Lasers in Medicine and Life Sciences Summer School (LAMELIS),

Principles and practice of laser surgery

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

Miklós Csanády MD. PhD.

associate professor

Department of Otorhinolaryngology, Head and Neck Surgery,

University of Szeged

LAMELIS 2019, Szeged, Hungary

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, **N**eo**d**ym doped - **Y**ttrium-**A**luminium-**G**ranat-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 the larynx:

Endoscopic (transoral) surgical intervention:

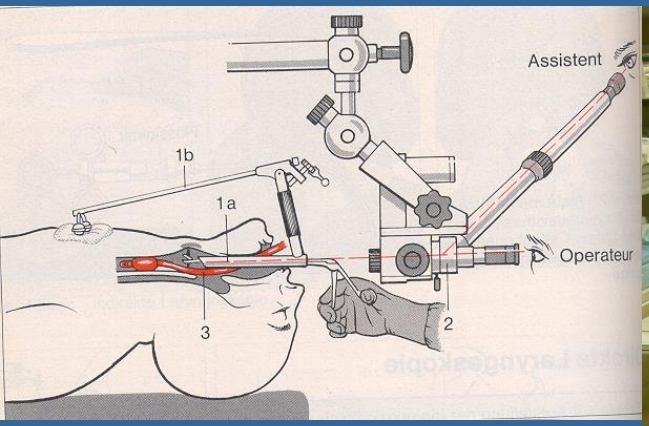
- Benign lesions

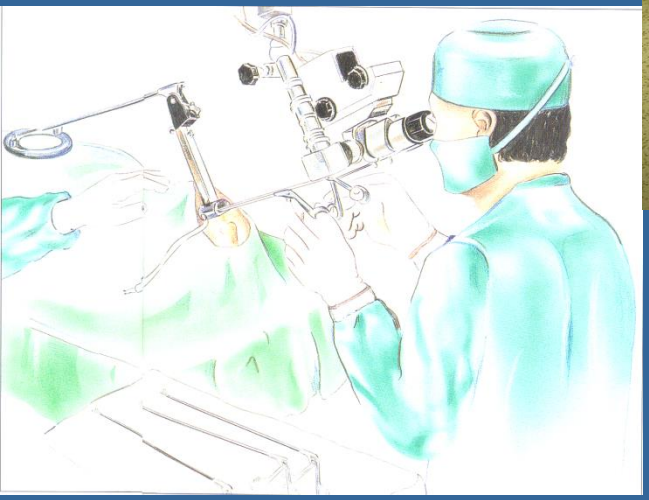
- Early malignant tumours of the larynx (hypopharynx)

Method

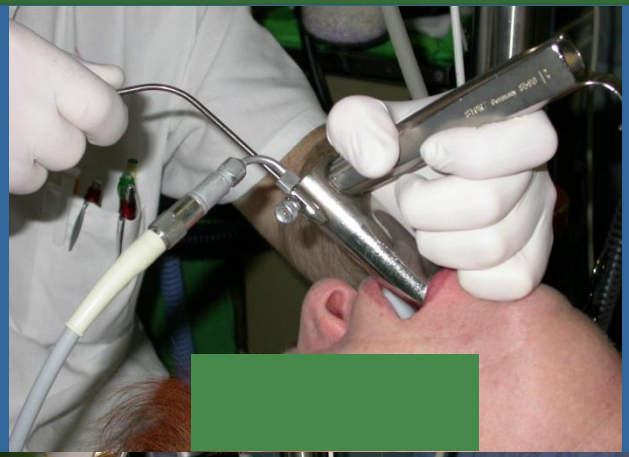
- Preoperative investigation: Endoscopy of the larynx, sonograpy and CT scan of the neck (MRI)
- Instruments: TLS 61 Tungsram laser and later Lasram, Daeshin laser surgical devices
- Opton, Leica microscope
- Kleinsasser and Weerda laryngoscope, laryngomicroscopic surgical instruments
- ITN (intratracheal narcosis), JET

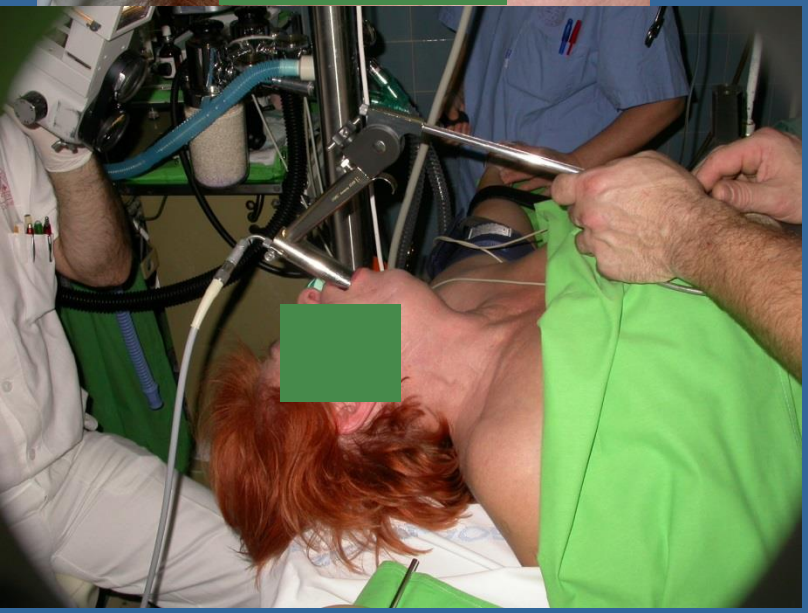
Laryngomicroscopy and laser resection in ITN or JET narcosis





Laryngomicroscopy, intact vocal folds, polyp





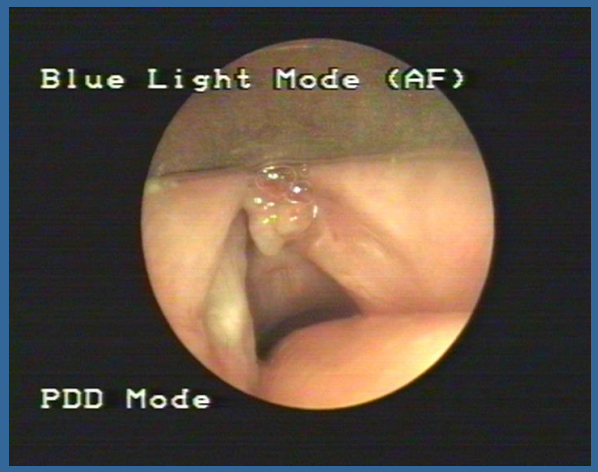
Benign lesions of the larynx, indications – laser treatment

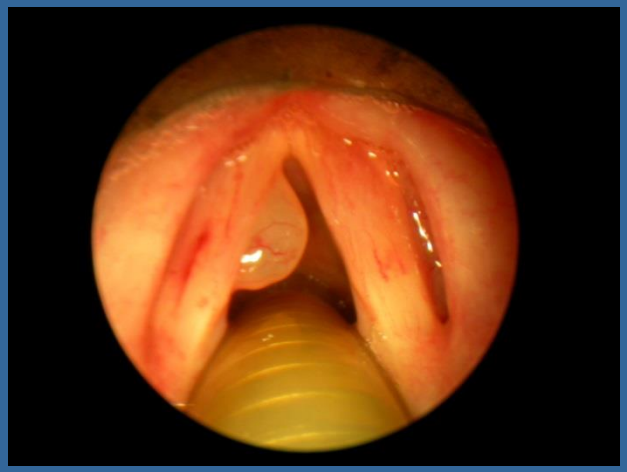
- Polyp
- Cyst
- Nodule
- Reinke oedema
- Laryngitis chronic (hyperplastic)
- Laryngocele
- Granuloma
- Contact ulcus
- Papilloma
- Benign lesions (tumours): hemangioma, chondroma, leiomyoma, fibroma
- Praecancerosis
- Oedema
- Tonsil, lingual hypertrophy
- Stenosis, laryngotracheal

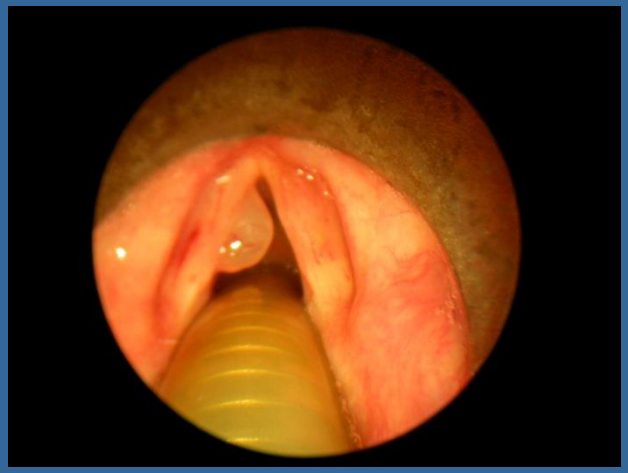
CO2 laser excision, vaporization in benign lesions

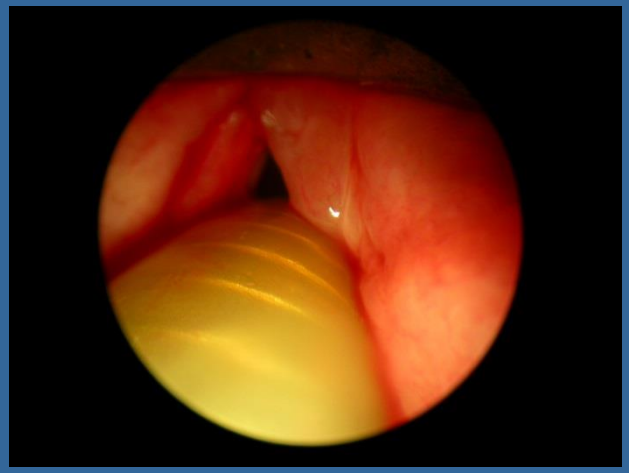
	1988-1994	2001-2007
• Polyp, cysta, nodulus, cicatrix, granuloma, Reinke edema, chr. laryngitis (hyperplastic), laryngocele, contact ulcer	52	26/1252
• Papilloma laryngis	53	42
•		
• Hemangioma	8	23
• Praecancerosis	21	56
• Oedema	18	41
• Laryngotracheal stenosis	52	73
• Laser arytenoidectomia	2	-
• Lingual tonsil hypertrophy	17	21

Polyp of the vocal cord





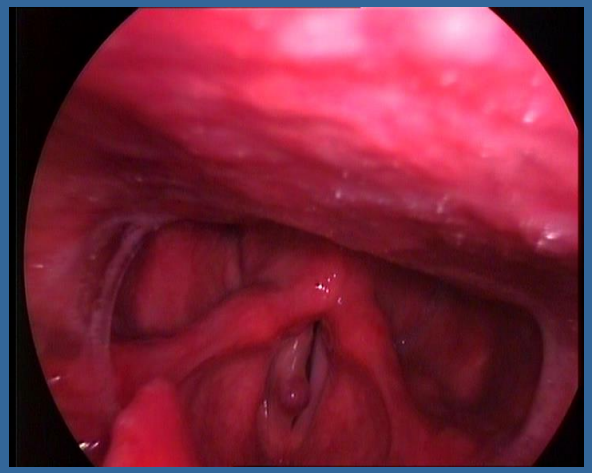


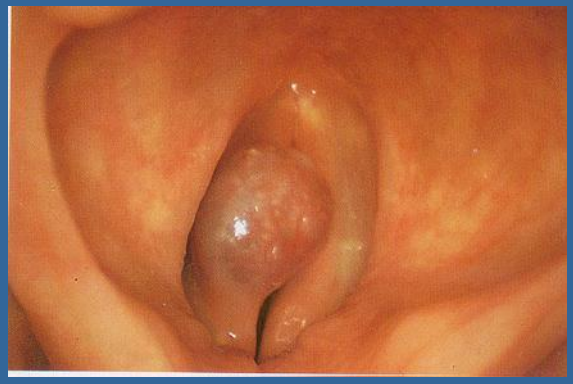


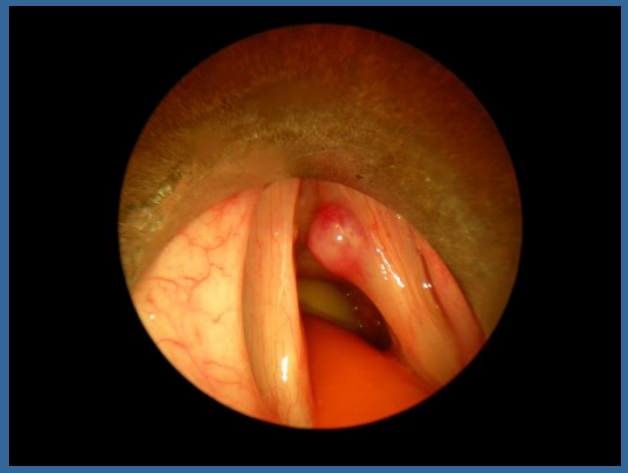
Polyp, vocal cord

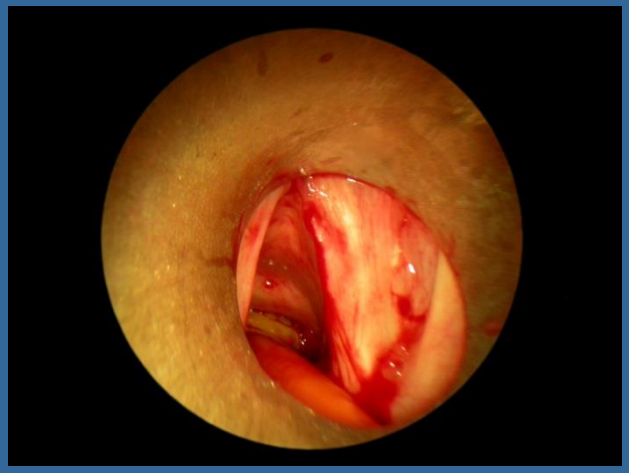
- Symptoms: dysphonia, hoarsness, unilateral
- Etiology: more freqently in male
- Pathogenesis: recurrent inflammations, hyperkinetic disorders and chronic irritation
- Types: peduncular and „wide” seated
- Therapy: laryngomicroscopy - removal with cold instrument (or laser)

