Application of endoscopic CO2 laser surgery for early malignant tumours of the larynx

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Laser

- LASER - Light Amplification by Stimulated Emission of Radiation
- Low energy laser: soft laser
- High energy laser
- Cut, coagulation laser
- Impuls, continuous mode
Human application of lasers

- **Gas lasers**: CO2 10.6 μm – larynx, pharynx, trachea, nose, ear, He-Neon (soft laser),
- **Ion lasers**: Argon 350-530 nm, Krypton 400-610 nm - dermatology
- **Diode laser**: 808 nm
- **Dye laser**: different wavelength
- **Excimer laser**: - ear
- **Neodym YAG**: 1064nm, Neodym doped - Yttrium-Aluminium-Granat-Laser, fiberoptic – trachea, brochi
- **Combi laser**: Nd:YAG+CO2 – pharynx trachea, brochi
- **KTP laser**: 532 nm - Potassium Titanyl Phosphate — nose
Specification of CO2 laser

- **CO2 laser - wavelength**: 10.6 μm
- Cutting laser, up to 0.5 mm diameter of vessel coagulation
- High energy, 60-100 W
- 0.25-0.80 mm spot – burning tissue
- Straight spread of laser beam (flexible optic also available)
- Coupled with microscope easy and exact manipulation
CO2 laser applications for transoral surgery of the larynx:

- Benign lesions
- Early malignant tumours of the larynx
Tumours of the larynx: Localization, distribution and prognosis

- Glottic tumours – vocal fold (about 48%)
- Supraglottic tumours (about 50%)
- Subglottic tumours (1-2%)
Carcinoma of the larynx

- Cancers of the larynx account for the majority of head and neck cancers; however, head and neck cancers account for only about 9% of all cancers diagnosed annually.
- In the United States, there are more cancers affecting the glottic larynx than the supraglottic larynx. Conversely, in Europe and many other parts of the world, supraglottic cancers outnumber glottic cancers.
- Cancers of the glottic larynx are more likely to be detected early because even small lesions produce voice changes readily noticeable by the patient and his/her family members; however, patients with smoking-related chronic laryngitis who are used to a chronically hoarse voice may not detect voice changes produced by an early cancer at this location. The supraglottis tends to be a more silent location because tumors here do not affect the voice until they are significantly more advanced. Patients with tumors in this area may present with a sore throat, pain on swallowing (odynophagia), or ear pain (otalgia).
Carcinoma of the larynx
Carcinoma planocellulare laryngis

Prevalence of the laryngeal tumour: 5.- 6. most frequent of the malignancies in adults.

Predisposition:

- Inherited genetic conditions (inherited, acquired, DNA mutation)
- Incidence in countries (continents)
- Habits: smoking - tobacco use (abuse)!!, alcohol consumption (lesion of the liver), chemicals, feeding, hygiene of the mouth
- Profession, pollution.
- Appearance: age of 50-70 years, Men-women ratio: 20:1 (USA: 5:1)
Pathogenesis

- Invasive carcinoma may develop from dysplasia and transforms to cancer (in situ)
- Precancerosis: Keratosis without atypia, Keratosis with atypia (I-III.), Cc. in situ
- Dysplasia I.- dysplasia II.- dyplasia III = in situ carcinoma
- More than 92% of laryngeal carcinoma: established as a squamous cell carcinoma
- Minority of the laryngeal malignant epithelial tumours: verrucous carcinoma, adenocarcinoma, basal cell carcinoma, carcinosarcoma
- Sarcoma is extremly rare: fibro-, myo-, chondrosarcoma, rhabdomyosarcoma
Prognosis of the laryngeal cancer depends on:

- Localization (supraglottic, glottic, subglottic site)
- Staging, TNM classification
- Differentiation of the tumour
- Metastasis formation
TNM classification

