3D-printed models of the nasal cavity as extended preoperative anatomical and functional information

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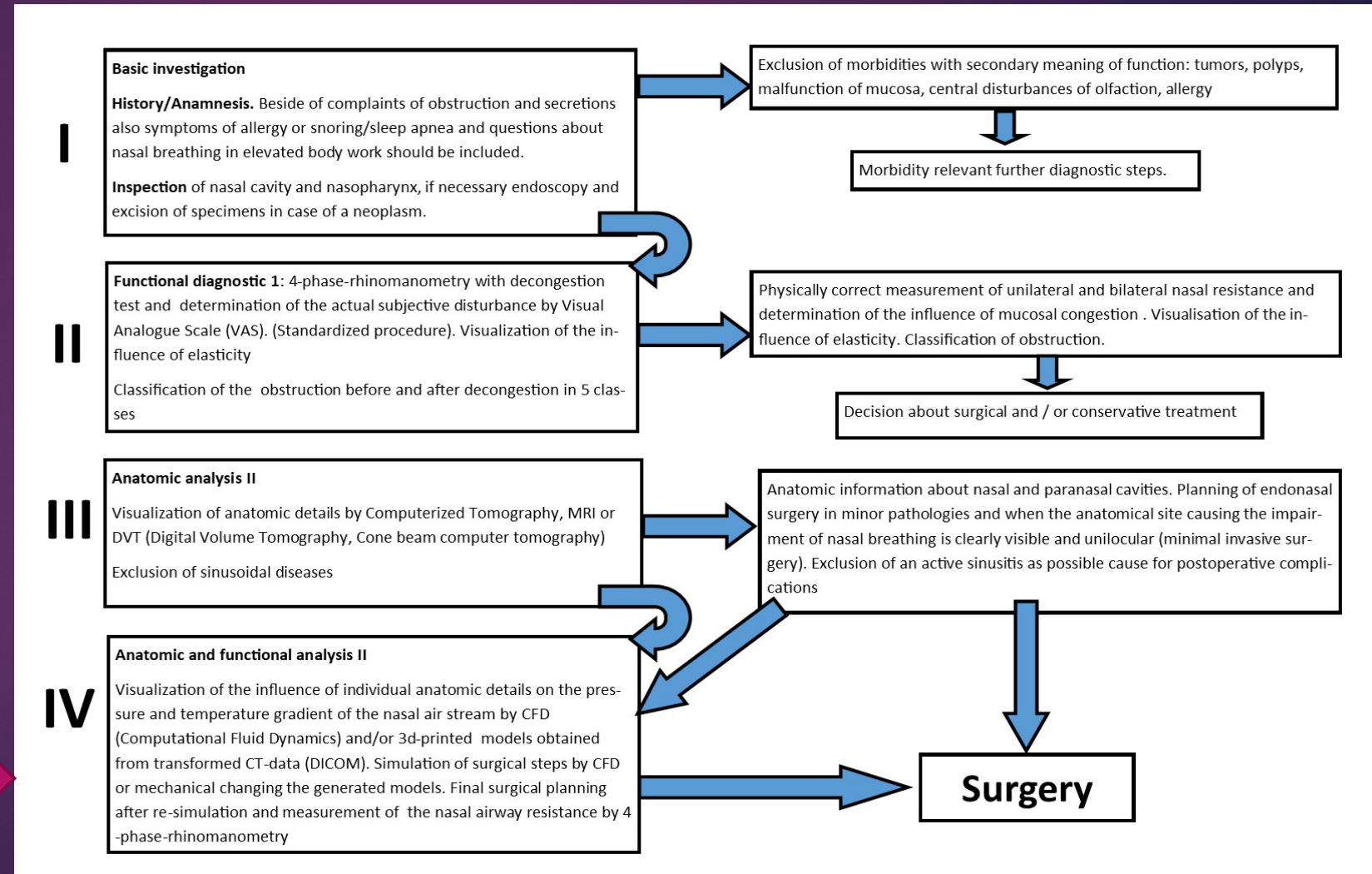The autors declare: no conflicts of interest

