

Laryngo- Tracheal Stenosis (LTS)

☑ **Definition:**

- luminal narrowing of the throat or airways

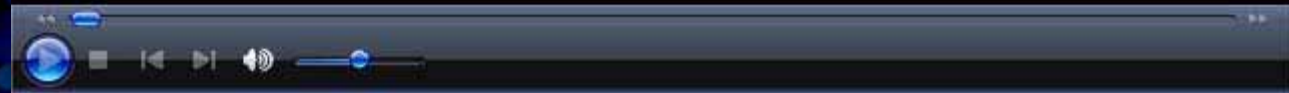
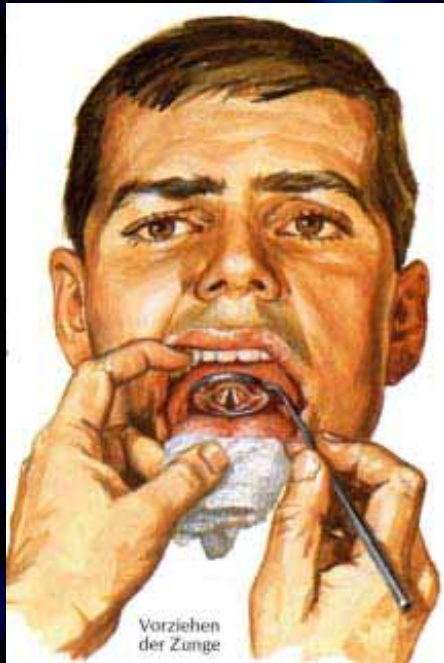
☑ **Etiology:**