- Laryngeal cancers are staged and classified according to the TNM system as explained in the latest manual of the ICD-O (International Classification of Diseases for Oncology) WHO, TNM Classification for Malignant Tumours – UICC and American Joint Commission on Cancer. There is a separate staging system for cancers that affect different subdivisions of the larynx. Subglottic cancer is quite rare and so we focus on cancers affecting the glottic and supraglottic larynx.
- Clinical evaluation: cTNM, pathological finding: pTNM
- Hungarian issue for laryngeal tumour classification: A gége- és hypopharynx-laphámrák osztályozása, kivizsgálása és kezelési javaslata Magyar Onkológia, 46, 4, 301-305, 2002
Laryngeal Cancer T staging
T1, T2 tumours: transoral laser surgery

Glottic Cancers
T1a: Tumour is confined to one vocal cord with normal mobility
T1b: Tumour involves both vocal cords but mobility is normal
T2: Extension of the tumour from the vocal cords to the supraglottic or subglottic larynx or impaired vocal cord mobility
T3: Tumour is confined to the larynx but there is fixation of the vocal cord
T4: There is invasion through thyroid cartilage and/or other tissues beyond larynx (e.g., trachea, thyroid, pharynx, soft tissue of neck).
Laryngeal Cancer T staging

T1, T2 tumours: transoral laser

- **Supraglottic Cancers**
  - T1: Tumour is confined to one subsite of the supraglottic larynx and there is normal vocal cord mobility
  - T2: Tumour invades mucosa of more than one adjacent subsite of supraglottis but vocal cord mobility remains normal
  - T3: Tumour is limited to the larynx with vocal cord fixation and/or extension to postcricoid area or preepiglottic tissues.
  - T4: Tumour invades through thyroid cartilage, and/or extends into soft tissues of the neck, thyroid, and/or esophagus

- **Staging of regional metastases (N) is as follows:**
  - N0: No evidence of regional metastases to cervical lymph nodes
  - N1: Single neck node up to 3 cm in greatest dimension
  - N2: Single node greater than 3 cm (but less than 6 cm), or multiple lymph nodes
  - N3: Any node greater than 6 cm in greatest dimension
TNM Stage, application of transoral laser surgery
The stage is assigned according to the following scheme:

T1 N0 M0   Stage I   - transoral laser surgery
T2 N0 M0   Stage II  - transoral laser surgery
T1-2N1M0   Stage III - transoral laser surgery + neck management
T3 N0 M0   Stage III
T3 N1 M    Stage III

T4, N0-N1 M0 Stage IVA
T1-4, N2 M0  Stage IVA
T1-4, N3 M0  Stage IVB
T1-4, N0-3, M1 Stage IVC

In general, the more advanced the overall stage the worse the prognosis. Prognosis is best for those who have no regional metastases (N0) and worst for those who have distant metastases (M1). Cancers of the supraglottic larynx and Morgagni sac are more likely to have regional neck metastases than are cancers of the glottic larynx.
Diagnostic in laryngeal neck tumours

- **Case history**: personal, familiar, social questionnaire, feeding
- **Clinical examination**: indirect - and direct laryngoscopy, endoscopy, palpation of the neck (metastasis)
- **Pathology** (primary tumour - biopsy, metastasis - fine needle aspiration)
- **Imaging** (CT, MRI, sonography of the neck, chest X-ray, sonography of the belly)
- **Staging**
- **Research**:
  - Examination of DNA (PCR), gen chips
  - Investigation of immun cells
  - Tumour markers
Symptoms, clinical patterns

• Vocal cord cancer  hoarseness
• Supraglottic cancer  dysphagia
  referred pain in the ear - otalgia irradiata (supplied by n. vagus)
  dyspnoe
  hoarseness
• Subglottic cancer  voice disorder
  dyspnoe
Diagnostic, evaluation, therapy: 
endoscopy of the larynx

Indirect laryngoscopy

Direct laryngoscopy:
Rigid endoscopy - diagnostic
Flexible endoscopy - diagnostic
Laryngomicroscopy – diagnostic and therapy

Laryngostroboscopy - phonation
Photodynamic endoscopy - oncology
Contact endoscopy - oncology, etc.
Endoscopy of the larynx with 70° rigid optic and fiberoscopy visualizing the larynx

fiberoscopy
laryngoscopy

Video-endoscopy: tumour of the vocal fold, outpatient
Direct laryngoscopy: laryngomicroscopy – general anaesthesia (ITN) or JET narcosis

