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Outcomes Following Cordotomy by Coblation for Bilateral Vocal Fold Immobility

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IMPORTANCE Bilateral vocal fold immobility (BVFI) can result in considerable voice and airway impairment. Although the carbon dioxide (CO_2) laser is commonly used in transverse cordotomy, the coblator, a minimally invasive, low-thermal technology, has been increasingly used in otolaryngology.

OBJECTIVE To investigate outcomes associated with coblation to treat BVFI.

DESIGN, SETTING, AND PARTICIPANTS A retrospective case series was conducted between January 2012 and June 2017 including 19 patients with BVFI who underwent cordotomy by coblation in a single tertiary care institution.

MAIN OUTCOMES AND MEASURES Clinical, operative, and health status data for all patients were reviewed. Quality of life was measured by the EuroQol 5-Dimensions (EQ-5D), and the Voice Handicap Index (VHI) was used to measure vocal cord function.

RESULTS Nineteen patients were eligible for inclusion, 15 of which underwent cordotomy by coblation for BVFI without stenosis. Mean age was 57 years with 13 (68%) women. The etiology of BVFI included thyroidectomy in 8 (42%) patients and prolonged intubation in 7 (37%). Mean length of surgery for BVFI without stenosis was 17 minutes; mean operating room (OR) time was 63 minutes compared with 88 scheduled OR minutes (effect size, 25 minutes; 95% CI, 9 to 40 minutes). During follow-up, 4 (27%) of these patients developed granulation tissue postoperatively. Following surgery, patient-reported shortness of breath significantly improved, with 10 of 14 (71%; 95% CI, 45% to 88%) patients with some level of preoperative breathing difficulty experiencing improvement in their breathing. Stridor also significantly improved, with 10 of 12 (83%; 95% CI, 55% to 95%) patients with some level of preoperative stridor improved after surgery. The EQ-5D results trended toward improvement postoperatively (0.67 to 0.80; effect size, 0.13; 95% CI, −0.10 to 0.34). The functional (22 to 12; effect size, −10; 95% CI, −19 to −2), emotional (23 to 11; effect size, −12; 95% CI, −23 to −3), and total VHI all significantly improved (68 to 39; effect size, −29; 95% CI, −49 to −8).

CONCLUSIONS AND RELEVANCE Initial outcomes of cordotomy by coblation revealed that this technique was a safe and efficient approach to treating BVFI. Coblation was associated with significant reduction in OR time compared with scheduled time, and patients experienced significant improvement in shortness of breath, stridor, and vocal cord function.

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Bilateral vocal fold immobility (BVFI) presents a challenging problem to the otolaryngologist. It is a potentially fatal condition that requires prompt and accurate diagnosis. The goal of treating patients with BVFI is to establish a patent airway, preserve the function of the glottic sphincter, and maintain acceptable voice quality if possible.[1] Surgical intervention is critical in patients with symptomatic airway compromise.[2]

The etiology of BVFI includes intubation trauma to the cricoarytenoid joints or posterior commissure, peripheral nerve injury from either neoplasm or surgery, and neuromuscular diseases.[3] Bilateral vocal fold immobility rarely occurs in the absence of a clear cause.[3] Complete evaluation prior to surgical intervention is important to establish the etiology, determine the chronicity of the bilateral motion impairment, and portend the likelihood of spontaneous recovery.

Various procedures can be performed to treat BVFI. For iatrogenic injury where there is a possibility of spontaneous recovery, tracheostomy is well accepted and appropriate. Endoscopic suture lateralization is another option for appropriately selected patients.[4] When recovery of vocal cord motion is unlikely or impossible, more ablative procedures such as vocal cordotomy with or without medial partial arytenoidectomy to enlarge the glottic airway may be pursued. Current endoscopic techniques typically employ laser technology to perform the cordotomy and ablate the medial aspect of the arytenoid to some degree.[3] These procedures are often well tolerated and seek to strike a balance between enlarging the airway and preserving voice. Laser usage can be an effective tool for these procedures but intraoperative bleeding can sometimes be encountered and postoperative granulation tissue and collateral heat injury is possible.[5] There is an opportunity for using technology that shortens surgical time and limits heat-related collateral soft tissue injury.

