

Core Messages

- › The vocal fold scar is an injury of variable severity sustained by the vibratory segment of the vocal cord.
- › In many cases glottic scars are accompanied by glottic insufficiencies caused by vocal fold defects.
- › A delay of 6 months is recommended before surgical treatment.
- › Speech therapy is useful and can be sufficient in case of a minor scar.
- › The main goal of surgery is to obtain a better closing and from there a better vocal fold vibration.
- › Medialization may help achieve sufficient glottic closure but not a normal voice.

Treatment of laryngeal scars is one of the most challenging topics in laryngology. Vocal fold scars can result from voice abuse and misuse, acute, or chronic laryngitis especially in combination with reflux disease, acid ingestion, blunt or sharp trauma to the larynx [11, 14], and iatrogenic trauma during intubation [2]. It also may result as a sequel to vocal cord surgery for dysplasia or carcinoma in situ [16] (Fig. 12a.1).

Supraglottic scars predominantly affect respiration and deglutition, whereas glottic scars result in dysphonia

and dyspnea. Symptoms associated with laryngeal scars are predominantly hoarseness, breathiness, voice effort, and voice fatigue [2]. In severe cases, aphonia and aspiration may be present sometimes in combination with a tracheotomy.

Glottic scars can be divided in four types.

Type I: mucosal, submucosal level—mild to moderate glottic insufficiency, reduced vibration

Type II: glottic insufficiency in a round anterior commissure region—anterior moderate defect; scars involving the vocalis muscle—no vibration, mild glottic insufficiency

Type III: glottic insufficiency—scar formation adherent to the inner perichondrium and the cartilage defect up to the supraglottic region, twisted arytenoids



Fig. 12a.1. Scar of the left vocal cord after intubation

C. Arens (✉)
Universitätsklinikum Magdeburg A.ö.R.,
Universitätsklinik für Hals-, Nasen- und Ohrenheilkunde,
Klinikdirektor, Leipziger Str. 44, 39120 Magdeburg, Germany
e-mail: christoph.aren@med.ovgu.de

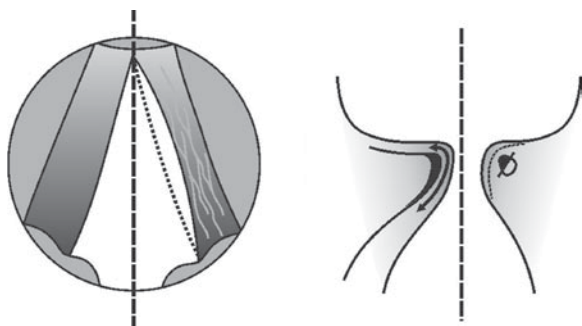


Fig. 12a.2. Type I. Scar of the vocal fold

Type IV: glottic insufficiency—anterior web formation, round anterior commissure, bilaterally reduced vibration

12a.1 Type I Scar of the Vocal Fold

The type 1 scar is an injury of variable severity sustained by the vibratory segment of the vocal cord [4, 6] (Fig. 12a.2). It affects Reinke's space and the vocal ligament. Vocal fold scars represent reparative disorganized tissue consisting mainly of fibrocytes producing collagen type I in the vibrating layer of the vocal fold, particularly the superficial layer of the lamina propria [22]. In contrast, the pliability of the vocal fold during phonation is guaranteed predominantly by fibers consisting of collagen type III as well as elastic fibers reaching into the basal layer of vocal fold mucosa. Depending on the severity of a scar, the vibration of the vocal fold can be completely impaired, leading to dysphonia. Scars can be localized in a single spot or can be present throughout the complete vocal fold. In many cases, glottic scars are accompanied by glottic insufficiencies caused by vocal fold defects.

Benninger et al. presented three rules: (1) The more mucosa excised, the more scar-forming activity of the lamina propria is stimulated. (2) Mucosal excision needs to be limited to precisely what is diseased or absolutely required. (3) Because fibroblast collagen is highest in the deeper layers of the lamina propria, the dissection must be kept superficial.

On stroboscopic examination, amplitude and mucosal waves show asymmetrical vibrations. The vocal cord defect may be visible. As with sulcus-vegeture, management is difficult [19].

A delay of 6 months is recommended before surgical treatment. Speech therapy is useful and can be sufficient in case of a minor scar [16, 20].

