Partial Laryngectomy With Imbrication Laryngoplasty for Glottic Carcinoma

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Background: Treatment options for unilateral glottic carcinoma include radiation therapy, partial laryngectomy, and endoscopic cordectomy. We used partial laryngectomy with imbrication laryngoplasty (PLIL) for definitive treatment with curative intent in a select group of patients.

Study Design: Retrospective multicenter review of 24 patients treated with PLIL. Data collection included demographics, tumor characteristics, time to decannulation, time to oral food intake, local control, survival, voice result as judged by the physician, voice result as judged by the patient, and patient satisfaction.

Setting: Five academic medical centers.

Methods: PLIL includes a composite resection of the entire vocal fold, with its ligament, muscle, adjacent paraglottic tissues, and the adjacent block of thyroid cartilage. A neocord is reconstructed by imbricating the remaining thyroid cartilage strips and covering them with a false vocal fold flap.

Results: A total of 24 patients (T1, n=13; T2, n=10; and T3, n=1) underwent PLIL. Median time to decannulation was 4 days, and median time to oral food intake was 5 days. Clear margins were achieved in 23 patients (96%). Follow-up ranged from 1 to 11 years (median duration of follow-up, 5.5 years). In the patients who had clear margins at the initial surgery, the rate of overall disease control was 100%. Voice quality was judged by the physician as good or excellent in 100% of the patients who underwent PLIL, and as better than typical hemilaryngectomy in 23 patients (96%). Twenty-three patients (96%) were satisfied with their voice quality.

Conclusions: PLIL provides us with a single modality curative approach to unilateral glottic carcinoma. It also provides rapid recovery of oral and/or nasal airway and swallowing, excellent voice quality, and a disease-control rate similar to or better than other treatment modalities.


It is widely accepted that stage I and stage II carcinoma of the glottis should be managed with a single therapeutic modality. In general, treatment options for stage I/II glottic cancer include radiation therapy, endoscopic surgery, laryngofissure with cordectomy, and partial vertical hemilaryngectomy with its different modifications and reconstructive options. Because all these therapeutic options result in preservation of the oral and/or nasal airway, the outcome measures used to compare results are disease-control rates and voice and swallowing functions. Other factors that should be considered include cost of treatment, rate of complications, and length of treatment. In many cases, subjective patient preference and physician bias contribute significantly to the decision-making process.

When a decision is made to treat with an external surgical procedure, and in a specific subgroup of T1 and T2 tumors (described below), we offer a modification of partial laryngectomy, ie, partial laryngectomy with imbrication laryngoplasty (PLIL). The purpose of this study is to present our oncologic and functional results in patients who underwent PLIL. It should be noted that the present study concentrates on a subgroup of patients with unilateral vocal fold cancer. It includes T1a tumors (limited to 1 vocal fold with normal mobility) and tumors limited to the vocal fold with impaired mobility. The latter group has been recognized by some authors as a separate T2b classification, differentiating it from the T2a subgroup, which denotes extension to the supraglottis or subglottis. It should also be noted that our study includes, but is not limited to, patients with “early” glottic can...
The reader is referred to the excellent article by Ferlito et al\(^\text{16}\) for the definition of early glottic cancer.

The objective of this article is to reintroduce the reader to the surgical technique of PLIL and to describe the actual surgical steps. This procedure, which is a modification of partial vertical hemilaryngectomy, may provide an additional surgical option for the management of select T1 and T2 glottic tumors.

### METHODS

#### PATIENTS

We retrospectively reviewed our surgical records and included in the study all patients who were treated with PLIL in the last 11 years. A history of laryngeal squamous cell cancer treated with PLIL was the only inclusion criterion. There were no exclusion criteria. Data collection included demographics, tumor characteristics, time to decannulation, time to oral food intake, local disease control, overall disease control, survival, voice quality as judged by the physician (poor, fair, good, or excellent), voice quality as judged by the patient (poor, fair, good, or excellent), and patient satisfaction. Also, we asked the surgeon to compare the voice quality of the patients who underwent PLIL with that of patients who have undergone typical hemilaryngectomy, endoscopic cordectomy, and/or radiation therapy. We also asked the patients to compare their voice quality before and after treatment.