Polyp, laryngomicroscopy, excision

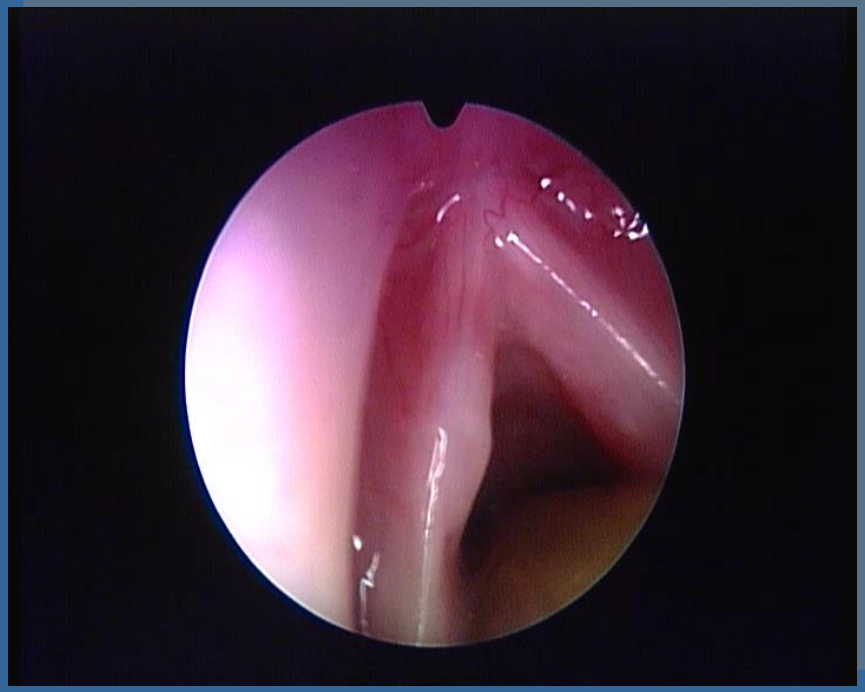




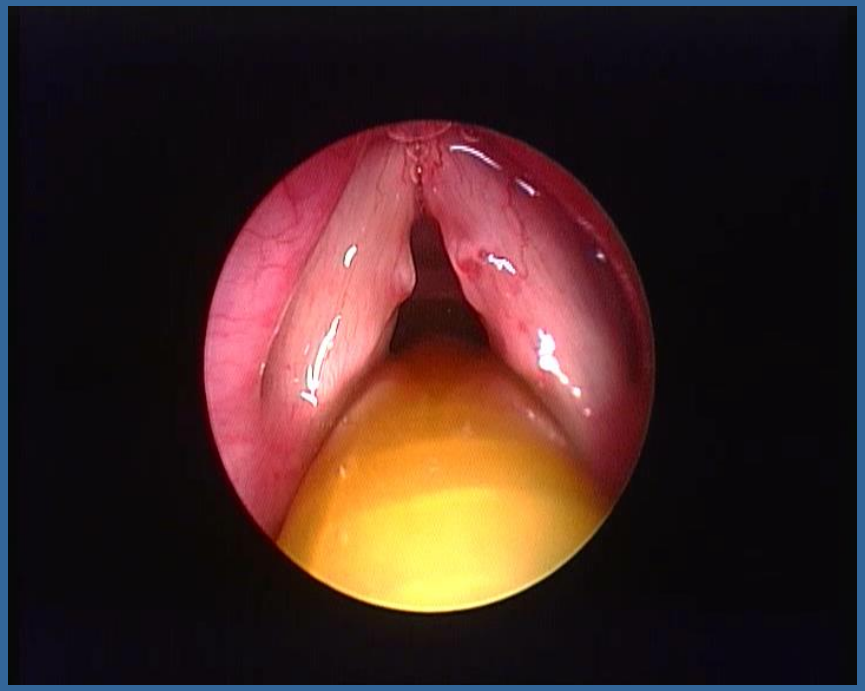


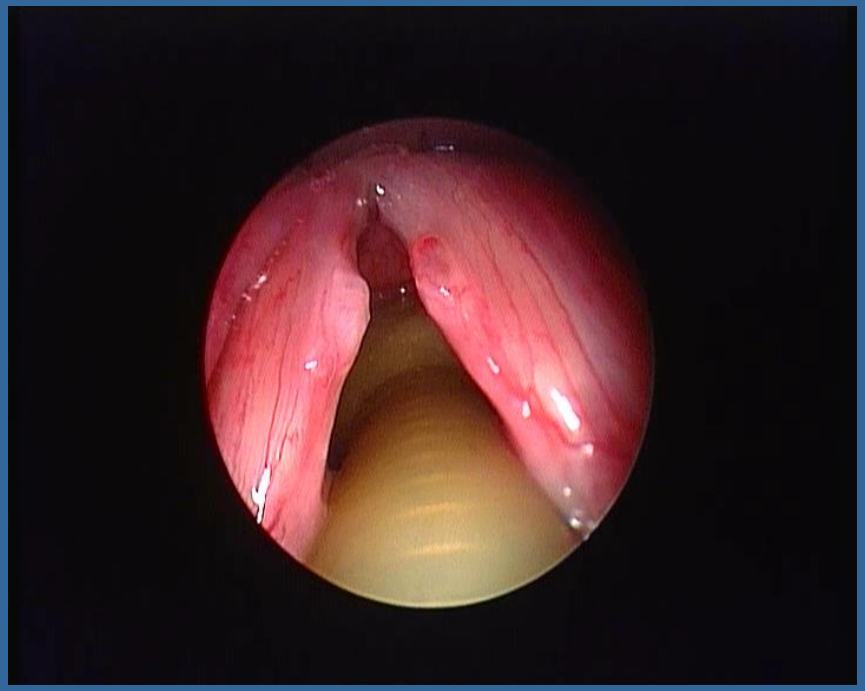


Cyst



Nodule of the vocal cords

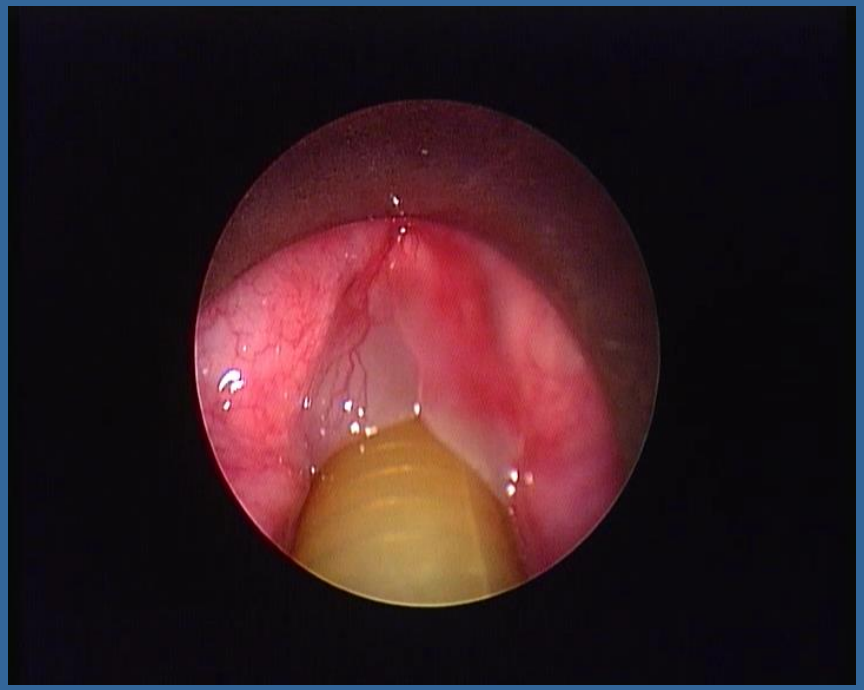


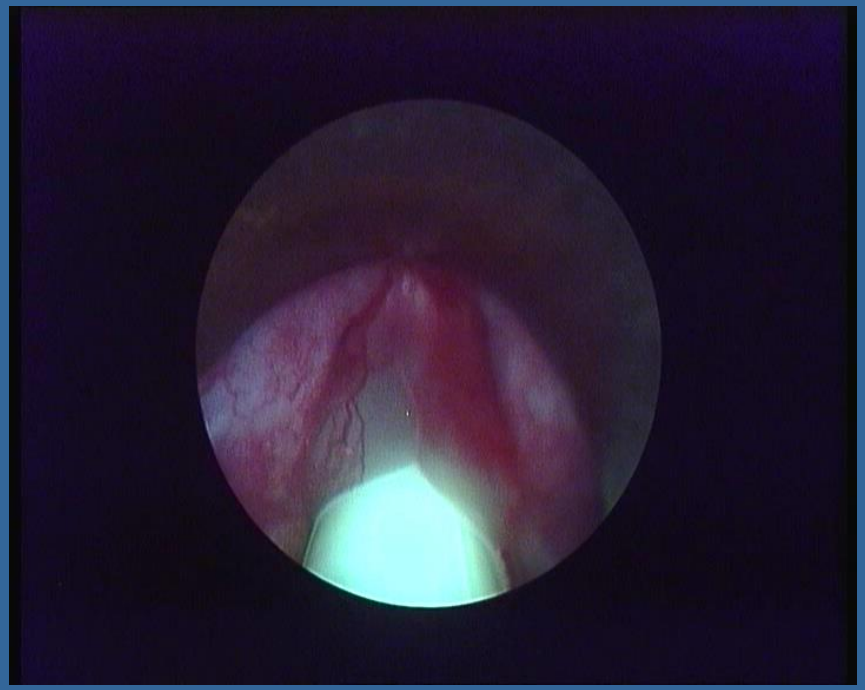


Nodule, laryngeal

- Symptoms: hoarsness, bilateral lesion
- Pathogenesis: abuse of vocal folds - chronic irritation
- Singer’s nodule, aerobic trainers, teachers, smokers
- Therapy: conservative – laryngeal diet, phoniatric treatment, in advanced case laryngomicroscopy – removal (laser)

Reinke’s edema

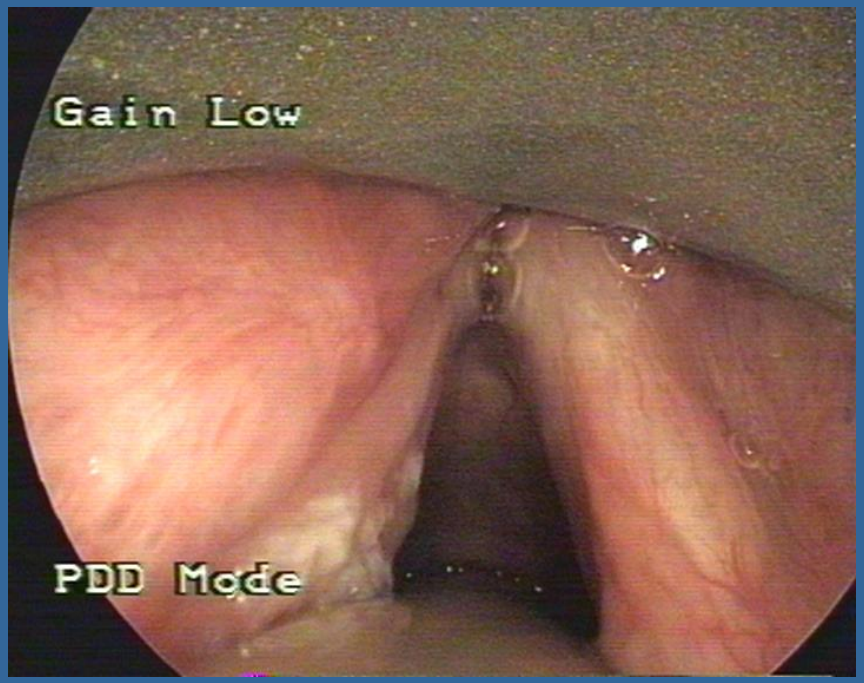


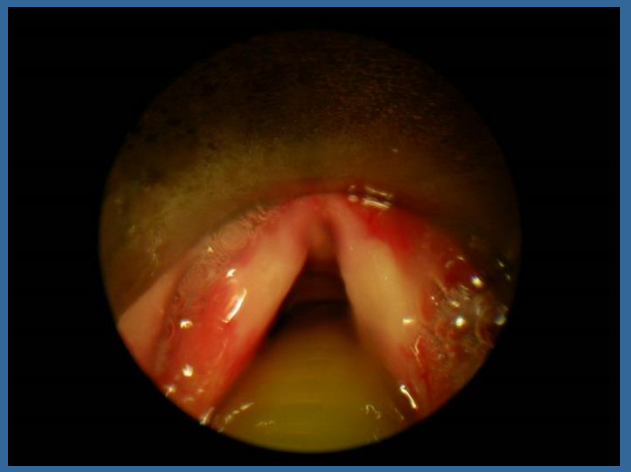


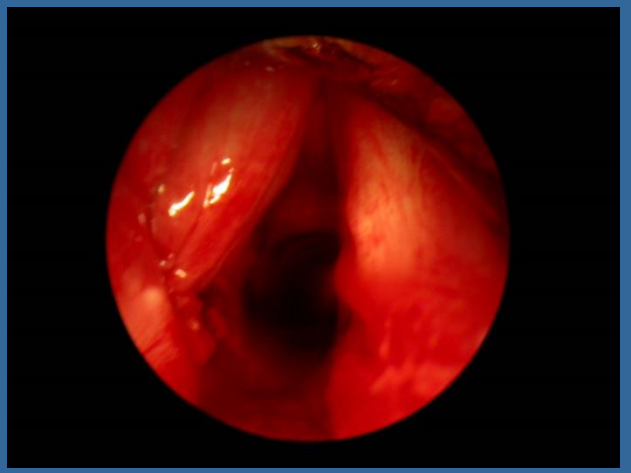
Reinke’s edema

- Symptoms: hoarsness, dysphonia, diplophonia, in extreme size - stridor
- Pathogenesis: in the Reinke’s space edema, vocal fold abuse, smoker women
- Therapy: laryngeal diet, laryngomicroscopy – suction of the edema (incision), in severe case decortication of the vocal cord, (laser excision)

Chronic laryngitis, leukoplakia







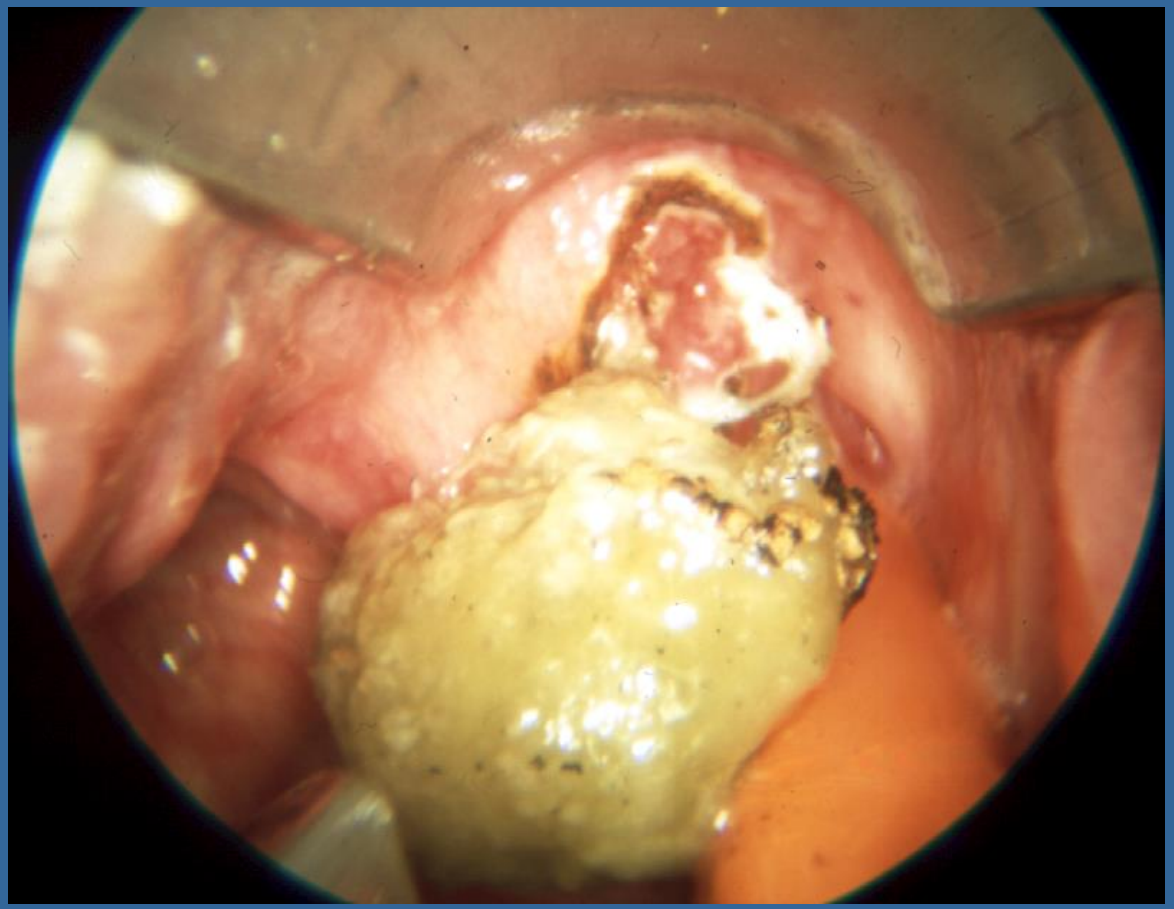
Chronic laryngitis

- Symptoms: hoarsness
- Pathogenesis: chr. irritation, smokers, chemical drugs, dust, enviromental
- Therapy: laryngeal diet, vitamin A, hyperplastic laryngitis: laryngomicroscopy – decortication, laser

Laryngocele

- Internal laryngocele (Morgagni-ventricule)
- External laryngocele
- Symptom: stridor, inspiratoric
- Therapy: endolaryngeal laser, external approach surgery