- 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**

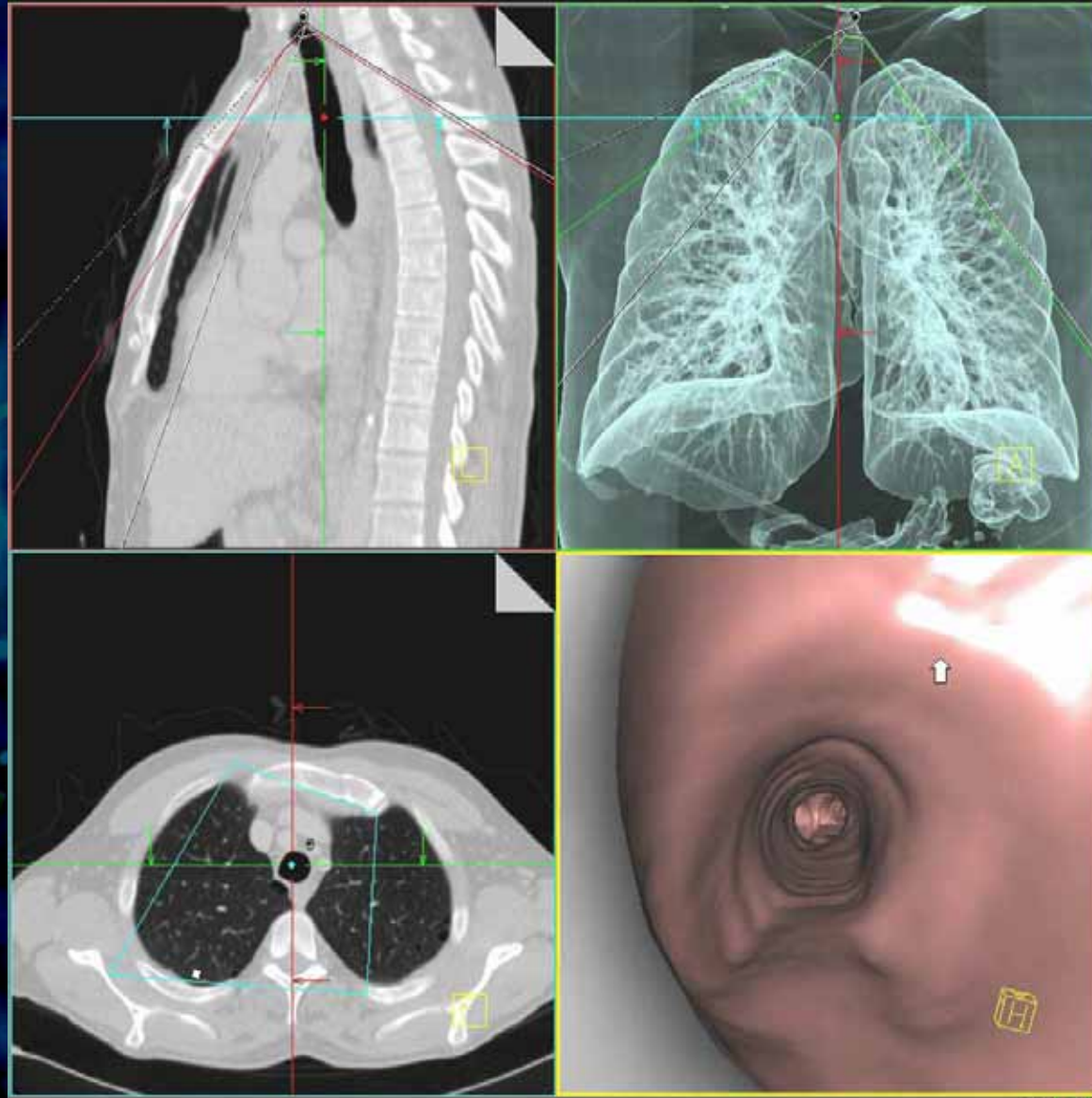
Imaging of LTS

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

LTS Imaging – 3D



LTS Imaging – VE



LTS – VE „Impact“

✓ Study: n=19

- Patients: n=15
- Controls: 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	Normal	Pathological	6

	FTB findings*		Total
	Normal	Pathological	
Total			

* $\kappa=0.776$, 95% CI 0.61-0.94

^aFalse-negative

Findings on axial S-C

Total

* $\kappa=1.00$, 95% CI 1.0-1.0,

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

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
Subsegment bronchus		

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

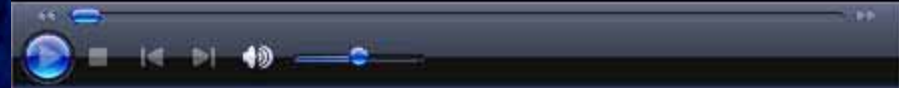
LTS Quantification – Endoscopy

High interobserver variability !!!!

Jewett et al. Ann Otol Rhinol Laryngol 1999)