#### SURGICAL TECHNIQUE

The procedure is performed with the patient under general anesthesia. Twenty-one patients underwent tracheotomy at the beginning of the procedure. Three patients did not undergo tracheotomy.\(^{17}\) These patients were nasotracheally intubated at the beginning of the procedure and were kept intubated for 2 to 3 days. Extubation was performed in the intensive care unit after 48 to 72 hours.\(^{17}\)

At the beginning of the procedure, the larynx is exposed by means of a 4- to 5-cm horizontal skin incision and with retraction of the strap muscles. A perichondrial flap is elevated off the ipsilateral thyroid lamina (Figure 1). An oscillating saw or heavy scissors are used to perform midline laryngotomy. If preoperative evaluation reveals that the tumor is close to the anterior commissure, the cartilage and mucosal cuts are made 2 or 3 mm lateral to the midline on the contralateral side. The larynx is now entered and the tumor is examined (Figure 2). It is reconfirmed that the tumor is limited to the level of the true vocal fold. Under direct vision, the ipsilateral thyroid cartilage cuts are now marked. The superior cut is at the level of the ventricle. The inferior cut is at, or just below, the level of the inferior aspect of the true vocal fold. Although the lower cartilage cut may be quite close to the inferior edge of the thyroid lamina, it is usually possible to leave a cartilage strip that is 4 to 8 mm in height. Before making the cartilage cuts, the surgeon uses a drill with a fine cutting burr to make small holes in the superior and inferior cartilage strips. Either 1 or 2 pairs of holes are made in each strip (Figure 3). Next, an oscillating saw is used to make the 2 horizontal cartilage cuts. In the next step, medium or heavy scissors are used to make the 2 translaryngeal horizontal cuts. The superior cut is made through the ventricle, paraglottic tissues, and the previously made superior cartilage cut. The inferior cut is made at the subglottic level through the paraglottic tissues and through the previously made inferior cartilage cut. The inferior cut may need to be made in a slight oblique fashion to preserve an inferior thyroid cartilage strip. The last step in tumor resection involves the use of curved scissors to make the posterior vertical cut. Depending on the exact location of the tumor, this cut may be made anterior to, or through, the arytenoid cartilage. The specimen is now removed (Figure 4). It includes the entire vocal fold, with its inferior and superior surfaces, the vocalis muscle, the paraglottic tissues, and the adjacent thyroid cartilage strip (Figure 5). The ventricular mucosa and sacculae are also included in the resected specimen. Hemostasis is achieved with a fine bipolar cautery forceps. The edges of resection are now sampled and submitted for frozen-section diagnosis to confirm complete tumor removal. The important areas to sample are the posterior, inferior, and anterior margins. Also, the lateral (ventricular) aspect of the mucosa may need to be sampled.

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Reconstruction of the ipsilateral hemilarynx includes 2 important steps: (1) imbrication of the remaining superior and inferior thyroid cartilage strips will reconstruct the cartilaginous framework, and (2) the development of superiorly based false vocal fold mucosal flap will provide complete closure of the endolaryngeal mucosal lining (Figure 6). It is much easier to develop the flaps first, before the cartilage strips are approximated. Using a very fine-toothed forceps, the mucosal edge of the false vocal fold is grasped. Using fine tenotomy scissors, the false vocal fold is “uncurled.” The scissors are used to separate the mucosa of the false vocal fold flap from the inner aspect of the superior thyroid cartilage strip. Undermining may continue superiorly to the level of the thyrohyoid membrane. Care should be taken to unfold the entire false vocal fold mucosa, which was facing the ventricle and saccule, and not to leave mucosal strips buried. A more limited undermining of the subglottic mucosa, separating it from the cricoid cartilage, can also be performed. This part of the procedure is very delicate and requires the use of fine instruments and fine bipolar cautery. Next, the cartilage strips are imbricated. The superior and inferior strips may be overlapped by placing the superior strip medial to the inferior strip (internal imbrication) or by placing the inferior strip medial to the superior strip (external imbrication). Two 2-0 or 3-0 sutures are placed through the predrilled holes to secure the 2 cartilage strips together with the knots placed externally. The bulging cartilage edge will provide the base for the neocord. Next, the superior false vocal fold flap is pulled down and attached to the subglottic mucosa with 5-0 absorbable sutures. Because the flap is undermined and because the height of the hemilarynx is reduced by the imbrication, approximation is achieved easily without any tension. Complete closure from posterior to the anterior commissure is achieved, providing the coverage and lining for the neocord. Absorbable 4-0 sutures are used to pull the anterior edge of the neocord and attach it to the very anterior edge of the contralateral vocal fold and through the contralateral thyroid cartilage. The larynx is now closed by approximating the thyroid alae with 2-0 nonabsorbable sutures (Figure 7). The ipsilateral external perichondrium is placed back to cover the imbricated thyroid cartilage and sutured anteriorly, superiorly, and inferiorly with 5-0 absorbable sutures (Figure 8). The strap muscles and the skin are approximated and closed in the usual fashion. The tracheotomy may be removed in 48 to 72 hours, and oral food intake is then allowed.

