Chapter 39 – Vocal Fold Injection via Microlaryngoscopy

Andrew S. Florea,
Clark A. Rosen

Vocal fold injection is a tool of paramount importance in the otolaryngologist's armamentarium for treating a variety of voice disorders. The ability to adequately approximate the vocal folds is critical for glottal competence, which is necessary for the proper production of voice and for swallowing. As such, multiple components within the larynx are required for phonation. The presence of an intact vibratory vocal fold cover over functional muscle of adequate bulk that is properly attached to a mobile and correctly positioned cricoarytenoid joint is necessary for accomplishing this task.[1]

Multiple factors can cause loss of tissue and volume of the vocal folds or impairment of adequate vocal fold neuromuscular function and ultimately result in glottal incompetence. Glottal incompetence or insufficiency produces a variety of symptoms, including dysphonia (soft, breathy), decreased volume, vocal fatigue, dysphagia, associated aspiration, and odynophonia. Restoration of glottal competence is essential not only for improving voice-related quality of life but also for preventing the development of potentially life-threatening dysphagia in patients with vocal fold paralysis after thoracic or esophageal surgery or stroke because such patients commonly have multiple comorbid conditions.[2]

The primary advantage of vocal fold injection over open laryngeal framework surgery (i.e., thyroplasty) is the minimally invasive nature of this approach. In addition, vocal fold injection provides more direct visualization of the vocal folds, which not only assists in precise volume expansion but also allows direct visualization of the vocal folds (microlaryngoscopy) for identification of separate vocal fold pathologic processes such as vocal fold scar or sulcus vocalis.[3]

PREOPERATIVE PLANNING

Before the actual surgical procedure, it is important to take several important steps. First, patients who have undergone voice therapy should be reevaluated in an outpatient clinic setting. It is important at this post–voice therapy visit to review the patient's history and inquire about any changes in symptoms that may have occurred as a result of voice therapy. At this visit a physical examination, including videolaryngoscopy or videostroboscopy, should also be repeated and compared with the initial examination. If the patient has not improved after voice therapy and is in need of further treatment or if the clinical decision was made to proceed to surgical treatment without presurgical voice therapy, it becomes important to obtain proper consent. The consent process includes a discussion of the risks, benefits, and alternatives of surgery, as well as material selection choices and selection rationale. At this point, preoperative laboratory testing and anesthesiology consultation should also be obtained for patients on a case-by-case basis. On the day of surgery, the patient should be properly identified in the operating room before induction of general anesthesia, and the previous examination findings should be reviewed to ensure that the correct vocal fold is being injected and the patient is appropriately marked.

Vocal Fold Injection Locations

Vocal fold injection can be divided into two separate categories based on the location of the injection within the vocal fold: superficial and deep, each having unique indications and techniques.

Superficial vocal fold injection is used in cases of vocal fold scar or localized loss of lamina propria. Superficial injection under high-power magnification with a 27- or 30-gauge needle is performed in an attempt to restore the size and function of the superficial portion of the lamina propria. Optimal materials presently do not exist for this procedure, and therefore it is not commonly performed. In the past, a variety of collagen-based products were used, with only moderate success.[4] Superficial injection is not aimed at correcting problems of glottal incompetence as commonly seen in patients with vocal fold paralysis, vocal fold atrophy, or vocal fold paresis.

Deep vocal fold injection, however, is indicated for correction of glottal incompetence. This chapter focuses on this important method of correcting glottal incompetence, and subsequent references to vocal fold injection will mean deep vocal fold injection.

PATIENT SELECTION

Obtaining a detailed history plus performing a thorough physical examination is essential in identifying the cause

and associated symptoms of glottal incompetence. The patient will commonly have complaints that may include dysphonia, vocal fatigue, decreased volume, decreased projection, dysphagia, and odynophonia. On physical examination, including videostroboscopy, decreased adduction with an increased open phase is seen in patients with glottal incompetence. In patients with vocal fold immobility in which no immediate cause is found or suspected from the history or physical examination, additional radiologic evaluation is required to rule out other disease processes (central nervous system, tumors of the neck, and either benign or malignant lung cancer) that could be causing paralysis of the vagus or recurrent laryngeal nerve (or both).

