Endoscopic Approach

13b

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Core Messages

- Transoral laser surgery is suited for the curative treatment of most T1–T2 carcinomas of the glottic and supraglottic larynx.
- The main advantage of this minimal access approach is reduced perioperative morbidity and hospital stay. Tracheotomy is usually not required, but postoperative monitoring in an intensive or intermediate care unit may be needed following more extensive procedures.
- Shielding the endotracheal tube is essential to avoid serious airway complications (ignition of oxygen)
- Postoperative aspiration (following surgery for supraglottic tumors or following arytenoid cartilage resection), secondary bleeding, dental injuries, and mucosal tears are the most common complications and sequelae.
- Exhaustive technical equipment, including contemporary CO_2 laser systems and focusing devices, operating laryngoscopes, multiple suction devices, and specially designed instruments are required for successful endoscopic tumor surgery.
- Comprehensive training in head and neck surgery and specialized instruction in the use of medical lasers is mandatory for laryngologists performing these procedures.

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Two novel approaches to the treatment of laryngeal and hypopharyngeal carcinoma have contributed to the spectrum of therapeutic options during the past two decades: transoral laser surgery, mostly used for early-stage carcinoma and sequential or concomitant chemotherapy and radiotherapy for organ preservation in advanced stages.

Although transoral approaches to head and neck carcinoma are certainly not new, they have long been given up for open surgical approaches that seemed more promising with regard to surgical radicality and oncological outcome. Transoral approaches were thought to be inadequate for oncological interventions because of what was believed to be limited visualization of the surgical field, bleeding, difficult manipulation, and inability to reconstruct soft tissue defects.

With technical advances in endoscopic surgery during the 1960s achieved by Kleinsasser [1] and his microlaryngoscopic technique of endolaryngeal microsurgery and the implementation of medical laser systems by Strong and Jako in the 1970s [2], things gradually changed beginning in the early 1980s. Clinical pioneers such as Grossenbacher, Motta, Rudert and Steiner in Europe and Vaughn, Davis, and Shapshay in North America were able to demonstrate that highly selected malignant lesions of the upper aerodigestive tract could now be operated on endoscopically with promising oncological and functional results.

These authors were able to show that transoral laser surgery provides advantages relating to its hemostatic effects and precision of tissue ablation. They reported that laser surgery causes minimal morbidity, offers good functional results, and provides a cost-effective alternative to open surgical procedures and to radiotherapy.

Therefore, transoral laser surgery is now a widely used surgical approach to small glottic and supraglottic carcinomas [3–6]. Moreover, successful treatment of

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stage II to IV lesions of the vocal folds, supraglottic larynx, oropharynx, and hypopharynx have repeatedly been reported in the literature [5–8]. The data presented in these studies indicated that transoral laser surgery leads to oncological results that are comparable to those attained with more conventional treatment modalities in selected groups of patients, and the surgical trauma- and treatment-related co-morbidites are reduced.

13b.1 Preoperative Diagnostic Procedures

The endoscopic management of laryngeal and hypopharyngeal tumors requires a meticulous preoperative evaluation of the patient (in terms of adequate exposure of the surgical field under microlaryngoscopy) and of the lesion itself. All available technical tools (including both endoscopy and imaging) should be employed to define the superficial and deep extension of the tumor precisely. Moreover, regional lymph nodes should be assessed before planning the most appropriate treatment with a simultaneous or delayed procedure on the neck.

Endoscopy represents the first-line diagnostic procedure to be considered as the gold standard for clinical tumor staging of the larynx and hypopharynx. Flexible and rigid fiberoptic endoscopes coupled to videolaryngoscopy allow us to obtain clear, magnified images of the superficial extension of the lesion, with the unique opportunity to assess laryngeal mobility and sensation. With glottic tumors, special consideration should be paid to evaluate uni- or bilateral vocal cord involvement, anterior commissure extension, and supra- or subglottic spread. With supraglottic and hypopharyngeal tumors, the precise evaluation of neoplastic extension to critical anatomical areas—e.g., the glottic plane, ventricle, aryepiglottic folds, piriform sinus, valleculae, base of the tongue—is of paramount importance to modulate the endoscopic surgical resection. In this light, the possibility of tailoring the resection intraoperatively based on microlaryngoscopic evaluation of the tumor allows the surgeon an additional degree of freedom not conceivable with the conservative open-neck approaches. In fact, resection of supraglottic tumors (e.g., involving the anterior commissure) are best performed by an endoscopic route. Currently, vocal cord and arytenoid mobility cannot be evaluated by objective measurements, and their function can only be expressed by generic terms ranging from impaired vocal cord mobility (due to a tumor mass or limited vocal muscle invasion) to fixation (for deep muscle infiltration or paraglottic space, cricoarytenoid joint, or recurrent nerve involvement).

Even though associated with a high degree of intra- and interjudge variability because of its subjectivity and the possibility of false-positive findings for adjacent inflammatory changes, preoperative videolaryngostroboscopy (VLS) by 70° or 90° rigid endoscopes allows macroscopic evaluation of glottic lesions and patterns of mucosal wave correlated with the degree of vocal ligament involvement. In fact, maintenance of the mucosal wave is an indirect sign of an intraepithelial lesion (up to carcinoma in situ), whereas a reduced or absent mucosal wave is suspicious for neoplasms transgressing the basal membrane into the lamina propria (ranging from microinvasive to frankly invasive carcinomas).

From a clinical point of view, rigid endoscopy under local anesthesia for supraglottic and hypopharyngeal tumors is not fully reliable owing to the difficulty of properly evaluating bulky tumors obscuring the anterior commissure and vocal cords, the ventricle, and the piriform sinus. In such a scenario, a flexible fiberscope is by far the most useful tool to evaluate vocal cord and/or arytenoid mobility as well as piriform sinus symmetrical expansion during phonation and swallowing.

Subsequently, a more detailed multiperspective endoscopic view of the larynx can be obtained by 0° and angled (30°, 70°, 120°) rigid telescopes during microlaryngoscopy. In this way, zones of the larynx and hypopharynx (anterior and posterior commissures, bottom and roof of the ventricle, subglottis, apex of the piriform sinus, and postcricoid area) traditionally considered “dark” can be adequately visualized (Fig. 13b.1). Adjunctive information can be obtained by combining the use of angled telescopes with special probes or microinstrumentation to evert and palpate the free edge of the true vocal cords, lift the false vocal folds to inspect the ventricle, and divaricate the arytenoids. Additionally, accurate palpation of the base of tongue and medial wall of the piriform sinus, arytenoid mobilization, displacement of the epiglottis to evaluate anterior commissure involvement, and exploration of the piriform sinus apex and postcricoid region can also be performed in the same setting of the intraoperative diagnostic workup. Moreover, adjunctive staging information can be derived from surgical maneuvers performed at the beginning of the endoscopic resection, such as infrapetiolar exploration to evaluate minimal

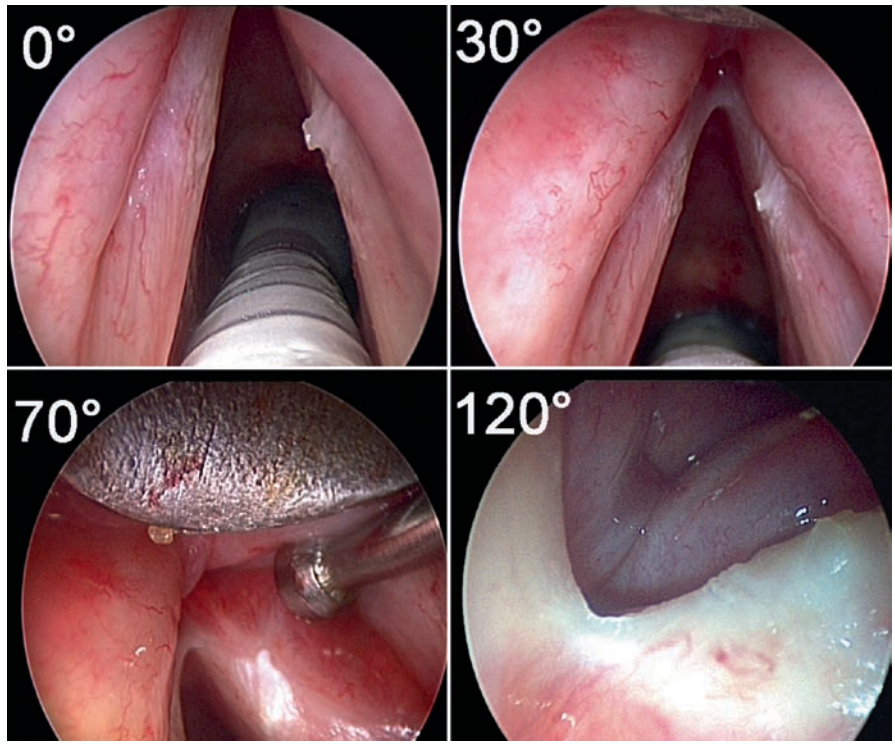

Fig. 13b.1. Intraoperative rigid endoscopy by 0° and angled (30°, 70°, 120°) telescopes of a leukoplastic lesion of the middle third of the right vocal cord clearly defines its superficial extension. Lifting the right false vocal fold by means of a curved suction tip coupled to a 70° rigid telescope allows exclusion of lateral extension to the floor and bottom of the ventricle

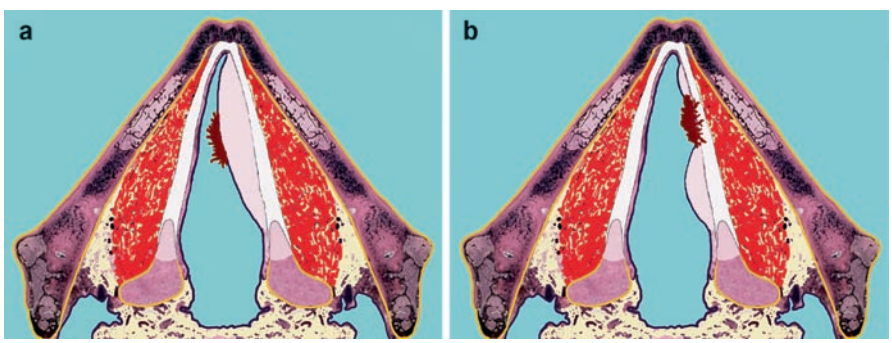

Fig. 13b.2. Two similar lesions of the middle third of the right vocal fold. (**a**) Complete mucoligamentous hydrodissection after intraoperative saline infusion (SI) into Reinke's space; the lesion is therefore limited to the overlying mucosal epithelium. (**b**) Incomplete ballooning of the epithelial layer due to initial involvement of the lamina propria

inner thyroid lamina involvement and transtumoral resection (e.g., at the level of the mid-suprahyoid epiglottis) to exclude preepiglottic space invasion [5].

