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Surgical Management of Phonotraumatic Lesions: Current Techniques

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Abstract

Purpose of Review Recurrent phonotrauma can lead to chronic mucosal damage and the development of benign lesions such as vocal nodules, polyps, and cysts. Traditionally, voice therapy with Speech and Language Pathology has been the mainstay for treatment of these lesions. However, surgical management is frequently employed in those lesions that persist in spite of therapy.

Recent Findings Over the past two decades, there have been many advancements in cold-knife surgical technique, as well as the introduction and development of laser management and intralesional steroid injections. In particular, there has been an increased emphasis on techniques for in-office management of lesions.

Summary As the field of laryngology continues to grow and develop, practitioners will continue to have safer and more effective treatment options, both in the operating suite and in the clinic setting, for management of phonotraumatic lesions.

Keywords Phonosurgery · Vocal fold lesion · Vocal nodule · Vocal polyp · Vocal cyst · Laryngeal surgery

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Introduction

Affecting most of the population at some point in their lives, dysphonia has been shown to contribute to social isolation, depression, and decreased quality of life [1, 2]. Among dysphonic patients who seek treatment, approximately 23 % are secondary to vocal fold nodules, polyps, or cysts [3]. Voice use leads to mechanical stresses when the vocal folds collide. Over time, this mechanical stress causes edema and can create a wound that ultimately leads to remodeling of the lamina propria and epithelium of the vocal folds [4]. Eventually, this remodeling results in the development of nodules, polyps, cysts, and other lesions [5]. These lesions can then affect glottic closure and vibration of the vocal folds, ultimately changing voice quality [6].

Traditionally, the first line management of phonotraumatic lesions has been working with speech language pathology as well as management of potential contributing factors, such as smoking cessation and laryngopharyngeal reflux [5]. Voice rehabilitation is based on the concept that the combination of inefficient phonation, time spent phonating, and patient biology lead to development of the lesions as described previously. Improvement of these behaviors can help to break the phonotraumatic cycle, encouraging the lesions to resolve. Voice therapy attempts to help the patient to attain more efficient voicing technique during therapy sessions, while helping to reinforce "carry-over." This aids the patient in incorporating these techniques into their daily life [7••, 8, 9].

Voice therapy techniques have been shown to be effective for many phonotraumatic lesions [9–13]. However, oftentimes, lesions persist in spite of therapy. Traditionally, for lesions that have failed to respond to voice therapy, laryngeal surgery has been the next line of management. The purpose of this report is to discuss surgical management of these phonotraumatic lesions, as well as to address recent changes within the surgical field including laser and steroid injection procedures.

History of Surgical Management of Phonotraumatic Lesions

Surgical resection of phonotraumatic lesions dates back to 1852 when Horace Green performed the first known transoral excision of a laryngeal polyp. However, the first direct laryngoscopy is attributed to Kirstein in 1885. Though practitioners were able to perform direct laryngoscopy after that time, the concept of the suspended laryngoscope, introduced by Killian in 1911 and further developed by Lynch 3 years later, allowed for surgeons to operate with two hands. This was further enhanced decades later when Albrecht adapted the microscope for use in laryngology in 1954 [14, 15]. Over the next decade, a commitment was made to laryngeal microsurgery, with the goal of maintaining and improving vocal function. Ultimately, the cold-knife approach to phonomicrosurgery was developed by Kleinsasser in 1964 [14].

The technique of Kleinsasser remained in favor until the 1980s, when additional research into the physiology and histology of the true vocal folds indicated that preservation of the vocalis muscle and lamina propria were vital to maintaining the mucosal wave and voice quality after surgery [16]. This prompted surgeons to focus on removing vocal fold pathology without creating significant scar. Sataloff et al. introduced the concept of the microflap in 1986 [17]. This involves creating an incision and dissecting the lesion in the subepithelial plane, so that the healthy overlying mucosa may be preserved. In 1991, Zeitels then introduced the concept of injecting a solution into Reinke's space allowing surgeons to better delineate normal tissue and disease [18]. The microflap concept was then built upon by Ossoff who expanded the technique into medial and lateral microflaps, depending on the most appropriate approach for specific lesions. This has become the gold standard for surgical management of benign lesions of the vocal fold [19, 20].

