This brochure comprises a detailed ‘How I do it’ teaching program derived from more than 30 years of experience and should be used in conjunction with the excellent supplementary teaching material and video clips.
Please note:

This brochure comprises a detailed ‘How I do it’ teaching program on Transoral Laser Microsurgery for Cancer of the Upper Aerodigestive Tract derived from more than 30 years of experience and should be used in conjunction with the excellent supplementary online teaching material and video clips.

The video clips offered in this online edition are accessible by clicking on the ‘play’ icon, e.g., [1,2].

Transoral Laser Microsurgery for Cancer of the Upper Aerodigestive Tract

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Göttingen, April 2013
Wolfgang Steiner
Transoral Laser Microsurgery (TLM) for Cancer of the Upper Aerodigestive Tract

Preliminary Remarks

This brochure has been designed to be used with and complemented by additional online contents and video clips. Together, they provide a comprehensive up-to-date teaching manual for Transoral Laser Microsurgery (TLM). The online video clips complement the brochure text showing many examples of the surgery and expand considerably on the important points in the technique. In conjunction with its online content, this brochure also complements and expands the scope of the original book.*

The basic principles concepts, techniques, instruments and post-operative management are all clearly demonstrated in the online video clips and the descriptions in the brochure are considerably enlarged upon and discussed in special presentations.

Basic Concepts of Function-Preserving Transoral Laser Microsurgery for Carcinomas of the Upper Aerodigestive Tract

Panendoscopy

Panendoscopy is undertaken as an initial procedure in order to define the extent of the primary tumour and to detect any possible second primary lesions. In cases with no previous definitive pathology available, appropriate biopsies are taken using the CO₂ laser and fine cup forceps. Using this technique, excellent quality biopsies are obtained without crush artefacts and with good haemostasis. The results of these biopsies guide subsequent overall treatment decisions. Panendoscopy and biopsy is undertaken before beginning any curative laser resection.

In Göttingen, panendoscopy is performed by initially ventilating the patient via face mask and then exposing the larynx with a semi-tubular laryngoscope, such as the Macintosh, under short-term muscle relaxant anaesthesia. Intubation is usually performed by the operating surgeon under endoscopic control (with a 30°- or 70° laryngoscope) and is followed by video documentation of the lesion and any subsequent surgery.

The larynx, trachea and bronchi are examined with a 30° rigid endoscope, which gives good access to all bronchial segments. Alternatively, a rigid ventilating bronchoscope may be used in conjunction with 0° and 90° rigid endoscopes. In cases with a difficult airway, a fiberoptic intubation is undertaken with the endotracheal tube mounted on the flexible endoscope to facilitate intubation. Next, a flexible bronchoscope is used to examine the distal trachea and bronchi.

In centers with excellent frozen section histological facilities, initial evaluation, biopsy and panendoscopy may be followed by immediate curative surgery. In Barcelona (Bernal-Spreckelsen), initial intraoperative endoscopy is undertaken to evaluate the site and extent of the primary tumour and to take appropriate biopsy specimens, if a definitive histological diagnosis has not been established yet. In contrast to Göttingen, panendoscopy is performed subsequent to TLM excision of the primary tumour, whilst awaiting confirmation of histologically clear resection margins in the frozen sections taken during excision of the primary tumour. This saves time and reduces duration of the overall procedure.

Inspection of the upper digestive tract is followed by a careful microscopic examination of the oral cavity and oropharynx, aided by gags and tongue depressors. Subsequently the hypopharynx is examined with a STEINER distending laryngo-pharyngoscope. Finally oesophagoscopy is performed using a rigid oesophoscope and additionally a 0° endoscope. Air insufflation may be used for dilation of the oesophagus. Occasionally, rigid endoscopy of the oesophagus may be difficult for anatomical reasons and a flexible oesophagoscopy is performed.

**Second Primary in the Bronchi or Oesophagus**

As a matter of course, the T stage of any primary tumour and the potential prognosis of any secondary tumour must be taken into account. In general, primary tumour resection is continued under the same anaesthetic setting unless evidence is indicating that there is a particular risk from a second primary at this time. Resection of the primary tumour is undertaken to preserve or improve the patient's quality of life, allowing any treatment option addressing a second primary to be adopted subsequently. Radical procedures, such as total laryngectomy, are generally not indicated in patients where a second primary tumour with a poor prognosis is discovered in either the oesophagus or bronchi.

**Anaesthesia**

Even though jet ventilation has become an accepted technique since the 1970’s and has been used on a regular basis by some teams around the world during laryngotraheal surgery, most anaesthetists and surgeons, who perform microsurgery, prefer the use of general anaesthesia with endotracheal intubation. This allows complete immobilisation of the vocal folds and poses no particular concerns for either surgeon or anaesthetist in terms of time.

A wide variety of endotracheal tubes have been advocated, but even the most up-to-date laser-safe tubes are more rigid, bulky, and expensive than their counterparts. Based on both experimental research and long-term experience, the teams at Göttingen* and Kiel** provided evidence that a size 5 PVC tube (inner diameter = 5 millimetres), occupying very little space in the operative field, will not catch fire at laser beam impact if the oxygen concentration administered during anaesthesia does not exceed 30%.

In Göttingen, endotracheal intubation is performed by the operating surgeon under endoscopic control and accompanied by video documentation of the tumour. The cuff is filled with air (formerly, with saline solution) and protected by small saline-soaked swabs or neurosurgical patties placed throughout the operative procedure. An extra shielding of the tube and protection of the surrounding mucosa is achieved by additional placement of moistened swabs. For further review of anaesthetic techniques, see the reference below.***

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Prerequisites of TLM

- Patients must be counselled with regard to the disease and the stepwise technique of endoscopic surgery. Ideally, they should be cooperative, motivated and willing to change their smoking and alcohol habits. They must be able to attend for regular follow-up visits and should be made to understand the potential need for re-resection if there is subsequent debate with regard to margins.

- A clear endoscopic exposure of the tumour must be obtained to allow complete resection with clear margins all around the lesion. The surgeon must be aware of the limitations of one's skills and must have a good sense of responsibility and insight into the difficulty of each particular case.

- Close cooperation with the pathologist is essential. The pathologist involved should be familiar with the special concerns and problems associated with the chosen surgical approach. Frozen section may be required intraoperatively and, certainly initially, the pathologist should be encouraged to attend the operating theatre and made to understand the issues of the postoperative examination of the resected tumour bulk and the specimens obtained from the margins.

Risks of TLM

- The most significant risk for the patient is undertreatment due to inadequate experience of the surgeon and inadequate exposure for resection of the tumour. Particularly difficult areas are the tongue base, hypopharyngeal / oesophageal junction and subglottis / upper tracheal area.

- It is vitally important that an oncologically sound resection carries a higher priority than the functional aspect. The assessment of larger lesions is only feasible by combining several views of different parts of the tumour to gain an overall impression.

- Surgeons should begin with smaller tumours and steadily increase their experience and skills in order to successfully accomplish these endoscopic procedures. Transoral procedures require previous experience in endoscopic techniques, anatomy and microsurgery.

- As outlined emphatically above, close cooperation and understanding with an expert head and neck pathologist is essential. The responsibility for complete clearance of resection margins lies with the surgeon. Proper orientation and adequate quality of specimens is essential to aid the pathologist in evaluating larger tumours.
Preconditions for Organ Preservation

- Careful selection of appropriate patients with an excellent probability of preserving function is essential in TLM.
- Severe persistent aspiration must be avoided, which requires the following:
  - in anterior tongue and oropharyngeal tumours one lingual artery and one hypoglossal nerve must be preserved.
  - in laryngeal cancer one arytenoid cartilage usually needs to be preserved.
  - in hypopharyngeal cancer, at least half of the larynx and 30% of the mucosal circumference of the hypopharynx and oesophageal inlet must remain.
- Extensive direct spread out into the lateral neck from an upper aerodigestive tract cancer is a contraindication.
- As mentioned above under ‘Risks’, the surgeon requires understanding of the anatomy, the natural history of the disease and its spread, previous endoscopic experience and the ability to work ‘from inside out’ in a way that is different from conventional surgery.

Limitations of TLM

- Although relatively uncommon, the main limitation is inadequate endoscopic exposure. This may be due to anatomical factors related to prominent teeth, a small jaw, trismus or spinal fixation and will depend, to some extent, on the experience of the surgeon and anaesthetist.
- Advanced tumours with risk of severe persisting aspiration.
- As a consequence of the poor prognosis, any form of surgery should be considered carefully in N 3 neck disease.
Oncological and Functional Principles of TLM

Before proceeding to discuss instrumentation and addressing the specific surgical procedures used in different anatomical areas, it is extremely important that all surgeons understand the oncological and functional principles of the TLM technique in addition to the surgical considerations.

- The principles are the same for all areas of minimally invasive transoral laser microsurgery, but whilst the primary concern is complete resection of the tumour and thus oncologically radical removal, additionally every effort is made to preserve as much normal tissue, and therefore as much function, as possible.

- Transoral laser microsurgery follows the spread of the tumour under microscopic control, adjusting resection to the operative findings. TLM is custom-tailored to the individual patient and results in oncologically sound resection with an excellent view of the limits and maximal preservation of normal tissue and function.

- The initial laser incision into and through the tumour is to enable the surgeon to estimate the depth of tumour penetration. This is an extremely important point, which necessitates that meticulous evaluation be performed under high magnification to determine clearly the deep margin. In the larynx and hypopharynx, the distinction between tumour and healthy tissue can generally be made quite easily in previously untreated patients. In doubtful cases, confirmation of clear surgical margins can be obtained by frozen section.

- Any tumour, for which a curative procedure with satisfactory postoperative function is possible, can be considered for TLM.

- If neck dissection is indicated, then selective neck dissection is performed for N0, N1 and N2 cases.

- Adjuvant (chemo-)radiotherapy is mainly indicated for
  - T4 primary site disease with extensive spread to the neck.
  - N2/3 stage.
  - Extracapsular lymph node spread
  - Lymphangiosis carcinomatosa or perineural invasion of the primary tumour or neck metastasis.

- Postoperative radiotherapy may start as early as two weeks after TLM. The technique is not in ‘competition’ with radiotherapy, indeed, both complement each other well, since blood supply to the organ receiving postoperative radiotherapy remains intact.

- A small spot size and superpulse mode on the laser lessen carbonization and aid the contrast between tumour and normal tissue.

- Differentiating tumour from normal tissue is more difficult in specific areas such as the arytenoid cartilage or tongue base. Experienced surgeons can differentiate normal tissue from malignant with considerable precision by assessing the degree and type of tissue carbonization occurring during the cutting with the laser. Using a small spot size and superpulse mode to cut, usually produces little or no carbonization in normal tissue in contrast to tumour. However, in the tongue base, there is often a variable degree of carbonization in tissues adjacent to the tumour mass due to the presence of glands, lymphoid tissue, chronic inflammation and associated fibrosis. These factors sometimes make it difficult to differentiate between tumour and normal tissue in the tongue base and frozen section evaluation is more often used in this region.

- Monobloc excision with wide margins, is not the aim of the technique. The larger tumours are divided into manageable units with the laser and removed stepwise until excision is complete.
Operative Procedures

- The extent of the tumour must be clearly distinguishable under the operating microscope and may differ from preoperative examination and imaging. The lesion must be resected until healthy tissue is found, and an appropriate safety margin is obtained.

- The CO₂ laser is predominantly used at low power settings of 3–5 watts in superpulse mode. With these preadjustments made, a modern high precision CO₂ laser should produce an almost charfree incision in normal tissue. Additionally, an Acuspot™ micromanipulator or microspot control may be used.

- Small, well-circumscribed tumours may be excised en bloc, but in the majority of incidences, the tumour will be excised in more than one section.

- TLM can be easily repeated if inadequate resection margins are proven by postoperative pathology. Re-resection should remove any residual disease. This situation is rarely possible after conventional open surgery, particularly after reconstruction. Positive margins may not be treatable with adjuvant radiotherapy and have a serious detrimental prognostic significance.

- Debulking of larger tumours can be undertaken in a piecemeal fashion but the laser may require more power and care should be taken not to cut too deeply into normal tissue. Severe bleeding from larger vessels in deep tumour can be more difficult to control. Clearly identifiable portions of tumour should be left behind during the debulking procedure so that these areas can subsequently be distinguished at a later stage when the final detailed resection with histologic control is undertaken.

- If surrounding tissue is involved, such as cartilage and bone, these structures should be included in resection and conventional microendoscopic instruments may be used in addition to the laser. A large grasping forceps may be used to avulse portions of cartilage partially mobilized by laser incisions.

Complete resection is obtained with variations in technique, using the CO₂ laser and the wide variety of instruments outlined in the addendum of this brochure, and these techniques are clearly demonstrated in the online video clips. See particularly.
Microsurgical Technique and Histopathologic Processing

In conventional surgery, a wide safety margin is often achieved at the expense of uninvolved structures, such as musculature, cartilage and bone, with significant functional implications. Transoral laser microsurgical laser resection, even of larger tumours, involves cutting through tumour to visualise the deep margins which then enables the surgeon to individually adjust the safety margin, so the tumour is resected with a clear margin and function is preserved at the same time. In general, an excision margin of 1–2 millimetres is appropriate at the laryngeal glottis. However, for supraglottis, oral cavity, oropharynx, and hypopharynx, a margin of at least 5 millimetres is preferable for small superficial tumours, and 5–10 millimetres for larger tumours, and those whose growth pattern is deeply infiltrating, and/or with a tendency to submucosal spread.

A more liberal resection may be indicated in the floor of the mouth, tongue, palate, and hypopharynx, as they have a greater potential for invasion and submucosal spread. In the upper digestive tract, the resection of a few additional millimetres of mucosa, submucosa and deeper tissue has no significant negative impact on healing and function, but allows maintenance of a wider safety margin.

Under high magnification on the operation microscope, the surgeon can recognize tumour extension into deeper tissues by cutting through the tumour and then individually adjusting the border of the resection. If the line of resection gets too close to the tumour, it can immediately be made wider. If any suspicious areas are detected, additional tissue can be excised and sent for frozen section, alternatively the results of subsequent definitive histology can be awaited and further tissue resected at the time of the subsequent delayed selective neck dissection.

Depth of infiltration, resection margins and differentiation of tumour are assessed by the pathologist. It is of utmost importance that all resection specimens be properly marked for orientation in order to enable the pathologist to make a valid assessment. The overall effectiveness of the pathology report also depends on the surgeon’s liaison with the pathologist. The main responsibility lies with the surgeon.

The surgeon must keep a record in the form of a diagram of the precise origin of all individual specimens resected and submitted to the pathologist. An increasing number of teams worldwide pin out the portions of specimen either onto a structure such as a cork board or dried slices of cucumber, which can then be embedded and sectioned along with the tumour. After each vertical incision through the tumour to the area of normal tissue has been made, the tissue portion harbouring the tumour is removed and the deep resection margin of this specimen is marked with a pen. Great care should be taken with this task, as a systematic marking considerably facilitates the work of the pathologist. In special cases, the lateral superficial margins of the specimen may also be marked.

Video documentation of the procedure, particularly of critical portions of the operation such as the taking of excisional biopsies in critical areas to prove negative margins, is very helpful. Biopsies with small grasping forceps are inadequate and three dimensional representative tissue should be taken with the laser; these specimens must be free of tumour. The surgeon must ask the pathologist clear questions and receive reliable answers.

Re-resection. Detailed operative notes with documentation of findings, intraoperative sketches, video documentation, (if possible), and good interaction with the pathologists are all essential requirements. Postoperatively, if the tumour is found to be located at the margin or comes close to the excision line, then further resection may be undertaken. Alternatively, depending on individual circumstances including localization of the primary tumour, tumour size and intraoperative situation, the patient may be re-assessed, (including laser-excised biopsies), over the first three months of follow-up, or may simply be asked to return for a regular follow-up examination.
Advantages of TLM Over Standard Conventional Surgery

- Transoral endoscopic approaches obviate the need for dissection through healthy tissues of the neck to gain access to these tumours. There is **minimal blood loss** and maximal preservation of important function-related structures.

- The **surgical microscope** enables the surgeon to expose the superficial and deep extension of the tumours more precisely than with conventional surgery and additionally facilitates detection of any surrounding severe dysplastic changes.

- Using the **microscope at a high magnification** is very useful in the detection of early carcinomatous changes and premalignant lesions. These areas may lie immediately adjacent to the frank tumour [II, 50a, 50b].

- The specific cutting properties of the CO2 laser allow **relatively bloodless cutting of tissues** with a maximum degree of accuracy, differentiating between tissue containing tumour or completely free of tumour. Small vessels are sealed with the laser beam which further aids in clearly visualizing the tissues. Immediate **coagulation** (monopolar or bipolar) and application of clips can be used for larger vessels minimizing blood loss, even in the case of larger resections.

- **Blood transfusion** is **not required** and the almost bloodless cutting of the tissues allows an excellent view, providing a rapid accumulation of surgical experience, which is further improved by feedback from histopathology. This combination helps in increasing operative accuracy.

- The unconventional **block stepwise resection** of larger tumours allows the surgeon to assess the cut surface of the tissue and to determine the exact extent of the tumour. This is in contradistinction to major open conventional resections where this assessment is only the privilege of the pathologist during subsequent sectioning of the specimens. As a consequence, transoral laser microsurgery **lowers** the risk of under- or overtreatment in comparison to the more classical open procedures.

- Transoral laser microsurgery provides the optimal situation for taking **accurate frozen section biopsies under magnification**.

- All surgical options are kept open during endoscopic surgery and the procedure may be changed to an external approach at any time. Fundamentally, transoral laser microsurgery is a staging procedure, which allows the surgeon to most accurately assess the real extent of the tumour in a way that endoscopy and imaging techniques cannot match. TLM can be completed or halted without significant oncological disadvantage and conversion to an open surgical procedure, using the CO2 laser and microscope, is always an option.