Application of microscope and rigid, long optic for the preop. diagnostic

Laryngomicroscopy
Method

- Preoperative investigations: Endoscopy of the larynx, sonography and CT scan of the neck (MRI)
- **Instruments**: TLS 61 Tungsram laser, Lasram and later Daeshin DS 40UB laser surgical devices
- Opton, Leica microscopes
- Kleinsasser and **Weerda** laryngoscopes
- Laryngomicroscopic instruments
- General anaesthesia (intratracheal narcosis)
Basic treatment options for early laryngeal carcinoma

- Surgery
- Radiation therapy
- Chemotherapy
- Combined treatments
- By Onco-Team board consultation, decision!
Treatment options of early malignancies of the larynx - Surgery

- Surgical interventions: transoral (endoscopic) versus open approach surgery/radiation therapy

- Goals to achieve:
  1. Good oncological result
  2. Functional results: preserving the laryngeal functions (vocal cord), acceptable voice, swallowing without feeding tube and trachea-canule
  3. Aesthetic results: no tracheostomy, no scar on the neck (endoscopic surgery),
  4. Cost-benefit relations
Endoscopic CO2 laser technique

Introduction of transoral laser resection to the laryngology

- USA: Jako, Strong, Vaughan, Davis, Zeitels
- Europe: Steiner, Ambrosch, Rudert, Thumfart, Eckel, Werner, Motta, Bernard-Sperkelsen, etc.
- Hungary: Bánhídy, Kásler, Czigner, Élő, Lichtenberger, Répássy
20 years experience with transoral CO2 laser surgery of laryngeal tumours at the University of Szeged

Early glottic cancer: endoscopic CO2 laser surgery was introduced at our department in 1987 by professor Czigner

-T1a, T1 b, (T2) glottic carcinoma - laser cordectomy


-Supraglottic and marginal laryngeal tumours (T1, T2)


Patient’s material, method

- More than 20 years experience with CO2 laser surgery of the early glottic cancer (327 laser cordectomy)
- 375 laser cordectomy was performed (324 patients), in patients with Tis-T2 vocal cord cancer between 1987 and 2011.
- 289 patients with a minimum of 5 years follow up were analysed.
- Preoperative investigations: Endoscopy of the larynx, sonography and CT scan of the neck (MRI)
- Laryngomicroscopy: Tungsram TLS61, Lasram laser and Daeshin – DS 40UB laser devices, Opton microscope, Kleinsasser and Weerda laryngoscopes, rigid optics
- Laser cordectomies were divided after the ELS classification into 6 types
- The resected specimen was sent oriented and marked for pathological examination
Cancer of the vocal fold - 289 patients

- Ratio - Male : Female = 5:1 (USA)
- At the Dept. ORL-HNS Szeged: male (87%) : female (13%) ratio = 7.5:1

Age: 40-70 years - 81%

Predisposing factors
- smoking ± alcohol consumption (75%)
- alcohol (4%)
- no reported (21%)
- Other etiology (gas, chemicals, dust – profession, irritation)
Risk factor analysis: smoking and alcohol in a case-control study (odds ratio-OR)

### SMOKING

- **CASE GROUP**: 22%
- **CONTROL GROUP**: 26%

**OR** = \( \frac{78 \times 74}{22 \times 26} = 10 \)

10x RISK

### ALCOHOL

- **CASE GROUP**: 48%
- **CONTROL GROUP**: 25%

**OR** = \( \frac{48 \times 75}{52 \times 25} = 2.7 \)

2.7x RISK
T classification of early vocal cord cancers – 289 patients underwent transoral laser surgery

- Tis - 21 patients
- T1a - 179 patients
- T1b - 57 patients
- T2 - 32 patients
- Laser device:
  - Daeshin – DS 40UB
  - Microspot
  - Ultra pulse mode
6 types of laser cordectomy in our patient’s material (%) (ELS classification)