LTS - Quantifizierung

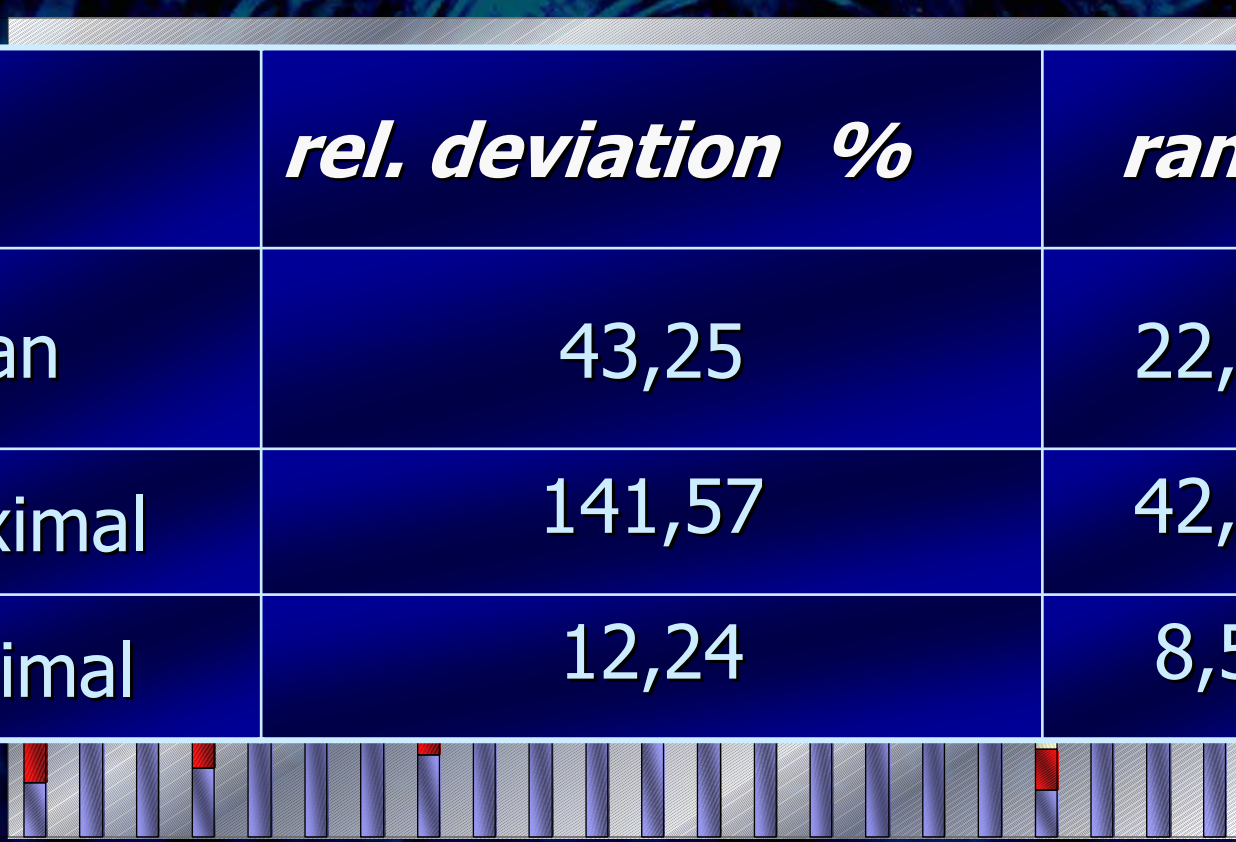
☑ **Visual –
semi-
quantitative**



LTS Quantification – Spiral CT

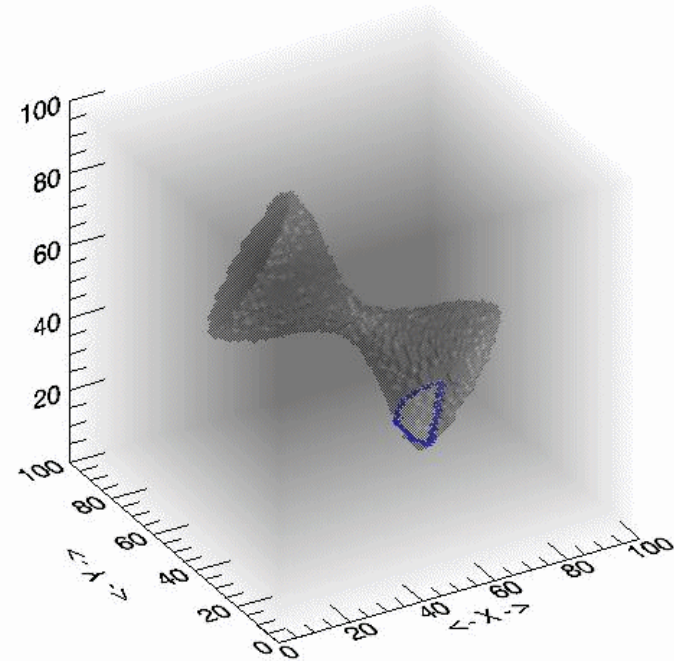
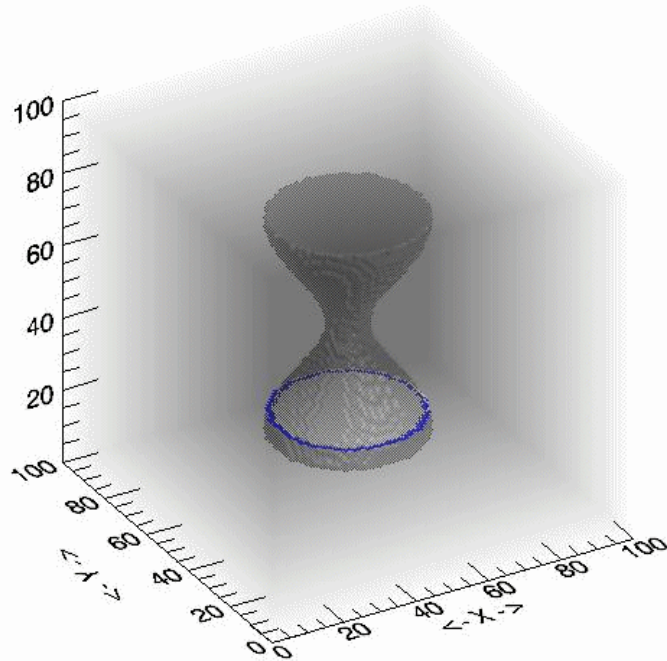
☑ **Interobserver Variance**

