OFFICE-BASED TREATMENT OF GLOTTAL DYSPLASIA AND PAPILLOMATOSIS WITH THE 585-NM PULSED DYE LASER AND LOCAL ANESTHESIA

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Treatment of glottal papillomatosis and dysplasia was mirror-guided and performed in surgeons’ offices in the 19th century. It migrated to the operating room in the 20th century to accommodate direct laryngoscopic surgery, which required assistants to administer anesthesia and procedural support. Presently, the primary treatment goals, which are disease regression and voice restoration or maintenance, are tempered by the morbidity of general anesthesia and potential treatment-induced vocal deterioration. In fact, general anesthesia has been appropriately considered to be an acceptable source of morbidity for the promise of a precise procedure, which usually ensures airway safety and an optimal vocal outcome. However, patients with recurrent glottal papillomatosis and keratosis with dysplasia are typically monitored with various degrees of watchful waiting until there is a subjective judgment (on the part of the patient and surgeon) that the disease is more of a liability than is the procedure to treat it. Innovations in the 585-nm pulsed dye laser delivery system have allowed for its use in the clinic with local anesthesia through the working channel of a flexible fiberoptic laryngoscope. A prospective assessment was done on 51 patients in 82 cases of recurrent glottal papillomatosis (30) and dysplasia (52). All individuals had previously undergone microlaryngoscopic management with histopathologic evaluation. Five procedures could not be completed because of impaired exposure (2) or discomfort (3). Of those patients who could be treated, there was at least a 50% disease involution in 68 of 77 cases (88%) and 25% to 50% disease regression in the remaining 9 (12%). Patient self-assessment of the voice revealed that 34 of 77 were improved, 39 were unchanged, 4 were slightly worse, and none were substantially worse. These data confirm that diseased mucosa can be normalized without resection or substantial loss of vocal function. The putative mechanisms, which vary according to the fluence (energy) delivered by the laser, are photoagglutination of subepithelial microcirculation, denaturing of epithelial basement membrane linking proteins, and cellular destruction. Furthermore, this relatively safe, effective technique allowed for treatment of many patients (in a clinical setting) in whom classic surgery-related morbidity would have often delayed intervention.

KEY WORDS — dysphonia, dysplasia, glottis, hoarseness, keratosis, laryngoscopy, papillomatosis, pulsed dye laser, vocal cord, vocal fold.

INTRODUCTION

The surgical management of superficial epithelial diseases of the vocal folds was primarily performed in the surgeon’s office (Fig 1) in the 19th century1,5 and in the operating room in the 20th century.6 This paradigm shift in the administration of care was due to developments in surgical technology and anesthetic approaches. The advances were guided by the principal treatment goal, ie, regression of the disease while optimizing function (airway and voice) and minimizing morbidity (ie, discomfort). The transition to the operating room was catalyzed by a shift to direct laryngoscopic7,8 endolaryngeal surgery. A comprehensive historical review of the treatment of glottal epithelial disease reveals the interdependence of technological advances in surgery and anesthesia. The observations herein will shed light on patterns of past present, and future pathways of innovation that are in line with Kirsten’s prophetic predictions8 of a century ago.

HISTORICAL PERSPECTIVES

It is well known that Bozzini9 conceived indirect mirror laryngoscopy in 1807, when he described the Lichtleiter (light conductor). Subsequently, there were a number of other physicians who described mirror laryngoscopy through the first half of the 19th century.3,10-12 By 1852, while still in the prelaryngology era, Green13 had described the first direct laryngoscope and visually controlled endoscopic resection of a laryngeal neoplasm. The advances of both indirect and direct laryngoscopy, as well as the first visually controlled endoscopic surgical procedure in the larynx, were formally described during a period

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considered by historians to be the prelaryngology era, as the field did not formally exist as a specialty. It was only after Garcia’s seminal article of 1855, “Observations on the Human Voice,” describing auto-mirror-laryngoscopy, that the field of laryngology arose. The field’s inception was based on Czermak’s\(^{15,16}\) and Turek’s\(^{17,18}\) tireless efforts toward developing and teaching mirror laryngoscopy and, unfortunately, their mutual wrangling over academic recognition for catalyzing the development of laryngology.

