. External laryngeal counter-pressure is first applied manually to determine its value for improving exposure and then applied with silk tape that is stretched from the lower laryngeal framework to the operating table. [Fig. 2] The magnitude of the pressure and vector of the force are adjusted to optimize the exposure of the lesion and the anterior glottis. A laryngeal cushion or gauze can be used to align and rotate the larynx to optimize the orientation of the surgical field within the laryngoscope lumen. If the CO₂ laser is to be used, both the patient and the endotracheal tube are protected in the appropriate fashion.

**Magnification**

An operating microscope fitted with a 400 millimeter front lens is used to examine the glottal surgical field at various magnifications. The first published report of the use of the surgical microscope during laryngoscopy was by Scalco, Shipman, and Tabb in 1960; they employed the Lynch spatula suspension laryngoscope for the task. Jako (in the United States) and Kleinsasser (in Europe) perfected surgical microlaryngoscopy. The surgical microscope was a

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Fig. 1 a. The Universal Modular (UM) Glottiscope

Fig. 2 Patient in elevated-vector suspension by means of modified Killian gallows. External counter-pressure is applied with 1-inch silk tape.
monumental innovation for enhancing the precision of endolaryngeal surgery because it provided high-power magnification with a three-dimensional stereoscopic field.

Precise phonomicrosurgery should typically be done at the highest magnification possible when delicate precise tissue dissection is necessary. The surgeon must be aware that the dial on the microscope does not necessarily reflect the magnification because of the 400 mm front lens. The highest magnification in most laryngeal surgical microscope systems is 10x - 13x. Selected larger lesions (i.e., larger cancers) can be resected at lower magnification to maintain general orientation. Although a video system is an excellent tool for documentation and maintaining the interest of the operating room staff, surgery should not be dependent on observing a two-dimensional video monitor. This approach ignores one of the fundamental assets of the surgical microscope, depth perception.

The subepithelial infusion technique

In addition to the magnified visual examination, the lesion is palpated with a blunt probe to help assess the texture of the lesion and the depth of deep tissue involvement. Subepithelial infusion of saline and 1/10,000 epinephrine into the superficial lamina propria (SLP) is done with a specialized needle (Endocraft LLC) and is used for a large majority of glottal lesions.

The subepithelial infusion distends the superficial lamina propria, which helps to preserve it. The hydrostatic pressure created by the infusion, as well as the epinephrine, enhance hemostasis during the delicate microdissection. The hydrostatic-induced tension in Reinke’s space also facilitates epithelial incisions, especially if hand instruments are not perfectly sharp. If an epithelial lesion has not invaded and/or obliterated the SLP, the infusion will hydrodissect under the lesion and lift it from the vocal ligament. Preoperative stroboscopy is helpful but not reliable for determining the depth of invasion of epithelial lesions such as keratosis. Pre-excisional knowledge about the depth of penetration of the lesion is critical for selecting instrumentation [cold versus laser] as well as for adjusting the deep margin precisely. Both of these factors are crucial to the patient’s postoperative vocal outcome. During superficial glottal procedures, hemostasis is achieved by topical application of 1:10,000 epinephrine-soaked cotton or neurosurgical cottonoids.

Polyps

Vocal fold polyps [Fig. 3] present in a spectrum of sizes, shapes, and tissue composition. They are typically the result of trauma to the superficial lamina propria, and most frequently, the microvasculature. Polyps are commonly found in the middle portion of

![Fig. 3 a. Microlaryngoscopic exam demonstrating fibrovascular polyp on the medial surface of the right vocal fold. The superficial lamina propria has been distended with an infusion of saline and 1/10,000 epinephrine.](image)

3b. The polyp is being retracted and a superior surface epithelial cordotomy is done prior to subepithelial resection.
the musculo-membranous region because the aerodynamically-induced shearing and collision forces on the SLP are greatest in this region. These lesions may be as sessile or pedunculated and they may also be vascular, fibrotic or mixoid. They are often accompanied by aberrant varices and ectasias.

There is great variation in the magnitude of involvement and replacement of the SLP by these lesions. This critical information is initially assessed by stroboscopy in the clinic, as well as by palpation under anesthesia with high-magnification observation. Frequently, a smaller traumatic fibro-vascular lesion will be noted on the opposing surface of the contralateral vocal fold. It can be difficult to determine whether the collision trauma from the polyp induced the smaller lesion or whether there were bilateral lesions in which one grew larger. This differentiation is only of academic interest since both lesions should typically be resected if there is palpable tissue alteration.