In patients with suspected vocal fold paralysis, laryngeal electromyography can also be used to determine the prognosis for spontaneous recovery; moreover, it assists the physician in deciding between a temporary or permanent implant for treatment.[5] In patients with vocal fold immobility or hypomobility who have laryngeal electromyographic findings suggesting a good prognosis for recovery, consideration should be given to injection with a temporary implant. However, in patients with dysphagia or a history of aspiration, immediate injection with a temporary implant is indicated. If there is no evidence of reinnervation on laryngeal electromyography or no vocal fold motion at 6 months after onset, a permanent implant should be considered if the patient remains symptomatic.

The indication for vocal fold injection is symptomatic glottal insufficiency as a result of vocal fold paralysis or vocal fold paresis. In most cases, it is warranted for patients to undergo a short course of speech therapy before deciding whether surgery is indicated for the patient's glottal insufficiency. If the patient has a large glottal gap associated with phonation (larger than approximately 3 mm) or severe lack of bulk or loss of tonicity of the vocal fold, it is extremely unlikely that voice therapy alone will be adequate to treat the patient's symptoms. For this reason, these patients can be considered for immediate surgical treatment with vocal fold injection.

Great care should be taken during the laryngeal endoscopy procedure to confirm that the contralateral vocal fold in patients with vocal fold paralysis has normal abductory range of motion. For patients with poor contralateral vocal fold abduction, vocal fold injection should be performed with great caution or not at all, given that patients with vocal fold injection are going to be at increased risk for airway embarrassment postoperatively. It is also important to note that a patient with a large glottal gap during phonation as a result of glottal insufficiency probably will not be successfully treated with a single vocal fold injection procedure because of limitations on the amount of augmentation material that can be properly placed in the vocal folds to close a very large glottal gap. For this reason, some patients may require repeat vocal fold injection or may be more suited for treatment with a laryngeal framework procedure such as thyroplasty or arytenoid adduction, or both (see Chapter 41).

Other causes of glottal insufficiency include vocal fold atrophy, vocal fold scar, and sulcus vocalis. Patients with these conditions who have inadequate improvement after voice therapy can also be aided by deep vocal fold injection.[2]

Material Selection

In 1911, Brunings injected paraffin via indirect laryngoscopy to medialize an immobile vocal fold; the patient's voice improved, but unfortunately, a paraffinoma subsequently developed. Since that time, ongoing research continues in an attempt to find the ideal injection material for vocal fold medialization. The ideal material should be long lasting, biocompatible, inexpensive, easy to use, and readily available, as well as have matching biomechanical properties of the deep aspect of the vocal fold. The alloplastic materials used extensively in the past, such as paraffin, silicone, and polytetrafluoroethylene (Teflon), are notorious for causing granulomas (Fig. 39-1) and foreign body reactions, and therefore a less reactive alternative implant material was sought.[6] The substances currently available for vocal fold injection can be divided into two categories: autologous and bioimplantable (Table 39-1). All these materials are designed solely for deep vocal fold injection (except the collagen-based products). Bovine collagen products (Zyplast, Zyderm) require preinjection skin testing because a localized inflammatory response can occur in 3.5% of the general population, with a delayed hypersensitivity reaction developing in an additional 1.3%.[7]