Over time, the primary driver for the development of laryngology was visually controlled surgical treatment of the airway and voice. A fundamental paradox has remained unexplained and bears heavily on our current treatment patterns, even affecting the viability of the new approach investigated herein. If both indirect and direct laryngoscopy were well described in the prelaryngology era, why did the field initially develop on the basis of indirect mirror-laryngoscopic surgery? This occurred despite the fact that direct endolaryngeal surgery is substantially more precise than is mirror-controlled surgery, as was borne out by 20th-century developments.

We believe that despite Green’s success in direct examination, mirror laryngoscopy was considerably easier and more comfortable for the patient during the era that preceded the introduction of local anesthesia. Green simply overpowered his first patient, who was an 11-year-old girl. Understandably, Green’s approach was not reliable in an adult without anesthesia. In fact, Kirstein’s experience with direct laryngoscopy in children 45 years later mirrored Green’s. “Obstreperous children, who will not allow any manipulation, can be made to submit to examination by force.”\(^{8(0)}\) Furthermore, Kirstein astutely explained that one of the most important contributions of autoscopy was the ability to examine and treat pediatric airway problems. This management had been extremely difficult with mirror laryngoscopy in most children, and frequently impossible in younger ones.

Conversely, mirror laryngoscopy in adults was well within the purview of many physicians, as evidenced by the fact that an opera teacher, Garcia, had mastered the technique. The introduction of topical cocaine for local anesthesia became a primary driver for laryngology\(^{8}\) in the 19th century. Koller,\(^{19}\) an ophthalmologist, introduced the concept of cocaine-induced mucosal anesthesia in September 1884. He then collaborated with Jelinek,\(^{20}\) who in October 1884 reported on and gave a live demonstration of the use of cocaine as a local anesthetic for mirror-guided endolaryngeal surgery.

Cocaine eventually became the facilitator for the reemergence of direct laryngoscopy\(^{8,21}\) and suspension laryngoscopy. Kirstein’s (Fig 2) seminal work entitled “Autoscopy of the Larynx and Trachea”\(^{7,8}\) marked the dominance of direct endolaryngeal surgery. He called his technique autoscopy so as not to compete with the established concept of the laryngoscope, which was a mirror. The humility and patience with which he introduced such an important
Fig 3. Jackson then perfected supine direct laryngoscopy, which furthered surgical capabilities. More assistants and equipment were necessary, and this approach facilitated laryngotracheal intubation for general anesthesia. (Reprinted with permission, The Laryngoscope.)

A paradigm shift in thinking was evidenced by the last sentence of his preface: "Of course many a laryngologist is convinced that the laryngological technique needs no additions; others may think differently. Only the future can decide this question."[p.21]

Kirstein clearly envisioned the enhanced surgical precision provided by direct laryngoscopy and astutely foretold the changeover to direct endolaryngeal surgery. "Autoscopy is veritably a surgical method...I nevertheless believe that finally, in the course of years, autoscopy will be generally accepted as the standard method for endolaryngeal and endotracheal surgery..."[p.47, 51-2] As is often the case, an advance in anesthesia (ie, cocaine) allowed for a surgical development.

The expanded capabilities of direct laryngoscopic surgery catalyzed a realignment of the goals, focus, and responsibilities of the surgeon. Kirstein performed autoscopy (direct laryngoscopy) in his office (Fig 2) with an assistant. Subsequently, Jackson championed moving direct laryngoscopic surgery to the operating suite, as illustrated in the first textbook of rigid endoscopy of the upper aerodigestive tract. He was influenced by Solis-Cohen's (Fig 1) surgical orientation and in fact borrowed Solis-Cohen's personal textbooks. Jackson was further influenced by Kirstein's investigations into direct laryngoscopy and tracheoscopy and Killian's research in rigid bronchoscopy.

