

Review Article

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Surgical management of acquired anterior glottic web: a systematic review

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Abstract

Background. Acquired anterior glottic web poses a significant challenge to laryngologists given its propensity to recur following treatment, and there are a wide variety of described techniques.

Methods. A systematic review of the medical literature was undertaken in order to identify all articles pertaining to the management of acquired anterior glottic web.

Results. Thirteen studies meeting the inclusion criteria were identified and analysed. All were retrospective series, with varying surgical techniques and outcome measures. Only two studies reported on the use of topical mitomycin C.

Conclusion. Mucosal graft techniques and keel placement appear to improve success rates, but both carry risks and disadvantages. Based on the available evidence, the use of topical agents such as mitomycin C cannot be recommended in the management of acquired anterior glottic web.

Introduction

Anterior glottic web can be described as a focal narrowing of the airway because of fibrotic tissue at the level of the true vocal folds. Acquired anterior glottic webs are more common than congenital webs. They may occur at any age, secondary to endotracheal intubation, laryngeal trauma or surgery close to the anterior commissure, radiotherapy, and rarely inflammatory processes. Symptoms can range from dysphonia and impaired exercise tolerance to airway obstruction, depending on the length of the web.

Surgery for anterior glottic web is carried out for two reasons: to establish a stable airway and to provide a functional voice. The surgical management of this condition poses a significant problem to the laryngologist given the propensity for web reformation following treatment and the lack of a clear consensus regarding the optimal surgical approach.

The management of anterior glottic web is not a new problem. Previous descriptions of bougie dilatation and excision via an external approach date back as far as the late nineteenth century.¹ However, it was in 1924 when Haslinger described his silver keel technique² and approaches recognisable to the present-day laryngologist entered common usage. McNaught modified this technique, using a tantalum keel placed via a laryngofissure.³ It has since been modified many times with various materials.

In the 1980s, when laser techniques became widely utilised, laser surgery was employed by many to divide anterior glottic webs. However, some have returned to cold steel division with or without mucosal flaps, as described by McGuirt *et al.*⁴ More recently, mitomycin C, an antineoplastic agent, was found to suppress fibroblast proliferation.⁵ It has subsequently been used topically after the division of anterior glottic webs, with varying success.^{6,7}

Despite the myriad techniques described, there is no general consensus on the management of anterior glottic web, and controlled trials on the subject are lacking. The existing evidence is based largely on observational studies. This systematic review was therefore undertaken to inform evidence-based management of anterior glottic web. Given the differing pathophysiological processes underlying congenital and acquired anterior glottic web, only acquired anterior glottic web has been considered for the purposes of this study.

Materials and methods

Study design and search strategy

A systematic search of the PubMed, Embase, and Cochrane databases was carried out to identify original articles published until October 2018. The research was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses ('PRISMA') criteria. A combination of Medical Subject Heading terms and free-text words were used in the search, as follows: 'anterior glottic web', 'laryngeal web', 'laryngeal synechia', 'vocal fold synechia', 'anterior commissure synechia', 'anterior glottic stenosis' or 'anterior laryngeal stenosis', and 'management', 'treatment', 'surgery', 'follow up' or 'surveillance'. Filters were then used to identify articles pertaining to

humans, with more than one patient. Reference lists of articles and narrative reviews published in the last 10 years were also manually searched for articles not identified by the initial search.

Inclusion and exclusion criteria

All studies investigating the management of acquired anterior glottic web in humans were assessed for inclusion. Studies in all languages were considered. Studies concerning congenital anterior glottic web or airway stenosis at other levels were excluded, as were those with fewer than two patients. Studies containing duplicated data from previously published work were also excluded, as were review articles, editorials and letters. No restrictions were placed on study design or study population.

Systematic review protocol and data extraction

Two authors (DB and JMF) independently screened all the titles and abstracts of studies generated by the search, using predefined inclusion and exclusion criteria. Subsequently, the full text of articles was screened if relevance was not obvious based only on the title and abstract. Any disagreement between the assessors regarding the suitability of articles for inclusion was settled by discussion between assessors or, failing this, by referral to the senior author.

