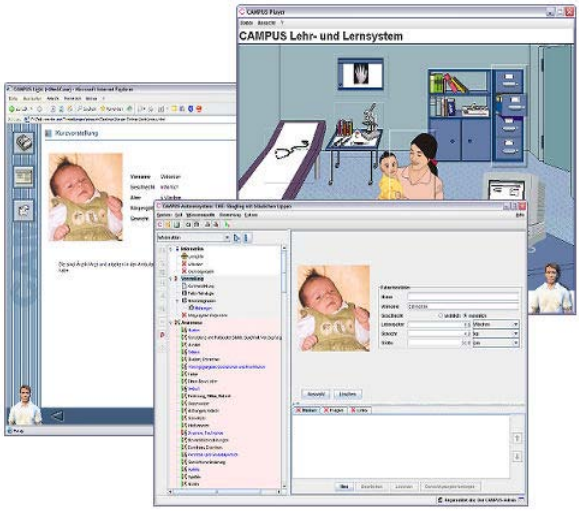
Tutorial Syllabus

Surface Visualization - Marching Cubes and its improvements - Smoothing of surface visualizations	(30 min.)
Direct Volume Visualization - Ray casting and texture-based approaches - Projection methods	(30 min.)
3D Vessel Visualization	(30 min.)
Virtual Endoscopy	(30 min.)
Virtual and Augmented Reality	(20 min.)
Medical Training and Surgical Planning	(20 min.)

Medical Training

Medical Training

- Increasing demand on (advanced) training in medicine
- Trend towards computer-aided learning and training systems
  - Browsing- und presentation systems (z.B. *VoxelMan)*
  - Interactive courses *(*z.B. *Campus)*
  - Web-based platforms (z.B. *webop*)
  - Surgical simulators (z.B. *Lap Mentor)*



***Campus*: web-based, interactive course, http://www.medicase.de/**

***Webop*: web platform for surgical education, http://www.webop.de/**

Laparoscopy simulator *Lap Mentor*, http://www.simbionix.com

LiverSurgeryTrainer (LST)

- SOMIT-FUSION: „Schonendes Operieren mit innovativer Technik“
- Teilprojekt: „Training computergestützer Operationsplanung in der Leberchirurgie“

- Conception of the *LiverSurgeryTrainer* based on learning theory:
  - Training of therapeutic decision making and planning for oncological interventions and living donor liver donations
  - Introduction to computer-aided surgery planning
  - Publication of new therapeutic and planning strategies

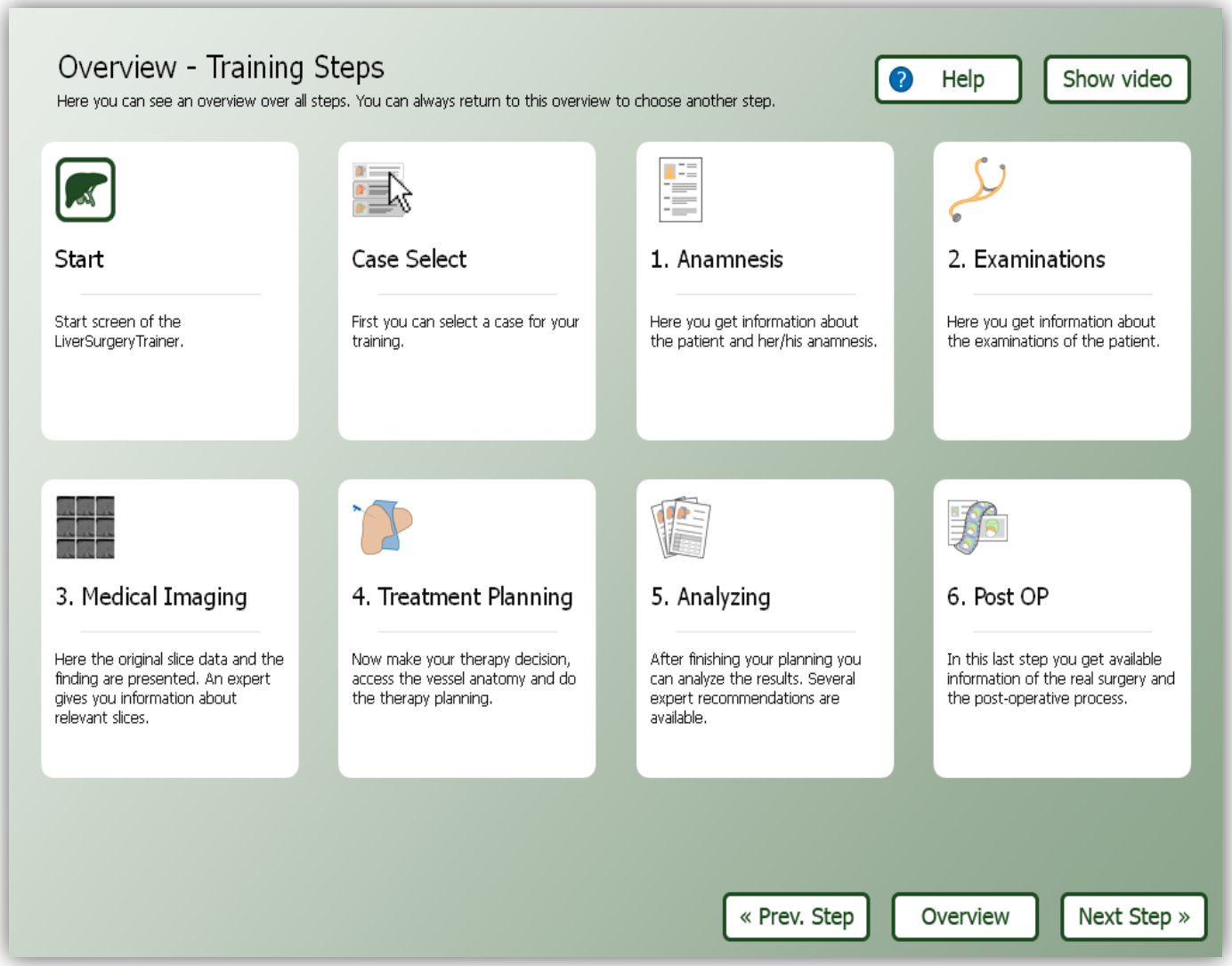
Didactical Background

- Specific complex cognitive skills (Pilots, Physicians,…)
- Learning modell for communication of instructional knowledge
- Four-Component-Instruction Design-Model [Merriënboer et al. 2002]

- Properties of the model:
  - Supportive information
    - **E.g., theoretical basics, case information**
  - Just-in-time information
    - **E.g., z.B. different levels of support**
  - Learning tasks
    - **E.g., extended right-sided resection**
  - Part-task practice
    - **E.g., resection of dummy objects**

