

Endoscopic Lysis of Anterior Glottic Webs and Silicone Keel Placement

John Edwards, MD; Neil Tanna, MD; Steven A. Bielamowicz, MD

Objectives: Acquired anterior glottic webs occur most commonly after endoscopic resection of laryngeal papilloma involving the anterior vocal folds. Treatment of anterior glottic webs has included a tracheotomy with laryngofissure and placement of a laryngeal stent or keel. We have used an endoscopic technique of web lysis and placement of a laryngeal keel without tracheotomy over the past 7 years.

Methods: A retrospective chart review was conducted of all cases of endoscopic web lysis and keel placement performed by the senior author (S.A.B.).

Results: Over the past 7 years, 10 patients underwent the procedure, with a mean follow-up of 18 months. The length of the anterior web was up to two thirds of the membranous vocal fold. Outcomes analysis revealed a recurrence in 1 patient and 2 minor complications necessitating treatment.

Conclusions: Endoscopic web lysis and keel placement offers superior results with less morbidity compared to open techniques.

Key Words: endoscope, glottis, keel, larynx, web.

INTRODUCTION

Anterior glottic webs can be either congenital or acquired. They can cause symptoms ranging from dysphonia and decreased exercise tolerance to severe airway obstruction. The level of severity of the symptoms is dependent upon the length of the laryngeal web. A uniform symptom in patients with anterior glottic webs is hoarseness and an inability to speak loudly. Congenital webs are rare, comprising fewer than 5% of all congenital anomalies of the larynx.¹ Acquired webs occur secondary to endotracheal intubation, laryngeal trauma, laryngeal surgery near the anterior commissure, radiotherapy, and, rarely, inflammatory processes such as tuberculosis or diphtheria.² Traditional techniques used to manage anterior glottic webs include a laryngofissure and placement of a keel. Since 1997, we have treated anterior glottic webs using endoscopic cold knife techniques with an endoscopic silicone keel placement.

METHODS

The charts were reviewed of all patients who underwent endoscopic lysis of anterior glottic webs with keel placement at The George Washington University Hospital by the senior author (S.A.B.) from 1997 to 2003. The variables examined were

age of the patient, cause of the glottic web, size of the web, technique for lysis of the keel, size of the keel placed, length of time the keel was left in place, complications of the procedure, evidence of recurrence, and duration of follow-up. The patients were evaluated before and after operation in a clinic setting with videostroboscopic examinations. None of the patients received mitomycin C injections while under the care of the senior author. Patients with active laryngeal papilloma and anterior glottic webs were treated with a cidofovir injection protocol until the disease in the larynx was minimal before the patient was considered as a candidate for web lysis and keel placement.³ The size of the anterior glottic web was estimated from videostroboscopic examinations performed in the clinic before the procedure.

The operative procedure was performed similarly in all cases. Each patient was taken to the operating room, and general anesthesia was induced, followed by intubation with a 5.5-mm cuffed endotracheal tube. The larynx was exposed with a Dedo-Pilling laryngoscope and suspended from a Mayo stand with a Lewy suspension apparatus. An operating room microscope was used to examine the larynx (Fig 1). The anterior glottic web was palpated with blunt instrumentation, and the length and thickness of the web was assessed. The web was then injected

From the Voice Treatment Center and the Division of Otolaryngology, The George Washington University, Washington, DC.

Correspondence: Steven A. Bielamowicz, MD, Division of Otolaryngology, The George Washington University, 2150 Pennsylvania Ave NW, Suite 6-301, Washington, DC 20036.



Fig 1. Anterior glottic web measuring approximately one quarter of length of membranous vocal fold before surgical management.

with 1% lidocaine with epinephrine. The web was divided by a cold knife technique in which a microlaryngeal sickle knife was used to initiate the cut, and the web division was completed with up-biting microlaryngeal scissors. The web was divided in a stepwise fashion from the superficial to deep layers up to the level of the anterior commissure in the midline. A sterile plastic ruler was then cut so that it could be held with a small alligator forceps, and an exact anterior-to-posterior web length was obtained.

