

## **Carbon Dioxide Laser Microsurgery for Laryngeal and Hypopharyngeal Cancer**

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Since Jako and Strong introduced the CO2 laser in microsurgery of the larynx in the 1970s, W. Steiner expanded since 1979 the indications from the excision of very early vocal cord lesions to more extended laryngeal and pharyngeal resections for T1 to T4 tumors.

In the last 27 years we have treated more than 3.500 patients with primary or recurrent cancer of the upper aerodigestive tract.

### **Oncologic and surgical principles**

The following basic principles of oncologic surgery apply to conservation surgery of the larynx as well as to transoral laser microsurgery :

the primary concern is complete tumor removal with sufficient resection margins and precise histopathologic examination of the resected specimen;

Compared to conventional surgery, there are, however, differences in how to reach this goal: not only is the surgical strategy based on and determined by the preoperative findings, but the transoral resection rather follows the individual spread of the tumor as seen under the microscope, in the form of “custom-tailored” surgery.

In cases of doubt, frozen sections are used. The findings on permanent histologic sections might indicate further surgery.

### **Transection of the tumor**

Depending on location and size, the tumor is removed in one block or blockwise using various laser laryngoscopes and microinstruments. This unconventional surgical technique, introduced by Steiner in the early eighties, is justified because the lymphatic vessels are sealed. We have not seen an increase of late neck or distant metastases during long term follow up using our technique. This segmental resection technique allows the surgeon to inspect the cut surface of the tissue, to distinguish between tumor and healthy tissue with the help of a highly magnifying microscope and thanks to the specific cutting properties of the CO2 laser. This enables the surgeon to be oncologically radical and to preserve functionally important tumorfree structures like cartilage, muscles, nerves, vessels, etc.

The main principle is : less surgical radicality without loss of oncological radicality.

### **Therapeutic concept**

Any tumor for which a curative procedure with preservation of function seems feasible is treated primarily with transoral laser surgical technique under the operating microscope. If **neck surgery** is indicated, a selective neck dissection is routinely performed for No to N2 cases, primarily as a delayed procedure.

Adjuvant **radiotherapy** is mainly indicated for advanced neck disease (multiple metastases, large solitary metastasis, rupture of the capsule a.s.o). It can start as early as 2 weeks after surgery.

### **Preconditions and limits**

Surgeons should have appropriate **experience** in endoscopic anatomy and microlaryngoscopy.

The key to this kind of surgery is adequate exposure with the help of special laryngoscopes, instruments and manipulation of the larynx from outside. The larynx needs to be adequately exposed with complete visualization of the cancer. Careful examination of the margins by the pathologist is the basis for verification of a sound resection. Finally, one needs the patient's compliance in abandoning carcinogenic habits and cooperating in follow-up.

## **Preconditions for organ preservation:**

### **Appropriate Patient's selection**

Sufficient laryngeal preservation must occur to allow adequate breathing, swallowing and voice. There should be a high probability of preservation of functionally important structures. Functional disorders such as severe persisting aspiration after extended resection and extensive tumor spread to the neck represent the real limitation of this procedure.

In laryngeal cancer at least one functioning arytenoid cartilage and in hypopharyngeal cancer at least half of the larynx and about 2 cm of the circumference of the hypopharyngeal and half of the upper esophageal mucosa should be preserved for functional reasons to avoid persisting aspiration or stenosis.

## **Results**

The results of more than 1200 previously untreated patients with early and advanced laryngeal and piriform sinus cancer will be presented. Patients with second primary, N3 neck or distant metastases were excluded. All patients were treated primarily with transoral laser microsurgery +/- selective neck dissection (homo- or bilateral), +/- postoperative (Chemo-) radiotherapy.

### **Early Glottic Carcinoma**

The observation that in small vocal cord lesions (Cais, MicroCa) diagnostic excisional biopsy was very often curative – as proved by histology after open or endoscopic surgery – was the main rationale for endoscopic surgery with curative intent.

### **Resection technique**

The small vocal cord lesions, e.g. midportion, is completely removed through an excisional biopsy. The use of a pulsed CO2 laser with a very small micromanipulator focus diameter results in minimal scarring and is particularly suitable for this application. The histologic assessment of the resection margins was facilitated by this technique, though relatively close margins were kept. The average distance between tumor and basal cut was ca. 1.5 mm. Usually the vocal function was almost normal after such limited excisions. Carcinomas involving more than 1/3 of the vocal cord and all larger tumors are best resected endoscopically by transecting the tumor and extending the laser incision to the vocalis muscle according to the individual tumor spread. The cancer is then removed in several pieces.