Jackson realized that optimal direct endolaryngeal surgery required an operating team, regardless of the position of the patient (Figs 3 and 4). This included individuals to assist with patient positioning, monitoring, and anesthesia, as well as to manage the myriad collection of new equipment. This move from the office to the operating room is even illustrated in the attire, which becomes surgical gowns (Figs 3 and 4) instead of street clothes (Figs 1 and 2). Because operating room management was a new paradigm, Jackson expended substantial effort delineating the technical roles of personnel. Taken together, a majority of endolaryngeal procedural interventions migrated from the clinician's office to the operating room within a decade.

In summary, the potential to expand surgical capabilities and precision with direct laryngoscopic surgery provided the catalyst to treat many laryngeal disorders in the operating room. In fact, a majority of critical 20th-century advancements (ie, microscope, general anesthesia, lasers) in direct laryngoscopic surgery required increasing support of an operative team both to administer the procedure and to maintain the equipment.

At present, a primary reason that endolaryngeal treatment of glottal dysplasia and papilloma remains in the operating room is the need for general anesthesia. This approach allows for precise optimal management of the primary goals, which are diagnostic accuracy, regression of disease, and voice restoration or maintenance. However, there is an unavoidable risk of morbidity associated with general anes-
thelia, and there are costs associated with the preoperative evaluation and procedural intervention.

In consequence, a majority of patients with recurrent glottal dysplasia and papillomatosis are followed with known disease until the adverse effects of the growth of the lesion(s) justifies the risk of morbidity and the costs of the surgical intervention. All surgeons and patients inherently acknowledge the disadvantages of general anesthesia in microlaryngoscopic treatment by cooperatively developing an individualized treatment algorithm. Essentially, observed disease is followed until one or a number of factors justify a decision to leave the watchful-waiting mode to embark on surgical intervention. These factors include airway restriction, voice deterioration, and worrisome visual appearance on clinic laryngoscopy.

This current management approach is based on pragmatic clinical factors that may not always align with optimal disease treatment. When these diseases occur in a more accessible region with less delicate function such as the oral cavity or skin, they are often treated sooner and by means of local anesthesia. We believe that there would be a substantially lower threshold for glottal intervention if a safe and efficacious treatment modality existed that did not require general anesthesia. Given the success encountered with the 585-nm pulsed dye laser (PDL) in treating glottal papillomatosis and dysplasia with general anesthesia, we sought to redesign the approach employing local anesthesia.

The design of this new pathway was based on the past 3-year experience using the PDL in the treatment of these diseases by means of microlaryngoscopy and general anesthesia. Photoangiolyis of the subepithelial microcirculation enhanced cold-instrument resection of the epithelial lesion(s) and also resulted in various degrees of normalization of unresected diseased mucosa. The 1-mm fiber was carried through a malleable aluminum cannula and introduced through the lateral slots of the universal modular glottiscope.

In designing the outpatient procedure, it was decided to use a flexible transnasal laryngoscope with an operating channel to deliver the laser energy. The first obstacle to be overcome was the need for greater flexibility of the delivery fiber so that the scope's range of motion could be preserved. This was solved by modifying the laser to a 0.6-mm-core fiber. Subsequently, we embarked on this investigation to determine whether we could treat selected patients with glottal papillomatosis or dysplasia by means of the 585-nm PDL with local anesthesia, thereby obviating the need for general anesthesia, a major component of the morbidity of management.

MATERIALS AND METHODS

From December 2001 to September 2002, a prospective assessment was done on 51 patients (see Table) who underwent 82 procedures with the 585-nm PDL for treatment of recurrent glottal epithelial disease: keratosis with dysplasia or recurrent papillomatosis. Patients who required surgical intervention were given the option of microlaryngoscopic resection, microlaryngoscopic resection with the use of the PDL, or flexible fiberoptic PDL treatment without resection. The study protocol was approved by the human studies institutional review board of the Massachusetts Eye and Ear Infirmary. No patient had a specimen retrieved for histopathologic assessment; however, all patients had undergone prior microlaryngoscopic excisional biopsies to establish the pathological diagnosis.