- **Individualized custom-tailored surgery.** This concept results in an oncologically sound resection of the tumour but maximizes the possible preservation of organ structure and function. As a consequence of **tumour transection**, which is an important principle of TLM, the real extension of the carcinoma is identified in a manner superior to preoperative radiology. The surgeon follows and resects the tumour as a custom-tailored operation. The tumour is completely removed three dimensionally.

- **No reconstructive surgery is necessary** and the circumstances provide favourable conditions for early application of adjuvant treatment [I, 0].

- TLM can be **applied repeatedly** at any stage for the treatment of a local recurrence or second primaries.

- TLM can be **integrated into any therapeutic concept** [I, 0]. **Adjuvant radiotherapy**, either with or without chemotherapy, may be started as early as two weeks after laser resection.

- TLM has a **low perioperative morbidity** and complication rate, with **tracheotomy** being **only rarely indicated**, even after substantial resections. Minimal oedema and lack of serious bleeding keep the overall postoperative complication rate low. Secondary laryngectomy for functional reasons is very rare.

- As a consequence, the mean length of hospital stay the mean duration of the patient’s illness and the overall costs are significantly reduced. The patients are re-integrated into life and work more quickly and completely.
Postoperative Complications*

- **Secondary haemorrhages** are uncommon, but occur most often superior and lateral to the upper edge of the thyroid cartilage. They should be treated using microlaryngoscopy under general anaesthesia with either diathermy or clipping of the vessel.

- **Dyspnoea** is rare, but may require steroid administration, laser excision of oedematous mucosa or, very rarely, tracheotomy.

- **Surgical emphysema** is rare and does not require active intervention. *Prophylaxis.*

- **Severe aspiration** is rare but may require tracheotomy and chest physiotherapy, antibiotics etc.

- **Postoperative pain** is minimal requiring moderate analgesia. Humidification is important to lessen coughing and secretions.

Additional Neck Dissection

Whilst this may be performed synchronously at the time of the primary tumour resection, it can also be performed after an interval of 1 to 2 weeks, when the complete histological report of the resected primary tumour is available. The exact timing of neck dissection may be influenced by non-oncological factors such as age of patient, country of origin, business/family commitments, and the health system in any particular country.

Simultaneous Neck Dissection

This has the advantage of one-time anaesthesia and a single hospital stay. Apart from that, in the case of larger tumours involving the lateral pharyngeal wall, the neck procedure can be undertaken first, allowing ligation in-continuity of vessels to diminish the risk of troublesome bleeding during the following transoral laser resection of the primary tumour. Intraoperative frozen section assessment of the lymph nodes may also be reported whilst the TLM procedure is undertaken.

Delayed Neck Dissection

This later procedure allows further re-resection of the primary tumour, if definitive histology suggests positive margins and may be performed in the same session as selective neck dissection. With extensive tumours of the lateral pharyngeal wall, neck dissection may be delayed for some weeks depending on the depth and extent of the TLM excision. This avoids any potential fistula formation.

The clinical and histological findings derived from the primary TLM procedure may also help in the decision-making with regard to delayed neck dissection, particularly in the No neck when, for example, a significantly deep invasion, lymphatic permeation and vascular invasion is found in the primary tumour site.


With regard to the **exact timing** of delayed dissection, then a **curative neck dissection** for a **N+ neck** is usually performed within one or two weeks after the initial TLM. An **elective selective neck dissection** for a **No neck** can be performed up to six weeks after the primary TLM, when further endoscopy to carry out check biopsies or deal with granulation or scar tissue can be undertaken.

Although not specifically researched, our experience is that patients recover faster and better, particularly with regard to swallowing, if the neck dissection is delayed rather than synchronous with the primary TLM.

### 2 TLM for Laryngeal Carcinoma

#### Glottic Carcinoma in situ, ‘Small’ T1a Carcinoma

**Diagnosis**

Glottic laryngeal carcinoma is suspected when a notable area of mucosa changes, often in the form of leukoplakia, and this most commonly occurs in the middle or anterior part of the mobile vocal fold. Examination is by means of rigid endoscopy (70° or 90°) or flexible endoscopy, which have replaced indirect laryngoscopy in most institutions.

Video stroboscopy and video recording may be made and voice analysis undertaken.

The patient’s risks factors are clearly assessed and documented. The initial clinical impression may be confirmed by cytological diagnosis in some departments.

In Barcelona, narrow band imaging (NBI) is increasingly used to assess the altered vascular supply of areas with cancer, compared to areas with chronic laryngitis.

**Natural History and Patterns of Spread of Glottic Carcinoma**

Carcinoma in-situ/severe dysplasia may exist for long periods of time without progressing to invasive carcinoma following initial TLM excision of the lesion and in these patients it is important that they remove risk factors such as smoking and alcohol. Invasive carcinoma on the vocal folds commonly originates on the free margin of the anterior half of the fold and initially spreads along the surface, most commonly in an anterior direction. This progression is very variable, but eventually the anterior commissure and contralateral vocal fold may be invaded. Occasionally, tumours may grow posteriorly to involve the vocal process or the anterior face of the arytenoid cartilage.

Extension may occur laterally and upward into the ventricle and ventricular fold and inferiorly into the subglottic region, eventually most commonly escaping the confines of the larynx through the cricothyroid membrane.

Tumour involving the anterior commissure may spread in any direction, but usually either superiorly or inferiorly and not uncommonly it invades the lower margin of the thyroid alar. It may extend outside the laryngeal framework through the cricothyroid membrane to become a T4 lesion.

Whole-organ sections of the pharyngo-laryngeal tumours have been undertaken for more than fifty years now and, as a consequence of this detailed research, we have a considerable understanding of the regional
Operative Procedures

Surgical Procedure for Circumscribed Early Lesions of the Mid Vocal Fold (pTis, pT1 small)

In cases with negative cytology or no previous histology, diagnostic / therapeutic excision is undertaken. This involves complete removal of all macroscopic disease of the vocal fold in the form of an excisional biopsy or en bloc resection with the CO₂ laser (Fig. 1).
The aim in all cases is total removal of the lesion and negative margins avoiding a second general anaesthetic, particularly in elderly patients or those with significant medical comorbidity. Hopefully, this will be achieved in more than 95% of patients as modern lasers allow dissection with minimal carbonization and almost bloodless delicate removal under high magnification with sparing of normal tissues.

Small, wet neurosurgical patties (1 x 1 cm) have a number of advantages when used in this surgery:

- They can be used to delicately wipe any char from the wound edge on the vocal fold. This gives maximum definition of the margin from healthy mucosa.
- They can separate and display the lesion clearly from the surrounding healthy mucosa.
- They can be positioned to protect the surrounding healthy mucosa.
- They can control minor bleeding by compression or by using 1 in 1000 adrenaline directly applied onto the neurosurgical patty.
- Only the smallest suction tube and low suction pressure should be used and any minor bleeding should not be coagulated.

The inexperienced surgeon may find it useful to set the laser on an interval mode and outline the lesion initially with series of single impulses in this mode before changing to a continuous setting joining up the line of dots and removing the entire lesion. Removal of these small superficial lesions with an adequate margin and preservation of a maximum of functioning tissue is not always easy and requires some experience to judge the extent of the lesion to achieve a good oncologic and functional result. The inexperienced surgeon commencing transoral laser microsurgery is best to begin removing early tumours from the aryepiglottic fold, suprahypoid epiglottis, or the medial wall of the piriform fossa. Exposure at these sites is usually excellent with a low risk of severe bleeding and the inexperienced surgeon can use the laser in continuous mode assessing the margins and thoroughly removing the lesion without concern that additional removal of an extra few millimetres will make a notable impact on the functional outcome.

It is absolutely essential that margins are clear and if a higher power level is used during debulking of larger lesions, it should be reduced when approaching and assessing margins. When excising segments of large tumours clearly visible tumour close to the margins is left in situ to allow later accurate removal and margin assessment at the periphery of these large lesions.
Pathology Evaluation and Follow-up

The pathologist evaluating the specimen should describe the depth of invasion and the distance between the tumour margin and the resection edge in normal tissue. The decision as to whether further re-resection is required, depends on evaluation of the overall clinical situation in a given patient, as well as the pathology. The findings must be discussed with the patient and a ‘wait-and-see’ policy may be justified in a cooperative patient, rather than an immediate further re-resection sacrificing additional healthy tissue of the vocal fold. The patient must fully cooperate with the subsequent detailed follow-up involving laryngoscopy, stroboscopy, video documentation and smear cytology, if available. Residual/recurrent tumour must be suspected, if healing is delayed, hyperplastic conspicuous scar tissue forms, or the vocal fold shows reduced mobility. A further TLM and excisional biopsy may be indicated (Figs. 2a–c).

2

a Residual tumour after laser surgery.
Glottic carcinoma on the left after a biopsy had been taken at another institution (a).
Four weeks after laser excision. There is erythema of the vocal fold and mushrooming granulation tissue. This was removed under topical anaesthesia. Endoscopic (90° telescope) and histological examination showed no malignancy in the excised specimen (b).
After another 6 weeks, a spindle-shaped swelling of the left vocal fold with a small area of granulation tissue became manifest. Together with the atypical scar formation, this raised the suspicion of residual tumour, which was confirmed cytologically and histologically after a second curative procedure (c).
Unexpected Deep Invasion of the Vocal Fold

The clinical findings, notably stroboscopy, may hint that a superficial looking tumour may be more deeply infiltrating, but when at transoral laser microsurgery the tumour is encountered in the submucosal space and extending into vocal ligament and underlying muscle, it must be resected with a wider clear margin to guarantee removal. Following an adequate excisional biopsy, additional information may be obtained from frozen section and, if necessary, further resection is undertaken of the deeper tissues from the entire wound surface and this second specimen submitted to histology (Fig. 1).

If the surgeon is experienced and feels that all tumour has been removed, a definitive histological result can be awaited. Additional resection may be undertaken at a second procedure, but with increasing experience these further resections become less common. Preoperative counselling in all patients is essential so that these issues are understood.

Previously Biopsied Carcinomas

It would be preferable if all patients with a lesion suspicious of laryngeal carcinoma were sent initially to a specialist referral centre. Unfortunately, that is not the case and previously biopsied glottic areas may be inflamed and granular tissue developing after initial biopsy can make differentiation between healthy tissue and disease more difficult. False-negative and false-positive results are possible. As much possible detail should be obtained from the referring clinician and, whilst too radical a second excisional procedure would lead to a poorer voice, it remains important that all disease is removed. It is obviously particularly important in any patients who have increased anaesthetic risks, that the second procedure has a more generous resection margin to safely remove any residual disease and avoid further microlaryngoscopic procedures. If the second procedure is too conservative, this excision would be of no benefit (Fig. 2a).

In Barcelona, patients having received a prior biopsy usually undergo cordectomy as the next step. If, e.g., a biopsy was taken on the mucosal level of the vocal folds showing affected or unclear margins, a cordectomy type II is performed, the margins are sent for frozen section and the patient is not awakened until all margins are found to be free of tumour.

Preparation of the Excised Specimen

These small specimens must be handled with great care and carefully pinned out and marked out by the surgeon (Fig. 3). The deep surface of the resection may be marked with a pen depending on the pathologist preferences, but everything must be done to help the pathologist with orientation and subsequent examination of the resected tissue.

Step serial sections are necessary for precise evaluation of the margins (Fig. 4). Although the pathologist and surgeon can easily identify the mucosal margin, it is the deep margin, often involving muscle, that is more difficult. This deep margin is the most important and must be clear, as healthy mucosa can grow over the wound covering deeper hidden tumour cells making follow-up evaluation difficult. In contrast, any residual tumour cells at the mucosal margin, or debatable areas of carcinoma in situ, that subsequently produce a new clinical lesion can be clearly seen at follow-up. This mucosal recurrence has a low risk, particularly in the larynx, and is rarely life-threatening.
**T1a ‘large’, T1b Glottic Carcinoma**

Larger T1a lesions may be resected in two or more pieces (Figs. 5, 6, 7a,b).

On the mucosal surface, a clear margin of 1–2 mm is usually sufficient, but if invasion extends beyond 3 millimetres in depth, a more appropriate safety margin may be 2 to 3 mm. If the lesion extends laterally into the ventricle a smaller diameter laryngoscope may allow improved visualization, but alternatively an appropriate portion of the adjacent ventricular fold may be excised to allow the optimal view of the lateral extent, without significant compromise of function. This deep lateral margin and resection within any deep musculature is marked with ink on the resected specimen to assist the pathologist.

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**5 Right-sided glottic carcinoma.** The diagram illustrates the technique for two-part resection. The first incision (a) is made posteriorly through healthy tissue with an adequate safety margin. The second cut goes through the middle of the tumour (b). The tumour borders can be seen on the cut surface (Fig. 6). A margin of 1–3 mm is chosen for resection and the first specimen is obtained by freeing the tumour laterally (c). Subsequently, anterior resection is performed with a margin of healthy tissue (d) and the operation is completed by lateral resection of the remaining tumour.

**6 The drawing shows the cut surface after a cut has been made through the carcinoma of the right vocal fold (T1). This allows the direct inspection of the depth of infiltration of the carcinoma and of the surrounding healthy structures (musculature).**

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**7 Glottic carcinoma (T1) before (a) and after (b) laser resection (endoscopic view, 90°).**
**T1b Tumour of Both Vocal Folds**

Rarely, both vocal folds may have tumour, but with healthy mucosa at the anterior commissure bilateral excision can be completed in a single TLM procedure without the risk of anterior commissure webbing.

Occasional exophytic tumours obstructing the entire anterior glottis require initial debulking, allowing better exposure to ascertain the base of these tumours and particularly to establish if the tumour is arising from just one vocal fold (Fig. 8).

In cases of involvement of the anterior commissure, this must be resected together with the bilateral fold lesion. Dissection is carried out along the thyroid cartilage under high magnification. The perichondrium should be found to be tumour free. This deep margin should be inked to improve orientation for the pathologist. The high recurrence rate reported for tumours involving the anterior commissure has its basis in the underestimation of the inferior and anterior tumour extent in this area. Squamous carcinomas notably infiltrate and break through the cricothyroid membrane. Adequate exposure of the anterior commissure is essential, the thyroid cartilage must be fully exposed and, if needed, parts of the cartilage and cricothyroid membrane may require removal. Attempting to undertake this as a single piece of tissue is rarely satisfactory and it must be sectioned (Fig. 9) to clearly see the real depth of infiltration in any portion of the tumour. The surgeon can easily miss tumour that has grown around the inferior edge of the thyroid cartilage and broken through the cricothyroid membrane.

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**Resection technique for an exophytic tumour of the anterior glottis.** This tumour originates from the right vocal fold and involves the anterior commissure. First, the posterior part of the tumour is resected (1, 2). Subsequently, the main bulk of the lesion is removed by amputating the exophytic component (3). A straight shield is used to protect the healthy left vocal fold. The exact tumour extensions in the anterior commissure become visible after debulking. The remaining tumour is mobilized medially and high magnification of the operating microscope is used to resect the anterior and lateral aspects of the tumour (4–7).

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**Carcinoma of the anterior glottis and subglottis.** In these cases, there is a definite possibility of infiltration not only of the thyroid cartilage, but even more so of the cricothyroid membrane. The resection of these tumours is performed in several pieces. A vertical incision is made in the area of the anterior commissure enabling the surgeon to visualize the deep tumour margin and to assess whether the soft tissues of the neck have been invaded (a). Following antero-inferior dissection along the thyroid cartilage, parts of the cricothyroid membrane can be removed, if required (b). The inferior aspect of the thyroid cartilage must be included in resection if safe removal under microscopic vision is not feasible due to infiltration of the soft tissues of the neck (c).
The CO₂ laser does cause increased carbonization of the cartilage and, if necessary, conventional endoscopic instruments such as a round knife and an elevator can be employed in the dissection of the thyroid cartilage. Laser power can be increased to 10–15 watts to cut through cartilage and the large grasping forceps used to mobilize the pieces II,7.

The perichondrium can be stripped from the cartilage and the deep margin marked for the pathologist. Tissue must be retracted firmly towards the lumen and this minimises the carbonization of the deep resection surface. The line of every section must reach sufficiently far anteriorly and inferiorly into the subglottis. The borders of the carcinoma must be clearly defined with an adequate safety margin.

Those surgeons with limited experience in laser surgery may need to change to an external approach II,5 to ensure exposure and complete resection of these tumours. The more experienced surgeons finding erosion of the thyroid cartilage and infiltration of the soft tissues of the neck can still resect the entire disease from a transoral approach, if the exposure is adequate II,14 II,16. If an external approach is required, then once exposure is obtained, the operation can continue with the same principles of laser microsurgery. Following removal of all tumour, primary closure of the defect using prelaryngeal neck musculature without tracheotomy is often possible II,16 II,22 II,24.

If subsequent laryngoscopy and stroboscopy suggest residual disease, a second laryngoscopy may be performed 4 to 6 weeks later and, if necessary, multiple excisional biopsies should be taken to exclude residual tumour. Shown in Figs. 10a–e is the local aftercare formerly used in Göttingen to prevent web formation II,6.

10 Local aftercare to prevent web formation following resection of a carcinoma of the anterior glottis and subglottis.

Following resection of anterior glottic carcinoma, a wound defect is extending onto the inside of the thyroid cartilage (a). Without local treatment, e.g., swabbing with a cotton wool applicator, a web would develop. The fibrin covering the wound would adhere to the contralateral side, granulation tissue would form abutting in the midline, and finally, epithelium would grow over the granulations and result in solid tissue bridging the anterior glottis (b).

A cotton wool applicator is introduced under endoscopic control. The fibrin is wiped off the anterior glottis close to the thyroid cartilage and adhesions are thereby prevented (c).

In the meantime, epithelization progresses anteriorly in the area of the operated folds are starting to cover the connective tissue that has already formed. The wound healing in the most anterior region in close proximity to the thyroid cartilage remains disturbed by the regular wiping with cotton wool swabs (d).