The aim: improving results of rhinosurgery

Missing success in functional rhinosurgery can result from

- ▶ Insufficient functional and anatomical preoperative diagnostic information
- ▶ Schematic application of surgical methods
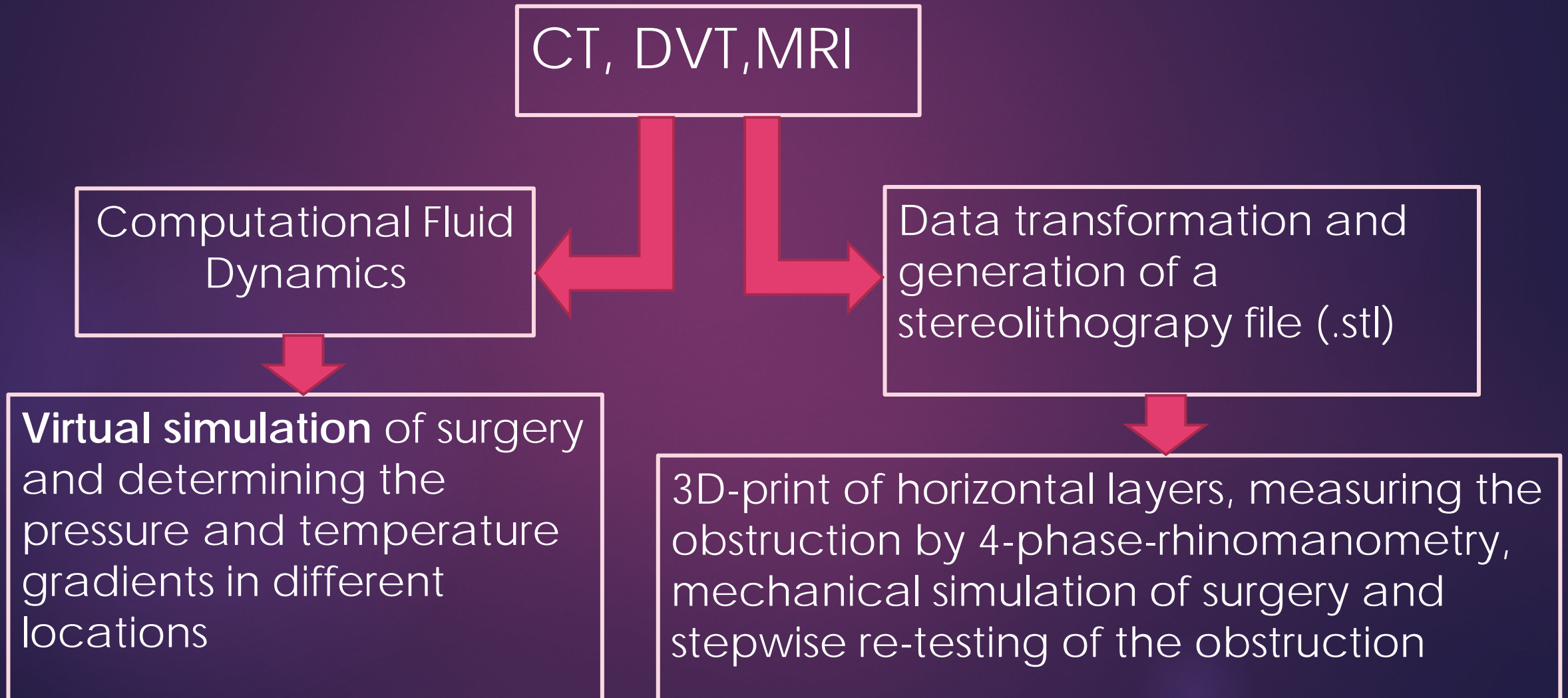- ▶ Missing experience or training of the surgeon
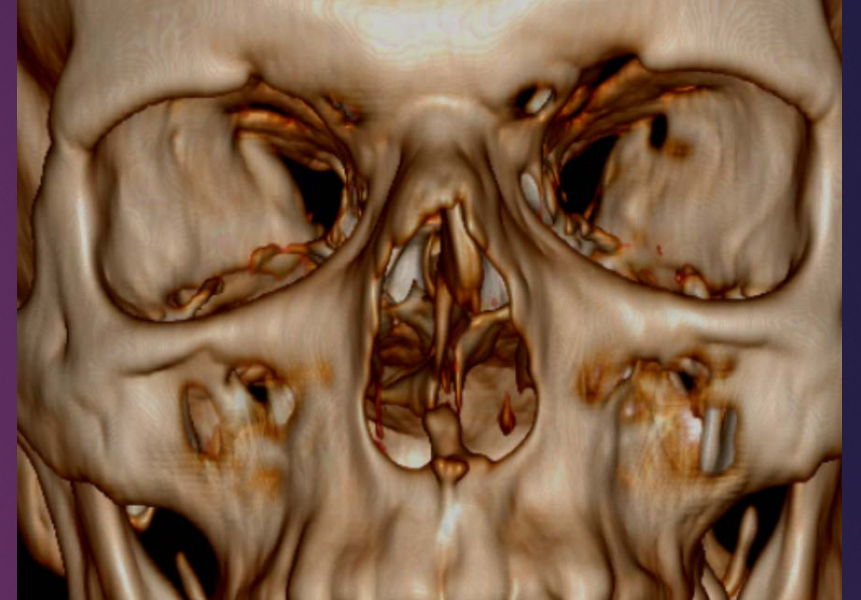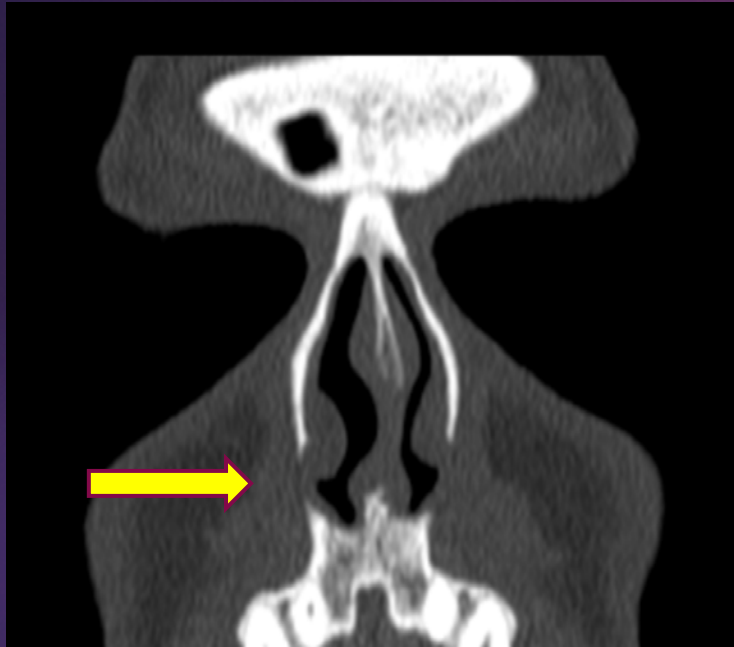
The step program of functional diagnostic

