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# Single and double mucosal microflap $CO_2$ laser "sliding" technique in the management of iatrogenic glottic web: anatomical and functional results

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## Abstract

**Purpose** An anterior glottic web consists of the formation of a bridge of scar tissue covered by epithelium between the anterior free edges of the true vocal cords and represents one of the most common complications of laryngeal endoscopic surgery for tumors involving the anterior commissure. Endoscopic surgery is the therapy of choice, but simple section of the web is burdened by a high recurrence rate. Topical application of mitomycin C, intracordal stents, and the use of mucosal microflaps have been proposed to improve outcomes. We report our experience with the use of single and double mucosal microflaps (sliding technique) during the management of iatrogenic anterior glottic web (IAGW).

**Methods** From November 2010 to December 2018, 30 patients (29 males, 1 female, mean age 65 years, range 47–87 years) were observed for IAGW, and 11 of these patients (36.7%) required surgical treatment. The Voice Handicap Index (VHI) and the GRBAS were used for the perceptive evaluation of pre- and post-operative voice quality.

**Results** A reduction of the web length was observed in all cases, and we did not observe any residual web at the mid-third of the glottis. The mean post-operative VHI score decreased from 45 to 24, and the mean post-operative GRBAS values were reduced from 2.8, 2.4, 2.3, 2.1, and 1.1 to 1.9, 1.4, 1.3, 1.1, and 0, respectively.

**Conclusions** The microflap technique represents an effective and reproducible one-step procedure that, in expert hands, allows to obtain good anatomical and functional results in a high percentage of cases.

**Keywords** Anterior glottic web · Microflap · Dysphonia · Microlaryngoscopy · $CO_2$ laser

## Introduction

Iatrogenic anterior glottic web (IAGW) consists of a bridge of scar tissue covered by epithelium between the anterior free edges of the true vocal cords [1]. IAGW is mainly observed after glottic surgery for tumors with involvement of the anterior commissure or after T1b treated endoscopically with a one-stage technique requiring the resection of the anterior thirds of both vocal cords that creates opposite raw wound surfaces; other causes of anterior glottic web are radiation therapy, prolonged intubation, laryngeal trauma, and inflammatory disease [1].

The clinical presentation of IAGW depends upon the extension of the web, beginning with slight dysphonia for very limited scar tissue confined to the anterior commissure and progressing to varying degrees of dysphonia that may be associated with dyspnea when IAGW reduces the laryngeal airway by more than 50% [1].

Minor IAGW may be asymptomatic or may present with mild voice symptoms and strained voice; it can be left untreated or referred to voice therapists [2], while surgery is the therapy of choice in moderate to severe symptomatic cases. Patients with severe airway obstruction could undergo temporary tracheostomy before the restoration of an

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adequate airway. Simple section of the web is an easy procedure, but it is burdened by a very high recurrence rate [2] since web formation is facilitated by the narrow V-shaped anatomy of the anterior commissure. Over the years, various surgical techniques to overcome the risk of restenosis after treatment of symptomatic IAGW have been reported in the literature; such techniques include endoscopic and open procedures and techniques with interposition of glottic stents or the use of mitomycin C [3]. In 1984, McGuirt et al. [4] first described an endoscopic microflap technique for the management of anterior glottic web that reduces the extent of the raw scar tissue left to heal spontaneously. In recent years, many variants of McGuirt's single microflap technique have been reported.

The present study reports a single-center cohort experience in the use of single and double endoscopic sutured mucosal microflaps to treat IAGW with the aim of standardizing a simple surgical technique and evaluating the postoperative voice quality and recurrence rate.

## Methods

Between November 2010 and December 2018, patients with IAGW that developed after endoscopic surgery for early to intermediate glottic squamous cell carcinoma were reviewed at the ENT Unit of an Italian tertiary university hospital.

Perceptual voice quality was evaluated using the GRBAS scale, which includes grade, roughness, breathiness, asthenia, and strain. Ratings of these aspects varied from 0 (normal) to 3 (severely injured). The parameters were rated by two phoniatricians. Self-assessment of voice quality was measured using the Voice Handicap Index (VHI). GRBAS and VHI scores were evaluated preoperatively and at approximately 3 months after surgery. Data are expressed as the mean ± SD and were compared using *t* tests. A $p$ value $< 0.05$ was considered significant.