After 4–5 weeks, a web has developed. The extent of this scar tissue depends on the individual healing characteristic of the patient and on the intensity of the postoperative local treatment (e).
Since the 1990s, bilateral vocal fold lesions with involvement of the anterior commissure are treated with a two-stage procedure in Göttingen. The most significant lesion is removed first and the second contralateral lesion excised 3–4 weeks later. This technique gives excellent functional results without the need for further local postoperative treatment which is inconvenient for both patient and surgeon.

If there is formation of an anterior commissure web with accompanying voice impairment, it may be necessary to remove the scar by laser and apply Mitomycin C (0.4 mg/ml for 3–5 minutes).

**T2a, T2b, T3, T4 Glottic Carcinoma**

Transoral laser microsurgery is recommended for all T2a tumours regardless of the pattern of spread as it is of little significance whether the tumour involves the subglottis and/or supraglottis. Superficially spreading carcinomas are particularly ideal for laser surgery. Large areas of the larynx are sometimes affected by this type of lesion but the carcinoma can be completely resected by extensive mucosectomy of the whole area.

**Please note:** The following comments apply generally for all larger tumours, not only for T2 laryngeal tumours. These tumours may be resected in several pieces and the deep margins stained for better orientation by the pathologist, but it is important with these larger lesions that exact topographic descriptions are provided on the pathology request form and in the patient records. Once again, the emphasis is on the operating surgeon to undertake this.

**Evaluation of deep margins is the most important and most critical aspect here.** In all larger tumours, the surgeon needs to analyse the whole case by bringing together all pieces of information to assess the localization and degree of the disease and thus decide on the possibility of additional resection, adjuvant treatment or careful long-term follow-up. Additional video documentation can assist with both the patient records and subsequent presentation at any pathology or multidisciplinary meeting.

**Involvement of the Arytenoid Mucosa**

Superficial T2 lesions may occasionally spread across the mucosa of the arytenoid cartilages and even into the interarytenoid area, although this is a rare occurrence. The mucosa can sometimes be peeled off these structures and their surrounding ligamentous and muscular structures allowing the function to be preserved following the dissection. Mucosalization of exposed cartilage takes approximately 4 weeks.

For exposure of the arytenoid cartilage see: [11, b. 11, 11, 12. 11, 15b. 11, 16. 11, 20. 11, 23. 11, 26. 11, 27. 11, 46.]

For excision in the interarytenoid region see: [11, 9. 11, 14. 11, 156. 11, 20. 11, 21. 11, 28. 11, 43. 11, 46. 11, 48.]

**The Paraglottic Space**

This space can be completely excised by transoral laser microsurgery and if the lower edge of the thyroid lamina is eroded by tumour, this can be removed until the surgeon is sure that the prelaryngeal tissues are tumour-free. Additionally, partial resection of the superior aspect of the cricoid cartilage may be performed.

For details of paraglottic resection, see: [11, 11, 11, 13a. 11, 13b. 11, 14. 11, 156. 11, 156. 11, 16. 11, 10. 11, 21. 11, 22. 11, 28.].
For cricoid cartilage exposure, see: [II,11] [II,13b] [II,16] [II,18] [II,19] [II,20] [II,21] [II,24] [II,28].

For partial resection of the cricoid cartilage, see: [II,14] [II,15b] [II,16] [II,18] [II,24].

**Subglottic Spread**

Resection of involved interarytenoid area or subglottis is performed at the end of the operation. The endotracheal tube can be mobilized with a small-caliber laryngoscope to improve exposure to the posterior glottis and subglottis. Distending laryngoscopes are not as suitable in this area. The closed laryngoscope of extra length and rounded distal aperture is usually preferable in this region. Moist neurosurgical patties can be carefully placed to protect the endotracheal cuff and often improve exposure to the subglottis and upper trachea by providing some expansion.

Tumour extension into the inferior subglottis and upper trachea is rare and may result in a technically borderline situation for endoscopic surgery. Considerable experience is required and good exposure may require the use of longer small-calibre laryngoscopes and removal of the endotracheal tube with subsequent apnoea or jet ventilation techniques. Superficial lesions may not be difficult, but it is vitally important not to miss deep infiltration of cartilage and extension out between the cricoid and first tracheal ring.

For subglottic spread, see: [II,11] [II,13a] [II,13b] [II,14] [II,15a] [II,15b] [II,16] [II,18] [II,21] [II,22] [II,24] [II,28].

For trachea, see: [II,25].

Visualization of the subglottic area is improved in Barcelona with jet ventilation. It is very important to reduce oxygenation down to 40% in order to avoid ignition. Generally, the area below the posterior commissure is the most difficult to expose.

**Impaired vocal fold mobility** or **fixation** of the vocal fold (with / without involvement of arytenoid cartilage) is usually diagnosed at laryngoscopy, but additional information may be obtained by CT or MRI, although these imaging studies may give false-positives and false-negatives. At transoral laser microsurgery, the variable extension of these tumours along the mucosal surface and into underlying tissue can be clearly seen. They may spread to and involve the musculature of the paraglottic space, the perichondrium and / or thyroid cartilage, the arytenoid and cricoid cartilages, the supraglottis and subglottis.

There are some disadvantages of using the CO₂ laser to resect cartilage. A high level of power is required often producing flashes from the cartilage with increased thermal damage of tissue and the risk of damage to larger extralaryngeal vessels with accompanying significant haemorrhage. As outlined earlier, additional use of conventional endoscopic instruments can be valuable to assist cartilage removal.

Finally, the **disease may reach the soft tissues of the neck** via the cricothyroid membrane or erosion through the thyroid cartilage. The varying forms of tumour spread must be carefully recorded in the patient’s oncology files to exactly correlate clinical, intraoperative and histological findings.
Operative Procedures
For all advanced tumours of the glottis, laser incisions are made through the tumour to divide it into smaller manageable portions and to assess the depth of invasion in any extension of the tumour. Incisions may be carried laterally onto the thyroid cartilage and to the superior aspect of the cricoid cartilage. If musculature is invaded up to the perichondrium, the tumour is resected by dissecting along the inner table of the thyroid cartilage, stripping off perichondrium, and if necessary, removing any suspected areas of infiltration in the thyroid cartilage. Laser incisions can be made through the thyroid cartilage and the involved portion excised. Specimens from adjacent prelaryngeal soft tissues are occasionally required to verify the completeness of the resection.

In Barcelona, the debulking technique is frequently performed by continuous wave application (scanner) which is a very fast technique. Once the areas of healthy tissue are reached, the cutting superpulse mode is used.

The Arytenoid Cartilage
Multiple previous transoral laser microsurgical resections have shown that impaired mobility and fixation need not be the result of infiltration of the arytenoid cartilage or the cricoarytenoid joint. Resection of the arytenoid cartilage is not necessary at the beginning of these operative procedures and during removal of the tumour an incision may be made between the vocal process and the body of the arytenoid cartilage to assess whether the tumour extension in a posterior direction does not involve the cricoarytenoid joint (Figs. 11a–c).

Extensive carcinoma of the right vocal fold with (queried) involvement of the arytenoid cartilage.
If the tumour reaches the area of the right arytenoid cartilage resulting in fixation or decreased movement, an initial exploratory incision is made immediately anterior to the body of the arytenoid. This uncovers the actual, submucosal, posterior extent of the tumour. Muscular and ligamentous structures in the proximity of the arytenoid can be infiltrated without actual involvement of the cartilage itself. Using this stepwise approach, it is often possible to preserve large parts or the entire arytenoid cartilage, if impaired mobility was not caused by its immediate involvement in the disease process (a).
The anterior mass, particularly of exophytic tumours, is initially resected to improve vision in the case of extensive glottic lesions that spread to the arytenoid cartilages and the interarytenoid area (b). The tube can then be displaced anteriorly in order to improve exposure of the posterior larynx (c).
However, if the arytenoid cartilage is involved and infiltrated in its ligamentous and muscular attachment, an attempt should still be made to preserve the posterolateral mucosal surface of the arytenoid and to limit the resection to only those parts of the cartilage, that need to be removed from an oncological point of view. By preserving the mucosal cover of the arytenoid cartilage and any relevant portion of the body, the patient retains tissue which is functionally important for laryngeal protection during swallowing.

A meticulous dissection technique under high magnification with retraction of the cartilage in different directions is necessary to cut the cartilage cleanly. Occasionally conventional microlaryngoscopic instruments such as scissors can be useful.

For partial arytenoid resection see: I, b and II, 4 II, 17 II, 22 II, 30 II, 46.

For (near) total arytenoid resection see: II, 10 II, 13b II, 18 II, 21 II, 24 II, 28.

**Postoperative Management for Advanced Laryngeal Tumours**

Occasionally, elderly patients with extensive partial resection of laryngeal carcinomas may require **intubation for 24 hours**. If this is not an option, occasionally a tracheotomy should be considered. The vast majority of glottic lesions will not require a tracheotomy and anterior glottic, subglottic and lateral resections have little impact on the function of swallowing, but this is a varying issue, not always predictable in patients. A nasogastric feeding tube should be inserted in patients who have undergone a complete resection of an arytenoid cartilage.

**Antibiotics**

Perioperative antibiotics are only given if large parts of thyroid and/or cricoid cartilage have been exposed or resected.

**Haemorrhage**

Postoperative haemorrhages are rare in transoral lasersurgery for glottic carcinomas and can usually be successfully managed by **electrocautery** at microlaryngoscopy.

**Oedema**

Very occasionally, oedema may be sufficient to affect the airway and normally rapid administration of **steroids** is usually sufficient to treat this, but occasionally, surgical removal may be required for excess oedematous mucosa II, 24.

The tendency to postoperative **aspiration** in the advanced cases is very variable between patients.

**Adjuvant Radiotherapy**

If adjuvant radiotherapy is considered after the more extensive resections, notably with additional advanced neck disease, the insertion of a percutaneous endoscopic gastrostomy with / without a **tracheotomy** should be contemplated at an early stage of the treatment.

**Wound Healing**

Varying degrees of fibrinous exudate and granulation occur on the wound surface. Surgical removal is only necessary if the airway or voice are significantly impaired and is usually carried out between 6–12 weeks post primary surgery. **Persistent granulation tissue, unusual scar tissue or**
new tissue formation, such as hyperplasia, leukoplakia, or papilliferous change, should always raise the suspicion of residual disease. Stroboscopy under magnification and smear cytology aid postoperative follow-up examination. Any suspicious areas should be completely excised by laser under microscopic control (Figs. 2a–c).

**Conclusion**

There is no justification for advocating laser surgery as the only treatment for malignant laryngeal tumours. The preferred treatment will depend on the localization and extent of disease, the patients medical comorbidities, and the expertise and experience available in different countries. It does, however, provide a comprehensive low-morbidity treatment with minimal inpatient stay and long-term results comparable to or better than other oncological treatments.

**Supraglottic Carcinoma**

**Diagnosis and Endoscopic Evaluation**

**Endoscopy**

In Göttingen, initial outpatient rigid endoscopy involves evaluation of the tumour, laryngo-pharyngeal function and video documentation. If the tumour is not histologically proved, a frozen section obtained by intraoperative laser biopsy at initial panendoscopy is performed under general anaesthesia, prior to proceeding to definitive transoral laser resection of the tumour.

In Barcelona, initial endoscopy under general anaesthesia is undertaken to evaluate the site and extent of the primary tumour and to take appropriate biopsies if a definite histological diagnosis has not been established yet. Further panendoscopy is undertaken after transoral laser removal of the primary tumour, whilst awaiting for confirmation of frozen sections taken during excision of the primary tumour. This saves time during the overall procedure.

The bronchi are examined using rigid endoscopes. A rigid oesophagoscope is used to evaluate the lower hypopharynx and upper two thirds of the oesophagus, in order to exclude a second primary tumour. The base of tongue is also carefully palpated to assist exclusion of any submucosal tumour.

**Imaging**

In Göttingen, ultrasound examination is undertaken for both sides of the neck but further imaging with MRI and/or CT has not been done routinely and is only considered in very advanced tumours when massive infiltration of lateral neck tissues is suspected and transoral resection contraindicated. The basic principle is for the surgeon to be guided by the intraoperative findings, which are more accurate than even modern imaging, and to adjust the operation accordingly.

In Barcelona, for all but small T1 tumours clearly seen endoscopically, the patients preoperatively undergo CT scanning of the primary and of the neck, with contrast enhancement to evaluate nodal disease. Bilateral nodal disease is common in large supraglottic tumours. Some additional evidence may be obtained for invasion of the tumour in or around the larynx, but care must be taken here because in terms of cartilage invasion, even the most recent CT scanning remains somewhat unreliable with up to 40% false-negatives. Narrow band imaging is increasingly used in Barcelona to further identify high-risk areas.
### Anaesthesia

For small supraglottic tumours, jet ventilation may be employed in Barcelona, but in the case of larger tumours with an increased susceptibility to significant bleeding, the preference is to intubate the patient with a number 5 Mallinckrodt tube, as is the practice in Göttingen. The tube is covered by saline-soaked neurosurgical patties in a manner identical to the protocol employed in Göttingen. Although the laser is predominantly used at a low power setting, with larger tumours and areas requiring resection of cartilage, it may be necessary to use superpulse mode at 10 watts or higher. Additionally, with large, bulky tumours, the team in Barcelona have used a scanner which may speed up the process of debulking the tumour.

### Operative Procedures

#### Suprahyoid Epiglottis

The only acceptable en bloc procedure for a supraglottic tumour is the circumscribed removal of an early T1 lesion on the free edge of the suprahyoid epiglottis. This is technically easy and allows wide margins with no functional implications, in contrast to T1 glottic tumours (Figs. 12a–b).

![A circumscribed tumour of the suprahyoid epiglottis can be safely and completely resected in one piece along the resection line shown in the drawings (a, b).](image)

Additionally involved areas of the adjacent ventricular fold can also be easily removed. Even with these early tumours, careful postoperative follow-up is required to assess the appearance of any nodal disease within the neck. In both Göttingen and Barcelona the preference is for a high definition ultrasound examination of the neck at intervals of 2–3 months for the first 2 years to make absolutely sure that the patient’s neck remains No.
Infrahyoid Epiglottis

If the tumour involves the infrahyoid epiglottis, the risk of spread into the preepiglottic space is considerable, even if there is no indication on the imaging. Under these circumstances, the entire epiglottis must be removed, along with the fat of the preepiglottic space to provide accurate histological examination and evaluation as to whether the tumour has spread into this area.

Inferior extension of a supraglottic tumour to the anterior commissure requires a radical resection of the anterior commissure area in the same manner as the treatment of tumours arising at the anterior commissure. The whole area must be thoroughly cleaned to the thyroid cartilage with resection of adjacent cartilage, if necessary, to make sure that this area is entirely cleared from tumour. A considerable advantage of this procedure is that once the whole epiglottis has been removed, along with the supraglottic tumour, an excellent view is obtained of the anterior commissure area, which is not always the case when dealing with a glottic tumour extending to the anterior commissure. Where the larger tumours infiltrate the preepiglottic space, it is necessary and feasible to obtain resection margins of 5–10 mm without significant functional compromise.

**T2/T3/T4 Supraglottic Tumours**

As with transoral surgery for all large tumours, the basic concept is to follow the tumour and adjust the procedure to the size and extension of the cancer in each individual case. As described above, the larger tumours may infiltrate the infrahyoid area extensively, reaching to the petiole and the anterior commissure. Tumours of the infrahyoid epiglottis must always be considered to have infiltrated the preepiglottic space, even in the absence of radiological evidence. A notable advantage of the transoral laser technique is that the tumour can be clearly seen at operation and a tumour-free excision margin of 5–10 mm is commonly achieved (Figs. 13a–b).

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**Fig. 13** Resection lines for a supraglottic carcinoma involving the preepiglottic space.
Once the tumour bloc is removed, further areas of excisional biopsies should be undertaken, if there are doubts about negative margins. Surgeons early in their career with transoral laser techniques should not be overly concerned by this larger margin, as in supraglottic tumours it does not make a significant difference to postoperative function. It is extremely important not to compromise on the entire excision of the tumour. Those patients having excision of large supraglottic tumours have a fine bore nasogastric tube inserted at the time of the operation and this may require to remain in place for 1–3 weeks whilst the area heals.

With the larger supraglottic tumours, it may occasionally be necessary to excise the superior aspect of the thyroid cartilage, and here again, the oncological surgeon must be aggressive as frozen section evaluation of this part of the resection is not possible. The spot size of the laser beam is decreased and the power increased in order to achieve a satisfactory resection of cartilage, with the additional use of conventional instruments, forceps and suction.

**Absolute haemostasis** must be obtained in the soft tissues and double clipping of superior laryngeal vessels in addition to coagulation, is necessary in all patients. There is an increased potential for supraglottic tumours to bleed both at and after resection, in contrast to the more common glottic tumours. The double-clipping technique reduces the risk of this potentially serious complication. In those patients with extensive tumours who have simultaneous bilateral neck dissection, it is a simple matter to ligate the superior laryngeal vessels at the time of the neck surgery.

**Advantages of the TLM supraglottic partial laryngectomy over the classic conventional open operation of Alonso.**

- The almost bloodless microscopic dissection allows the surgeon to limit the resection to those structures affected by tumour.
- Thyroid cartilage, superior laryngeal vessels and nerves can often be spared with a high degree of oncological safety and minimal functional impairment.
- There is minimal blood loss and rarely the need for a tracheotomy.
- The patients have faster and better rehabilitation of swallowing and voice.
- They have a shorter hospital stay and less chance of long-term supraglottic stenosis.

**Extralaryngeal Disease**

In Göttingen, tumours involving thyroid and arytenoid cartilages and breaking through the thyrohyoid membrane or the thyroid cartilage into the soft tissues of the neck have been followed as far as the subcutaneous tissues with complete removal.