In cases of glottic cancer limited to the true vocal cord, subepithelial saline infusion (SI) by means of an appropriately angled needle allows further confirmation of preoperative VLS findings regarding involvement of the lamina propria by the neoplastic growth. Complete hydrodissection of the mucoligamentous plane, with consequent ballooning and lifting of the lesion from the underlying intermediate layer of the lamina propria suggests purely intraepithelial confinement of the neoplastic nests. Moreover, the mechanical expansion of Reinke's space after SI facilitates subsequent removal of the lesion itself, serving as a heat sink to protect the vocal ligament from thermal damage in the case of a laser procedure. An incomplete or absent mucoligamentous hydrodissection after SI has the same implications as a reduced or absent mucosal wave as detected on the VLS, and it is associated with transgression of the basal membrane by neoplastic cells through the vocal ligament (Fig. 13b.2). Even SI in

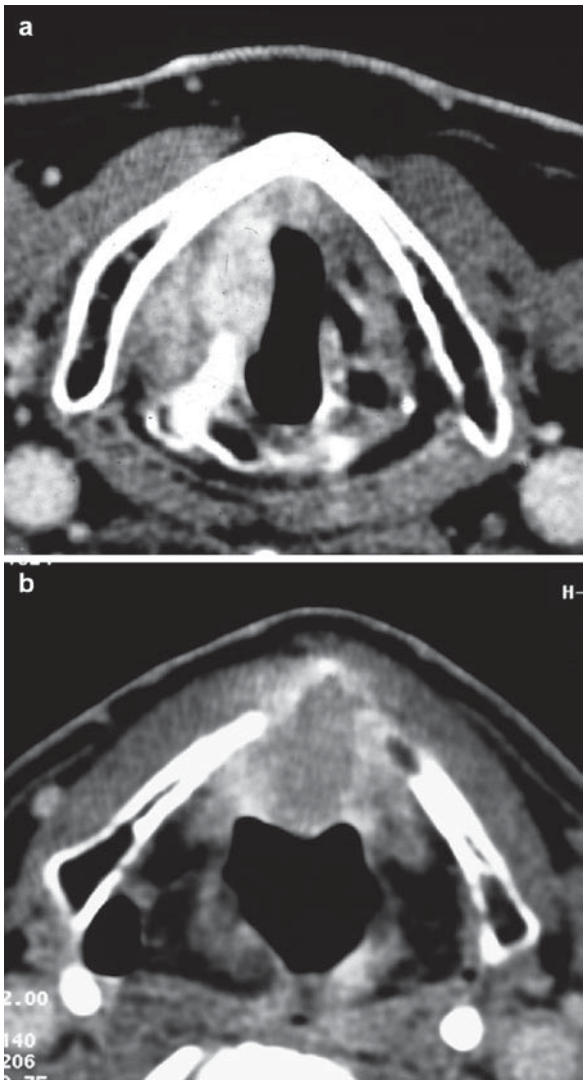

Fig. 13b.3. Preoperative axial computed tomography (CT) scans after contrast medium administration. (**a**) Right paraglottic space involvement of a tumor extending from the anterior commissure (with increased thickness) to the arytenoid cartilage (sclerosed and without the normal fat tissue posterolateral to its body). (**b**) Anterior transcommissural lesion involving the preepiglottic space and massively eroding the thyroid cartilage at the level of its notch, beyond the external perichondrium, with possible initial infiltration of the deep layer of the strap muscles

Reinke's space is associated with possible drawbacks, mainly concerning false-negative cases in the event of limited lamina propria involvement by a few nests of neoplastic cells. For this reason, the results of intraoperative SI should always be integrated with those of preoperative VLS. If the two tests give conflicting results, the cordectomy should be tailored according to the more pessimistic scenario (i.e., as if they were both positive for vocal ligament involvement). Applying such a simple diagnostic algorithm in the University of Brescia, Italy, the combination of VLS and SI obtained specificity, sensitivity, positive predictive values (PPV), negative predictive values (NPV), and accuracy of 89%, 100%, 88%, 100%, and 94%, respectively [9].

Integration of endoscopic findings with those from radiological imaging is nowadays an essential prerequisite for correct staging and treatment of any neoplastic lesion of the larynx and hypopharynx. As a matter of fact, relying on the endoscopic information alone can lead to clinical underdiagnosis in 40–55% of cases [10] with consequent inappropriate therapeutic planning and less effective locoregional oncological control. Recently, computed tomography (CT) (with particular emphasis on the multislice technique) and magnetic resonance imaging (MRI) are playing a definite role in imaging for preoperative assessment of laryngeal and hypopharyngeal cancer. CT scanning presents some unique advantages, making this diagnostic tool the gold standard in the modern radiological assessment of these tumors. Its reduced examination time with minimal patient compliance needed and wide availability make it a sound diagnostic tool. Only a few elements of uncertainty arise, such as in the presence of minimal thyroid cartilage erosion and paraglottic space involvement. In such selected cases, subsequent MRI scans can increase diagnostic accuracy, even though roughly 20% of them display movement artifacts, thereby reducing the imaging quality (Fig. 13b.3).

The radiological checklist for the endoscopic surgeon should therefore always include an assessment of invasion of the visceral spaces (with particular reference to submucosal supracommissural and/or subcommissural extension, posterolateral paraglottic space invasion, and preepiglottic space involvement), laryngeal framework infiltration, and tumor extension beyond laryngeal sites (e.g., base of the tongue, soft tissues and major vessels of the neck, prevertebral fascia) (Fig. 13b.4).

The N category plays a definitive role in terms of prognosis of these tumors, particularly when dealing with supraglottic and hypopharyngeal bulky lesions. Combining clinically evident and occult lymph nodes metastases from intermediate (T2–T3) supraglottic and hypopharyngeal tumors, more than 30% can be expected to present regional disease at the time of diagnosis. In this respect, the gold standard imaging technique is ultrasonography examination of the neck