Scar surgery of the vocal folds should break up stiff scars to restore better elasticity and replace lost volume to gain complete glottic closure [3]. Laryngeal framework medialization, unilateral or bilateral, has been proposed [5, 9].

Microphonosurgery, similar to what is proposed for sulcus-vegeture can also be realized [18]. The epithelium, frequently atrophic must be freed from the deep part of the lamina propria. It is necessary to recreate a zone of detachment between the submucosal tissue and the epithelium. Hydrotomy or injection of saline solution, vasoconstrictors, or steroids can be helpful (Fig. 12a.3a, b)

In case of atrophy, injection of homologous collagen or fat is proposed to restore the shape and the volume of the vocal fold [15, 18]. Hyaluronic acid can also be injected to improve the pliability of the vocal fold [6, 10] (Fig. 12a.4a, b).

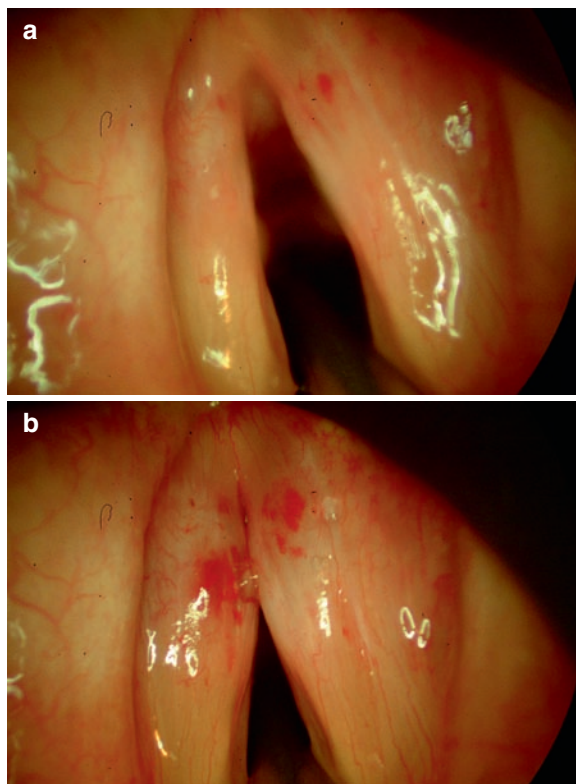


Fig. 12a.3. Bilateral superficial scar of the vocal cords. (a) Before. (b) After hyaluronic acid injection

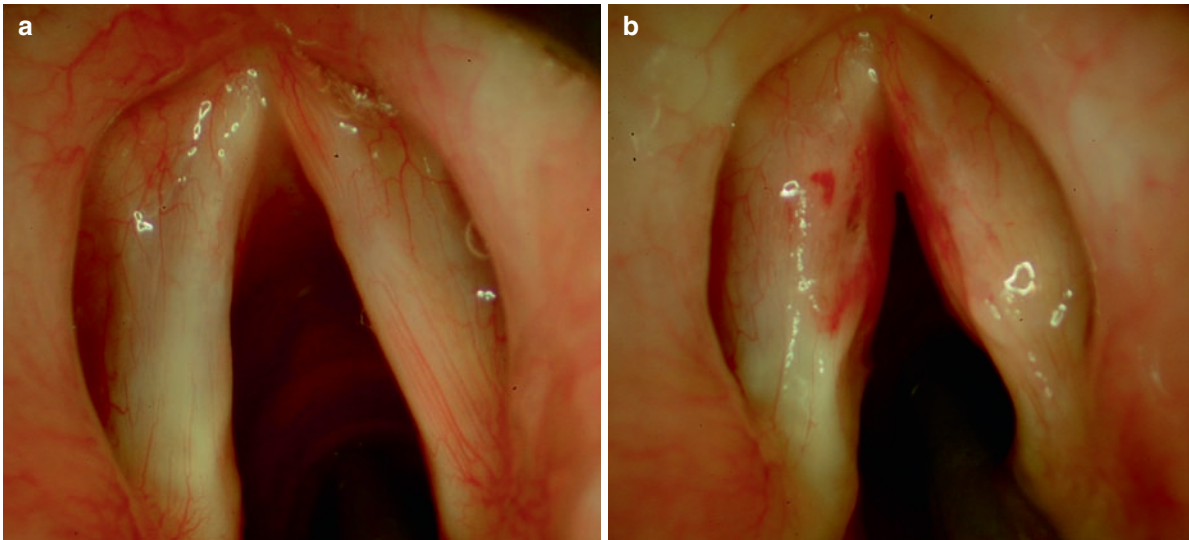


Fig. 12a.4. Bilateral scar of the vocal fold. (a) Before surgery. (b) After microsurgery: elevation of the epithelium, freeing of the subepithelial scar, and homologous collagen injection

These lesions are frequently bilateral and the two sides can be operated on at the same time. If the surgery has been difficult for one of the sides, it may be advisable to wait 6 months before approaching the other side.