In Barcelona, the policy is not to use transoral laser surgery for obvious T4 cases with involvement of extralaryngeal tissues, but a significant proportion of T3 cases may be found to have small amounts of extralaryngeal disease not seen on modern imaging. Following resection of parts of the thyroid cartilage, it may be necessary to follow the tumour to a limited degree into extralaryngeal tissues. Those tumours, which are firm and well circumscribed allow a thorough removal from these extralaryngeal tissues, but the more unusual form of soft, diffuse tumour does not always allow a safe oncological removal at this point of the procedure. If exposure is not adequate, conversion to open (laser) surgery may be required.
Postoperative Management

Longer lasting swallowing problems must be expected after major resections extending into the tongue base and/or hypopharynx and tracheotomy and/or percutaneous endoscopic gastrostomy (PEG) may be necessary with

- Elderly patients.
- Patients with compromised respiratory function and reserve.
- Bleeding tendency (patients on warfarin, haemodialysis etc.).
- Expectation of postoperative adjuvant radiotherapy.

Antibiotics

Other than patients with known chronic obstructive pulmonary disease who may require antibiotics, there is no particular antibiotic prescribing postoperatively.

Surgical Emphysema

To prevent emphysema, in Göttingen a firm bandage to the neck is applied and, if despite this measure some emphysema occurs, it is treated expectantly.

Haemorrhage

Those patients, who have had extensive supraglottic tumours remain in hospital for a minimum of 7–8 days as a consequence of the possibility of postoperative bleeding. Occasionally, patients may be required to return to theatre for coagulation or clipping at microlaryngoscopy under general anaesthesia. It can be difficult to find a notable bleeding point in the areas of oedema, exudation and fibrin formation. The operating surgeon needs to suction away or to remove by laser thoroughly the overlying layers to define the bleeding point with accuracy.

Swallowing

Patients commence swallowing postoperatively on a soft diet with a doctor or head and neck speech/swallowing therapist in attendance at the time of the initial swallowing. In most cases, rehabilitation of swallowing occurs in a time period of 2–4 weeks.

Tracheotomy

In Barcelona, tracheotomy is undertaken in those patients who present as an emergency with a large, obstructing supraglottic tumour, or in those cases where the anaesthetist requests this at the time of general anaesthesia, because intubation is difficult or dangerous. In Göttingen, the surgeon's policy is to perform intubation under direct laryngoscopy and to laser debulk large obstructing tumours prior to further assessment and definitive treatment.

Additional Neck Dissection

In Barcelona, patients with pT2–4, N0/+ tumours, have bilateral, mainly selective neck dissections of levels 2 and 3 performed immediately following the primary TLM. This also allows external ligation of superior laryngeal vessels if there are concerns with possible haemorrhage.

If the procedure is delayed (Göttingen) – e.g., 1 week in N+ necks – it does allow assessment of the definitive pathology report and a further opportunity to go back to the primary site endoscopically if there are concerns about any margin.

N0 necks may be treated with selective neck dissection after 4 – 6 weeks or reviewed at intervals of 2–3 months by ultrasound and, if needed, rescued by neck dissection, if a positive node is detected.
Preoperative Diagnosis

Inspection of the oral cavity and oropharynx is undertaken with the microscope aided by gags, tongue depressors and retractors, as necessary. Full panendoscopy and palpation of the tongue base is as previously described. Excessive alcohol and tobacco consumption is common in these patients and synchronous and metachronous tumours must be ruled out and the patients appropriately counselled.

In younger patients, the recent increase in HPV-related oropharyngeal squamous carcinomas is causing concern in many countries and preoperative biopsy analysis for HPV should be undertaken as it is important with regard to treatment and prognosis.

Lesions may have had previous cytological evaluation or inadequate biopsies undertaken under local anaesthetic. Small, circumscribed lesions are completely excised with the laser under the microscope, and more extensive disease is evaluated by deep incisional laser biopsy. The depth of these lesions is an important prognostic factor and needs adequate biopsy for evaluation and further careful consideration at subsequent surgery.

Operative Procedures

There are some notable differences in the laser excision of early lesions in the oral cavity and oropharynx from lesions elsewhere in the upper aerodigestive tract.

Small T1 lesions up to 10 mm in diameter are excised en bloc, but with a relatively wide margin of 5 – 10 mm. It is important to maintain this distance from the deep edge of the tumour, and it is equally important not to angle the laser excision edge towards the deep margin during excision. At histology, attention should be given to deep margin evaluation and multiple thin slices must be taken through the specimen to detect any protrusions into the deeper muscle. Larger lesions may require resection in several pieces and the surgeon must carefully select the relevant margin pieces for the pathologist, correctly marking the important deep margin for evaluation. With very large tumours some debulking may be undertaken which are simply large tumour pieces with no relevant margins. Whilst all this material is sent to the pathologist it is important to consider the overall workload of the pathologist and to only ask for detailed evaluation of the important margin specimens. It is usually the deep margin that is the important one requiring marking and only occasionally does the mucosal margin require specific marking. It is important during debulking to leave clearly visible pieces of tumour close to the margins so that three dimensional excisional biopsies can then be taken subsequently of the high risk margins. Occasionally, as in conventional surgery, it may not be completely possible to totally prove clear margins if they comprise a large vessel, nerve, or bone. The emphasis is on the surgeon to provide the pathologist with the best possible material and details and to constantly liaise with this key colleague.
From a technical viewpoint of surgery, these areas are divided into three groups, which are:

- Floor of mouth, buccal area with retromolar trigone, palate and posterior wall of oropharynx.
- Tongue, base of tongue, and vallecula.
- Tonsil and lateral wall of oropharynx.

There are fundamental principles common to all these sites, but also differences, which will be highlighted below.

**Fundamental Principles Common to All Sites**

Access to lesions in the oral cavity is usually obtained easily, except for patients with severe trismus. Gags, dental blocks, tongue depressors and specialized retractors, all have their function in particular cases and those with integrated suction channels aid in the removal of laser plume. An assistant using a large-bore pharyngeal sucker can keep the operative view clear of plume, and additionally, a large-bore intranasal suction catheter can be used.

Nasal intubation can assist in improving vision in many cases, but is not essential.

Tumours of the oropharynx may require the use of the large-bore, short STERNER distending oropharyngoscope (with chest support).

Tumours above 10 mm in diameter are initially divided by one or more cuts made into the tumour to directly assess the depth of invasion, a step of crucial importance, as outlined above. These larger lesions are excised in portions and are always subjected to a full evaluation of margins. They are not excised en bloc in the manner of conventional surgery.

In contrast to surgery of the larynx and hypopharynx, small bleeding points may be controlled by bipolar electrocautery, while haemostasis of larger bleeding points may be accomplished by ligation rather than clipping, though the latter is reliable if double clipping of vessels is undertaken.

Wound areas may be covered with collagen mesh and fibrin glue. Nasogastric tubes are commonly required for short periods in the case of larger tumours.

**Floor of Mouth**

These tumours can be followed into the surrounding tissues, irrespective of direction or extent of spread, in all but the most advanced cases. The head position may require multiple readjustment when the tumour extends to the tongue or mandible (Figs. 14a–c).
If massive deep infiltration of the musculature is found, the laser excision may be extended, requiring removal of the sublingual glands and portions of the submandibular ducts or gland. This rarely poses problems and at subsequent delayed neck dissection, the submandibular gland/glands may be removed. Delaying the neck dissection prevents fistula formation and does not affect prognosis.

If the tumour just reaches the mandible, the periosteum can be dissected off and its deep surface marked with ink and sent for frozen section analysis. If the bone is infiltrated, the area is widely excised using the laser and conventional instruments with partial resection being possible in many cases.

The bone adjacent to a laser wound can be left to heal spontaneously after partial resection in many cases. Patients rinse their mouths with antiseptic solution several times daily and receive prophylactic antibiotics for 10 days. Wound healing takes 3–4 weeks, or longer in the case of larger tumours, but is only delayed usually in cases receiving (preoperative) radiotherapy.

Nutrition throughout the perioperative period is important, as too is patient compliance, particularly alcohol abstinence. Active tongue movement exercises directed by a head and neck speech and language specialist are extremely useful beginning early postoperatively.

**Buccal Mucosa and Palate**

Early superficial and exophytic lesions of the **buccal mucosa**, that do not infiltrate deeply into the parotid gland or skin, can be resected by TLM. The wounds heal spontaneously and the parotid duct continues to function, even when partially excised. For advanced lesions, conventional surgery with reconstruction may be required.

Lesions of the **soft palate** are amenable to removal by TLM, whilst protecting the posterior nasopharyngeal and oropharyngeal mucosa with moist swabs or neurosurgical patties. Reconstruction is rarely required even with extensive removal of the soft palate. If adjacent hard palate needs to be removed in addition to the soft palate, a dental prosthesis assists with speech and swallowing. Free flap reconstruction is only occasionally required (Figs. 15a–c).
**Posterior Oropharyngeal Wall**

These lesions may extend superiorly into the nasopharynx or inferiorly into the hypopharynx but rarely present technical difficulties during surgery. The STEINER distending oropharyngoscope or laryngopharyngoscope have shown to be very useful in removing an inferiorly extending tumour and temporary splitting of the soft palate in the case of superior extension is rarely needed.

The laser wounds heal well in this area, but swallowing may initially be significantly impaired due to scarring with decreased pharyngeal mobility and sensation (Figs. 16a–c).

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**Tongue, Base of Tongue and Vallecula**

Although the exposure and removal of tongue lesions with the laser often seems to be a technically easy task, accurate identification of tumour margins, particularly the deep margin, can be difficult on account of the following factors:

- Increased char formation due to the glandular and vascular elements of tongue tissue.
- Intraoperative differentiation of normal tissue from tumour is more difficult than in the larynx.
- Deep tumour extensions are relatively common.
- Advanced cancers may require up to 75% of the tongue, being removed with significant initial functional problems.

Advanced tongue cancer may have a poor prognosis related to regional and distant metastases, second primary tumours or systemic disease. Combined synchronous chemotherapy and radiotherapy may be the preferred option for advanced disease in centres where it is available. Radical excisional surgery, such as total glossectomy, with or without total laryngectomy, is rarely indicated.

TLM excision for T1, T2 and selected cases of T3/4, with or without selective neck dissection, offers a lower morbidity and better functional result than combined synchronous chemoradiation.
Haemostasis is achieved by bipolar diathermy or suction diathermy for smaller vessels and ligation, stitch ligation, or double clipping of larger vessels. Small laser wounds do not require stitching and heal with excellent function.

Large hemiglossectomy-size resections may benefit from sutures for 5–6 days to reduce bleeding and discomfort from the raw area allowing an early onset of oral feeding. Reconstruction is not required and does not improve subsequent function, which depends largely on tongue mobility, not volume.

**Tongue base** lesions are arguably the most unfavourable for TLM, especially if exposure proves difficult. However, if full excision is feasible, the subsequent healing and functional outcome exceeds that of conventional surgery and reconstruction. The lingual tonsil tissue adds to the difficulty of differentiating between tumour and normal tissue and more frozen section evaluation may be required initially until the surgeon has gained in experience. Surrounding anatomical landmarks are less obvious in the tongue base and care to remain oriented is required. Protrusion of the tongue base into the line of vision is prevented by using the STEINER distending oropharyngoscope with right and left lateral wings.

Small lesions (approx. 5 mm) are rare, but can be excised en bloc with a generous margin of at least 5 mm. However, most tongue base lesions are considerably larger and all require multiple cuts through the tumour (with a minimum of two cuts perpendicular to each other through the centre of the tumour).

**Useful Practical Hints for TLM of the Base of Tongue:**

- Pull the tongue well forward before inserting the oropharyngoscope, which then helps to maintain this position. A tongue depressor may assist in insertion.
- Remember to intermittently remove the oropharyngoscope to release traction on the tongue and also assess the whole tongue base area with an anaesthetic laryngoscope, and 30° / 70° endoscopes, so as to achieve an accurate overall assessment of the tongue base.
- Use low power settings in superpulse mode at 4–6 watts through healthy tissue to avoid charring. Likewise, avoid tangential cutting with increased charring.
- Proceed layer by layer, keeping your precise orientation and avoiding deep exploration in any one area.
- Remove manageable blocks of tissue and provide immediate haemostasis to maintain a clear view of tissue.
- Examine the cut surface under the highest possible magnification. *Frozen sections* are often required, but the **most important sections of the larger tumours are those in the final stages, where margins need to be assessed promptly**, once the major tumour bulk has been removed. The specimens should be carefully orientated and marked for the pathologist.
- The surgeon should be well aware of the propensity for submucosal spread and multiple microscopic foci of these tumours and to take generous specimens of the wound cavity in all three dimensions for submission to the pathologist.
Lateral Oropharyngeal Wall:
Tonsil, Glossotonsillar Groove and Palatal Arches

Surgery and histological evaluation of the tonsil differs from other regions. Elsewhere, small circumscribed lesions of 5–10 mm can be excised en bloc, but for early stage tonsil lesions, the minimal excision is a tonsillectomy. Early tumours may grow submucosally and may be microinvasive carcinomas only detected as part of the workup for an unknown primary tumour. The histological assessment requires multiple serial sectioning of the whole tonsil (Figs. 17a–b).

Larger tonsillar tumours require preoperative CT and MRI assessment to assist in evaluating the depth of extension (Figs. 18a–b). At surgery, at least three horizontal incisions, superior, inferior and mid tonsil, are made initially to assess depth of tumour as the close proximity of the carotid vasculature limits the lateral extent of resection. Additional spread into the floor of mouth, tongue and hypopharynx can usually be resected, but superior extension to the Eustachian tube is a contraindication.

Tonsillar carcinoma on the left side in a young woman.
The exophytic tumour can be seen before laser resection (a). Several metastases were found in the specimen obtained from ipsilateral selective neck dissection. Findings after intraoral laser resection (b). The patient did not have postoperative radiotherapy and has been disease-free for more than 18 years.
Useful Practical Hints for TLM of the Tonsil:

- Differentiation of tumour and normal tonsillar tissue is difficult within the tonsil (due to the lymphatic tissue and inflammation, which causes more carbonization.) In contrast, it is much easier outside the capsule in the pharyngeal muscle. Remember, complete tonsillectomy is the minimal procedure.

- If the tumour extends laterally through the pharyngeal muscle, look for pulsation and carefully assess fascia and fatty tissue in this space. Work under high magnification and use the laser at low power, proceeding cautiously. Alongside the carotid vessels, conventional grasping forceps and suction may be used. Smaller vascular branches may be clipped and the defect covered with collagen mesh and fibrin glue.

- The glossotonsillar groove is a high risk area for deeper resections and requires excellent exposure and care with the lingual artery, and hypoglossal nerve.

- If a larger tumour cannot be completely resected in an intraoral approach or if there is a substantial risk of secondary haemorrhage, then the neck may be opened and the feeding vessels ligated. A neck dissection can be performed in the same session and a local muscle flap may be used to cover the defect in a few cases, if required.

The drawing demonstrates on the right side the close proximity of the great vessels and delineates the limits of the intraoral operation. An abnormal course of the internal carotid artery is shown on the left side. In rare instances, the vessel can reach to within a few millimeters of the tonsillar capsule.

![Diagram of arteries of the head and neck](image_url)

Corrosion specimen of the arteries of the head and neck showing the anatomical relation of the pharynx to the great vessels. This knowledge helps to avoid severe intra- and postoperative bleedings.

- Inferior labial a.
- Facial a.
- Internal carotid a. (loop formation)
- Ascending palatine a.
- External carotid a.
- Lingual a.
- External carotid a.
- Ascending pharyngeal a.
- Ossified thyroid cartilage
- Superior laryngeal a.
- Cricothyroid a.
- Superior thyroid a.
- Common carotid a.
- Inferior thyroid a.
- Subclavian a.
- Thyrocervical trunk

 Courtesy of Prof. em. Bernhard N. Tillmann, Institute of Anatomy, Christian Albrechts University of Kiel, Germany.
Postoperative Management

Pain

Pain is not severe after most oropharyngeal laser resections but some patients do have severe neuralgia-type pain radiating to the ear and require appropriate analgesia. Pain should be controlled at all times to promote early swallowing and obviate the tendency for saliva to accumulate in the mouth.

Haemorrhage

Unlike laryngeal TLM, bleeding is more frequent and potentially severe in all areas of the oral cavity and oropharynx. The lingual artery and its branches carry the highest risk and should always be double-clipped or ligated. There is no increased postoperative risk of bleeding from lateral wall resections in comparison to routine tonsillectomy, but it may be more severe and require return to theatre to deal with under general anaesthesia.

Functional Disturbance

Bilateral section of the hypoglossal nerves causes very severe swallowing and speech problems and must be avoided. Pain control is essential, and early tongue mobilization exercises explained and encouraged by the doctor or head and neck speech/swallowing therapist. Loss of sensation and motor function must be understood, but early return of excellent function is possible with preoperative and early postoperative patient instruction. These early swallowing exercises are of paramount importance.

PEG Tube

The insertion of a PEG tube prior to major resection may be undertaken if this service is available. It is best before surgery, not after, when patients feel that they have ‘failed’ to swallow. It is essential if adjuvant radiotherapy and chemotherapy are likely in cases with advanced metastatic disease. Even with a PEG tube in place, the early postoperative tongue mobilization exercises are of paramount importance before, during and after chemoradiotherapy to prevent immobility due to scarring and increasing fibrosis. Waiting for swallowing therapy to begin weeks after treatment is inappropriate.

Postoperative Follow-up

Regular oral and pharyngolaryngeal endoscopic assessment and ultrasound examination of the neck are essential. They may be supplemented by CT and / or MRI in high-risk patients at 6-month intervals, particularly if these assessments have been carried out preoperatively so that accurate comparison of preoperative and postoperative images can be made.
**TLM for Tumours of the Hypopharynx**

Hypopharyngeal tumours are classified by their subsite of origin, namely, the piriform fossa, the postcricoid region and the posterior hypopharyngeal wall. A transoral approach and resection planning must take into account the known deep patterns of spread beyond those specific loci of origin: for TLM to succeed, the furthest reach of these tumours needs to be accessible and resectable to a negative margin.

**Diagnosis and Endoscopic Evaluation**

**Endoscopy, Mapping Biopsies and Case Selection**

Endoscopy on the awake patient with phonation may allow better assessment of the piriform fossa and postcricoid region.

In Barcelona, fibreoptic nasendoscopy on the awake patient is improved by performing a Valsalva maneuver, which closes the larynx and fully opens the piriform fossae and sometimes even allows inspection of the postcricoid area.