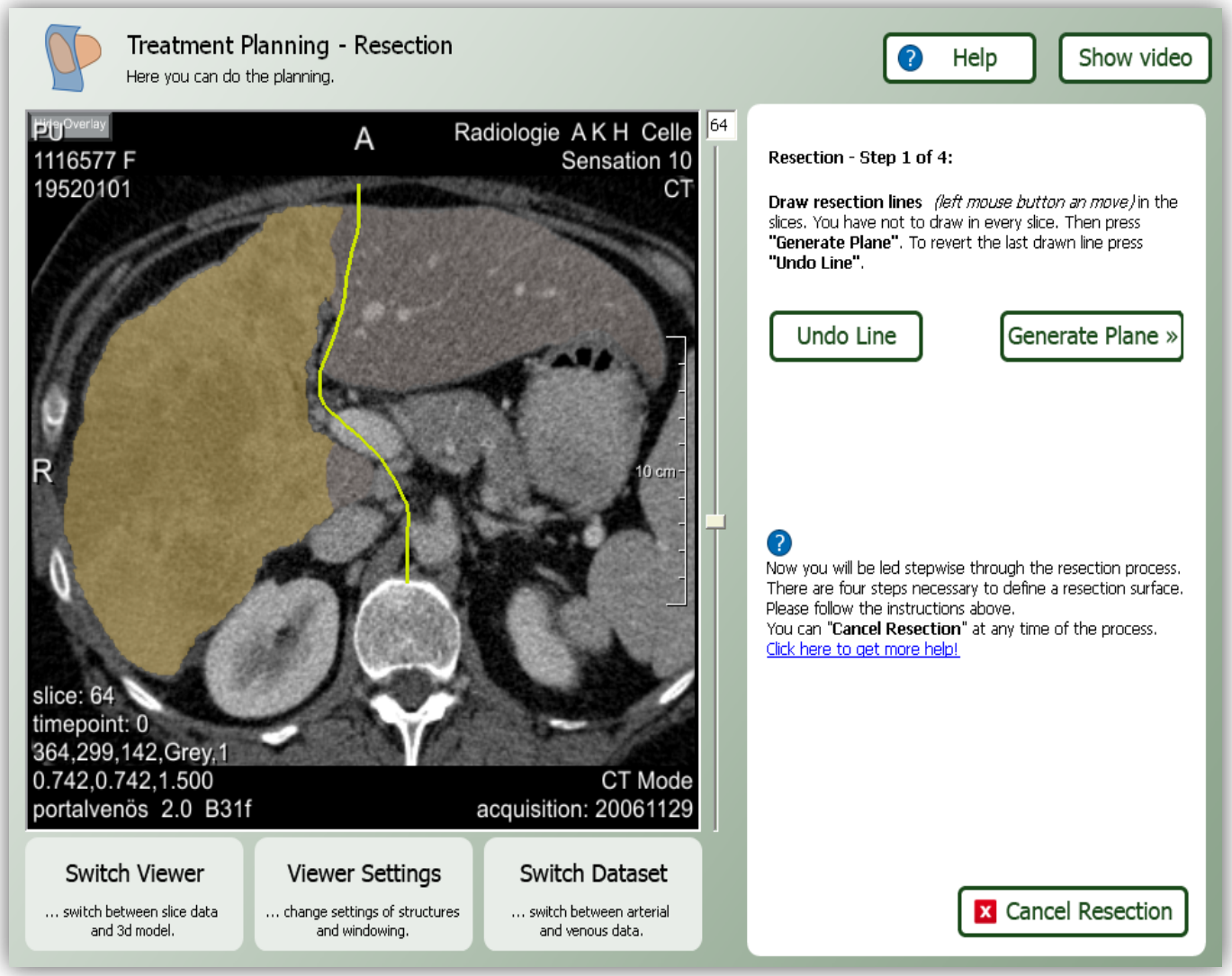
Welcome Screen

- Overview of all steps



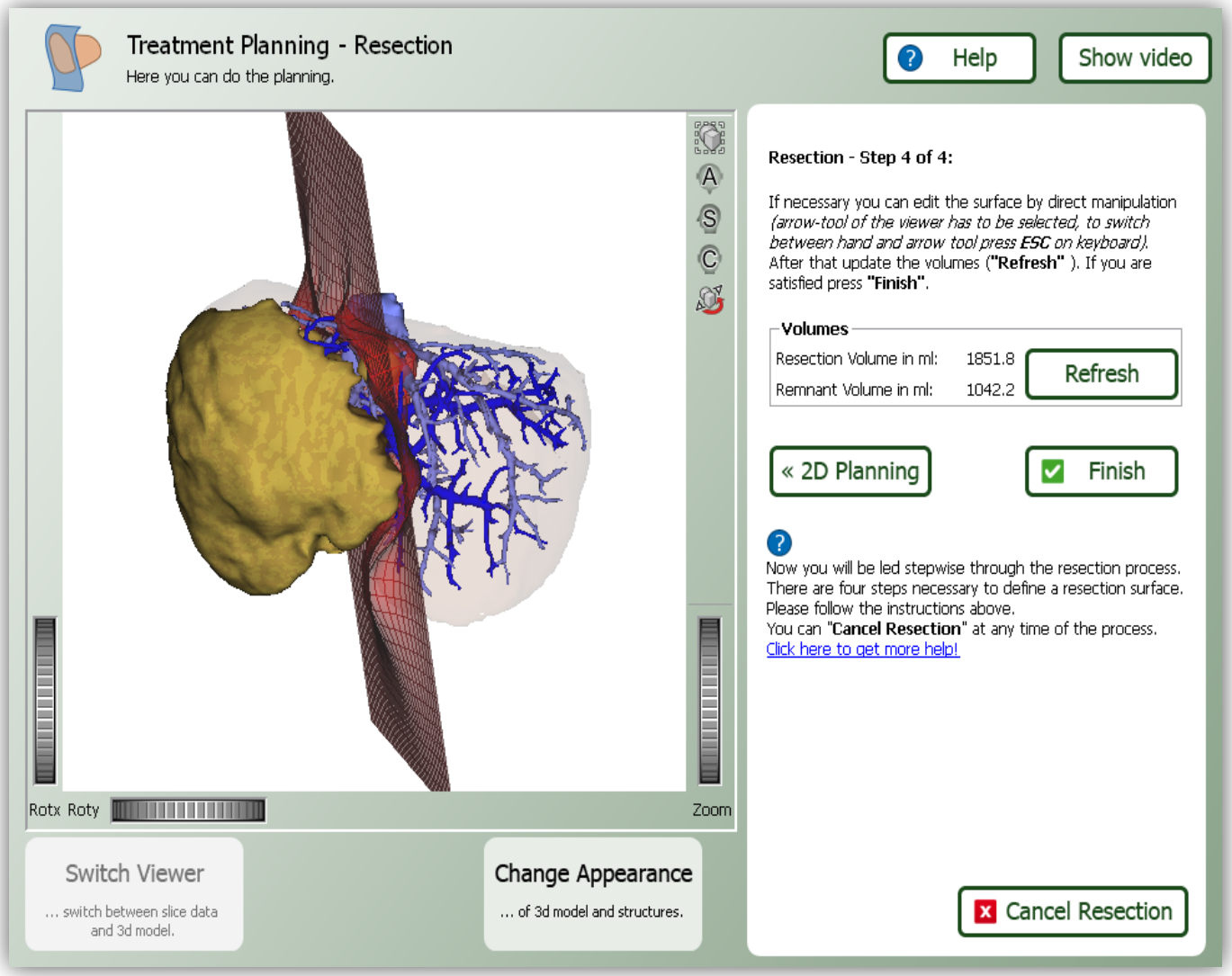
Resection Plane

- Examine vasculature and define resection plane in 2D



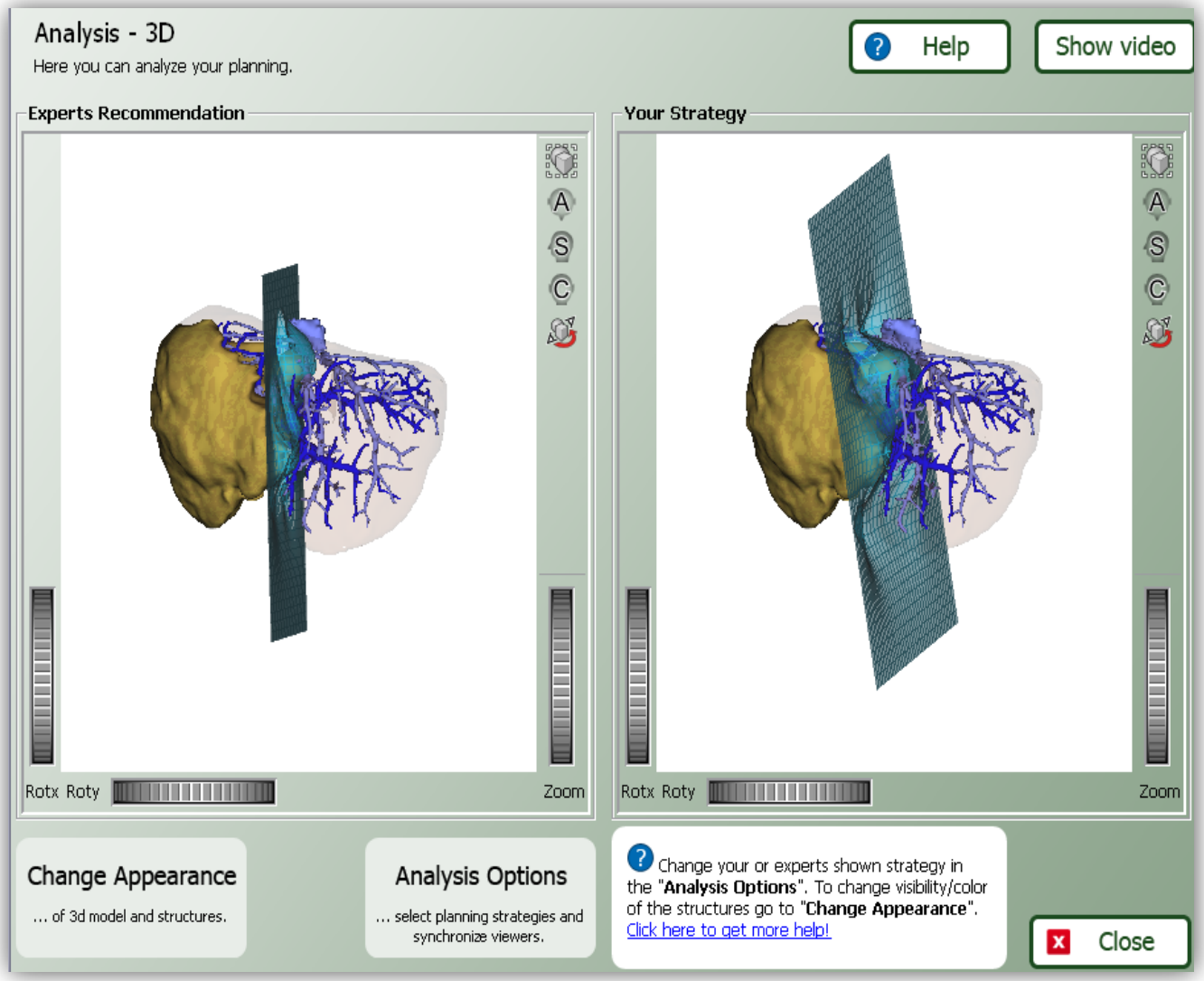
Resection Result

- View the resection result in 3D and refine if necessary in 2D/3D



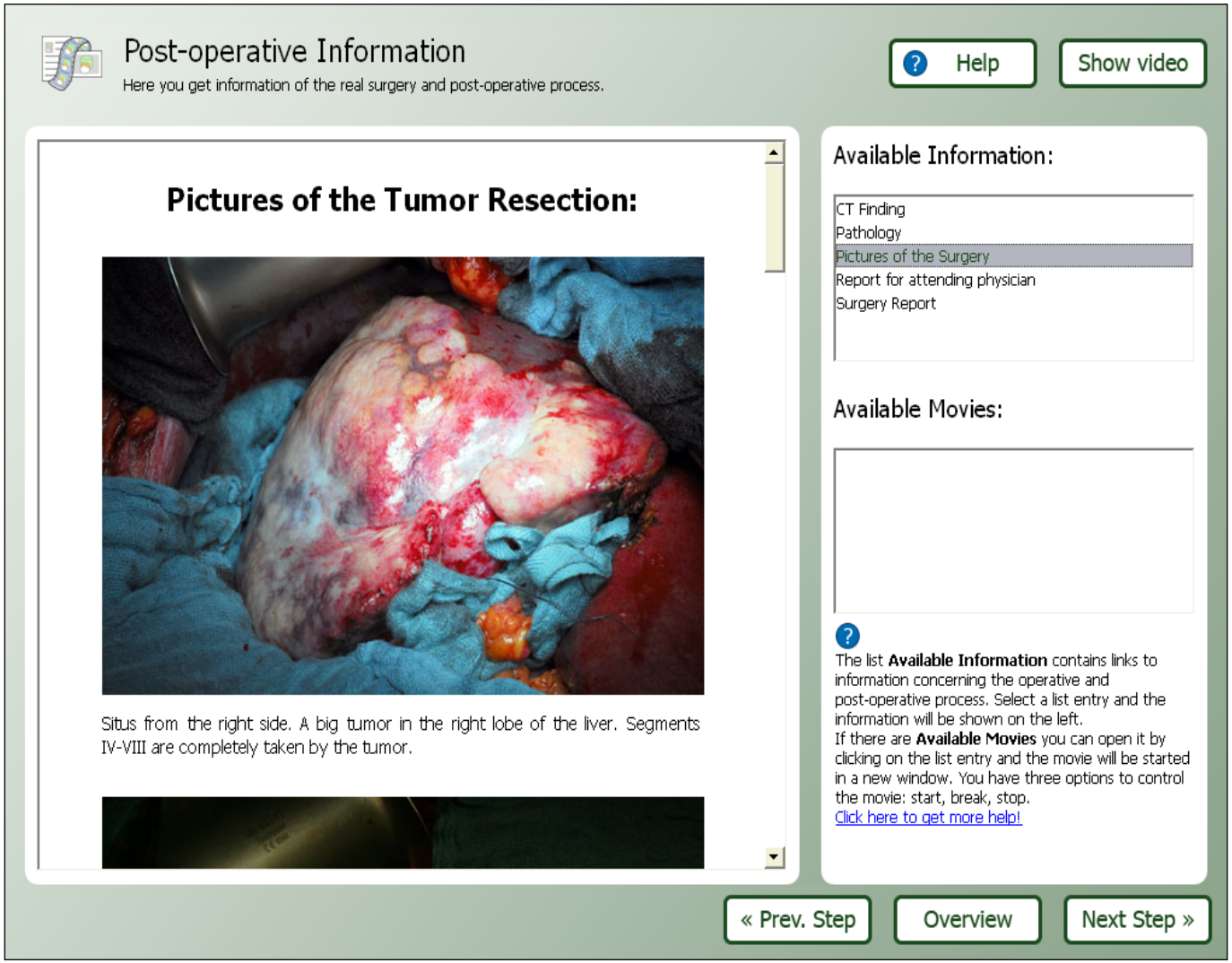
Resection Assessment

- Compare the recommendation of an expert with your strategy



Additional Information

- View media of the real surgery and the post-operative process



Evaluation

- Formative evaluation in spring 2007 [Cordes2007]
- Invitation of 32 surgeons world-wide
- Supply of a DVD including extensive material for self-study
- 2 cases (tumor resection and living donor liver transplantation)
- Online questionnaires for evaluation
- Return rate: 13 questionnaires
- Consistently positive feedback but wishes for:
  - A more clearly arranged user interface
  - Increased performance
  - A simplified resection strategy for beginners
- Summative evaluation is pending