Pre- and intra-operative laryngeal work-up included objective local examination by flexible and rigid endoscopy coupled in 2013 with narrow-band imaging (NBI), panendoscopy with 0° and 30° rigid scopes associated with IMAGE 1S (Storz, Germany), and enhanced contact endoscopy (ECE) to spot any early recurrent lesion at the level of the IAGW [5].

Classification of the degree of the glottic web was performed according to Cohen [6] and Koltai and Mouzakes [7]. Type 1 glottic web describes an anterior web involving less than 35% of the glottis, type 2 describes a glottic web involving 35–50% of the glottis, type 3 web has closure of 50–75% of the glottis, and type 4 glottic web obstructs 75–100% of the glottis.

The indication for surgical treatment was the endoscopic diagnosis of IAGW involving at least the anterior and middle third of the vocal cords and a VHI ≥ 40, while patients with a type 1 IAGW and those who were less symptomatic (VHI < 40) were not considered for surgery.

### Surgical technique

The procedure was performed under general anesthesia with orotracheal intubation, through Zeiss Universal S2 or Zeiss S21 (Jena, Germany) microscopic view coupled with an AcuPulse 40ST $CO_2$ laser (Yokneam, Israel) with an AcuBlade (Yokneam, Israel) focusing system (settings: 10 watts, super pulsed, single or continuous mode, 1–2 mm Acublade).

Complete exposure of the glottis was achieved with the use of Kleinsasser laser laryngoscopes modified by Rudert with the Riecker–Kleinsasser suspension system (Storz, Tuttlingen, Germany).

A submucosal injection of 0.1–0.2 ml 1:10,000 adrenaline in saline solution was performed prior to surgical dissection to obtain the hydrodissection of the mucosa when possible.

The flaps are harvested from a donor site (vocal cord that provides the mucosal flap) and sutured to a recipient site (vocal cord that receives the flap), since the harvesting of the flap usually starts from the opposite vocal cord.

The single technique starts with a $CO_2$ laser incision of the superior aspect of one of the vocal folds, from the anterior commissure to the posterior part of the web, as laterally as possible even inside the opposite ventricle. A mucosal microflap is raised using a laser and cold microinstrumentation to reach the floor of the donor ventricle. Submucosal scar tissue is removed or vaporized along with the mucosa of the inferior aspect of the web. The flap is then pulled down to cover the recipient fold and is fixed with one stitch using an absorbable 6/0 suture (maximum needle diameter 0.33 mm, length 8 mm, and curvature ¼), covering the medial aspect of the recipient fold with mucosa. The contralateral medial aspect is left to heal spontaneously.

The double technique starts with the harvesting of a first flap in a similar manner as in the single flap technique (Fig. 1a, b); after removal of the scar by $CO_2$ laser, the mucosa of the inferior aspect of the web is released from the inferior aspect of the opposite vocal cord (donor vocal cord). When the microflaps have been harvested, the lower mucosal flap is flipped up and the upper flap is flipped down to cover the wound on the exposed vocal cords (sliding technique as shown in Fig. 1c). The suture is mandatory to avoid detachment of the flaps; usually, one stitch is sufficient for each side (Fig. 1d–f).

The presence of a suspect superficial lesion at the level of the IAGW was not a contraindication for the microflap