Basic investigation

I

History/Anamnesis. Beside of complaints of obstruction and secretions also symptoms of allergy or snoring/sleep apnea and questions about nasal breathing in elevated body work should be included.

Inspection of nasal cavity and nasopharynx, if necessary endoscopy and excision of specimens in case of a neoplasm.

Exclusion of morbidities with secondary meaning of function: tumors, polyps, malfunction of mucosa, central disturbances of olfaction, allergy

Morbidity relevant further diagnostic steps.

Functional diagnostic 1: 4-phase-rhinomanometry with decongestion test and determination of the actual subjective disturbance by Visual Analogue Scale (VAS). (Standardized procedure). Visualization of the influence of elasticity

II

Classification of the obstruction before and after decongestion in 5 classes

Physically correct measurement of unilateral and bilateral nasal resistance and determination of the influence of mucosal congestion . Visualisation of the influence of elasticity. Classification of obstruction.

Decision about surgical and / or conservative treatment

Anatomic analysis II

III

Visualization of anatomic details by Computerized Tomography, MRI or DVT (Digital Volume Tomography, Cone beam computer tomography)

Exclusion of sinusoidal diseases

Anatomic information about nasal and paranasal cavities. Planning of endonasal surgery in minor pathologies and when the anatomical site causing the impairment of nasal breathing is clearly visible and unilocular (minimal invasive surgery). Exclusion of an active sinusitis as possible cause for postoperative complications

Anatomic and functional analysis II

IV

Visualization of the influence of individual anatomic details on the pressure and temperature gradient of the nasal air stream by CFD (Computational Fluid Dynamics) and/or 3d-printed models obtained from transformed CT-data (DICOM). Simulation of surgical steps by CFD or mechanical changing the generated models. Final surgical planning after re-simulation and measurement of the nasal airway resistance by 4-phase-rhinomanometry