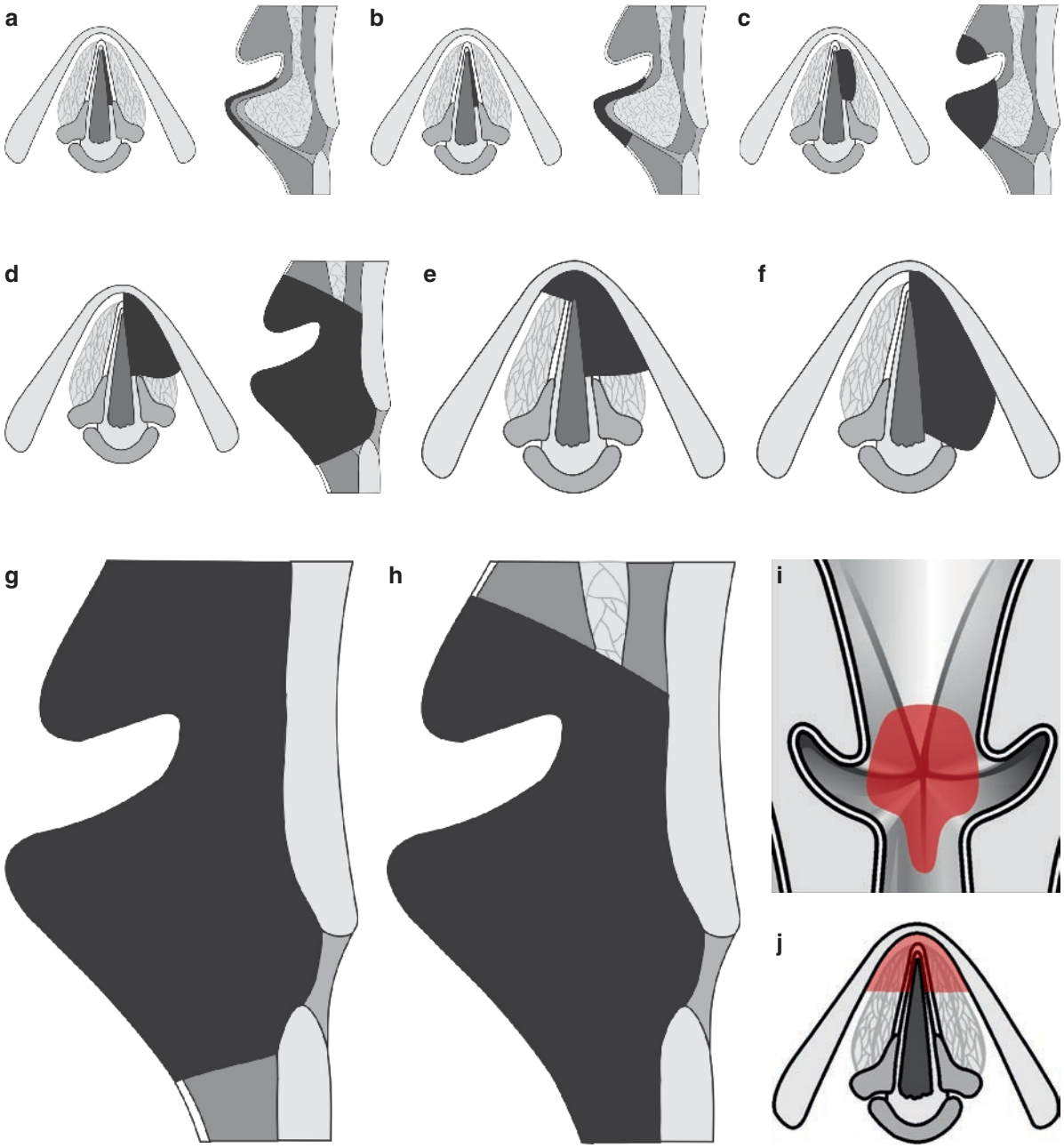

Fig. 13b.4. Endoscopic cordectomy. Proposal for a classification by the Working Committee, European Laryngological Society that is a synthesis of the year 2000 classification and the 2007 modification. (**a**) Subepithelial cordectomy (type I). (**b**) Subligamental cordectomy (type II). (**c**) Transmuscular cordectomy (type III). (**d**) Total or complete cordectomy (type IV). (**e**) Extended cordectomy encompassing the contralateral vocal fold (type Va). (**f**) Extended cordectomy encompassing the arytenoid (type Vb). (**g**) Extended cordectomy encompassing the ventricular fold (type Vc). (**h**) Extended cordectomy encompassing the subglottis (type Vd). (**i**, **j**) Cordectomy for cancers arising from the anterior commissure (type VI). (Reprinted with permission (From Remacle et al. [12, 13], with permission)

combined with fine-needle aspiration cytology of suspicious lymph nodes. Such a technique surpasses the diagnostic accuracy of CT and MRI, allowing detection of occult metastatic foci in nodes < 5 mm in greatest diameter. Precise preoperative assessment of the neck status can play a decisive role in choosing between an endoscopic procedure alone or an endoscopic procedure combined with simultaneous or delayed, unilateral or bilateral neck dissection.

13b.1.1 Surgical Technique

The CO_2 surgical laser is clearly the preferred laser system for oncological surgery of the larynx. It is coupled to an operating microscope and is generally set at an output power of 2–6 W in a super pulse or continuous mode at a spot size of approximately 0.8 mm^2. Patients are intubated transorally (using a laser-shielded tube) for surgery except for those who have a preexisting tracheotomy. Various laryngoscopes, including bivalved adjustable laryngoscopes, are used to expose the larynx. Repeated readjustment and repositioning of the laryngoscope is frequently required to achieve optimal exposition of the surgical field. Two suction devices should be available throughout the operation: One is mounted on the operating laryngoscope, and the other is handled by the surgeon throughout the intervention and is used to evacuate the plume and manipulate the tissue.

Specimens are resected in one piece whenever possible. In every case, the tumor must be resected with sufficient safety margins—which is equally important during laser surgery and open approaches—and R0 resection must be confirmed histologically. The development of modern laser systems permits laser application with lower power settings so that charring and necrosis of specimen margins could be reduced in comparison to older laser systems. Thus, the pathologists can accurately evaluate the resection margins.

Dissection of a tumor in two or more portions (a concept introduced by W. Steiner, Göttingen, Germany) allows the surgeon to scrutinize the cutting surfaces under the microscope and make a more confident assessment of the depth of tumor invasion. Up to now, no definitive arguments could be found against piecemeal laser resection even if a higher risk of increased metastasis seems possible based on an animal experimental study [11]. However, those examinations were performed in a highly aggressive tumor model on lymphogenic metastatic spread, so further studies are required. Although the question is not yet settled, cutting through malignant tumors during surgery does not comply with the generally accepted basic concepts of oncological surgery. If large tumors are to be resected transorally, the surgeon has to weigh the advantages of transecting the tumor for easier handling of the specimen against the potential dangers of manipulation-related tumor spread.

Specimens should be oriented anatomically after removal to facilitate histopathological examination of the margins. The value of frozen sections remains unclear to date, and not all experienced laser surgeons use them routinely.

Patients should receive 250 mg of methylprednisolone intravenously during the intervention and 80 mg orally during the first 2–5 days after surgery depending on the extent of the surgery. Extubation is usually performed some 30 minutes after the end of the intervention, and patients must be closely observed after extubation for airway control.

13b.1.2 Classification of Procedures for Glottic Carcinoma

In the year 2000, the European Laryngological Society (ELS) Working Committee on Nomenclature proposed a classification of endolaryngeal procedures for the treatment of glottic dysplasia and carcinoma. They did so with the aim of reaching better agreement and uniformity concerning the extent and depth of resection of cordectomy procedures (guidelines) by offering reproducibility to laryngologists to allow relevant comparisons with the literature when presenting/publishing the results of cordectomy [12]. The classification was meant to be a synthesis of the categorizations available in the literature and the classifications that had been previously and separately presented by some authors. The aim was not to define or restrict therapeutic indications. Rather, by means of this common classification, the authors hoped to permit comparison of postoperative results achieved by different centers and to improve instruction and training of younger surgeons.

The classification described eight types of cordectomy: subepithelial cordectomy (type I); subligamental cordectomy (type II); transmuscular cordectomy

(type III); total cordectomy (type IV); extended cordectomy including the contralateral vocal fold and the anterior commissure (type Va); one arytenoid cartilage (type Vb); subglottic structures (type Vc); or the ventricle and paraglottic space (type Vd). This classification was subsequently used by many surgeons to describe their endoscopic interventions. However, the classification did not propose any specific management for lesions originating in the anterior commissure, which have been included so far among the indications for type Va cordectomy. This situation was a source of discussion and possible confusion when comparing results from different studies.

To resolve this problem, a new cordectomy category, encompassing the anterior commissure and the anterior part of both vocal folds—type VI cordectomy—was proposed by the ELS Working Committee on Nomenclature in 2007 [13]. The members of the working committee thought that tumors with invasion of the thyroid or cricoid cartilages or arytenoid cartilage fixation were not suitable candidates for transoral laser surgery. Therefore, the classification does not include resection types for these advanced (T3 and T4) glottic carcinoma. A synthesis of the year 2000 classifications and the 2007 modification is given here (Fig. 13b.4 a–i).

13b.1.2.1 Subepithelial Cordectomy (Type I)

Subepithelial cordectomy is resection of the vocal fold epithelium, passing through the superficial layer of the lamina propria. This surgical procedure spares the deeper layers and thus the vocal ligament. Subepithelial cordectomy is performed for cases of vocal fold lesions suspected of premalignant or malignant transformation. As the entire epithelium is generally affected in various degrees of severity, it is usually necessary to resect it completely to avoid leaving in place a dysplastic or even carcinomatous area. In rarer cases where epithelial modifications are restricted to a segment of the vocal fold, the clinically normal epithelium may be preserved. Because subepithelial cordectomy ensures histopathological examination of the entire epithelium of the vocal fold, the main role of this surgical procedure is diagnostic. It can also be therapeutic if histological results confirm hyperplasia, dysplasia, or carcinoma in situ without signs of microinvasion. Indeed, by definition, these lesions are limited to the epithelium. If, on the other hand, there are signs of invasive tumor spread, a further procedure is required.

13b.1.2.2 Subligamental Cordectomy (Type II)

Subligamental cordectomy is resection of the epithelium, Reinke's space, and the vocal ligament. It is performed by cutting between the vocal ligament and the vocal muscle. The vocal muscle is preserved as much as possible. The resection may extend from the vocal process to the anterior commissure. At a diagnostic level, this procedure is indicated for cases of severe leukoplakia when a lesion shows clinical signs of neoplastic transformation and stroboscopic examination indicates deep infiltration, or "vibratory silence." When palpated, this infiltration feels thickened and the mucosa cannot freely be moved over the underlying structures. At a therapeutic level, subligamental cordectomy is indicated for cases of microinvasive carcinoma or severe carcinoma in situ with possible microinvasion.

13b.1.2.3 Transmuscular Cordectomy (Type III)

Transmuscular cordectomy is performed by cutting through the vocalis muscle. The resection encompasses the epithelium, lamina propria, and part of the vocalis muscle. The resection may extend from the vocal process to the anterior commissure. Partial resection of the ventricular fold may be necessary to expose the entire vocal fold. Transmuscular cordectomy is indicated for small superficial cancers of the mobile vocal fold that reach the vocalis muscle without deeply infiltrating it.

13b.1.2.4 Total or Complete Cordectomy (Type IV)

Complete cordectomy extends from the vocal process to the anterior commissure. The depth of the surgical margins reaches the internal perichondrium of the thyroid ala. Sometimes the perichondrium is included with the resection. Anteriorly, the incision is made in the anterior commissure. It is important that the attachment of the vocal ligament to the thyroid cartilage is cut. Complete cordectomy is indicated for T1a cancer infiltrating the vocalis muscle. Extension of a

neoplasm may spread as far as the anterior commissure without involving it.

13b.1.2.5 Extended Cordectomy Encompassing the Contralateral Vocal Fold (Type Va)

Extended cordectomy was meant to include the anterior commissure and, depending on the extent of the tumor, either a segment or the entire contralateral vocal fold. This approach is somewhat controversial because resection around the anterior commissure is technically difficult and leads to poor phonatory results. This resection type is now commonly replaced by type VI cordectomy.