Cordotomy is performed laterally. The scar formation is dissolved and the sliding flap prepared. Just by loosening the scars the mucosal flap drifts medially. In case of a volume deficit, we implant fat for an improved glottic closure leading to better vocal function (Fig. 12a.5).

The CO₂ laser technique thermal damage must be used with great caution to avoid thermal activation. This can be prevented by general avoidance of lasers in vocal fold surgery. Cold instruments are used to preserve as much mucosa as possible.

Other strategies that have recently shown advances include growth factor therapy [8] and cell therapy using

stem cells or mature fibroblasts [12, 13]. The effects of these new treatments have not fully been confirmed clinically, but there seems to be great therapeutic potential in such regenerative medical strategies [7].

The management outcome, as in cases of sulcus-vertegeture, may not be altogether satisfactory and the patient must be warned accordingly. The maximum benefit is not apparent until 4–5 months postoperatively [17]. The surgical treatment can be supported by antireflux agents.

Postoperative speech therapy is advisable to correct the excessive reactive supraglottic contraction. Bit by bit, as speech therapy progresses, the voice becomes stronger, more “comfortable,” even if the timbre remains husky. Most of these patients feel improved because of the decreased voice fatigue, voice abuse, and dysphasia in the throat and the increased voice sound. Although complete restoration of the vocal cord may not be achieved, the surgery does improve glottic closure and the timbre [15, 17].

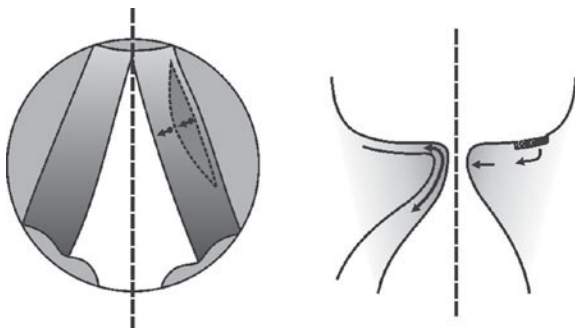


Fig. 12a.5. Lateral cordotomy and loosening of the scar

12a.2 Type II Scar (After Partial Cordectomy)

With type II cordectomy, the initial surgery leads to a mild to moderate loss of volume; it involves the vocalis muscle with the rigid scar formation not being able to be a sufficient counterpart to the normal vocal fold. This

finding is often accompanied by a moderate anterior defect and a round anterior commissure (Fig. 12a.6). During videostroboscopy, reduced or absent amplitude of vibration with loss of the mucosal wave can be detected. Therefore, augmentation and medialization is needed to close the glottic gap. During microlaryngoscopy, a pouch is created and the scar formation dissected. During the second step, the vocal fold is augmented with septal cartilage or fatty/connective tissue. After implantation of the autologous tissue, the pouch is closed by several sutures (Fig. 12a.7). Medialization may help achieve sufficient glottic closure but not a normal voice.

Medialization thyroplasty, unilateral or bilateral, has been proposed [5, 9].

12a.3 Scar Type III (After Total or Enlarged Cordectomy)

With type III cordectomy, scar formation is adherent to the inner perichondrium and the cartilage (Fig. 12a.8). The huge defect also involves supraglottic structures. The arytenoid may be twisted. Glottic closure is impossible. These patients with huge defects can be aphonic and develop supraglottic phonation.

Therefore, a vocal pouch with its maximum at the glottic level has to be created. In these cases, it may be difficult to create a sufficient pouch without perforation at the subglottic level. Septal cartilage is placed in several layers in the pouch. Finally, the pouch is closed with 5–0 or 6–0 Vicryl sutures (Fig. 12a.9). Reconstruction of the anterior commissure and the volume in the posterior third of the glottis can be a problem. Sittel et al. [21] described a similar procedure transcervically that can be performed under local anesthesia. The cartilage is placed in a pocket that has been developed from the upper rim of the thyroid cartilage. The result is monitored endoscopically, and the patient can be asked to phonate. Finally, the cartilage is fixed in the pocket with sutures to the thyroid or with fibrin glue.