To determine access for transoral approaches, feasibility of conservation procedures and accurate evaluation of tumour spread, panendoscopic examination of the aero- and upper digestive tract under general anaesthesia is of paramount importance. Haughey recommends that except for small tumours, the endoscopy be separately scheduled from the main resection. This is especially pertinent if the tumour is persistent following chemoradiation treatment failure, when even extensive submucosal spread well beyond visible tumour is often seen. In these and most circumstances, mapping biopsies prior to resection are especially helpful, sampled from the intended peripheral margins of resection, and submitted for permanent section analysis.

The ideal case is one in which insertion and opening of the bivalved scopes gives an excellent view of a clearly delineated lesion and Extensive posterior laryngeal invasion that precludes function-preserving partial surgery, gross tongue base involvement, circumferential or near-circumferential oesophageal spread, and involvement of the carotid sheath are contraindications for transoral resection. An exception to this is seen in Imaging

**Imaging**

Computed tomography or magnetic resonance imaging may be helpful for assessment of tumour extent, particularly laryngeal or extrapharyngeal spread and cartilage involvement. Preoperative ultrasound examination of the neck for nodal metastases, refined further by fine needle biopsy is especially helpful in neck node (N) staging and neck surgery planning. These studies supersede the anatomic detail of PET-CT and its positive / negative predictive value when ultrasound-guided fine needle aspiration is added, to elucidate nodal involvement. Adequate investigation for distant metastasis, either by CT, MRI or PET-CT should be considered, especially in the presence of neck metastasis.

It should be noted, however, that the tight confines of the hypopharynx may limit clear depiction and / or an accurate radiologist’s interpretation of tumour extent on imaging, especially at the primary site. This underscores the need for careful endoscopy.
Co-Morbidities

Pulmonary function status is an important consideration during preoperative planning of conservation, transoral surgery for hypopharyngeal cancer. This is assessed on the grounds of history, physical examination of the chest and pulmonary function studies. Particular caution is relevant in cases where there will be partial supraglottic, arytenoid or paraglottic space resection: under these circumstances, perioperative tracheotomy is usually advisable (Haughey).

Correction of anemia in cases of Patterson Brown Kelly syndrome is advised, as is standard (e.g., cardiac) anaesthetic risk assessment, especially for smokers.

Natural History and Patterns of Spread of Hypopharyngeal Carcinoma

Piriform Fossa

Piriform fossa tumours arising from the medial wall infiltrate the aryepiglottic fold and spread into larynx, reaching both the paraglottic space and preepiglottic space. The former space can also be involved by direct anterior spread from tumours infiltrating from the anterior angle of the piriform fossa, resulting in endolaryngeal extension without obvious mucosal involvement. Posteromedial extension into the postcricoid area, leading to posterior cricoarytenoid muscle infiltration will immobilize the ipsilateral vocal fold due to loss of abduction. Less commonly, direct invasion of the cricoarytenoid joint and/or the recurrent laryngeal nerve also results in fixation of the hemilarynx.

Tumours arising in the lateral piriform wall, however, may extend laterally through the inferior constrictor's insertion and around the posterior border of the lamina of the thyroid cartilage or laterally invade and erode the posterior cartilage/bone directly. This way, they extend to the outer thyroid lamina, the strap muscles, and about or surround the common carotid artery. When these tumours extend posteromedially, they involve the posterior hypopharyngeal wall, at both the mucosal and constrictor level. With superior extension up the lateral oropharyngeal wall, these tumours sometimes ascend deeply along the superior cornu of the thyroid cartilage.

Postcricoid and Posterior Wall

Deep extension of postcricoid tumours can result in contralateral spread, involvement of the posterior cricoarytenoid muscle(s) and the cricoarytenoid joint(s). Inferior extension from postcricoid tumours or piriform apex lesions can encroach upon the cricoid cartilage. Postcricoid as well as posterior hypopharyngeal wall tumours tend to spread inferiorly in a submucosal plane towards the oesophageal inlet. Posterior hypopharyngeal wall tumours may extend superiorly and laterally to the posterolateral oropharyngeal wall or towards the piriform inlet. By direct posterior extension, they may penetrate the inferior constrictor, the buccopharyngeal fascia and then traverse the prevertebral space, fascia and musculature. Hypopharyngeal tumours, especially postcricoid tumours have a propensity to spread submucosally, which may obscure easy endoscopic evaluation of their actual extent.
Operative Procedures

TLM Resection Technique

Optimum access to the primary tumour is paramount for TLM resection of hypopharyngeal cancer and is usually achieved with a STEINER distending laryngo-pharyngoscope \(^1\) or fixed-bore laryngoscopes. Resection starts with a transtumoural cut to estimate the depth of the tumour's penetration into the pharyngeal wall, followed by ‘multibloc’ resections, until healthy tissue is identified and a negative margin is achieved on frozen section. Immediate, preliminary debulking of exophytic components filling the field of view (Figs. 19a–g), greatly facilitates the procedure by creating good exposure and working space for multibloc resection.

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The resection lines for hypopharyngeal carcinomas of different sites and extents are shown.

- Carcinoma of the medial wall of the piriform fossa (a).
- Infiltration of the superior aspect of medial, anterior, and lateral wall of the piriform fossa (b).
- The right piriform fossa is almost completely occupied by the tumour that has grown circumferentially (c).
- Carcinoma of the medial wall of the piriform fossa with suspected infiltration into the larynx in the area of the arytenoid cartilage. Prior to excision of the entire arytenoid cartilage along its base on the cricoid cartilage, an exploratory incision is made in order to assess the depth of infiltration in the region of the arytenoid (curved arrow) (d).
- Carcinoma of the postcricoid area (e).
- Carcinoma of the right piriform fossa with invasion of larynx and oropharynx (f).
- Extensive hypopharyngeal carcinoma with progression from the right piriform fossa toward the postcricoid area and the posterior wall of the hypopharynx (g).
**Piriform Fossa**

For piriform fossa tumours, resection is usually commenced superiorly and laterally and advanced around the anterior angle towards the medial wall. This step-by-step resection progresses in a cranio-caudal direction. The tumour is removed layer by layer. It is essential to obtain good magnification and visualization of the tumour as resection advances, to clearly discern between normal and abnormal tissue. Orientation is maintained by keeping some normal mucosa and identifiable structures, such as the arytenoid(s) in endoscopic view.

Improvement of the exposure of the piriform fossa is achieved in Barcelona by inserting (under rotating movements) a Kuntscher nail (1.5 mm) through the most anterior aspect of the thyroid cartilage. Endoscopically the nail cannot be seen intralaryngeally. The nail can then be surrounded by a bandage and fixed to a Mayo table, which then can be elevated. The detached larynx is thus displaced anteriorly and can be fixed laterally, which renders a full opening of the hypopharynx. At the end of the surgical procedure, the nail is withdrawn and the small perforations covered with Steri-Strips™. (Described first in the German edition, but this technique has not been used for many years in Göttingen).

A mucosal margin of at least 5 mm for superficial tumours and 10 mm for larger infiltrating tumours is recommended. In the absence of frank aryepiglottic fold invasion on medial wall piriform tumours, complete oncological resection can be accomplished with a relatively narrow margin by preserving the arytenoid cartilage, but carefully removing the mucosa alone from its lateral surface. This reduces the risk of postoperative aspiration and impairment of swallowing and also avoids injury to the lateral cricoarytenoid muscle. In superficial medial wall piriform tumours with no arytenoid/cricoid infiltration, it is usually possible to preserve these structures along with the ventricular fold, thus causing minimal functional morbidity. For lateral tumour(s) approaching or infiltrating the thyroid cartilage, the perichondrium may be stripped off and be the medial clear margin, or involved cartilage may be resected along with any accessible extracartilagenous extensions.

In situations where there is inadequate access to resect the posterior or inferior components of the piriform tumours or for tumours with extension into the neck soft tissue, the transoral approach can be combined with a lateral pharyngotomy (*Haughey*), utilizing the access afforded by the neck dissection. The pharyngotomy or laryngotomy closure can be reinforced by constrictor muscle advancement, mobilization of adjacent strap muscle, and/or an additional patch graft of cadaveric acellular dermis. Additionally, a platysma myofascial flap may be used.

**Postcricoid Region**

Tumours confined to the postcricoid area are amenable to excision by TLM, the ideal candidates being lesions that are superficial and have minimal inferior extension. A useful technique in this locus is to split the tumour longitudinally or sideways to assess depth, removing in halves or thirds.

**Posterior Pharyngeal Wall**

Exposure for posterior hypopharyngeal wall lesions is usually very good. Limited deep penetration beyond the prevertebral fascia into the prevertebral muscles or the anterior spinal ligament is not necessarily a contraindication for TLM. However, complications like vertebral osteomyelitis or abscess formation can very rarely occur, but may follow adjuvant radiotherapy.

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*STEINER W, AMBROSCH P. Endoskopische Laserchirurgie der oberen Luft- und Speisewege. Schwerpunkt Tumorchirurgie. Stuttgart – New York: Thieme; 1997*
Postoperative Management

Haemorrhage
Postoperative catastrophic bleeding has been reported following salvage TLM resection of piriform fossa tumours. Meticulous haemostasis with identification, clipping and cautery should be ensured during surgery. Knowledge of the ‘inside-out’ anatomy of the pharynx, and the location of the superior laryngeal / and superior thyroid arteries is fundamental for safe haemostasis. It is prudent, during the neck dissection, to again tie or double-clip the endoscopically encountered vessels or even to do so when no neck dissection is performed, particularly for procedures involving resection of deep, infiltrating piriform tumours.

Airway Care – Tracheotomy
For small lesions, extubation is safe. For larger lesions with deep resection around named vessels, para- or preepiglottic space resection, or where significant oedema is present at the procedure’s conclusion, a tracheotomy is performed in St. Louis cases (Haughey), with a view to early decannulation. In Göttingen, the preference is for overnight intubation, cortisone administration and tracheotomy, only if indicated after extubation.

Nutrition
In early lesions, a nasogastric tube is rarely necessary, but for larger lesions involving extensive resection (particularly more than half the circumference of mucosa in the region of the oesophageal inlet) the Göttingen team prefers a large-bore nasogastric tube to act as a stent for 3–4 weeks. A percutaneous gastrostomy may be inserted following resection of advanced tumours, particularly if adjuvant treatment is necessary.

In all cases that may have initial problems with the deglutition, in Barcelona a nasogastric feeding tube is introduced during general anaesthesia. This is easier than doing it in the awake patient. In larger resections, rehabilitation of swallowing may take longer. Therefore, they usually do not see an indication for an early gastrostomy, unless severe or recurrent aspiration pneumonia occurs (Bernal-Sprekelsen).

Wound Healing
Healing occurs mainly by secondary intention and the wound becomes epithelialized within 4–6 weeks. Scarring and lateralization of the vocal fold may ensue after deep resection for tumours of the medial piriform walls, causing aspiration and marked voice deterioration. Haughey recommends that this may be obviated by grafting the paraglottic space with autogenous tissue and / or performing a vocal fold medialization arytenoid pexy, after the completion of TLM resection, via lateral pharyngotomy access. Upon complete disease clearance, a rectangle of clavicular periosteum is harvested, rolled and placed into the paraglottic space between the thyroid cartilage and vocal fold using monocryl suture. The arytenoid pexy entails medial anchoring and positioning of the arytenoid on the cricoid cartilage at the cricoarytenoid joint in a fashion that results in satisfactory vocal fold medialization. This technique has not been applied in Göttingen, perhaps reflecting differences in patient population or technique.

Reconstruction of the piriform inlet region can be done by advancing a thin flap of tongue base or pharyngeal mucosa and / or suturing a piece of cadaveric acellular dermis into the wound. See also above for closure of the pharyngotomy wounds (Haughey).
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The video clips (by Wolfgang Steiner) mentioned below have been selected to provide a shorter concentrated overview of the technique.

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<td>T3</td>
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### Special Examples

#### Larynx

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<td>15a</td>
<td>II 02‘15”’</td>
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<tr>
<td>T4</td>
<td>16</td>
<td>II 04‘00”’</td>
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<td>rT3</td>
<td>21</td>
<td>II 04‘11”’</td>
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<tr>
<td>rT3</td>
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<tr>
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<td>22</td>
<td>II 10‘19”’</td>
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<table>
<thead>
<tr>
<th>Subglottis</th>
<th>Number</th>
<th>Duration</th>
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<td>II 11‘45”’</td>
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<table>
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<tr>
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<td>II 04‘00”’</td>
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<tr>
<td>38</td>
<td></td>
<td>01‘35”’</td>
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<table>
<thead>
<tr>
<th>T3</th>
<th>Number</th>
<th>Duration</th>
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<tr>
<td>rT3</td>
<td>41</td>
<td>II 04‘00”’</td>
</tr>
<tr>
<td></td>
<td>47a</td>
<td>II 02‘12”’</td>
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<table>
<thead>
<tr>
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<th>Number</th>
<th>Duration</th>
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</tr>
<tr>
<td>50a</td>
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<td>II 02‘24”’</td>
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<table>
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<tr>
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<th>Duration</th>
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</thead>
<tbody>
<tr>
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<td>51</td>
<td>II 05‘00”’</td>
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Even though some of these patients suffered from (very) advanced primary or recurrent tumours, long-term survival with normal quality of life could be achieved in all patients.
Supplementary Content – Statistical Survey

Statistical Data of 1669 Patients with Carcinoma of the Upper Aerodigestive Tract (pT1–4) Treated Curatively by Transoral Laser Microsurgery

### Glottic Carcinoma n = 826 (1979 – 2006)

#### Therapy

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<tr>
<th>pT</th>
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<th>2a</th>
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#### Adjuvant R(CT)T

| n | 38 | 9 |

### Glottic Carcinoma n = 826 (1979 – 2006)

#### Postoperative Complications

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<th>2a</th>
<th>2b</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>404</td>
<td>142</td>
<td>127</td>
<td>122</td>
<td>31</td>
</tr>
</tbody>
</table>

- Bleeding: n % 2 (6.5) 1 (0.8) 1 (0.8) 1 (0.8) 2 (6.5)
- Oedema: n % 2 (0.5) 1 (0.7) 2 (1.6) 1 (3.2)
- Stenosis: n % 1 (0.8)
- Perichondritis: n % 2 (1.6) 1 (0.8)
- Aspiration: n % 1 (0.8)

### Glottic Carcinoma n = 826 (1979 – 2006)

#### Pre- and postoperative Management

<table>
<thead>
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<th>1a</th>
<th>2a</th>
<th>2b</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>404</td>
<td>142</td>
<td>127</td>
<td>122</td>
<td>31</td>
</tr>
</tbody>
</table>

- Feeding tube: n % 1 (0.7) 8 (6) 53 (44) 42 (22) 71 (21)
- Temporary PEG: n % 1 (0.7) 3 (2.5)
- Temporary tracheotomy: n % 1 (0.7) 1 (0.8) 5 (4) 4 (13)

### Glottic Carcinoma n = 826 (1986 – 2006)

#### 5-year Kaplan Meier Survival Rates

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<th>1a</th>
<th>2a</th>
<th>2b</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>404</td>
<td>142</td>
<td>127</td>
<td>122</td>
<td>31</td>
</tr>
</tbody>
</table>

- Overall: % 88 (65) 72 (65) 59 (65)
- Recurrence free: % 85 (57) 76 (58) 62 (62)
- Disease specific: % 100 (65) 72 (65)
- 5-year local control rates: % 87 (67) 83 (72) 83 (81)
- Larynx preservation: % 98 (83) 93 (84) 84 (83)

### Supraglottic Carcinoma n = 277 (1979 – 2006)

#### Therapy

<table>
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<th>II</th>
<th>III</th>
<th>IVa</th>
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<td>TLM</td>
<td>n</td>
<td>24</td>
<td>75</td>
<td>88</td>
</tr>
<tr>
<td>%</td>
<td>36</td>
<td>64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| n | 213 | 77 |
| % | 83 | 67 |
| Bilateral | 50 | 67 | 67 | 99 |

#### Adjuvant R(CT)T

| n | 147 | 53 |
| % | 2 | 3 | 14 | 16 | 45 | 50 |

### Supraglottic Carcinoma n = 277 (1979 – 2006)

#### Postoperative Complications

<table>
<thead>
<tr>
<th>n</th>
<th>%</th>
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<td>Dyspnoe</td>
<td>12</td>
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<td>11</td>
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<tr>
<td>Pneumonia</td>
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### Supraglottic Carcinoma \( n = 277 \) (1979 – 2006)

#### Post- and postoperative Management

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<td>77.2</td>
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<td>13</td>
<td>4.7</td>
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<tr>
<td>Permanent PEG</td>
<td>5</td>
<td>1.8</td>
</tr>
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<td>Temporary tracheotomy</td>
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<td>3.6</td>
</tr>
<tr>
<td>Permanent tracheotomy</td>
<td>2</td>
<td>0.7</td>
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### Supraglottic Carcinoma \( n = 277 \) (1979 – 2006)

#### 5-year Kaplan Meier Survival Rates

<table>
<thead>
<tr>
<th>Stage</th>
<th>I / II</th>
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<tbody>
<tr>
<td>( n )</td>
<td>99</td>
<td>178</td>
</tr>
<tr>
<td>Overall survival</td>
<td>% 76</td>
<td>59</td>
</tr>
<tr>
<td>Recurrence free</td>
<td>81</td>
<td>65</td>
</tr>
<tr>
<td>Disease specific</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>( pT )</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>( n )</td>
<td>26</td>
<td>92</td>
</tr>
<tr>
<td>5-year local control rates</td>
<td>% 83</td>
<td>78</td>
</tr>
<tr>
<td>Larynx preservation</td>
<td>96</td>
<td>96</td>
</tr>
</tbody>
</table>