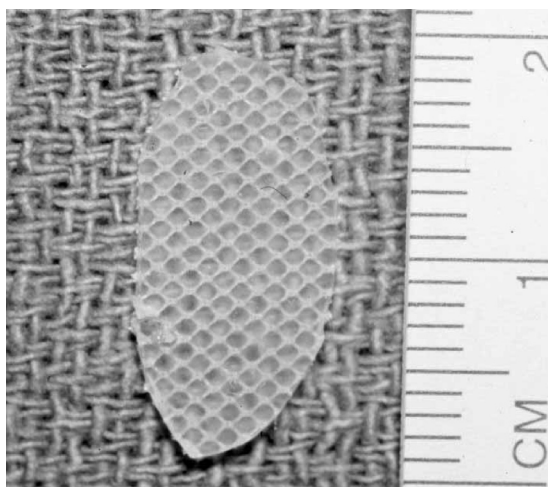


Fig 2. Thickness of customized keel, made from reinforced silicone sheeting, is 0.5 mm. Length and width are measured along axes parallel and perpendicular, respectively, to ruler.



Fig 3. Angiocatheter is introduced through cricothyroid membrane in midline.

A keel was fashioned from 0.5-mm-thick reinforced silicone sheeting shaped as a rectangle with rounded edges (Fig 2). The width of the silicone rectangle was created 1 mm greater than the length of the web. The length of the keel was estimated to extend from the upper portion of the cricothyroid membrane to the petiole of the epiglottis in the midline. The keel was delivered into place with alligator forceps to estimate the fit of the keel. The keel was fashioned so that the entire cut edge of the web was “covered” by the keel.

We placed 2-0 Prolene sutures approximately 2 mm from the superior and inferior edges of the keel. The edge closest to the suture insertion sites was placed in the anterior commissure. The needle of a 16-gauge angiographic catheter was bent at a 60° angle. An assistant introduced the catheter needle through the inferior aspect of the cricothyroid membrane while the surgeon visualized the midline introduction into the tracheal lumen. The ends of the Prolene suture, placed through the inferior aspect of the silicone keel, were delivered into the bevel of the angiographic catheter with alligator forceps. The suture was advanced from the tracheal lumen to the hub of the needle above the surface of the skin. Once the suture was retrieved at the hub of the needle, the catheter was removed (Fig 3). The catheter needle was then introduced through the thyrohyoid membrane immediately superior to the thyroid notch and directed inferiorly so that the needle entered the supraglottic lumen at the petiole of the epiglottis in the midline (Fig 4). The sutures were then pulled, and alligator forceps were used to deliver the keel into position without tangling the suture material. The keel was ascertained to fit firmly against the anterior commissure (Figs 5 and 6). The sutures were secured over silicone buttons acting as bolsters on the anterior neck.



Fig 4. Angiocatheter is introduced above thyroid notch through thyrohyoid membrane and angled inferiorly through petiole to enter midline of airway.

The keel was left in place for 2 weeks, after which time the patient returned to the operating room. Suspension microlaryngoscopy was then performed, and the keel was grasped with alligator forceps and removed through the mouth after the Prolene sutures were cut and removed from the anterior part of the neck.

RESULTS

Ten patients underwent endoscopic lysis of anterior glottic webs with placement of a silicone keel from 1997 to 2003 at The George Washington University Hospital. This group included 2 women and 8 men. Their ages ranged from 29 to 69 years, with an average age of 49 years. The average duration of follow-up was 18 months. As seen in the Table, the causes of the anterior glottic webs included 8 cases in which a history of laryngeal papillomatosis with multiple operations to excise the papilloma led to formation of an anterior glottic web as a consequence either of the disease or of the laryngeal op-

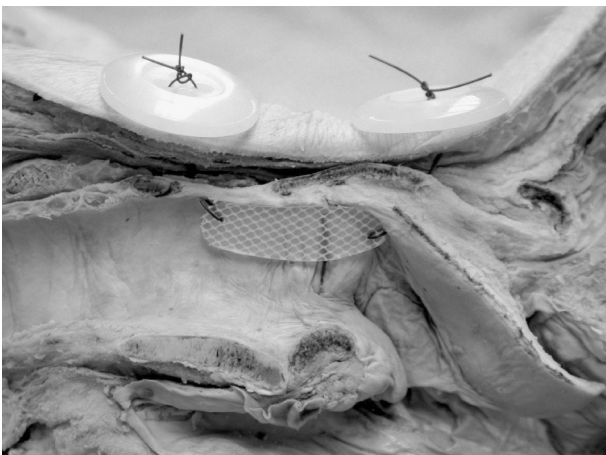


Fig 5. Silicone keel is secured to skin with Prolene over silicone buttons.