- I. Subepithelial excision - 16%
- II. Subligamental excision
- III. Intramuscular excision - 34% (type II., III.)
- IV. Total cordectomy - 38%

- V. a, Extension: anterior commissure
- V. b, Extension: arytenoid (vocal process)
- V. c, Extension: subglottis
- V. d, Extension: ventricle (Morgagni sac)
- VI. Anterior commissure - 12%

Eur Arch Otorhinolaryngol (2000) 257, 227-310
Endoscopic cordectomy, proposal for a classification by the Working Committee (ELS)
At the beginning of the CO2 laser application, endolaryngeal laser surgery was used for T1a glottic tumours.
T1a vocal cord tumour (ALA), laser cordectomy, type II.
Vocal cord tumour T1a, type I.
laser cordectomy (ALA)
T2 vocal cord tumour, type V. laser cordectomy (ALA)
T1a vocal cord carcinoma, laser cordectomy type II.-III. (AF)
T1b tumour, vocal cord: laser resection, anterior commissure, thyroid cartilage
CT and pathological section: evaluation of the anterior commissure
After laser cordectomy left
Recurrent tumour: vocal cord - T2:
T1 vocal cord cancer
laser cordectomy (video)
Pathological establishment of T1, T2 vocal cord cancers after laser cordectomy

Squamous cell cancer - cc. planocellulare (96%)
cc. verrucosum (3%)
cc. mucoepidermoid (1%)
Postoperative oncological and functional results

- Laser cordectomy, types I.-VI.:  
- Survival  
- Mobility of the vocal cords  
- Phonation  
- Quality of voice depends on the extension of excision
Results

- 289 laser cordectomy: 5 years survival: Tis tumours 100%, T1a 92%, T1b 77% and T2 83%
- For 87% of our patients with early glottic cancer CO2 laser excision proved to be a successful treatment, as a primary endoscopic surgery
- Types of laser cordectomy: I. type - 16%, II.-III. type - 34%, IV. type - 38%, V. type -12%
Results after salvage therapy - laser cordectomy

Survival after salvage therapy: 97%.

In 96% of our patients larynx and voice have been preserved.

- 5 years laser specific survival: 93%

Salvage therapies (13%):

- Repeated laser resection 6%
- Hemilaryngectomy 3%
- Laryngectomy 3%
- Radiation therapy, fronto-lat. resection 1%
- Neck management: RND 3%
Phonation after laser cordectomy, types I., III., IV.

I.

III.

IV.

III.
Laser cordectomy types III., IV., V. (removal of vestibular fold)
Endoscopy, phonation post type IV., V. laser cordectomy
Scar formation (anterior comissure)
Granulation - phonation with false cord – phonation deteriorated
Functional results
subjective voice analysis

- Voice Handicap Index (n=23)
**Functional results**

**Objective voice analysis with programme Praat**

**Jitter (%)**

- II (n=2)
- III (n=9)
- IV (n=4)
- V (n=9)
- VI (n=1)

**Schimmer (%)**

- II (n=2)
- III (n=9)
- IV (n=4)
- V (n=9)
- VI (n=1)

**Mean Phonation Time (s)**

- II (n=2)
- III (n=9)
- IV (n=4)
- V (n=9)
- VI (n=1)
Cost benefit: transoral laser resection of tumours of the vocal cord

- Time of endoscopic surgical resection - laser cordectomy: 10 - 40 min.
- Hospitalization: 1-3 days
- Costs:
  - Laser cordectomy: 50000 Ft
  - versus external approach surgery or radiation therapy: 300000 - 500000 Ft
Conclusions

Laser cordectomy represents a minimally invasive, transoral surgical method with good oncological and good (type I, II, III) or acceptable (type IV, V, VI) functional results (quality of life).
There was no swallowing disorder

- Smoking plays an important role in the development of glottic cancer in our patients too.
20 years experience with endolaryngeal CO2 laser surgery of the early supraglottic tumours