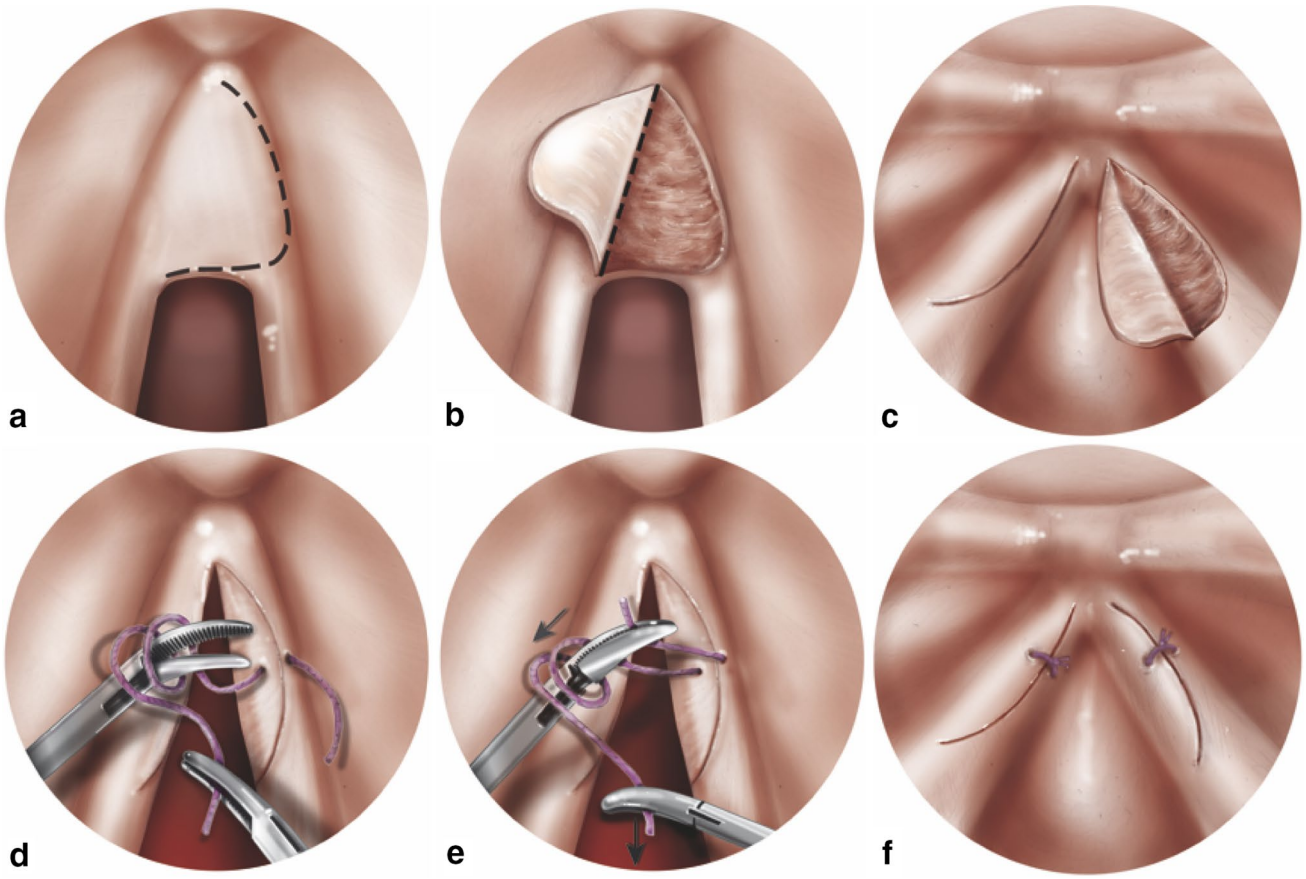


**Fig. 1** Diagram showing the main steps of the double microflap technique: incision of the mucosa (**a**), raising of the first microflap on the left vocal cord (**b**), intra-operative view after the pull-down of the first (left) microflap (**c**), microsuture technique with the direction of the traction of the endoscopic suture (**d**, **e**), and the final result (**f**)

technique; in such cases, an excisional biopsy was simultaneously performed.

All patients underwent post-operative voice therapy, and a minimum of 3 months of follow-up. Voice outcomes were evaluated by Student's *t* test.

## Results

During the study period, 30 patients (29 males, 1 female, mean age 65 years, age range 47–87 years) were observed for IAGW developed within 3 months after endoscopic curative surgery for early-to-intermediate squamous cell carcinoma.

Eleven patients (36.7%) met the inclusion criteria and underwent surgical correction.

The patients developed a symptomatic IAGW after type Va cordectomy in nine cases (81.8%), after type Vad cordectomy in one case (9.1%), and after type VI cordectomy in one case (9.1%) according to Remacle's classification [8, 9]. All patients showed a type 2 IAGW. We did not observe any patient with subglottic stenosis after transoral microsurgery.

Three patients had a type 2 IAGW and underwent a double technique. Six patients presented with a type 2 IAGW and underwent a single mucosal flap technique. The two remaining patients presented with a type 2 IAGW associated with a suspect lesion of the anterior commissure. They underwent excisional biopsy at the same time as correction of their IAGW with a single mucosal flap technique (Table 1). Histology of the suspect lesion showed a recurrent superficial in situ squamous cell carcinoma in one case, and mild dysplasia of the epithelium in the other case.