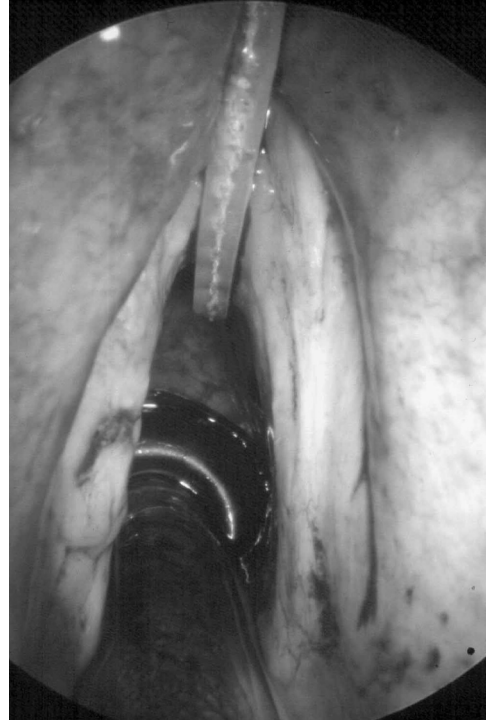


Fig 6. After web lysis, keel was sutured in place.

erations. One patient had a history of idiopathic subglottic stenosis that had been managed with laryngotracheal reconstruction. One patient developed an anterior glottic web after radiotherapy for a T1 N0 M0 squamous cell carcinoma of the anterior true vocal fold.

The average size of the silicone keel was 15 × 6 mm. The sizes of the anterior glottic webs treated ranged from one quarter to two thirds of the membranous vocal fold. All of the keels except 2 were secured with 2-0 Prolene suture. The first 2 endoscopic keels placed were secured with 26-gauge wire. All of the patients had the keel removed at 2 weeks in the operating room, except for the patient who had undergone radiotherapy for a squamous cell carcinoma. This patient returned to the office on postoperative day 5 with significant cellulitis of the anterior neck around the site of the buttons. He was returned to the operating room for early removal of the keel. Even though the keel was removed at 5 days after placement, a web recurrence was not observed. The other complication occurred in a patient who had non-reinforced silicone 0.5-mm sheeting used as a keel. The sutures pulled through on postoperative day 2; the patient was taken back to the operating room for removal of that keel and replacement with reinforced silicone sheeting. One patient had a minor recurrence of the web at the anterior commissure, manifesting as 1 to 2 mm of blunting of the anterior angle. No other patient developed a

PATIENT DEMOGRAPHICS, KEEL DETAILS, AND OUTCOMES

Age (y)	Cause	Follow-Up (mo)	Keel		Duration (d)	Complications	Recurrences	Web Length
			Dimensions (mm)	Suture				
68	T1 squamous cell carcinoma with radiotherapy	23	10 × 5	Wire	5	Infection	None	Anterior third
40	Papilloma	39	20 × 9	Wire	14	None	None	Anterior half
51	Idiopathic subglottic stenosis	13	15 × 7	Prolene	14	None	None	Anterior quarter
54	Papilloma	33	10 × 5	Prolene	14	None	None	Anterior half
52	Papilloma	25	10 × 5	Prolene	14	None	None	Anterior half
29	Papilloma	16	10 × 5	Prolene	14	None	Minor	Anterior quarter
52	Papilloma	2	18 × 5	Prolene	14	None	None	Anterior third
33	Papilloma	13	20 × 5	Prolene	14	Suture dehiscence	None	Anterior third
69	Papilloma	3	20 × 10	Prolene	14	None	None	Anterior two thirds
43	Papilloma	9	20 × 8	Prolene	14	None	None	Anterior third

recurrence of the web (Fig 7).

DISCUSSION

Anterior glottic webs occur most commonly after endoscopic resection of laryngeal papilloma near the anterior commissure. Raw mucosal edges at the anterior medial surface of the vocal fold after resection of laryngeal papilloma or carcinoma can lead to the development of scarring that spans both vocal folds. Anterior web formation has been noted to occur in patients who undergo carbon dioxide (CO₂) laser excision of papilloma. Web development is limited by staging the surgical resection of lesions involving the anterior aspect of both vocal folds by resecting one side at a time and allowing for com-

plete healing prior to surgery on the opposite side.