The microflap technique has led to significantly improved outcomes after phonosurgery; however, the technique is not without flaws. This technique decreases scarring of the vocal fold but does not eliminate it in spite of good surgical technique. Clinically significant scar can form when overlying mucosa becomes adherent to the vocal ligament, affecting vibration and ultimately leading to suboptimal voice outcomes. Postoperative voice rest attempts to prevent flap displacement and promote optimal healing [21]. Another concern regarding phonosurgery has been the associated risks of the operating room. In addition to the risks of general anesthesia, there is possible injury to the lips, teeth, gingiva, and cervical spine. Efforts over the past decade have been focused on minimizing the risks of surgery, both for the creation of scar, as well as creating alternatives to the operating suite.

Advances in Direct Laryngoscopic Technique

Woo et al. first recognized the inherent risk of scarring with microflap displacement and began investigation of suturing of the microflap in order to stabilize the flap and decrease scarring. He placed microsutures on 18 patients all of whom reported subjective improvement in their voice postoperatively. This suggested that microsuturing may aid in healing of the microflap [22]. Fleming et al. then expanded on this work in 2001, when they performed a controlled canine study comparing microflaps with and without microsutures. It was found that unsutured vocal folds exhibited 75 % larger scar cross-sectional area than the sutured vocal folds, indicating that microsuturing may contribute to better outcomes [23]. Yilmaz et al. performed a randomized trial comparing microsuturing to control after microflap in 40 patients. They found that sutured vocal folds seemed to heal faster on videostroboscopy than unsutured vocal folds, while the end points were the same [21].

Microsuturing in laryngeal surgery has not been widely adopted. This is largely due to the extreme difficulty of successfully suturing a microflap. In 2009, Tsuji et al. described the T-shaped microsuture technique which was felt to be less technically demanding. The technique uses a short segment of 4-0 nylon suture tied with 7-0 Vicryl to reduce pull through of the suture, while tying the knot completely under microscopic vision. This single surgeon technique had a low risk of tissue rupture, and could be performed quickly [24].

Instead of suturing, Franco et al. introduced the concept of photochemical repair using Rose Bengal. Rose Bengal bonds in response to light and does not change the surface temperature that would cause tissue damage. They found in a canine model that photochemically bonded microflaps remained intact when exposed to compressed air, while unclosed microflaps did not [25]. In 2015, fibrin glue was compared to suture closure of microflaps in a bovine model. The authors found that fibrin glue provided no additional benefit over no-closure [26]. While these techniques are not being widely used in humans, they suggest that there may be safer and less technically challenging alternatives for closing microflaps in the future.

Another method through which surgeons have attempted to improve upon microlaryngeal surgery is through the use of Hopkins rod rigid endoscopes. A recent case report described where a vocal fold lesion was resected through telescopic guidance. Using both 0° and 30° telescopes, the surgeon was able to visualize the lesion, while using microscissors to dissect the nodule from the overlying mucosa [27]. This technique is frequently employed with the Gray's minithyrotomy technique when addressing sulcus deformities [28]. These applications demonstrate that microlaryngeal surgery can be aided with or even performed using an endoscope versus microscope. The endoscope provides increased field of vision and depth of surgical field, while providing unmatched views of the anterior commissure and ventricles.

Laser Management of Phonotraumatic Lesions

Lasers were first introduced in laryngeal surgery in the 1960s when Jako began investigating the effects of CO_2 lasers on cadaveric vocal cords. Ultimately, he published his work in 1972, introducing an endoscopic delivery system for the CO_2 laser [29]. In the same year, he with Strong introduced the concept of laser surgery of the larynx [30]. Over the next three decades, multiple groups began investigating the effects of the CO_2 laser on mucosa [31–33]. However, in spite of this research, laser phonosurgery did not become a major part of microlaryngeal surgery until the 1990s. Since the end of the 20th century, much research has been done in order to create safer, more effective laser surgery.

Over the past decade, three types of lasers have dominated laryngeal surgery. The first is the original carbon dioxide laser, introduced by Jako [29]. The CO_2 laser functions at 1060 nm, which is maximally absorbed by water. This interaction with water causes a combination of hemostasis and tissue ablation [34]. In contrast, the pulsed dye laser (PDL), introduced in 1998 for vocal fold use, functions at 585 nm [35]. Similarly, the potassium titanyl phosphate (KTP) laser, introduced in 2006, functions at 532 nm [36]. Both the PDL and KTP lasers are maximally absorbed by oxyhemoglobin. The absorption by oxyhemoglobin is theorized to selectively treat the vasculature of the pathologic lesion, sparing the surrounding normal tissue [37].