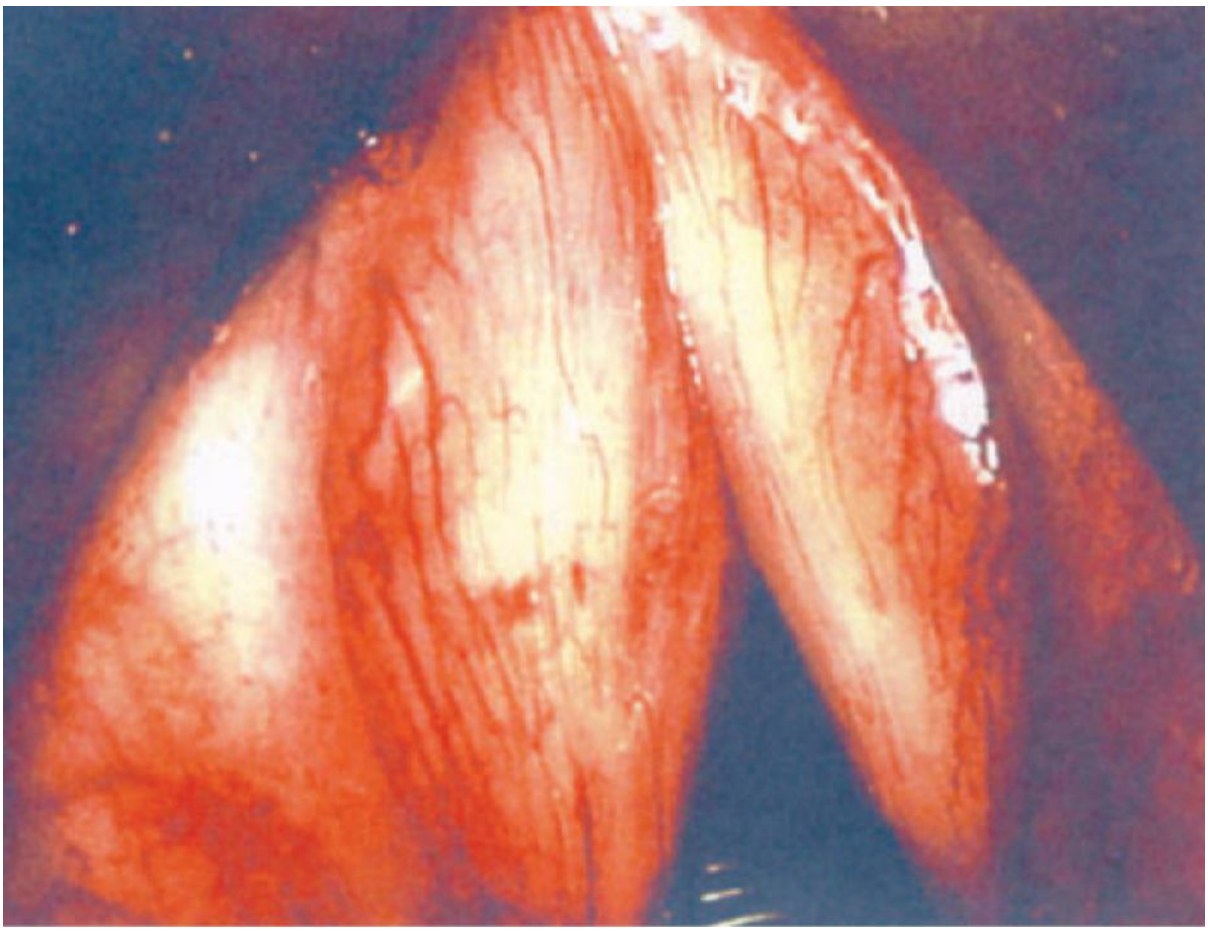

Figure 39-1 Left vocal fold Teflon granuloma.

Table 39-1 -- MATERIALS CURRENTLY USED FOR VOCAL FOLD INJECTION

Autologous	Bioimplantable
Fat	Calcium hydroxylapatite (CaHA) (Radiesse)
Fascia	Bovine collagen (Zyderm and Zyplast) Hyaluronic acid (Hyalaform, Restylane, Perlane) Cadaveric collagen (Cymetra, Cosmoderm, Cosmoplast) Miscellaneous (Radiesse Voice Gel, Gelfoam, Surgifoam, Teflon)

Radiesse (calcium hydroxyapatite [CaHA]) is a water and glycerin gel carrier containing suspended spherules of CaHA. The gel carrier is eventually reabsorbed, and the CaHA remains at the injection site.[8,9] The CaHA in most instances remains present for a long time. Radiesse Voice Gel, which is the isolated gel carrier, appears to last approximately 2 to 3 months and thus is a good temporary vocal fold injection material.[10]

Gelfoam/Surgifoam is a saline-diluted gelatin powder that is injected as a paste. This injection material has been used for approximately 20 years with consistent success.[11] The duration of augmentation, however, is approximately 4 to 6 weeks, and the material may have a negative impact on vocal fold vibration and requires a large-bore needle (18 or 19 gauge) for injection.