### Oral Cavity Carcinoma \( n = 232 \) (1986 – 2006)

#### Therapy

<table>
<thead>
<tr>
<th>Stage</th>
<th>I / II</th>
<th>III</th>
<th>IVa</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLM</td>
<td>( n )</td>
<td>119</td>
<td>54</td>
</tr>
<tr>
<td>SND</td>
<td>( n )</td>
<td>62</td>
<td>50</td>
</tr>
<tr>
<td>bilateral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n )</td>
<td>78</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Adjuvant RT/T</td>
<td>( n )</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>

### Oral Cavity Carcinoma \( n = 232 \) (1986 – 2006)

#### Postoperative Complications

<table>
<thead>
<tr>
<th>Condition</th>
<th>( n )</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding</td>
<td>12</td>
<td>5.2</td>
</tr>
<tr>
<td>Oedema</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Aspiration</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Dyspnoea</td>
<td>1</td>
<td>0.4</td>
</tr>
</tbody>
</table>

### Oral Cavity Carcinoma \( n = 232 \) (1986 – 2006)

#### Post- and postoperative Management

<table>
<thead>
<tr>
<th>Procedure</th>
<th>( n )</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding tube</td>
<td>96</td>
<td>41.4</td>
</tr>
<tr>
<td>Temporary PEG</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Temporary tracheotomy</td>
<td>1</td>
<td>0.4</td>
</tr>
</tbody>
</table>

### Oral Cavity Carcinoma \( n = 232 \) (1986 – 2006)

#### 5-year Kaplan Meier Survival Rates

<table>
<thead>
<tr>
<th>Stages</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IVa</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n )</td>
<td>58</td>
<td>61</td>
<td>54</td>
<td>59</td>
</tr>
<tr>
<td>Overall survival</td>
<td>71</td>
<td>61</td>
<td>62</td>
<td>26</td>
</tr>
<tr>
<td>Recurrence free</td>
<td>73</td>
<td>49</td>
<td>68</td>
<td>53</td>
</tr>
<tr>
<td>Disease specific</td>
<td>( pT )</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>( n )</td>
<td>68</td>
<td>100</td>
<td>45</td>
<td>19</td>
</tr>
<tr>
<td>5-year local control rates</td>
<td>% 83</td>
<td>63</td>
<td>71</td>
<td>84</td>
</tr>
</tbody>
</table>
### Tonsil Carcinoma n = 102 (1987 – 2006)

#### Therapy

<table>
<thead>
<tr>
<th>Stage</th>
<th>I / II</th>
<th>III</th>
<th>IVa</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLMM</td>
<td>n</td>
<td>13</td>
<td>29</td>
</tr>
<tr>
<td>StCC</td>
<td>n</td>
<td>97</td>
<td>85</td>
</tr>
<tr>
<td>Bilateral</td>
<td>n</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Adjuvant RCT</td>
<td>n</td>
<td>66</td>
<td>65</td>
</tr>
</tbody>
</table>

### Tonsil Carcinoma n = 102 (1987 – 2006)

#### Postoperative Complications

- **Bleeding**: 18 (17.6%)
- **Aspiration**: 2 (1.9%)

### Tonsil Carcinoma n = 102 (1987 – 2006)

#### Path and postoperative Management

<table>
<thead>
<tr>
<th>Management</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding tube</td>
<td>64</td>
<td>62.7</td>
</tr>
<tr>
<td>Temporary PEG</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>Permanent PEG</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>Temporary tracheotomy</td>
<td>1</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Tonsil Carcinoma n = 102 (1987– 2006)

#### 5-year Kaplan Meier Survival Rates

<table>
<thead>
<tr>
<th>pT</th>
<th>1 / 2</th>
<th>3 / 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>99</td>
<td>178</td>
</tr>
</tbody>
</table>

- **Overall survival**: 59% (56%)
- **Recurrence free**: 64% (60%)
- **Relapse specific**: 74% (68%)
- **5-year local control rates**: 78% (75%)

### Tongue Base Carcinoma n = 82 (1986 – 2007)

#### Therapy

<table>
<thead>
<tr>
<th>Stage</th>
<th>I / II</th>
<th>III</th>
<th>IVa</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLMM</td>
<td>n</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>SMR</td>
<td>n</td>
<td>75</td>
<td>41</td>
</tr>
<tr>
<td>Bilateral</td>
<td>n</td>
<td>38</td>
<td>46</td>
</tr>
<tr>
<td>Adjuvant RCT</td>
<td>n</td>
<td>45</td>
<td>55</td>
</tr>
</tbody>
</table>

### Tongue Base Carcinoma n = 82 (1986– 2007)

#### Postoperative Complications

- **Bleeding**: 11 (14.6%)
- **Edema**: 1 (2.4%)
- **Dyspnoe**: 1 (1.2%)
- **Aspiration**: 2 (2.4%)
- **Pneumonia**: 1 (1.2%)
### Tongue Base Carcinoma n = 82 (1986-2007)
#### Peri- and postoperative Management

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding tube</td>
<td>66</td>
<td>80.5</td>
</tr>
<tr>
<td>Temporary PEG</td>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td>Temporary tracheotomy</td>
<td>1</td>
<td>1.2</td>
</tr>
</tbody>
</table>

### Tongue Base Carcinoma n = 82 (1986-2007)
#### 5-year Kaplan Meier Survival Rates

<table>
<thead>
<tr>
<th>Stages</th>
<th>I / II</th>
<th>III</th>
<th>IIVa</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>7</td>
<td>14</td>
<td>61</td>
</tr>
</tbody>
</table>

- **Overall survival:** %
  - 70
  - 44
  - 58
- **Recurrence free:**
  - 86
  - 54
  - 69
- **pT**
  - 1 / 2
  - 3
  - 4

<table>
<thead>
<tr>
<th>n</th>
<th>29</th>
<th>15</th>
<th>38</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>94</td>
<td>81</td>
<td>78</td>
</tr>
</tbody>
</table>

### Piriform Fossa Carcinoma n = 150 (1986-2003)
#### Therapy

<table>
<thead>
<tr>
<th>Stages</th>
<th>I / II</th>
<th>III</th>
<th>IVa</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>22</td>
<td>44</td>
<td>84</td>
</tr>
</tbody>
</table>

- **Squamous**
  - n %
    - 139 93
  - Bilateral
    - 31 21
  - Adjuvant radiotherapy / chemotherapy
    - n %
      - 79 53

### Piriform Fossa Carcinoma n = 150 (1986-2003)
#### 5-year Kaplan Meier Survival Rates

<table>
<thead>
<tr>
<th>Stages</th>
<th>I / II</th>
<th>III</th>
<th>IVa</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>22</td>
<td>44</td>
<td>84</td>
</tr>
</tbody>
</table>

- **Overall survival:** %
  - 72
  - 61
  - 43
- **Recurrence free:**
  - 79
  - 59
  - 49
- **Disease specific:**
  - 100
  - 85
  - 57

<table>
<thead>
<tr>
<th>n</th>
<th>20</th>
<th>41</th>
<th>67</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>83</td>
<td>78</td>
<td>75</td>
</tr>
</tbody>
</table>

**Larynx preservation:** 99

### Piriform Fossa Carcinoma n = 150 (1986-2003)
#### Peri- and postoperative Management

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding tube</td>
<td>122</td>
<td>81</td>
</tr>
<tr>
<td>Temporary PEG</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Permanent PEG</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Temporary tracheotomy</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

### Piriform Fossa Carcinoma n = 150 (1986-2003)
#### Postoperative Complications

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding</td>
<td>11</td>
<td>7.3</td>
</tr>
<tr>
<td>Oedema</td>
<td>3</td>
<td>2.0</td>
</tr>
<tr>
<td>Hypopharyngeal stenosis</td>
<td>1</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Supplementary Content – Curriculum vitae

Wolfgang Steiner, MD, Göttingen, Germany
Professor em. HonFRCS of England

Academic Career

Born in Crailsheim, Germany, in 1942, Wolfgang Steiner graduated from Medical University School of Erlangen-Nürnberg in 1969. He trained in internal medicine and general surgery and obtained his medical degree in 1971. From 1971 to 1986 he worked at the ENT University Hospital in Erlangen (Chairman: Professor Malte Erik Wigand) completing his ENT specialization in 1975. He has been a member of the senior staff since 1978. In 1979, he qualified for professorship in ENT and became Associate Professor in 1985. Wolfgang Steiner was Professor and Chairman of the ENT Department at the University of Göttingen from 1986 to 2007.

Representation of Professional Bodies


Publications, Scientific Work and Teaching Activities

He has authored over 200 journal publications in different languages and has been editor or co-editor of several books. His textbook on ‘Endoscopic laser surgery of the upper aerodigestive tract: with special emphasis on cancer surgery’, was published in German in 1996 and in English by Georg Thieme Verlag Stuttgart, Germany, in 2000.

Wolfgang Steiner is the pioneer of organ-preserving transoral laser microsurgery for cancer of the upper aerodigestive tract (UADT) and of selective neck dissection (N0-2) in carcinoma of the larynx, oro- and hypopharynx since 1979.

He has travelled extensively around the world to demonstrate his technique and present his results in numerous international meetings, workshops and surgery courses.

Courses

63 national and international courses (participants from 46 countries) on laser microsurgery with special regard to cancer of the upper aerodigestive tract were held in Göttingen, Germany, from 1990 to 2007.

Furthermore, Wolfgang Steiner worked as a faculty member (surgeon and lecturer) of 39 laser courses in different countries: Argentina, Australia, England (Royal College of Surgeons, London) Finland, Greece, India, Italy, New Zealand, Portugal, Spain, South Africa, Taiwan and Venezuela.

He was a guest speaker of ENT and Head and Neck Societies in Argentina, Austria, Belgium, Brazil, Canada, Chile, China, Columbia, Cyprus, Czechia, Egypt, Finland, Hungary, India, Italy, Japan, New Zealand, North England, Poland, Portugal, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Turkey and USA.

Special Lectures and Memberships

- Frank Lamberson Lecture, 1999, University of Ann Arbor, USA.
- Joseph Ogura Lecture, 2002, Washington University, St. Louis/USA.
Prof. Steiner is honorary member of the Austrian, German, Hungarian, Polish, South African and Spanish ENT-Societies, of the Foundation for Head and Neck Oncology of India, of the South African Society of Head and Neck Oncology, and of the Royal College of Surgeons of England.

He is a corresponding member of the American Head and Neck Society, the American Laryngological Association, the American Broncho-Esophagological Association and of several national and international societies for Otolaryngology, Head and Neck Surgery, Endoscopy, Minimally Invasive Therapy and Laser Surgery.

He was also a member of the Advisory and Editorial Board of several national and international scientific journals.

Past memberships of Prof. Wolfgang Steiner

- Sachverständigenrat der Deutschen Forschungsgemeinschaft (Advisory Board of the German Society for the Support and Advancement of Scientific Research).
- Komitee des Gesundheitsministeriums zur Krebsprüfung und -früherkennung (Committee of the German Ministry of Health for Cancer Prevention and Early Detection).
- German TNM Committee of the Union for International Cancer Control (UICC).
- The International Federation of Oncological Head and Neck Societies (IFOS)

Honors and Awards

Wolfgang Steiner was granted several national and international professional honors and awards, especially for the pioneer work in endoscopic mass screening (Award of the Hufeland Foundation, Germany, 1984) and transoral laser surgery for organ preservation in cancer of the upper aerodigestive tract (Ludwig Haymann Award, Germany, 1997).

- Presidential Citation of the American Head and Neck Society, San Francisco/USA, 2000.
- National Award 2005 of the German Cancer Society for Clinical Oncology, Würzburg/Germany.
- Przemysław Pieniążek Medal of the Polish Otolaryngology Society, Lublin/Poland, 2004
- Presidential Honorary Citation at the First Congress of the Confederation of European Otorhinolaryngology, Head and Neck Surgery (CEORL-HNS), Barcelona/Spain, 2011.
- Dr. Fritz Erler Scientific Award of the University of Erlangen-Nürnberg, Germany, for ‘excellence in transoral laser microsurgery of malignant tumors of the upper aerodigestive tract’ in 2012.
- Guest of Honor of the World Congress on Larynx Cancer in Australia (Cairns), 2015 (Closing Remarks).

His life’s work has been acknowledged in the following review: Harris AT et al. Transoral laser surgery for laryngeal carcinoma: has Steiner achieved a genuine paradigm shift in oncological surgery? Ann R Coll Surg Engl. 2018 Jan;100(1):2-5. The authors come to the conclusion that his contribution to the surgical management of laryngeal cancer constitutes a conceptual breakthrough and hence a true paradigm shift in oncological surgery.

Wolfgang Steiner has been married to his wife Grazia since 1966. They have three sons: Robert, Christian and Martin and five grandchildren.
Supplementary Content

Reference List of the Göttingen TLM Study Group

STEINER W, CANIS M (Göttingen), AMBROSCH P (Kiel), MARTIN A (Berlin), KRON M (Ulm) et al.

  Glottic carcinoma pT1/2 n = 40, pTis n = 11


- STEINER W. Aspects of clinical differential diagnosis and therapy of early laryngeal cancer.
  n = 118, including 20 microcarcinomas.


  First presentation of the results of “regional limited functional neck dissection” = selective neck dissection (1979–1981), n = 56.

  Surgical course and workshop 1982 at the Erlangen University ENT Hospital, 1982.

- STEINER W. 1. Lascherurgia endoscopica del carcinoma laringeo. 215–221.


- STEINER W. HERBST M. Kombinationsbehandlung von Hypopharynxkarzinomen mit endoskopischer Laserchirurgie und Nachbestrahlung.
  First report on TLM for hypopharyngeal carcinoma.

  Limits: T4 spread to the lateral neck, extensive infiltration of the cricoid cartilage, fixation of both arytenoid cartilages since 10 years no block resection, no defect closure by flaps, “regional limited functional neck dissection” N0–2 (selective neck dissection), delayed, postop. radiotherapy early possible, healing and function excellent, rarely tracheotomy necessary, early carcinoma: TLM treatment of choice advanced carcinoma: TLM with / without radiotherapy as an alternative to total laryngectomy.


- STEINER W, HOMMERICH CP. Diagnosis and treatment of the N0 neck of carcinoma of the upper aerodigestive tract.


- STEINER W. Therapy of hypopharyngeal carcinoma.
Transoral Laser Microsurgery for Cancer of the Upper Aerodigestive Tract


(1979–1991), n = 466, early and advanced glottic and supraglottic cancer.


(1979–1993), n = 403, glottis and supraglottis.


BRAUN U. Anesthesiological aspects of laser surgery in otolarynology.


Transoral Laser Microsurgery for Cancer of the Upper Aerodigestive Tract


STEINER Basic LASER Laryngo-Pharyngoscopy Set for Adults
STEINER Basic LASER Laryngo-Pharyngoscopy Set for Adults

1. 8661 AN STEINER Distending Operating Laryngo-Pharyngoscope, for adults, lightweight construction, with antireflex coating for LASER treatment, channel removing vapor integrated in handle and blade, length 18 cm, for use with Clip, for proximal illumination 497 AC and Laryngoscope Holder 8575 K/KC
2. 8666 DN STEINER Distending Operating Oropharyngoscope, for adults, lightweight construction, with antireflex coating for LASER treatment, with right and left side wings to prevent the tongue/soft tissue from obstructing the lumen, channel removing vapor integrated in handle and blade, length 14 cm, for use with Clip, for proximal illumination 497 AC and Laryngoscope Holder 8575 K/KC
3. 8661 CN STEINER Operating Laryngoscope, medium-large, for adults, with antireflex coating for LASER treatment, with integrated channel to remove vapor, outer diameter proximal 26 x 18 mm, length 18 cm
4. 8661 DN Same, small, for adults with difficult anatomical circumstances and for children, with antireflex coating for LASER treatment, with integrated channel to remove vapor, outer diameter proximal 23 x 15 mm, length 19 cm
5. 8663 AH Grasping Forceps, straight, serrated, sheath insulated, with cleaning connector, working length 23 cm (not illustrated)
6. 8663 BH Grasping Forceps, curved to right, serrated, sheath insulated, with cleaning connector, working length 23 cm
7. 8663 CH Same, curved to left
8. 8593 GM Miniature Grasping Forceps, extra delicate, serrated, with triangular jaws, curved upwards to right, with cleaning connector, working length 23 cm
9. 8593 HM Same, curved upwards to left
10. 8662 D LARYNGOFORCE® II Grasping Forceps, delicate, serrated, special matt finish, with cleaning connector, working length 22 cm
11. 8662 E Same, with oval alligator jaws, small
12. 8662 FL LARYNGOFORCE® II Grasping Forceps, with oval alligator jaws, medium, special matt finish, with suction channel to remove LASER vapors, with cleaning connector, working length 22 cm
13. 8662 GL Same, with oval, fenestrated alligator jaws, large
14. 8665 T Clip, titanium LT 200, medium, 5 mm, sterile, package of 36 cartridges with 6 clips each
15. 8665 L LARYNGOFORCE® II Clip Forceps, jaws curved to left, with cleaning connector, working length 22 cm, for use with Clip 8665 T
16. 8665 R Same, jaw curved to right
17. 8606 D Coagulation Suction Tube, with ergonomic handle, insulated, with connection for unipolar coagulation, with Cleaning Stylet 8606 FM, outer diameter 2 mm, working length 23 cm
18. 8606 E Same, outer diameter 2.5 mm
19. 8606 F Same, outer diameter 3.5 mm
20. 8596 R Protector, to protect tissue against unintentional LASER irradiation, curved upwards, oval, diameter 7 mm, special matt finish, with suction channel to remove LASER vapors, working length 23 cm
21. 497 AC Clip, for proximal illumination
22. 8575 K Laryngoscope Holder and Chest Support, GÖTTINGEN model, including:
   - Laryngoscope Holder, GÖTTINGEN model, with adjustment wheel
   - Support Rod, movable, with metal ring, diameter 9 cm, length 94 cm
23. 26005 M Unipolar High Frequency Cord, with 5 mm plug for AUTOCON® II 400 SCB system (111, 115, 122, 125), AUTOCON® II 200, AUTOCON® II 80, KARL STORZ AUTOCON® system (50, 200, 350) and Erbe type ICC, length 300 cm (not illustrated)

As required:

- 8575 L Support Table, GÖTTINGEN model, for Laryngoscope Holders 8575 K/KC, 8574 KT/KW, autoclavable, including:
  - Swivel Arm, with movable plate
  - Holding Rod, for height adjustment
  - Attachment Blocks, can be mounted on operation table equipped with standard sliding rail 25 x 10 mm (not illustrated)

It is recommended to check the suitability of the product for the intended procedure prior to use.
A special chest support system has been designed to meet the requirements of transoral tumor surgery in the pharynx and larynx, together with an adjustable platform that can be secured in any of three dimensional positions, allowing effortless changes in the position of the laryngo-pharyngoscope during tumor surgery. Extremely lateral angles, as are often necessary for work in the pharynx, are easily achieved and maintained.

