Laryngo- Tracheal Stenosis (LTS)

- ☑ **Definition:**
  - luminal narrowing of the throat or airways
- ☑ **Etiology:**
  - intubation for mechanical ventilation, trauma, airway surgery, reflux, malformations (EA, Vessels……)
- ☑ **Therapy planing needs to know:**
  - number, site, degree, extent, & dynamics

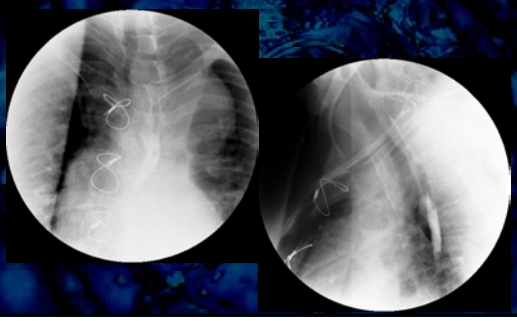
LTT – Clin. Examination

Imaging of LTS

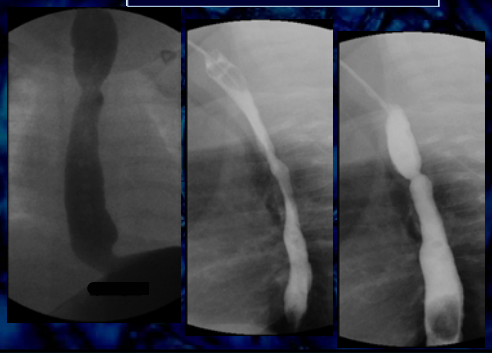
- ☑ **Conv. X-Rays:**
  - Chest-X, Softtissue X-Rays
- ☑ **Fluoroscopy**
- ☑ **Conv. Tomography**
- ☑ **Magnetresonance Tomography**
- ☑ **Spiral Computertomography**
- ☑ **3D Reconstructions**
- ☑ **Virtuelle Endoscopy**