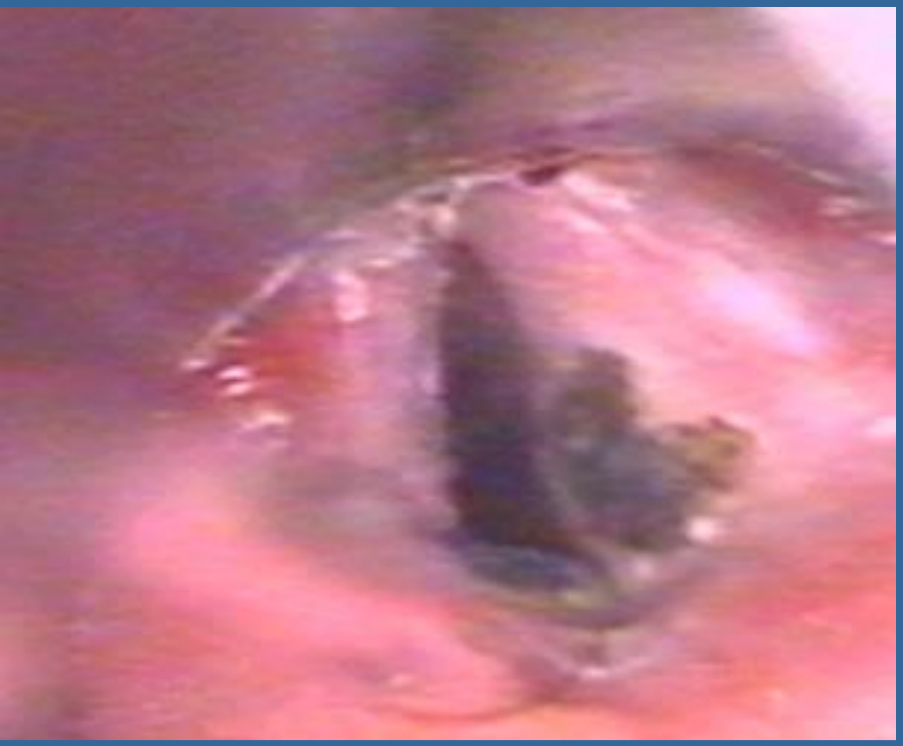
Laryngeal cyst - CO2 laser excision

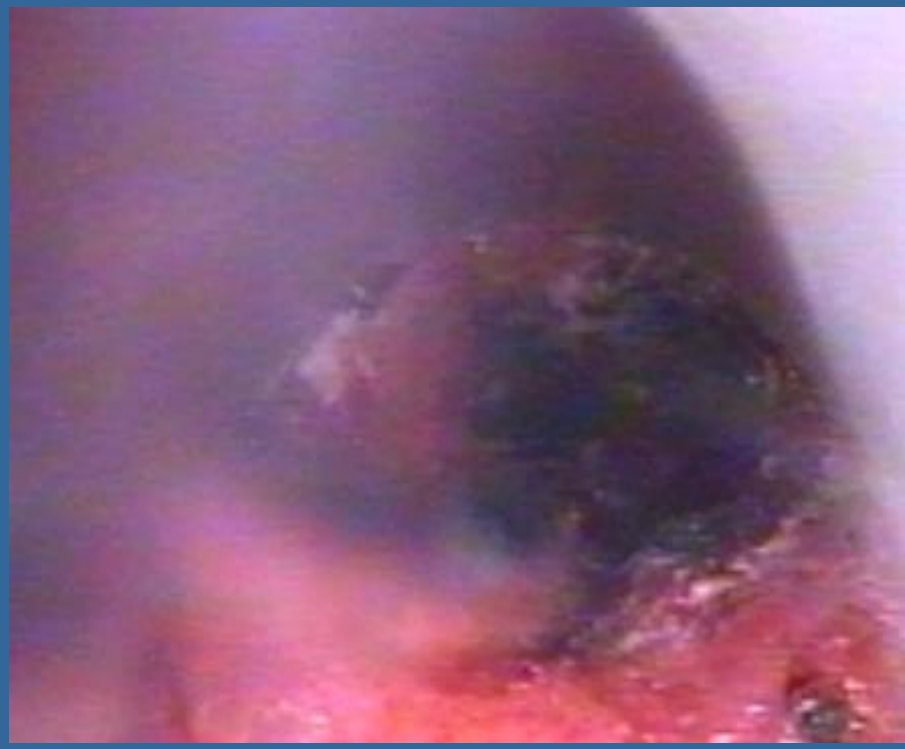


Pediatric laryngeal diseases

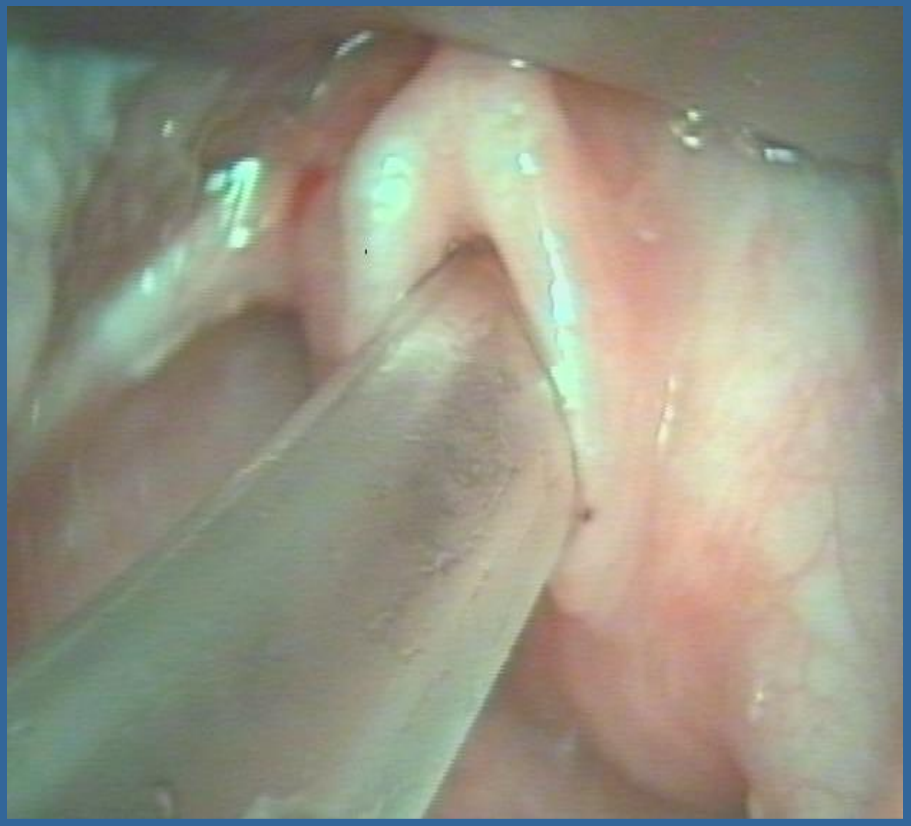
- Cyst
- Granuloma
- Hemangioma laryngis
- Laryngocele
- Develomental disorders – stenosis (web)

Hemangioma laryngis endoscopic laser excision

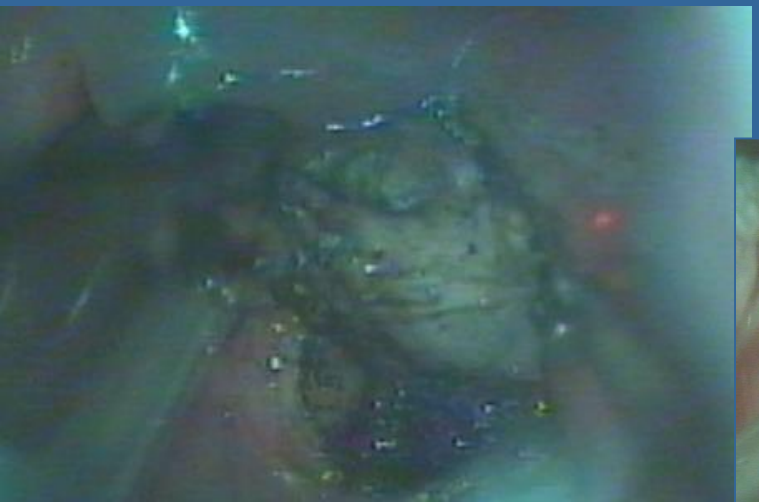


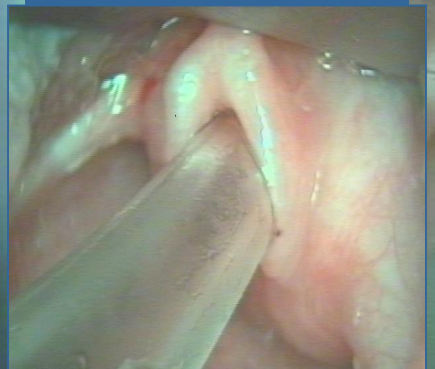


Laryngocele

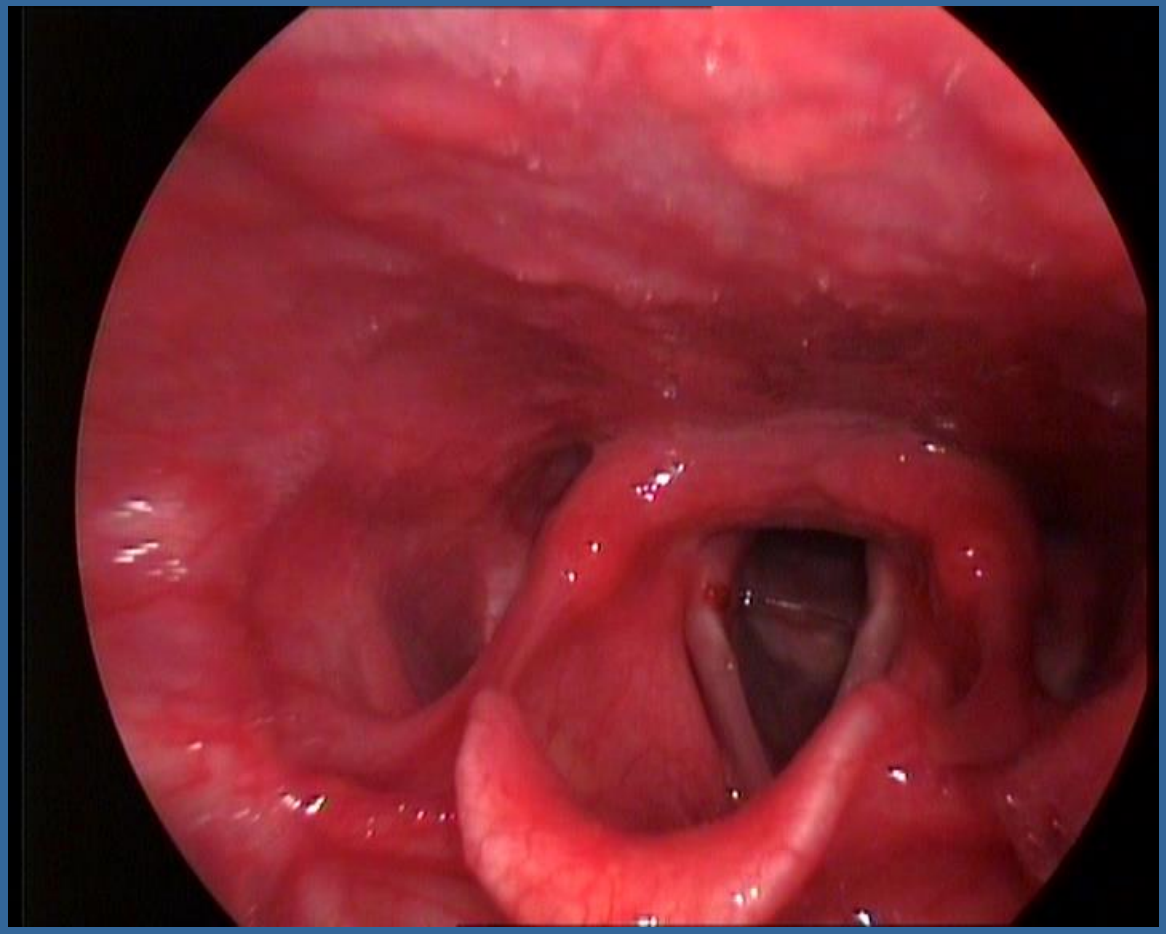


Laryngocele endoscopic laser excision





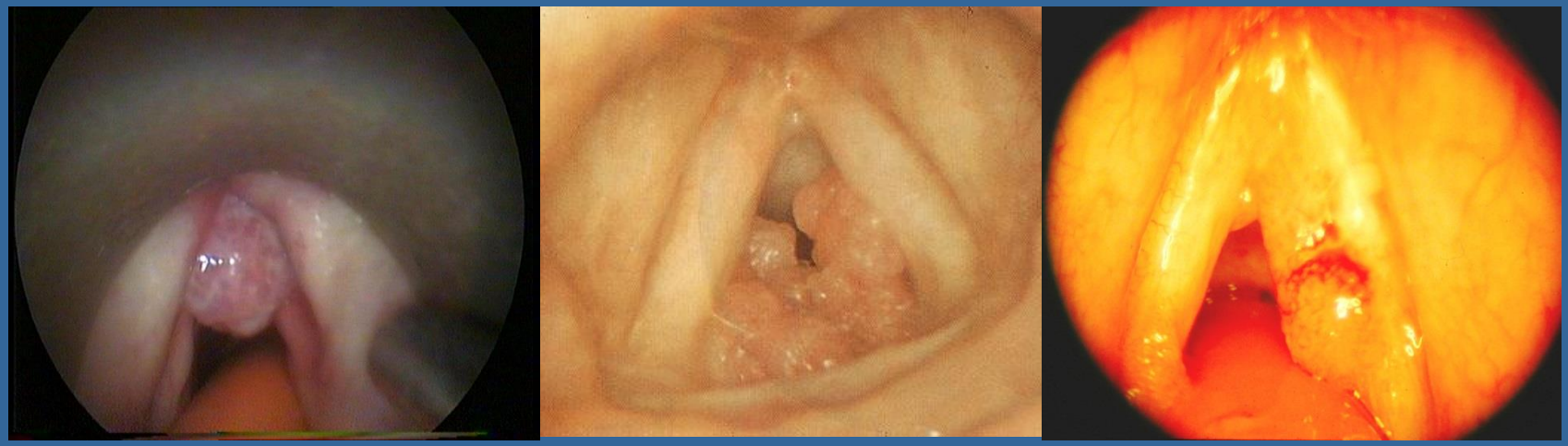
Postintubation granuloma



Granuloma laryngis, contact ulcer

- Symptoms: hoarsness, stridor
- Pathogenesis: postintubation (some weeks later), chronic irritation
- Therapy: laryngomicroscopy – removal with „cold instrument„ or laser

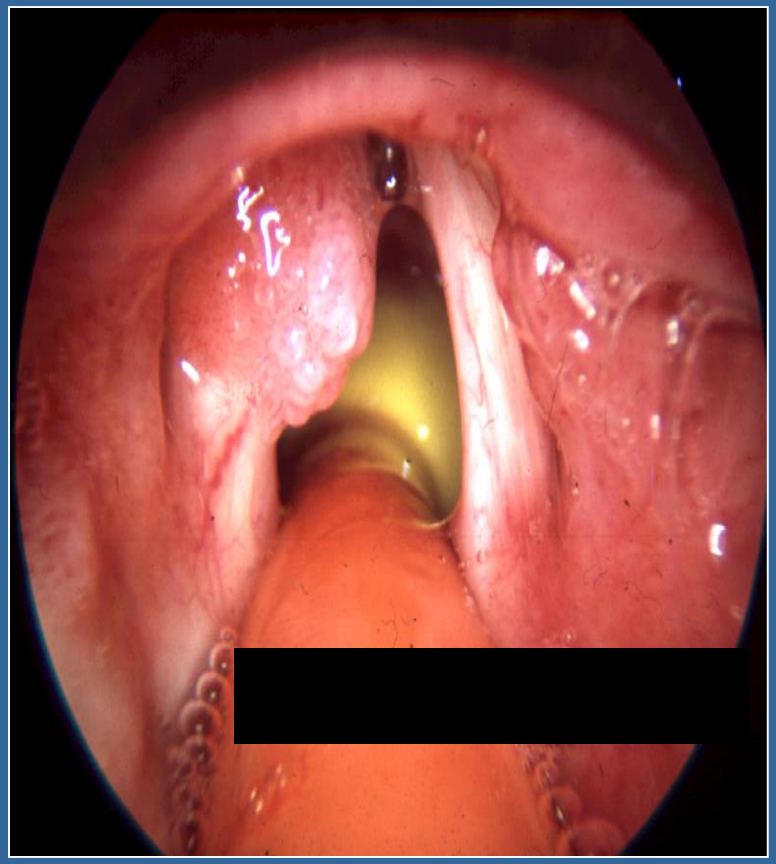
Laryngeal papilloma

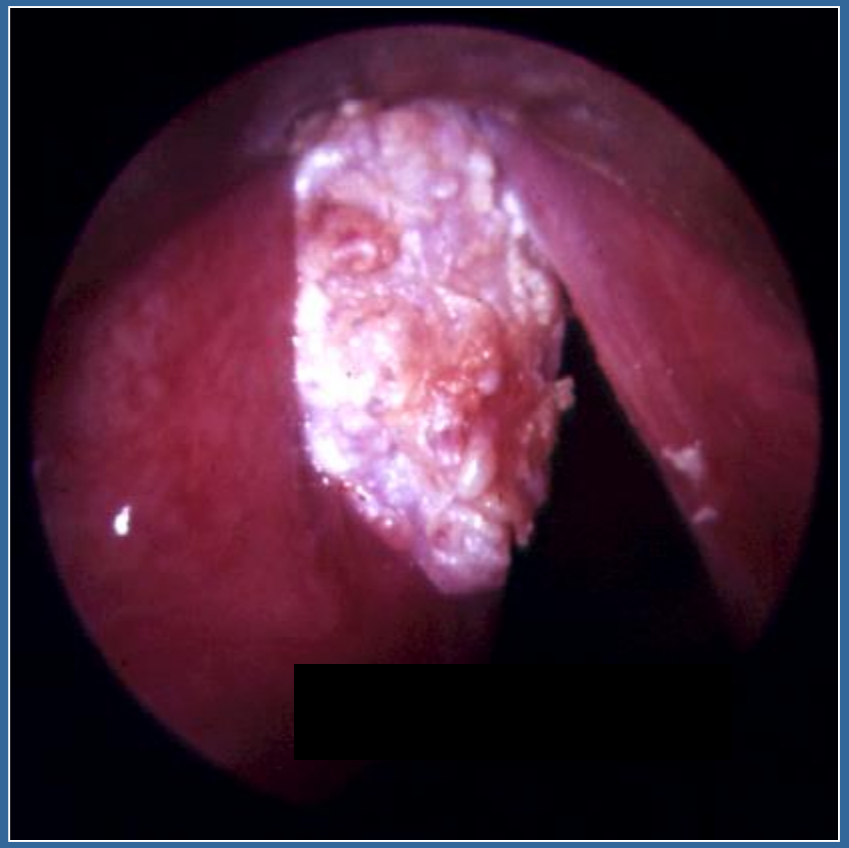


Laryngeal papillomas

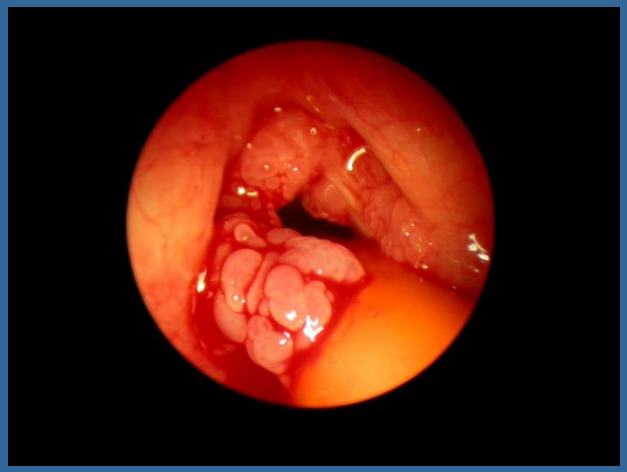
- Symptoms: hoarsness, dyspnoe
- Pathogenesis: human papilloma virus (6,11 juvenil types, 16,18 adult types)
- Theapy: laryngomicroscopy CO2 laser, antiviral drugs, vaccination (Silgard)

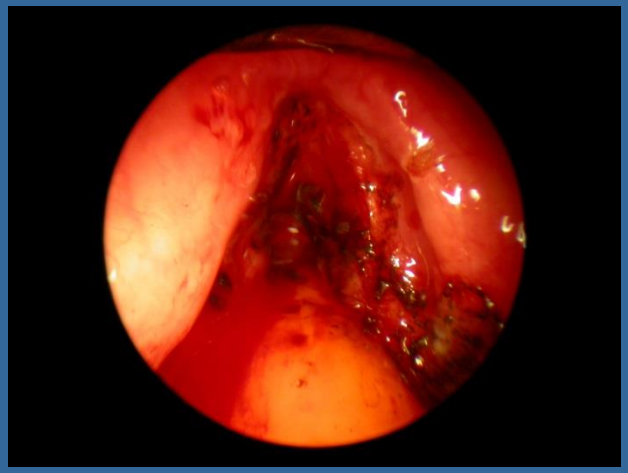
Laryngeal papillomas: standard indication - endolaryngeal laser surgery