13b.1.2.6 Extended Cordectomy Encompassing the Arytenoid (Type Vb)

Extended cordectomy encompassing the arytenoid is indicated for vocal fold carcinoma involving the vocal process or the arytenoid cartilage posteriorly. The arytenoid cartilage should be mobile. The cartilage is partially or totally resected. The posterior arytenoid mucosa may be preserved if this decision seems oncologically sound.

13b.1.2.7 Extended Cordectomy Encompassing the Ventricular Fold (Type Vc)

According to certain schools, total cordectomy can be extended to the mucosa of Morgagni's ventricle, the paraglottic tissues, and the ventricular fold. This procedure (type Vc) is indicated for ventricular cancers or for transglottic cancers that spread from the vocal fold to the ventricle. The specimen encompasses the ventricular fold and Morgani's ventricle.

13b.1.2.8 Extended Cordectomy Encompassing the Subglottis (Type Vd)

If necessary, cord resection can be continued underneath the glottis to expose the cricoid cartilage (Fig. 13b.8). In selected cases, this extended cordectomy (type Vd) is suitable for T2 carcinoma with limited subglottic extension without cartilage invasion.

13b.1.2.9 Cordectomy for Cancers Arising from the Anterior Commissure (Type VI)

Type VI cordectomy is indicated for cancer originating in the anterior commissure, extended (or not) to one or both vocal folds, without infiltration of the thyroid cartilage. The surgery comprises anterior commissurectomy with bilateral anterior cordectomy. If the tumor is in close contact with the cartilage, resection can encompass the anterior angle of the thyroid cartilage. To remove Broyle's ligament, the incision must be started above the insertion plane of the vocal folds, at the base of the epiglottic insertion, and is extended through Broyle's ligament. To achieve this resection, it may be necessary to resect the petiole of the epiglottis and the anterior parts of the ventricular folds to ensure sufficient visualization. Resection of the anterior commissure may include the subglottic mucosa and cricothyroid membrane because cancers of the anterior commissure tend to spread toward the lymphatic vessels of the subglottic area.

13b.1.3 Supraglottic Carcinomas

Among the indications for laser surgery in patients with laryngeal cancer, surgical treatment of supraglottic carcinoma plays a prominent role. This is mainly due to the often better functional results than those achieved with open partial resection [14, 15]. Of course, there remain indications for open surgery, which is, again, a reason why head and neck surgeons should be trained in the complete field of laryngeal surgery and not focus uniquely on one treatment method [6, 16, 17]. In the following, however—and this is the objective of this chapter—laser surgery of supraglottic carcinoma is described with its main aspects.

The main advantage of transoral laser microsurgery is that the resection can be tailored to the extent of the tumor [5, 18, 19]. Instead of using an open technique, the surgeon can proceed according to the often clear delineation between healthy and affected tissue provided by the operating microscope.

Endoscopic laser surgery is most appropriate for resecting carcinomas on the free edge of the epiglottis, central suprahyoid carcinomas, and carcinomas located on the lingual surface of the epiglottis, on the margins of the ventricular fold, or on the aryepiglottic folds.

En bloc resection is mainly possible for small, circumscribed carcinomas of the supraglottis; the technique is

comparable to resection of early glottic cancer. Laser microsurgery can be recommended because carcinomas in this area can be resected with more sufficient safety margins compared to glottic carcinomas. The postoperative functional results are highly satisfactory.

Tumor infiltration of carcinomas of the infrahyoid epiglottis is rather difficult to determine preoperatively, particularly in the area of the petiole. Thus, it is often also difficult to stage T1 and T3 carcinomas preoperatively. However, clinical experience shows that infiltration of the preepiglottic space must be considered with all carcinomas of the infrahyoid region. In cases of infiltration, laser surgery is not contraindicated; but this surgery requires complete exposure of the tumor after division of the preepiglottic fat pad. This goal may best be achieved by cutting through the vallecula with the laser. Bleeding of the vessels is controlled with conventional electrocautery or by means of titanium clips, which have proved to be appropriate. The medial glossoepiglottic fold is divided, requiring splitting the suprahyoid epiglottis in the sagittal plane. Parasagittal incision must also be considered occasionally if it facilitates exposure of lateral supraglottic structures (e.g., the aryepiglottic fold). After exposure of the preepiglottic fat and the laryngeal aspect of the tumor-bearing infrahyoid epiglottis, the tumor is divided in the sagittal direction, and the incision is performed vertically. Sometimes the advanced-stage tumor requires transverse incision of the lesion. If tumor infiltration into the thyroid cartilage or one of the arytenoid cartilages is found, these areas can be included in the resection. Depending on the extent of resection, unilateral arytenoid resection causes more or less significant postoperative swallowing difficulties. Resection of both arytenoid cartilages must be avoided to prevent persistent severe postoperative dysphagia with aspiration. The surgeon must always be aware when resecting extensive lesions that the resection margins may extend from inside the larynx into the subcutaneous tissue of the neck.

In contrast to open surgery, nasogastric tube feeding can usually be limited to only a few days, and temporary tracheostomy can generally be avoided. Thus, the endoscopic technique can be considered mostly superior to conventional open surgery with regard to quality of life, especially during the first postoperative weeks. Furthermore, there is no age limit compared to open supraglottic partial laryngectomy. Transoral CO_2 laser surgery can be called the method of choice for tumor resection of lesions in the above-mentioned sites and stages as the functional results and the obviously better oncological results are superior to those attained with primary radiochemotherapy.

Of course, this does not mean that supraglottic partial laryngectomy performed with CO_2 laser is a risk-free method. The author has seen cases in which there was significant postoperative bleeding or persistent functional deficits such as swallowing difficulties with aspiration. However, this is no criticism of laser surgery in itself but should emphasize the risks and make surgeons more aware to the importance of careful postoperative follow-up. Regarding the risk of postoperative bleeding, it must be ensured that patients are under continuous supervision during the postoperative phase so they can be adequately treated in case of an emergency, including provision of rapid intubation if required.

At this point, the limitations and complications of transoral laser surgery of laryngeal carcinomas must be mentioned. Several publications have reported on this topic since 1971, and a series of possible complications has been identified: local infection, emphysema, fistulation, bleeding, respiratory distress due to stenosis or edema, swallowing difficulties, and aspiration pneumonia [20, 21]. The complication rate is determined mainly by the experience of the surgeon. Furthermore, it became obvious that the complications are less frequent after laser surgery of early laryngeal cancer than after laser treatment of advanced carcinoma.

Large supraglottic tumors can also be resected transorally when the tumor can be clearly exposed and the intervention is performed by an experienced surgeon. In these cases, laser surgery is much less limited by the technical possibilities than by the functional outcome. The patient may, for example, experience postoperative swallowing difficulties depending on the extent of the resection in the arytenoid region. It was mentioned previously that the resection of both arytenoid cartilages should be avoided because it would cause significant postoperative dysphagia with inevitable aspiration. Similar problems may occur when unilateral resection of the arytenoid cartilage is performed together with resection of the corresponding base of the tongue.

Even the laryngeal skeleton may be affected by postoperative complications. Most frequently it is observed in patients who have received pre- or postoperative radiochemotherapy. Protracted chondritis is sometimes seen, including formation of cartilaginous or bony sequestra that can often but not always be removed by a transoral access. Laser surgical treatment of advanced laryngeal carcinomas requires a particularly high degree

of experience and technical training of the surgeon. It is easy to see that it is difficult to resect advanced supraglottic carcinomas through a narrow tube—far more difficult than tumor resection by an open approach. If piecemeal resection is applied, it requires a high degree of concentration by the surgeon and close cooperation with the pathologist to assess the adequacy of the resection margins accurately. Hence, we can understand the need for intensive training programs in transoral laser microsurgery to achieve excellent results. Clinical training should start with laser surgery of circumscribed supraglottic lesions. After gaining more experience, the treatment spectrum can be enlarged to more extended supraglottic carcinomas.

Established oncological principles should always determine the most suitable treatment concepts of supraglottic cancer. This is especially true for advanced supraglottic tumors, although carcinomas in their initial stages must also be taken seriously. There are still controversial discussions between the surgery and radiooncology departments. This problem should be resolved in the future so a substantial interdisciplinary discussion in the sense of tumor conferences may be established. This objective can be achieved by recognizing the personal and method-specific limitations of the various treatment options. Categorical rejection of one form of treatment is as wrong as radical advocacy of others. This is also true for transoral laser microsurgery of the supraglottic larynx. There are definite indications for laser surgery, but there are also considerable anatomical and functional limitations.

When discussing the optimal treatment option for supraglottic carcinomas, it must be considered that the primary tumor can be successfully treated by surgery and/or radiotherapy in most cases. The frequently poor prognosis of the patients suffering from laryngeal squamous cell cancer is generally based on the lymphogenic metastatic spread of this tumor and on the occurrence of distant metastases that may be observed in the further course of the disease.

To define individual treatment strategies, interdisciplinary discussions relating to those issues must be pursued from various aspects so a consensus can be found. Only by understanding that treatment of oncology patients is a specialized discipline and accepting that these patients must be treated in specialized centers can we finally be able to offer patients an optimized, individual treatment concept that is supported by an internationally established consensus.

13b.2 Recurrences: Follow-Up, Diagnosis, and Management

The essential prerequisite for endoscopic management of laryngeal and hypopharyngeal tumors is ensuring adequate patient compliance to a compulsive postoperative follow-up. Tailored endoscopic resections often are performed within millimetric safe margins and such an ultraconservative approach is potentially dangerous if the patient escapes regular controls by the same surgeon who performed the procedure. Particularly when dealing with tumors at high risk of recurrence—T2 glottic cancer with anterior transcommissural extension, T3 glottic or supraglottic tumors with lateral extension to the bottom of the ventricle and paraglottic space, every hypopharyngeal tumor—an even more strict clinical and radiological follow-up is strongly recommended (Figs. 13b.5 and 13b.6).