Data from included studies were extracted using a standardised proforma in Microsoft Excel spreadsheet software (Redmond, Washington, USA). Categories for data extraction included sample size, participant age, surgical technique, anterior glottic web size, recurrence rate, follow-up duration and post-operative voice quality.

Data analysis

Given the variety of outcome measures employed in different studies, statistical meta-analysis of results was not possible. Results were therefore consolidated according to intervention and outcome measure, and are presented descriptively.

Risk of bias and quality assessment

All studies were assessed for quality and risk of bias by both reviewers, according to a modification of the system described in the *Cochrane Handbook for Systematic Reviews of Interventions*, version 5.1.0.⁸ Because of the large number of retrospective, non-randomised, non-blinded studies on the subject, more weight was placed on the descriptions of interventions and reporting of outcomes, than on randomisation and blinding.

Results

Search results and study selection

The search strategy detailed above yielded 294 articles. By screening the titles and abstracts, 272 articles could be excluded because it was clear they did not meet the inclusion criteria. This left 22 studies for which the full text was assessed. Of these, 13 studies met the inclusion criteria.^{9–21} Figure 1 shows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

Characteristics of included studies

The 13 studies meeting the inclusion criteria included a total of 203 patients ranging in age from 5 to 80 years, and all were retrospective case series. Three of the studies included a total of five patients with congenital anterior glottic web, and it was impossible to separate these from the acquired anterior glottic webs in the reported data.^{9,17,20} After discussion between authors, it was decided they should be included, as the congenital anterior glottic web patients made up only a small proportion of the patients in each study. Table 1 shows general characteristics of the included studies, and Table 2 summarises the key findings.

The length of follow up ranged from 3 to 48 months. The outcome measures reported varied significantly. All studies reported recurrence rate, and the majority reported the re-operation rate. Qualitative measures included self-ratings of voice impairment, the Voice Handicap Index score, the grade, roughness, breathiness, asthenia and strain ('GRBAS') scale score, videostroboscopy findings and fibre-optic laryngoscopy findings. Objective outcome measures included maximum phonation time, phonation quotient, frequency range, fundamental frequency, and jitter and shimmer analysis findings. These objective measures were unfortunately difficult to compare given the heterogeneity in reporting within the different studies.

Open versus endoscopic approaches

Although once a popular approach for anterior glottic web surgery, open surgery via laryngofissure is now seldom used given the advances in endoscopic equipment and techniques. Open surgery does still have a role in the management of thick anterior laryngeal webs with subglottic involvement.²² Nevertheless, 12 of 13 studies identified in this review utilised an endoscopic approach.

Izadi *et al.* described a technique used in two patients with bulky anterior glottic webs extending into the subglottis, which involved access via a laryngofissure, division of the anterior glottic web, and insertion of a composite graft of cartilage and perichondrium to act as a keel (Figures 2 and 3).¹⁴ In both cases, there was a subjective improvement in voice quality, but no objective improvement. The authors conceded that the open approach has significant drawbacks, including the need for a tracheostomy, but maintain that it has advantages in those with subglottic extension of an anterior glottic web. By contrast, all studies that described an endoscopic approach were able to avoid a tracheostomy in all patients.

Web division

Six of the 13 papers described 'cold steel' dissection in 118 patients,^{9,10,12,13,19,20} with the aim of reducing thermal damage to vocal mucosa and thus the rate of recurrence. The carbon dioxide (CO₂) laser has been described as a method for dividing anterior glottic web, and 6 studies used it exclusively in 67 patients. In one study, both techniques were used, but it did not specify which patients underwent which technique.¹⁸ The techniques were so variable in terms of keel placement and duration that meaningful comparison between the laser and 'cold steel' outcomes was difficult; however, the recurrence rates in the pooled groups were 15 per cent and 22 per cent respectively.