- Introduction of the transoral laser surgery of the T1, T2 supraglottic tumours (1989-)
Patient’s material:
T1, T2 supraglottic tumours (1989-2010)

- 63 Patients (15%): transoral CO2 laser-resection (1989-2010)

- 85% of patients with supraglottic tumour underwent external approach surgical intervention (supraglottic laryngectomy, laryngectomy)
**63 patients - staging**

Transoral CO2 laser-resection

40 patients with tumour of the epiglottis (36 T1N0, 4 T1N1), 4 pat. - tumour of the ventricular fold (4 T1N0), 13 pat. with supraglottic-vallecula tumour (10 T2N0, 3 T2N1) and 6 pat. with supraglottic-aryepiglottic fold (3 T2N0, 3 T2N1)

<table>
<thead>
<tr>
<th>Localization</th>
<th>Epiglottis</th>
<th>Ventricular fold</th>
<th>Supraglott.-vallecula</th>
<th>Supraglott.-aryepiglott. fold</th>
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<tbody>
<tr>
<td>supraglott.</td>
<td>36 patients</td>
<td>4 patients</td>
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<tr>
<td>tumour</td>
<td>4 patients</td>
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<td>Staging</td>
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<td>T1N0</td>
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<td>T1N1</td>
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<tr>
<td>T2N0</td>
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<tr>
<td>T2N1</td>
<td></td>
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<tr>
<td>Total</td>
<td>40 pat.</td>
<td>4 pat.</td>
<td>13 pat.</td>
<td>6 pat. = total of 63 patients</td>
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</table>
Patient’s material: supraglottic tumours of the larynx (1989-2010)

- Transoral laser resection in 63 patients (40 patients with epiglottis tumour, 4 with ventricular fold, 13 with supraglottic-vallecula and 6 with aryepiglottic fold tumour)
- Of the 63 supraglottic carcinoma 10 patients underwent endolaryngeal laser excision which was combined with simultaneous modified neck dissection (mRND), (4 patients with tumour of the epiglottis (T1N1), 3 supraglottic-vallecula (T2N1) and 3 supraglottic-aryepiglottic fold tumour (T2N1) + primary neck metastases)
- 20 patients got radiation therapy
Supraglottic cancer T1 tumour of the epiglottis and after CO2 laser-resection (partial epiglottectomy)
Supraglottic CO2 laser resection

M. Csanády · L. Iván · J. Czigner

Endoscopic CO₂ laser therapy of selected cases of supraglottic marginal tumors

Eur Arch Otorhinolaryngol (1999) 256: 392–394
Role of imaging (CT, MRI) in the transoral laser surgery of early (T1, T2) supraglottic tumours without infiltration of the preepiglottic space.
Infrahyoid carcinoma of the epiglottis, early and late postoperative results after transoral laser resection

Without spreading to the preepiglottic space/ no detectable metastasis

Laser epiglottectomy (video)
Carcinoma of the supraglottic-vallecula
Endoscopic CO2 laser resection + mRND (video)
Tumour of supraglottic-aryepiglottic fold
Transoral laser resection (video)
Endoscopic laser resection and horizontal supraglottic laryngectomy: postoperative results

- Endoscopic supraglottic laser resection (epiglottectomy)

- Horizontal supraglottic laryngectomy (external approach)
Role of CT in the follow up: detection of late neck metastasis 6 years after transoral supraglottic laser resection
Post transoral supraglottic laser resection: late neck metastasis, ND
Late postoperative functional result after transoral laser resection of supraglottic tumour (video)

No aspiration, glottis closure is intact
Cost benefit of transoral laser supraglottic resection

- Time of endoscopic surgical resection (laser supraglottic resection): 0.5 - 1h (versus horizontal supraglottic laryngectomy 1.5 - 2.5 h)
- Hospitalization: 3-8 days
- Average hospitalization time of transoral laser supralgottic resection: 6 days versus horizontal supraglottic laryngectomy 17 days

- Costs:
  - Laser supraglottic resection 70000 Ft + (neck dissection)
  - Horizontal supraglottic resection: 315000 Ft-
  - Depending on complications
Hospitalization after laser supraglottic resection (TLR), horizontal supraglottic resection (HSPR) and total laryngectomy (TL)

Hospitalization time

![Bar chart showing hospitalization days and calculated hosp. time with complication for different procedures.]