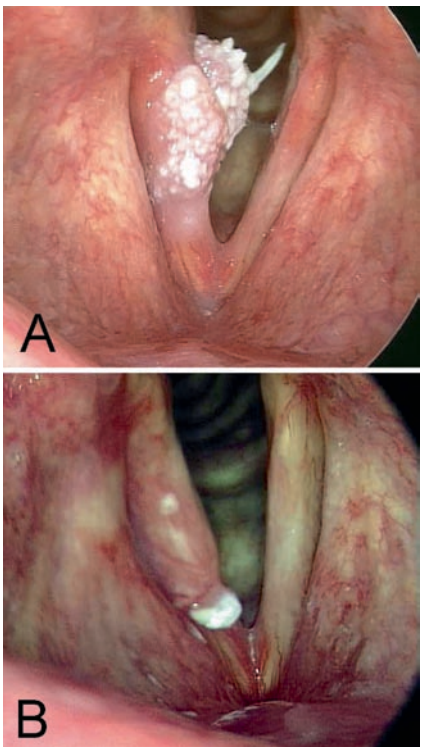

Fig. 13b.5. Videolaryngoscopic examination of a patient affected by a verrucous lesion of the middle third of the right vocal cord. The patient subsequently submitted to subligamental cordectomy (type II) (**a**). Videolaryngoscopic examinations of the same patient 9 months after surgery. A superficial leukoplasic lesion, suspicious for recurrence, was detected at the level of the anterior third of the residual vocal fold, requiring a second microlaryngoscopic procedure (**b**)

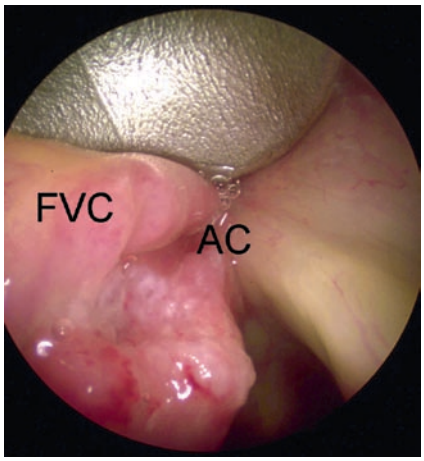

Fig. 13b.6. Intraoperative rigid endoscopy with a 70° telescope. Erythroplasic lesion involves the entire left vocal fold with massive extension to the floor, bottom, and roof of the ventricle. *AC*, anterior commissure; *FVC*, false vocal cord

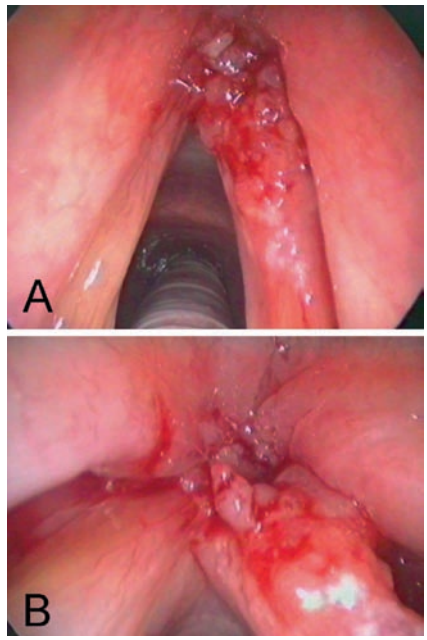

Fig. 13b.7. Superficial recurrence of mucosal dysplasia

In the University of Brescia experience, endoscopy under local anesthesia should be carried out at least every 2 months for the first 2 years after surgery and with decreasing frequency in the subsequent years. VLS can be added to the evaluation of patients treated for early glottic cancer, and the gold standard for all the other lesions remains VLS by rigid and/or flexible endoscopes. Video-recording and storage of serial postoperative controls can further assist in comparisons among clinical pictures possibly related to the healing process (granulomas, synechiae) or to suspicious recurrences and second tumors.

As previously described for the preoperative setting, strict cooperation between the endoscopic surgeon and an experienced radiologist is mandatory during follow-up. Our policy encompasses periodic CT scans (usually once a year during the first 2 years after surgery even in the absence of endoscopic abnormalities) in patients with T2–T3 glottic and supraglottic tumors. For hypopharyngeal lesions, we usually prefer MRI with the same time schedule. Any endoscopic abnormalities deemed not related to normal postoperative sequelae and with a possible deep pattern of disease progression should be immediately evaluated by the appropriate imaging examination. Neck monitoring should be performed with a closer attitude (ultrasonography every 4 months during the first 2 years) in patients with T3 glottic and T2–T3 supraglottic tumors submitted to a "wait and see" policy, and it can be used with longer intervals (once a year) in patients treated by neck dissection. In the case of suspicious ultrasonographic findings, fine-needle aspiration cytology is always recommended. The institutional strategy for postoperative oncological surveillance can vary widely depending on the site and stage of the primary lesion, local facilities, and population variables; but it should at least include evaluation of the chest once a year. Moreover, the recent introduction of positron emission tomography (PET)–CT scanning represents a potential tool for more effective and compulsive whole-body oncological follow-up.

Recurrences after endoscopic surgery can follow completely different patterns of progression. Aside from superficial persistence/recurrence of mucosal dysplasia with possible progression to invasive cancer (easily detected by endoscopic evaluation) (Fig. 13b.7), the main concerns of follow-up examination should always be directed to the early diagnosis of deep submucosal neoplastic progression to the visceral spaces, laryngeal framework, and soft tissues of the neck (Fig. 13b.8). Symptoms such as worsening dysphonia and progressive dysphagia with associated otalgia should always be taken into account, with a prompt, careful search for submucosal laryngohypopharyngeal bulging, impaired vocal cord and/or arytenoid mobility, and recurrent palsy. The presence of any of these clinical features should also prompt liberal use of CT or MRI of the neck and possibly the chest.

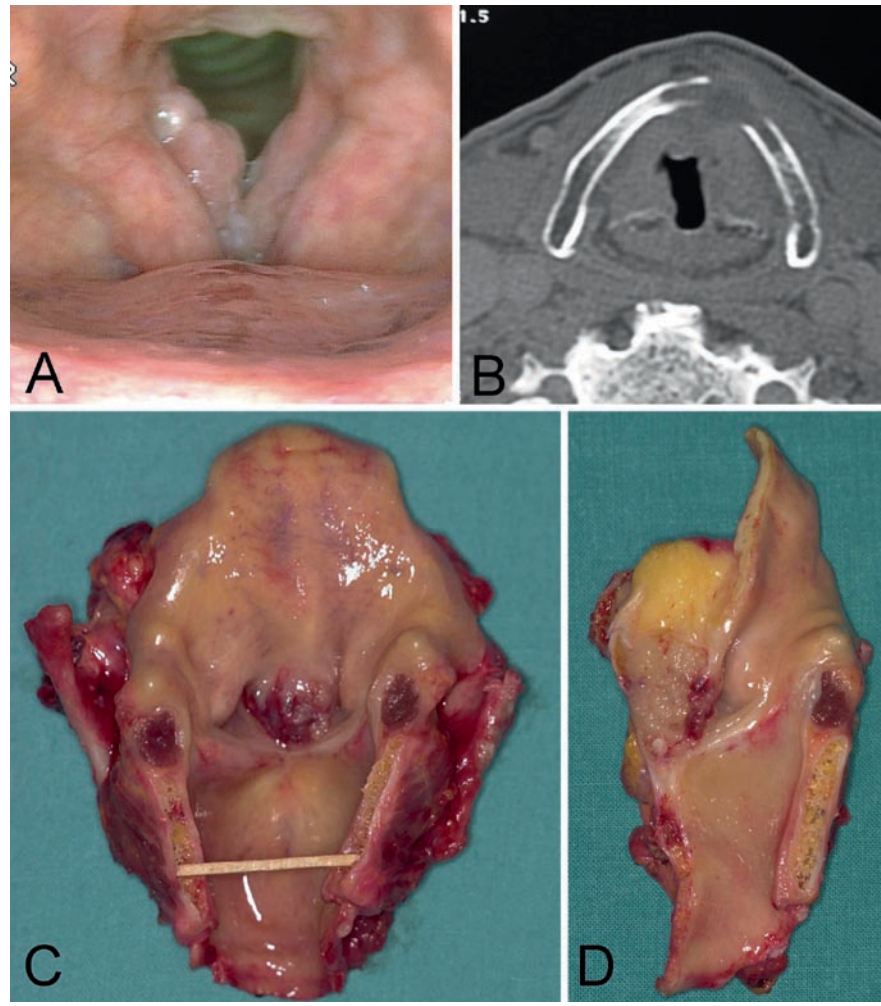

Fig. 13b.8. Video-laryngoscopic examination of a patient affected by erythroleukoplasic lesions involving both vocal cords (**a**). The patient submitted to an extended cordectomy (type Va) encompassing both false and true vocal folds. The patient was reevaluated 6 months later by flexible endoscope with detection of a suspicious area limited to the petiolar region. He was therefore submitted to CT scanning with detection of massive thyroid cartilage disruption (**b**). The patient underwent total laryngectomy (**c**). Cutting the specimen through a sagittal plane revealed massive infiltration of the preepiglottic space and cartilaginous framework (**d**)

If there is a local recurrence, more re-treatment options are available after initial laser surgery than after initial radiotherapy or open surgery because wound complications as a result of previous irradiation are not encountered and the laryngeal framework is still intact, preventing early extralaryngeal spread of local failures [22]. Therefore, such recurrences allow further organ-sparing procedures if they are discovered in a timely way. In such situations, all treatment options are still available, such as further endolaryngeal surgery, conventional partial laryngectomy, radiotherapy, or total laryngectomy. Superficial persistence/recurrence either in subsites adjacent to the primary tumor or with a multifocal pattern resembling field cancerization usually has a favorable outcome when treated by further endoscopic resection. Complementary radiotherapy has a beneficial role in the presence of multiple local recurrences after more than one surgical attempt and whenever the vocal outcome becomes a major issue while counseling the patient [23]. Oncological outcomes are usually not worsened in such a salvage scenario, being comparable to those observed in the primary therapeutic setting. By contrast, the situation of submucosal progression of residual neoplastic cells toward the deep visceral space is certainly much more difficult. Previous endoscopic removal of the natural barriers to tumor spread (Broyle's ligament, conus elasticus, vocal ligament, quadrangular membrane, epiglottis), though less important than with open-neck partial laryngectomy, makes the subsequent patterns of tumor diffusion unpredictable. However, preservation of the cartilaginous laryngeal framework during initial laser sugery prevent recurrences from spreading beyond the larynx.