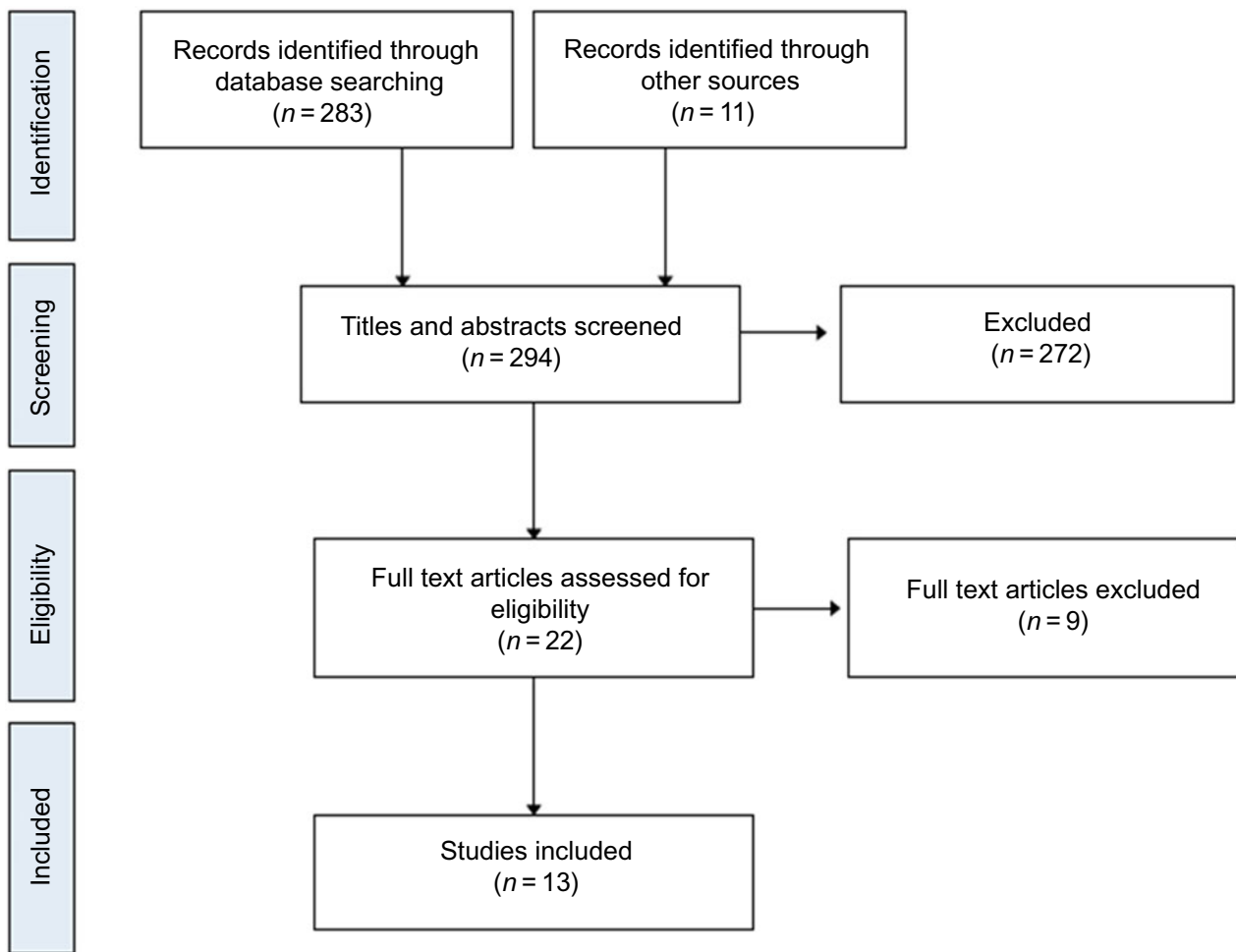


Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses ('PRISMA') flowchart describing the search strategy.