Advances in Carbon Dioxide Laser Surgery

Since its introduction in the 1970s the CO_2 laser has been the primary laser utilized in laryngeal surgery. In 1976, Mihaski et al. demonstrated that the zone immediately adjacent to the laser crater becomes carbonized. In addition, tissue even further removed from the crater, up to 0.5 mm demonstrated interstitial edema and vacuole formation [31]. This thermal injury can cause scarring of adjacent tissue, leading to potentially worse voice outcomes. Therefore, much research has gone into finding means of eliminating damage to surrounding tissue while using the CO_2 laser.

One of the most important improvements to the CO_2 laser has been the creation of the pulsed laser. By pulsing the beam, surgeons are able to expose the tissue to high energy levels over shorter periods of time, allowing tissue to cool between pulses, ultimately reducing tissue necrosis and carbonization [38]. The super pulsed and ultra pulsed lasers, with an exposure time of milliseconds, have made this laser safer and more precise.

The creation of the micromanipulator scanning system, a computer operated system designed for laser surgery, further improved the accuracy and safety of the CO_2 laser. This system, now under the trade name of "AcuBlade" or "AcuSpot" (Lumenis Surgical, San Mateo, CA) guides the laser over the designated surface with a specific depth, power, and sweep time to optimize accuracy and lessen damage to deeper tissues [39].

Multiple surgeons have published on the improved outcomes found using the micromanipulator system with superpulse or ultrapulse CO_2 lasers. Geyer et al. used a combination of the super pulsed CO_2 laser with the AcuSpot micropanipulator system to excise 191 benign glottic lesions. This approach led to significant improvement in both subjective and objective voice outcomes, demonstrating the efficacy of super pulsed lasers for excision of benign lesions of the vocal folds [40].

Advances in Fiberoptic Lasers

In recent years, there has been an increased emphasis on the benefits of in-office procedures over those performed in the operating room. Specifically, by performing in-office management of phonotraumatic lesions, patients are able to undergo procedures without having to receive general anesthesia or undergo direct laryngoscopy. This decreases the risk of complications associated with the procedures. In addition, it eliminates the need for patients to miss an entire day of work secondary to postoperative recovery from general anesthetic. Another advantage of in-office phonotraumatic lesion management is the significant decrease in patient cost compared to that for procedures performed in the operating room [41•, 42••, 43].

Given the potential advantages of in-office procedures, many surgeons have investigated the use of lasers in the office setting. The PDL and KTP lasers have been a large focus of in-office laser management of phonotraumatic lesions. In 2012, a multi-institutional study examined the efficacy of the KTP laser on 102 benign lesions, both phonotraumatic and nonphonotraumatic. They demonstrated significant decrease in sizes of all phonotraumatic lesions with improvement or no change in mucosal wave and glottic closure in >90 % of their patients [36].

Sridaran et al. specifically examined the effect of the KTP laser on in-office management of 31 patients with vocal fold polyps and demonstrated both significant improvement in VHI-10 scores, as well as objective decreases in polyp size [44••]. Studies focusing on the use of the PDL also showed similar results in the treatment of polyps. One study with 29 patients showed that half had greater than 50 % reduction in polyp size, while another with 75 polyp patients showed a >95 % reduction in lesion size with complete recovery of the mucosal wave, significant improvement in the GRBAS scale, as well as objective voice measures [45, 46].

It is important to note that, while many patients have excellent results with in-office management, multiple studies report that more than one treatment is required for complete resolution in 5–33 % of cases [42••, 43]. However, no study specified the repeat treatment rate necessary for phonotraumatic lesions.

Interestingly, there are a few studies that have been performed that show a combination of laser and cold excision of phonotraumatic lesions in the office setting. In 2013, Wang et al. described a combined method of management of small vocal fold polyps in the office [47]. Transnasal endoscopy was used to visualize the polyp. The KTP laser fiber was then inserted through the endoscope working channel to photocoagulate the lesion. Once photocoagulated, a flexible blunt-ended grasping forceps was inserted through the working channel of the endoscope and used to grasp and remove the cauterized lesion. They compared the outcomes of in-office laser-assisted polypectomy to in-office laser photocoagulation of small polyps (defined as less than 30 % of the length of the true vocal fold). They found that at two weeks, 85 % of patients who underwent laser-assisted polypectomy demonstrated complete recovery or significant improvement in the mucosal wave. This increased to 95 % at 6 weeks. Conversely, at 2 and 6 weeks, respectively, 56 and 76 % of patients who only underwent KTP laser ablation showed significant improvement in the mucosal wave. Thirteen percent of patients who only received KTP laser ablation went on to have surgical resection of their polyps. They concluded that in-office laser-assisted polypectomy is both safe and effective [47].