**RESULTS**

We performed PLIL on 24 patients with unilateral glottic squamous cell carcinoma (Washington University, St Louis, MO).
Mo, 8 patients; State University of New York–Downstate Medical Center, Brooklyn, 7 patients; University of California, Los Angeles, 4 patients; University of Southern California, Los Angeles, 3 patients; and West Virginia University, Morgantown, 2 patients). There were 20 men and 4 women, with an age range of 37 to 78 years and a mean age of 59.6 years. Four patients had undergone previous radiation therapy. The treatment failed in 2 of the 4 patients, and recurrence developed on the same vocal fold in the other 2. The tumor staging on presentation was T1 (13 patients), T2 (10 patients), and T3 (1 patient). There was no involvement of the anterior commissure in any of these patients. All patients presented without evidence of regional metastatic disease. Follow-up has ranged from 1 to 11 years, with a median of 5.5 years. Seventeen patients have been followed up for more than 3 years, and 7 have been followed up for 1 to 3 years.

All patients underwent PLIL as described above. Tracheotomy was performed in 21 patients. For the patients who underwent tracheotomy, the median time to decannulation was 4 days. Twenty patients (92%) had oral food intake within 2 weeks. Complete removal of the primary tumor with clear margins was achieved in 23 patients (96%). One patient had a positive inferior margin found on permanent processing of the specimen. He was offered more extensive surgery (conventional partial vertical hemilaryngectomy) but refused. He received a full course of radiation therapy. Ten months later, he developed recurrent disease in the supraglottic larynx and eventually died of laryngeal cancer. One patient developed a second primary laryngeal tumor 3½ years after undergoing PLIL but responded well to radiation therapy. He still had no evidence of cancer 11 years after surgery. Two patients died of unrelated causes 67 and 73 months after surgery. Therefore, we had 1 laryngeal cancer–related death in our series (4%).

Voice quality was judged by the physician as good or excellent in all patients. Voice quality was judged by the surgeon to be better than that after typical hemilaryngectomy in 23 patients (96%). There were 15 patients who underwent PLIL (63%) whose voice quality was

Figure 6. Reconstruction. A, Superiorly based false vocal fold flap is developed. B, The inferior cartilage strip is brought medially (external imbrication). C, The overlapping cartilage strips are sutured together. D, The endolaryngeal mucosa is closed.

Figure 7. The laryngotomy is closed.

Figure 8. The partial laryngectomy with imbrication laryngoplasty is completed.
PLIL was introduced by Pleet et al\textsuperscript{18} in 1977 and again by Liu et al\textsuperscript{19} in 1986. They reported excellent results with 38 patients with T1/T2 glottic cancer and concluded that “through-and-through resection of mucosa, tumor, soft tissue, adjacent perichondrium, and thyroid cartilage with imbrication reconstruction represents a significant and logical advancement in the management of patients with T1 and T2 carcinoma. . . .”\textsuperscript{18,19} Since then, very few authors have referred specifically to this technique.\textsuperscript{11,17} Our technique is very similar to the original one, with a few modifications. Our results agree with the original statement of Pleet et al.\textsuperscript{18} It should be noted that 1 component of PLIL, the endolaryngeal mucosal reconstruction with false vocal fold flap, has been used as a reconstructive method for other types of partial laryngeal surgery.\textsuperscript{12} This flap, combined with the imbricated/medialized cartilaginous framework, results in improved voice quality compared with that of conventional hemilyrngectomy or “radical” cordectomy. Since the false fold flap is attached anteriorly to the midline at the level of the contralateral true fold, it forms a good phonating “partner” for the normal cord. This procedure results in a smaller glottic gap, less breathiness, and, because the false fold mucosa is loose and mobile, a better mucosal wave. Stage I/II cancers of the glottis are managed effectively by a single modality treatment protocol.\textsuperscript{1,5,9} Factors influencing the choice of treatment in a specific patient include exact staging, voice quality expectations, likelihood of continuous exposure of carcinogens, local geographic referral patterns, experience and expertise of the treating physician, and patient preference.\textsuperscript{1,3,5,9} However, physician bias continues to play an important role. In reviewing the relevant literature, we encountered statements ranging from “I believe that most patients with carcinoma of the larynx are best treated surgically”\textsuperscript{20} to “I tend to treat all patients with T1-T3 laryngeal cancers with primary radiation.”\textsuperscript{21} Exhaustive discussion on the advantages and disadvantages of each treatment option available for T1/T2 glottic cancer is beyond the scope of this presentation. However, we do believe that surgeons should consider PLIL as an excellent option for surgical management of T1a and selected T2 tumors. When outcome measures such as local disease control, postoperative course, length of treatment, voice quality, swallowing function, and patient satisfaction are considered, PLIL compares favorably with radiation therapy, endoscopic surgery, open cordectomy, and partial vertical hemilyrngectomy. Also, there is increasing information about alarming rates of second primary tumors in patients with head and neck cancer, including those with early-stage laryngeal cancer.\textsuperscript{22} The future availability of radiation therapy as a treatment modality in these cases should be considered, especially in patients who continue their exposure to carcinogens.\textsuperscript{7}