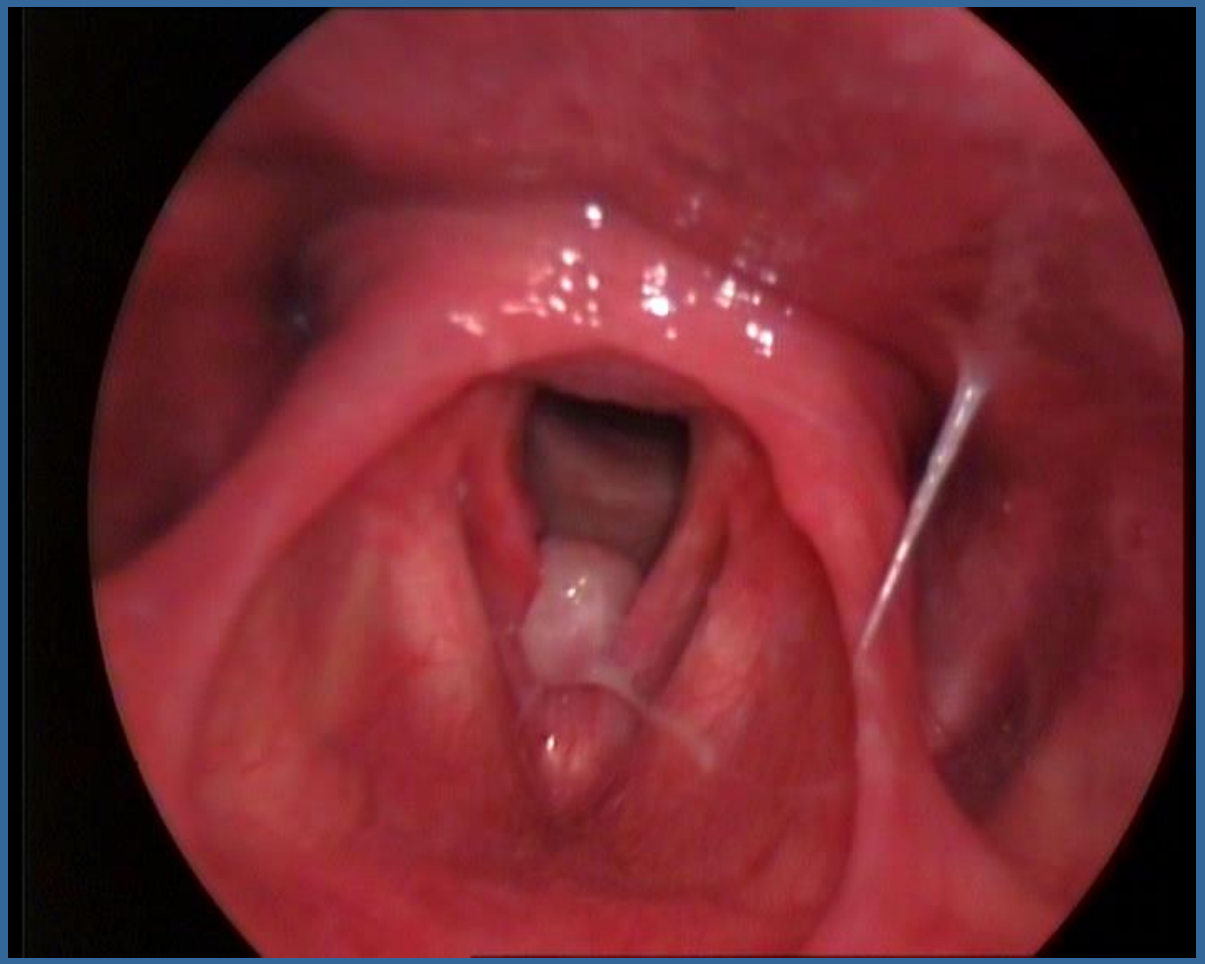


Laryngeal papilloma, CO2 laser excision, vaporization

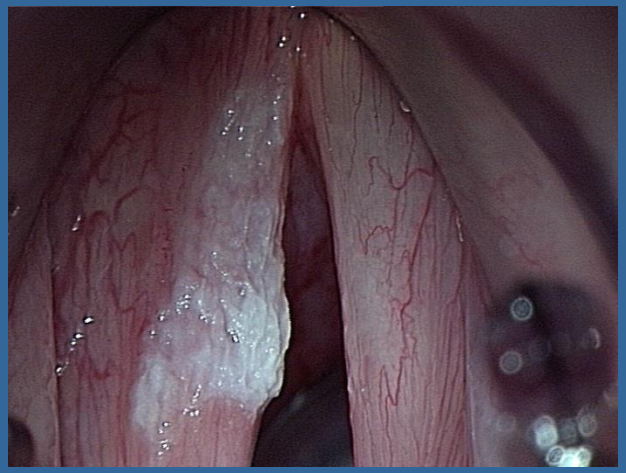


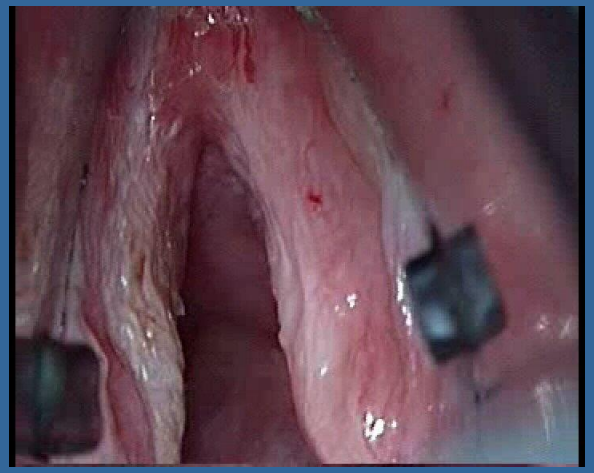


Leiomyoma



Praecancerosis





Praecancerosis

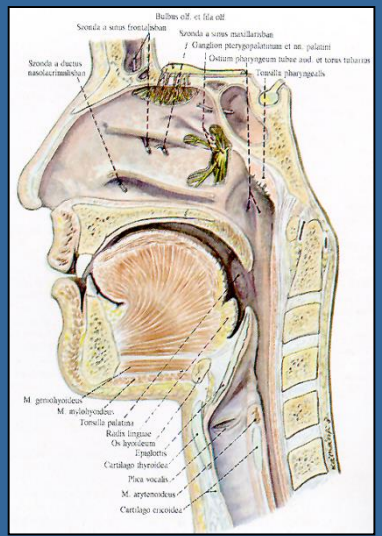
- Symptom: hoarsness
- Pathogenesis: Dysplasia I-II-III. types, smoking, chr. irritation
- Therapy: laryngomicroscopy – decortication, laser excision

Malignant tumours of the larynx:

Localization, distribution and prognosis

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

prognosis



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, aquired, 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.
- Appearence: 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 layngeal 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

Diagnostic in laryngeal neck tumours

- Case history: personal, familiar, social questionaire, 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

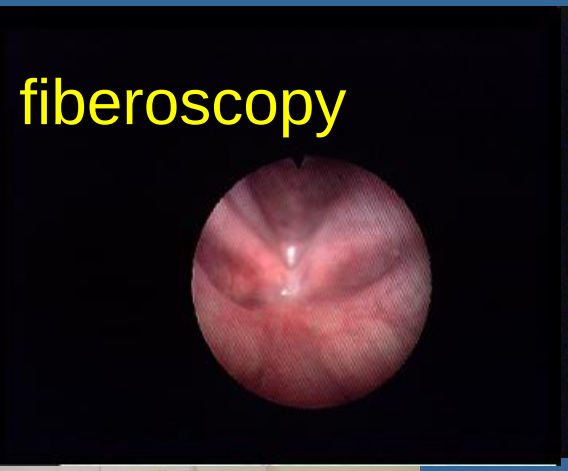
Diagnostic, evaluation, therapy: endoscopy of the larynx

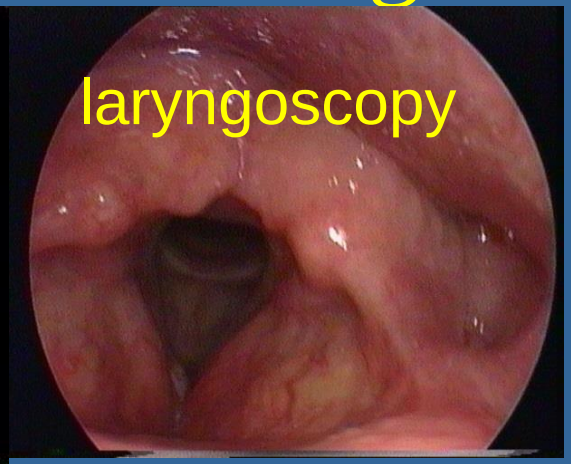
Indirect laryngoscopy

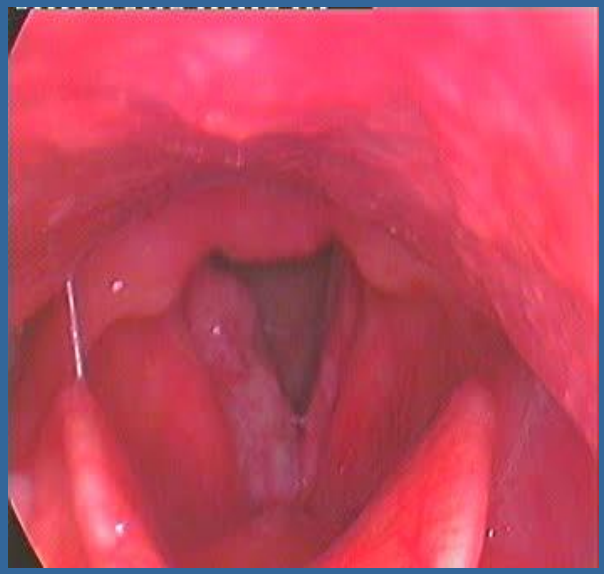
Direct laryngoscopy:
Rigid endoscopy - diagnostic
Flexible endoscopy - diagniostic
Laryngomicroscopy – diagnostic and therapy

Laryngostroboscopy - phonation
Photodynamic endoscopy - oncology
Contact endoscopy - oncology, etc.

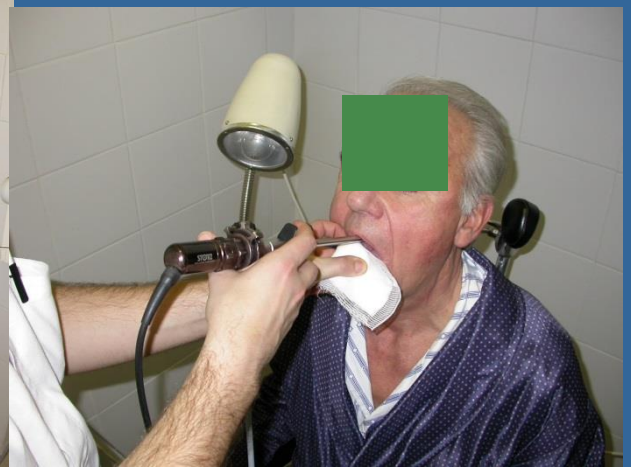
Endoscopy of the larynx with 70º rigid optic and fiberoscopy visualizing the larynx



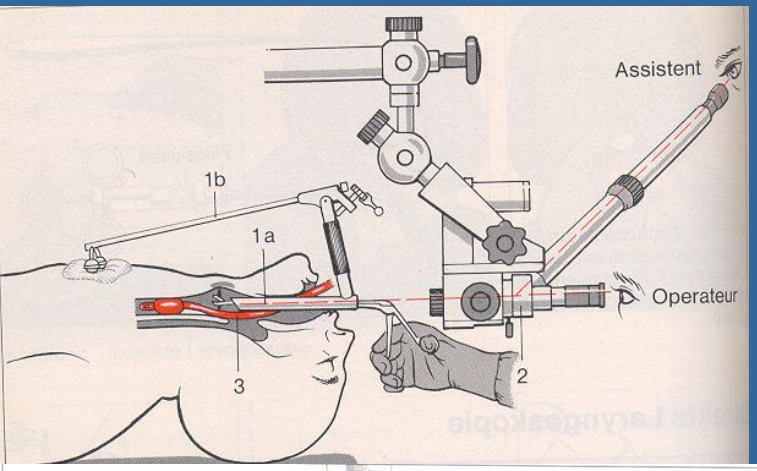


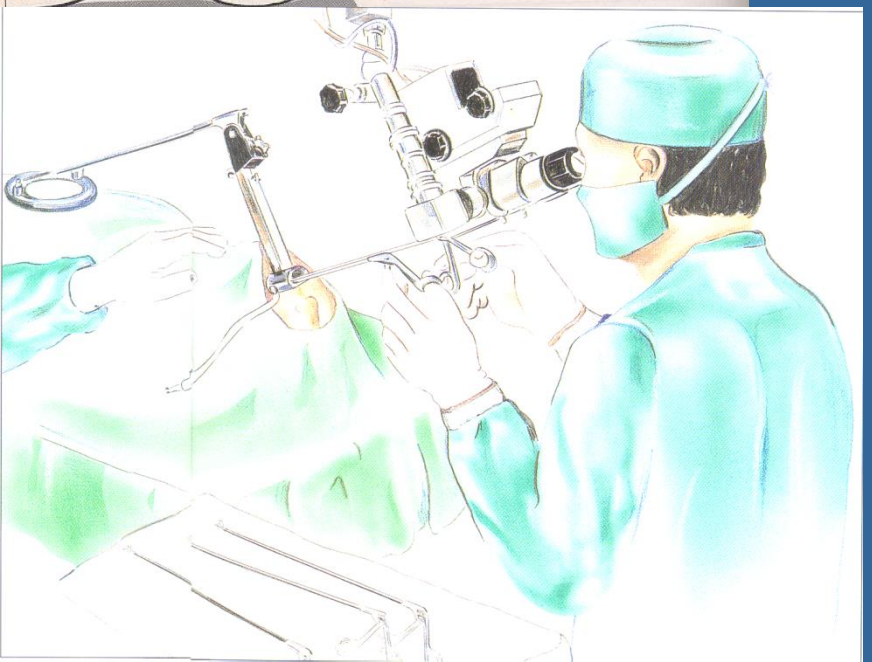


Video-endoscopy: tumour of the vocal fold, outpatient

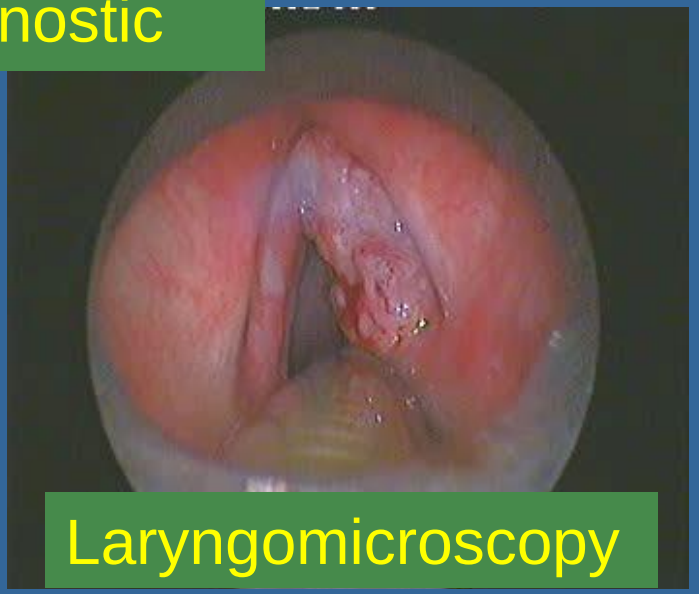


Direct laryngoscopy: laryngomicroscopy – general anaethesia (ITN) or JET narcosis





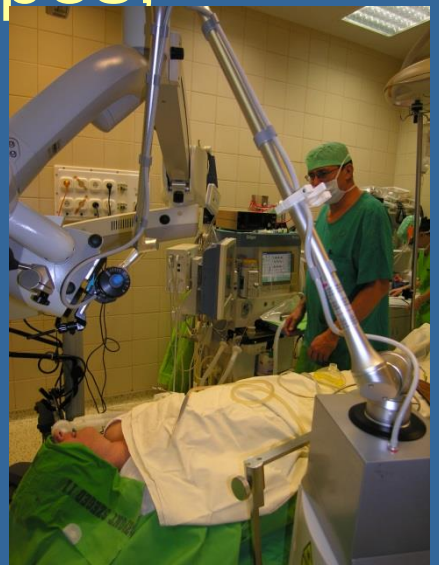
Application of microscope and rigid, long optic for the preop. diagnostic



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 eraly laryngeal carcinoma

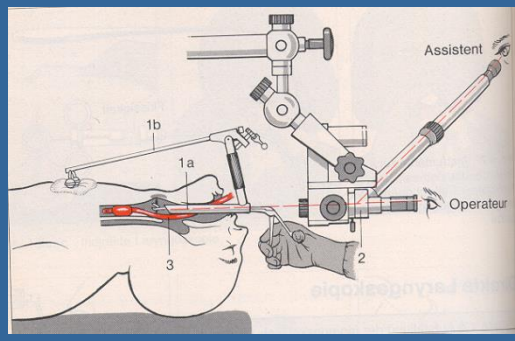
- Surgery
- Radiation therapy
- Chemotherapy
- Combined treatments
- By Onco-Team board consultation, decision!

Treatment options of early (T1, T2) 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

30 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***



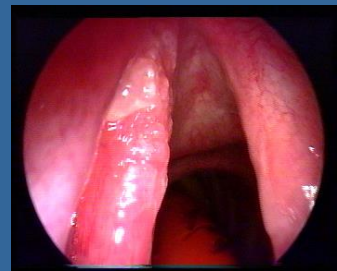
-T1a, T1 b, (T2) glottic carcinoma - *laser cordectomy*

Csanády M., Czigner J., Sávay L.:
Endolaryngeal CO2 laser microsurgery of early vocal cord cancer. A retrospective study. In: Rudert H., Werner J.A. (eds.): „Lasers in Otorhinolaryngology and in Head and Neck Surgery". Adv. Otorhinolaryngol, Karger, Basel, 1995. vol. 49, pp. 219-221.