Anterior glottic webs are a known complication of CO₂ laser excision of laryngeal papilloma, ranging from 7% to 47%.⁴⁻⁹ Wetmore et al,⁹ in 1985, reported a delayed tissue complication rate of 45% in a combined study of pediatric and adult patients. Crockett et al⁵ reported a delayed tissue complication rate of 36% in pediatric patients and 17% in adult patients. Both of these groups advocated aggressive total removal of papilloma, even from the anterior commissure. Benjamin and Parsons⁴ recommended minimizing trauma to opposing surfaces across the anterior commissure and reported a 20% rate of glottic web formation. Holland et al⁶ reported a 42% rate of web formation in a study of 31



Fig 7. Anterior glottic web comprises anterior third of membranous vocal fold **A)** before and **B)** after endoscopic keel management.

pediatric patients with recurrent respiratory papilloma treated with CO₂ laser excision. They saw an increase in delayed complications, including glottic webs, in patients who had more operative procedures, as well as a decreased incidence of web formation in patients treated for laryngopharyngeal reflux.

Four surgical approaches to anterior glottic webs have been described in the literature. The first is excision of the glottic web followed by dilation, as first described by Jackson and Coates¹⁰ in 1930 and advocated again by Stasney¹¹ in 1995. This procedure can require multiple dilations or repeat anterior glottic web excisions to achieve good results. Repeat treatments are necessary with this technique because the web lysis results in raw mucosal edges in close proximity. The raw mucosal edges of the vocal folds will re-epithelialize, and because of the close contact at the anterior commissure, healing across the mucosal edges may lead to a scar that spans these areas with recurrent web formation.¹²

The second surgical approach is a laryngofissure with placement of a keel, as classically described by McNaught¹³ in 1950. McNaught¹³ used a tantalum keel placed between the edges of the thyroid lamina. A second open procedure was required to remove the keel, and a tracheotomy was required to prevent airway obstruction.^{12,13} The third surgical approach is advocated in our report: lysis of the web and placement of a keel through an endoscopic approach. Haslinger first described this procedure in 1922, when he placed a silver keel secured by wires through the thyrohyoid and cricothyroid membranes by an endoscopic approach.¹² The silver plate was bent in half, with the sharp edge directed forward. His technique was not consistently successful and was abandoned.¹² Dedo¹² postulated that the long, straight edge of Haslinger's keel did not fit securely into the anterior commissure, allowing for recurrence of the web. Dedo,¹² in 1979, reported his experience with 6 patients with endoscopic placement of a triangular-shaped Teflon keel made from a nasal septal splint. He noted a 1- to 3-mm recurrence at the anterior commissure, yet good voicing.¹² The size of the keel in adults was up to 4 cm in the caudal-cephalad direction in the Dedo¹² study. In the adult patients, no tracheotomy was required with this procedure. The keel was left in place for 2 to 4 weeks, depending on the thickness of the web. Parker and Das Gupta² used a CO₂ laser to excise an anterior glottic web in 2 patients. A tubular silicone keel with a posterior flange was left in place for 4 weeks. Both of these patients had a preexistent tracheotomy. To obviate some of the difficulty with placement of sutures through the thyrohy-

oid and cricothyroid membranes, Lichtenberger and Toohill¹⁴ designed an endo-extralaryngeal needle carrier to pass the sutures from the airway outward through the neck. They suggested using a triangular-shaped silicone keel as described by Dedo,¹² left in place for 3 weeks. In their study, 8 of 13 patients had a residual anterior glottic web (10% to 20% of the membranous vocal fold). Casiano and Lundy¹⁵ reported 3 cases of anterior glottic webs, which they treated with CO₂ laser vaporization and endoscopic placement of a silicone keel. As with our technique, the sutures were placed through a 16-gauge catheter, but the keel was left in place for 3 weeks. They described keel removal in the office with a flexible nasolaryngoscope.

The fourth surgical approach is to divide the web and then raise a mucosal flap to cover one or both of the exposed epithelial surfaces of the true vocal folds. McGuirt et al,¹ in 1984, used a CO₂ laser to create a mucosal flap consisting of mucosa from one vocal fold and the web to provide unilateral cord coverage; the flap was "spot-welded" with the CO₂ laser to the inferior surface of the true vocal fold. Instead of using a keel, mucosal flaps were raised to prevent contact of the raw mucosal edges and recurrence of the web. Schweinfurth¹⁶ described a technique by which the web is divided in the midline, and superior and inferior flaps are raised over each true vocal fold and then sutured together. This is an improvement compared to open laryngofissure, but these techniques are more technically difficult than simple lysis of the web and keel placement. Jamie Koufman (personal communication, 2003) has described an anteriorly based false vocal fold flap that is used to cover the raw mucosal surfaces. The false vocal fold flap is held in place by Super Glue. In the postoperative period, she has found that the flap falls off without recurrence of the web.