Benninger et al. [1] recommended medialization for glottic gaps of at least 1.5 mm. This procedure may be combined with lipoinjection in an attempt to reestablish the mucosal wave. In most cases of these huge defects, the created counterpart is stiff and immobile.

Laryngeal framework surgery is indicated only if it follows optimally managed voice therapy. The surgery

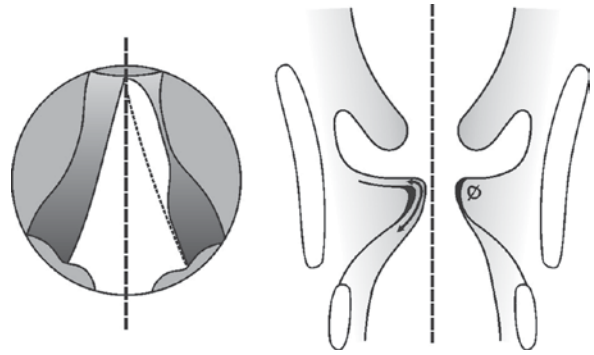


Fig. 12a.6. Type II glottic scar. Mild to moderate loss of volume involving the vocalis muscle with rigid scar formation

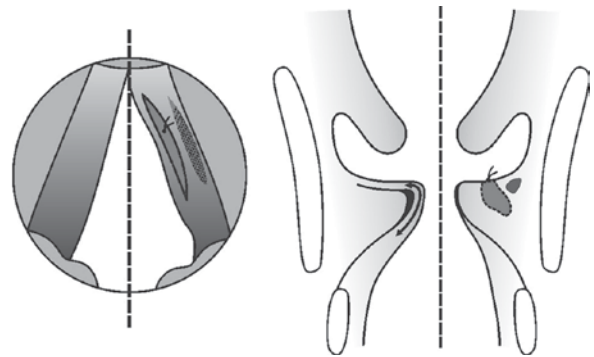


Fig. 12a.7. Type II glottic scar. A pouch is created, and the scar is dissected. In the second step, the vocal fold is augmented with septal cartilage or fatty/connective tissue

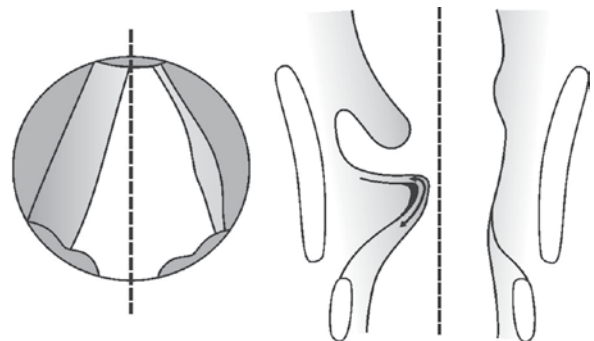


Fig. 12a.8. Type III glottic scar. Scar formation is adherent to the inner perichondrium and the cartilage

is advocated only when the posttherapy voice outcome does not meet the patient's requirements. Even when not entirely satisfied with their voice, patients often decline this complementary functional surgery.

After cordectomy, a minimum 6-month period is enforced before proceeding with framework surgery.

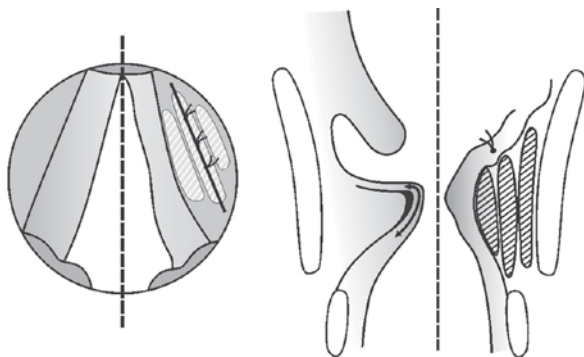


Fig. 12a.9. Type III glottic scar. A vocal pouch with maximum at the glottic level must be created. Septal cartilage is placed in several layers in the pouch

This surgery-free interval is respected to allow the scarring process to take place, to verify the absence of early recurrence, and to evaluate the voice rehabilitation achieved by voice therapy alone.