-Supraglottic and marginal laryngeal tumours (T1, T2)

Csanády M., Czigner J., Iván L.:
Endoscopic CO2 laser therapy in selected cases of supraglottic tumors.
Eur. Arch. Otorhinolaryngol. 1999, 256, 392-394

Csanády M., Vass G, Czigner J., Jóri J.:
Endoscopic CO2 laser management of selected supraglottic marginal tumors and neck dissection Eur. Arch. Otolaryngol. 2011.



Patient's material, method

- 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, sonograpy 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***

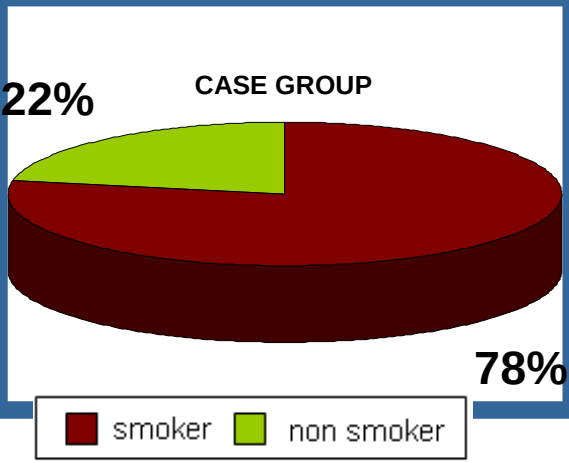
Age: 40-70 years - 81%

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)

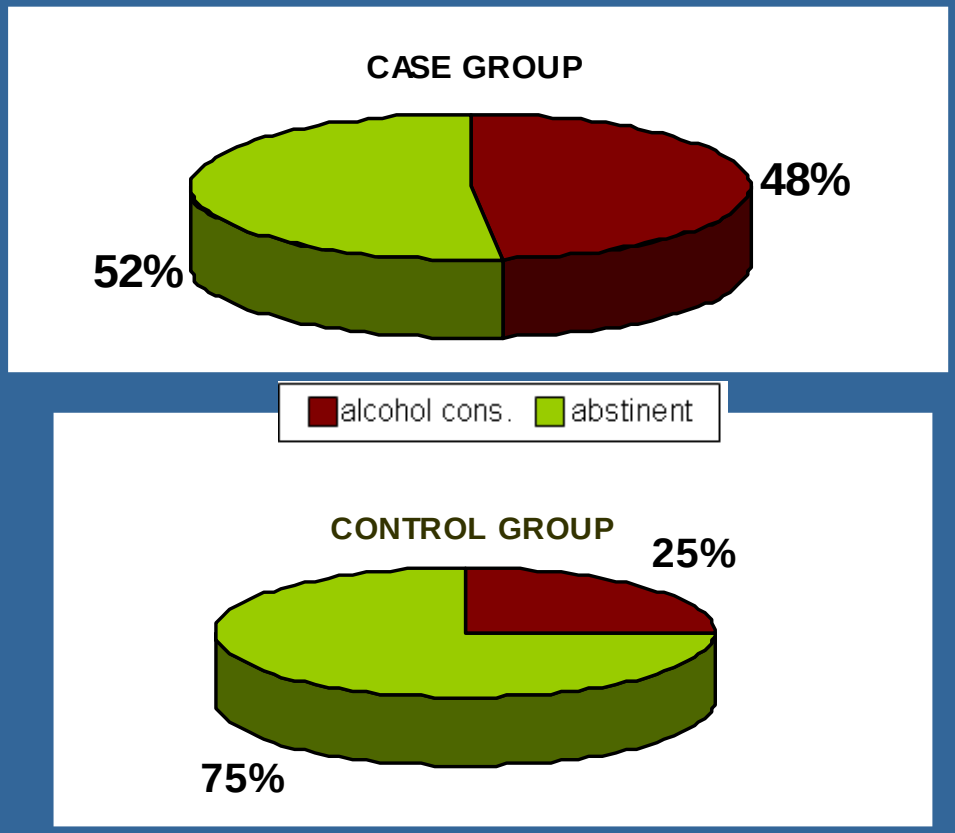
SMOKING



OR=(78x74)/(22x26)=**10**

10x RISK

ALCOHOL

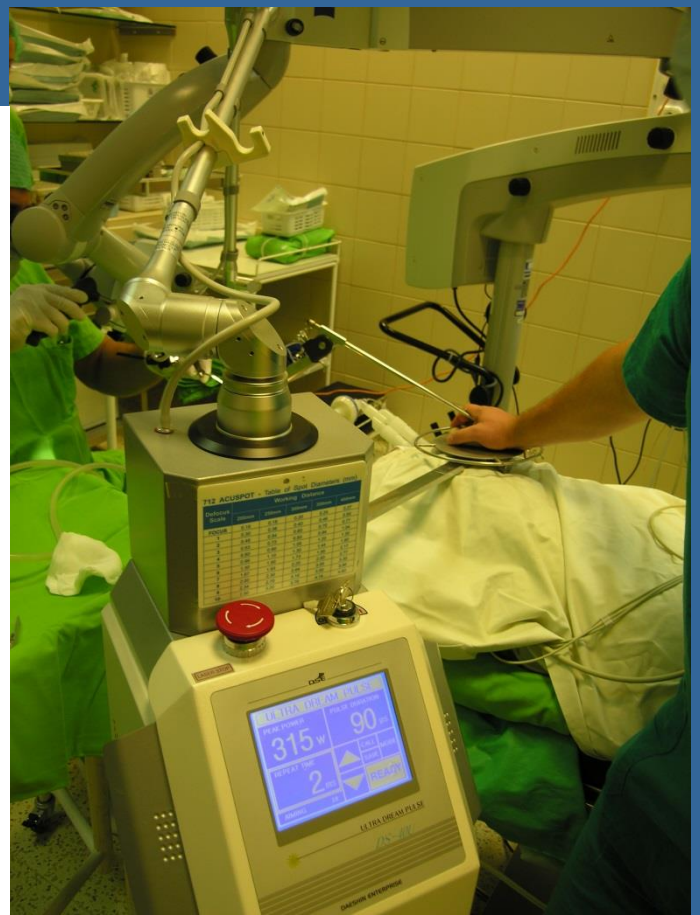


OR=(48x75)/(52x25)**=2.7**

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)**

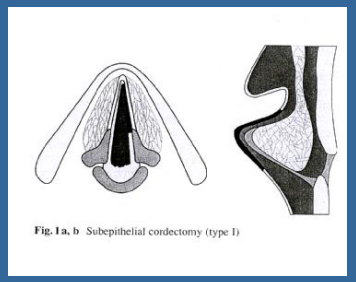


Fig. 1a, b Subepithelial cordectomy (type I)

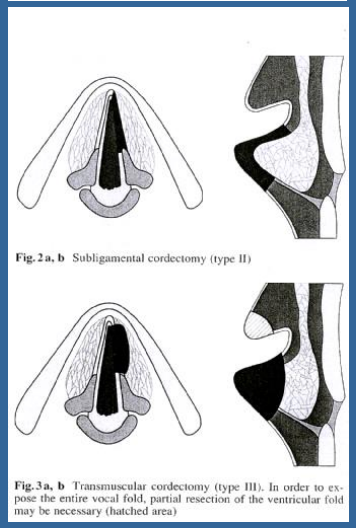


Fig. 2a, b Subligamental cordectomy (type II)

Fig. 3a, b Transmuscular cordectomy (type III). In order to expose the entire vocal fold, partial resection of the ventricular fold may be necessary (hatched area)

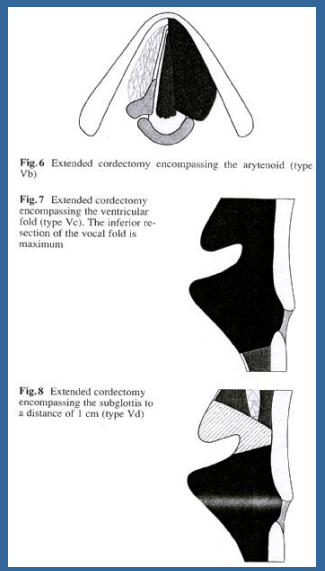


Fig. 6 Extended cordectomy encompassing the arytenoid (type Vb)

Fig. 7 Extended cordectomy encompassing the ventricular fold (type Vc). The inferior resection of the vocal fold is maximum

Fig. 8 Extended cordectomy encompassing the subglottis to a distance of 1 cm (type Vd)

Fig. 4a, b Total or complete cordectomy (type IV). The ipsilateral ventricular fold can be removed partially or totally to ensure complete resection of the vocal fold (hatched area)

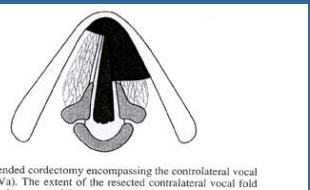
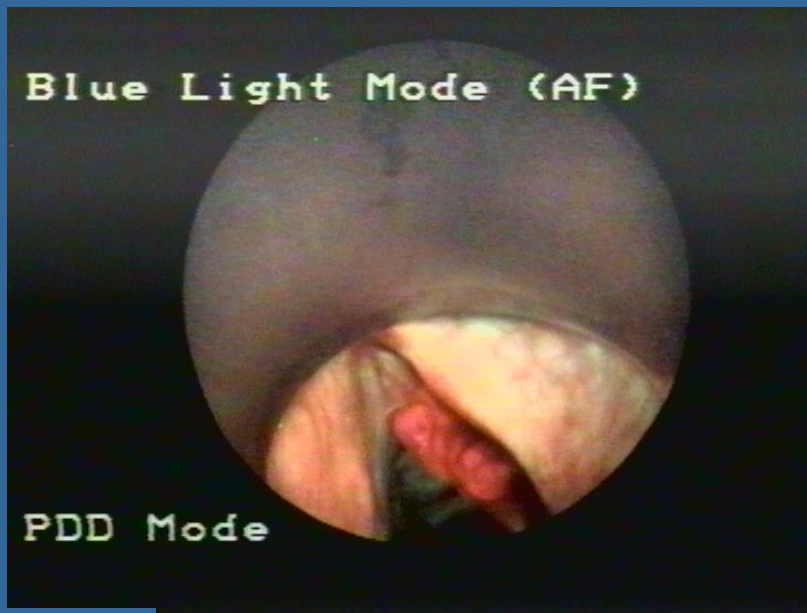
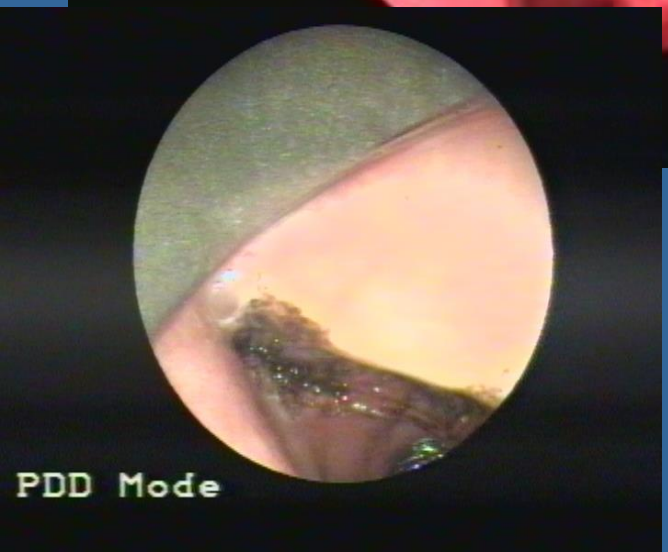
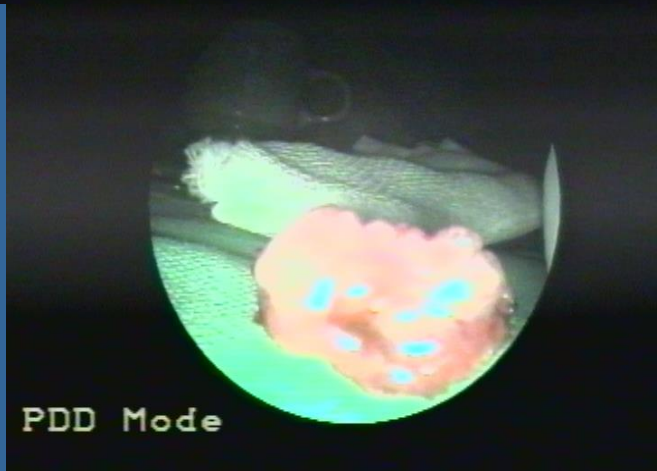


Fig. 5 Extended cordectomy encompassing the controlateral vocal fold (type Va). The extent of the resected contralateral vocal fold depends on the extent of the tumor

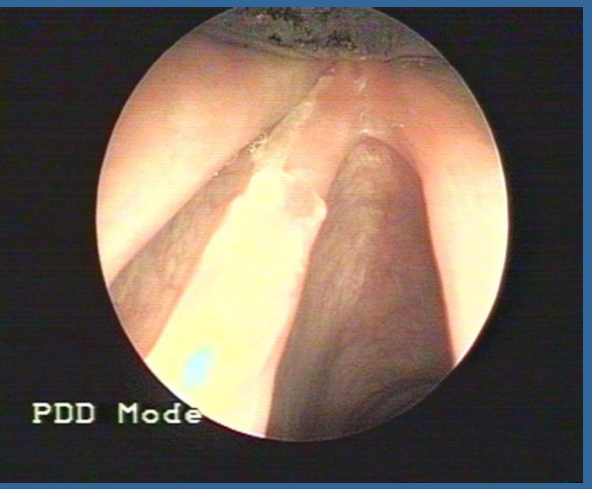
T1a vocal cord tumour (ALA), laser cordectomy, type II.

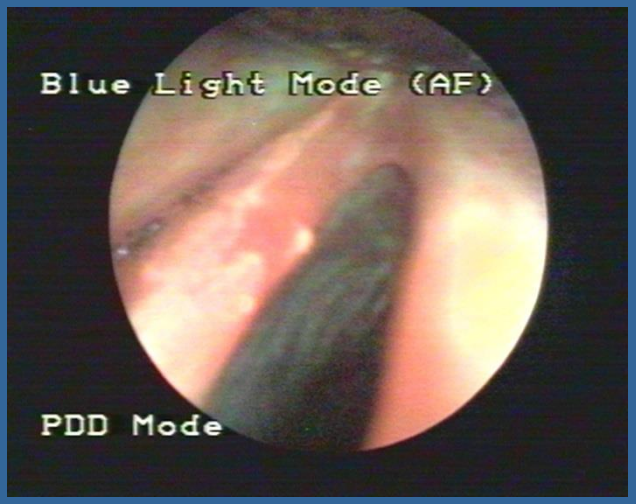


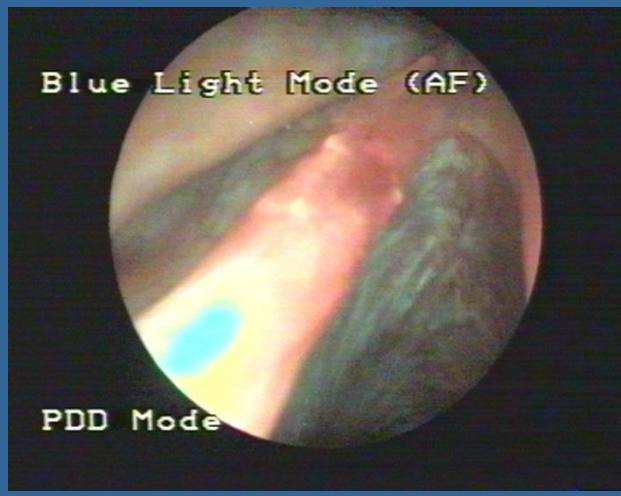


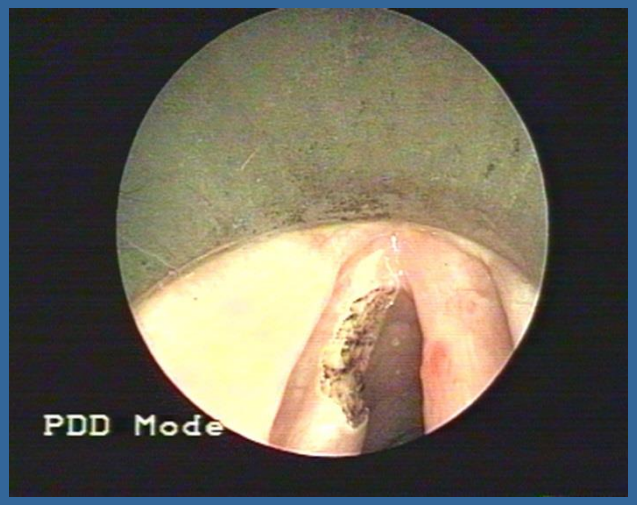


Vocal cord tumour T1a, type I. laser cordectomy (ALA)