Surgery

2 ways to simulate the functional effect of intended surgical steps

CT, DVT, MRI

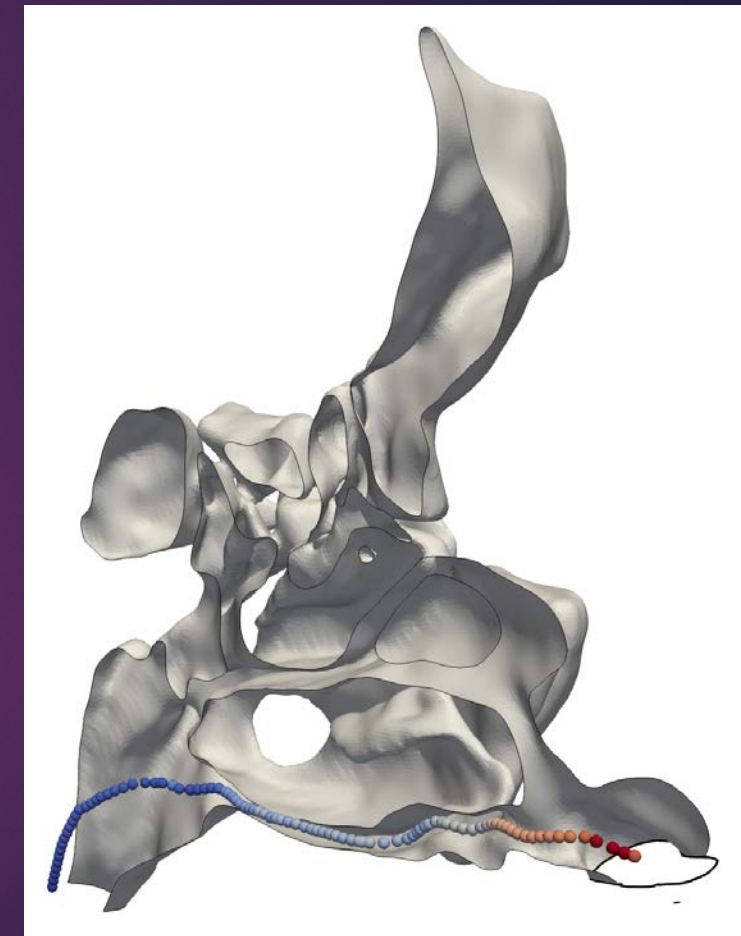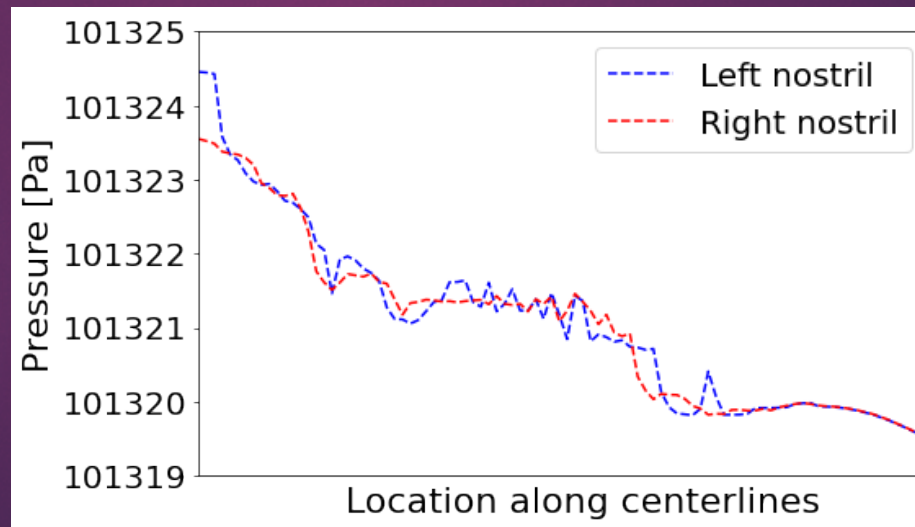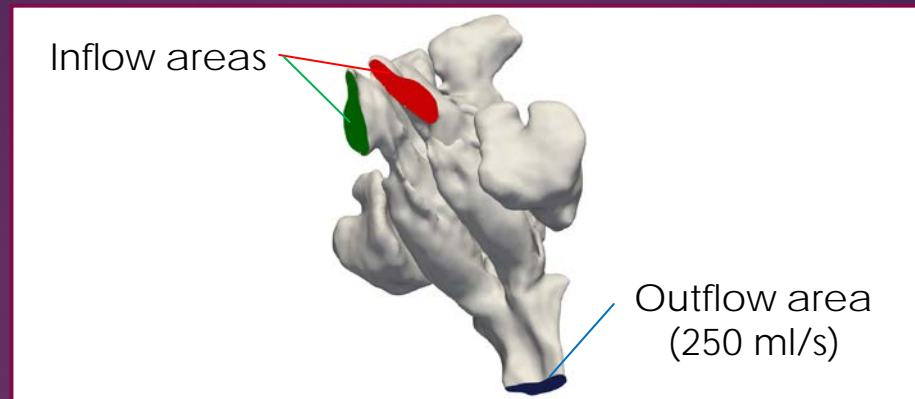Computational Fluid Dynamics