Laryngeal framework medialization is performed under general anesthesia. The patient is intubated with a no. 6 tube (8.2 mm outer diameter), the standard tube in microsurgery. The operation is performed under transnasal fiberoptic control. The landmarks used for establishing the thyroid cartilage window are standard.

The window is left intact to minimize the risk of tearing the fibrous tissue of the vocal cord bed during the dissection and positioning of the implant. The dissection, between the inner wall of the thyroid cartilage and the fibrous tissue that edges the window, requires meticulous care and must continue in close contact with the cartilage when the inner perichondrium is not identified. This undermining must cover a large enough area to ensure that the implant is put in place without fibrous tissue resistance and consequent tearing. This dissection is lengthier and more laborious than the dissection required for paralysis of the vocal cord.

The findings suggest that self-assessment scales are more significant for the indication of framework surgery than perceptual evaluation scales or acoustic and aerodynamic measures. The improvements produced by the latter seem limited, and the perceptual evaluation scales fail to cover a long enough listening period. In contrast, self-assessment allows the patients to examine their entire dynamic speech range. The patients in our experience notice improved resistance to vocal fatigue and report that phonation requires less effort.

Augmentation by collagen injection can be complementary.

12a.4 Scars Type IV (After Bilateral Resection Including the Anterior Commissure)

Lesions

- Glottic insufficiency
- Anterior web formation
- Round anterior commissure
- Bilaterally reduced vibration

Therapy

- Resection of anterior web formation or lesions
- Anterior mucosal flaps, stents

12a.4.1 Alternating Mucosal Flaps, Type IVa

A mucosal flap is at the surface of one vocal fold and is pedicled at the edge of the contralateral vocal fold (Fig. 12a.10a).

If necessary a second flap can be prepared (Fig. 12a.10b). Upside-down transposition of the flaps is achieved, and fixation is completed by suturing with 6.0 Vicryl (Fig. 12a.10c).

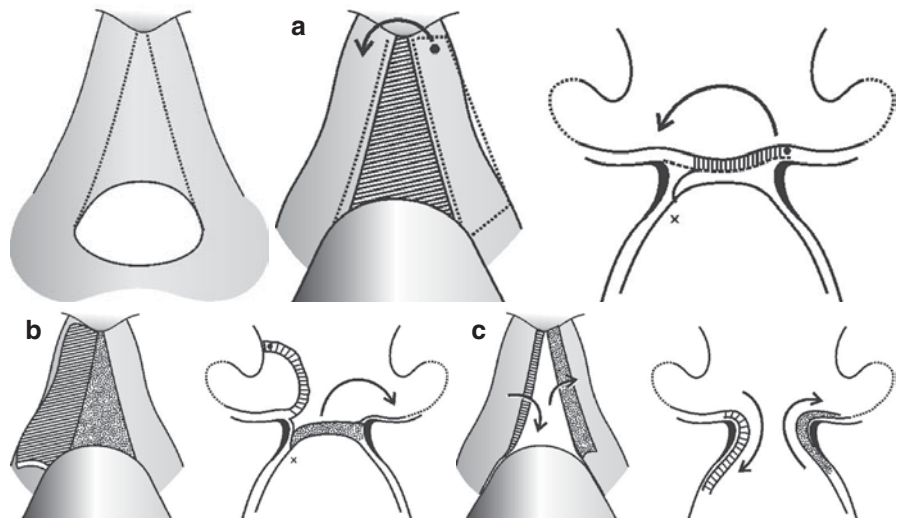
12a.4.2 Anterior Glottic Web Formation Type IVb

Endolaryngeal stent (according to Lichtenberger)

12a.5 Tips and Pearls

- Hyaluronic acid can be injected to improve the pliability of the vocal fold.
- Laryngeal framework medialization is performed under general anesthesia because the dissection, between the inner wall of the thyroid cartilage and the fibrous tissue that edges the window, requires meticulous care.
- The findings suggest that self-assessment scales are more significant for the indication of framework surgery than perceptual evaluation scales or acoustic and aerodynamic measures.