## Results of 333 vocal cord cancer pT1a ( 1979 - 2001)

Extent of the tumor: more than 1/3 of the vocal cord: 68%; anterior commissure involvement: 22%; only midportion vocal cord invasion: 14%.

4 postoperative endoscopically treated complications: bleeding 2, edema 2.

No tracheotomy, no feeding tube!

Glottic Cancer pT1a n=333		
Median follow-up	→	72 mth
Complication Rate	→	1.2 %
Local Control	→	96.2 %
Larynx Preservation Rate	→	97.6 %
Disease specific surv.	→	100 %
Overall Survival	→	86.8 %

(5-year Kaplan-Meier Estimates)

## Involvement of the anterior commissure

Involvement of the anterior commissure remains the most controversial issue regarding laser surgery for early glottic carcinoma. There are reports in the literature of high recurrence rates after laser treatment of anterior commissure tumor.

We analyzed anterior commissure involvement in 446 cases of early glottic cancers, treated in Göttingen from 1986 to 2004.

Impact of Anterior Commissure Involvement on Local Control (n=446 Patients; 1986 - 2004)			
<b>Anterior Commissure involved</b>	<b>pT1a (n=55)</b>	<b>pT1b (n=35)</b>	<b>pT2a (n=64)</b>
Local control [%]	76.3	77.1	75.0
Larynx preservation [%]	94.5	88.6	89.1
<b>Anterior Commissure not involved</b>	<b>pT1a (n=237)</b>	<b>pT1b (n=17)</b>	<b>pT2a (n=38)</b>
Local control [%]	86.9	88.2	84.2
Larynx preservation [%]	98.7	100	97.3

(Absolute figures)

The results of the study show that involvement of the anterior commissure is reflected in the prognosis (higher local recurrence and salvage laryngectomy rates). Although the involvement of the anterior commissure is followed by an increased rate of local recurrences we see no contraindication against laser surgery, since the larynx preservation rates are comparable to

those after external surgery. The survival rates are similar.

In our opinion, the main cause for local recurrences in this area is insufficient surgical radicality. Prerequisites for surgery of the anterior commissure are adequate exposure, stepwise tumor resection and a meticulous histologic assessment. To avoid recurrences, the resection should include the anterior vocal ligaments, the perichondrium of the thyroid cartilage and the cricothyroid membrane. If there is tumor spread into the neck or evidence of thyroid cartilage infiltration, the thyroid cartilage must be resected partially for better exposure to ensure curative resection. If the exposure is not adequate, external approach using microscope and CO2 laser is recommended. Primary closure with prelaryngeal muscles without tracheotomy is performed.

## Conclusions

Comparing the **different treatment modalities** of early glottic cancer the following conclusions can be made:

Laser microsurgery is superior to **open surgery** for the following reasons: the possibility of an outpatient procedure, shorter operating time, less risk for overtreatment, better voice quality, less morbidity (no feeding tube or tracheotomy), less complications, similar oncologic results.

Laser microsurgery is superior to **radiotherapy**, which is overtreatment in early glottic cancers. Small glottic tumors are often removed by the diagnostic biopsy. The oncological results are, without any doubt, better for laser surgery than for radiotherapy. We have fewer local recurrences and salvage laryngectomies as well as less morbidity.

The conclusions of several studies of **vocal function** following different treatment modalities are that in comparison with open surgery, the quality of voice is superior after laser surgery, and the voice quality in highly selected patients with vocal cord carcinoma treated by laser resection can be as good or even better than in patients whose cancer was similarly staged after radiotherapy.

The findings of different studies indicate that the total **cost** of radiotherapy and open surgery is significantly **higher** than that of laser surgery.

Our long-term results indicate that with certain precautions, laser microsurgical resection is the treatment of choice for most early stages of glottic cancer with respect to oncology, function, and economy.

## Advanced Glottic Carcinoma

### Resection technique

For the resection of (moderately) advanced glottic cancer incisions are made through the cancer to divide it into smaller blocks. The incisions are extended laterally onto the thyroid cartilage and inferiorly onto the cricoid cartilage. If the musculature is subtotally infiltrated, the tumor is resected by dissecting the perichondrium along the inner table of thyroid or cricoid cartilage. If infiltration of the thyroid cartilage is suspected, parts of the cartilage are included in the resection. Additional biopsies from adjacent paralaryngeal soft tissue can be used to confirm that the tumor resection was complete. The arytenoid cartilage is partially or totally resected.