Support Table, GÖTTINGEN model, for Laryngoscope Holders 8575 K/KC, 8574 KT/KW, autoclavable, including:
Swivel Arm, with movable plate
Holding Rod, for height adjustment
Attachment Blocks, can be mounted on operation table equipped with standard sliding rail 25 x 10 mm
STEINER Operating Laryngoscopes
for Transoral LASER Microsurgery with integrated channel to remove vapor especially suitable for the endolarynx (glottis and subglottis)

Full size illustration:
inner diameter in mm proximal and distal

*8661 CN STEINER Operating Laryngoscope, medium-large, for adults, with antiflex coating for LASER treatment, with integrated channel to remove vapor, outer diameter proximal 26 x 18 mm, length 18 cm

*8661 DN STEINER Operating Laryngoscope, small, for adults with difficult anatomical circumstances and for children, with antiflex coating for LASER treatment, with integrated channel to remove vapor, outer diameter proximal 23 x 15 mm, length 19 cm

*497 AC Clip, for proximal illumination

*) These instruments are integral part of the Basic Set for Transoral LASER Microsurgery, see pages 62–63.
STEINER Distending Operating Laryngo-Pharyngoscopes and Oropharyngoscope
for Transoral LASER Microsurgery – Laryngo-Pharyngoscope: especially recommended for supraglottis and hypopharynx

*8661 AN
STEINER Distending Operating Laryngo-Pharyngoscope, for adults, lightweight construction, with antireflex coating for LASER treatment, channel removing vapor integrated in handle and blade, length 18 cm, for use with Clip, for proximal illumination 497 AC and Laryngoscope Holder 8575 K/KC

Oropharyngoscope: especially recommended for tongue base

*8666 AN
STEINER Distending Operating Laryngo-Pharyngoscope, for adults, lightweight construction, with antireflex coating for LASER treatment, with right and left side wings to prevent the tongue/soft tissue from obstructing the lumen, channel removing vapor integrated in handle and blade, length 18 cm, for use with Clip, for proximal illumination 497 AC and Laryngoscope Holder 8575 K/KC

*8666 DN
STEINER Distending Operating Oropharyngoscope, for adults, lightweight construction, with antireflex coating for LASER treatment, with right and left side wings to prevent the tongue/soft tissue from obstructing the lumen, channel removing vapor integrated in handle and blade, length 14 cm, for use with Clip, for proximal illumination 497 AC and Laryngoscope Holder 8575 K/KC

*) These instruments are integral part of the Basic Set for Transoral LASER Microsurgery, see pages 62–63.
STEINER Retractor Set
for Oral Cavity and Oropharynx

Special features of oral retractor sets:
- Retractors consist of 2 adjustable arms equipped with valves of different length and width
- The instrument is used to hold the cheeks to the side to facilitate access to the oral cavity and the oropharynx
- Oropharynx distender with tongue blade for holding the endotracheal tube on the tongue; with integrated connector for suction of laser vapors
- Particularly suitable for operations in the palate, tonsil and oropharyngeal posterior wall areas
- Tongue blade with connection on each side for the suction of laser vapors; lateral opening for sufficient vapor evacuation during laser use

8661 R
STEINER Retractor for oral cavity and oropharynx, set including:
① 8661 RA Retractor, distending horizontal, without valves
② 8661 RB Pair of valves for 8661 RA, 15 mm x 75 mm
③ 8661 RC Pair of valves for 8661 RA, 24 mm x 62 mm
④ 744500 Retractor, for vertical distending, w.o. blades
743925 X Blade for 744500, 30 mm x 80 mm
743930 X Blade for 744500, 32 mm x 85 mm
⑥ 8661 RF Blade for 744500, 20 mm x 25 mm

742900 Mouth Gag, large fenestrated blades, length 17 cm
WEERDA Distending Diverticuloscope
for use with CO₂-LASER

Outer dimensions in mm:
proximal:

12067 A  WEERDA Distending Diverticuloscope, length 24 cm, with adaption for Suction Tube 12067 M
Proximal size open:  max. 40 x 27 mm
                  min. 29 x 27 mm
Distal size open:   max. 65 x 18 mm
                  min. 7 x 18 mm

8590 GF  Fiber Optic Light Carrier, for distal illumination, working length 14 cm, for use with Laryngoscopes 8588 BV, 8590 A-JN, 8590 T, 8590 JV/TV and Diverticuloscopes 12067 A, 12068 A

8590 ML  Suction Tube, to remove vapor, for LASER treatment, outer diameter 3 mm

12067 M  Suction Tube, to remove vapor, flat, size 6 x 3 mm
Operating Instruments
for Transoral Laser Microsurgery

These Grasping Forceps allow for a gentle yet firm hold on tissue. They are available in five sizes, four of which are equipped with an integrated suction channel to remove vapor. All instruments are manufactured with a special, matte finish, that effectively absorbs the laser energy. This is particularly advantageous during photo or video documentation due to the elimination of interfering reflections.

Special features:
- **Ultrafine Grasping Forceps** with triangular, fenestrated jaws, curved upward to the right or left

8593 GM

*8593 GM  Miniature Grasping Forceps, extra delicate, serrated, with triangular jaws, curved upwards to right, with cleaning connector, working length 23 cm

*8593 HM  Same, curved upwards to left

8662 GL

*8662 D  LARYNGOFORCE® II Grasping Forceps, delicate, serrated, special matt finish, with cleaning connector, working length 22 cm

*8662 E  LARYNGOFORCE® II Grasping Forceps, with oval alligator jaws, small, special matt finish, with cleaning connector, working length 22 cm

8662 EL  Same, with suction channel to remove LASER vapors

8662 F  LARYNGOFORCE® II Grasping Forceps, with oval alligator jaws, medium, special matt finish, with cleaning connector, working length 22 cm

*8662 FL  Same, with suction channel to remove LASER vapors

8662 G  LARYNGOFORCE® II Grasping Forceps, with oval, fenestrated alligator jaws, large, special matt finish, with cleaning connector, working length 22 cm

*8662 GL  Same, with suction channel to remove LASER vapors

8662 GLR  Same, with suction channel to remove LASER vapors, with ratchet

8662 H  LARYNGOFORCE® II Grasping Forceps, with triangular, fenestrated alligator jaws, extra large, special matt finish, with cleaning connector, working length 22 cm

8662 HL  Same, with suction tube for LASER vapors

*) These instruments are integral part of the **Basic Set for Transoral LASER Microsurgery**, see pages 62–63.
Coagulation Instruments
for Transoral LASER Microsurgery

Special features:
- **Unipolar Cannula** for suction and coagulation. An ergonomic handle enables steady and targeted work. Also suitable for dissecting and retracting tissue. The instrument is insulated, with cleaning stylet, and available in diameters of 2 mm, 2.5 mm and 3.5 mm.

- **Fine Grasping Forceps**, curved to the right or left, with insulated sheath.

- **Clip Forceps** for endoscopic ligation of blood vessels with vascular clips. Jaws are curved to the right or left.

*) These instruments are integral part of the Basic Set for Transoral LASER Microsurgery, see pages 62–63.
Additional Instruments
for Transoral LASER Microsurgery

Special features:
- **Vocal Cord and False Cord Retractor** for visualization of the vocal cords’ upper surface by retracting the false vocal cords during laser surgery of limited vocal cord carcinoma. Similarly, retraction of the true vocal cords gives better access to subglottic pathology.

- **Protectors** for shielding the distal mucosa against accidental LASER beam exposure, e.g. for protecting the subglottis during laser resection of the free edge of the vocal cord in the unintubated patient. Available in sizes of 5 and 7 mm, each with an integrated suction channel.

- **Suction tube with protecting shield** and ergonomic handle for retracting tissue during LASER incision. The straight distal end may also be used as a shield, e.g. for protection of the contralateral vocal cord during laser resection.

*) These instruments are integral part of the Basic Set for Transoral LASER Microsurgery, see pages 62–63.
Surgical Instruments
for Treatment of Zenker's Diverticulum for Laser Resection of Tumor Extending from the Hypopharynx to the Upper Esophagus

Special features:
- All instruments are equipped with a suction channel for removing vapor
- Special matte finish for CO₂-LASER treatment

**Insulated Cannula** for suction/coagulation, with ergonomic handle, fitting for unipolar coagulation, with cleaning stylet 12067 PM, working length 30 cm, outer diameter 3.5 mm

**Grasping Forceps**, alligator, with 1x2 teeth, double action jaws, sheath with suction channel to remove vapor, handle with ratchet to arrest jaw parts, working length 30 cm

*Please note:* Insulated instruments are not to be used simultaneously with a laser device.
Video Rhino-Laryngoscope
for use with IMAGE1, TELECAM SL II, TELECAM DX II, TELE PACK and TELE PACK X LED

Special features:
- Large viewing angle and movable distal tip facilitates orientation
- Waterproof, fully immersible for cleaning and disinfection
- Sterilizable with EtO gas, Steris® and Sterrad®
- Excellent optical quality – of both lens system and video chip
- Superior life span due to robust mechanical design
- Sensitive and stable control via ergonomic handle
- Short insertion tip with smooth-running and non-twisting angle mechanism
- Optimally matched, non-rotational insertion sheath
Video Rhino-Laryngoscope
for use with IMAGE1, TELECAM SL II, TELECAM DX II, TELE PACK and TELE PACK X LED

11101 VP/VN

11101 VP  PAL    CCD Video Rhino-Laryngoscope
direction of view 0°, angle of view 85°, deflection up 140°, down 140°, outer diameter 3.7 mm, working length 30 cm, for use with IMAGE1, TELECAM SL II, TELECAM DX II, TELE PACK and TELE PACK X LED

11101 VN  NTSC   CCD Video Rhino-Laryngoscope
direction of view 0°, angle of view 85°, deflection up 140°, down 140°, outer diameter 3.7 mm, working length 30 cm, for use with IMAGE1, TELECAM SL II, TELECAM DX II, TELE PACK and TELE PACK X LED

Following accessories are included:

27677 VC    Case
13242 XL    Leakage Tester, with bulb and manometer
11025 E     Pressure Compensation Cap

Note: The video connecting cables are not included in the set and must be ordered separately!

22200077   Video Endoscope Adaptor, color systems PAL/NTSC, length 90 cm, for use with GI CCU and IMAGE1
or
22200177   IMAGE1 Video Endoscope Adaptor, for video endoscopes, color system NTSC, length 90 cm, for use with all KARL STORZ video endoscopes
or
20213070   Video Connecting Cable, for all KARL STORZ video endoscopes and TELE PACK X LED, TELE PACK, TELECAM SL II FI, TELECAM SL II, TELECAM DX II, length 60 cm
Rhino Pharyngo Laryngo-Fiberscope

Special features:
- Large viewing angle and moveable distal tip for better orientation
- Waterproof, fully immersible for cleaning and disinfection
- Simple leakage test takes only a few minutes and requires no additional accessories
- Sterilizable with EtO gas, Steris® and Sterrad®
- Recommended for use in combination with KARL STORZ Endovision® TELECAM® System
- Exceptional optical quality of both lens and fiber optic image transmission bundle
- Resistant construction and robust mechanics

11101 RP

Rhino-Pharyngo-Laryngo-Fiberscope, office model, deflection up/down 180°/90°, direction of view 0°, angle of view 70°, distal tip outer diameter 3.5 mm, working length 30 cm, including:
- Case
- Pressure Compensation Cap
- Leakage Tester
Laryngo-Pharyngoscopes
for Endoscopic Exploration and Documentation

8707 DA

**Laryngo-Pharyngoscope**, with integrated HOPKINS®
lateral telescope 90°,
4x magnification focusing device,
diameter 10 mm, length 15 cm,
*autoclavable*,
fiber optic light transmission incorporated,
color code: blue

8706 CA

**Laryngo-Pharyngoscope**, with integrated HOPKINS®
lateral telescope 70°,
oval sheath, 7.2 x 9.3 mm,
working length 17 cm,
*autoclavable*,
fiber optic light transmission incorporated,
color code: yellow
HOPKINS® Telescopes – autoclavable
for Endoscopic Exploration and Documentation

Larynx and Hypopharynx:

8712 BA

HOPKINS® Forward-Oblique Telescope 30°,
enlarged view, diameter 5 mm, length 24 cm,
autoclavable,
fiber optic light transmission incorporated,
color code: red

8712 CA

HOPKINS® Lateral Telescope 70°,
enlarged view, diameter 5 mm, length 24 cm,
autoclavable,
fiber optic light transmission incorporated,
color code: yellow

Trachea:

8714 AA

HOPKINS® Straight Forward Telescope 0°,
enlarged view, diameter 6.5 mm, length 35 cm,
autoclavable,
fiber optic light transmission incorporated,
color code: green

Oral Cavity and Oropharynx:

8711 AA

HOPKINS® Straight Forward Telescope 0°,
enlarged view, diameter 10 mm,
working length 20 cm,
autoclavable,
fiber optic light transmission incorporated,
color code: green
With the IMAGE1 S camera platform, KARL STORZ once again sets a new milestone in endoscopic imaging, consolidating their reputation as an innovative leader in minimally invasive surgery. The IMAGE1 S camera platform offers surgeons a single system for all applications. As a modular camera platform, IMAGE1 S combines various technologies (e.g., rigid, flexible and 3D endoscopy) in one system and can therefore be adapted to individual customer needs. Furthermore, near infrared (NIR/ICG) for fluorescence imaging, the integration of operating microscopes and the use of VITOM® 3D exoscopes is possible via the camera platform.

**Brilliant imaging**
- Versatile visualization options for diagnosis and therapy
- Innovative S-Technologies for easy differentiation of tissue structures
- Clear and razor-sharp imaging
- Natural color rendition
- Automatic light source control

**CLARA:** Homogeneous illumination

**CHROMA:** Contrast enhancement

**CLARA + CHROMA:** Homogeneous illumination + contrast enhancement

**SPECTRA A:** Color hue shift and exchange (filtering reds)

**SPECTRA B:** Spectral color shift (intensification of greens and blues)

*SPECTRA A: Not for sale in the U.S.*
*SPECTRA B: Not for sale in the U.S.*
IMAGE1 S
As individual as your requirements

Innovative Design
- Side-by-side View: Parallel display of standard image and visualization mode possible
- Multiple source management: Simultaneous control, display and documentation of two image sources possible (e.g., hybrid procedures)
- Intuitive user guidance (dashboard, live menu and setup menu)
- Intelligent icons display settings and status
- Individual presets possible
- 50 patient data records can be archived

Economical and futureproof
- Modular platform: Rigid, flexible and 3D technology can be selected according to individual preferences
- Easy integration of new technologies
- Forward and backward compatibility
- No additional equipment (e.g., special light sources) required for S-Technologies

* SPECTRA A: Not for sale in the U.S.
* SPECTRA B: Not for sale in the U.S.
IMAGE1 S
As individual as your requirements

IMAGE1 S 3D
IMAGE1 S 3D is a further component in the IMAGE1 S camera platform. The 3D system provides surgeons with excellent depth perception. Furthermore, the 3D stereoscopic imaging system is particularly valuable for activities that demand a high degree of spatial perception. The 3D camera platform from KARL STORZ impresses with its wide range of applications – from laparoscopy, gynecology, ENT to microsurgical interventions.