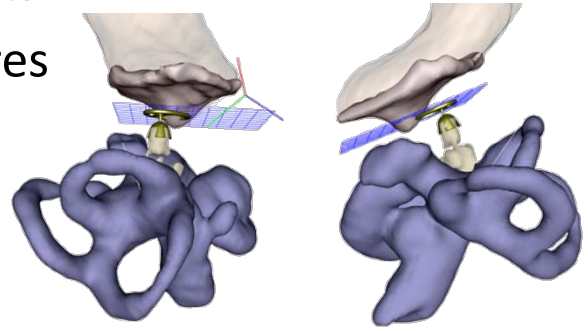
http://www.liversurgerytrainer.de/

Surgical Planning

Surgical Planning

- Part of treatment planning process

- (Visualization) goals:
  - Risk assessment
  - Estimate size, location, regional distribution of pathologies
  - Determine regional anatomy, e.g., rare variants
  - Measurements, e.g., distances to risk structures
  - Access planning, e.g., in thorax surgery
  - Implant placement
  - Integration of functional simulations



- Success criterion for a planning system:
  - Influence on treatment decisions, in particular on the surgical strategy

NeckSurgeryPlanner (NSP)

- Support of ear nose throat (ENT) surgery
- Major application fields:
  - Tumors in the throat, mouth, nose, and ear region
  - Neck dissections (removal of pathologic lymph nodes)
- Integration of techniques for segmenting important structures, e.g., the tumor, lymph nodes, blood vessels, muscles [Cordes2006]
- Integration of dedicated visualization techniques, measurement facilities [Tietjen2010], and automated animations [Mühler2010]

- Supported by two DFG grants and one EXIST grant from BMBF
- Starting in 2004 and lasting 5 years in total