**Results of 338 patients with pT2 and pT3 glottic cancer ( 1979 - 2001 )**  
**Distribution of stage: II 71 %, III 27 %, IV 2 %.**  
 Median Follow-up interval 69 months.

**Cancer of the Glottis**  
n=338

**Therapy**

	pT2a n=128	pT2b n=115	pT3 n=95
Laser	116 (91%)	87 (76%)	42 (44%)
Laser + ND	12	15	41
Laser + RAD	-	11	3
Laser + ND + RAD	-	2	9

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**Glottic carcinoma**  
n=338

**Postoperative Complications**

	pT2a n=128	pT2b n=115	pT3 n=95
Postop. Bleeding (MLS)	1	1	1
Glottic stenosis (MLS)	0	0	1
Laryngeal edema (MLS)	0	0	2
Perichondritis (MLS)	0	2	1
Subcut. Emphysema	0	3	1
Tracheotomy	0	0	3
Pneumonia	1	0	0

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**Cancer of the Glottis**  
n=338

**Postoperative Swallowing**

	pT2a n=128	pT2b n=115	pT3 n=95
Nasal feeding tube			
none	126 (98%)	108 (94%)	56 (59%)
1-7 days	-	6	27
8-30 days	1	1	12
> 30 days	1 (PEG)	-	-

no permanent PEG tube  
no functional LE

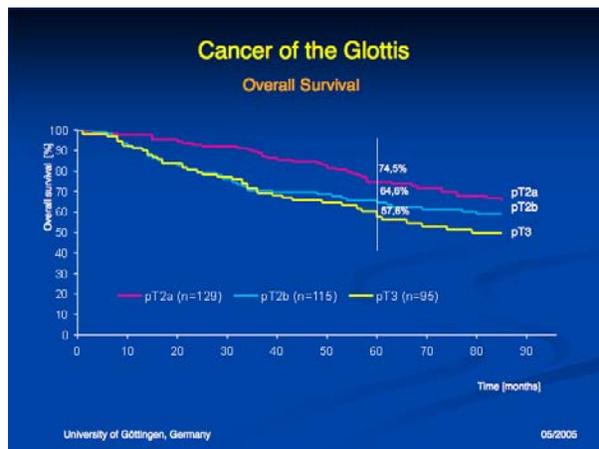
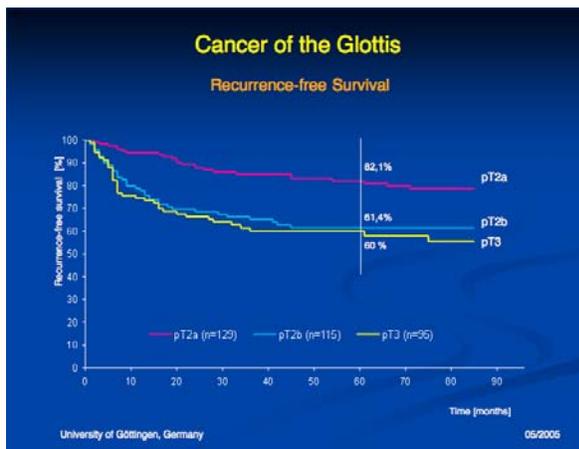
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**Cancer of the Glottis**  
n=338

**Local Control**

	pT2a n=128	pT2b n=115	pT3 n=95
Patients with local recurrences	21 (16%)	35 (30%)	29 (31%)
Salvage Laryngectomy	5 (4%)	16 (14%)	15 (16%)

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## Conclusions

The oncological results are superior to primarily radiated patients with T2 and T3 glottic cancer. Compared to the results of open surgery they are similar, especially the salvage laryngectomy rates. Functional results were very satisfactory. About two thirds of the patients had voice analysis postoperatively. Speech intelligibility in the telephone test was greater than 90 % in both groups.