Benefits of IMAGE1 S 3D
- Brilliant and razor-sharp imaging in 2D and 3D
- Switchover from 3D to 2D at the touch of a button
- Easy integration into the IMAGE1 S platform
- CLARA, CHROMA, SPECTRA* in 2D and 3D
- 3D system with video endoscopes with diameters of 10 mm and 4 mm as well as VITOM® 3D

Benefits of 3D integration into the IMAGE1 S camera platform
- Communication between all units
- One system for multiple applications
- Reduced space requirements
- One user interface for all applications
- Synergy effects between the OR workflow and financing

* SPECTRA A / SPECTRA B: Not available for sale in the U.S.A.
IMAGE1 S – A System for all Requirements

Connects all technologies IMAGE1 S CONNECT™

- 10 mm 3D video laparoscope
- 4 mm 3D video endoscope
- Flexible video endoscopes
- 1-chip camera heads
- PDD camera heads
- Microscopy camera head
- 3D endoscopy IMAGE1 S D3-LINK™
- Open to future technologies
- 2D endoscopy IMAGE1 S X-LINK
- 2D endoscopy IMAGE1 S H3-LINK
- Near Infrared (NIR/ICG) 3-chip camera head FI
- 3-chip camera heads
- e.g., 4K/UHD
- VITOM® 3D
**IMAGE1 S Camera System**

**TC 200EN**

**IMAGE1 S CONNECT**, connect module, for use with up to 3 link modules, resolution 1920 x 1080 pixels, with integrated KARL STORZ-SCB and digital Image Processing Module, power supply 100–120 VAC/200–240 VAC, 50/60 Hz including:

- **Mains Cord**, length 300 cm
- **DVI-D Connecting Cable**, length 300 cm
- **SCB Connecting Cable**, length 100 cm
- **USB Flash Drive**, 32 GB, USB silicone keyboard, with touchpad, US

*Available in the following languages*: DE, ES, FR, IT, PT, RU

**Specifications:**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD video outputs</td>
<td>- 2x DVI-D&lt;br&gt;- 1x 3G-SDI</td>
</tr>
<tr>
<td>Format signal outputs</td>
<td>1920 x 1080p, 50/60 Hz</td>
</tr>
<tr>
<td>USB interface</td>
<td>4x USB, (2x front, 2x rear)</td>
</tr>
<tr>
<td>SCB interface</td>
<td>2x 6-pin mini-DIN</td>
</tr>
<tr>
<td>Power supply</td>
<td>100–120 VAC/200–240 VAC</td>
</tr>
<tr>
<td>Power frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Protection class</td>
<td>I, CF-Defib</td>
</tr>
<tr>
<td>Dimensions w x h x d</td>
<td>305 x 54 x 320 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>2.1 kg</td>
</tr>
</tbody>
</table>

**For use with IMAGE1 S CONNECT Module TC 200EN**

**TC 300**

**IMAGE1 S H3-LINK**, link module, for use with IMAGE1 FULL HD three-chip camera heads, power supply 100–120 VAC/200–240 VAC, 50/60 Hz, for use with **IMAGE1 S CONNECT TC 200EN** including:

- **Mains Cord**, length 300 cm
- **Link Cable**, length 20 cm

**Specifications:**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera System</td>
<td>TC 300 (H3-Link)</td>
</tr>
<tr>
<td>Supported camera heads/video endoscopes</td>
<td>TH 100, TH 101, TH 102, TH 103, TH 104, TH 106&lt;br&gt;(fully compatible with IMAGE1 S)&lt;br&gt;22220055-3, 22220056-3, 22220053-3, 22220060-3, 22220061-3, 22220054-3, 22220085-3&lt;br&gt;(compatible without IMAGE1 S technologies CLARA, CHROMA, SPECTRA*)</td>
</tr>
<tr>
<td>LINK video outputs</td>
<td>1x</td>
</tr>
<tr>
<td>Power supply</td>
<td>100–120 VAC/200–240 VAC</td>
</tr>
<tr>
<td>Power frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Protection class</td>
<td>I, CF-Defib</td>
</tr>
<tr>
<td>Dimensions w x h x d</td>
<td>305 x 54 x 320 mm</td>
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<tr>
<td>Weight</td>
<td>1.86 kg</td>
</tr>
</tbody>
</table>

* SPECTRA A: **Not for sale in the U.S.**
** SPECTRA B: **Not for sale in the U.S.**
HD Imaging with Operating Microscopes

Direct Adaption

With the operating microscope the surgeon always has a perfect view of the operating field. Assistents, OR nurses and students, however, often experience poor video presentation, especially if FULL HD visualization is not available.

KARL STORZ offers a one-stop-shop solution to upgrade any surgical microscope with state-of-the-art FULL HD imaging technology. To achieve optimal results, all components in the video chain – from the camera system to the monitor – must be of the highest quality.

The most straightforward and professional connection between camera and microscope is the so-called direct adaption.

Here the H3-M COVIEW microscope camera and the corresponding QUINTUS® TV adaptor are directly connected to the microscope via the C-MOUNT connection.
IMAGE1 S Camera Heads

For use with IMAGE1 S Camera System
IMAGE1 CONNECT Module TC 200EN, IMAGE1 H3-LINK Module TC 300
and with all IMAGE1 HUB™ HD Camera Control Units

TH 106  IMAGE1 S H3-M COVIEW Three-Chip FULL HD
Camera Head, 50/60 Hz, IMAGE1 S compatible, progressive
scan, with C-MOUNT thread for coupling to microscopes,
2 freely programmable camera head buttons,
with detachable camera head cable, length 900 cm,
for use with IMAGE1 S and IMAGE1 HUB™ HD/HD

20200131  Keypad, for H3-M camera head, for convenient control of the
most important H3-M camera functions, with PS/2 connector,
cable length 1 m, alternative to a standard keyboard, for use
with H3-M or H3-M COVIEW camera heads, only compatible
with IMAGE1 HUB™ HD, not compatible with IMAGE1 S

Specifications:

<table>
<thead>
<tr>
<th>IMAGE1 S FULL HD Camera Heads</th>
<th>IMAGE1 S H3-M COVIEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product code</td>
<td>TH 106</td>
</tr>
<tr>
<td>Image sensor</td>
<td>3x 1/3” CCD chip</td>
</tr>
<tr>
<td>Dimensions w x h x d</td>
<td>45 x 50 x 60 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>240 g</td>
</tr>
<tr>
<td>Optical interface</td>
<td>C-MOUNT connection</td>
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<tr>
<td>Min. sensitivity</td>
<td>F 1.9/1.4 Lux</td>
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<tr>
<td>Grip mechanism</td>
<td>C-MOUNT connection</td>
</tr>
<tr>
<td>Cable</td>
<td>detachable</td>
</tr>
<tr>
<td>Cable length</td>
<td>900 cm</td>
</tr>
</tbody>
</table>
HD Imaging with Operating Microscope
System Components

QUINTUS® – High-Performance TV Adaptor for Operating Microscopes

Unleash the full performance of your operating microscope from CARL ZEISS MEDITEC – with FULL HD imaging solutions from KARL STORZ.

The new QUINTUS® TV adaptor is the perfect interface between the operating microscope and the H3-M CO-VIEW FULL HD microscope camera head from KARL STORZ. The innovative features of QUINTUS® are easy to use, making it one of the most flexible TV adaptors on the market.

Product Features:
- A rotating C-MOUNT connection at the QUINTUS® TV adaptor allows immediate adaption of the camera orientation during mounting.
- The focus control makes it possible to easily achieve parfocality (perfectly sharp camera and microscope images).
- The iris control provides convenient and optimal adjustment of the depth of field.
- Pan (X) function enables adjustment of the horizontal position of the camera image.
- Tilt (Y) function enables adjustment of the vertical position of the camera image. The pan and tilt functions help the surgeon to adjust the position of the camera image according to his individual needs.
- The QUINTUS® ZOOM model also features a variable focal length f = 43–86 mm. This allows the surgeon greater flexibility in choosing the exact zone required for documentation.

Focal length of the QUINTUS® TV adaptor:
The QUINTUS® TV adaptor is available in the fixed focal lengths f = 45 and f = 55 mm or as a zoom model with variable focal length 43–86 mm. This provides an optimal FULL HD image in 16:9 in conjunction with the H3-M COVIEW HD microscope camera head from KARL STORZ.

Focal lengths: H3-M COVIEW camera image detail using a QUINTUS® TV adaptor with the fixed focal lengths of 45 and 55 mm.

Variable focal length: Adjustable H3-M COVIEW camera image detail using a QUINTUS® zoom adaptor with variable focal length of 43–86 mm.
HD Imaging with Operating Microscope

System Components

**QUINTUS® TV Adaptor** for operating microscopes from CARL ZEISS MEDITEC with fixed focal length

- **QUINTUS® Z 45 TV Adaptor**, for CARL ZEISS MEDITEC operating microscopes, $f = 45$ mm, recommended for IMAGE1 HD H3-M/H3-M COVIEW camera heads

- **QUINTUS® Z 55 TV Adaptor**, for CARL ZEISS MEDITEC operating microscopes, $f = 55$ mm, recommended for IMAGE1 HD H3-M/H3-M COVIEW, H3, H3-Z as well as IMAGE1 S1 and S3 camera heads

**QUINTUS® Zoom TV Adaptor** for operating microscopes from CARL ZEISS MEDITEC with variable focal length

- **QUINTUS® Zoom TV Adaptor**, for CARL ZEISS MEDITEC operating microscopes, with variable focal length $f = 43–86$ mm, for use with all KARL STORZ cameras (SD and HD)

**Further accessories for operating microscopes from CARL ZEISS MEDITEC**

- **Iris**, for ZEISS Pentero®, iris as a necessary extension between the QUINTUS® TV adaptor and the operating microscope ZEISS Pentero®

- **Optical Beamsplitter 50/50**, for use with ZEISS operating microscope or colposcope

*Note:* Optical beamsplitters for other operating microscopes (i.e. LEICA or Möller-Wedel) are available directly from the manufacturers.
HD Imaging with Operating Microscope

System Components

QUINTUS® TV Adaptor for operating microscopes from LEICA Microsystems with fixed focal length

- **QUINTUS® L 45 TV Adaptor**, for LEICA Microsystems operating microscopes, f = 45 mm, recommended for H3-M microscope camera head
- **QUINTUS® L 55 TV Adaptor**, for LEICA Microsystems operating microscopes, f = 55 mm, recommended for IMAGE1 HD H3-M/H3-M COVIEW, H3, H3-Z as well as S1 and S3 camera heads

QUINTUS® TV Adaptor for operating microscopes from LEICA Microsystems with variable focal length

- **QUINTUS® Zoom TV Adaptor**, for LEICA Microsystems operating microscopes, with variable focal length f = 43–86 mm, for use with all KARL STORZ cameras (SD and HD)

QUINTUS® TV Adaptor for operating microscopes from Möller-Wedel with fixed focal length

- **QUINTUS® M 45 TV Adaptor**, for Möller-Wedel operating microscopes, f = 45 mm, recommended for IMAGE1 HD H3-M/H3-M COVIEW camera heads
- **QUINTUS® M 55 TV Adaptor**, for Möller-Wedel operating microscopes, f = 55 mm, recommended for IMAGE1 HD H3-M/H3-M COVIEW, H3, H3-Z and S1, S3 camera heads

**Note:** Optical beamsplitters for other operating microscopes (i.e. LEICA or Möller-Wedel) are available directly from the manufacturers.
**IMAGE1 S Camera Heads**

For use with IMAGE1 S Camera System
IMAGE1 S CONNECT Module TC 200EN, IMAGE1 S H3-LINK Module TC 300
and with all IMAGE1 HUB™ HD Camera Control Units

**TH 100**

**IMAGE1 S H3-Z Three-Chip FULL HD Camera Head**, 50/60 Hz, IMAGE1 S compatible, progressive scan, soakable, gas- and plasma-sterilizable, with integrated Parfocal Zoom Lens, focal length \( f = 15–31 \text{ mm} \) (2x), 2 freely programmable camera head buttons, for use with IMAGE1 S and IMAGE1 HUB™ HD/HD

**Specifications:**

<table>
<thead>
<tr>
<th>IMAGE1 FULL HD Camera Heads</th>
<th>IMAGE1 S H3-Z</th>
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<tbody>
<tr>
<td>Product no.</td>
<td>TH 100</td>
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<tr>
<td>Image sensor</td>
<td>3x ( \frac{1}{3}'' ) CCD chip</td>
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<tr>
<td>Dimensions w x h x d</td>
<td>39 x 49 x 114 mm</td>
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<td>Weight</td>
<td>270 g</td>
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<tr>
<td>Optical interface</td>
<td>integrated Parfocal Zoom Lens, ( f = 15–31 \text{ mm} ) (2x)</td>
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<tr>
<td>Min. sensitivity</td>
<td>F 1.4/1.17 Lux</td>
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<tr>
<td>Grip mechanism</td>
<td>standard eyepiece adaptor</td>
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<tr>
<td>Cable</td>
<td>non-detachable</td>
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<tr>
<td>Cable length</td>
<td>300 cm</td>
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</tbody>
</table>

**39301 Z3TS**

**Plastic Container for Sterilization and Storage** of camera heads IMAGE1 H3-Z, H3-ZA, H3-FA, IMAGE1 S H3-Z, H3-ZA and H3-FA, autoclavable, suitable for use with steam, gas and hydrogen peroxide sterilization, Sterrad® compatible, external dimensions (w x d x h): 385 x 255 x 75 mm

**Please note:** The instrument displayed is not included in the plastic container.

Only camera heads marked “autoclave” can be placed in the tray for steam sterilization.
Monitors

9619 NB 19" HD Monitor, color systems PAL/NTSC, max. screen resolution 1280 x 1024, image format 4:3, power supply 100–240 VAC, 50/60 Hz, wall-mounted with VESA 100 adaption, including:
- External 24 VDC Power Supply
- Mains Cord

9826 NB 26" FULL HD Monitor, wall-mounted with VESA 100 adaption, color systems PAL/NTSC, max. screen resolution 1920 x 1080, image format 16:9, power supply 100–240 VAC, 50/60 Hz including:
- External 24 VDC Power Supply
- Mains Cord
Monitors

### KARL STORZ HD and FULL HD Monitors

<table>
<thead>
<tr>
<th>Wall-mounted with VESA 100 adaption</th>
<th>19”</th>
<th>26”</th>
</tr>
</thead>
<tbody>
<tr>
<td>9619 NB</td>
<td>9826 NB</td>
<td></td>
</tr>
</tbody>
</table>

#### Inputs:
- DVI-D
- Fibre Optic
- 3G-SDI
- RGBS (VGA)
- S-Video
- Composite/FBAS

#### Outputs:
- DVI-D
- S-Video
- Composite/FBAS
- RGBS (VGA)
- 3G-SDI

#### Signal Format Display:
- 4:3
- 5:4
- 16:9
- Picture-in-Picture
- PAL/NTSC compatible

#### Optional accessories:
- 9826 SF Pedestal, for monitor 9826 NB
- 9626 SF Pedestal, for monitor 9619 NB

### Specifications:

<table>
<thead>
<tr>
<th>KARL STORZ HD and FULL HD Monitors</th>
<th>19”</th>
<th>26”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop with pedestal</td>
<td>optional</td>
<td>optional</td>
</tr>
<tr>
<td>Product no.</td>
<td>9619 NB</td>
<td>9826 NB</td>
</tr>
<tr>
<td>Brightness</td>
<td>200 cd/m² (type)</td>
<td>500 cd/m² (type)</td>
</tr>
<tr>
<td>Max. viewing angle</td>
<td>178° vertical</td>
<td>178° vertical</td>
</tr>
<tr>
<td>Pixel distance</td>
<td>0.29 mm</td>
<td>0.3 mm</td>
</tr>
<tr>
<td>Reaction time</td>
<td>5 ms</td>
<td>8 ms</td>
</tr>
<tr>
<td>Contrast ratio</td>
<td>700:1</td>
<td>1400:1</td>
</tr>
<tr>
<td>Mount</td>
<td>100 mm VESA</td>
<td>100 mm VESA</td>
</tr>
<tr>
<td>Weight</td>
<td>7.6 kg</td>
<td>7.7 kg</td>
</tr>
<tr>
<td>Rated power</td>
<td>28 W</td>
<td>72 W</td>
</tr>
<tr>
<td>Operating conditions</td>
<td>0–40°C</td>
<td>5–35°C</td>
</tr>
<tr>
<td>Storage</td>
<td>-20–60°C</td>
<td>-20–60°C</td>
</tr>
<tr>
<td>Rel. humidity</td>
<td>max. 85%</td>
<td>max. 85%</td>
</tr>
<tr>
<td>Dimensions w x h x d</td>
<td>469.5 x 416 x 75.5 mm</td>
<td>643 x 396 x 87 mm</td>
</tr>
<tr>
<td>Power supply</td>
<td>100–240 VAC</td>
<td>100–240 VAC</td>
</tr>
<tr>
<td>Certified to</td>
<td>EN 60601-1, protection class IPX0</td>
<td>EN 60601-1, UL 60601-1, MDD93/42/EEC, protection class IPX2</td>
</tr>
</tbody>
</table>
Cold Light Fountains and Accessories
for Diagnosis and Treatment

Fiber Optic Light Cable,
with straight connector, diameter 3.5 mm,
length 180 cm
495 NL

Same, size 4.8 mm
495 NB

Fiber Optic Light Cable,
with straight connector,
extremely heat-resistant, with safety lock,
increased light transmission,
diameter 3.5 mm, length 230 cm
495 NAC

Cold Light Fountain XENON 300 SCB

Cold Light Fountain XENON 300 SCB
with built-in antifog air-pump, and integrated
KARL STORZ Communication Bus System SCB
power supply:
100–125 VAC/220–240 VAC, 50/60 Hz
including:
Mains Cord
SCB Connecting Cable, length 100 cm
20133027
Spare Lamp Module XENON
with heat sink, 300 watt, 15 volt
20133028
XENON Spare Lamp, only,
300 watt, 15 volt

Cold Light Fountain XENON NOVA® 175

Cold Light Fountain XENON NOVA® 175,
power supply:
100–125 VAC/220–240 VAC, 50/60 Hz
including:
Mains Cord
2013501
XENON Spare Lamp,
175 watt, 15 volt
20132026
**Equipment Cart**

**Equipment Cart**

wide, tall, rides on 4 antistatic dual wheels equipped with locking brakes, 3 shelves, mains switch on top cover, central beam package with integrated electrical subdistributors with 12 sockets, grounding plugs

*Dimensions (w x h x d):*
- Equipment cart: 830 x 1474 x 730 mm,
- Shelf: 630 x 25 x 510 mm,
- Caster diameter: 150 mm

*Consisting of:*
- **Base module**, equipment cart, wide
- **Cover**, equipment cart, wide
- **Beam package**, equipment cart, tall
- 3x **Shelf**, wide
- **Drawer unit with lock**, wide
- 2x **Equipment rail**, long
- **Camera holder**
- 2x **Mains Cord**, length 100 cm

**Monitor Swivel Arm,**

height- and side-adjustable, can be turned to the left or right, swivel range 180°, overhang 780 mm, overhang from centre 1170 mm, load capacity max. 15 kg, with monitor fixation VESA 5/100, for use with equipment carts UG xxx
**Recommended Accessories for Equipment Cart**

**UG 310**

**Isolation Transformer**, 
200 V–240 V; 2000 VA with 3 special mains sockets, automatic cut-out, 3 grounding plugs, dimensions: 330 x 90 x 495 mm (w x h x d), for use with Equipment Carts UG xxx

**UG 410**

**Earth Leakage Monitor**, 
200 V–240 V, for mounting to equipment cart, control panel dimensions: 44 x 80 x 29 mm (w x h x d), for use with Isolation Transformer UG 310

**UG 510**

**Monitor Holding Arm**, 
height- and side-adjustable, tilting, mountable to the left or right, swivel range up to 320°, overhang 530 mm, load capacity max. 15 kg, monitor mount VESA 75/100, for use with Equipment Carts UG xxx
Notes