In 2015, the same group then compared outcomes of patients who received KTP laser-assisted polypectomy to patients who underwent traditional microlaryngoscopic surgery [48•]. After only 2 weeks, they found that 87 % of patients who underwent the in-office procedure versus 76 % of conventional surgical patients who had either a normal or significantly improved mucosal wave. At the 2 week postoperative point, patients of both groups were noted to have significant improvements in both subjective and objective voice outcomes, as measured by visual analog scale, VHI-10, and acoustic analysis, though the patients who underwent in-office procedures had higher self-rated voice quality overall. At 6 weeks, there were no significant differences between treatment groups. Overall, this suggested efficacy of in-office polypectomy as compared to cold-knife polyp management in this specific cohort [48•].

In addition to efficacy, there has also been a focus on the safety of in-office laser procedures. Del Signore et al. examined the safety of angiolytic laser in-office use for a wide variety of lesions, phonotraumatic and dysplastic, and demonstrated that the procedures were very well tolerated [42••]. In addition, he demonstrated a low complication rate of only 4 % with in-office use of angiolytic lasers among the 255 patients studied. These complications were vocal fold stiffness, atrophy, and transient, but prolonged hyperemia. In similar studies, Centric et al. demonstrated no complications amongst their 33 patients, and only Koufman saw a 0.9 % complication rate amongst 151 patients [43, 49]. In addition to the low complication rate, all three aforementioned studies demonstrated tolerability for in-office laser procedures of greater than 97 % [42••, 43, 49].

Other Uses of Angiolytic Lasers

Over the past decade, the vast majority of research for applicability of angiolytic lasers have been in the in-office setting. However, it is important to note that angiolytic laser can, and is, often used in the operating theatre. Burns et al. analysed the distribution of KTP laser use, both in the office and in the operating room at their institution, and found over a 1-year period that 54 % of all their clinic procedures and 46 % of their endoscopic procedures in the operating room utilized the KTP laser [50].

In 2015, Byeon et al. looked at the safety and efficacy of a combined PDL laser and cold-knife polypectomy of hemorrhagic vocal polyps in the operating suite. They first used the PDL to photocoagulate the polyp, then transitioned to cold-knife technique to perform microflap excision. In all patients, they were able to completely remove the lesion without significant bleeding or intraoperative complications. Postoperatively, they demonstrated significant improvement in both subjective and objective outcomes, demonstrated by VHI-10 scores, GRBAS scale, and acoustic analysis. This study demonstrated that angiolytic lasers may be utilized safely and effectively in the management of lesions too large for in-office laser treatment alone [51].

Caveat Emptor

It is important to note that the technique and patient selection have a significant impact on outcomes with laser surgical techniques. Oftentimes, a surgeon can be given a false sense of security when performing procedures with the various lasers. Despite the "angiolytic" properties of the PDL and KTP lasers, these modalities do impart a greater degree of thermal injury to adjacent tissue than an ultra pulsed CO_2 laser [52••]. It is more important as to how the laser is used than which laser or if a laser is used at all. The angiolytic lasers can be used to blanch lesions or can be used to ablate the lesion just as with CO_2 laser. Choosing the correct patients for awake vs. asleep surgery, cold vs. laser excision is essential for optimal outcomes. Nasal and laryngeal anatomy, as well as baseline patient anxiety can have a profound impact on the patient's ability to tolerate in-office procedures. Ultimately, the results of the various surgical tools and techniques are heavily governed by the skills and experience of the surgeon. Since both cold and laser techniques seem to have comparable outcomes, the surgeon-specific results should weigh heavily on the decision of which approach is chosen.

Steroid Management of Phonotraumatic Lesions

Steroids have frequently been used in the field of laryngology for the management of inflammatory disease due to their anti-inflammatory and immunomodulatory properties, such as with sarcoidosis, systemic lupus erythematosus, and granulomatosis with polyangiitis. In spite of these benefits of steroids, their systemic use has been associated with significant adverse effects, such as hyperglycemia, osteoporosis, and avascular necrosis [53]. Recognition of these complications has led to increased interest in intralesional injections, which allow for high local concentrations of steroid while avoiding systemic risks [54•].