Data transformation and generation of a stereolithograpy file (.stl)

Virtual simulation of surgery and determining the pressure and temperature gradients in different locations

3D-print of horizontal layers, measuring the obstruction by 4-phase-rhinomanometry, mechanical simulation of surgery and stepwise re-testing of the obstruction

CT or DVT

▶ Sufficient information about variations in anterior –posterior direction and about paranasal sinuses

▶ Limited information for planning of surgical steps in complicated anatomy in vertical direction

CFD analysis: area-averaged pressure

Flow entering right nostril
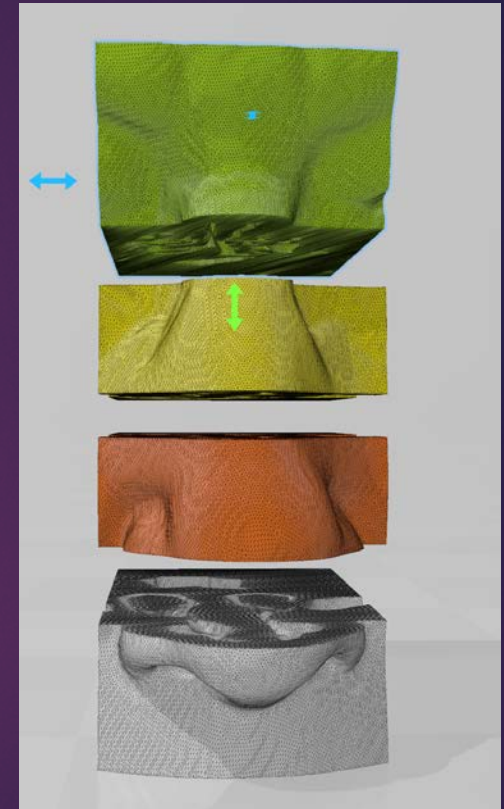
Flow entering left nostril
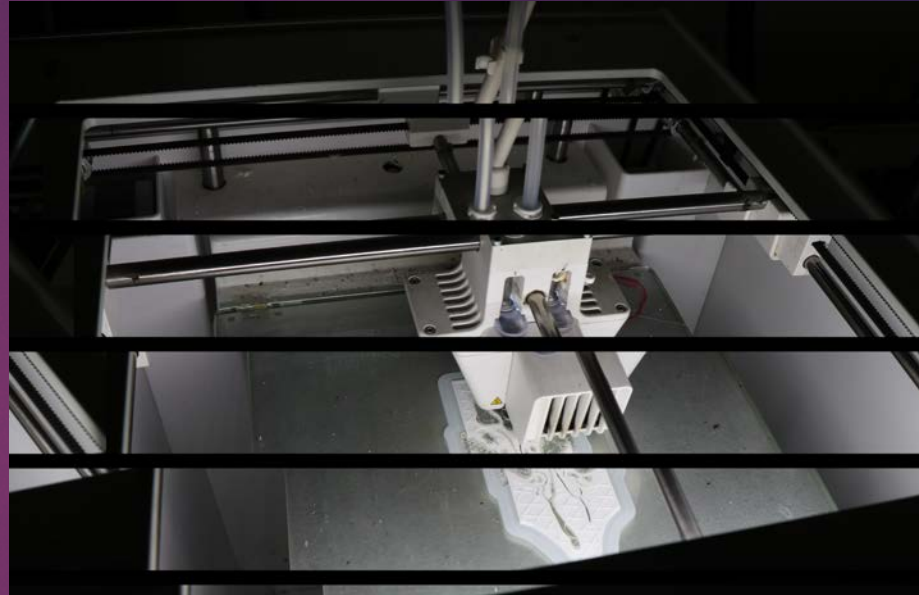
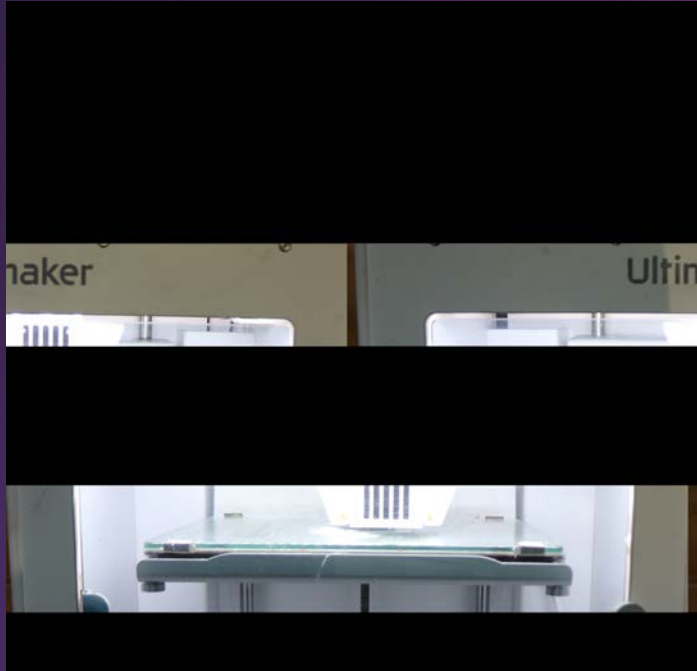# Workflow of 3-D-Printing
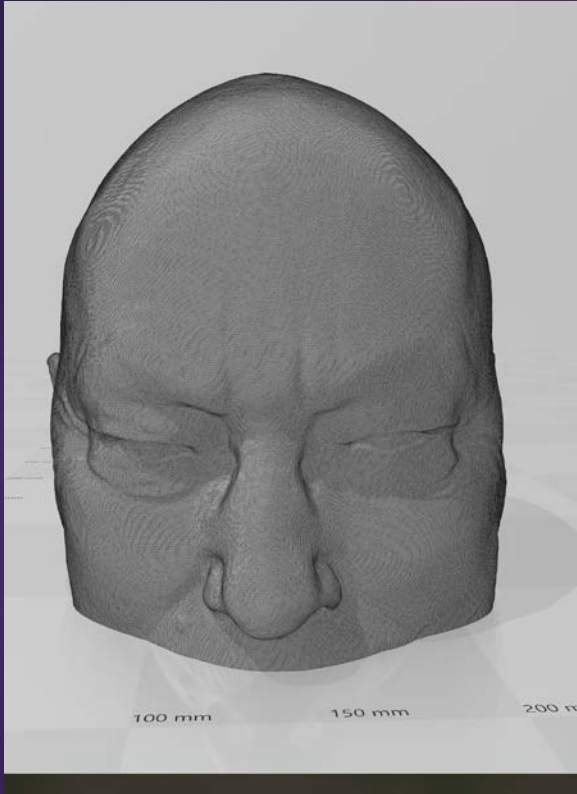
1. Import of stl-data
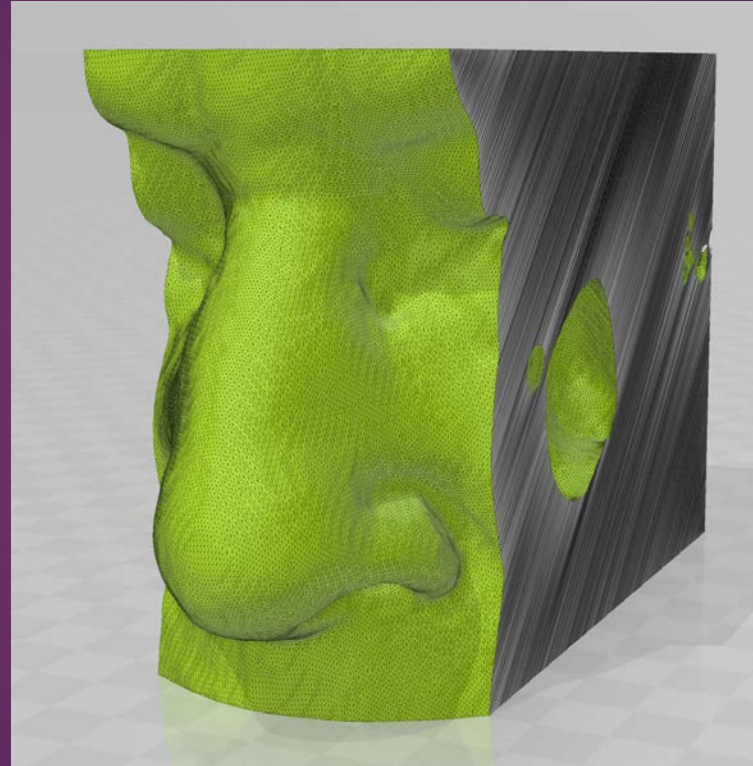
2. Selection of region of interest