## Supraglottic Carcinoma

### Resection technique

Laser resection of supraglottic tumors is done stepwise. A partial or total resection of the pre-epiglottic fat is necessary in carcinomas of the infrahyoid epiglottis, because of possible microscopic tumor invasion and is mandatory in cases of macroscopic invasion. Depending on the tumor extension the operation may extend to the hyoid bone anteriorly and, if necessary, include a partial resection of the hyoid bone. Inferiorly the resection follows the inside of the thyroid cartilage toward the anterior commissure. If there is suspicion of tumor spread to the glottis and/ or paraglottis, this regions are included in the resection.

**Results of 216 patients with supraglottic carcinomas (T1 to T4 / 1980 - 2000)**  
**Distribution of stage: I 10% , II 29% , III 30% , IVa 31% .**

Supraglottic carcinoma n=216		
Therapy		
	I + II	III + IV
Laser	31 (37,5%)	12 (9%)
Laser + ND	50 (60%)	78 (59%)
Laser + RT	2 (2,5%)	1 (0,5%)
Laser + ND + RT	-	42 (31,5%)
	83	133

Supraglottic carcinoma n=216		
Postoperative Complications		
	pT1/pT2 n=95	pT3/pT4 n=121
Postop. bleeding (MLS)	5	13
Laryngeal edema (MLS)	1	4
Laryngeal stenosis	1	3
Pneumonia	2	2

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Supraglottic carcinoma n=216		
Tracheotomy		
	pT1/pT2 n=95	pT3/pT4 n=121
Prophylactic	1	3
Aspiration	0	2*
Edema	1	1
Stenosis	0	2*
Postop. bleeding	0	1

\* permanent tracheotomy: 1/1

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**pT1 and pT2 Supraglottic Carcinoma (n=95)**

	pT1 (n=23)	pT2 (n=72)
5y local control rate [%]	95	85
Salvage laryngectomy [%]	4	1
5y overall survival rate [%]	87	73
5y rec.-free survival rate [%]	91	77
median follow-up interval: 52 months		

12/2002

**pT3 and pT4 Supraglottic Carcinoma (n=121)**

	pT3 (n=76)	pT4 (n=45)
5y local control rate [%]	79	69
Salvage laryngectomy [%]	5	16
5y overall survival rate [%]	67	54
5y rec.-free survival rate [%]	67	60
median follow-up interval: 52 months		

12/2002

## Conclusions

The oncological results are comparable to those achieved by open surgery (partial or total laryngectomy), the functional results are superior. In comparison to radiotherapy or chemo-/radiotherapy the oncological results are superior and the functional results similar.

## Piriform Sinus Carcinoma

The resection technique is the same as for the larynx. In deep infiltrating lateral wall tumors we have to be very careful to avoid intraoperative severe bleeding. In some patients a transcervical approach for exposure of the big vessels in combination with a transoral approach is recommended.

### Results of 129 patients with piriform sinus cancer (T1 to T4 / 1981 - 1996 )

**Distribution of stage: I 8 % , II 18 % , III 20 % , IV a 54 % .**

The median follow-up interval was 44 months.

**Piriform Sinus Carcinoma (n=129)**

**Postoperative and late complications**

Postoperative Hemorrhage	5 (3.9%)
- endoscopic coagulation	4
- endoscopic coagulation, tracheotomy	1
Postoperative Edema	1 (0.8%)
- microlaryngoscopic removal of mucosa	
Posttherapeutic hypopharyngeal stenosis	1 (0.8%)
- gastrostomy tube	

**Piriform Sinus Carcinoma (n=129)**

**Functional Results**

	No.	%
No feeding tube	35	27.1
Feeding tube	94	72.9
<i>- median duration 7 days (range: 1-25 days)</i>		
Undisturbed oral intake	126	
Severe aspiration	2	1.6

### Piriform Sinus Carcinoma n=129

UICC 92	Local recurrence		Loco-reg. rec.	
	No.	%	No.	%
pT1 n=24	2	8.3	0	0
pT2 n=74	5	6.7	3*	4.1
pT3 n=17	2	11.8	0	0
pT4 n=14	3	21.4	2	14.3