Mucosal flap surgery

Four studies described the use of a mucosal flap to reduce the recurrence of anterior glottic web after division, in a total of 64 patients.^{13,15,19,21} In these studies, the mucosal flap was used instead of a keel, to ensure that no two raw surfaces were left opposing each other. Deganello *et al.* described division of the web by CO₂ laser following elevation of a mucosal flap on one side.¹⁵ The authors reported suturing the flap at the inferior surface of the vocal fold, so that on one fold there is a raw surface but on the other side the flap covers the fold. Xiao *et al.* divided the web into superior and deep surfaces, cutting each along opposite sides parallel to the vocal folds.¹⁹ They then draped the mucosa of the upper surface down over one fold and sutured it in place, to bring the lower surface upwards and suture it onto the other fold.

The series reported by Deganello *et al.* was small, with only four patients.¹⁵ Complete resolution of the anterior glottic web was reported in three patients, with one patient suffering mild residual anterior glottic web with minimal symptoms. The series by Xiao *et al.* was larger, with 32 patients.¹⁹ They identified a residual anterior glottic web in only four patients, with significant improvement in subjective and objective measures of voice in all patients. Xu *et al.* used their technique only in eight patients not deemed to require, or to be able to tolerate, a silicone keel.¹³ They reported a residual web in five of the eight patients treated with a mucosal flap alone.

The study by Cao and Sun was the only one describing a technique that combined the use of both the mucosal flap technique and a 0.3 mm thick silicone keel for larger webs

(9 out of 20 patients).²¹ For patients with smaller webs, a mucosal flap technique using size 7-0 polypropylene sutures was applied to close at least one side of the freshly incised mucosa. The adhesive web tissues were removed with a CO₂ laser. This procedure was not standardised, but tailored to individual patients. The authors reported an overall recurrence rate of 15 per cent; however, only one (5 per cent) of their patients developed a recurrent web of more than 20 per cent of the length of the vocal folds.

Keel use

The nautical term 'keel' describes a fin-shaped structure that is sited in the midline, separating the left and right sides of the glottis. Its aim is to prevent the apposition of raw surfaces at the anterior commissure during mucosal healing.

Eight studies with a combined total of 124 patients described the use of a keel following division of the anterior glottic web.^{9,11-13,17,18,20,21} In all studies, silicone elastomer was used to fashion the keel, securing it with transcutaneous sutures tied over a button or silicone tube on the skin of the anterior neck. The interval between placing and removing the keel varied from two to five weeks. In six of the eight studies, a second general anaesthetic was required,^{9,12,13,17,18,21} with only two studies reporting opting to remove the keel transnasally or transorally in the consulting room.^{11,20}

In general, papers that described the use of a keel following anterior glottic web division reported good outcomes. The complete resolution rate was 84 per cent in the pooled patients

Table 1. Characteristics of included studies

Study	Year	Study design	Country	Cases (<i>n</i>)	Age (mean (range); years)	Open or endoscopic	Keel?	Laser or cold steel	Mitomycin C?	Mucosal flap?
Lichtenberger & Toohill ⁹	1994	Retrospective case series	USA	13	50 (19–67)	Endoscopic	Yes	Cold steel	No	No
Stasney ¹⁰	1995	Retrospective case series	USA	2	n/a (38–61)	Endoscopic	No	Cold steel	No	No
Casiano & Lundy ¹¹	1998	Retrospective case series	USA	3	n/a (n/a)	Endoscopic	Yes	Laser	No	No
Edwards <i>et al.</i> ¹²	2007	Retrospective case series	USA	10	49 (29–69)	Endoscopic	Yes	Cold steel	No	No
Xu <i>et al.</i> ¹³	2009	Retrospective case series	China	25	n/a (6–56)	Endoscopic	Yes	Cold steel	No	No
Izadi <i>et al.</i> ¹⁴	2010	Retrospective case series	Iran	2	20 (18–22)	Open	No	Laser	No	No
Deganello <i>et al.</i> ¹⁵	2010	Retrospective case series	Italy & Netherlands	4	58 (n/a)	Endoscopic	Yes	Laser	No	Yes
Su <i>et al.</i> ¹⁶	2010	Retrospective case series	China	20	45 (18–71)	Endoscopic	No	Laser	No	No
Benmansour <i>et al.</i> ¹⁷	2012	Retrospective case series	France	18	46 (5–76)	Endoscopic	Yes	Laser	Yes	No
Paniello <i>et al.</i> ¹⁸	2013	Retrospective case series	USA	18	48 (24–80)	Endoscopic	Yes	Both	No	No
Xiao <i>et al.</i> ¹⁹	2014	Retrospective case series	China	32	38 (11–80)	Endoscopic	No	Cold steel	No	Yes
Chen <i>et al.</i> ²⁰	2017	Retrospective case series	China	36	43 (14–75)	Endoscopic	Yes	Cold steel	Yes	No
Cao & Sun ²¹	2018	Retrospective case series	China	20	48 (8–65)	Endoscopic	Yes	Laser	No	Yes