- 3 Observer, 22 Trachealstenoses

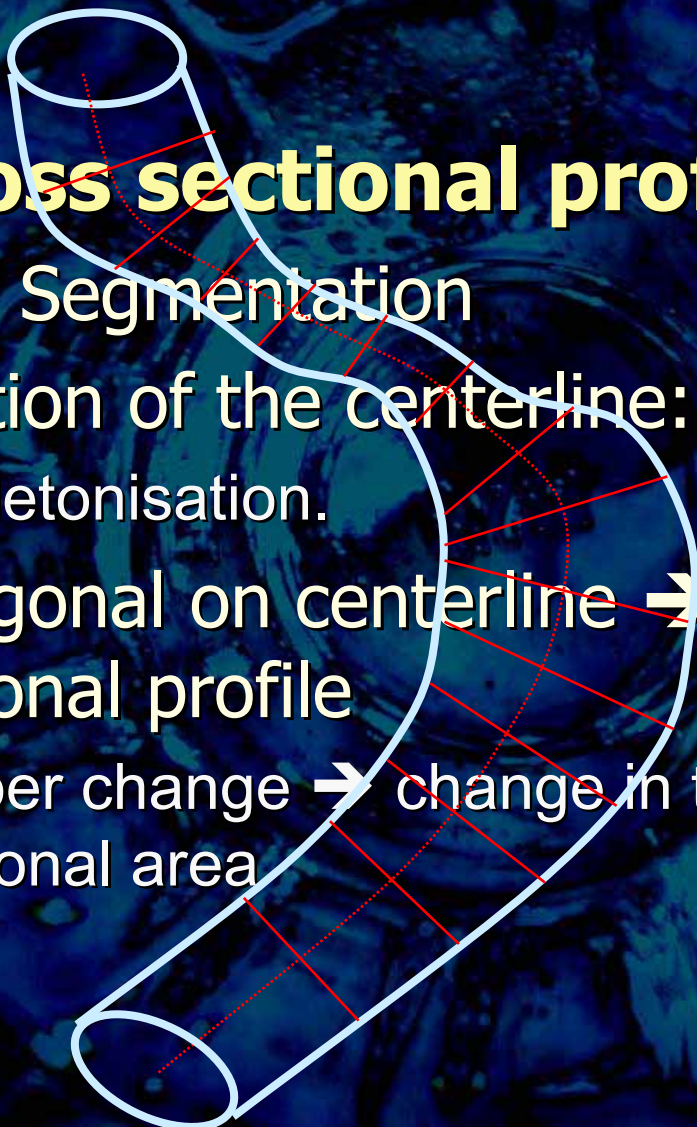


	<i>rel. deviation %</i>	<i>range</i>
mean	43,25	22,91
Maximal	141,57	42,00
minimal	12,24	8,50

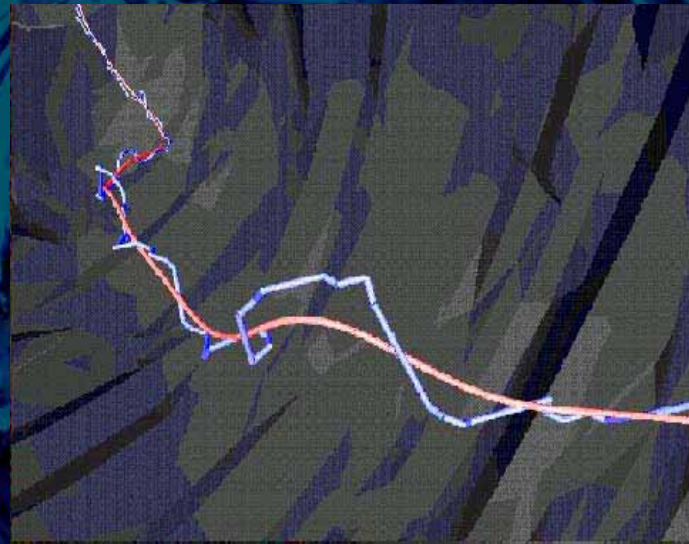
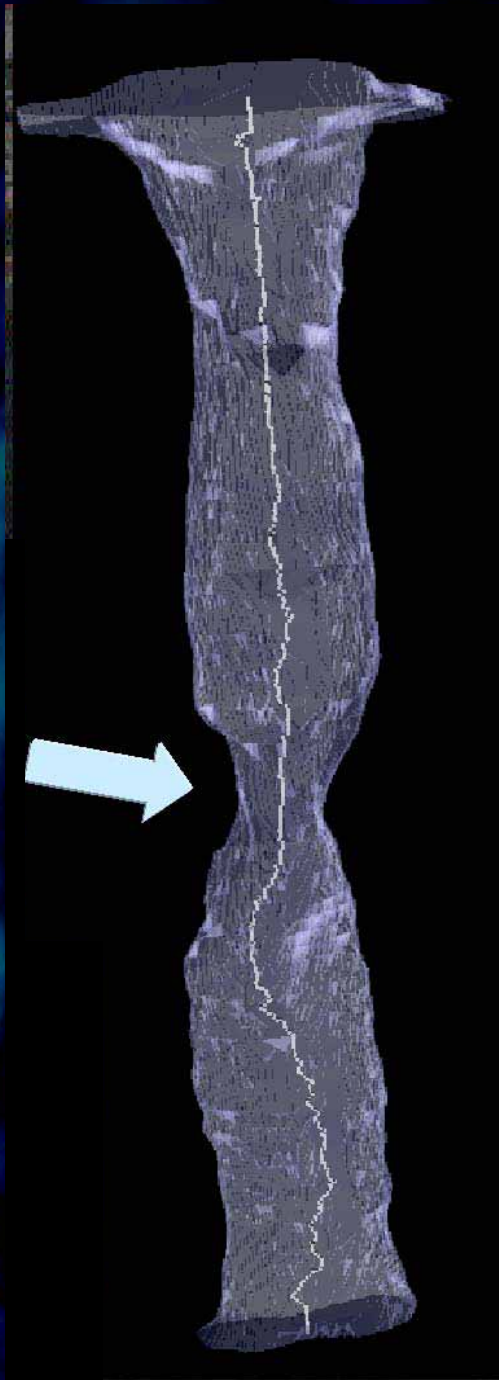
LTS – Quantification