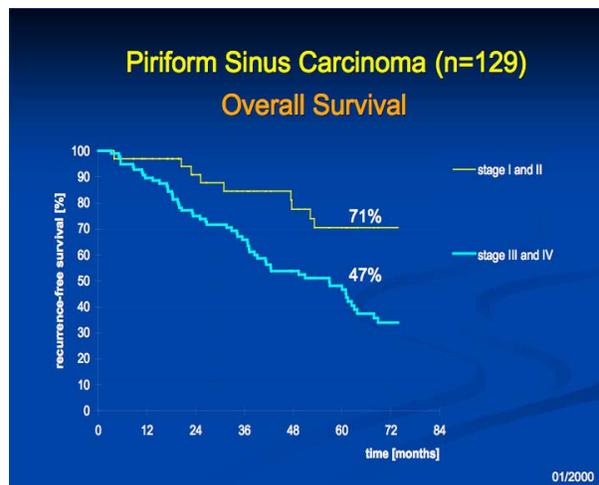
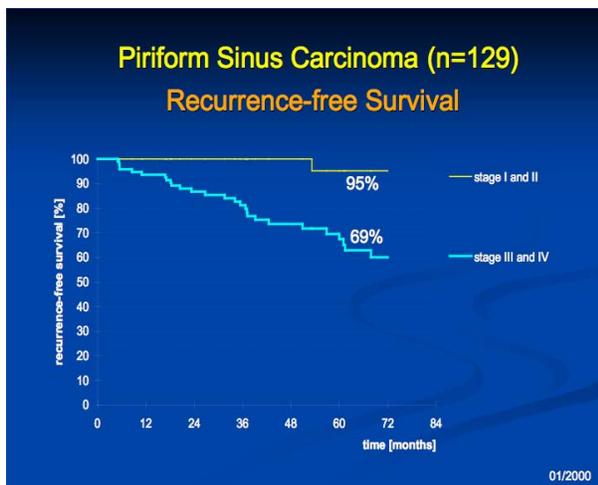
\* 1 x contralaterally

04/2000

### Piriform Sinus Carcinoma (n=129)

#### Salvage Therapy of Local and Locoregional Recurrences (n=17)

	No.	%
Laser microsurgery	5	29
Laser microsurgery + radiotherapy	3	18
Partial pharyngectomy with laryngeal preservation	1	6
Partial pharyngectomy with total laryngectomy	1	6
Palliative treatment	6	35
Unknown	1	6



## Advantages versus Standardtherapy

Thanks to the specific cutting properties of the CO<sub>2</sub> laser and the high magnification of the microscope, as well as the transoral approach and the unconventional technique of blockwise resection of larger lesions, the tumor can be removed safely by individually adapted, custom-tailored surgery with preservation of functionally important structures. Further advantages are that there is a free option for any kind of surgery, laser surgery can be repeated at any time, it can be integrated into any therapeutic concept, no reconstructive surgery is necessary, there are low rates of perioperative and postoperative morbidity and complications, costs are reduced, and faster and more complete reintegration into work and social life is achieved, as well as improvements in the patients' psychological situation

In the last two decades we could show that transoral laser microsurgical resection for organ preservation is an efficient alternative treatment to open surgery for moderately and more advanced laryngo-pharyngeal tumors. The oncological results are similar, the functional results are better and the morbidity lower. Transoral laser surgery is much more effective than any organ-preserving chemo-radiotherapeutic regimen. The morbidity and complication rates are lower, more organs are preserved, the survival rates are better. Our aim is to avoid a permanent tracheostomy for psychological, social, and professional reasons.

Apart from the local control and survival rates the quality of life, which means breathing, swallowing, talking without tracheotomy, is considered to be increasingly important. We as

surgeons have to consider this fact to prolong a life worth living.

Despite the modern possibilities of voice rehabilitation after total laryngectomy, such as voice prostheses, the effects of a permanent tracheotomy negatively impact quality of life.

The challenge for head and neck surgeons is to give patients a greatest chance for cure without loss of quality of life.

At present our favourable results demonstrate only a positive trend towards better survival following organ-preserving surgery, but they encourage us to continue the organ- and function-preserving approach.

Final proof of the efficiency of our therapeutic concept requires well-designed prospective studies with standardized surgical procedures carried out by head and neck surgeons skilled in laser surgery.

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Steiner W, Martin A, Ambrosch P, Pradier O, Kron M. Results of transoral laser microsurgery for supraglottic carcinoma. Accepted for *Ann Otol Rhinol Laryngol*

For head and neck surgeons who are interested in transoral laser microsurgery of cancer of the upper aerodigestive tract we recommend the following surgical manual (“cook book”) : Steiner W, Ambrosch P. (2000) : *Endoscopic laser surgery of the upper aerodigestive tract. With special emphasis on cancer surgery.* Georg Thieme, Stuttgart, New York