The first coblation tonsillectomy was performed in the late 1990s.[6] Since that time, the coblator has been increasingly used in the field of otolaryngology.[7] The coblator uses radiofrequency energy through a saline medium to create a plasma that breaks molecular bonds in the tissue, causing the tissue to dissolve at relatively low temperatures.[8] We describe the utility and outcomes of coblation for vocal cordotomy and partial arytenoidectomy for patients with BVFI.

We sought to use this approach to perform vocal cordotomy to treat BVFI with the COBLATOR II Arthrocare via a direct microlaryngoscopic approach. We hypothesized that coblation would be an effective and efficient method to treat BVFI.

Key Points

Question What is the role of coblation in cordotomy to treat patients with bilateral vocal fold immobility (BVFI)?

Finding In this case series of 19 patients with BVFI, coblation was associated with a significant reduction in operating room time compared with scheduled time, and patients experienced significant improvement in shortness of breath, stridor, and vocal cord function.

Meaning Coblation may be a viable alternative to using lasers for cordotomy to treat BVFI.

Table 1. Patient Characteristics

Characteristic	BVFI Without Stenosis, No. (%)	Posterior Glottic Stenosis, No. (%)
No.	15	4
Female	11 (73)	2 (50)
Age at surgery, mean (range), y	57 (49-65)	54 (41-67)
Race		
White	13 (87)	4 (100)
Black	2 (13)	0
Smoking status		
Never smoker	9 (60)	1 (25)
Former smoker	5 (33)	3 (75)
Current smoker	1 (7)	0
BMI (range)	29.3 (26.5-32.0)	25.1 (12.1-39.0)
Etiology		
Postthyroidectomy	8 (53)	0
Prolonged intubation and/or trauma	5 (33)	2 (50)
Idiopathic	1 (7)	1 (33)
Other	1 (7)	1 (17)
Prior tracheotomy	3 (20)	2 (50)
Prior cordotomy	2 (13)	3 (75)

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

Methods

Patient Selection

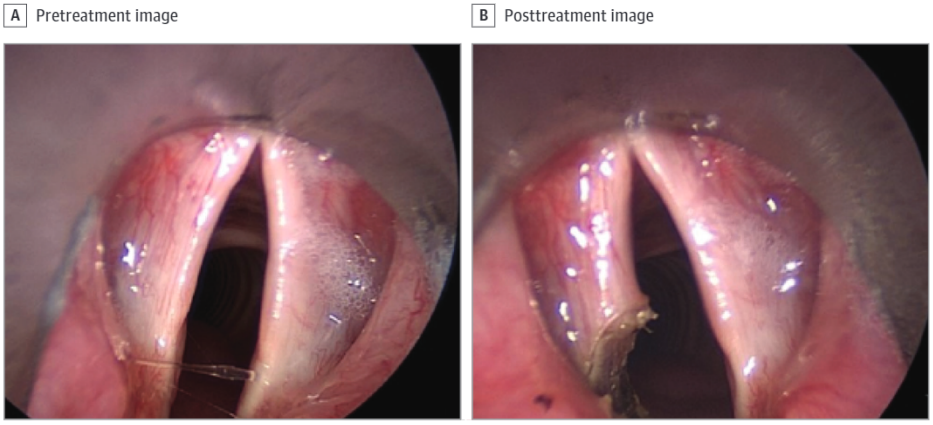
Institutional review board approval was obtained prior to study initiation. A consecutive retrospective review of all patients with BVFI undergoing vocal cordotomy by coblation at a single tertiary care institution between January 2012 and June 2017 was conducted. Patients requiring the use of a KTP laser to assist with complete ablation of arytenoid cartilage and those under 18 years were excluded.

If the patient had a prior tracheotomy, general anesthesia was induced and the tracheostoma was used for ventilation. In the remaining patients who did not have a tracheostomy, the procedure was completed via supraglottic jet ventilation or intermittent apnea. The Pilling-Teleflex Dedo laryngoscope or Universal Modular Glottiscope (Endocraft, LLC) were the most commonly used laryngoscopes. The coblator PROCISE LW laryngeal wand (Smith & Nephew) was used on a power setting of 7 for coblation. Lidocaine was applied to the vocal folds and the patient was then either intubated or mask ventilated by the anesthesia team. No patients required a tracheotomy with this procedure.