Hyaluronic acid (HA) is a ubiquitous substance present in almost all tissues in the human body, including the vocal folds, joints, and cornea. It is a high-molecular-weight glycosaminoglycan and possesses viscoelastic properties that ultimately regulate soft tissue hydration properties.[12] Multiple different formulations of HA (Perlane, Restylane, Hylaform) are available for “off-label” use as a deep vocal fold injection material, and it is theorized that the different particle size in each formulation determines the duration of successful augmentation (i.e., Perlane is believed to last longer because of its relatively larger particle size). Animal studies have indicated that the implant may last up to 1 year in the injected tissue.[13] In humans, however, studies appear to indicate that approximately 25% of patients injected with HA for glottal insufficiency will require reinjection within 24 months.[14]

Vocal fold lipoinjection is also used to treat glottal incompetence associated with small to medium-sized glottal

gaps up to 4 mm. Although used for approximately the last 10 to 15 years, success with lipoinjection is somewhat variable, because unpredictable reabsorption of the implanted fat occurs within the first 4 to 6 weeks after injection.[15] Consequently, approximately 30% overinjection of the vocal fold is needed to compensate for expected implant loss in the immediate postoperative period. The overinjection will result in dysphonia for approximately the first 3 weeks postoperatively. After the 6-week resorption process is completed, the level of resultant augmentation remains permanent. As such, vocal fold lipoinjection remains an ideal option for patients with intact contralateral neuromuscular vocal fold function (normal abduction) who desire to avoid open neck surgery and have concerns about the use of a foreign substance as implant material.[16–18]

SURGICAL TECHNIQUE

Deep Vocal Fold Injection via Microlaryngoscopy

Microsuspension laryngoscopy offers excellent visualization and access for vocal fold injection. The main disadvantage of this procedure is an inability to adequately assess vocal fold augmentation because the patient is under general anesthesia.

1. After induction of general anesthesia has been achieved and the preoperative videolaryngoscopy or videostroboscopy has been reviewed, visualization of the larynx is achieved with a large-caliber laryngoscope suspended in place with a gallows or fulcrum suspension device.
2. Zero-, 30-, and 70-degree telescopes are used to achieve optimal visualization of the larynx and allow in-depth analysis of the precise pathology and defect requiring correction. The ideal point for deep injection is at the intersection of two anatomic landmarks: (1) a line drawn horizontally across the vocal fold at the level of the vocal process and (2) the superior arcuate line (junction of the superior surface of the vocal fold and laryngeal ventricle) (Fig. 39-2). The augmentation material is injected slowly, approximately 5 mm deep to the mucosa.
3. Initially, augmentation should be visible at the level of the infraglottis, which then subsequently spreads superiorly to the level of the glottis.
4. If necessary, a second injection site may be used at the midmembranous vocal fold along the superior arcuate line.
5. If the patient is in poor medical condition and is at an increased risk for perioperative morbidity or mortality with general anesthesia, topical anesthesia and intravenous sedation can be used and endoscopic vocal fold injection can be performed. This approach involves the use of a small slotted laryngoscope and a telescope.[3]
6. Visualization of the injection allows proper determination of the required amount and location of the deep injection (Fig. 39-3).
7. Lidocaine is applied to the larynx to prevent postoperative laryngospasm.