LTS Imaging – Conv.XRay

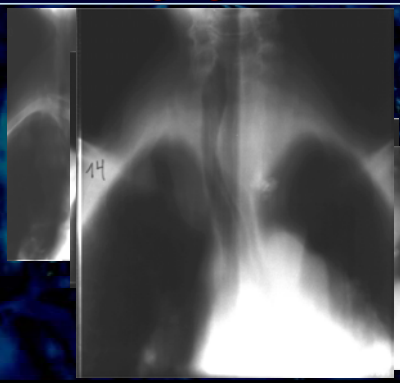
LTS Imaging – Softtissue XRay



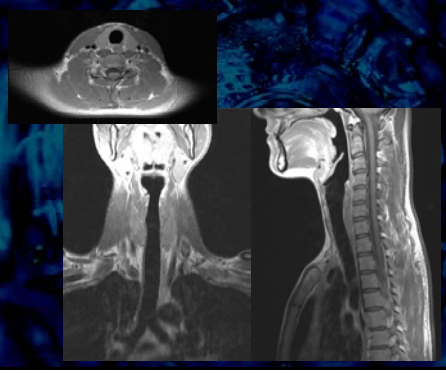
LTS Imaging - Fluoro



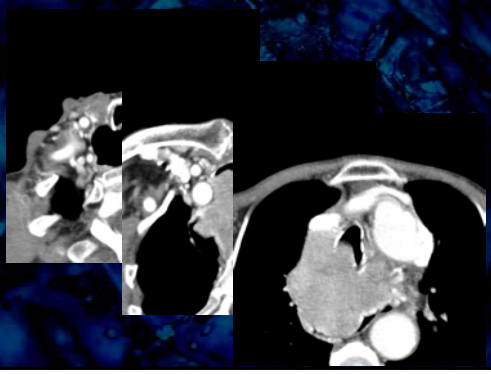
LTS Imaging – conv.Tomo



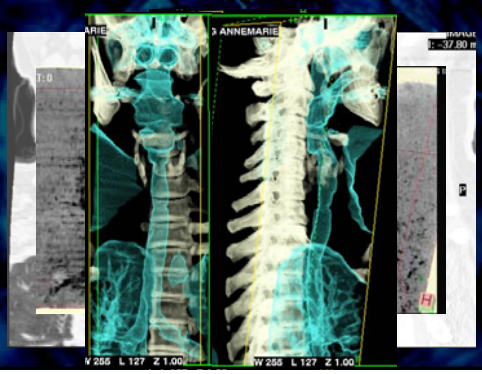
LTS Imaging – MR



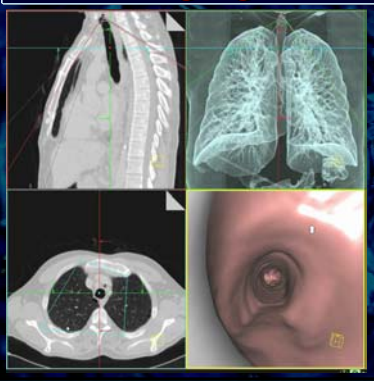
LTS Imaging – Spiral CT



LTS Imaging – 3D



LTS Imaging – VE



LTS – VE „Impact"

- ☑ **Study: n=19**
  - Patients: n=15
  - Controlls: n=4
- ☑ **Comparision – reporting with/without VE - 2 observers:**
  - Axiale Schichten, MPR
  - Axiale Schichten, MPR und VE

LTS – VE „Impact"

	FTB findings*	Total
	Normal	Pathological
Findings		
Total		

	FTB findings*	Total
	Normal	Pathological
Findings on axial S-(		
Total		

*κ=0.776,

*False-neg

*κ=1.00, 95% CI 1.0-1.0,

Table 3. VTB in pediatrics: age dependency of bronchial order suitable for exploratio

Generation of bronchi	Number of patients	Average age (years)
Trachea	19	6.3
Mainstem bronchi	19	6.4
Lobar bronchus	15	7.3
Segment bronchus	5	11.1
Subsegel		

Table 4. Age dependency of VTB quality (n=19)

VTB quality	Number of patients	Average age (years)
Poor	4	2.7
Good	9	6.5
Excellent	6	9.3

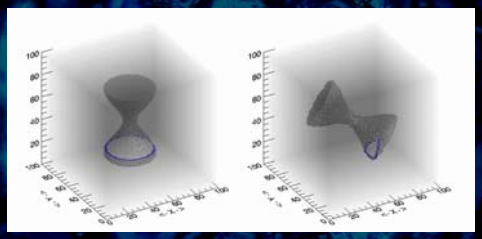
E.Sorantin et al.
Ped Radiol (2002) 32: 8-15

LTS Quantification – Endoscopy

☑ **High interobserverariability !!!!**

Jewett et al. Ann Otol Rhinol Laryngol 1999)

LTS – Quantification



LTS - Quantifizierung

☑ **Visual – semi-quantitative**

LTS Quantification – Spiral CT

☑ **Interobserver Variance**

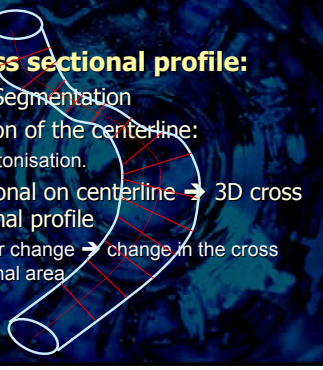
- 3 Observer, 22 Trachealstenoseses

	rel. deviation %	*range*
mean	43,25	22,91
Maximal	141,57	42,00
minimal	12,24	8,50