Data Collection

Demographic, medical history, operative, and health status measure (HSM) data were retrospectively collected from electronic medical records. Preoperative data included sex,

Figure. Vocal Folds Before and After Coblation Cordotomy



A, Vocal folds before coblation cordotomy. B, Vocal folds after coblation cordotomy.

age, race, smoking status, body mass index (BMI, calculated as weight in kilograms divided by height in meters squared), etiology of BVFI, surgical history, and tracheostomy status. Operative data included type of procedure, length of procedure, total OR time, and scheduled OR time. Postoperative data included decannulation, development of granulation tissue, treatment for granulation tissue, and requirement for revision surgery. Patient-reported degree of shortness of breath and stridor on examination were collected before and after surgery. Shortness of breath (no limitations, exercise intolerance, or daily limitations) and stridor on examination (none, mild, or severe) were both recorded with 3 possible measures. These were post hoc scales to describe severity of shortness of breath and stridor; therefore, they have not yet been validated and do not have established minimal clinically important differences (MCID). Nevertheless, with only 3 clearly defined levels of severity for both shortness of breath and stridor, we believe that even a single-level improvement represents clinically meaningful benefit. Health status measure data, such as the EuroQol-5 Dimension (EQ-5D) and Voice Handicap Index (VHI) were collected both prior to and following surgery. The EQ-5D is a quality of life (QOL) measure that includes 5 dimensions of a patient's health state: mobility, self-care, completion of usual activities, pain/discomfort, and anxiety/depression. Each is scored on a scale from 1 to 3, and an index is derived from the 5 subscores to represent the patient's overall health state ranging from 0 to 1.[9-11] The MCID for the EQ-5D index has been reported to be 0.1.[12] The VHI is a validated self-administered questionnaire that assesses the functional, emotional, and psychosocial consequences of voice disorders.[13-15] A difference in 13 to 16 points in the VHI has been proposed to be clinically meaningful, although it remains unclear what specific changes in the subsections of the VHI are clinically meaningful.[16]

Charge data were extracted using the institution's financial utilization engine. These data were generated based on patient-level resource utilization and include the total cost of delivering care in the outpatient and inpatient settings across the health system. Charges were collected from 365 days prior to admission to 365 days after admission and subdivided into 30-, 90-, and 365-day preadmission and postadmission windows. Relevant charges were defined as any preadmission or postadmission health care costs associated with treating BVFI. To present costs from the payer's perspective, bills were normalized to national Medicare reimbursement rates based on cost-to-charge ratios and presented as 2017 dollars.[17,18]

Statistical Analyses

All collected data were analyzed using R statistical software (version 3.4.0, R Foundation for Statistical Computing).[19] Descriptive statistics for quantitative variables were presented as means with 95% confidence intervals (95% CI) or medians with interquartile ranges, while categorical variables were presented as counts with percentages. Effect sizes were reported with corresponding 95% CI to represent differences between preoperative and postoperative measures.[16]

Results

Patient and Operative Characteristics

A total of 19 patients underwent vocal cordotomy by coblation during the study period, 4 of which had posterior glottic stenosis in addition to BVFI (**Table 1**). Thirteen (68%) patients were women with a mean age of 56 years. Seventeen (89%) patients were white. Ten (53%) patients had no smoking history, whereas all but 1 (42%) of the remaining patients were former smokers. The mean BMI was 28.3. The etiology of BVFI included postthyroidectomy in 8 (42%) patients, prolonged intubation and/or trauma in 7 (37%), idiopathic in 2 (11%), cancer in 1 (5%), and pneumonia in 1 (5%). Prior to surgery, 26% of patients had a tracheostomy, and 26% of patients had undergone prior cordotomy. Images of the vocal folds prior to and after a coblation cordotomy are noted in the **Figure**.

The 15 patients who received cordotomy by coblation to treat BVFI without stenosis and without the use of a laser were included for subsequent analyses. Among these patients, the cordotomy was performed with limited partial arytenoidec-

tomy with the removal of the vocal process of the arytenoid in 7 (47%) of 15 patients (**Table 2**). The mean procedure time was 17 minutes, defined as the time elapsed between the insertion and removal of the laryngoscope. The actual time for the coblation portion of the cordotomy operation ranged from 20 to 60 seconds and in some cases was completed with the patient apneic. In addition, the mean total OR time necessary was approximately 1 hour, considerably less than the mean scheduled OR time (63 vs 88 minutes; effect size, 25 minutes; 95% CI, 9 to 40 minutes), whereas scheduled OR time is the average OR time for cordotomy based on historical OR times at our institution.