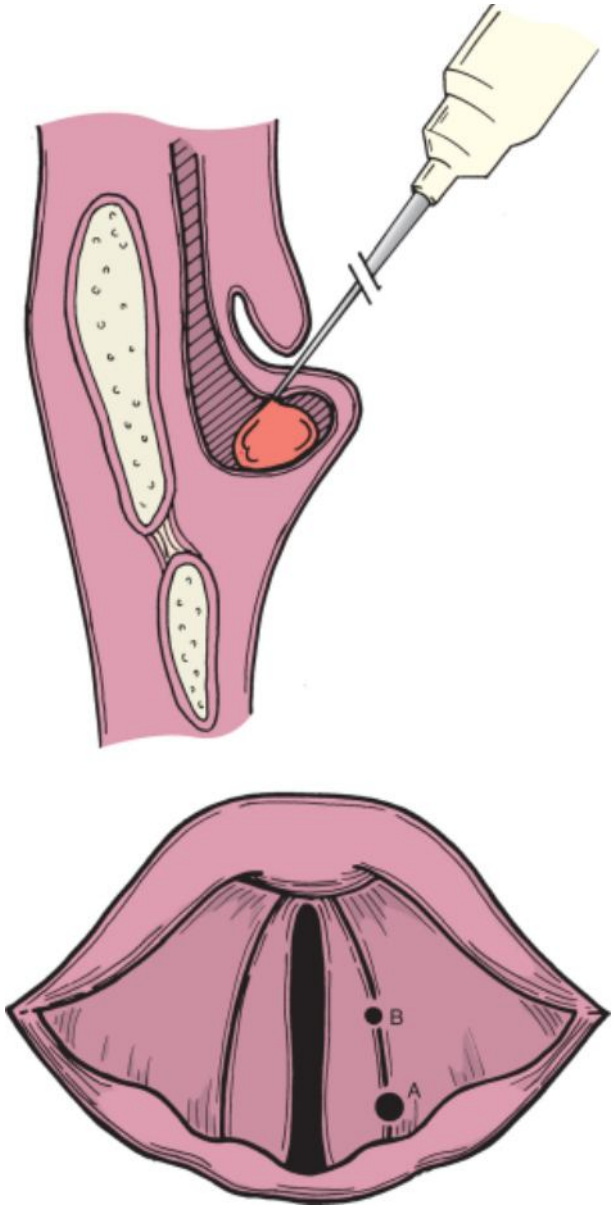

Figure 39-2 Diagram of the ideal location of deep vocal fold injection. Point B represents the second injection site if inadequate medialization is achieved with the first injection (point A).