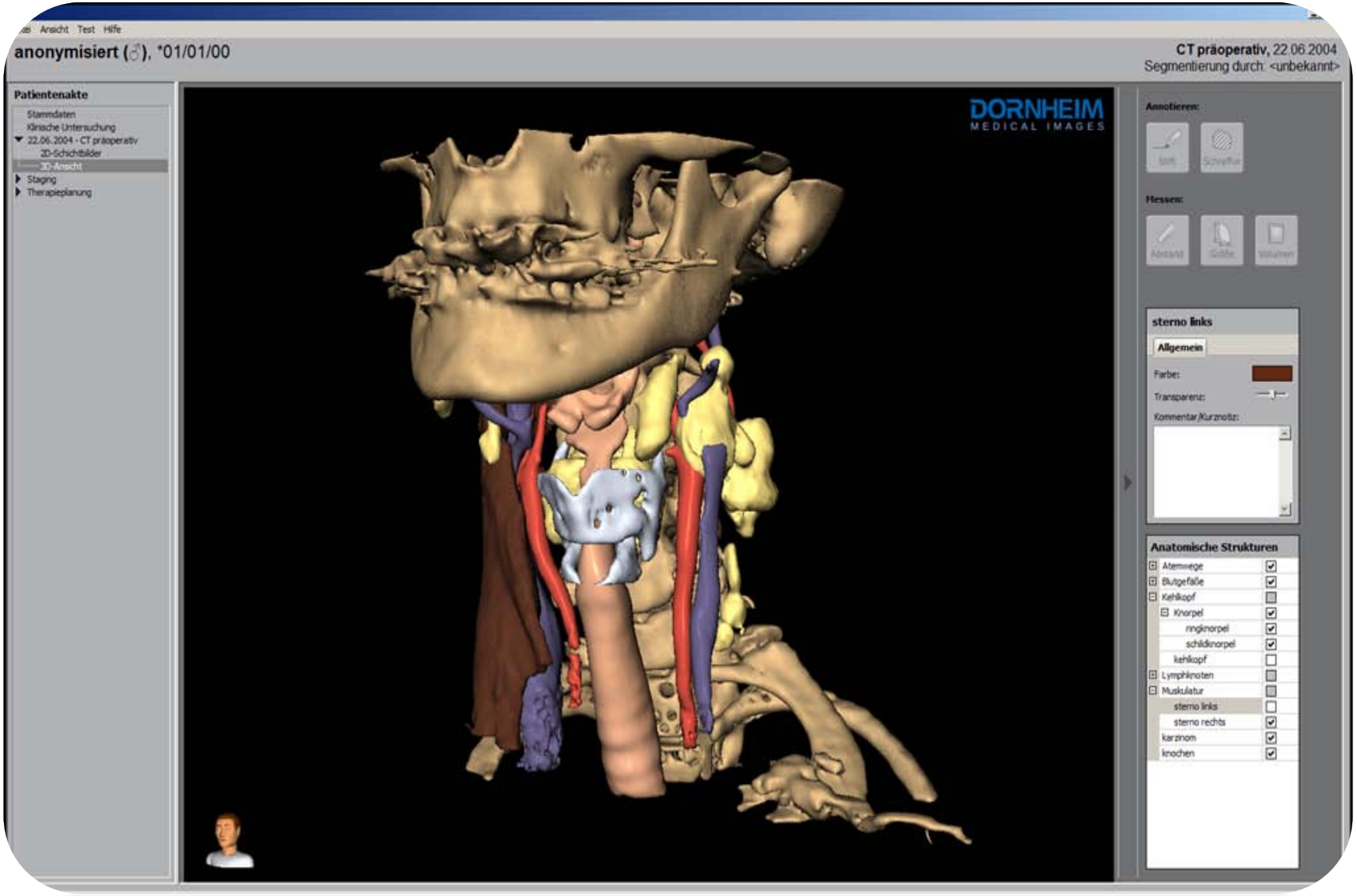
DFG Deutsche Forschungsgemeinschaft

Bundesministerium für Bildung und Forschung

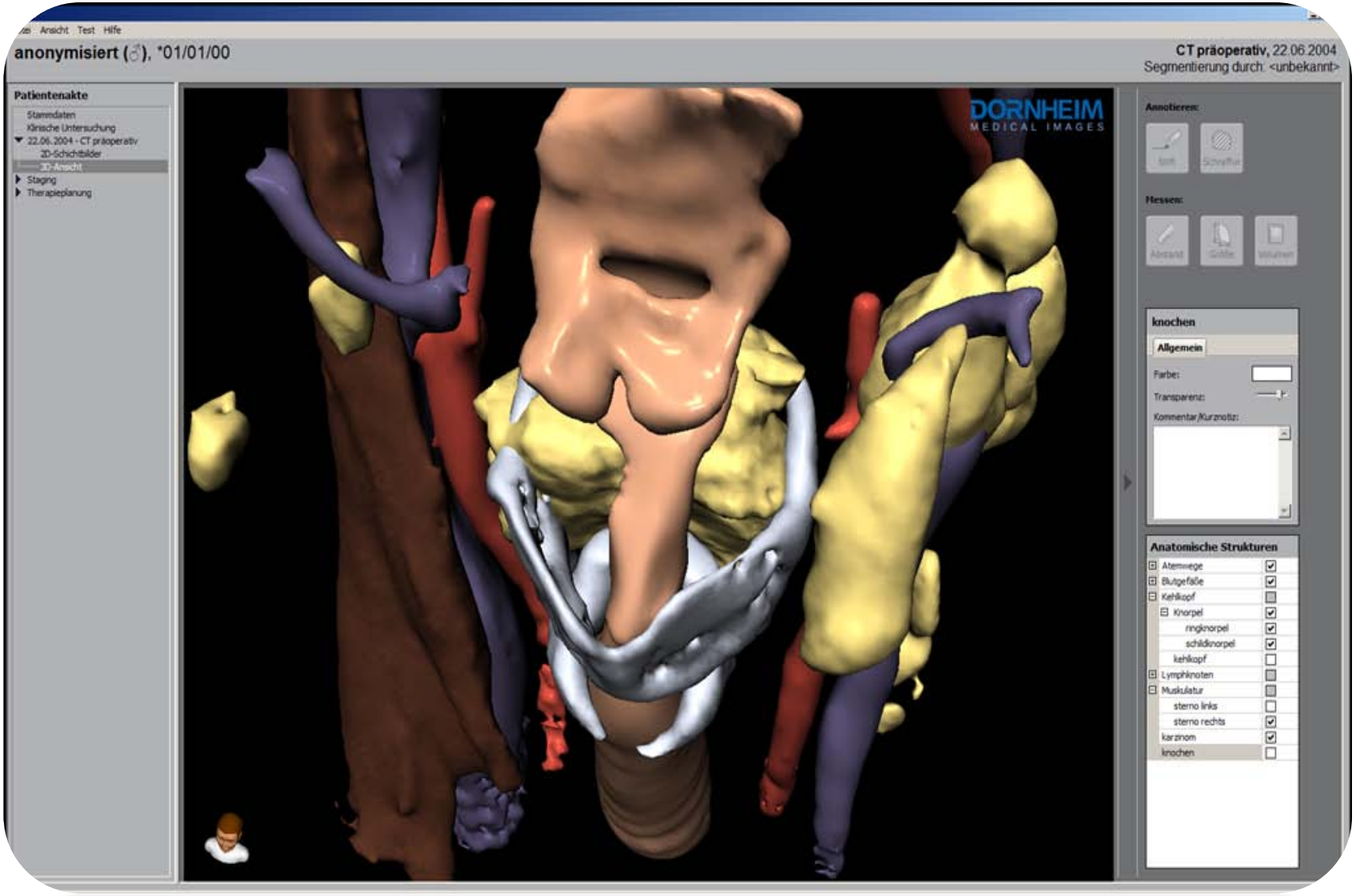
In-depth Task Analysis

- Detailed analysis of the medical workflow at the ENT department in Leipzig
- Methods:
  - Interviews, observations, small questionnaires, video and audio recording
  - Long user stories (including motivation of the stakeholders)
  - Verification of these stories with clinical users
- Results:
  - Importance of panendoscopy and its documentation
  - Integration of findings from panendoscopy with results from CT data
  - Assessment of infiltrations of anatomic structures by a tumor
  - Incorporation of measurement facilities
  - Support documentation!
  - Use of planning tools in tumorboard discussions

Patient Anatomy



Location of the Primary Tumory

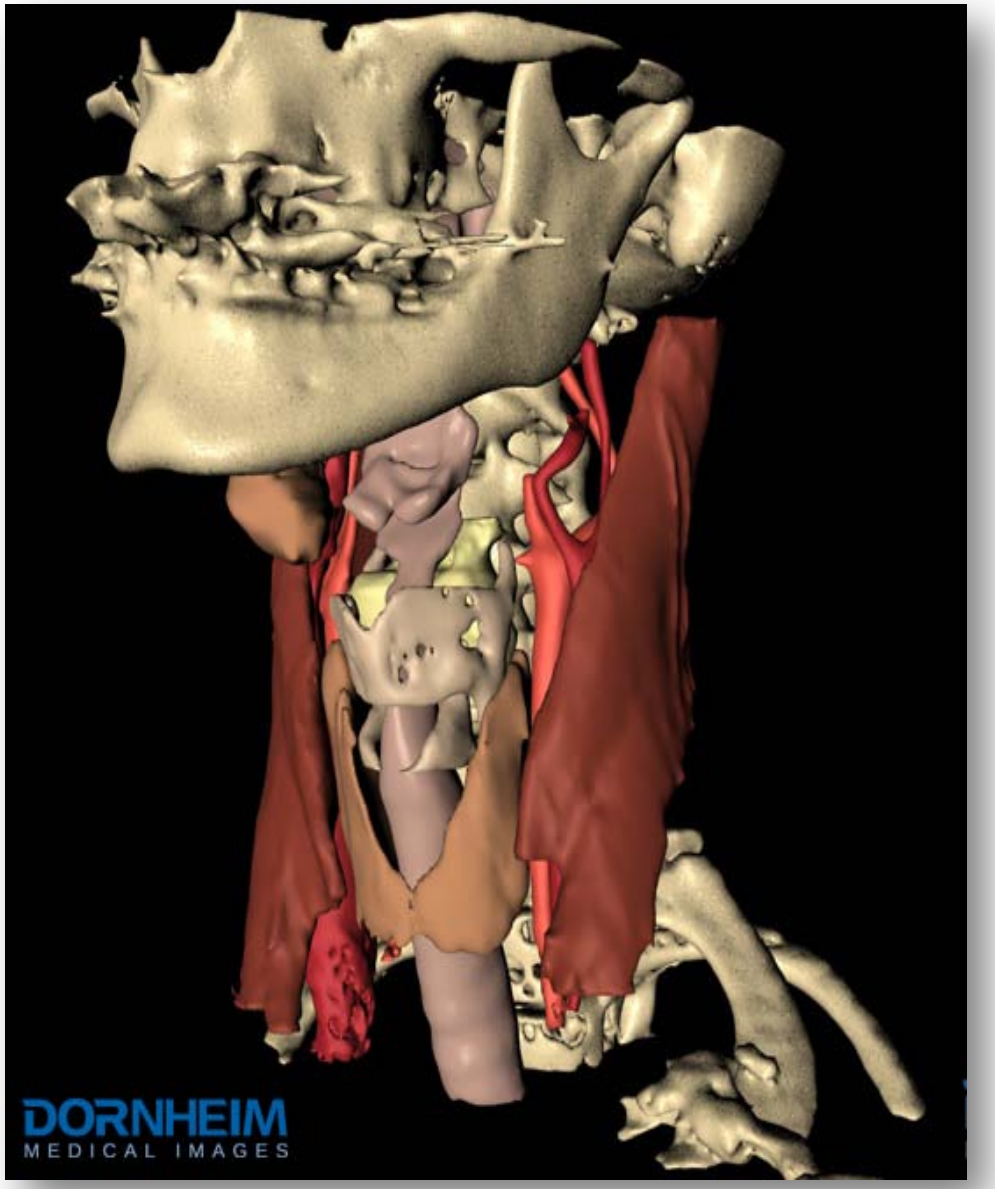


Quality of Visualizations

Different studies related to:

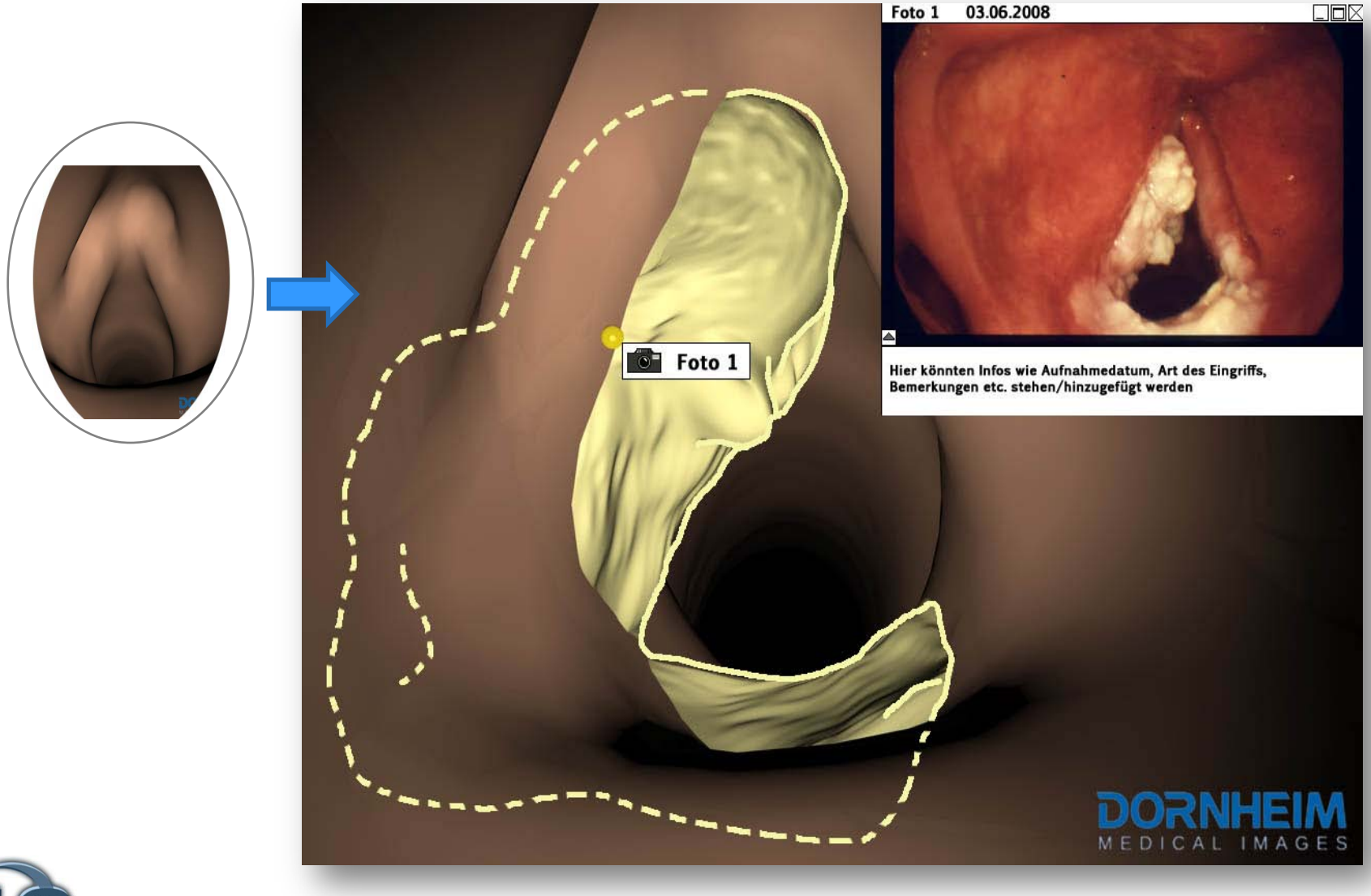
- Shininess,
- Textures,
- Illumination effects