For this reason, the use of endoscopic laser resection usually has been discouraged for infiltrating anterior commissure carcinoma because of inadequate exposure and the close proximity of underlying cartilage. Supracricoid open partial procedures may be more appropriate for these lesions as consistent data in the literature demonstrate that local control rates can be achieved with this technique that are clearly superior to those reported here [22].

13b.3 Sequelae and Functional Outcomes

One of the favorite arguments supporting radiotherapy for early glottic cancer has always been better vocal function when compared to cordectomy through thyrotomy and vertical partial laryngectomies [24]. Perhaps the most striking change that has emerged from the endoscopic approach is the possibility to precisely modulate the deep extent of resections in such a way that the term "cordectomy" alone is no longer appropriate to describe this procedure. In this light, the ELS classification allows one to define and clearly distinguish the extent of excision, which facilitates making meaningful comparisons between vocal outcomes after different types of cordectomy. Another consequence of such a classification is the possibility of comparing vocal outcome after endoscopic surgery with those achieved after radiotherapy.

Even though a truly complete voice evaluation has not yet been achieved, a comprehensive vocal analysis according to the ELS Working Committee [25] should include subjective evaluation using a questionnaire such as the Voice Handicap Index (VHI) [26], perceptual voice evaluation by a panel of Speech Pathologists and Otolaryngologists according to the GRBAS scale [27], and objective analysis by computerized systems including a number of parameters such as Fundamental Frequency, Jitter, Shimmer, and Noise to Harmonic Ratio. Following these guidelines, the University of Brescia retrospectively analyzed the functional outcomes after different types of cordectomy performed for early glottic cancer [28–31]. In those patients, we observed no statistically significant differences in the voice after types I and II cordectomy compared to a group of normal subjects. However, significant dysphonia has been documented only after type III, IV, and V resections, mainly due to two key factors: anterior commissure synechiae (particularly after type Va cordectomy) and substantial glottic gap after removal of a significant amount of vocal muscle (more than one-third of its depth), necessitating a further phonosurgical procedure. Staged phonosurgery may be indicated in patients with severe dysphonia [32].

Fascinating future developments in the area of tissue engineering (e.g., replacement of the lamina propria by stem cells of autologous fibroblasts) will hopefully allow re-creation of the normal pliability of the vocal cord "cover" resected by endoscopic procedures. Nonetheless, the present state of the art of phonosurgery is limited to obtaining partial recovery of vocal function by purely acting on the medialization of the scarred vocal fold to close the glottic incompetence. In our experience, no adjunctive phonosurgical treatment was needed after types I and II cordectomy owing to the optimal postoperative conversational voice obtained after a standard voice therapy protocol and vocal hygiene, including voice rest for at least 2 weeks after surgery and smoking cessation. On the other hand, the glottic incompetence arising from wider resections could be corrected in different ways.

Our (Brescia) treatment policy is to restore good glottic closure immediately after type III cordectomy by a primary intracordal autologous fat injection (PIAFI) performed at the end of the endoscopic resection. Abdominal fat tissue is processed, avoiding any contact with air, and injected into the residual vocal muscle lateral to the vocal process (Fig. 13b.9). The increase in the neocord mass likely to be achieved is fine-tuned by precise modulation of the injection controlled by 30° rigid endoscopy. In this way, a near-normal conversational voice is obtained from the day after surgery owing to good glottic closure, which reduces vocal fatigue and social handicap. In particular, a comparison of vocal outcomes between patients treated by type III cordectomy alone with those submitted to this procedure followed by PIAFI showed a positive trend for the latter patients in terms of VHI and objective voice evaluations. Furthermore, a statistically significant improvement was reached in terms of the GRBAS scale. No complications or significant prolongation of the overall surgical time were observed as a result of PIAFI. A potential shortcoming of this technique is the variable resorption rate of the injected fat. However, this has not been observed to date during our short-term follow-up [33].

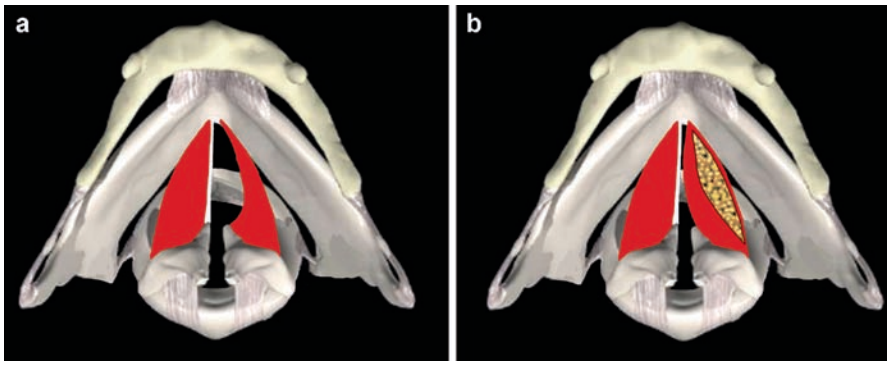

Fig. 13b.9. Primary intracordal autologous fat injection (PIAFI) after transmuscular cordectomy (type III). Note the glottic gap due to endoscopic resection (**a**) and its immediate correction after fat injection into the residual vocal muscle and paraglottic space (**b**)

Other authors prefer to perform phonosurgical voice rehabilitation only following a disease-free interval of at least 6 months to 1 year. After this time, they may use standardized thyroplasty or vocal cord injection techniques [34–37].

After types IV and V cordectomy, a wider glottic gap usually reduces the possibility of good glottic closure, and the fibrotic nature of the neocord prevents any mucosal wave. After a mandatory lapse of at least 1 year, patients who are strongly motivated to improve vocal performance can be treated by personally tailored phonosurgical procedures, including medialization thyroplasty and/or anterior commissure laryngoplasty [37–39].

The first procedure is aimed at medializing the scarred neocord when a linear glottic gap is interposed between the operated side and the contralateral normal vocal fold in cases of type IV excision. In such a scenario, the use of autologous cartilage, titanium, or Gore-Tex implants allows us to modulate the amount of medialization precisely and gradually without any risk of mucosal penetration or overcorrection.

On the other hand, the anterior commissure laryngoplasty procedure is suggested in cases of "keyhole"-shaped anterior incompetence secondary to type Va cordectomy. Such a defect can be successfully corrected only by posteromedial displacement of the contralateral thyroid lamina under that of the more affected side. In this case, the normal vocal cord loses tension and is shortened with subsequent filling of the anterior "keyhole" gap. The reshaping of the thyroid cartilage is then stabilized by means of a rigid microplate (Fig. 13b.10).

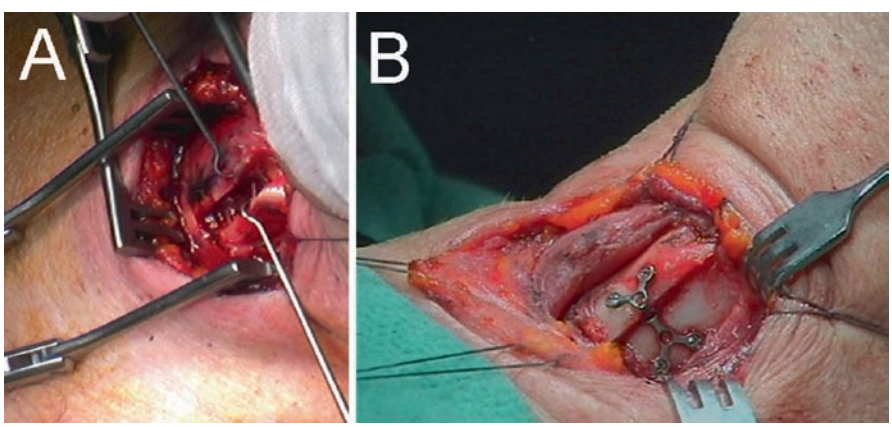

Fig. 13b.10. Intraoperative views during anterior commissure laryngoplasty according to Zeitels for correction of an anterior "'keyhole' gap after right type Va cordectomy. Thyrotomy is performed paramedially on the side of the less involved vocal cord (*left*) (**a**) to displace posteromedially the uninvolved thyroid lamina underneath the contralateral one (*right*). In such a way, detension of the left vocal fold combined with reshaping the anterior commissure closes the "keyhole" gap. This position is then maintained in place by a molded titanium microplate (**b**)

Our preliminary results after such phonosurgical approaches to the scarred vocal cord after types IV and V cordectomy showed improved glottic closure in 74% of patients when comparing the preoperative laryngoscopic examination with the postoperative one.