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

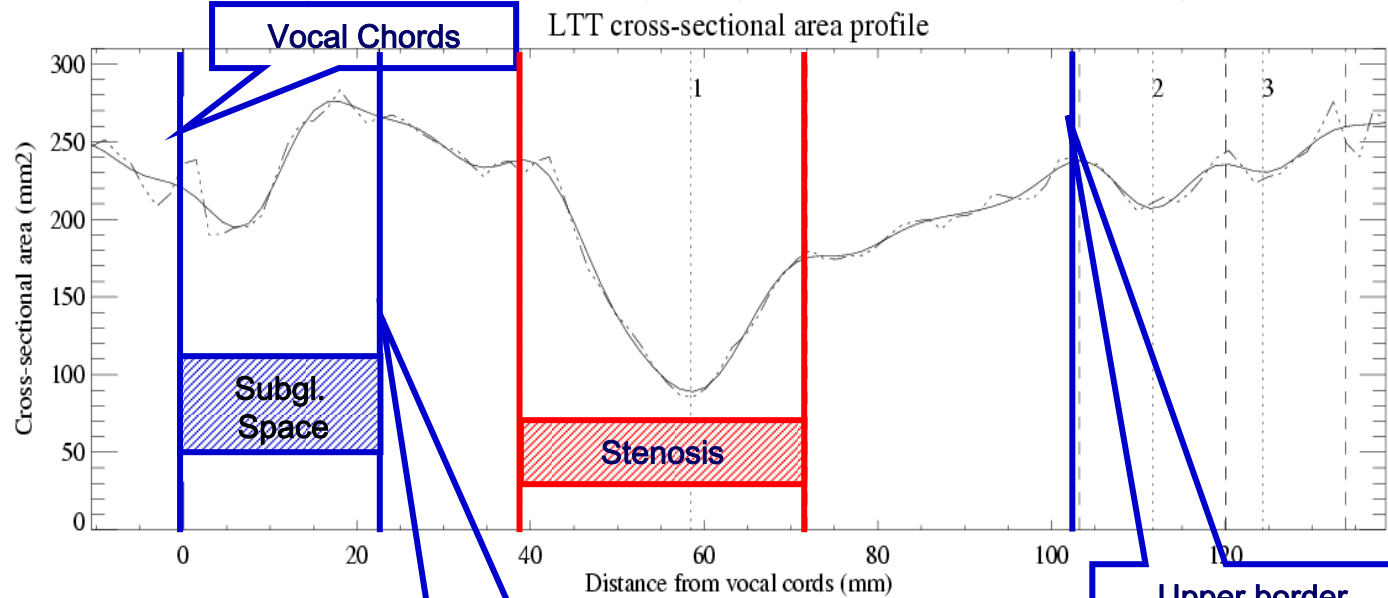
Patient name: N N

Birth date: YYYYMMDD Study date: YYYYMMDD

Landmark0: 0.00mm (10.54mm)

Landmark1: 22.58mm (33.11mm)

Landmark2: 102.35mm (112.88mm)