The advantages of the endoscopic lysis of anterior glottic webs and keel placement include the elimination of an external surgical procedure. The laryngofissure approach appears to be a relatively safe and effective method for web management, but a similar outcome can be accomplished with the endoscopic technique with a reduction in the morbidity associated with the open procedure. In our series, a tracheotomy could be avoided. The endoscopic keel placement did not interfere with eating, and most patients returned to work with the keel in place.

Most studies recommend the placement of a keel for 3 to 4 weeks. In 9 of our 10 patients, the silicone keel was removed after 2 weeks, and 1 patient had the keel removed on postoperative day 5 because of a wound infection. As only 1 minor recurrence was

observed, we can advocate a shorter time period for keel removal.

Reinforced 0.5-mm silicone sheeting is readily available and can be easily contoured to fit the larynx of each individual patient. We recommend using reinforced sheeting, as the Prolene suture pulled through non-reinforced silicone sheeting in 1 patient on postoperative day 2. In this series, stainless steel wires were originally used to secure the keel in the larynx, as described by Dedo.¹² Because of difficulties with manipulating the wires, we began using Prolene sutures without suture breakage. The

Prolene suture is much easier to introduce and manage endoscopically in the larynx than is wire and appears to have a similar level of safety.

CONCLUSIONS

Anterior glottic webs are often seen in patients after multiple procedures for resection of laryngeal papillomatosis. Endoscopic lysis of the web with placement of a silicone keel is an effective technique for management of anterior glottic webs and can be performed on an outpatient basis without a tracheotomy. The keel can be relatively safely removed at 2 weeks with minimal risk of web recurrence.

REFERENCES

1. McGuirt WF, Salmon J, Blalock D. Normal speech for patients with laryngeal webs: an achievable goal. *Laryngoscope* 1984;94:1176-9.
2. Parker DA, Das Gupta AR. An endoscopic Silastic keel for anterior glottic webs. *J Laryngol Otol* 1987;101:1055-61.
3. Bielasowicz S, Villagomez V, Stager SV, Wilson WR. Intralesional cidofovir therapy for laryngeal papilloma in an adult cohort. *Laryngoscope* 2002;112:696-9.
4. Benjamin B, Parsons DS. Recurrent respiratory papillomatosis: a 10 year study. *J Laryngol Otol* 1988;102:1022-8.
5. Crockett DM, McCabe BF, Shive CJ. Complications of laser surgery for recurrent respiratory papillomatosis. *Ann Otol Rhinol Laryngol* 1987;96:639-44.
6. Holland BW, Koufman JA, Postma GN, McGuirt WF Jr. Laryngopharyngeal reflux and laryngeal web formation in patients with pediatric recurrent respiratory papillomas. *Laryngoscope* 2002;112:1926-9.
7. Ossoff RH, Werkhaven JA, Dere H. Soft-tissue complications of laser surgery for recurrent respiratory papillomatosis. *Laryngoscope* 1991;101:1162-6.
8. Saleh EM. Complications of treatment of recurrent laryngeal papillomatosis with the carbon dioxide laser in children. *J Laryngol Otol* 1992;106:715-8.
9. Wetmore SJ, Key JM, Suen JY. Complications of laser surgery for laryngeal papillomatosis. *Laryngoscope* 1985;95:798-801.
10. Jackson C, Coates G. The nose, throat, and ear and their diseases. Philadelphia, Pa: WB Saunders, 1930:755.
11. Stasney CR. Laryngeal webs: a new treatment for an old problem. *J Voice* 1995;9:106-9.
12. Dedo HH. Endoscopic Teflon keel for anterior glottic web. *Ann Otol Rhinol Laryngol* 1979;88:467-73.
13. McNaught RC. Surgical correction of anterior web of the larynx. *Trans Am Laryngol Rhinol Otol Soc* 1950:232-42.
14. Lichtenberger G, Toohill RJ. New keel fixing technique for endoscopic repair of anterior commissure webs. *Laryngoscope* 1994;104:771-4.
15. Casiano RR, Lundy DS. Outpatient transoral laser vaporization of anterior glottic webs and keel placement: risks of airway compromise. *J Voice* 1998;12:536-9.
16. Schweinfurth J. Single-stage, stentless endoscopic repair of anterior glottic webs. *Laryngoscope* 2002;112:933-5.