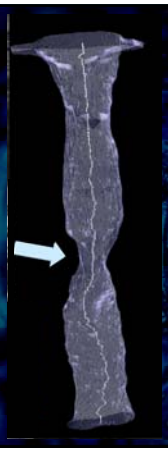
LTS – Quantification

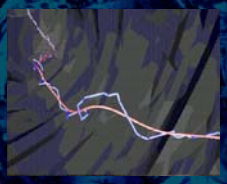
☑ **3D-Cross sectional profile:**

- Airway Segmentation
- Extraction of the centerline:
  - Skeletonisation.
- Orthogonal on centerline → 3D cross sectional profile
  - Caliber change → change in the cross sectional area

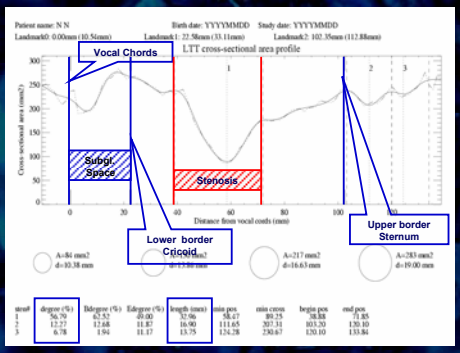


LTT - Skeleton



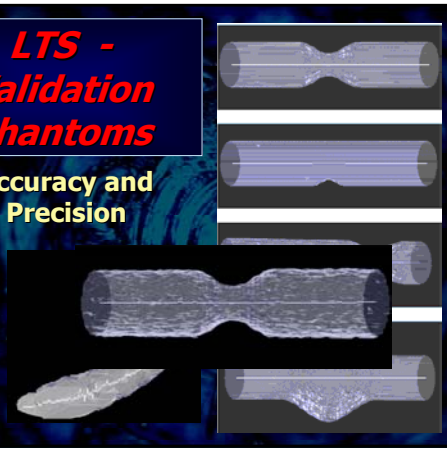


LTS – Quantification



LTS - Validation Phantoms

☑ Accuracy and Precision



Clinical Studies

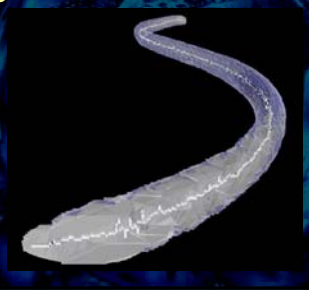
☑ Patients (n=36 24 weeks to 92a)
- all invested by endoscopy and CT

☑ Normal controls (n=18)

	Site of Stenosis	Endoscopy: larynx	subglottic	tracheal	subglottic and trachea	larynx-subglottic and trachea	total
S-CT	larynx						
	subglottic		5				5
	trachea			20			20
	subglottic and trachea				8		8
	larynx -subglottic and trachea	3					3
	total	3	5	20	8		36

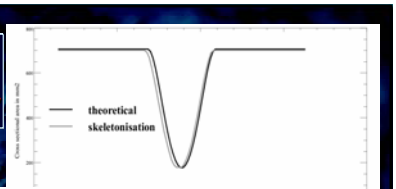
LTS - Validation Phantoms

☑ length measuremtens: 1% error

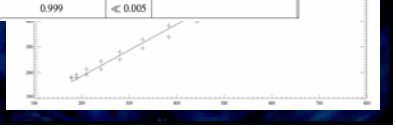


Results - Phantoms

☑ Theo… vs comp… cross… sectio… profile



VGB	Noise %	Correlation Coefficient	p-Value	rel.difference in % between corresponding sections
# 1	0	0.998	≪ 0.005	8.1%
	10	0.997	≪ 0.005	
# 4	0	0.998	≪ 0.005	7.8%
	10	0.999	≪ 0.005	



Results - Phantoms Accuracy (LTS length, degree)