n/a = not applicable

Table 2. Summary of key findings

Study	Cases (n)	Recurrence rate (%)	Re-operation rate (%)	Complete resolution rate (%)	Follow-up duration*	Outcome evaluation	Main findings
Lichtenberger & Toohill ⁹	13	62	39	39	n/a	SRVI, fibre-optic laryngoscopy	High recurrence rate following cold steel AGW division & silicone keel; 2 patients required re-operation for granulation at keel site
Stasney ¹⁰	2	100	50	0	5–20	SVRI	Good voice outcomes & minimal residual web following web division & serial out-patient dilatation
Casiano & Lundy ¹¹	3	0	0	33	n/a	SVRI	CO ₂ laser division with silicone keel. Subjective voice improvement in all 3 patients, but objective improvement in only 1
Edwards <i>et al.</i> ¹²	10	10	0	90	18	Fibre-optic laryngoscopy	Good outcomes on fibre-optic laryngoscopy following sharp division & silicone keel placement. 1 infection & 1 early keel extrusion
Xu <i>et al.</i> ¹³	25	4	4	96	6–48	GRBAS, VHI, stroboscopy,	Excellent objective & subjective results with combination of mucosal flaps & keels
Izadi <i>et al.</i> ¹⁴	2	100	0	0	4–10	Stroboscopy, SVRI	Subjective voice improvement, but no objective improvement. Concluded that this approach should be reserved for patients with subglottic extension of AGW
Deganello <i>et al.</i> ¹⁵	4	25	0	75	n/a	Stroboscopy,	Complete resolution in 3 of 4 patients treated with CO ₂ laser & mucosal suture (no keel)
Su <i>et al.</i> ¹⁶	20	20	15	35	13	GRBAS, stroboscopy, SVRI	Good objective outcomes in voice quality with 1-stage laser procedure without keel
Benmansour <i>et al.</i> ¹⁷	18	0	0	100	48.4	VHI, stroboscopy	Excellent results following CO ₂ division, mitomycin C application & keel placement
Paniello <i>et al.</i> ¹⁸	18	11	0	89	Min = 3	Fibre-optic laryngoscopy	Good results, but complications in 4 of 18 patients
Xiao <i>et al.</i> ¹⁹	32	12.5	0	87.5	6	GRBAS, VHI, stroboscopy, MPT	Good results following single-stage mucosal flap procedure, with no complications
Chen <i>et al.</i> ²⁰	36	28	n/a	72	Min = 12	VHI	10 of 36 patients suffered recurrent AGW following cold steel division & silicone keel
Cao & Sun ²¹	20	15	0	85	6–12	GRBAS, VHI	15% recurrence, although only 5% with a recurrence of >20% of vocal fold length. Heterogeneous cohort as 3 different techniques used

*Values reflect average follow-up duration or range (or minimum ('min') where specified), in months. n/a = not applicable; SRVI = self-rated voice impairment; AGW = anterior glottic web; CO₂ = carbon dioxide; GRBAS = grade, roughness, breathiness, asthenia and strain scale; VHI = Voice Handicap Index; MPT = maximum phonation time