Prior to resecting a polyp, a 532nm pulsed-KTP laser can effectively photocoagulate associated varices, ectasias and feeding vessels. Unlike the 585nm pulsed-dye laser (PDL), the pulsed-KTP laser seldomly results in vessel-wall rupture. When resecting polyps, an epithelial cordotomy adjacent to the lesion provides the definitive information about the nature of the involvement of the normal SLP and is the initial step in the resection of the lesion. Since the epithelium overlying a sessile polyp is typically normal, all or a portion of it is usually preserved to facilitate rapid healing. Essentially, sessile polyps are being managed similarly to subepithelial cysts. Pedunculated polyps are often amputated by means of retraction and resection by means of microscissors.

Subepithelial infusion of saline and epinephrine enhances the precision of the resection of most of these lesions. The infusion places the normal mucosa on tension, which facilitates the epithelial cordotomy. The infusion also increases the depth of the SLP and exaggerates the discrepancy of the normal SLP from the fibro-vascular polyp tissue. These factors enhance maximal preservation of normal SLP during the dissection. The epinephrine in the solution as well as the hydrostatic pressure within the Reinke’s compartment improve hemostasis, which is critical when working at high magnification.

As stated earlier, sessile lesions are ideally removed by means of an epithelial microflap and a subepithelial resection of the polyp contents. Pedunculated lesions with a narrow pedicle are optimally resected by retraction and amputation. The surgeon will need to individualize the resection approach based on pathological presentation. Care should be taken to palpate the component of the polyp that is in the SLP so that it is adequately excised.

**Fibrovascular nodules**

Vocal fold nodules [Fig. 4] may present visually and acoustically in a varied manner. There are divergent opinions as to the value of phonomicrosurgical intervention. It is likely that the different philosophy about the efficacy of a surgical intervention is based (in part) on confusion in the literature as to what constitutes vocal nodules. Remarkably, the most common phonomicrosurgical lesions that we encounter for resection in vocalists are nodules and most commonly in opera singers. There is little disagreement that these lesions are the result of vocal abuse or inappropriate vocal use. Therefore, irrespective of the decision to excise vocal nodules, virtually all of these individuals will benefit from vocal therapy.

Strobo-videolaryngoscopy is critical when assessing nodules. High-pitch assessment is necessary to analyze the mechanical effect that fibro-vascular nodules have on vocal fold vibration. The nodules may be even better defined if the high frequency phonatory task is also done with low subglottal pressures such that the patient becomes diplophonic or aphonie with an aperiodic mucosal wave or the acoustic signal ceases. In this setting, the stretching the vocal fold physiologically thins any residual SLP that is left under the fibro-vascular nodule so that the voice becomes disordered. This type of evaluation also exhibits evidence that surface nodular excrescences frequently have significant unrecognized involvement of the SLP than might be clinically suspected during stroboscopic examination at a normal pitch frequency. This iceberg effect is found intraoperatively when an epithelial cordotomy is performed.

In most cases, it is advantageous to employ surgery as a secondary management. The philosophy regarding surgical intervention is highly individualized to patients and surgeons as well as associated involved professionals such a speech language pathologists and voice teachers, who spend the greatest amount of time with the patient. An initial trial of vocal therapy should reduce hyperfunctional behavior...
and reduce the generalized edema of the SLP that typically accompanies these lesions. Even if the nodules do not resolve and disappear visually, the patient may be satisfied with the quality and stamina of their voice such that surgical intervention is not necessary. If the patient desires further improvement, and clear nodules are seen, phonomicrosurgical excision may further enhance vocal quality. The prior vocal therapy will benefit the patient during the postoperative rehabilitative process to prevent injury and recurrence.

The philosophy that nodules should not be resected despite their continued presence after adequate vocal rehabilitation arose from unsatisfactory surgical outcomes. In many cases, the trauma induced by the procedure was more deleterious to vocal fold vibration than the lesion itself. This was especially so when the CO₂ laser without a microspot was used injudiciously and/or small nodules were avulsed or stripped. During the last decade, as the instrumentation and techniques have improved, the author has been increasingly resecting nodules, which have been refractory to vocal rehabilitation.