A=84 mm²
d=10.38 mm

A=190 mm²
d=13.86 mm

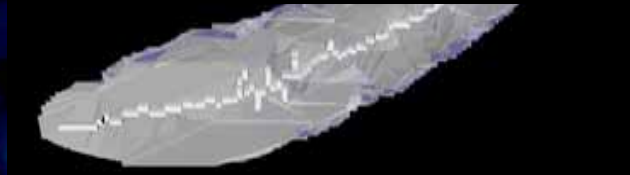
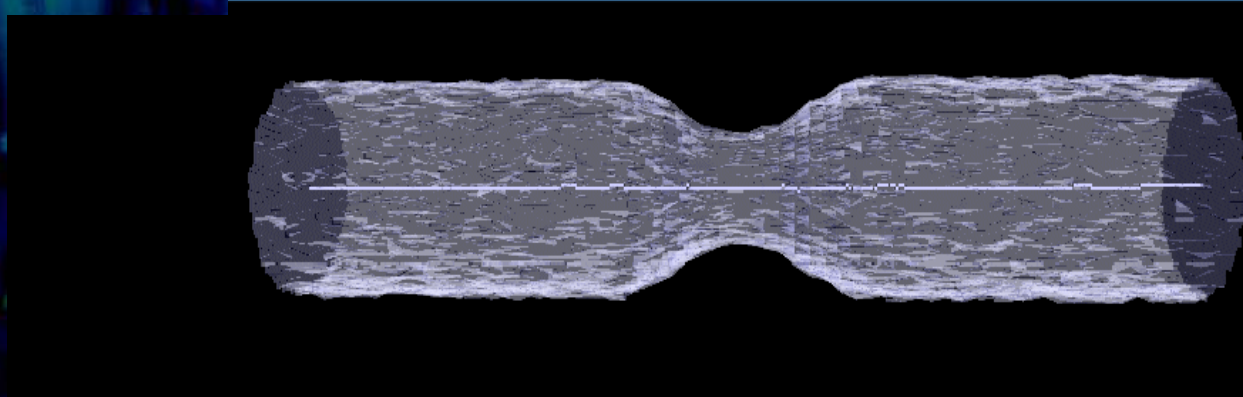
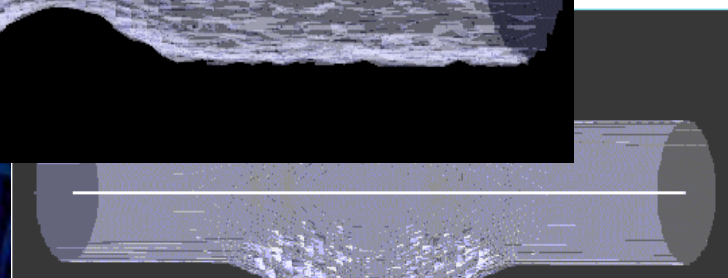
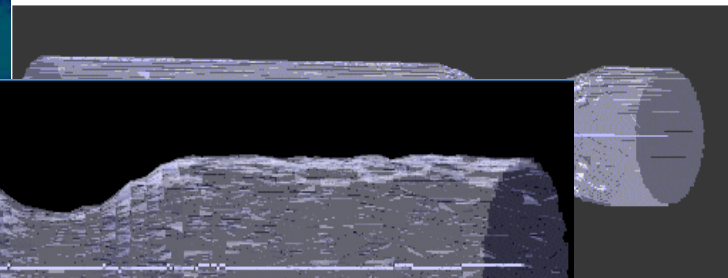
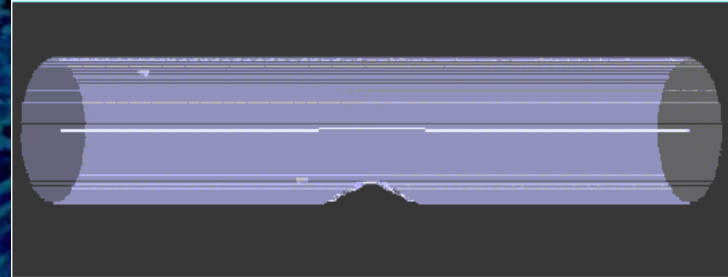
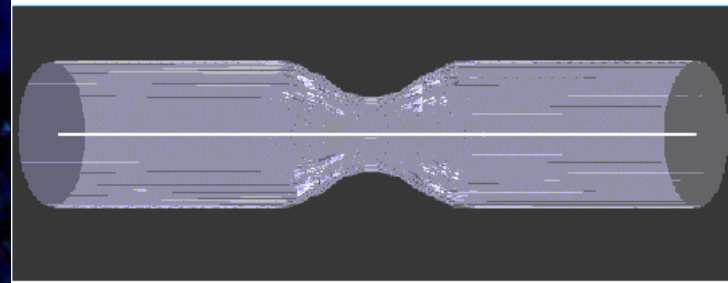
A=217 mm²
d=16.63 mm

A=283 mm²
d=19.00 mm

sten#	degree (%)	Bdegree (%)	Edegree (%)	length (mm)	min pos	min cross	begin pos	end pos
1	56.79	62.52	49.00	32.96	58.47	89.25	38.88	71.85
2	12.27	12.68	11.87	16.90	111.65	207.31	103.20	120.10
3	6.78	1.94	11.17	13.75	124.28	230.67	120.10	133.84