Fig. 12a.10. Anterior synechia, alternating mucosal flaps. (a) Mucosal flap at the surface of one vocal fold, pedicled at the edge of the contralateral vocal fold. (b) Preparation of a second flap. (c) Upside-down transposition of the flaps and fixation by suturing



References

1. Benninger MS, Alessi D, Archer S, Bastian R, Ford C, Koufman J, et al (1996) Vocal fold scarring: current concepts and management. *Otolaryngol Head Neck Surg* 115(5): 474–482
2. Berry DA, Reiningger H, Alipour F, Bless DM, Ford CN (2005) Influence of vocal fold scarring on phonation: predictions from a finite element model. *Ann Otol Rhinol Laryngol* 114(11):847–852
3. Dailey SH, Ford CN (2006) Surgical management of sulcus vocalis and vocal fold scarring. *Otolaryngol Clin North Am* 39(1):23–42
4. Eller R, Heman-Ackah Y, Hawkshaw M, Sataloff RT (2007) Vocal fold scar/sulcus vocalis. *Ear Nose Throat J* 86(6):320
5. Friedrich G (1998) External vocal fold medialization:surgical experiences and modifications. *Laryngorhinotologie* 77(1): 7–17
6. Hansen JK, Thibeault SL (2006) Current understanding and review of the literature:vocal fold scarring. *J Voice* 20(1):110–120
7. Hirano S (2005) Current treatment of vocal fold scarring. *Curr Opin Otolaryngol Head Neck Surg* 13(3):143–147.
8. Hirano S, Bless DM, Nagai H, Rousseau B, Welham NV, Montequin DW, et al (2004) Growth factor therapy for vocal fold scarring in a canine model. *Ann Otol Rhinol Laryngol* 113(10):777–785
9. Isshiki N, Shoji K, Kojima H, Hirano S (1996) Vocal fold atrophy and its surgical treatment. *Ann Otol Rhinol Laryngol* 105(3):182–188
10. Jia X, Yeo Y, Clifton RJ, Jiao T, Kohane DS, Kobler JB et al (2006) Hyaluronic acid-based microgels and microgel networks for vocal fold regeneration. *Biomacromolecules* 7(12): 3336–3344
11. Kitahara S, Masuda Y, Kitagawa Y (2005) Vocal fold injury following endotracheal intubation. *J Laryngol Otol* 119(10): 825–827
12. Krishna P, Rosen CA, Branski RC, Wells A, Hebda PA (2006) Primed fibroblasts and exogenous decorin: potential treatments for subacute vocal fold scar. *Otolaryngol Head Neck Surg* 135(6):937–945
13. Lee BJ, Wang SG, Lee JC, Jung JS, Bae YC, Jeong HJ, et al (2006) The prevention of vocal fold scarring using autologous adipose tissue-derived stromal cells. *Cell Tissue Organ* 184(3–4):198–204
14. Lim X, Tateya I, Tateya T, Munoz-Del-Rio A, Bless DM (2006) Immediate inflammatory response and scar formation in wounded vocal folds. *Ann Otol Rhinol Laryngol* 115(12):921–929
15. Neuenschwander MC, Sataloff RT, Abaza MM, Hawkshaw MJ, Reiter D, Spiegel JR (2001) Management of vocal fold scar with autologous fat implantation:perceptual results. *J Voice* 15(2):295–304
16. Ramacle M, Lawson G, Hedayat A, Trussart T, Jamart J (2001) Medialization framework surgery for voice improvement after endoscopic cordectomy. *Eur Arch Otorhinolaryngol* 258(6):267–271
17. Remacle M, Lawson G (2007) Results with collagen injection into the vocal folds for medialization. *Curr Opin Otolaryngol Head Neck Surg* 15(3):148–152
18. Remacle M, Lawson G, Kechian J, Jamart J (1999) Use of injectable autologous collagen for correcting glottic gaps:initial results. *J Voice* 13(2):280–288
19. Rosen CA (2000) Vocal fold scar:evaluation and treatment. *Otolaryngol Clin North Am* 33(5):1081–1086
20. Rousseau B, Hirano S, Chan RW, Welham NV, Thibeault SL, Ford CN, et al (2004) Characterization of chronic vocal fold scarring in a rabbit model. *J Voice* 18(1):116–124
21. Sittel C, Friedrich G, Zorowka P, Eckel HE (2002) Surgical voice rehabilitation after laser surgery for glottic carcinoma. *Ann Otol Rhinol Laryngol* 111(6):493–499
22. Thibeault SL, Gray SD, Bless DM, Chan RW, Ford CN (2002) Histologic and rheologic characterization of vocal fold scarring. *J Voice* 16(1):96–104