Similar to the aforementioned techniques for excising vocal polyps, phonomicrosurgical resection of vocal nodules can be performed by means of an

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**Fig. 4 a.** Microlaryngoscopic exam demonstrating fibrovascular nodules in a musical-theatre performer.

b. A subepithelial infusion is done in the left vocal fold. The lumen of the needle can be seen through the transparent epithelium.

c. A subepithelial resection is done and the fibrovascular tissue is withdrawn through the epithelial cordotomy.

d. Subsequent to the resections, there is maximal preservation of superficial lamina propria and the vocal folds are smooth and straight without loss of epithelium.
epithelial microflap or by amputation. Observations from the post-resection results of a cohort of vocal performers revealed that the voice result is enhanced by a subepithelial resection of the fibro-vascular SLP. However, currently this approach is limited by suboptimal hand instrumentation. Cold instruments provide improved precision considering the small size of these lesions and the need for palpation during the procedure. The use of the subepithelial infusion technique must be used selectively. Some nodules that are less well defined visually and by palpation may become obscured by the infusion-induced distension of the SLP.

**Varices And Ectasias**

Varices and ectasias [Fig. 5] of the vocal folds are the result of microvascular trauma within the SLP. The majority of the patients with a history of recurrent vocal hemorrhage, who require phonomicrosurgical intervention, are female vocalists. Many patients will undergo resection of these vascular malformations while the surgeon is excising separate vocal fold pathology, which was the indication for the surgery. Lesions were most frequently noted on the superior surface of the middle musculo-membranous vocal fold, which has been termed the striking zone. In the 1990s, these lesions were treated by cold-instrument dissection. The 532nm pulsed-KTP laser has become our treatment of choice since we can achieve optimal selective photoangiolyis with minimal collateral heat to the surrounding SLP. Unlike our experience with the 585nm PDL, vessel-wall rupture is minimized.

These superior-surface lesions are generally situated where the lateral extent of mucosal wave excursion would reverse direction. This suggested that these vascular injuries were the result of a deceleration force similar to a whiplash injury. We believe that the inertial force of the mucosal wave of the SLP and the intraluminal blood of the microvasculature are restricted by the elastic recoil of the tissues and the overlying epithelium. This leads to subepithelial vascular trauma, which is easily visible through the normal translucent epithelium. The cushioning effect of the SLP prevents vessel rupture deeper within Reinko's compartment. The superficial location of these vascular malformations just under the basement facilitates surgical accessibility without significant trauma to the underlying SLP.

If a pulsed angiolytic laser is not available, these vascular lesions can be resected by means of cold instruments and multiple epithelial cordotomies. The approach is analogous to a vein stripping of the superficial venous system from the lower extremity to redistribute the aberrant vascularity. It was advantageous to redistribute the susceptible central vascular-malformations of the vocal folds out of the striking zone where they were much more likely to hemorrhage.

Cold-instrument resection was highly successful in

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**Fig. 5 a.** Microlaryngoscopic exam demonstrating a large varix-ectasia complex is seen on the superior surface of the left vocal fold. A subepithelial infusion is done and the 6mm fiber for the pulsed KTP laser is seen directed at the lesion.

**5b.** Subsequent to treatment, there is minimal epithelial disturbance.
preventing recurrent hemorrhage and despite multiple epithelial cordotomies, there was no postoperative deterioration in vocal function or mucosal wave pliability. This was so despite the fact that; a. many incisions were made on the medial vocal fold surface and b. virtually of patients were singers. The findings of that study also revealed that patients healed more slowly after CO$_2$ laser ablation than after cold-instrument resection. There were several patients who developed epithelial stiffness subsequent to laser ablation.

Cysts

Subepithelial cysts [Fig. 6] arise in the SLP and present in a variety of sizes. They may be attached to the vocal ligament and/or the epithelial basement membrane. Small cysts may also be freely suspended within the SLP. Small cysts may be confused with nodules if visual examination is performed without stroboscopy. Stroboscopic examination typically reveals a characteristic asymmetric disordered oscillation of the mucosa because of the well circumscribed stiffness in the area of the cyst. If the cyst protrudes from the medial surface of the glottal edge, a nodule

Fig. 6 a. Microlaryngoscopic exam demonstrating an infusion being done in the left vocal fold where a subepithelial cyst is noted.

b. The cyst is seen through the epithelial cordotomy.

c. The cyst is seen under higher magnification.

d. The cyst has been resected and there is no loss of epithelium. The vocal fold is now normally contoured.
may be observed on the contralateral vocal fold. Asymmetric spheroid masses on the medial surface of the vocal fold should alert the clinician that there may be a cyst on one side.