A PhotoGenica V 585-nm PDL (Cynosure Inc., Chelmsford, Massachusetts), used primarily for cutaneous vascular lesions, was modified and used to photoablate the vocal fold microvascularity (450-μs pulse width, 2.0-J-per-pulse maximum output, 2-Hz repetition rate, 0.6-mm fiber, approximately 1- to 2-mm spot size, 65- to 250-J/cm² fluence) to perform laser-assisted resection. Visual guidance was achieved by observing the PDL fiber through the distal working channel of a flexible transnasal laryngoscope. This was initially accomplished with a Pentax model FNL-15RP3 scope that has a 5.0-mm outside diameter and a working channel of 2.0 mm.

The FNL-15RP3 utilizes standard technology in which both illumination and imaging are accomplished via a bundle of optical fibers that run the entire length of the flexible scope, with a CCD (charge coupled device) video chip camera attached to the eyepiece of the scope for display and recording purposes. More recently, a Pentax model VNL-155OT scope was used that also has a 2.0-mm working channel and is only slightly larger, with a 5.1-mm outside diameter. Although the VNL-155OT still uses optical fibers for illumination, superior, higher-resolution imaging capability is provided via the placement of the CCD video chip in the distal end (examination tip) of the scope.

Surgical Technique. The procedure is typically performed with 2 assistants (Fig 5), similar to Jackson's model of sitting direct laryngoscopy (Fig 3). Intranasal anesthesia was administered topically with a
no episodes of laryngospasm. No patient received an intravenous line; however, several anxious patients took 5 to 10 mg of Valium perorally before the procedure. Resuscitation equipment was available down the hall, but was not present in the treatment room.

Examples of different procedures are noted in Figs 6-8. A straight cleaved, 0.6-mm–core diameter, fused silica fiber was placed through the working channel of a flexible fiberoptic laryngoscope until it was flush with the distal end of the lumen. The flexible laryngoscope was then passed through the nose and pharynx until the larynx and its associated disorder were well visualized. The output of the laser was typically set to 600 to 800 mJ per pulse. Once the surgical site was visualized, the fiber was advanced several millimeters until it was also in the visual field (Fig 6D).

The entire lesion and approximately 5 mm around the visible margins were treated with the PDL. A treatment end point was photocoagulation of the sublesional microcirculation as evidenced by intraluminal thrombus formation with darkening of the vessels (Fig 7D). Another end point was visible blanching (Fig 7B) and/or separation of the epithelial lesion (Fig 7C), which was identified in most cases. The fiber was not a fixed distance from the tissues, but varied between contact and approximately 2 mm, such that average fluences ranged from approximately 24 J/cm² (approximately 2-mm distance) to 270 J/cm² (contact; Fig 9). It was not unusual to place the fiber in delicate contact with the lesion to establish the fiber-to-tissue distance, and this was one means of adjusting the fluence to effect the treatment end

**Fig 5.** Procedural setup for flexible laryngoscopic pulsed dye laser (PDL) office treatment. Yellow light is seen coursing through glass fiber, which is positioned through working channel of laryngoscope. Note position of patient, which is similar to that in Figs 1-3. Operating team is wearing surgical attire, whereas patient is wearing street clothes, in practice similar to that of 19th-century surgery.

Nebulized solution of 2% lidocaine hydrochloride and 0.125% phenylephrine hydrochloride. The lower pharynx and larynx were anesthetized with a nebulized solution of 4% lidocaine hydrochloride. In selected cases, the larynx and pharynx were anesthetized by dripping the plain lidocaine solution with a cannula through the working channel and/or by direct application of the solution with an angled rigid cotton holder. Local nerve blocks with 2% lidocaine hydrochloride were also used at times. A suction catheter for evacuating the laser plume was placed transnasally into the pharynx as was appropriate.