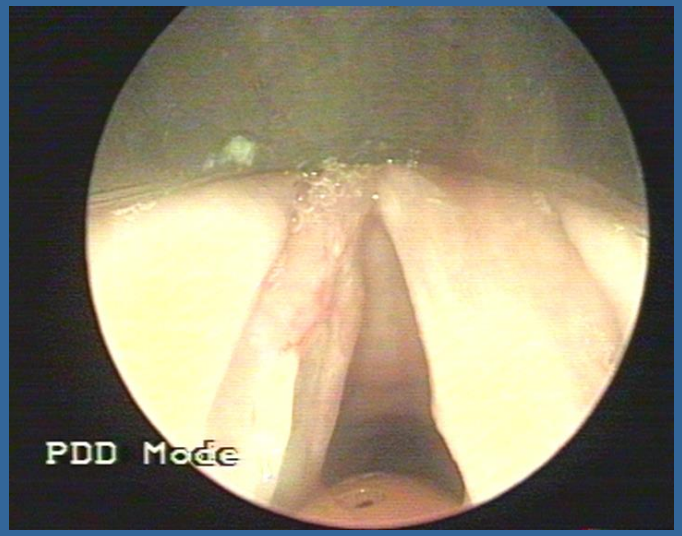


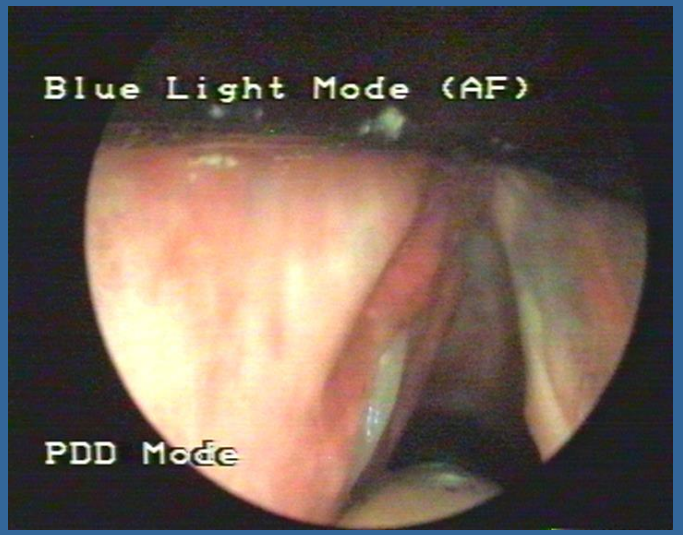


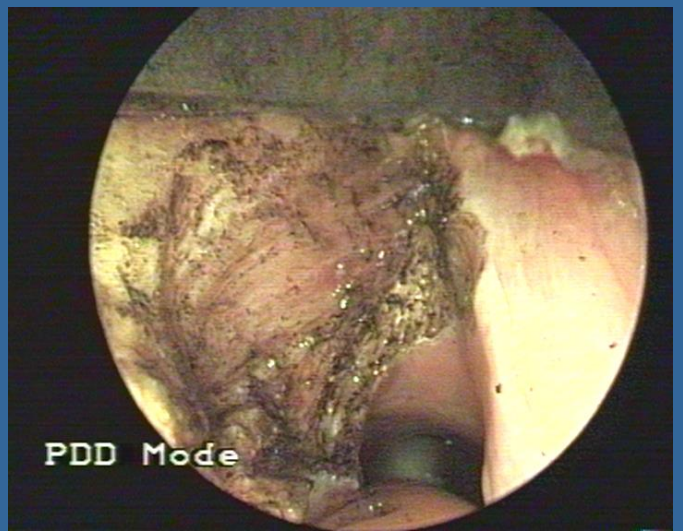




T2 vocal cord tumour, type V. laser cordectomy (ALA)







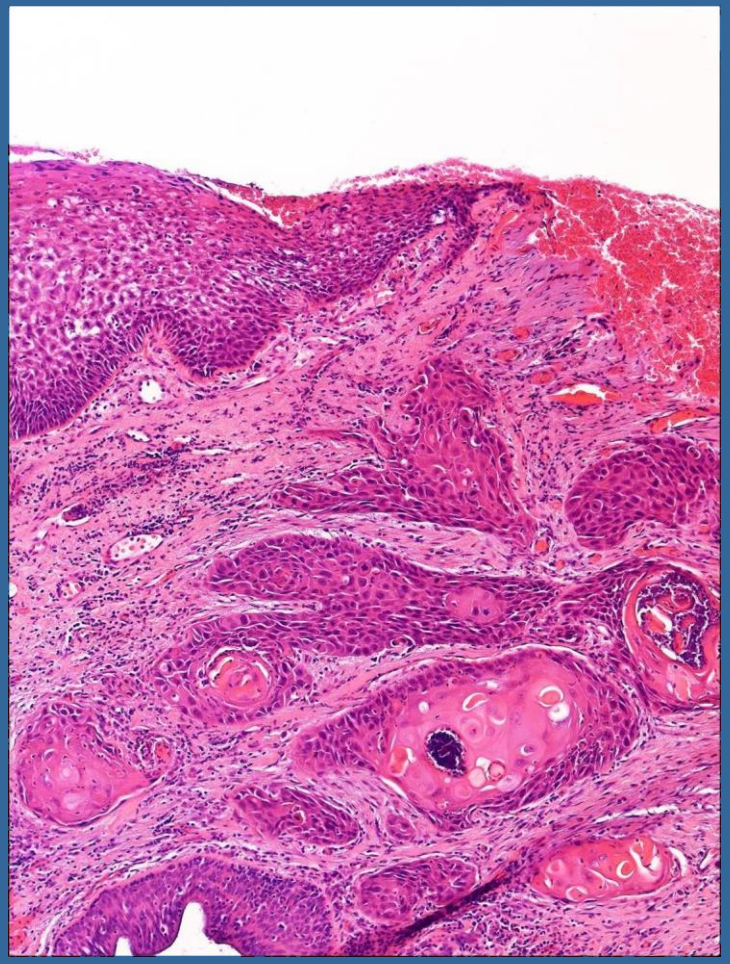
T1 vocal cord cancer laser cordectomy (video)

Pathological establishment of T1, T2 vocal cord cancers after laser cordectomy

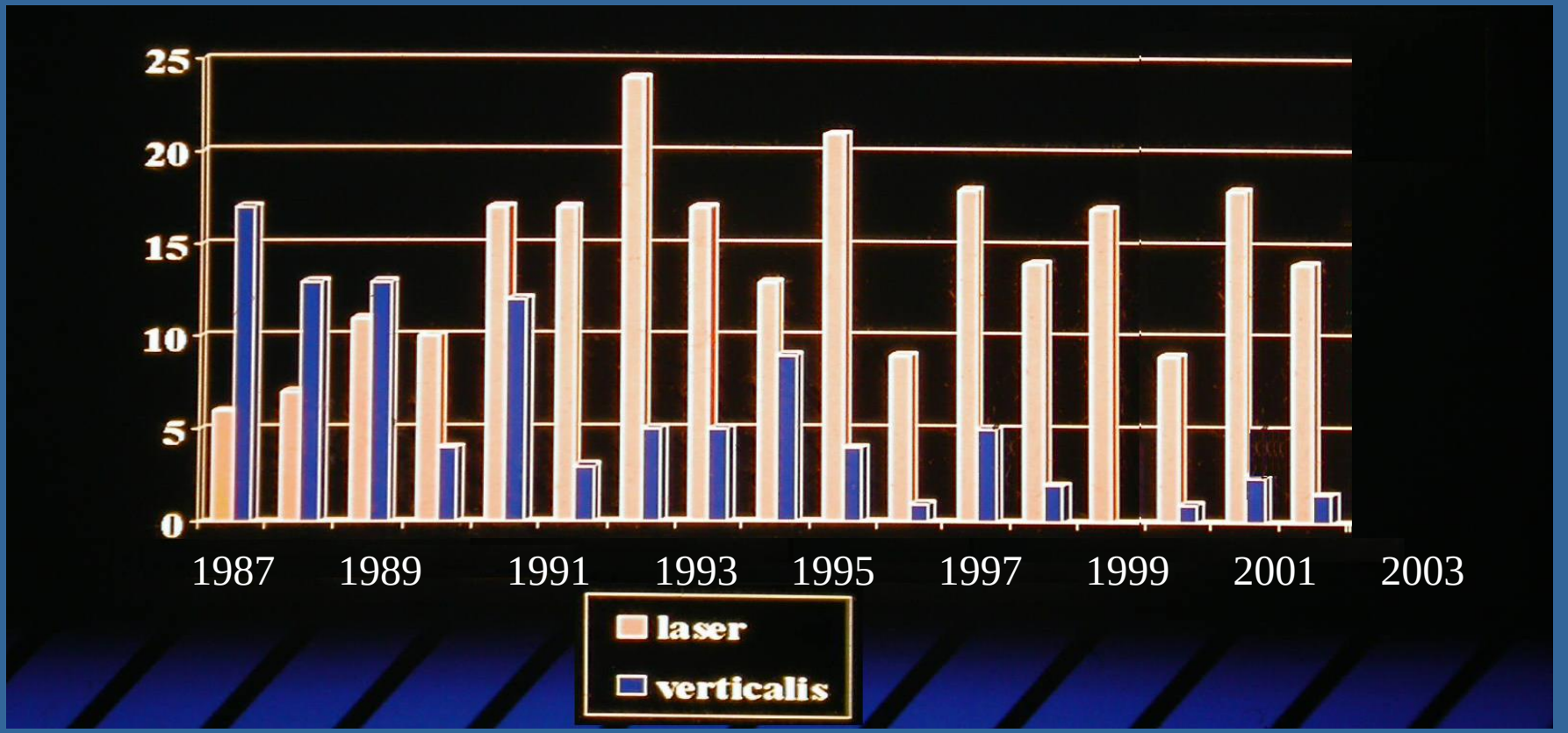
Squamous cell cancer - cc. planocellulare (96%)

cc. verrucosum (3%)

cc. mucoepidermoid (1%)

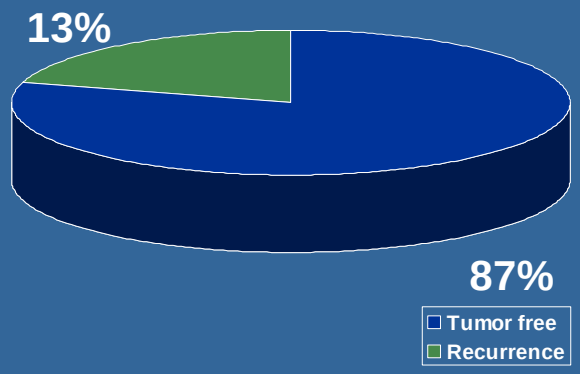


Surgery of the early glottic cancer 1987–2003: open approach, vertical partial laryngectomy was replaced by transoral (endoscopic) laser surgery



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%

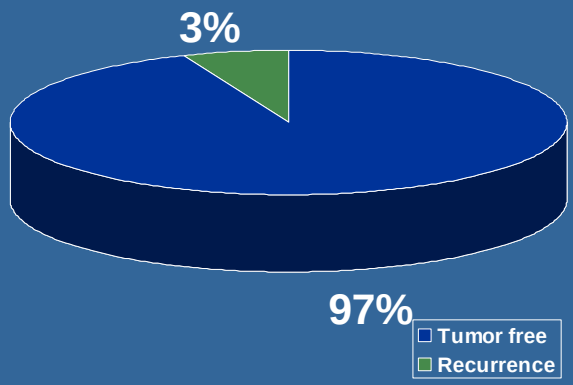


Results after salvage therapy - laser cordectomy

Survival after salvage therapy: 97%.

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

- 5 years laser specific survival: 93%

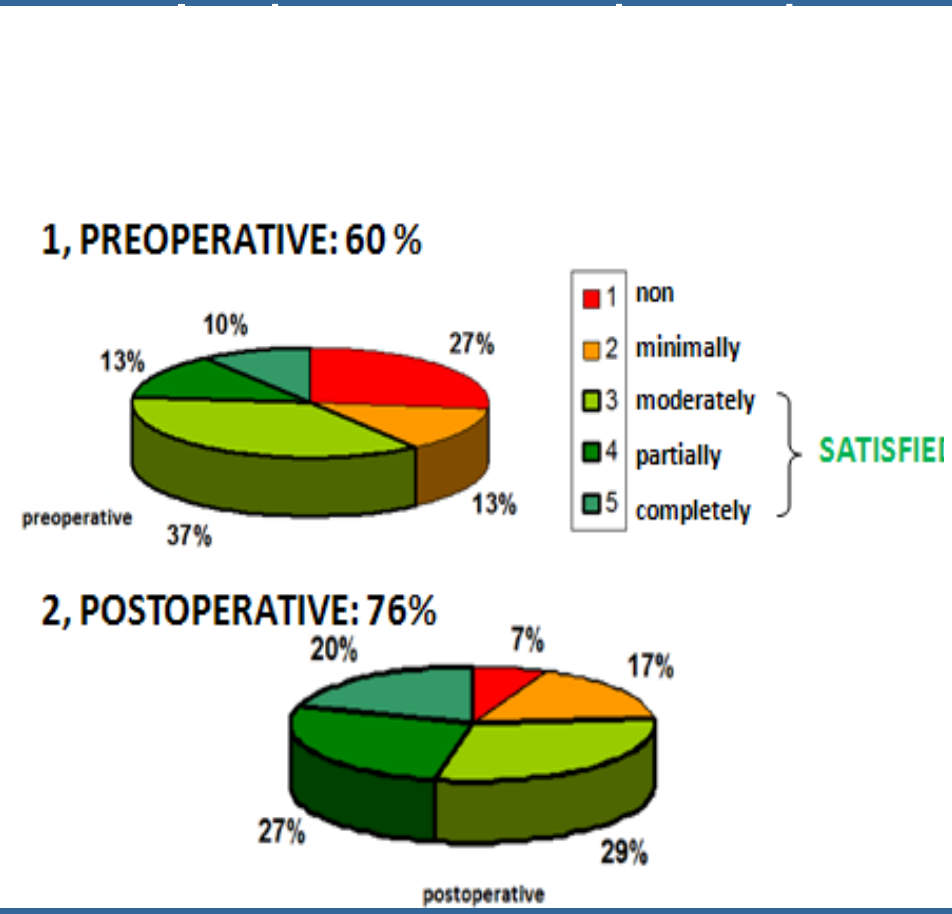


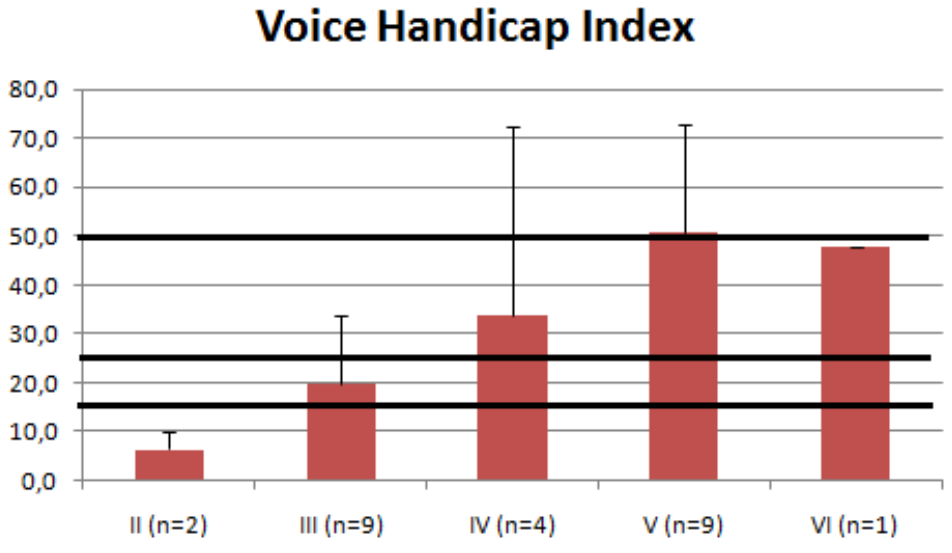
Salvage therapies (13%):

- *Repeated laser resection 6%*
- *Hemilaryngectomy 3%*
- *Laryngectomy 3%*
- *Radiation therapy, fronto-lat. resection 1%*
- *Neck management: RND* 3%

Functional results
subjective voice analysis

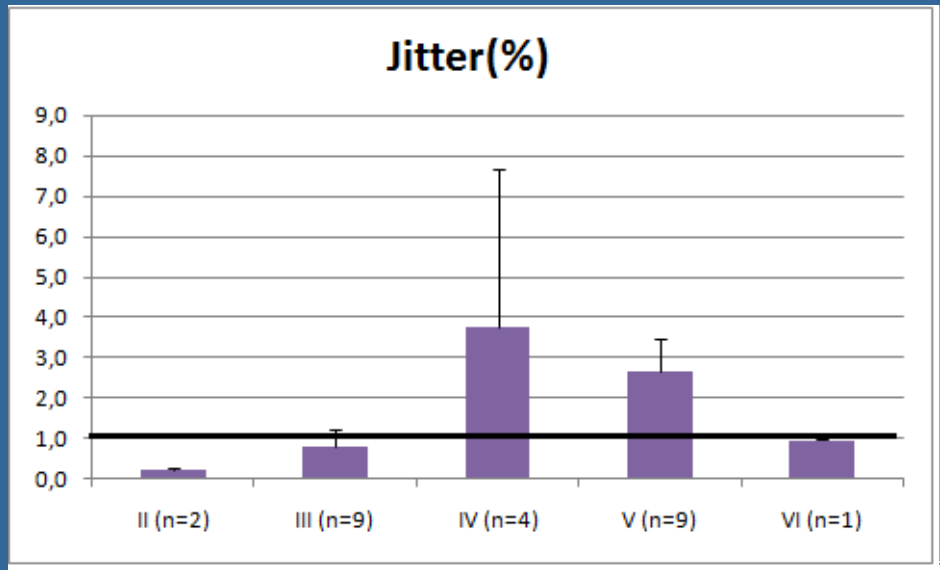
- Voice Handicap Index (n=23)