Most subepithelial cysts probably arise from obstructed ducts within the SLP. They may contain mucous or may be composed of an epithelial rest (similar to a cholesteatoma). On occasion, small ovoid subepithelial masses that are thought preoperatively to be a cyst within the SLP, are found at microlaryngoscopy to be fibrous masses. These masses are usually firmer to palpation and may be the result of an old microvascular injury or a rheumatoid lesion. The subepithelial infusion technique is extremely helpful during the phonomicrosurgical resection of well-defined cysts and firm masses within the SLP. Similar to small nodules, the infusion can obscure the boundaries of small cysts and lead to unnecessary dissection and trauma of normal SLP.

Masses within the SLP should be resected with cold instruments with few exceptions. It is not uncommon for the cyst to rupture, especially towards the end of the dissection, while grasping the fragile wall for retraction. The surgeon must be careful to retrieve the entirety of the cyst wall without undo trauma to the underlying normal SLP. Great care should be taken to minimally disturb any normal SLP and epithelium. This approach will optimize postoperative mucosal-wave oscillation and vocal quality. Although the wave usually improves, it does not typically return to normal if the cyst has already replaced a substantial amount normal SLP, which will not regenerate. The need for extremely fine delicate tangential-dissection precludes effective use of the CO2 laser or other continuous-wave lasers.

Polypoid Corditis/Reinke’s Edema

Polypoid corditis [Fig. 7] presents as extensive swelling of the SLP (Reinke’s space). The swelling is usually situated on the superior surface of the musculo-membranous vocal fold. This entity is another manifestation of vocal-fold pathology that is of multifactorial genesis. These patients typically smoke extensively, have laryngo-pharyngeal reflux, and demonstrate vocal hyperfunction. The swelling probably occurs from the increased aerodynamic pressures that drive vocal-fold mucosal oscillation in a general environment of glottal mucositis, which is secondary to smoking and reflux. The swelling is typically bilateral but often asymmetric in volume.

Individuals with polypoid corditis describe gradual onset of a rough and abnormally low-pitched voice (females: <130 Hz, males: <110 Hz) because the mass-loaded folds oscillate at an inordinately low frequency. Females present more frequently than men and undergo phonomicrosurgical management more frequently because of the greater discrepancy from their normal fundamental frequency (180-230 Hz).

Airway symptoms are unusual if the arytenoids abduct normally since the edema is confined to the anterior glottal aperture. Epithelial pliability and mucosal-wave characteristics vary greatly between patients and are dependent on the viscoelasticity of the pathological SLP. Some individuals have hyperdynamic pliable waves and others, who have sustained severe phonotrauma, demonstrate poor pliability and mass motion of the epithelium and pathological SLP. When the edema is extensive, it can potentially obscure an occult malignancy.

Treatment of Reinke’s edema begins with elimination of predisposing risk factors. These individuals should discontinue smoking, have their reflux controlled, and should undergo preoperative vocal therapy before undergoing a procedure. Systemic steroids are not routinely used to treat Reinke’s edema and topical beclomethasone has not been shown to be effective. Patients should be advised that if they continue to smoke, the problem will not resolve without surgery, and will likely recur subsequent to surgical resection. Many surgeons will not operate on patients with Reinke’s edema if they continue to smoke unless there is concern that cancer may coexist with the polypoid condition. However, extensive edema may obscure the identification of an early malignancy in the office so that some individuals will undergo earlier microlaryngoscopic intervention if keratosis is noted.

Surgery has been the mainstay of treatment for Reinke’s edema. Vocal-fold stripping was designed as a one-handed, unmagnified treatment for Reinke’s edema by means of a monocular laryngoscope. Unfortunately, this procedure is imprecise, and frequently, excessive SLP and epithelium are removed. This can result in a prolonged period of healing, and often, stiff scarred vocal-folds. Although the vocal folds appear normal by means of a mirror or fiberoptic exam, stroboscopy reveals loss of epithelial pliability and lack of vibration.

A number of years ago, Hirano described a more
precise technique, which involves incising the epithelium, elevating the mucosa as a flap. Then the gelatinous matrix within the SLP is reduced followed by redraping the flap and trimming the excess mucosa. A microscissors is used for the initial incision unless there is prominent subepithelial vascular injection, in which case a KTP laser can be advantageous. The gelatinous hypertrophied SLP should then be carefully contoured and reduced to a more normal volume. This can be done by suctioning or by direct removal. Great care must be taken not to over reduce the SLP, which results in an inordinately stiff vocal system. The vocal ligament should never be visualized directly. Over reduction of the SLP can result in a severely strained harsh voice since these individuals already employ high subglottal pressures to drive their floppy mass-loaded folds. Vocally, it is preferable to leave a larger fold than to create a visually-pleasing smaller fold.