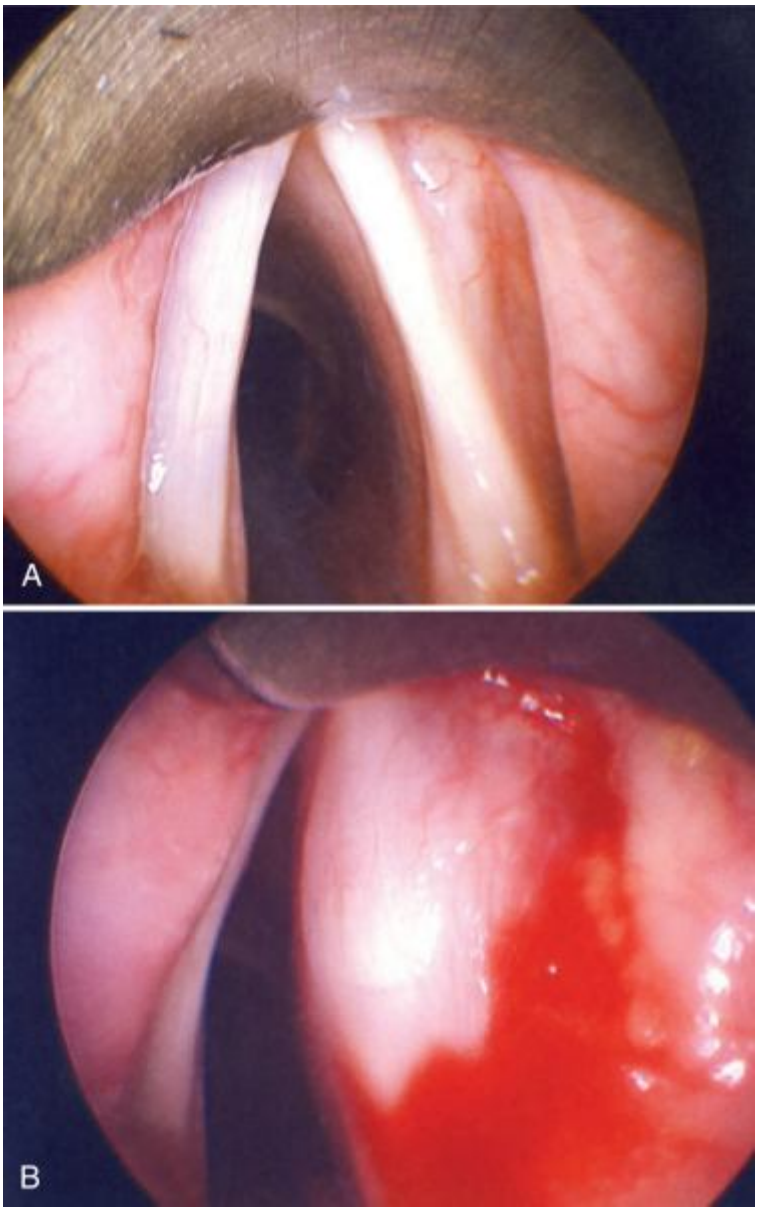

Figure 39-3 Preoperative (**A**) and postoperative (**B**) photographs of a patient with right vocal fold paresis who underwent deep vocal fold injection with Cymetra.

For lipoinjection of the vocal fold, fat must be obtained before vocal fold injection. In patients with adequate subcutaneous fat, a low-pressure liposuction device is ideal because it allows rapid, minimally invasive harvest of well-preserved fat globules. During liposuction, care must be taken to control the depth of the cannula and prevent inadvertent penetration of the underlying peritoneum or overlying skin. Patients who have minimal subcutaneous abdominal fat usually require an open harvest technique, generally in the infraumbilical area or through a preexisting abdominal scar. Regardless of the method used for harvest, the fat must be prepared before lipoinjection to prevent the inflammatory response associated with attached blood and free fatty acids, which reduce graft survival.[16]

Fat Preparation Process before Lipoinjection

1. Fat is placed in a funnel lined with strips of Merocel, and suction tubing is applied to the funnel while at least 2 L of saline are used to remove the free fatty acids and attached blood from the harvested fat material.
2. The rinsed fat is then soaked with 100 units of regular insulin for 5 minutes, thereby theoretically improving fat cell survival.
3. Afterward, the fat is transferred to a dry Merocel-impregnated sponge and allowed to air-dry for a short period (3 to 5 minutes) before loading into the injection device.
4. The same technique as described earlier for deep injection via microsuspension laryngoscopy applies for lipoinjection. Thirty percent overcorrection of the vocal fold is required to compensate for the expected fat loss that occurs during the 6 weeks after transplantation. Because overcorrection is necessary, patients

with poor abduction of the contralateral vocal fold should be injected only unilaterally, and careful attention should be directed to avoiding airway compromise (Fig. 39-4).