In all cases, the web dissection was performed with a $CO_2$ laser, and the mucosal flap was harvested using the laser and cold instruments (Fig. 2a, b). In all patients, regular glottic shape was successfully achieved during surgery (Fig. 2c). The procedure was well tolerated by all patients, and no clinical complications were observed.

The mean follow-up was 3.1 years (range 3 months to 5 years). At 1 and 3 months after surgery, all patients

**Table 1** Clinical features and surgical technique for the 11 patients treated for symptomatic IAGW. Series of patients: gender, age, etiology, and surgical treatment

| Pt/sex/age | Etiology | Surgical technique treatment |
|---|---|---|
| 1/M/62 | Type Va $CO_2$ laser cordectomy | Web lysis with $CO_2$ laser + single mucosal microflap |
| 2/M/68 | Type Va $CO_2$ laser cordectomy | Web lysis with $CO_2$ laser + single mucosal microflap |
| 3/M/68 | Type Va $CO_2$ laser cordectomy | Web lysis with $CO_2$ laser + single mucosal microflap |
| 4/M/80 | Type Va $CO_2$ laser cordectomy | Excisional biopsy of suspicious lesion + web lysis with $CO_2$ laser + single mucosal microflap |
| 5/M/54 | Type Va $CO_2$ laser cordectomy | Web lysis with $CO_2$ laser + double mucosal microflap |
| 6/M/76 | Type Vad $CO_2$ laser cordectomy | Web lysis with $CO_2$ laser + single mucosal microflap |
| 7/M/63 | Type VI $CO_2$ laser cordectomy | Web lysis with $CO_2$ laser + single mucosal microflap |
| 8/M/81 | Type Va $CO_2$ laser cordectomy | Web lysis with $CO_2$ laser + double mucosal microflap |
| 9/M/75 | Type Va $CO_2$ laser cordectomy | Excisional biopsy of suspicious lesion + web lysis with $CO_2$ laser+ single mucosal microflap |
| 10/M/64 | Type Va $CO_2$ laser cordectomy | Web lysis with $CO_2$ laser + single mucosal microflap |
| 11/M/87 | Type Va $CO_2$ laser cordectomy | Web lysis with $CO_2$ laser + double mucosal microflap |

underwent fibro-laryngoscopy (FL), GRBAS scale assessment, and VHI evaluation.

In all patients, the glottic lumen recovered an almost complete triangular shape with a regular overlying mucosa and with only a minimal residual IAGW limited to the most anterior part of the glottis near the anterior commissure (Fig. 3); one patient in whom the scar was considered to reduce the approximation of the vocal cords refused further surgery as he was symptomless (VHI = 30). Three months after surgery, all patients presented post-operative statistically significant improvement in voice quality parameters (GRBAS and VHI) with $p$ values < 0.0001 (Table 2).

## Discussion

IAGW represents a well-known complication of laryngeal endoscopic surgery for tumors involving the anterior commissure. The scar tissue resulting from such surgery can easily develop in the form of a web at the anterior commissure because of the proximity of both sides of the wounded vocal cord mucosa in a V-shape, while webs at the mid-membranous portion of the vocal folds are less frequent [2]. As previously reported in the literature, IAGW was observed in 8.4% of a series of 261 patients who underwent endoscopic surgery for glottic squamous cell carcinoma, but symptomatic web requiring endoscopic treatment under general anesthesia was observed in only 1.9% of the cases [10].

IAGW can be asymptomatic or can cause symptoms ranging from dysphonia and decreased exercise tolerance to severe airway obstruction; however, although the level of severity of the symptoms varies according to the length of the laryngeal web, a constant symptom is hoarseness and the inability to speak loudly [2, 11].