		Noiselevel	Mean	Minimum	Maximum	p-value
Length	absolute	all	2.14mm	0.28mm	4.82mm	p> 0.05 n.s.
	relative	all	3.41%	0.67%	6.79%	
	absolute	0	1.74mm	1.33mm	2.14mm	p> 0.05 n.s.
	relative	0	3.09%	3.01%	3.17%	
	absolute	10	2.55mm	0.28mm	4.82mm	p> 0.05 n.s.
	relative	10	3.73%	0.67%	6.79%	
Degree	absolute % narrowing	all	2.53	0.12	8.50	p> 0.05 n.s.
	relative % of true values	all	1.22%	0.16%	3.57%	
	absolute	0	0.54	0.12	0.96	p> 0.05 n.s.
	relative	0	0.28%	0.16%	0.40%	
	absolute	10	4.53	0.56	8.50	p> 0.05 n.s.
	relative	10	2.16%	0.75%	3.57%	
n.s.: not significant						

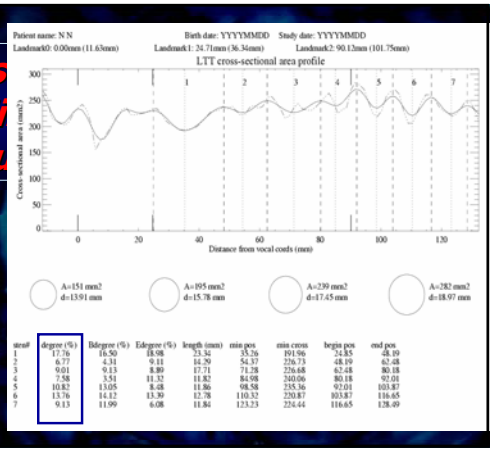
Results - Phantoms Precision (LTS length, degree)

		Mean	Minimum	Maximum	p-value
Length	absolute	0.92mm	0.02mm	2.68mm	p> 0.05 n.s.
	relative	1.87%	0.10%	3.66%	
Degree	absolute % narrowing	2.56	0.29	9.46	p> 0.05 n.s.
	relative % of noise free variant	6.72%	0.39%	20.44%	
n.s.: not significant					

Results - Clinical Studies

	normals	patients	p-value
number of edited slices (mean)	2.41	3.9	p=0.06
analyszed sites	46	31	
degree – mean (minimum- maximum)	8.8% (0.3% – 20.5%)	60.5% (25.9% – 95.5%)	p<0.0001
length – mean (minimum- maximum)	23.1mm (0.95cm – 5.48cmm)	42.3mm (1.26cm – 8.31cm)	p<0.0001

Res Cli Stu



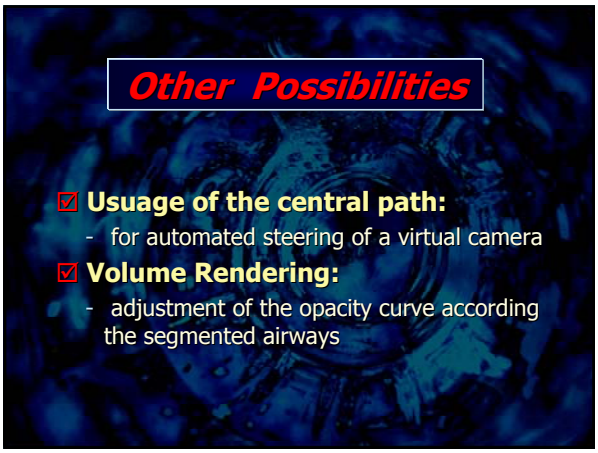
Conclusions

- ☑ **Realistic 3D reconstructions from S-CT are possible**
- ☑ **Virtual endoscopy presents data in a familiar way for the ENT surgeon**
- ☑ **3D cross sectional charts:**
  - provide quantitative information
    - number
    - site
    - lenght
    - degree

Conclusions

- ☑ **3D cross sectional charts:**
  - accurate
  - precise
  - caliber changes up to 20% in normals

ROAD MAPPING ACHIEVED


Other Possibilities
☑ Usuage of the central path:
- for automated steering of a virtual camera
☑ Volume Rendering:
- adjustment of the opacity curve according the segmented airways