Table 2. Operative Characteristics

Characteristic	BVFI Without Stenosis, No. (%)
No.	15
Arytenoidectomy	7 (47)
Length of procedure, mean (range), minutes	17 (10-24)
Total OR time, minutes	63 (48-79)
Scheduled OR time, (range) minutes	88 (70-105)
Scheduled vs actual OR time difference, mean (range), minutes	25 (9-40)
Follow-up time, mean (range), days	516 (166-865)
Decannulated	2 (67)
Postoperative granulation tissue	4 (27)
Mild (untreated)	2 (50)
Moderate (medical treatment)	1 (25)
Severe (surgical treatment)	1 (25)
Revision surgery	7 (47)
Time to revision, mean (range), days	239 (5-482)

Abbreviation: BVFI, bilateral vocal fold immobility.

These 15 patients who underwent cordotomy by coblation for BVFI without glottic stenosis or use of a laser were followed postoperatively for a mean of 516 days. During follow-up, 4 patients (27%) developed granulation tissue; half of these instances resolved without treatment, whereas 1 patient received medical treatment and the other underwent surgical excision. Compared with patients in whom the carbon dioxide (CO_2) laser was used, patients who underwent cordotomy by coblation seemed to have less prolonged healing with improved glottic airway. However, owing to variable follow-up times, it was infeasible to quantitatively assess healing times. Among those patients with a tracheostomy prior to surgery, 3 (60%) of 5 patients were successfully decannulated following surgery. Seven (47%) of 15 patients underwent at least 1 subsequent revision surgery to treat BVFI. This is consistent with our philosophy of static procedures for BVFI, where we err on being conservative to limit permanent impact on the voice.

Patient-reported shortness of breath was recorded before and after surgery as no limitations, exercise intolerance, or daily limitations. Prior to surgery, 6 (40%) patients expressed daily limitations and 8 (53%) patients experienced exercise intolerance (**Table 3**). Patients experienced considerable improvement in their breathing after coblation—only 1 (7%) patient expressed daily limitations and 7 (47%) patients expressed exercise intolerance following surgery. Among the 14 patients with some level of preoperative difficulty breathing, 10 (71%) patients experienced

Table 3. Patient Outcomes for Patients Undergoing Cordotomy by Coblation for BVFI Without Stenosis[a]

Characteristic	Preoperative	Postoperative	Effect Size (95% CI)
Shortness of breath			
No limitations	1 (7)	7 (47)	
Exercise intolerance	8 (53)	7 (47)	
Daily limitations	6 (40)	1 (7)	
Improvement (n = 14), %			71 (45 to 88)
Stridor			
None	3 (20)	11 (73)	
Mild	9 (60)	4 (27)	
Severe	3 (20)	0	
Improvement (n = 12), %			83 (55 to 95)
EQ-5D			
Mobility	1.3 (0.8 to 1.9)	1.5 (0.5 to 2.1)	0.2 (−1.4 to 1.3)
Self-care	1.2 (0.7 to 1.6)	1.0 (1.0 to 1.0)	−0.2 (−0.6 to 0.3)
Usual activities	1.7 (1.1 to 2.2)	1.7 (1.1 to 2.2)	0.0 (0.0 to 0.0)
Pain/discomfort	2.0 (1.3 to 2.7)	1.5 (0.6 to 2.4)	−0.5 (−2.1 to 1.1)
Anxiety/depression	1.8 (1.0 to 2.6)	1.5 (1.9 to 2.1)	−0.3 (−1.1 to 0.9)
Index	0.67 (0.45 to 0.89)	0.80 (0.59 to 0.99)	0.13 (−0.10 to 0.34)
VHI			
Physical	24 (18 to 29)	16 (9 to 23)	−8 (−20 to 5)
Functional	22 (15 to 28)	12 (5 to 18)	−10 (−19 to −2)
Emotional	23 (13 to 34)	11 (3 to 18)	−12 (−23 to −3)
Total	68 (49 to 88)	39 (19 to 58)	−29 (−49 to −8)

Abbreviations: EQ-5D, EuroQol 5-Dimensions; VHI, Voice Handicap Index.