A complete diagnostic assessment is mandatory prior to treatment. The most important preoperative evaluation is indirect FL to precisely assess and document the extent of the IAGW on the 3D projections and the mobility of the arytenoids [12]. Eventual early recurrence can be spotted at the time of FL, as observed in two cases of our series; in such cases, perioperative evaluation takes advantage of

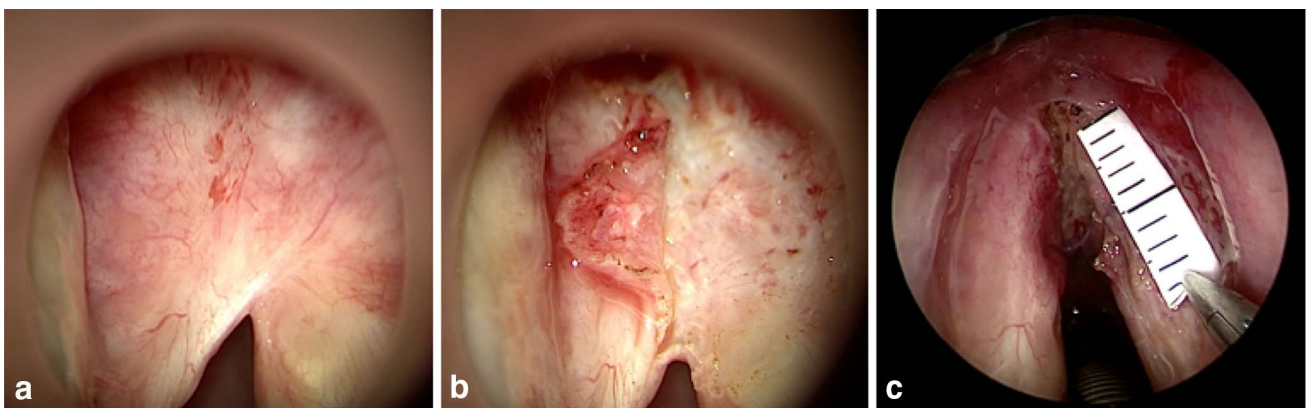


**Fig. 2** Intra-operative view: type 2 IAGW (**a**); raising of the left microflap (**b**); and the final result after the completion of the double microflap technique (**c**)

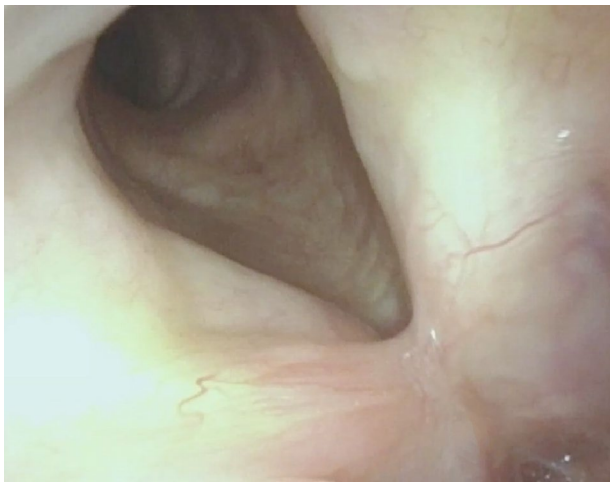

**Fig. 3** Endoscopic control of the same patient shown ins of Fig. 2 at 3 months after surgery showing the physiological triangular shape of the glottis associated with a regular overlay mucosa despite the minimal residual IAGW, which is limited to the most anterior part of the glottis

bioendoscopy methods (NBI and/or Image1 S$^{TM}$) that can be helpful in differentiating benign from potentially malignant changes of the mucosa [5].

Many subjective and objective methods can be used to evaluate the voice before and after surgery, but GRBAS, VHI, and objective assessment of the maximum phonation time are the most used in the literature [2, 13–17]. The thickness of the web should be taken into consideration when planning surgery. Computed tomography and/or magnetic resonance imaging of the neck can determine the length and width of the glottic stenosis, and can find underlying pathologies such as neck masses or recurrence of laryngeal benign or malignant tumors, features that can significantly change treatment options [2]. Direct laryngoscopy usually confirms the extent of the stenosis.

Chen et al. [13] observed that thick webs had a markedly higher recurrence rate compared with thin webs (88.9% vs 7.41%, $p < 0.001$). In our experience, all webs were limited to the glottic plane without extension to the subglottis and/or supraglottis; as a consequence, our patients did not require evaluation of the IAGW by radiologic imaging, and FL was considered adequate for web staging. In case of impairment of laryngeal mobility, laryngeal electromyography after the exclusion of a deep recurrent tumor by imaging could be helpful in differentiating between stenosis and vocal-fold paralysis [12], but it was never necessary in our cohort of patients.