Glottic tumors staged as T2 deserve a special discussion. Currently, a T2 glottic cancer is defined as tumor extending beyond the vocal cord itself (supraglottis or subglottis) and/or tumor with impaired vocal fold mobility.\textsuperscript{3} However, there is an abundance of information in the relevant literature that indicates significant differences between these 2 subgroups with respect to clinical course, response to radiation therapy, and local control rates.\textsuperscript{1,9,13-15} In fact, both Wang\textsuperscript{15} and Wiggersraad et al\textsuperscript{6} used a subdivision to T2a and T2b to review their series and to report outcome. They assigned T2a staging to tumors with supraglottic or subglottic extension but normal vocal fold mobility, and T2b staging to tumors with impaired mobility of 1 vocal fold.\textsuperscript{4} An important lesson to be learned from patient series describing outcome for each of these 2 subgroups separately is that impaired vocal fold mobility has a negative impact on local disease control regardless and independent of the presence or absence of extension beyond the vocal cord.\textsuperscript{1,4,11-13} Wiggersraad and colleagues stated, “We may conclude that the presence or absence of normal cord mobility is an important prognostic factor for ultimate local control.”\textsuperscript{4} More importantly, they stated, “Salvage surgery is far less successful in T2b patients than in T2a patients.” Although subdivision of the T2 group has not been incorporated formally into the TNM staging system, it seems that we should use this subdivision in the

![Figure 9](https://archotol.jamanetwork.com/)

PHOTOGRAPHS TAKEN 2 years after partial laryngectomy with imbrication laryngoplasty in a 53-year-old woman. The contralateral normal cord is shown in adduction (A), paramedian position (B), and full abduction (C). The arrows indicate the reconstructed left neocord. In reviewing the relevant literature, we encountered statements ranging from “I believe that most patients with carcinoma of the larynx are best treated surgically”\textsuperscript{20} to “I tend to treat all patients with T1-T3 laryngeal cancers with primary radiation.”\textsuperscript{21} Exhaustive discussion on the advantages and disadvantages of each treatment option available for T1/T2 glottic cancer is beyond the scope of this presentation. However, we do believe that surgeons should consider PLIL as an excellent option for surgical management of T1a and selected T2 tumors. When outcome measures such as local disease control, postoperative course, length of treatment, voice quality, swallowing function, and patient satisfaction are considered, PLIL compares favorably with radiation therapy, endoscopic surgery, open cordectomy, and partial vertical hemilyrngectomy. Also, there is increasing information about alarming rates of second primary tumors in patients with head and neck cancer, including those with early-stage laryngeal cancer.\textsuperscript{22} The future availability of radiation therapy as a treatment modality in these cases should be considered, especially in patients who continue their exposure to carcinogens.\textsuperscript{7}

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decision-making process for any individual patient with glottic cancer.\textsuperscript{1,5,9,13-15} In view of the different outcomes after radiation therapy in the 2 subgroups, and considering our experience and results with respect to local disease control, voice quality, swallowing function, and length of treatment, the surgical option in general, and PLIL in particular, may provide a therapeutic option for patients with impaired vocal fold mobility.

The main weakness of our retrospective study is that we report subjective voice assessment. However, the main objective of this study was to reintroduce the technique and the surgical steps. As the study shows acceptance and satisfaction of the patients and the surgeons, and as the oncologic results are comparable to other treatment modalities, future studies should use validated voice outcome tools for objective assessment.

CONCLUSIONS

PLIL provides us with a single-modality curative approach to unilateral glottic carcinoma. It also provides rapid recovery of the oral and/or nasal airway and swallowing, excellent voice quality, and a disease-control rate similar to or better than other treatment modalities.

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