[a] Continuous variables reported as mean (95% CIs); categorical variables reported as count (%).

improvement (95% CI, 45% to 88%). Stridor was also recorded on 3 levels as none, mild, and severe. Patients demonstrated similar improvement with regard to stridor; whereas 3 (20%) patients had severe stridor and 9 (60%) patients had mild stridor prior to surgery, only 4 (27%) patients had mild stridor after coblation with the remaining 11 (73%) patients demonstrating no stridor. Among the 12 patients with some level of preoperative stridor, 10 (83%) patients experienced improvement (95% CI, 55% to 95%).

Patient QOL measured by the EQ-5D index increased from a mean of 0.67 preoperatively to 0.80 postoperatively. The mean absolute difference for the group was 0.13 (95% CI, −0.10 to 0.34) and 9 (60%) of 15 patients achieved a clinically meaningful change of 0.1 or greater. Patient voice quality consistently and significantly improved postoperatively and all dimensions of the VHI improved over follow-up. Among these, the functional component of the VHI (22 vs 12; effect size −10; 95% CI, −19 to −2), the emotional component of the VHI (23 vs 11; effect size, −12; 95% CI, −23 to −3), and the total change in VHI (68 vs 39; effect size, −29; 95% CI, −49 to −8) were significantly improved. The results of the physical component of the VHI trended toward improvement (24 vs 16; effect size, −8; 95% CI, −20 to 5). The absolute difference of −29 (95% CI, −49 to −8) in the VHI was nearly double the range of 13 to 16 points considered to be clinically meaningful.[16]

Vocal cordotomy by coblation also appeared to be a cost-effective method to treat BVFI (**Table 4**). Prior to the operation, the median total costs of medical care were $1272, $2471, and $2471 for the 30-, 90-, and 365-day preoperative time periods, respectively, nearly all of which were in the outpatient setting and for the purposes of treating BVFI. These costs remained low and tended to decrease following surgery. The median total costs of medical care were $0, $939, and $1693 in the 30-, 90-, and 365-day day postoperative time periods, respectively, again largely in the outpatient setting and for the treatment of BVFI.

Table 4. Financial Characteristics for Patients Undergoing Cordotomy by Coblation for BVFI Without Stenosis

Characteristic	Statistic, Median (IQR), $
Preoperative costs	
30-Day	
Outpatient	1272 (1091-3062)
Inpatient	0 (0-0)
Relevant[a]	1113 (614-2208)
Total	1272 (1091-3062)
90-Day	
Outpatient	2471 (1182-8152)
Inpatient	0 (0-0)
Relevant[a]	1317 (1092-3284)
Total	2471 (1182-8152)
365-Day	
Outpatient	2471 (1190-8152)
Inpatient	0 (0-0)
Relevant[a]	2208 (1182-4466)
Total	2471 (1190-8152)
Postoperative costs	
30-Day	
Outpatient	0 (0-368)
Inpatient	0 (0-0)
Relevant[a]	0 (0-153)
Total	0 (0-368)
90-Day	
Outpatient	939 (153-1732)
Inpatient	0 (0-0)
Relevant[a]	755 (153-1732)
Total	939 (153-1732)
365-Day	
Outpatient	1693 (640-86 357)
Inpatient	0 (0-0)
Relevant[a]	1594 (640-249 176)
Total	1693 (640-249 176)

Abbreviation: IQR, interquartile range.

[a] Relevant defined as costs related to care for BVFI.

Discussion

Coblation has become an increasingly useful tool for otolaryngologists in recent years. In addition to its frequent use for tonsillectomies, coblation has been used for the removal of laryngeal Teflon granulomas,[8] treatment of recurrent respiratory papillomatosis,[20] and removal of suprastomal tracheal granulomas, neurofibromas, and arteriovenous malformations.[21] In each case, coblation has been demonstrated to be an acceptable alternative to the CO_2 laser. The coblator device tip uses radiofrequency energy through a saline medium to create a plasma. The plasma's energized particles break molecular bonds in the tissue, causing the tissue to dissolve at relatively low temperatures.[8] This helps to avert considerable lateral heat distribution into the tissue, while also reducing the risk of airway fire.[20] We describe the utility and outcomes of coblation for vocal cordotomy and partial arytenoidectomy for BVFI.