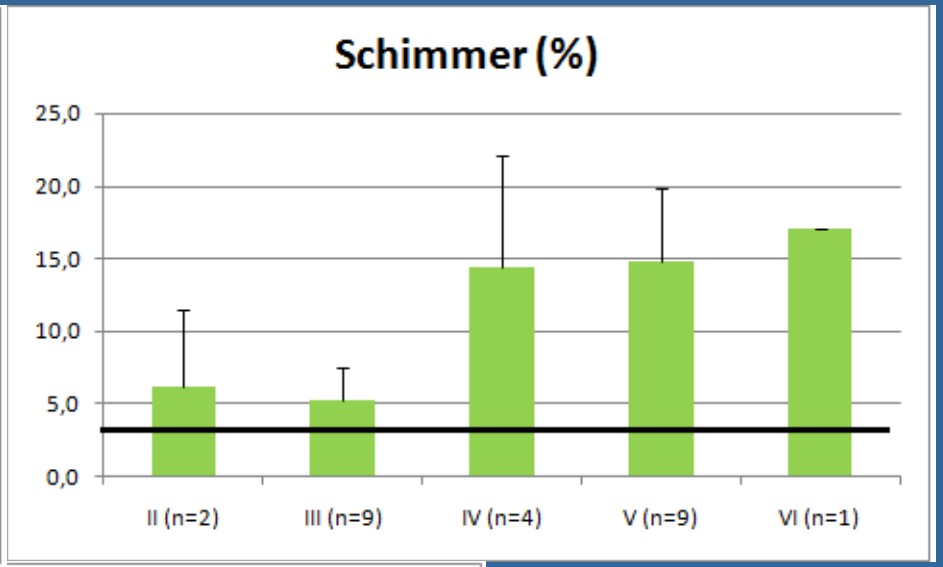


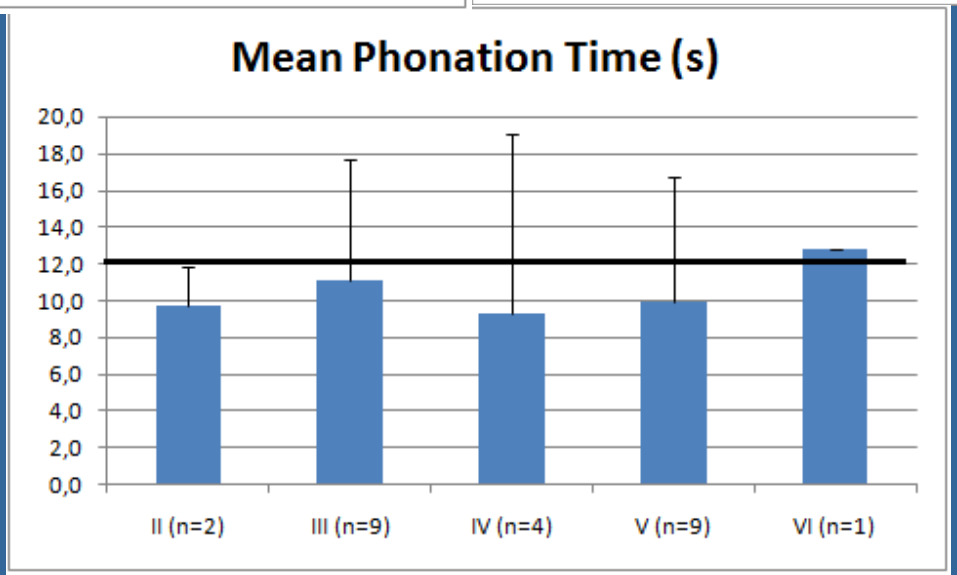


Functional results

Objective voice analysis with programme Praat







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

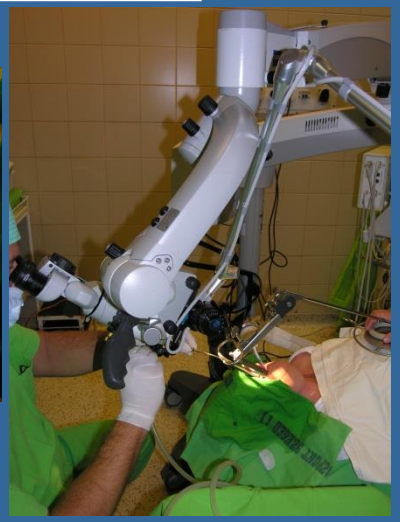
- **Smoking** plays an important role in the development of glottic cancer in our patients too.

30 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

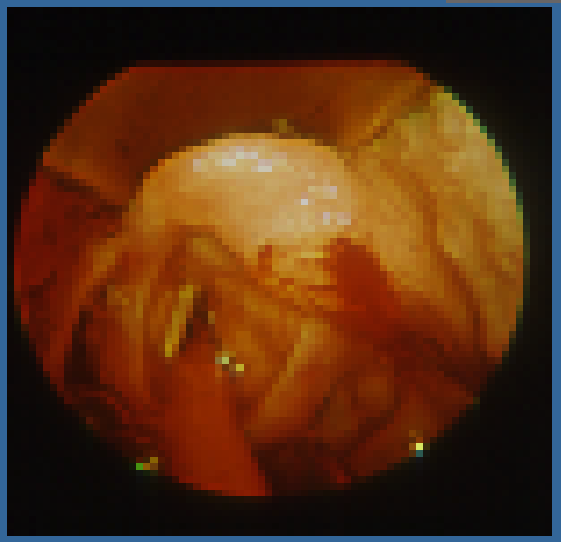
40 patients with tumour of the epiglottis (36 T1N0, 4 T1N1), 4 pat. - tumour of the ventricular fold (4 T1N0), 13 pat. with supraglottic-vallecula tumour (10 T2N0, 3 T2N1) and 6 pat. with supraglottic-aryepiglottic fold (3 T2N0, 3 T2N1)

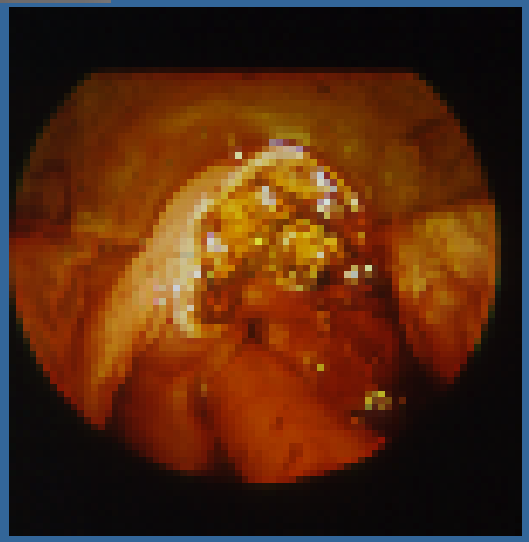
Localization supraglott. tumour **Staging**	Epiglottis	Ventricular fold	Supraglott.-vallecula	Supraglott.-aryepiglott. fold
T1N0 **T1N1**	36 patients 4 patients	4 patients		
T2N0 **T2N1**			10 patient 3 patients	3 patients 3 patient
Total	40 pat.	4 pat.	13 pat.	6 pat. = total of 63 patients

Patient's material: supraglottic tumours of the larynx (1989-2010)

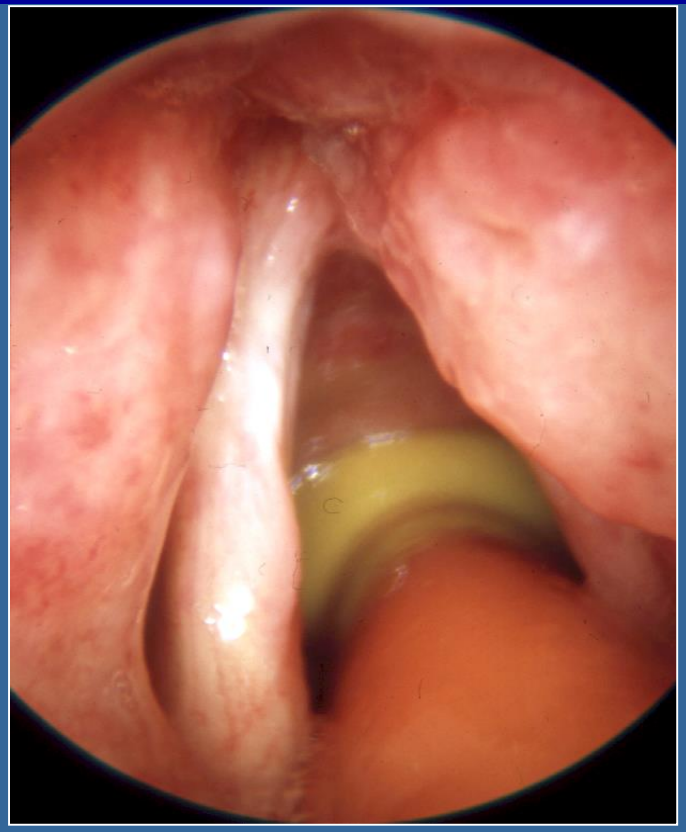
- Transoral laser resection in 63 patients (40 patients with epiglottis tumour, 4 with ventricular fold, 13 with supraglottic-vallecula and 6 with aryepiglottic fold tumour)
- Of the 63 supraglottic carcinoma 10 patients underwent endolaryngeal laser excision which was combined with simultaneous modified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

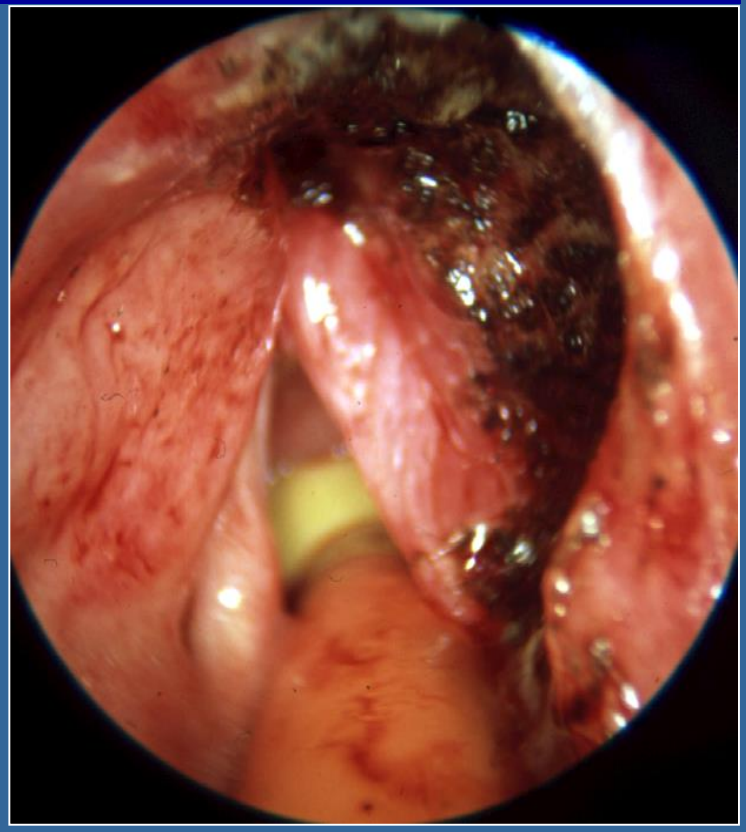
Supraglottic cancer T1 tumour of the epiglottis and after CO_2 laser-resection (partial epiglottectomy)





Supraglottic CO2 laser resection



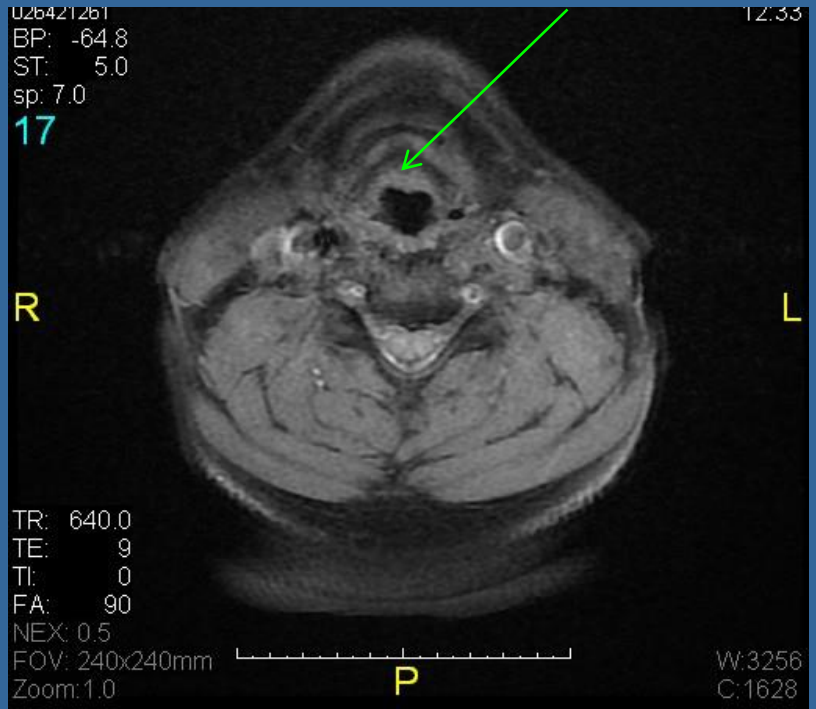


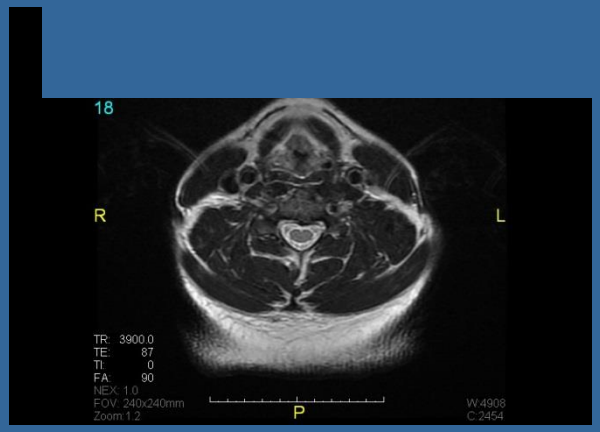
M. Csanády · L. Iván · J. Czigner

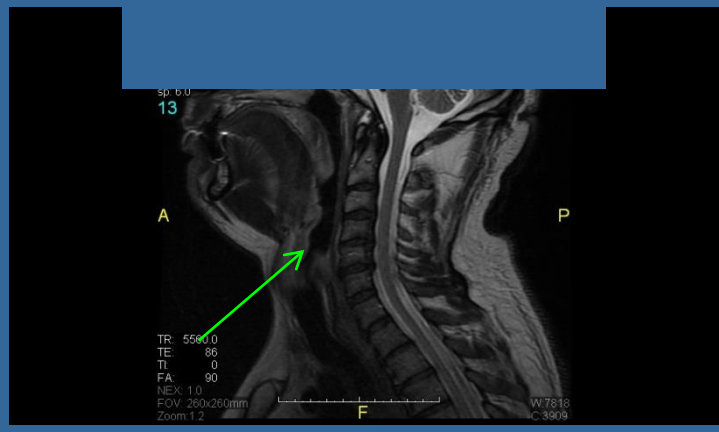
Endoscopic CO_2 laser therapy of selected cases of supraglottic marginal tumors

Eur Arch Otorhinolaryngol (1999) 256:392–394

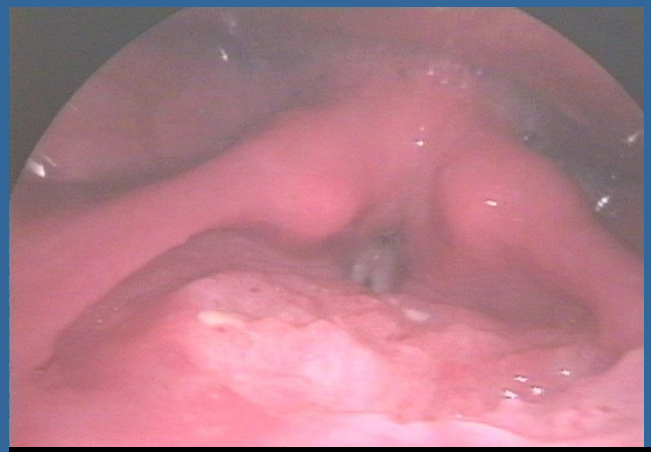
Role of imaging (CT, MRI) in the transoral laser surgery of early (T1, T2) supraglottic tumours without infiltration of the preepiglottic space



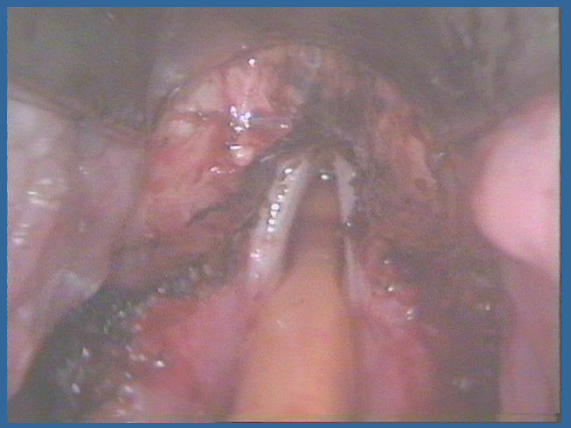




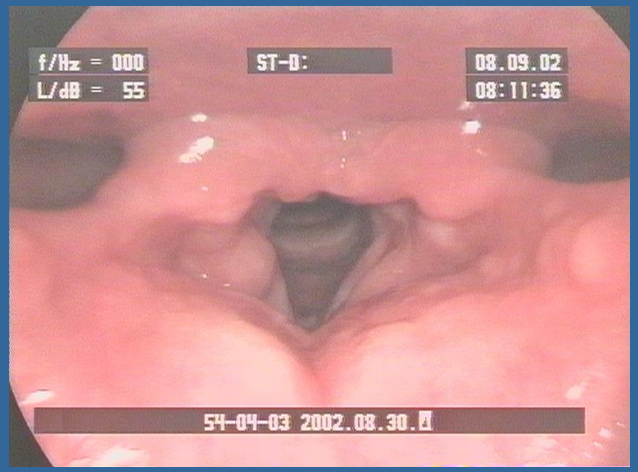
Infrahyoid carcinoma of the epiglottis, early and late postoperative results after transoral laser resection



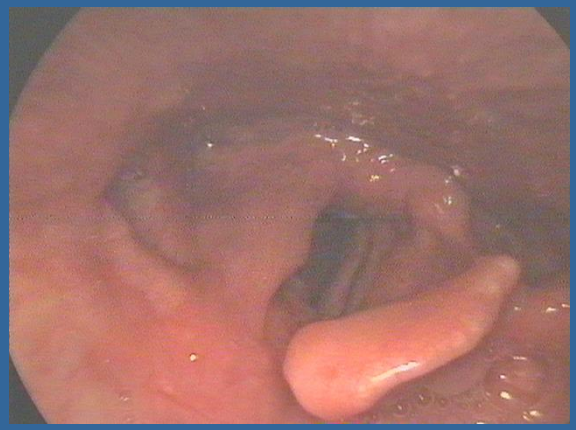
Without spreading to the preepiglottic space/ no detectable metastasis