Type 1 IAGW may be asymptomatic or may present with mild voice symptoms; it can be left untreated or referred to voice therapy [2], while IAGW presenting with severe voice and/or airway impairment generally requires surgical management. In our series, an asymptomatic type 1 IAGW was observed in 19 patients who did not undergo treatment, whereas surgery was considered the treatment of choice in the 11 patients who met our inclusion criteria.

Treatment of IAGW has undergone a constant evolution in the recent decades. Edwards et al. [11] classified the surgical approaches for IAGW into four main categories: (1) excision of the glottic web followed by dilation; (2) formation of a laryngofissure by an open approach with placement of a keel as a barrier between the vocal cords; (3) sectioning of the web using cold instruments and/or lasers and placement of a keel through an endoscopic approach; and (4) endoscopic sectioning of the web followed by the raising of a mucosal flap to cover one or both of the exposed epithelial surfaces of the vocal folds. All of these methods have been described alone or associated with placement of a keel and/or the use of mitomycin C [11]. The main challenge of all of these techniques is the need to overcome the problem of excessive scar formation that can cause recurrence.

Endoscopic methods based on simple scar release and local endoscopic dilation by bougies and/or a balloon have been poorly reported in the literature [18, 19], with only temporary benefits, and these methods generally require multiple procedures [11, 15]; this type of method was never considered in our series.

Open management of IAGW can be considered a more invasive procedure, since it includes a surgical approach by laryngofissure with placement of a keel, sometimes a tracheostomy, and a second open procedure to remove the keel [20]. The laryngofissure, although offering an open and wide exposure of the glottis, represents a "highway" to the anterior neck for eventual recurrence, losing the chance of a controlled in-box recurrence and leading to a potential lower laryngeal preservation rate and lower disease-specific survival. We do not advocate its use,

**Table 2** Comparison of pre- and post-operative subjective voice assessments of patients who underwent the single and double microflap technique for IAGW

| | Grade | Roughness | Breathiness | Asthenia | Strain | VHI |
|---|---|---|---|---|---|---|
| Preoperative | 2.8 ± 0.4 | 2.4 ± 0.7 | 2.3 ± 0.6 | 2.1 ± 0.3 | 1.1 ± 0.3 | 45 ± 3.6 |
| 3 months after surgery | 1.9 ± 0.3 | 1.4 ± 0.5 | 1.3 ± 0.5 | 1.1 ± 0.5 | 0 | 24 ± 3.5 |
| *p* | < 0.0001 | < 0.0001 | < 0.0001 | < 0.0001 | < 0.0001 | < 0.0001 |

but it can be considered after regular follow-up when the chances of a recurrence decrease.

Endoscopic keel placement has been reported to be effective and to reduce web recurrence, resulting in a recurrence rate of 0–27.7% [2, 11, 13, 15, 21]. It could be considered mandatory when the mucosal tissue remaining at the anterior commissure is not sufficient to achieve complete closure of the epithelium by mucosal flap suturing. However, the stent itself has several disadvantages: it may increase the risk of infection, leading to the recurrence of stenosis once the stent is removed, and it requires two separate operations under general anesthesia [2]. Furthermore, because endoscopic keels are usually hand-manufactured by the surgeon, their use is off-label and has possible medico-legal implications. Dislodgment of the keel can potentially acutely obstruct the airway, requiring emergency tracheostomy (personal unpublished experience of one of the authors during residency training).

Mitomycin C has been advocated to prevent recurrences [15, 16]. In 2010, Veen and Dikkers analyzed all published articles reporting the use of topical mitomycin C, and found no evidence of either effectiveness or systemic adverse side effects; local adverse effects were described in the 3.53% of the investigated human population, but no side effects occurred when the application of mitomycin C was followed by irrigation with saline solution [22]. In 2009, Hirshoren and Eliashar [23] supported the use of steroids, antibiotics, and anti-reflux medications, while they considered the efficacy of mitomycin C as unproven. In our hospital, the use of mitomycin C is considered off-label, and it has never been used by our team.