Once the SLP has been reduced, the epithelium is redraped and trimmed appropriately. There are varied opinions as to whether both vocal folds should be worked on simultaneously. Exuberant resection of epithelium and SLP antero-medially may leave two opposed raw surfaces at the anterior commissure, which can lead to web formation. If the incisions and dissection are confined to the superior surface of the vocal folds, bilateral procedures were not associated with complications.

Microflap cyto-reduction avoids removing excessive

Fig. 7 a. Microlaryngoscopic exam demonstrating substantial Reinke’s edema (polypoid corditis) is seen in the right vocal fold.
   b. Subsequent to an epithelial cordotomy, the excessive superficial lamina propria is suction contoured.
   c. With the flap retracted, the thin epithelium is noted to be transparent and translucent.
   d. The vocal folds are now normally contoured.
amounts of mucosa and healing time is therefore shortened. If leukoplakia/keratosis or other suspicious process involves the mucosa, that tissue should also be removed for pathologic examination. This may cause a defect to be present which will lengthen the healing time. After an initial period of vocal rest (~10 days) patients should receive vocal therapy and should be monitored closely. Preventing recurrence is dependent on modification of the predisposing factors, especially smoking.

Control of the medical factors along with surgical resection will usually elevate the fundamental frequency of female patients to approximately 150 Hz, which is commensurate with the normal fundamental frequency for female smokers. Patients should also undergo a course of voice therapy postoperatively since the biomechanics of the glottal sound production has been radically altered and they have become accustomed to phonating with excessive subglottal pressure.

**Papillomatosis**

Patients, who have recurrent respiratory papillomatosis [Fig. 8] (RRP) of the glottis most frequently present with hoarseness. Commonly, the glottal disease is confined to the musculo-
membranous region, although it is not unusual to find extension in the inter-arytenoid region, ventricle, and subglottis. Exophytic disease can lead to stridor and airway compromise, especially in children.

Patients with RRP are tremendously challenging. When aggressive recurrent disease is encountered, the surgeon and patient must delicately balance airway safety, the effects of multiple general anesthesias, as well as quality of life and employment disturbance from the vocal dysfunction and procedural disability. This often requires extensive communication to ensure that the patient’s and surgeon’s goals are mutually aligned.

It is important to remember that RRP is typically not cured with surgical removal of the disease. Thus, a more aggressive resection does not result in an improved chance for a cure or a decreased chance for recurrence. The general behavior of the disease usually leads to eventual recurrence. Therefore, all surgical treatment, regardless of the methodology of the removal, should be based on the principles of precise, conservative removal/cytoreduction of the disease. The importance of gentle, precise surgical debulking/removal is paramount to the surgical management of RRP.

Ideally, surgical intervention is performed by individuals who retain high-level expertise in microsurgical procedures of the larynx. Successful management is dependent on skilled operating-room supporting staff, communication with anesthesiology colleagues, and availability of current microsurgical instrumentation. This includes state-of-the-art laryngoscopes, hand instruments, and lasers. It is valuable for the surgeon to be facile with several surgical techniques to remove the disease since the different regions of laryngeal mucosa often require different surgical approaches and instrumentation (varied lasers, microsurgical cold-steel, and microdebrider).

Approaches for surgical removal of RRP are evolving; instrumentation should be individualized and selected with care to optimize precision. It must be emphasized that RRP is an epithelial disease and that it is critical to preserve the underlying SLP and other key structures (anterior commissure tendon and vocal process). Furthermore, the natural history of RRP is that it recurs, which usually necessitates multiple procedures in the lifetime of a patient. These factors must be omnipresent in the surgeon’s mind since preservation of normal laryngeal tissue will facilitate optimal function for the future after a medical solution will ultimately be conceived.

Because of its excellent angiolytic properties, at present, we exclusively employ the 532nm pulsed KTP laser along with cold instruments in the treatment of glottal papillomatosis. We have abandoned using the CO2 laser and the PDL in the glottis. Remarkably, although we initiate a patient’s first treatment for papillomatosis in the operating room, the majority of our surgical interventions are now as an office-based treatment with local anesthesia through a flexible laryngoscope.

Intralesional injection of cidofovir is an adjunctive/experimental treatment for RRP. Cidofovir is a known antiviral that is FDA approved for CMV retinitis. Preliminary experience with intralesional injection of the RRP disease with cidofovir has been highly favorable. However, long-term results are scant with respect to side effects, complications and cessation of treatment have been demonstrated. This is especially so with regard to the effect on the voice outcome and the pliability of the sublesional superficial lamina propria.

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