- TLR: 6,44 7,94 hosp. time with complication
- HSPR: 17,21 34,93 hosp. time with complication
- TL: 18,00 23,25 hosp. time with complication
- 1db: 21,29 57,71 hosp. time with complication
- 2db: 13,00 83,00 hosp. time with complication

Salvage laryngectomy
Dysphagia, aspiration after TLR, HSPR, TL

Dysphagia, aspiration post TLR, HSPR and TL

![Bar chart showing percentage of dysphagia and aspiration after TLR, HSPR, and TL.](chart.png)
Social life questionnaire (The EuroQol Group - EQ-5D-3L questionnaire)

Postop. daily activity

<table>
<thead>
<tr>
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<th>TLR (N=6)</th>
<th>HSPR (N=14)</th>
<th>TL (N=5)</th>
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<tbody>
<tr>
<td>EQ-5D-3L</td>
<td>1.33</td>
<td>1.86</td>
<td>1.8</td>
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Psychologic problems

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<th>HSPR (N=14)</th>
<th>TL (N=5)</th>
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<tbody>
<tr>
<td>EQ-5D-3L</td>
<td>1.5</td>
<td>1.93</td>
<td>1.8</td>
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Average satisfaction after surgeries

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<th>TLR (N=6)</th>
<th>HSPR (N=14)</th>
<th>TL (N=5)</th>
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<tbody>
<tr>
<td>Average satisfaction</td>
<td>65</td>
<td>52.5</td>
<td>52</td>
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Feeding, gastrostomy, PEG

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<th>TLR (N=6)</th>
<th>HSPR (N=14)</th>
<th>TL (N=5)</th>
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<tbody>
<tr>
<td>Postoperative period</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Feeding</td>
<td>16.6%</td>
<td>35.4%</td>
<td>0%</td>
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</table>
Results

- 47 (75%) patients with early supraglottic cancer became free of tumor after single laser resection
- 16 patients (25%) developed local recurrence
- 1 patient had irresecable neck metastasis (tumor free supraglottis), who died of metastases
- Salavge-therapies (16 patients): 7 repeated laser-resections, 3 radiation therapies, 4 horizontal supraglottic laryngectomies, 2 total laryngectomies, 5 RNDs (late neck metastases) – after salvage therapies there is no sign of recurrence
- Local tumor free survival: 85%
- Survival after salvage therapy: 98%
- Larynx sparing treatment: 96%
85% local tumour-free survival of supraglottic cancer patients after a transoral CO2 laser resection (Kaplan-Meier curve)

63 patients – T1, T2 supraglottic tumours
Conclusions

• In selected patients with early supraglottic tumour (63 patients/15%) transoral laser resection proved to be a good endoscopic surgical option versus horizontal supraglottic laryngectomy

• In 10 patients transoral laser method was combined with neck dissection in one session

• There was no need for tracheostomy and postoperative aspiration was rarely severe depending on the extension of the resection

• Postoperative quality of life of transoral laser resection highly exceeds of external approach, horizontal supraglottic laryngectomy
Advantages of transoral CO2 laser technique

- Minimally-invasive surgical intervention - faster recovery
- No need for tracheostomy
- Minimal intraoperative bleeding
- No or moderate edema – rarely developed
- Moderate (severe) aspiration, but less deglutition problem than after open access surgery (partial laryngectomy)
- Acceptable - good swallowing and voice
- Feeding tube or PEG is rarely required, only after extensive transoral supraglottic resection
- Shorter hospitalization: 2-8 days vs. 1-3 weeks - cost benefit!
FUTURE: TRANSORAL ROBOT ASSISTED SURGERY (TORS)! – DA VINCI SURGICAL ROBOT

TRANSORAL ROBOT ASSISTED SURGERY (TORS) – DA VINCI
Thank you for your attention!