Swallowing is usually not impaired after standard types I–V cordectomy as defined by the ELS Classification. However, impairment may arise when the surgeon embraces more extended procedures to treat bulky T2 and T3 glottic tumors with significant subglottic and/or supraglottic extension, encompassing removal of both vocal cords, one or both the false vocal folds, the ventricle, and the petiole of the epiglottis (procedures that we usually define as endoscopic partial laryngectomy, or EPL, largely corresponding to the newly defined type VI cordectomy of the ELS classification) (Fig. 13b.11). A retrospective analysis of such patients treated at our institution revealed that they rarely needed postoperative nasogastric feeding tube (< 10% of cases and for a maximum 5 days), never required tracheostomy, and stayed in the hospital for a mean of 3 days. The postoperative voice after EPL turned out to be slightly better than that after supracricoid partial laryngectomy (SCPL) in patients matched for T category. However, the most important advantage of the endoscopic treatment when compared to the open-neck partial laryngectomy approach was in regard to the swallowing function. As a matter of fact, when we studied deglutition of patients treated by EPL, we found some kind of neovestibule and/or subglottic bolus aspiration in 20% of them by videoendoscopic examination of the swallow and in 27% by videofluoroscopy. These rates grew, respectively, to 57% and 71% when these diagnostic tools were applied to evaluating the swallow of patients treated by SCPL.

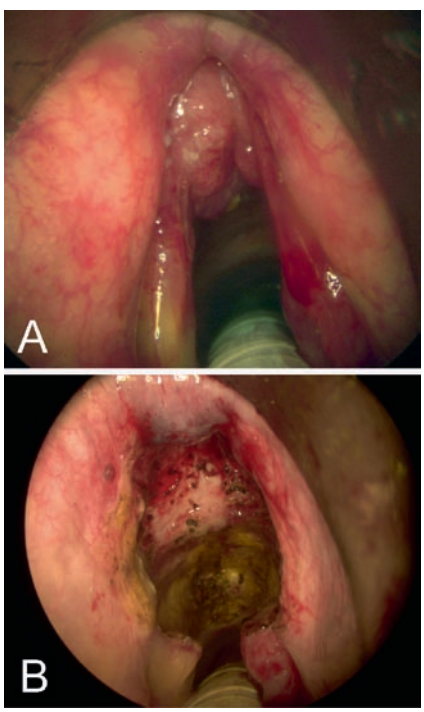

Fig. 13b.11. Intraoperative endoscopy of a T2 lesion with anterior transcommissural extension using a 0° rigid telescope (**a**). Laryngeal framework infiltration was ruled out by CT scans. Endoscopic partial laryngectomy was performed with exposure of the thyroid cartilage, cricothyroid membrane, and cricoid arch (**b**)

One of the most important advantages of endoscopic resection of supraglottic cancer compared to both radiotherapy and open-neck horizontal supraglottic laryngectomy is the possibility of excising the tumor within millimetric free margins while sparing adjacent uninvolved supraglottic subsites and structures such as hyoid bone, base of tongue musculature, prelaryngeal muscles, cartilaginous framework, and the external branch of the superior neurovascular pedicle (Fig. 13b.12). Such a cautious approach to laryngeal structures has a significantly better functional outcome in terms of perioperative morbidity and faster postoperative recovery of swallowing than that achieved with open-neck surgery.

A retrospective study was performed at our institution that compared two groups of patients affected by supraglottic tumors matched for T category and treated with horizontal supraglottic laryngectomy or endoscopic resections. A number of advantages become evident after endoscopic surgery [31]. All patients undergoing open-neck surgery needed both a tracheotomy and a nasogastric feeding tube compared to only 14% and 21%, respectively, of those who underwent endoscopic procedures. Moreover, when needed, the mean duration of tracheotomy and nasogastric feeding tube dependence were 35 and 19 days, respectively, for the open-neck group versus 4 and 5 days, respectively, for the endoscopic group. The mean hospitalization time was also significantly shorter after endoscopic procedures (10 vs. 26 days). A comprehensive evaluation of swallowing was performed by a subjective questionnaire employing the M.D. Anderson Dysphagia Inventory [40], videofluoroscopy, and videoendoscopic examination during deglutition of a colored gel. Even though subjective measurements by the M.D. Anderson

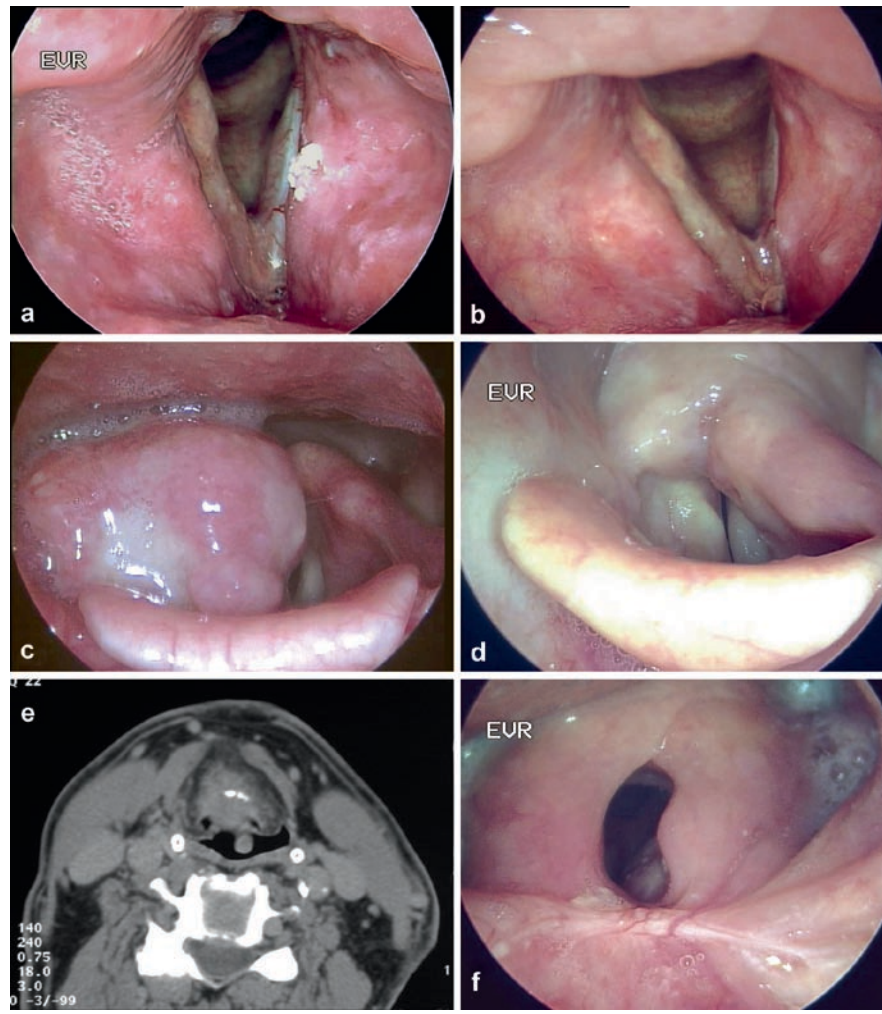

Fig. 13b.12. Modulation of endoscopic supraglottic resections from simple ventriculectomy (**a**, **b**), to partial (**c**, **d**), and complete (**e**, **f**) supraglottic laryngectomy

Dysphagia Inventory questionnaire showed similar results, there was a statistically significant difference when comparing the results obtained by the swallowing tests. Patients treated by open-neck surgery showed 36% and 80% rates of subglottic aspiration as detected by videoendoscopic evaluation of deglutition and videofluoroscopy, respectively, compared to 8% and 21% after endoscopic treatment, respectively. Therefore, in the case of supraglottic tumors, impaired swallowing fundamentally affects patients' quality of life, whereas voice function usually does not represent a major concern. This assumption was confirmed by our comprehensive evaluation of the voice by VHI, GRBAS, and objective analysis, which showed no statistically significant differences between the two groups and a matched control population.

Early hypopharyngeal tumors certainly play a minor role among the indications for endoscopic surgery. For their nature (submucosal spread and early lymph node metastases) and late diagnosis (related to the silent areas where these tumors grow and the peculiar socioeconomic status of the patients usually affected by these lesions), hypopharyngeal malignancies are often diagnosed in an advanced stage. However, there is a relative paucity of open-neck conservative approaches that can be applied to these lesions. Thus, endoscopic management can certainly play a definitive role as an alternative to the costly, highly morbid organ preservation protocols in strictly selected early tumors of the hypopharynx.

As in the case of supraglottic lesions, the main sequels of endoscopic procedures for hypopharyngeal

lesions are usually related to swallowing, which can be significantly hampered for a prolonged time. A nasogastric feeding tube or, more frequently, percutaneous endoscopic gastrostomy (PEG) may be needed during the long-lasting rehabilitative training protocol of swallowing. In Steiner's experience [5], 27% of 129 patients regained oral feeding on the first postoperative day without the need for a nasogastric feeding tube. In the remaining patients, a feeding tube was positioned and held in place for a mean of 9 days after surgery (range 1–25 days). A definitive gastrostomy tube was left in only two patients with severe aspiration but who refused total laryngectomy. Tracheotomy is usually not an issue so long as resection does not involve extensive adjacent supraglottic areas. Voice is generally not affected at all except in case of tumors involving the posterior half of the medial wall of the piriform sinus. When treating these lesions, in fact, the endoscopic surgeon can be forced to cause temporary or persistent damage to the recurrent nerve at its point of entry in the posterior paraglottic space.

13b.4 Tips and Pearls

- Tumors with complete fixation of one arytenoid cartilage are usually not suited for transoral laser surgery.
- Tumors arising from the anterior commissure are particularly difficult to expose and resect. Perform preoperative imaging (CT or MRI) prior to surgery and consider open (supracricoid) partial laryngectomy as a surgical alternative to laser surgery.
- With rare exceptions, subglottic carcinomas are not suited for transoral surgery.
- Perform adequate imaging of the larynx in the presence of supraglottic lesions to assess the true extent of the tumor before planning endoscopic surgery.
- Use laser-shielded tubes when performing CO_2 laser surgery for laryngeal tumors.
- Use two suction devices—one to evacuate the smoke and one to suction blood and manipulate the tissue during surgery.
- Administer perioperative antibiotic prophylaxis in all cases that require exposure of laryngeal cartilages.
- Insert a feeding tube at the end of the procedure in patients with supraglottic tumors or with resection of one arytenoid cartilage.
- Use dental protection to avoid dental trauma.
- Inspect the pharynx and oral cavity at the end of the operation to identify mucosal tears and bleeding.