Coughing was commonplace; however, there were

**Fig 6.** Seventy-two-year-old man who had undergone many prior microlaryngeal procedures for recurrent respiratory papillomatosis. A) Rigid telescopic office laryngoscopy displays diffuse recurrent glottal papillomatosis even throughout anterior commissure and into subglottis. B) Flexible fiberoptic PDL treatment with fiber directed at anterior commissure. Note diminished optical resolution of laryngoscopic image. C) Follow-up procedure on same patient is done several months later and reveals near-total regression of disease. Note enhanced laryngoscopic image with distal-chip camera. D) There was small focus of residual disease in anterior commissure, which was treated easily. Again, note enhanced image quality.
point.

Contact treatment mode with the side of the fiber was often used for medial-surface lesions (Fig 8B), since it was often difficult to angle the fiber to be perpendicular to the treatment surface. Finally, the contact mode was also used on exophytic papillomatous lesions (Fig 7B) and nonphonatory surfaces such as the anterior commissure tendon (Fig 6). The fluence associated with the contact mode clearly led to tissue ablation (Figs 6D and 7D), as well as lesion separation (Fig 7C) and photoangiolyis of the microcirculation (Fig 7D).

Posttreatment Assessment. Disease regression was assessed in the clinic between 4 and 8 weeks after the procedure. A classification scheme had been devised to categorize patient results for prior studies,27,28 and this subjective observational rating scale was employed in this investigation, as well. Disease resolution was quantified by comparing findings of examinations performed at presentation to videoeosendoscopic evaluations performed at the conclusion of treatment. A 4-level grading scheme was used to delineate the degree of resolution: 0% to 50%, 51% to 70%, 71% to 99%, and 100%. A favorable outcome was defined as greater than 50% resolution of disease. A self-assessment of voice quality was done by the patients at least 6 weeks after the procedure; better, same, slightly worse, or substantially worse.

RESULTS

Seventy-seven of 82 cases were successfully treated and 5 cases were aborted, 2 because of inadequate exposure and 3 because of discomfort. None of the 77 treatable patients were judged to be unresponsive. Sixty-eight of the 77 treatable cases (88%) were judged to have >50% disease regression; 25% to 50% disease regression was noted in the remaining 9 (12%). In 34 of the 77 cases, patients reported that their voices were improved. Thirty-nine noted no change as compared to before surgery, and only 4 patients (2 with papilloma and 2 with keratosis) thought that their voices were slightly worse. The 4 patients with mild deterioration denied substantial alteration of vocal activities. There were 2 mild episodes of epistaxis, which were managed with pressure, and there were no major complications.

DISCUSSION

Successful management of recurrent glottal pap-
Fig 8. Sixty-four-year-old man has undergone more than 10 microlaryngoscopic procedures with general anesthesia at various institutions for recurrent keratosis with carcinoma in situ. A) There are diffuse geographic areas of disease seen throughout glottis, which had substantial scarring of superficial lamina propria. B) There is lesion on internal surface of left anterior commissure. Fiber is positioned tangentially to treat lesion. C) There was thin keratosis on anterior-superior surface of right vocal fold, which is not well seen in A. Lesion and surrounding perimeter are treated. D) At conclusion of treatment, areas that have been treated are extremely white, because epithelium has been separated from underlying subepithelial soft tissue. Photocoagulotic ecchymosis is seen at perimeter of lesions.

Fig 9. Schematic diagram demonstrates properties of PDL energy delivery.
is mutual agreement that a surgical procedure is warranted. This is usually a subjective determination based primarily on the severity of symptoms and the findings on laryngoscopic examination. Vocal needs, as well as feasibility of follow-up, are also important considerations. Understandably, practice patterns vary considerably among surgeons and patients. Nevertheless, there is uniformity in the belief that recurrence of disease is expected, and this is inevitably accepted to various degrees. It is our impression that both surgeons' and patients' varied tolerance or acceptance of recurrent disease would diminish if the use of general anesthesia was not a mandatory component of treatment. However, the goal of obviating procedural morbidity through the use of local anesthesia should not substantially compromise the primary metrics for success, which are disease regression and voice outcome.