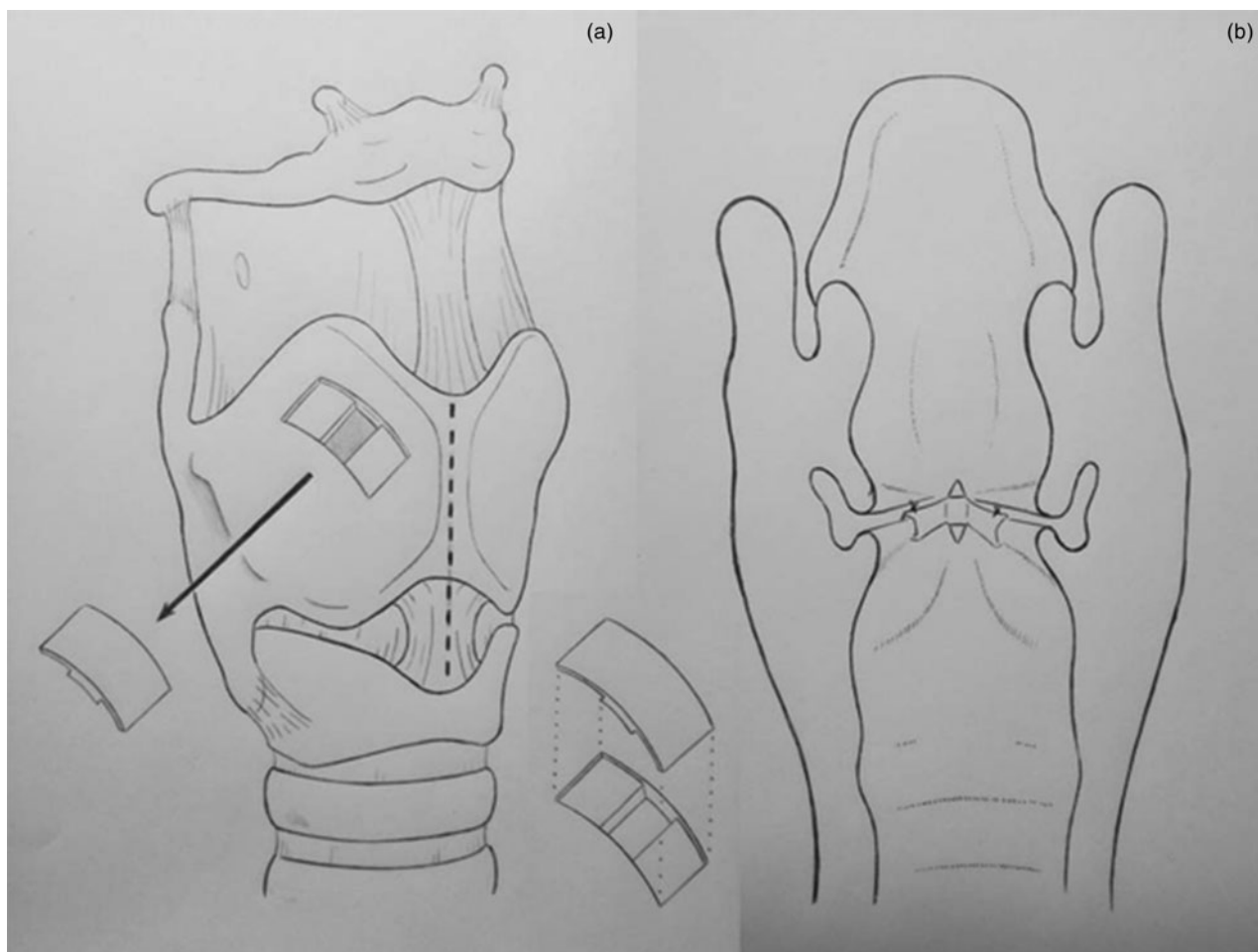


Fig. 2. Autologous keel 'butterfly technique', as described by Izadi *et al.*,¹⁴ whereby a segment of thyroid cartilage outer perichondrium along with a sliver of cartilage is excised (a), and, after division of the anterior glottic web via a laryngofissure, secured at the anterior commissure to prevent web reformation (b). The dashed line in (a) represents the site of laryngofissure incision.