At present, the CO_2 laser is the mainstay method for performing cordotomy.[22-24] Although this is generally a safe and effective approach for restoring the airway and providing patients with benefits, such as improved exercise tolerance, there are numerous adverse effects associated with use of the laser. Owing to the higher temperatures generated by the laser, these patients tend to more often develop granulation tissue requiring subsequent excision. Furthermore, patients more often suffered from postoperative vocal edema requiring either oral corticosteroids or tracheotomy. Last, it remains unclear whether cordotomy using the CO_2 laser provides any significant patient benefit with regard to vocal fold function.

There are many advantages to using the coblator over the CO_2 laser. For instance, no laser protection is required with the coblator, thus helping to reduce operative set-up and procedure time. This increased efficiency in the OR is

evident both in the short 17-minute operative time required for vocal cordotomy by coblation, as well as the 25 minutes of OR time saved compared with scheduled OR time. Although the actual time required to perform the cordotomy once the patient is in suspension laryngoscopy is difficult to measure, coblation requires a brief period for completion, typically 20 to 60 seconds. It can also be done with the use of a microscope or a rigid telescope. The coblation hand piece also offers the surgeon the ability to work tangentially, with less need to adjust the microscope as one might for a CO_2 laser mounted on a micromanipulator or pattern generator. The coblation wand also offers bipolar cautery that may be useful if bleeding is encountered. The ability to perform the procedure rapidly and often with the patient apneic is appealing. In our group, no patient who did not have a tracheostomy required one to do the procedure.

The patients included in this case series consistently showed improvement in the glottic airway immediately following the procedure and during follow-up. Based on the extensive experience of the authors using the CO_2 laser for cordotomies, healing time also appeared to be expedited compared with procedures using the CO_2 laser. These improvements following surgery are especially notable given the observed improvements in patient breathing, stridor, and HSM during follow-up. In particular, most patients experienced significant improvements in both their shortness of breath symptoms (71%) and stridor (83%). Furthermore, the mean absolute difference in the EQ-5D index was 0.13 with 9 of 15 patients improving by more than the established MCID of 0.1,[12] suggesting that patients undergoing cordotomy by coblation for BVFI can experience a clinically meaningful improvement in overall QOL. Furthermore, the average improvement in the VHI (29 points) was both statistically significant and nearly double the range of 13 to 16 points considered to be clinically meaningful,[16] suggesting that cordotomy by coblation for BVFI is especially successful at providing patients with clinically meaningful improvement in their vocal fold functioning. Thus, coblation appears to be an efficient and effective substitute for the CO_2 laser for performing vocal cordotomy.

Limitations

The present study includes several limitations. As a retrospective study, the collected data reported by clinicians were not standardized, potentially subjecting our results to measurement bias, although the senior author has used this device exclusively for his lateralization procedures for BVFI without stenosis for the past 3 years. In particular, our scales for measuring shortness of breath and stridor have not been previously validated; however, we believe that these allow for detection of important trends with even a single-level improvement representing clinically meaningful benefit. Similarly, although the differences in 13 to 16 points in the total VHI are believed to be clinically meaningful, it remains unclear what level of change in the individual components of the VHI are clinically meaningful. Our results are also subject to selection bias because clinicians may have chosen to use coblation in a certain subset of patients more likely to benefit from coblation over the CO_2 laser, thus limiting the generalizability of these results. This may be true with regard to avoiding tracheostomy. Although we do not plan a tracheotomy for patients who are functioning with BVFI without a tracheostomy, we recognize that patient factors and comorbidities may make performing a tracheostomy prior to cordotomy and/or partial arytenoidectomy a safer choice regardless of the ablative technology used to perform the glottic widening procedure.

Conclusions

To our knowledge, the present study is the first to investigate outcomes associated with the use of coblation to perform vocal cordotomy in the treatment of BVFI. Initial outcomes of cordotomy by coblation reveal this technique to be a safe, efficient, and effective approach to treating BVFI. Coblation required very short operative times and considerably reduced the total operating room time requirement. In addition, patient-reported shortness of breath, stridor on examination, and vocal cord function improved significantly over follow-up. Coblation is a useful addition to the surgeon's armamentarium for endoscopic airway surgery.

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Study concept and design: Benninger, Xiao, Bryson.
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Drafting of the manuscript: Benninger, Xiao.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Xiao.
Administrative, technical, or material support: Bryson.
Study supervision: Benninger, Osborne, Bryson.

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