

Functional respiratory imaging-aided virtual preoperative planning in nasal surgery: towards a personalized approach

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Introduction and Aim: Objective outcomes of functional nasal surgery are difficult to assess. Currently available objective measures, such as acoustic rhinometry and rhinomanometry have several shortcomings and do not allow for preoperative surgical planning. The use of functional respiratory imaging (FRI) in rhinology is a novel concept. FRI is a combination of advanced 3D model reconstruction from medical imaging that is updated with computational fluid dynamics (CFD) in order to obtain objective measures of nasal airway dimensions combined with the subsequent physiology of the patient specific nasal airflow. It also enables surgeons to preoperatively perform virtual surgery and to assess the unique influence of the different components of nasal airway surgery. In this study we evaluate the feasibility of FRI-based pre-operative planning of functional nasal airway surgery.

Material and Methods: Pre- and postoperative 3D nasal airway models were created based on cone beam computed tomographic images in a 55 year old man that underwent functional rhinoplasty including, septoplasty and nasal valve repair for symptoms of nasal obstruction. Virtual surgery of the preoperative 3D model was performed. The virtual surgery consisted out of a straightening of the septum and the ethmoid bone. Furthermore also the nasal bone was straightened and spreader grafts were inserted for a widening of the nasal valve. Lastly a reduction of the inferior turbinate was also performed. CFD calculations of nasal airflow, airflow distribution, and nasal airway resistance were performed in the pre-operative model, the model with virtual surgery and the post-operative model.

Results: When analyzing the effects of the virtual surgery we found a reduction of nasal resistance in both the nasal vestibule and the respiratory region. Also, a more homogenous distribution of airflow between the left and right side was observed. The post-operative nasal model demonstrated similar results.

Conclusions: This preliminary study demonstrates that FRI-aided virtual surgery may be useful in preoperative computation of functional outcomes of nasal surgery. It has the potential to allow surgeons to perform personalized nasal surgery using preoperative

virtually simulated models. Development of automated and less labor-intensive FRI-aided virtual surgery models should facilitate surgeons to implement this tool in an outpatient clinical setting.