across studies, compared with 77 per cent in the pooled group of patients who underwent mucosal flap suturing without keel placement. However, there were significant complications reported in patients treated with a keel, including spontaneous extrusion due to suture rupture,^{12,18,20} skin infection^{12,18} and granuloma formation.^{9,11,18}

Mitomycin C

Only two papers identified in this review described the use of mitomycin C in the management of anterior glottic web.^{17,20} Both reported topical application via a cottonoid pledget to the wound site immediately after anterior glottic web division. However, each study used a different dose and regimen for applying mitomycin C. Benmansour *et al.* used 2 mg/ml mitomycin C applied for two periods of 2 minutes.¹⁷ Chen *et al.* using 0.4 mg/ml mitomycin C applied for 10 minutes.²⁰

Discussion

The management of anterior glottic web is complex. It should be individualised and undertaken in a centre with appropriate expertise. Multidisciplinary management, with collaboration between otolaryngologists, anaesthetists, paediatricians and speech therapists, is vital. Both endoscopic and open approaches have been described for division of the anterior glottic web, with the thickness of the web and degree of

subglottic involvement dictating the surgical approach. The advent of improved endoscopic technology has shifted the indications for the surgical approach, with open approaches now being reserved for selected cases with significant subglottic extension.

Despite the increasingly ubiquitous nature of lasers in laryngeal surgery in recent decades, sharp dissection of the laryngeal web, by sickle knife or micro-scissors, is still used by many surgeons. 'Cold steel' laryngeal surgery is often advocated to minimise heat-induced scar formation.²³ Interestingly, there does not seem to be a clear improvement in outcomes with sharp techniques compared with the laser in anterior glottic web surgery; in fact, the studies included in this review point to a slightly better outcome with the laser. This may be because the most important factor is adequate coverage of the raw surface, either by keel or mucosal flap, rather than the technique of web division.

The rationale behind the use of a keel in anterior glottic web surgery is to maintain separation between healing tissues, thus preventing further scarring and recurrent web formation. Numerous materials have been used, and an evolution has been seen, with initial work utilising pewter, metal and Teflon stents, advancing to the use of silicone.^{3,24} Silicone is an ideal material, as it is inert, flexible, and easy to cut to the desired shape and size.

In 1991, Lichtenberger designed and used an endo-extralaryngeal needle holder to successfully place a silicone

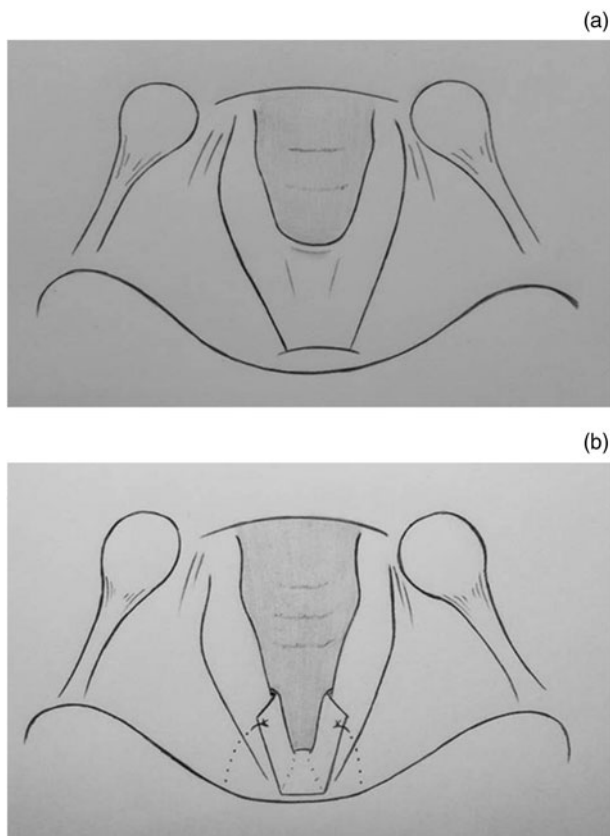


Fig. 3. View from above the anterior glottic web before (a) and after (b) division and insertion of autologous keel (as described by Izadi *et al.*¹⁴).