Office-based injections of vocal fold lesions were first introduced by Yanagihara et al. in 1964 [55]. In spite of this introduction 50 years ago, steroid injections into the vocal fold were not widely used. However, over the last decade, there has been an increased interest in intralesional injection for phonotraumatic lesions. This increased interest is supported by a variety of animal models which have shown that steroid injections delay both the inflammatory and neovascular response after laryngeal insult. In addition, histologic evaluation after steroid injection of rabbit larynges demonstrated decreased collagen deposition during healing after injury [56, 57].

Currently, there are three methods through which steroids are injected into vocal fold lesions: transoral, transcutaneous, or transnasal. The transoral approach, introduced in 2004, passes a large curved needle through the mouth, along the base of tongue and into the larynx [58, 59]. While it is successful, this method can be complicated by the gag reflex [60]. The transcutaneous approach eliminates the concern for gag by allowing for needle injection of the true vocal fold through the thyrohyoid, thyroid cartilage, or cricothyroid membrane. However, this method can also cause bleeding, complicating the procedure [60]. Most recently, Wang et al. introduced a transnasal approach for injection, which allows for endoscopic injection of steroid via the working channel of the flexible fiberoptic endoscope. This method is well tolerated, prevents the gag reflex, and reduces bleeding from the airway mucosa [60]. Regardless of the method of steroid injection, multiple studies have shown the efficacy of intralesional steroid injections for management of phonotraumatic lesions. Regardless of lesion type, all reported studies show a response rate of 80 % or greater. These studies used triamcinolone acetonide (40 mg/mL), methylprednisolone (40 mg/mL), or dexamethasone sodium phosphate (5 mg/mL) [61–63].

In a comparative study, Wang et al. used a mixture of dexamethasone sodium phosphate (5 mg/mL) and triamcinolone acetonide (10 mg/mL) into patients with vocal fold nodules, polyps, and mucous retention cysts via the transnasal or transoral approach. They found that more than 80 % of patients with vocal nodules showed subjective improvement two months after the procedure. The nodules more likely to respond to steroids were soft nodules in patients with less vocal demand in their lives. Among the patients with polyps and cysts, 90 % showed improvement. Polyps that were more likely to respond were in patients who had symptoms for less than 12 months and "no symptoms of laryngopharyngeal reflux." There were no identified predictive factors for cyst response to steroids [7••].

The main concern of steroid injections is vocal fold atrophy. To this end, Shi et al. reported two cases of vocal fold atrophy after serial dexamethasone steroid injections [64•]. However, in the larger studies reviewed, only four cases of vocal fold atrophy were reported [60]. More common complications were deposition of white triamcinolone plaques within the true vocal fold and hematoma after injection. Both of these complications resolved spontaneously without long-term sequelae [7••, 62, 63].

Conclusion

Voice changes affect a significant proportion of the population resulting in a significant impact on quality of life. Phonotraumatic lesions such as vocal fold nodules, polyps, and cysts are a frequently treated entity within the field of otolaryngology. In the past, treatment management primarily consisted of surgical management via the microflap technique. However, over the past two decades, there have been significant advancements in their management, both through cold-knife excision, laser therapy, and steroid injections. The focus of these and future developments is the preservation of adjacent tissue, improved wound healing, and increased safety overall. Further investigation into vocal fold physiology will provide better understanding of why and which lesions patients develop. This knowledge will help to identify if, when, and which surgery should be offered.

The greatest challenge in the treatment of phonotraumatic lesions is striking the appropriate balance between conservative and surgical management techniques with appropriate postoperative care. Treatment with voice therapy in advance of any more invasive intervention should be prioritized, as resolution of the lesion without surgery is always preferred. As all patients have unique considerations, it is necessary to tailor treatment plans according to the patient. It should also be noted that the efficacy of any surgical tool or technique is ultimately limited by the capabilities of the user.

As the field of laryngology continues to grow and develop, practitioners will continue to have safer and more effective treatment options, both in the operating suite and in the clinic setting, for management of phonotraumatic lesions.

Compliance with Ethical Guidelines

Conflict of Interest Dr. Nyssa Fox Farrell and Dr. Matthew Scott Clary declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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