Adapted to anatomic structures, such as bones, muscles, vessels



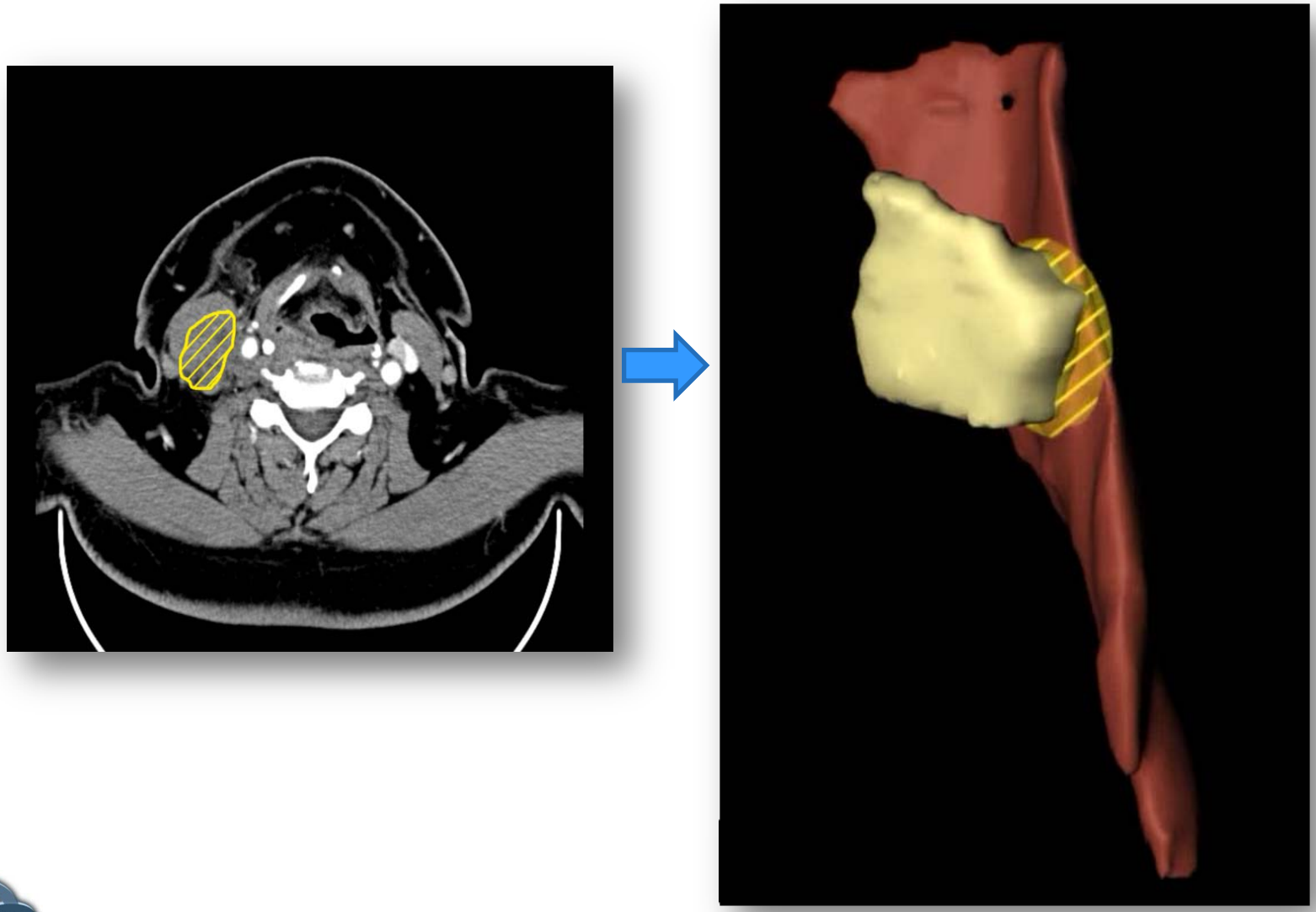
Virtual Panendoscopy

- Attach photos



Infiltrations

Sequences of simple visualizations for assessing infiltrations



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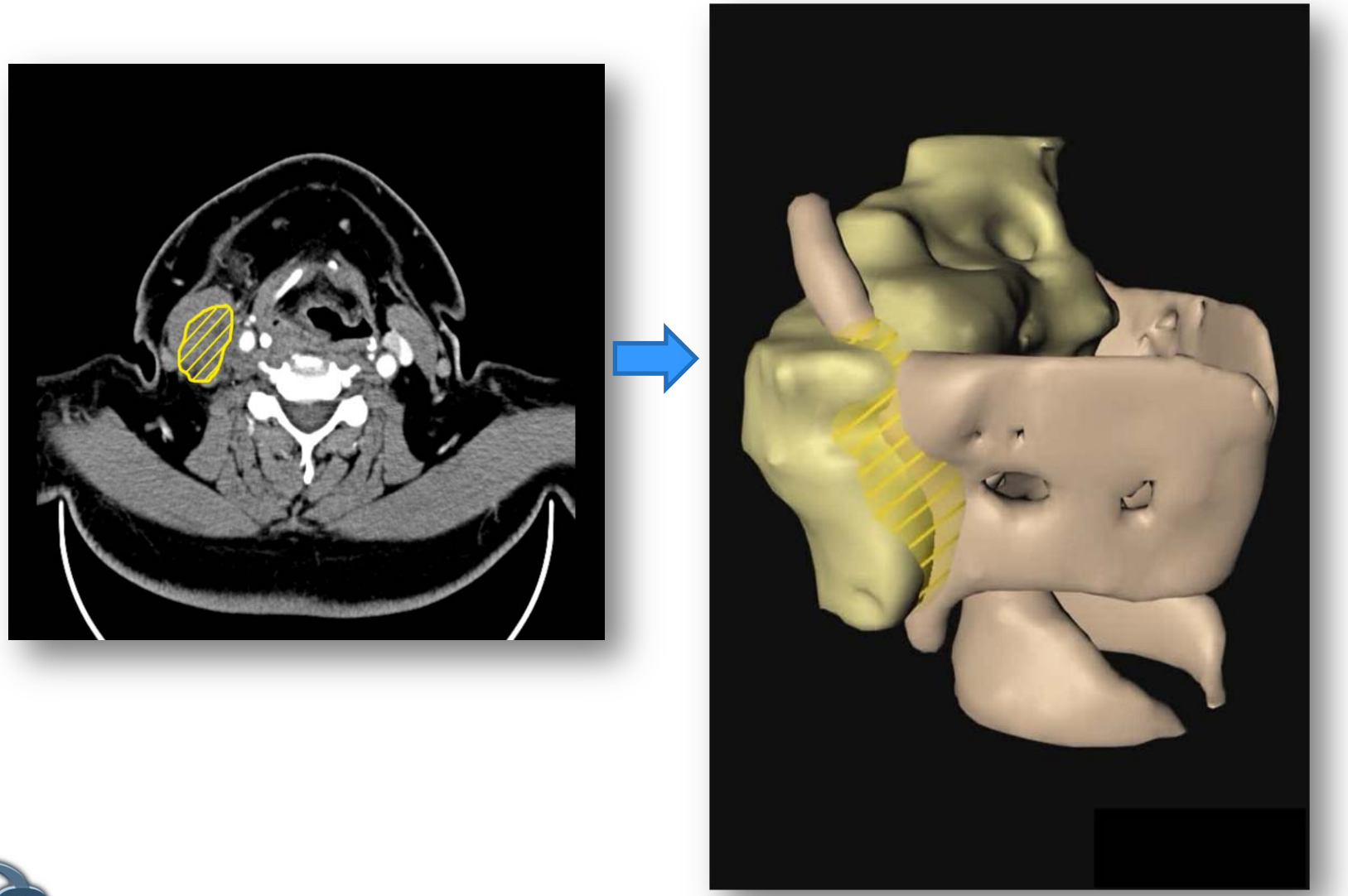
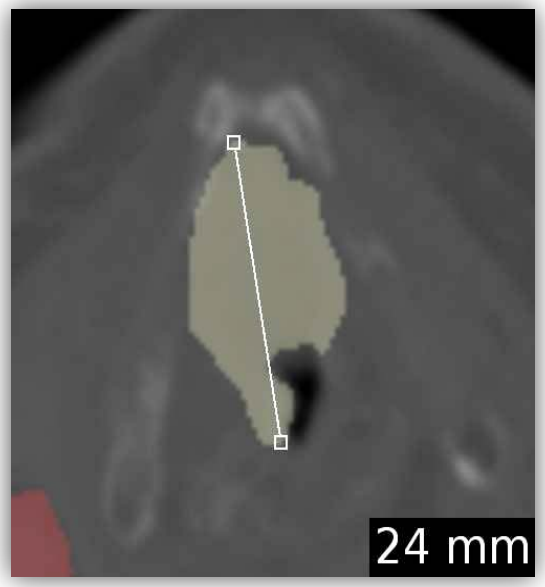
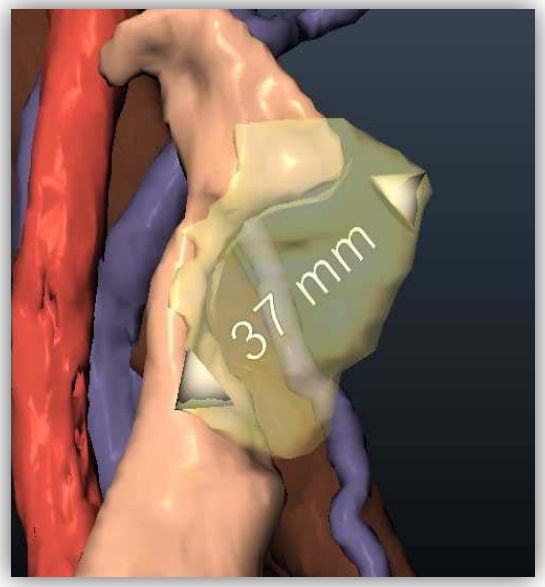
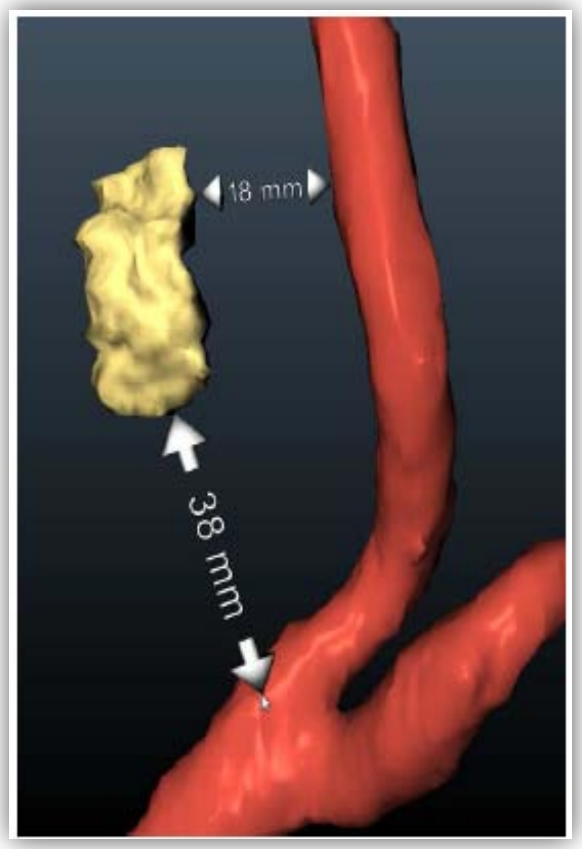


Incorporation of Measurements

Computation of extents and minimal distances to directly support tumor staging and therapeutic questions [Rössling2010]