elastomer sheet into the larynx.⁹ This minimally invasive technology, which does not require tracheostomy, has been widely used to treat anterior glottic webs since then, with subsequent modifications depending on the individual centre's experience. In recent years, silicone keel placement has achieved certain therapeutic effects.^{12,17,18,20} However, the disadvantages of this kind of surgery are the need for two general anaesthetics, local tissue damage, slow recovery, and the possibility of partial rejection and infection.

Proponents of the mucosal flap technique point to the disadvantages of keels. They instead suggest the use of existing mucosa to cover raw surfaces and thus prevent contact at the anterior commissure, without the need for any foreign object. In 2002, Schweinfurth performed a scar release for laryngeal web separation, and suture of the mucosal flaps, on a 14-year-old with recurrent laryngeal papilloma.²⁵ In 2010, Deganello described a new surgical technique in four patients, involving web division by CO₂ laser, and suturing of the resulting mucosal flaps to cover the raw surfaces on the vocal folds.¹⁵

Based on these reports, Xiao *et al.* described a modified 'Z'-shaped mucosal flap, with arguably the best results of those centres reporting mucosal flap techniques.¹⁹ The satisfactory clinical outcomes, along with the avoidance of a keel, make this an attractive approach; however, it is not suitable for thick webs, and the technical difficulty of the procedure makes it unsuitable for low volume centres. In order to overcome the problem of thick webs without renouncing the mucosal flap technique, Cao and Sun simply decided to combine keel placement with the use of a mucosal flap for webs involving more than 35 per cent of the glottis.²¹

The use of medical adjuncts such as botulinum toxin and mitomycin C has also been described. Botulinum toxin may

be injected into the interarytenoid and thyroarytenoid muscles, resulting in a temporary paresis of the adductor muscles. The aim is to prevent over-adduction in the posterior commissure region during the post-operative healing period.²⁶ Whether this reduces the risk of restenosis is debatable.

Mitomycin C is an antineoplastic agent that inhibits fibroblast proliferation, and thereby modulates wound healing and scarring. In 2006, Simpson and James suggested that mitomycin C might reduce the risk of restenosis when applied topically to a surgically treated area.⁷ However, mitomycin C is a potential carcinogen. A case of laryngeal carcinoma that may have been induced by its topical use in the treatment of a glottic web has been reported.²⁷ Better quality evidence for its efficacy, including optimal timing of administration and dosage, is required before recommending its use.

Limitations

There is a relative dearth of published evidence on the management of anterior glottic web in the medical literature, which makes it difficult to draw clear conclusions on the optimal management strategy. Furthermore, many studies are retrospective, and various different outcome measures have been used to evaluate the results. This makes comparison between studies difficult and meta-analysis impossible.

Conclusion

The optimal treatment of acquired anterior glottic web remains controversial. 'Cold steel' division is theoretically preferable to laser, in order to minimise surgery-related scar formation between freshly divided surfaces. However, keel placement and the use of mucosal flaps both effectively prevent web reformation by separating the divided mucosa at the anterior commissure, thus reducing the importance of the technique used to divide the web. Placement of a keel has several disadvantages such as the need for two separate operations under general anaesthesia, prolonged recovery, and the risk of infection and granuloma formation. The mucosal flap technique, despite being technically more challenging, seems to produce high success rates. A small percentage of patients are likely predisposed to web reformation and development of granulation tissue, despite excellent surgical technique. The use of topical agents such as mitomycin C needs more high-quality evidence, both in terms of efficacy and safety, before being recommended. Future research in the form of large prospective studies is required in order to better inform best practice.

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Competing interests. None declared

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