This ambition of treating patients by means of local anesthesia was realized by converging technical advancements. Our prior work with general anesthesia demonstrated that PDL photoangiolyssis could lead to glottal epithelial disease regression without bimanual microscope-controlled tissue resection. This concept incorporates elements of Folkman's theory that neoplasia requires angiogenesis. In our treatment model, nonionizing radiation (light energy) is employed to alter subepithelial microcirculation instead of chemical agents. On the basis of prior work, as well as this investigation, we have not observed that the 585-nm PDL substantially alters the natural history of recurrence that is associated with these lesions. Therefore, surgeons should be aware that the clinical scenario may mandate that a biopsy be done.

Depending on the proximity of the fiber to the tissue, there are two other clinically observed soft tissue effects that probably influence disease resolution. First, there is an observed separation effect between the epithelial basement membrane and the underlying superficial lamina propria, without apparent injury to the latter. The putative mechanism for this separation is photothermal and/or photoacoustic denaturing of basement membrane linking proteins. Second, there is observable tissue ablation when the fiber is in extremely close proximity to or in contact with the tissue. On the basis of these functional properties, the PDL generally appears extremely well suited to treat selected noncancerous mucosal disease.

Our prior experience with the PDL in the operating room also demonstrated that photoangiolyssis of normal subepithelial microvasculature did not substantially alter vocal function. This experience was observed in this investigation, as well. The patients who described voice deterioration reported that it was mild. They were not discouraged from having future procedures. The deterioration probably occurred as a result of overzealous contact-mode treatment. The 585-nm PDL was carefully chosen for this work. Its wavelength and pulse duration are specifically tailored to target hemoglobin and destroy vessel walls while still containing the heat within the vessel and leaving surrounding tissue unaffected. The PDL is used routinely in the treatment of cutaneous portwine stains on infants in whom heat damage and/or scarring causes substantial morbidity.

Our observations revealed that as in the skin, the PDL is a "smart" laser and is unlikely to injure normal tissue — even the delicate superficial lamina propria. Given that this was our initial experience, we were encouraged by the fact that no patients thought that their voices were made substantially worse. Excellent voice results have been observed by Bower et al. as well. Voice improvement has been confirmed by stroboscopic examinations, which reveal enhanced pliability of glottal mucosa. We believe that this results from reconfiguration of the superficial lamina propria, as well as regression of the surface lesion. This observation is often more pronounced in those patients who have had prior procedures. In other clinical scar models, Alster et al. have observed that connective tissue can be made more pliable by treating it with the PDL; this finding lends credence to our preliminary vocal fold observations.

Now that we are satisfied with the efficacy of disease regression and have made a subjective assessment that the procedure is not generally hazardous to the voice, a formal vocal outcome investigation is under way to analyze acoustic and aerodynamic measures. Our prior investigations have demonstrated that stroboscopy is marginal as an objective measure of vocal function.

There is a surgical learning curve in using the PDL, since fluence is difficult to determine exactly. Therefore, we suggest that a noncontact mode should be used until the surgeon is familiar with the laser. This mode reduces the primary potential morbidity and scarring of the superficial lamina propria, since the effective tissue penetration at the wavelength used is approximately 2 mm. Typically, the lesions that were most suitable were approximately 1.5 mm in thickness. In a noncontact mode, the necessary level of manual precision was diminished with the PDL as compared with effective microlaryngoscopic dissection with a CO2 laser and/or cold instruments. One can envision the fiber delivery of light as being similar in technique to airbrush shading of paint.
Thus, it became plausible that selected glottal epithelial diseases could be treated by means of local anesthesia and without resection. Our initial placement of a 1-mm-diameter fiber through the channel of the fiberoptic laryngoscope demonstrated that a smaller-diameter fiber with greater flexibility was necessary to accommodate the angulation of the nasopharyngeal passage and fine distal control of the fiberoptic laryngoscope. The delivery system was greatly improved with a 0.6-mm-diameter fiber.