Tumor Staging and Documentation

TNM-Klassifikation **T1N3M?** ☐

Tumor: T1 T2

Ausdehnung:41x35x19 mm
Volumen 17ml

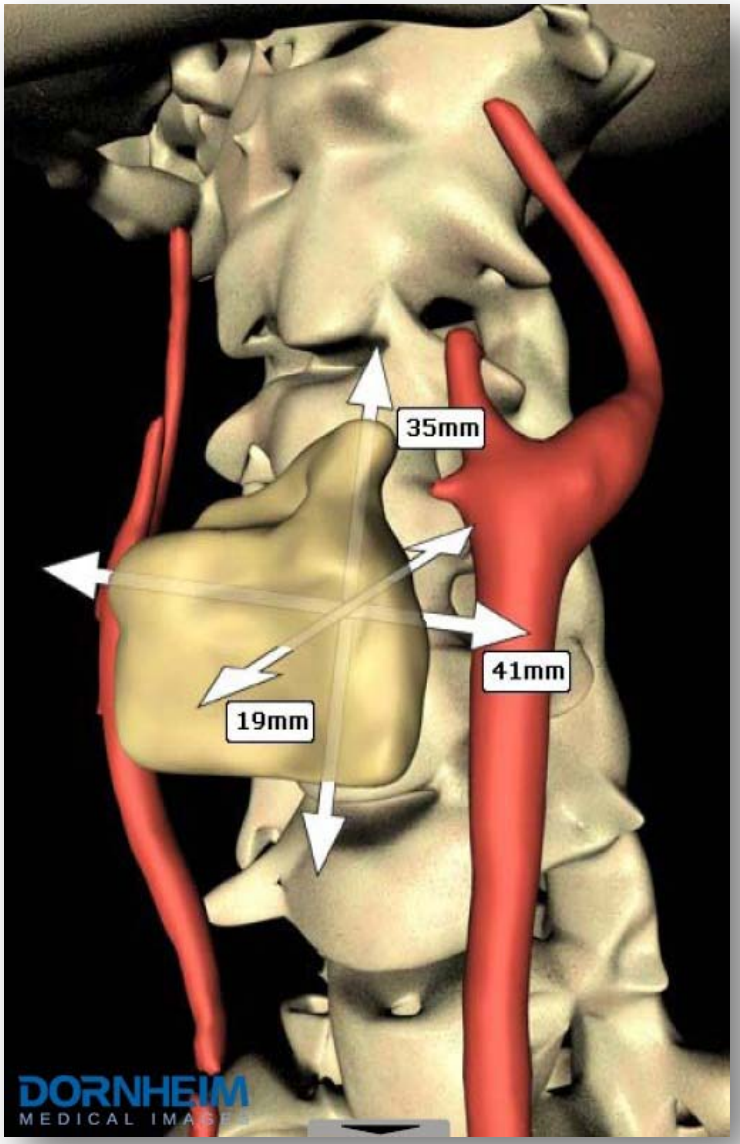
- Infiltration Schildknorpel

Nodes: N3 ☐

Node 1 > 20mm
Node 2 > 18mm
Node 3 > 24mm

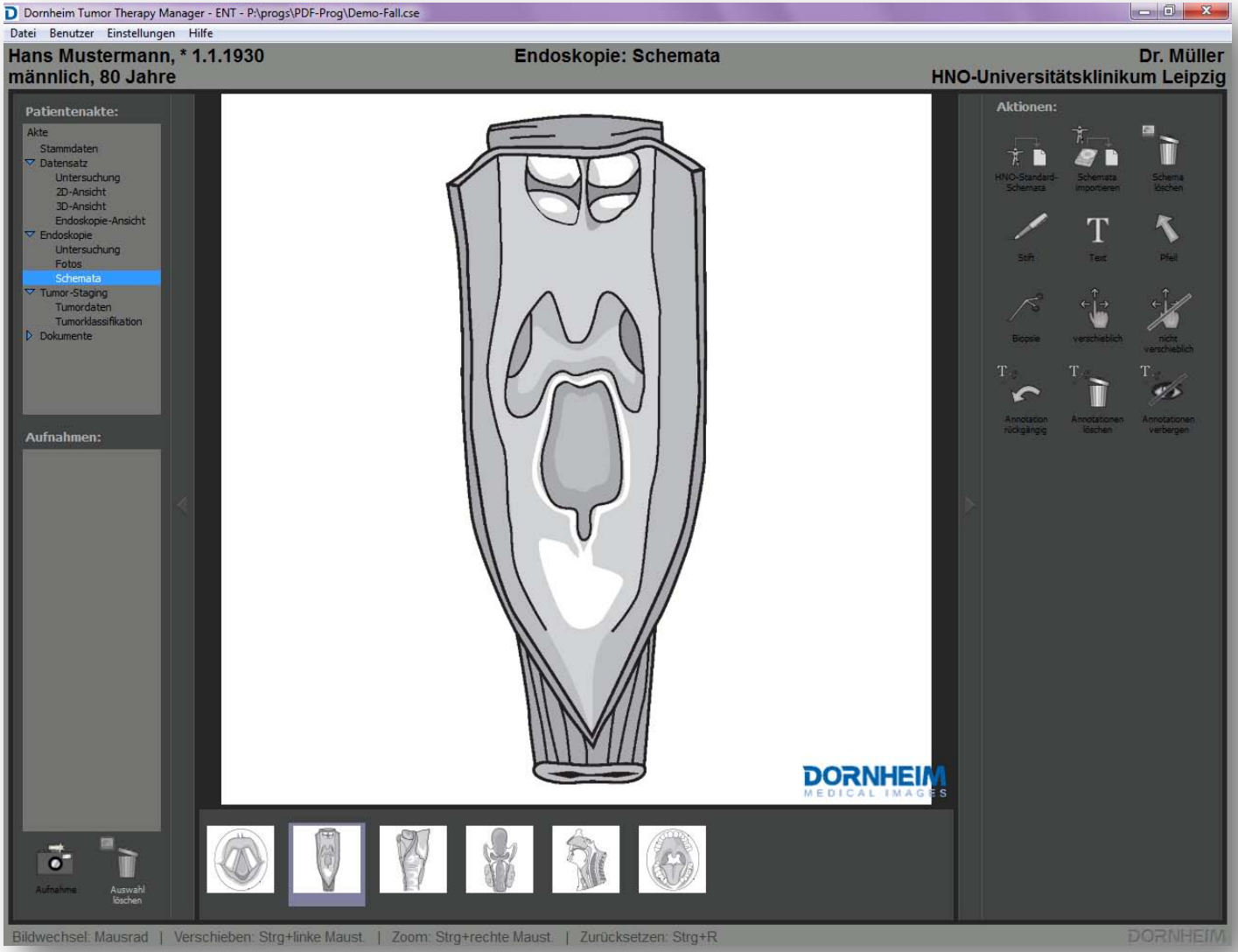
- Lymphknotenbefall nur linksseitig

Metastasen (?) ☐



Documentation

Schematic drawing of neck anatomy for (automatic) annotation



Evaluation

Planning:

- Documentation of 7 operations
- Planning first without, later with 3D-vizualization of relevant structures

Results [Fischer2009]:

- In 4/7 cases infiltration of risk structures was assessed differently (e.g. 1x infiltration of the salivary gland was detected, 1x infiltration of the salivary gland was excluded)
- Determined trust of surgeons (*Level of Trust*): 7/7 > 50%, average: 67%
- In 2/7 cases the surgical strategy was adapted
- In all 7 cases the TNM-classification suggested by the system was considered correct.

Literature

Boehm [2009]: “3D-Panendoscopy”. International Journal of Computer Assisted Radiology and Surgery.

Cordes [2006]: “Preoperative Segmentation of Neck CT Datasets for the Planning of Neck Dissections”. In: Proc. of SPIE Medical Imaging: Image Processing.

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Mühler [2010]: “Animationen und Explorationstechniken zur Unterstützung der chirurgischen Operationsplanung“. PhD thesis, University of Magdeburg.

Rössling [2010]: “Fast and flexible distance measures for treatment planning“, IJCARS.

Tietjen [2010]: “Illustrative Visualisierungstechniken zur Unterstützung der präoperativen Planung von chirurgischen Eingriffen“. PhD thesis, University of Magdeburg.