3. Slicing by 4 horizontal cuts

3D-Printing: experiences

- Printing by 2 channels with support material recommended
- Test material for later grinding, cutting: thermoplastic materials!
- Use compact material (Tough PLA, CPE + or similar) better then elastic

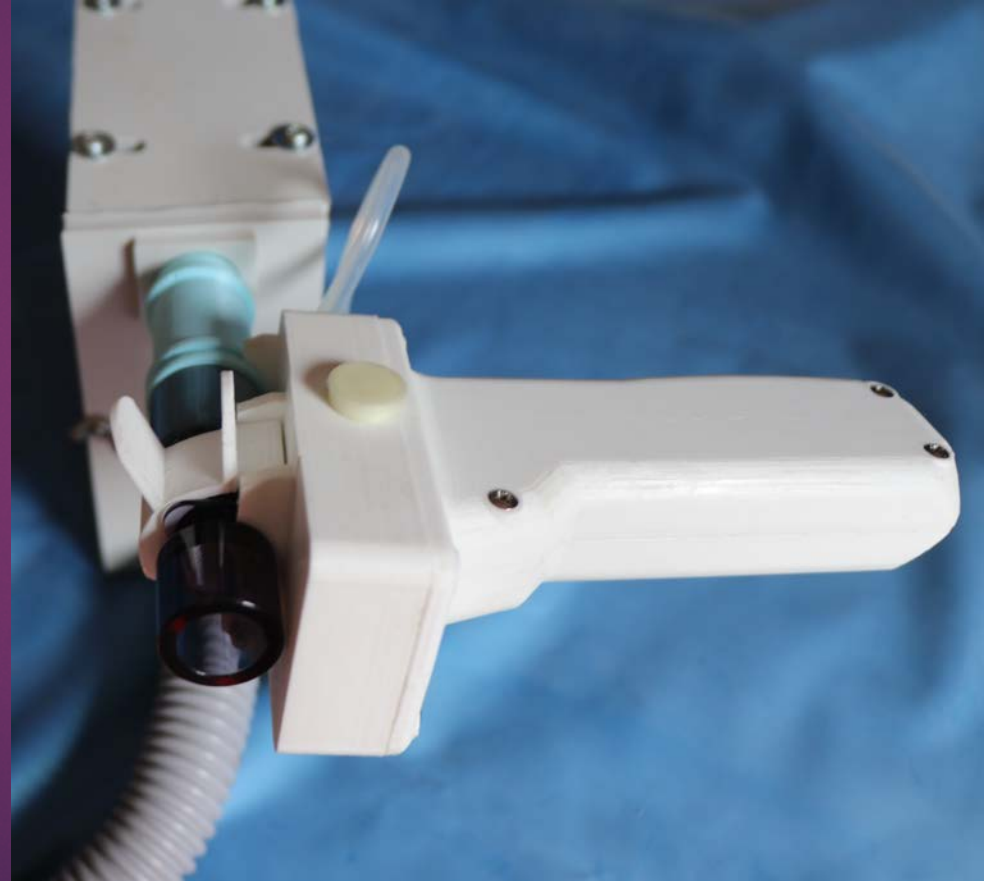# Example: multiple stenoses of the nasal channel

Preparing rhinomanometric control of simulated „surgical" steps

Encasing in a normative housing

Measuring log. Resistances by 4PR2

First and expected results

1. Additional information obtained from CT/MRI
2. Planning of surgical steps in difficult cases, if there is no agreement with the optical impression and the dgree of impairment of nasal resistance
3. Individually adapted surgery instead of „textbook methods"
4. High didactic effect for beginners in surgery

Get a personal impression at the booth of RHINODIAGNOST!

Thank you!