References

1. Kleinsasser O (1962) [laryngomicroscopy (lens laryngoscopy) and its importance in the diagnosis of premorbid diseases and early forms of carcinoma of the labium vocale.]. Arch Ohren Nasen Kehlkopfheilkd 180:724–727
2. Strong MS, Jako GJ (1972) Laser surgery in the larynx. Early clinical experience with continuous CO_2 laser. Ann Otol Rhinol Laryngol 81:791
3. Ambrosch P (2007) The role of laser microsurgery in the treatment of laryngeal cancer. Curr Opin Otolaryngol Head Neck Surg 15:82–88
4. Eckel HE, Thumfart W, Jungehulsing M, Sittel C, Stennert E (2000) Transoral laser surgery for early glottic carcinoma. Eur Arch Otorhinolaryngol 257:221–226
5. Steiner W, Ambrosch P, Hess CF, Kron M (2001) Organ preservation by transoral laser microsurgery in piriform sinus carcinoma. Otolaryngol Head Neck Surg 124:58–67
6. Werner JA, Dunne AA, Folz BJ, Lippert BM (2002) Transoral laser microsurgery in carcinomas of the oral cavity, pharynx, and larynx. Cancer Control 9:379–386
7. Eckel HE, Staar S, Volling P, Sittel C, Damm M, Jungehuelsing M (2001) Surgical treatment for hypopharynx carcinoma: Feasibility, mortality, and results. Otolaryngol Head Neck Surg 124:561–569
8. Steiner W, Fierek O, Ambrosch P, Hommerich CP, Kron M (2003) Transoral laser microsurgery for squamous cell carcinoma of the base of the tongue. Arch Otolaryngol Head Neck Surg 129:36–43
9. Peretti G, Piazza C, Berlucchi M, Cappiello J, Giudice M, Nicolai P (2003) Pre- and intraoperative assessment of midcord erythroleukoplakias:A prospective study on 52 patients. Eur Arch Otorhinolaryngol 260:525–528
10. Nakayama M, Brandenburg JH (1993) Clinical underestimation of laryngeal cancer. Predictive indicators. Arch Otolaryngol Head Neck Surg 119:950–957
11. Sapundzhiev NR, Dunne AA, Ramaswamy A, Sitter H, Davis RK, Werner JA (2005) Lymph node metastasis in an animal model:Effect of piecemeal laser surgical resection. Lasers Surg Med 36:371–376
12. Remacle M, Eckel HE, Antonelli A, Brasnu D, Chevalier D, Friedrich G, Olofsson J, Rudert HH, Thumfart W, de Vincentiis M, Wustrow TP (2000) Endoscopic cordectomy. A proposal for a classification by the working committee, european laryngological society. Eur Arch Otorhinolaryngol 257: 227–231
13. Remacle M, Van Haverbeke C, Eckel H, Bradley P, Chevalier D, Djukic V, de Vicentiis M, Friedrich G, Olofsson J, Peretti G, Quer M, Werner J (2007) Proposal for revision of the european laryngological society classification of endoscopic cordectomies. Eur Arch Otorhinolaryngol 264:499–504
14. Rudert HH, Hoft S (2003) Transoral carbon-dioxide laser resection of hypopharyngeal carcinoma. Eur Arch Otorhinolaryngol 260:198–206

15. Rudert HH, Werner JA, Hoft S (1999) Transoral carbon dioxide laser resection of supraglottic carcinoma. Ann Otol Rhinol Laryngol 108:819–827
16. Dunne AA, Davis RK, Dalchow CV, Sesterhenn AM, Werner JA (2006) Early supraglottic cancer: How extensive must surgical resection be, if used alone? J Laryngol Otol 120:764–769
17. Dunne AA, Folz BJ, Kuropkat C, Werner JA (2004) Extent of surgical intervention in case of n0 neck in head and neck cancer patients:An analysis of data collection of 39 hospitals. Eur Arch Otorhinolaryngol 261:295–303
18. Rudert H (1988) [laser surgery in ent surgery] laser-chirurgie in der hno-heilkunde. Laryngol. Rhinol. Otol.(Stuttg) 67:261
19. Steiner W, Vogt P, Ambrosch P, Kron M (2004) Transoral carbon dioxide laser microsurgery for recurrent glottic carcinoma after radiotherapy. Head Neck 26:477–484
20. Klussmann JP, Knoedgen R, Wittekind C, Damm M, Eckel HE (2002) Complications of suspension laryngoscopy. Ann Otol Rhinol Laryngol 111 (11):972–976
21. Sesterhenn AM, Dunne AA, Werner JA (2006) Complications after co(2) laser surgery of laryngeal cancer in the elderly. Acta Otolaryngol 126:530–535
22. Eckel HE (2001) Local recurrences following transoral laser surgery for early glottic carcinoma: Frequency, management, and outcome. Ann Otol Rhinol Laryngol 110:7–15
23. Peretti G, Piazza C, Bolzoni A, Mensi MC, Rossini M, Parrinello G, Shapshay SM, Antonelli AR (2004) Analysis of recurrences in 322 tis, t1, or t2 glottic carcinomas treated by carbon dioxide laser. Ann Otol Rhinol Laryngol 113:853–858
24. Bron LP, Soldati D, Zouhair A, Ozsahin M, Brossard E, Monnier P, Pasche P (2001) Treatment of early stage squamous-cell carcinoma of the glottic larynx: Endoscopic surgery or cricohyoidoepiglottopexy versus radiotherapy. Head Neck 23:823–829
25. Dejonckere PH, Bradley P, Clemente P, Cornut G, Crevier-Buchman L, Friedrich G, Van De Heyning P, Remacle M, Woisard V (2001) A basic protocol for functional assessment of voice pathology, especially for investigating the efficacy of (phonosurgical) treatments and evaluating new assessment techniques. Guideline elaborated by the committee on phoniatrics of the european laryngological society (els). Eur Arch Otorhinolaryngol 258:77–82
26. Benninger MS, Ahuja AS, Gardner G, Grywalski C (1998) Assessing outcomes for dysphonic patients. J Voice 12: 540–550
27. Piccirillo JF, Painter C, Fuller D, Haiduk A, Fredrickson JM (1998) Assessment of two objective voice function indices. Ann Otol Rhinol Laryngol 107:396–400
28. Manfredi C, Peretti G (2006) A new insight into postsurgical objective voice quality evaluation: Application to thyroplastic medialization. IEEE Trans Biomed Eng 53:442–451
29. Peretti G, Piazza C, Balzanelli C, Cantarella G, Nicolai P (2003) Vocal outcome after endoscopic cordectomies for tis and t1 glottic carcinomas. Ann Otol Rhinol Laryngol 112:174–179
30. Peretti G, Piazza C, Balzanelli C, Mensi MC, Rossini M, Antonelli AR (2003) Preoperative and postoperative voice in tis-t1 glottic cancer treated by endoscopic cordectomy: An additional issue for patient counseling. Ann Otol Rhinol Laryngol 112:759–763
31. Peretti G, Piazza C, Cattaneo A, De Benedetto L, Martin E, Nicolai P (2006) Comparison of functional outcomes after endoscopic versus open-neck supraglottic laryngectomies. Ann Otol Rhinol Laryngol 115:827–832
32. Sittel C, Eckel HE, Eschenburg C (1998) Phonatory results after laser surgery for glottic carcinoma. Otolaryngol Head Neck Surg 119:418–424
33. Bolzoni Villaret A, Piazza C, Redaelli De Zinis LO, Cattaneo A, Cocco D, Peretti G (2007) Phonosurgery after endoscopic cordectomies: I. Primary intracordal autologous fat injection after transmuscular resection:Preliminary results. Eur Arch Otorhinolaryngol 264(10):1179–1184
34. Friedrich G, de Jong FI, Mahieu HF, Benninger MS, Isshiki N (2001) Laryngeal framework surgery: A proposal for classification and nomenclature by the phonosurgery committee of the european laryngological society. Eur Arch Otorhinolaryngol 258:389
35. Friedrich G, Remacle M, Birchall M, Marie JP, Arens C (2007) Defining phonosurgery:A proposal for classification and nomenclature by the phonosurgery committee of the European laryngological society (els). Eur Arch Otorhinolaryngol 264(3):251–256
36. Sittel C (2004) Polydimethylsiloxane particles are not experimental in the human larynx. J Biomed Mater Res B Appl Biomater 69:251
37. Sittel C, Friedrich G, Zorowka P, Eckel HE (2002) Surgical voice rehabilitation after laser surgery for glottic carcinoma. Ann Otol Rhinol Laryngol 111:493–499
38. Zeitels SM (2004) Optimizing voice after endoscopic partial laryngectomy. Otolaryngol Clin North Am 37:627–636
39. Zeitels SM, Hillman RE, Franco RA, Bunting GW (2002) Voice and treatment outcome from phonosurgical management of early glottic cancer. Ann Otol Rhinol Laryngol Suppl 190:3–20
40. Chen AY, Frankowski R, Bishop-Leone J, Hebert T, Leyk S, Lewin J, Goepfert H (2001) The development and validation of a dysphagia-specific quality-of-life questionnaire for patients with head and neck cancer:The m. D. Anderson dysphagia inventory. Arch Otolaryngol Head Neck Surg 127:870–876