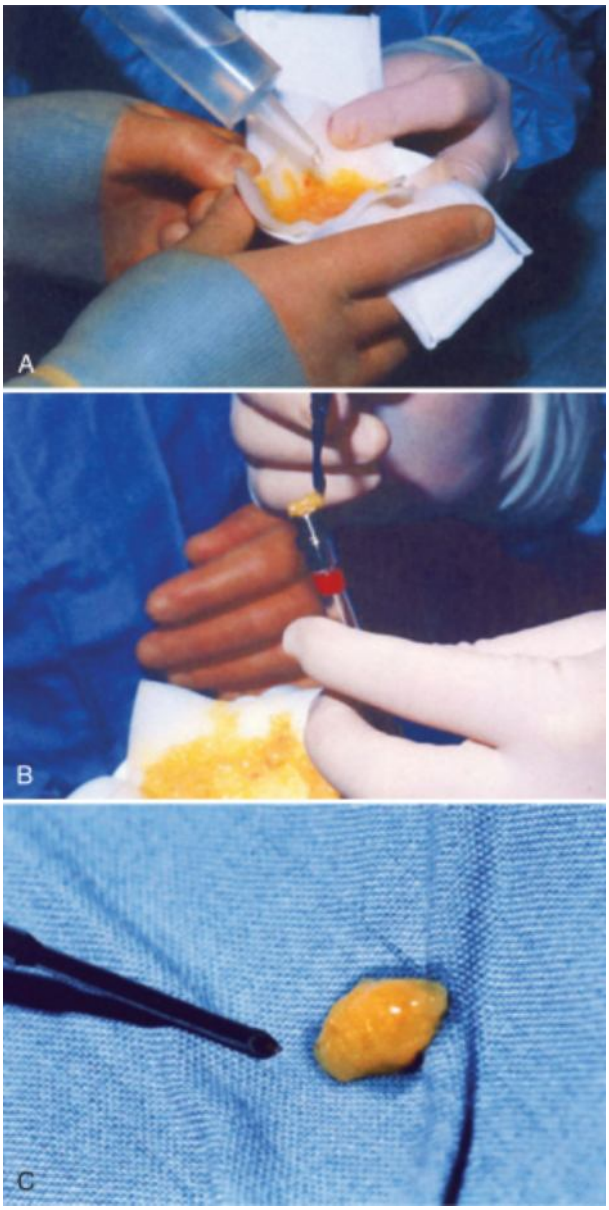

Figure 39-4 Different stages of fat harvest and preparation for lipoinjection. **A,** Rinsing fatty acids and enzymes from harvested fat. **B,** Loading fat into a syringe. **C,** Fat globule after injection. Note the relatively large-bore needle.

POSTOPERATIVE MANAGEMENT

After lipoinjection of the vocal folds, 6 days of absolute voice rest is recommended to avoid implant migration and extrusion. Additionally, patients who undergo lipoinjection should receive a short course of oral corticosteroids. The steroids reduce postoperative swelling, thereby decreasing the possibility of airway compromise.

Only 24 to 48 hours of voice rest is recommended after deep vocal fold injection with the different implants described earlier. For alloplastic and biocompatible implants, a single dose of intravenous antibiotics is administered intraoperatively.[3]

COMPLICATIONS

Airway compromise is the most serious complication of deep vocal fold injection. In patients with a contralateral hypomobile vocal fold, lipoinjection should be used with caution because a higher potential for airway compromise exists as a result of the need for overinjection. Should airway compromise occur, close observation, humidified oxygen, intravenous steroids, and intravenous antibiotics can be used for treatment. If unimproved after these conservative measures, short-term intubation or even tracheostomy should be considered to allow time for postoperative edema to decrease and return of a patent airway. Removing the implant material should also be

considered.

In cases of overinjection without airway compromise, the patient should be observed for up to 6 months to allow complete healing, resolution of edema, and reabsorption of the implant (for temporary materials) before considering removal of the implant. If a decision to remove the implant is made, the material can be removed via a lateral cordotomy under suspension microlaryngoscopy.

In cases of underinjection, in which the patient remains symptomatic but does not have dysphagia or aspiration, further injection augmentation can generally be done as early as 6 weeks postoperatively.

PEARLS

- Vocal fold injection is an excellent tool for the treatment of glottal insufficiency secondary to vocal fold paralysis, paresis, or atrophy.
- Vocal fold injection augmentation is performed relatively quickly without the need for an open surgical procedure.
- For implant placement it is critical that the injection be placed in a deep plane and not superficial within the vocal fold.
- Careful material selection specific to the patient's deficit and clinical situation is essential for successful augmentation.
- Temporary injection of the vocal fold can be used as a “trial” to determine whether vocal fold augmentation is an appropriate treatment method for the patient.

PITFALLS

- It is important to avoid injection anterior to the midmembranous portion of the true vocal fold because a strained vocal quality will probably result.
- Great care must be taken with deep vocal fold injection in patients with poor abduction of the contralateral vocal fold because respiratory compromise may ensue.
- To avoid inflammation or rapid reabsorption when performing lipoinjection, great care must be taken when processing and handling the fat implant material.
- Planned overinjection should be performed only when using substances that are known to have an element of reabsorption.
- Preoperative review of the patient's videolaryngoscopy and stroboscopy is important in confirming the patient's deficit and avoiding wrong-site surgery.