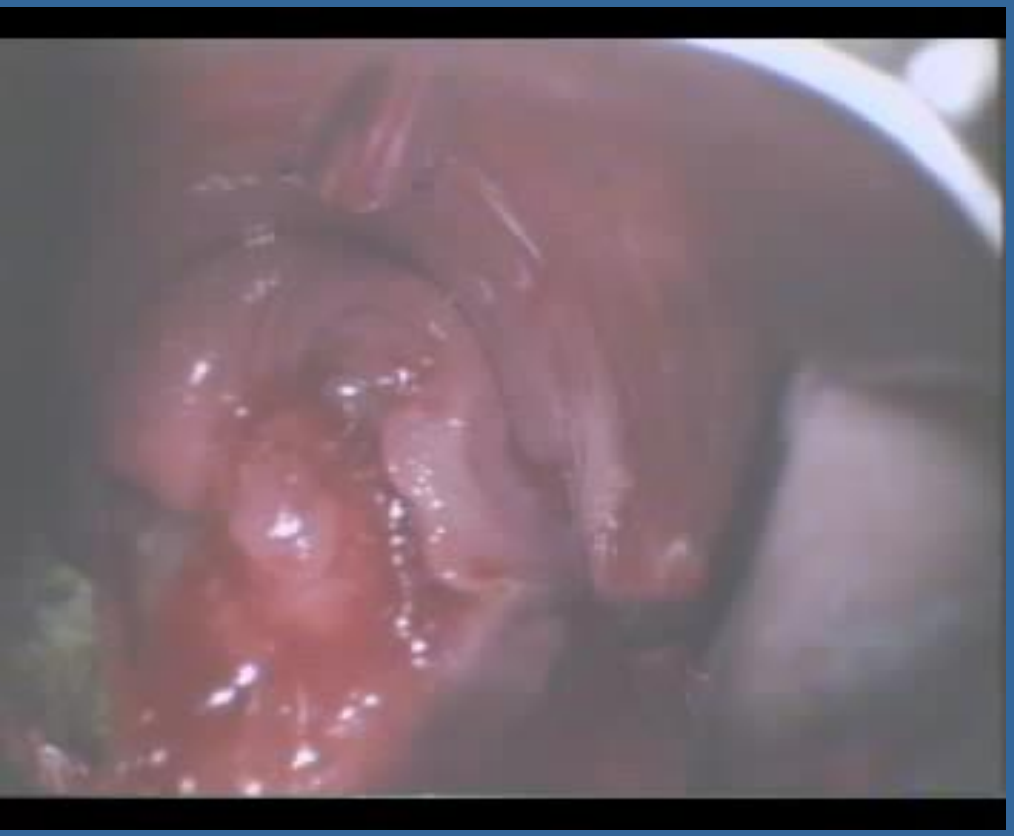
Laser epiglottectomy (video)

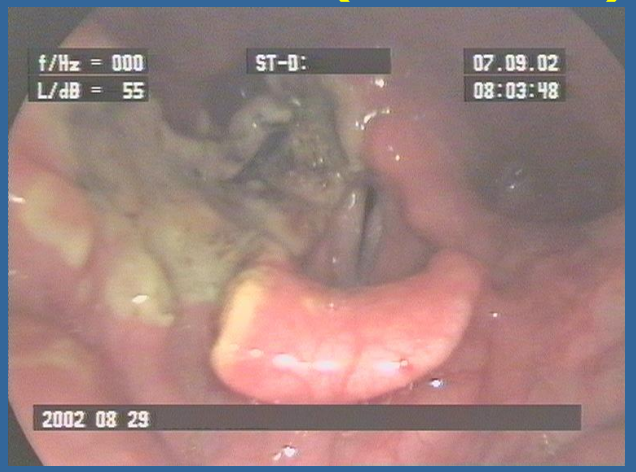


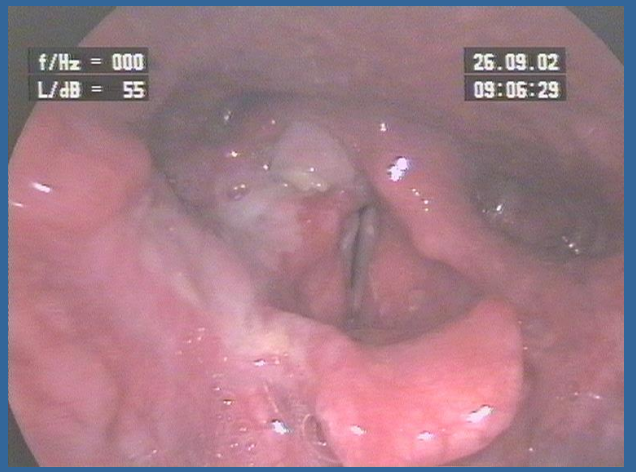
Carcinoma of the supraglottic-vallecula Endoscopic CO2 laser resection + mRND (video)



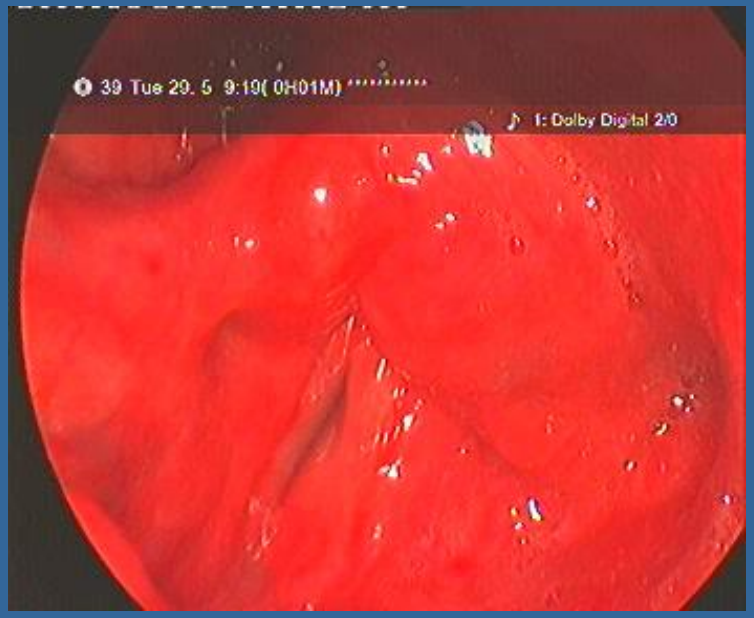
Tumour of supraglottic-aryepiglottic fold Transoral laser resection (video)

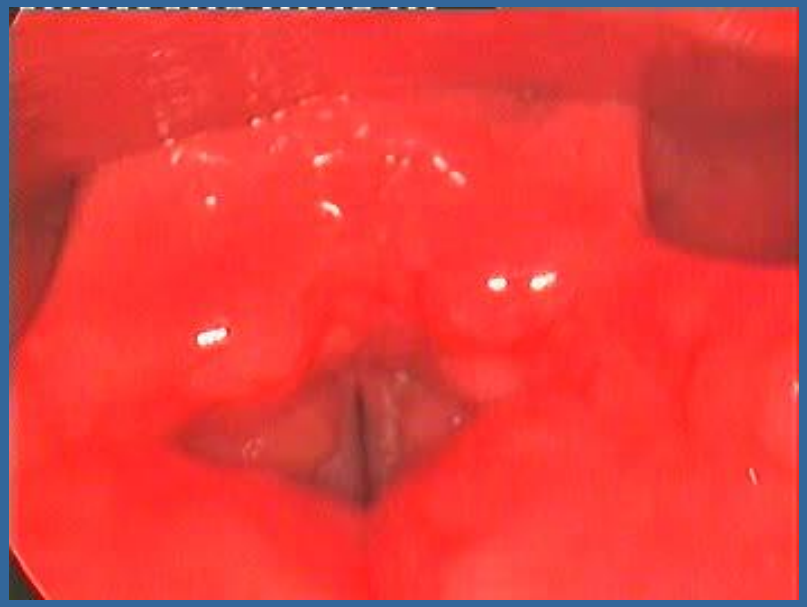






Late postoperative functional result after transoral laser resection of supraglottic tumour (video)



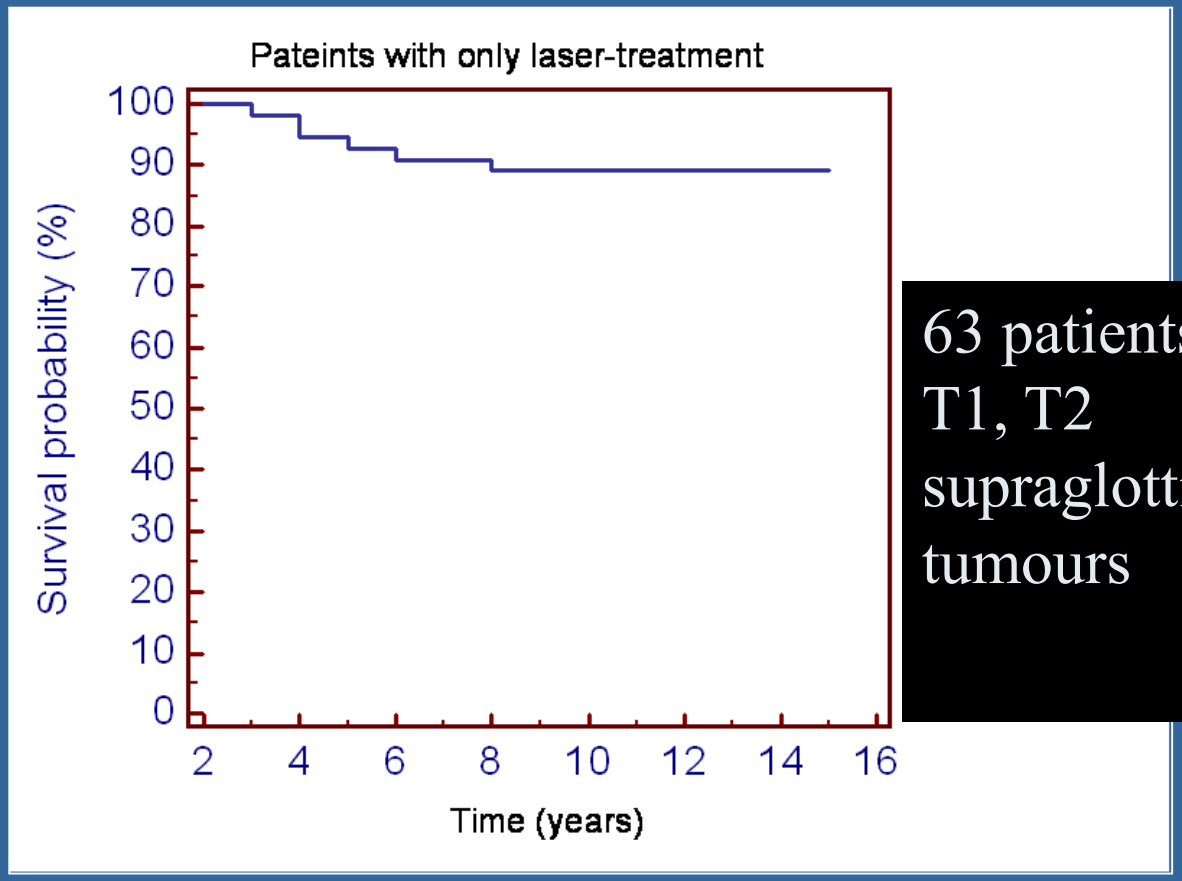


No aspiration, glottis closure is intact

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
- Salvage-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

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

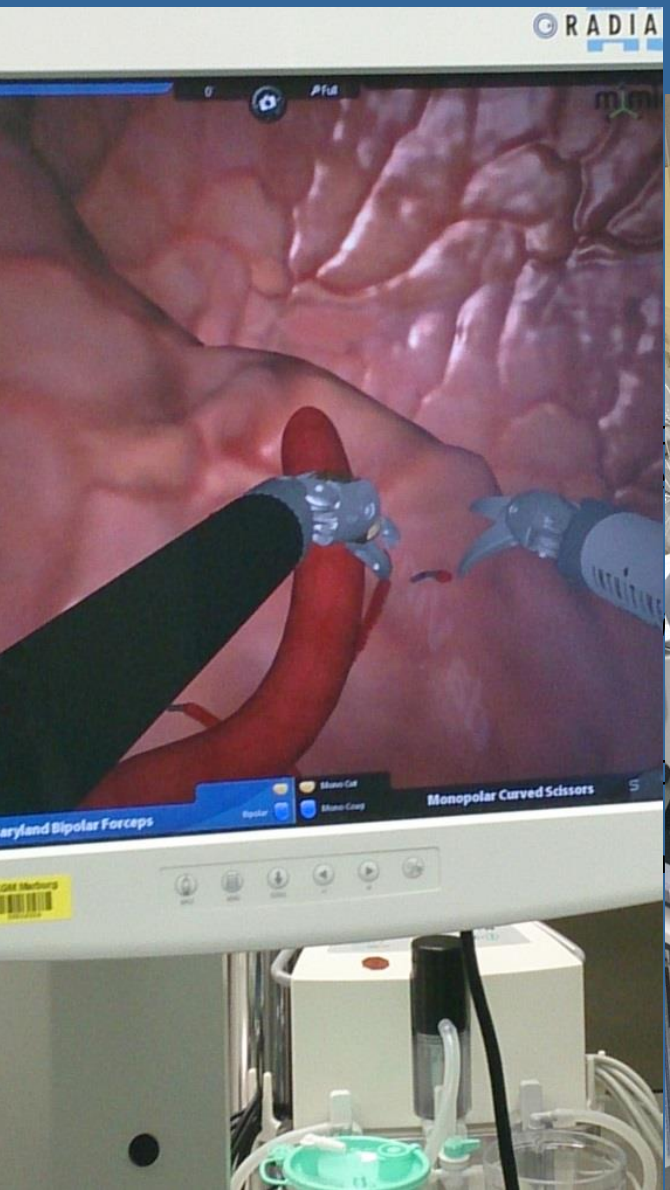
Conclusions

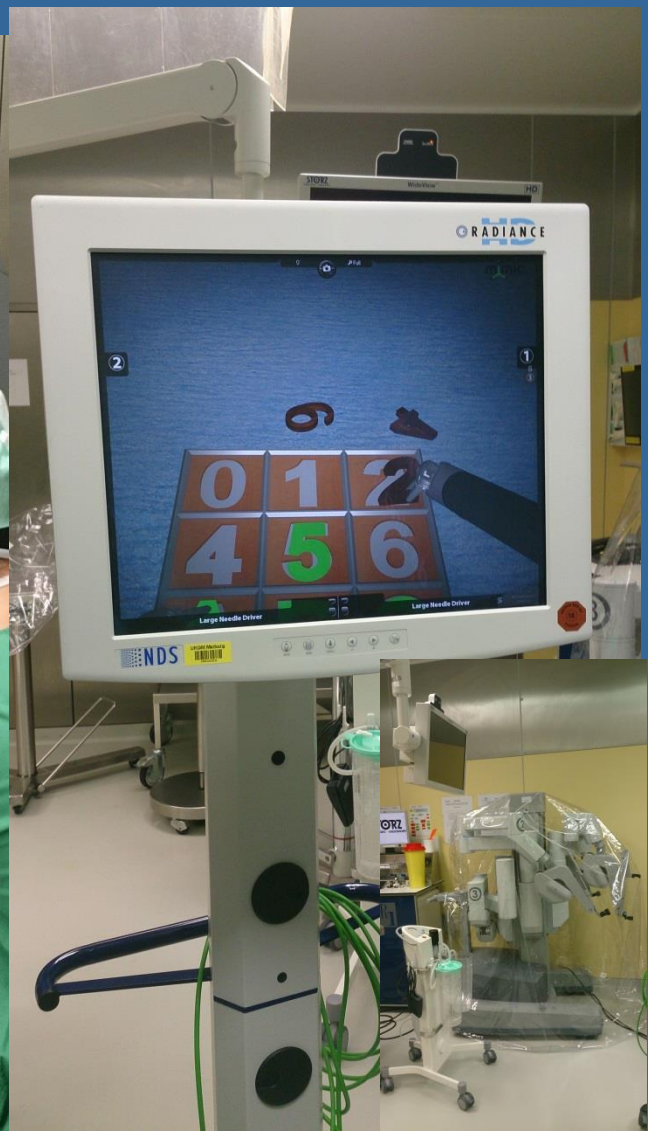
- In selected patients with early supraglottic tumour (63 patients/15%) transoral laser resection proved to be a good endoscopic surgical option versus horizontal supraglottic laryngectomy
- In 10 patients transoral laser method was combined with neck dissection in one session
- There was no need for 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

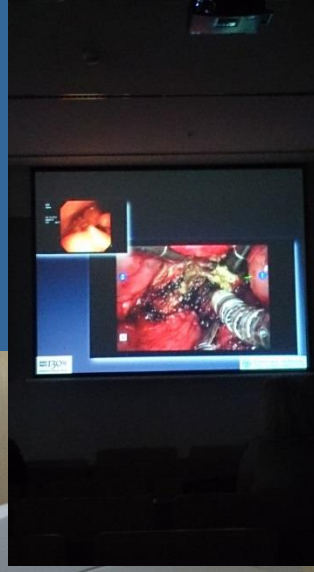
- Minimally-invasive surgical intervention - faster recovery
- No need for tracheostomy
- Minimal intraoperative bleeding
- No or moderate edema – rarely developed
- Moderate (severe) aspiration, but less deglutition problem than after open access surgery (partial laryngectomy)
- Acceptable - good swallowing 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!

FÜL-ORR-GÉGÉSZETI ÉS FEJ-NYAKSEBÉSZETI KLINIKA
UNIVERSITAS SCIENTIARUM SZEGEDIENSIS
SZEGEDI TUDOMÁNYEGYETEM