Relative contraindications to effective treatment include bulky papillomatosis because of the inability to easily remove tissue. Exposure of the ventricle was difficult because of the inability to retractor the vestibular fold. However, with the angulation capabilities of the flexible fiberoptic laryngoscope, the anterior commissure and undersurface of the vocal folds were often surprisingly easy to treat. As in our previous investigations, we did not observe new adhesions or webs.

The experience described herein revealed that the procedure was well tolerated, in that 77 of 82 patients were treatable and all of those had some positive treatment response. We used a prior model for assessment of disease regression, which was pragmatic and effective despite being subjective. We observed that there was >50% disease regression in 88% of cases. These data reveal that PDL treatment by means of local anesthesia was less effective in comparison with our prior experience with the laser in the operating room. However, this was not unexpected, given the microlaryngoscopic advantages of enhanced exposure, greater magnification, tissue retraction, an immobile surgical site, and better lighting. The spectrum of responses probably reflects substantial variation in energy delivery (fluence).

Dosimetry at the tissue surface is difficult to quantify when PDL pulses are delivered in a diverging beam from the tip of an optical fiber, because the exposure spot size varies strongly with distance. Although a collimated delivery beam would simplify dosimetry, this would also remove the surgical advantages of being able to control tissue effects by adjusting the distance from fiber to tissue. In essence, dosimetry was estimated and controlled by observation of immediate tissue effects. The primary visual metrics for assessing dosimetry are 1) blanching of papillomatous epithelium, 2) separation of the epithelium from the underlying subepithelial soft tissue, and 3) mucosal ecchymosis. The requirement for precise dosimetry is relaxed because of the "smart" properties of the laser.

A high-resolution distal-chip flexible fiberoptic laryngoscope facilitated these observations of effect, but remains less accurate than stereoscopic surgical microscopy. The flexible medical endoscopes that have the CCD video chip at the distal tip were first described in the 1980s for gastrointestinal applications. Only recently has the ability to miniaturize the CCD chips allowed for the development of flexible endoscopes that are of a small enough diameter for transnasal applications.

Despite the fact that PDL treatment of diseased glottal epithelium by flexible fiberoptic laryngoscopy with local anesthesia was less efficacious than treatment by microlaryngoscopy with general anesthesia, there are considerable advantages to the former. The reduced risk of morbidity associated with local anesthesia in the clinic considerably facilitates the treatment of older patients, particularly those with substantial cardiovascular or pulmonary disease. This scenario is not uncommon in aging societies with a predilection to tobacco use. In the younger and working population, there is less lifestyle disturbance if general anesthesia in the operating room is avoided. Follow-up management of papillomatosis and dysplasia must be individualized on the basis of individual patterns of disease behavior, as well as surgeon and patient preference. Considerations include the frequency and appearance of disease recurrence, preoperative and postoperative vocal deterioration, the comfort level of the patient and surgeon with the technical aspects of the procedure, and the geographic proximity of the patient to the health care facility.

There are a number of limitations to this surgical approach. First and foremost, we did not obtain a specimen for histopathologic analysis. We considered this omission to be acceptable for a number of reasons. Most important, all of these patients had prior microlaryngoscopic biopsies, and the indication to perform further post-PDL intraoperative biopsies and/or treatment was unchanged according to the laryngoscopic appearance during the office examination. Therefore, if the posttreatment clinic examination findings improved so that transparent, normal-appearing epithelium was observed, a biopsy was unnecessary. However, if there was insufficient resolution or response to treatment after 3 to 4 weeks, the operating room option remains available. It is highly unlikely that there would be a clinically unrecognized new malignancy, given the prior noncancerous biopsies, and even less likely that a several-week delay would have a deleterious effect on long-term outcome.

Another disadvantage of the local anesthesia approach is that more procedures were probably done. The predominant reason was that our threshold for intervention was decreased commensurate with the diminished risk of morbidity associated with local
anesthetic treatment. In addition, individual operations were generally less effective. We were understandably less aggressive using the PDL with local anesthesia because of reduced visual precision and the fact that the vocal folds were moving. The surgical fee was approximately 50% of its operating room counterpart; however, the hospitalization fees (anesthesia, nursing, recovery, pathology, etc) were approximately 10% of typical fees. It is our hope that with greater experience in this new treatment pathway, we will be able to more closely simulate the treatment capabilities that we achieve using general anesthesia.