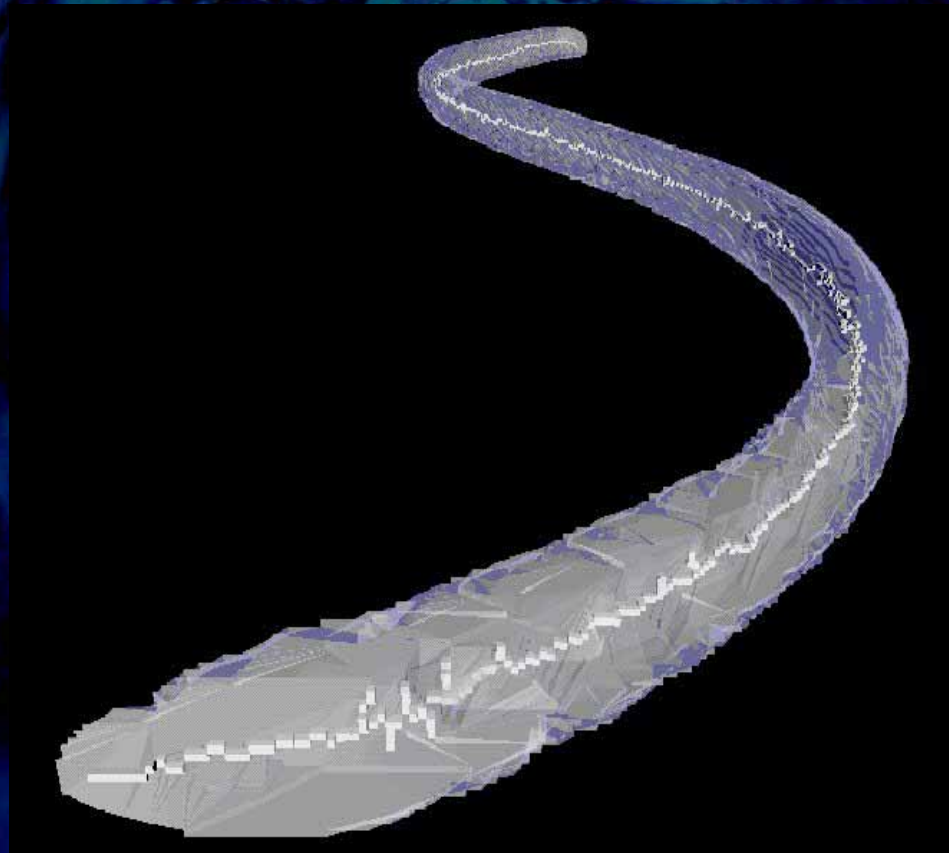
LTS - Validation Phantoms

**Accuracy and
Precision**



LTS - Validation Phantoms

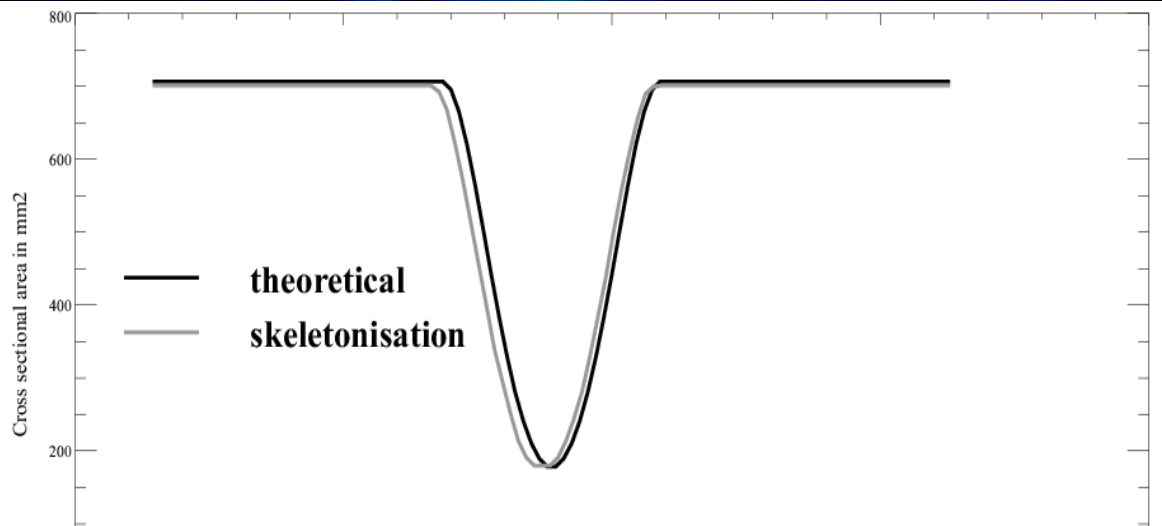
length measurements: 1% error



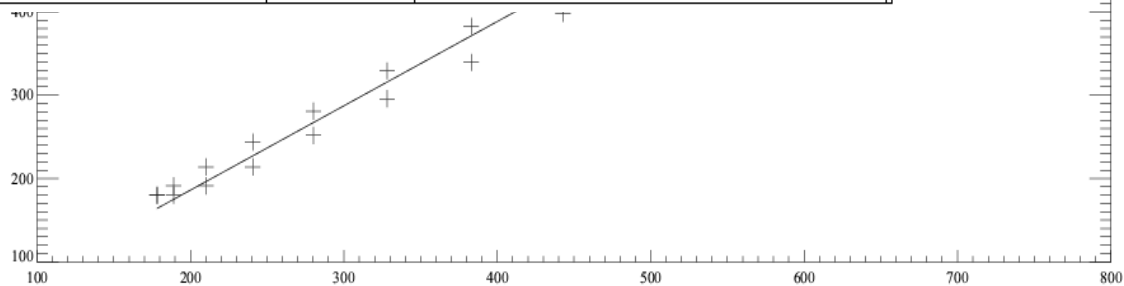
Results - Phantoms



Theoretical
vs
computed
cross
sectional
profile



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



Res
cli
stu

Patient name: N N

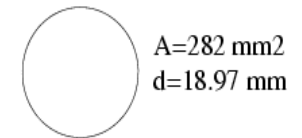
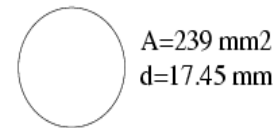
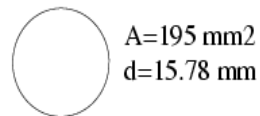
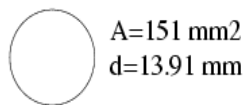
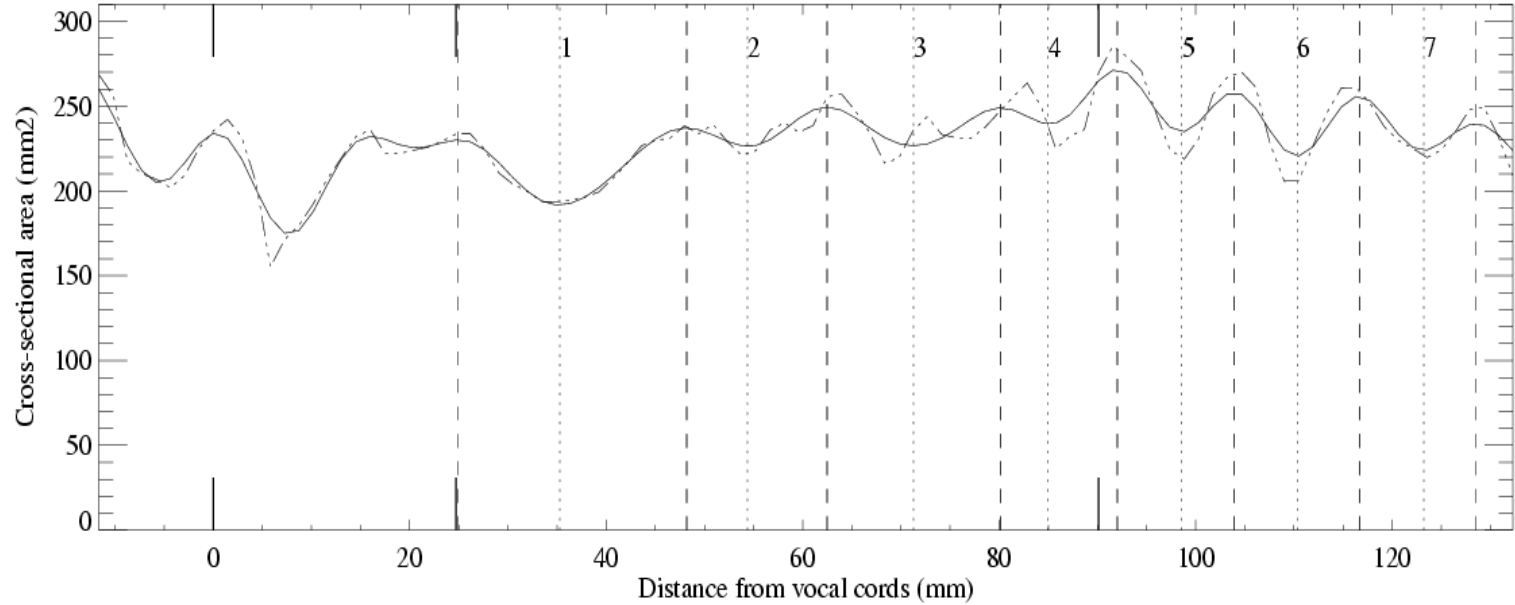
Birth date: YYYYMMDD Study date: YYYYMMDD

Landmark0: 0.00mm (11.63mm)

Landmark1: 24.71mm (36.34mm)

Landmark2: 90.12mm (101.75mm)

LTT cross-sectional area profile



sten#	degree (%)	Bdegree (%)	Edegree (%)	length (mm)	min pos	min cross	begin pos	end pos
1	17.76	16.50	18.98	23.34	35.26	191.96	24.85	48.19
2	6.77	4.31	9.11	14.29	54.37	226.73	48.19	62.48
3	9.01	9.13	8.89	17.71	71.28	226.68	62.48	80.18
4	7.58	3.51	11.32	11.82	84.98	240.06	80.18	92.01
5	10.82	13.05	8.48	11.86	98.58	235.36	92.01	103.87
6	13.76	14.12	13.39	12.78	110.32	220.87	103.87	116.65
7	9.13	11.99	6.08	11.84	123.23	224.44	116.65	128.49

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
 - length
 - degree

Conclusions

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



**ROAD MAPPING
ACHIEVED**

Other Possibilities

- ☑ **Usage of the central path:**
 - for automated steering of a virtual camera
- ☑ **Volume Rendering:**
 - adjustment of the opacity curve according to the segmented airways