Endoscopic microsurgery has received an increasing attention in the management of IAGW because of the reduced surgical morbidity associated with this type of surgery [24]. To improve and speed up healing, many authors used techniques based on pedicled or free flaps of the mucosa [1–4, 14, 17, 24, 25]; the mucosal flap technique speeds up the re-epithelialization by covering the raw surface of the vocal folds in juxtaposition, and, as an additional benefit, decreases the risk of improper healing. The double-flap procedure could be considered a butterfly technique if both flaps are pedicled on the supraglottic or subglottic aspect of the anterior commissure (we believe that a more appropriate term should be "sliding technique", since one flap slides up and one slides down). The procedure described in the present study is a sliding double-flap technique in which one flap is pedicled superiorly and the opposite flap is pedicled inferiorly to double the chance of juxtaposing healthy mucosa between the raw vocal cords. In our experience, the technique starts with a lateral $CO_2$ laser incision of the mucosa, allowing us to harvest one or two flaps that can be used to cover at least one raw surface after the removal or vaporization of the scar tissue. The use of 10 watts in a superpulsed emission modality with the use of the AcuBlade reduces the thermal damage with very low chance of enhanced fibrosis.

The most challenging surgical step is the endoscopic microsuturing of one or both flaps. All of the reported series using the microflap technique show precise diagrams of how to suture the flaps, usually showing more than one microsuture, that in our opinion, it is truly difficult to be realistically reproduced by a moderately experienced endoscopic surgeon. The narrow space of the anterior commissure, the use of nondedicated instruments (usually curved crocodile laryngeal microforceps to hold the needle), and sometimes the need for smaller laryngoscopes for the difficult exposure of the anterior commissure makes the suture of the flaps even more difficult. In our experience, one stitch with an absorbable 6/0 vicryl suture for each flap was always sufficient to keep the flaps steady in the long term. The 6/0 vicryl was strong enough to avoid being ripped using crocodile microforceps, and the dimensions of the needle (maximum diameter of 0.33 mm, length of 8 mm, and curvature of ¼) allowed for a relatively easy, reproducible, and effective technique. Suture of the microflap was feasible in all cases in the present series, and it was considered reliable enough to stabilize the microflap. Fibrin glue has been described as a useful tool in laryngeal microsurgery to stabilize the microflap, reducing the risk of granuloma formation or defective healing [26]. The glue could be used in case of unfavorable anatomy of the larynx that could make the suture difficult or even impossible. In our previous experience (data not shown), the use of fibrin glue represented an additional cost and did not yield predictable results.

The choice between the single- or the double-flap technique is evaluated during the procedure on the basis of clinical and anatomic characteristics: when the IAGW is associated with a suspect glottic lesion and an excisional biopsy is performed during the same surgery, there is generally not enough mucosa to harvest two flaps, whereas the double technique is preferred when there is sufficient mucosa to harvest two flaps.

Endoscopic management of IAGW shows a paramount benefit in that it is single stage and minimally invasive; in our series, the mean recovery time was 1.1 days, and no patient experienced complications requiring tracheostomy.

Evaluation of the results of surgical treatment for IAGW is a controversial issue, and a wide range of recurrence rates (0–33.3%) has been reported in the literature [1, 2, 11, 13–15, 21]. Although minimal residual scar tissue is often observed on the anterior aspect of the glottis, especially after type Va and type VI cordectomies, the surgical treatment aims to reduce the length of the web and consequently to improve voice quality. In the literature, the microflap technique without keel placement and/or mitomycin C has been associated with recurrence rates of 12.5–33.3% [1, 2, 14]. In

our series, the length of the web decreased significantly after surgery in all cases, voice parameters improved (as shown in Table 2), and no patient needed further procedures under general anesthesia. As a consequence, we considered the procedure highly efficacious.

There is no general agreement on comparing the functional results, because there are few published series reporting subjective voice results [2, 13–17]. In our series, GRBAS scores showed a high correlation with VHI scores and patients' clinical behavior, supporting the use of these methods for the evaluation of voice outcomes. On the basis of these parameters, our patients experienced an overall improvement in all voice parameters after surgery (Table 2).

## Conclusion

The microflap (single or double sliding) technique with one single suture per flap represents an effective and easily reproducible one-step method for the treatment of IAGW. With a reasonable level of experience, this technique allows to obtain good anatomical and functional results in a high percentage of cases, reducing the need for more invasive procedures.

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### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** The research described herein did not involve any animal models. The research involved human participants and was conducted in accordance with the ethical standards adopted by the institutional and national research committees and with the principles set forth in the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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