A disadvantage of the 585-nm PDL, as used in this study, is that it is difficult to accurately quantify the energy delivery and real-time tissue effects despite the fact that it is unlikely to cause substantial soft tissue injury to the vocal folds. This is the case regardless of anesthetic approach, but is more pronounced without stereoscopic microlaryngoscopic visualization. These functional characteristics of the PDL are in sharp contrast to the familiar properties of the CO2 laser, by which the mucosal surface is vaporized. In addition, the vocal fold is more difficult to treat in an awake patient with the flexible laryngoscope, since the target tissue is moving. Finally, in using flexible fiberoptic laryngoscopes, there are unavoidable tangential vectors for visualization and laser delivery that cannot be overcome by bimanual tissue retraction and facile fiber alignment. There are substantially greater degrees of freedom of fiber positioning with a malleable cannula through a rigid laryngoscope with general anesthesia.

In terms of the shortcomings of flexible fiberoptic PDL treatment, we believe that there are innovations achievable in the foreseeable future. A side-firing fiber tip would significantly enhance control over treating the medial vocalizing surface of the vocal fold. This would dramatically diminish the comparative advantage of bimanual dexterity with microlaryngoscopic surgery. Additionally, high-resolution (distal-chip camera), real-time stroboscopy would provide indirect assessment of acute edema of the superficial lamina propria, which is an indirect metric for energy delivery. At present, one could remove the distal-chip flexible scope and assess by telescopic stroboscopy; however, this approach is cumbersome and too time-consuming in light of the window of opportunity that exists before more local anesthesia is required. Alternatively, stroboscopic capability exists with other flexible fiberoptic laryngoscopes; however, the optical resolution is suboptimal as compared with that of the distal-chip technology.

Treatment of glottal papilloma and dysplasia of the vocal folds with the 585-nm PDL and local anesthesia is yet another innovation that arose from the rich 150-year evolution of endolaryngeal surgery. Given our successful experience in the use of this laser in the operating room with general anesthesia, it was a natural progression to evaluate its use with local anesthesia. However, at this time, we do not believe that glottal papilloma and keratosis should be treated by means of local anesthesia without a prior histopathologic diagnosis and an established pattern of recurrent disease. The 585-nm PDL is a platform technology that will likely serve as a driver for a variety of future innovations in management of laryngeal diseases, as well as disorders of other areas of the body that involve superficial diseased mucosa (ie, Barrett’s esophagus, dysplasia of the cervix, granulation in the nose and ear).

CONCLUSIONS

1. The historical investigations described herein reveal that technological advances in direct laryngoscopy at the beginning of the 20th century catalyzed the migration of treatment of glottal epithelial disease from the surgeon’s office to the operating room.

2. A majority of patients tolerated 585-nm PDL treatment of glottal papillomatosis and keratosis by means of flexible fiberoptic laryngoscopy and local anesthesia.

3. Although all treatable patients responded to PDL treatment by means of flexible fiberoptic laryngoscopy and local anesthesia, the disease regression was judged to be less complete than that in our prior experience with microlaryngoscopy and general anesthesia.

4. With this limited experience, we did not observe that the 585-nm PDL alters the natural history of recurrence of papillomatosis or dysplasia.

5. Our subjective threshold for treatment intervention was diminished with flexible fiberoptic laryngoscopy and local anesthesia, as compared with our prior experience with microlaryngoscopy and general anesthesia. Hence, we are performing more frequent procedures.

6. Converging technological advances allowed for the treatment of glottal papilloma and dysplasia by means of local anesthesia. This approach may serve as a harbinger of a substantial paradigm shift in the management of selected mucosal diseases, especially in the vocal folds. This experience warrants further investigations and/or applications of the PDL in other medical fields, as well as continued development in otolaryngology.
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