Supplementary Online Content

Vanhille DL, Garcia GJM, Asan O, et al. Virtual surgery for the nasal airway: a preliminary report on decision support and technology acceptance. *JAMA Facial Plast Surg*. Published online October 12, 2017. doi:10.1001/jamafacial.2017.1554

This supplementary material has been provided by the authors to give readers additional information about their work.

ONLINE-ONLY SUPPLEMENT

Creation of Three-Dimensional Models and Virtual Surgery

A pre-surgery CT scan of one NAO patient was obtained with 0.6 mm slice thickness and a pixel size of 0.31mm x 0.31mm. Three-dimensional digital models of the nasal passages (excluding paranasal sinuses) were created in Mimics 16.0 (Materialise Inc., Plymouth, Michigan) using a range of -1024 to -300 Hounsfield units to segment the airspace. Models were exported in STL format and imported into ICEM-CFD 14.0 (ANSYS, Inc., Canonsburg, Pennsylvania), where planar nostrils and outlet surfaces were created and the geometry was meshed with approximately 4 million tetrahedral cells. Virtual surgery models were created to reproduce inferior turbinate reduction, septoplasty, and/or various combinations of these procedures. The seven possible surgical combinations are septoplasty, left inferior turbinate reduction, right inferior turbinate reduction, bilateral inferior turbinate reduction, septoplasty with left inferior turbinate reduction, septoplasty with right inferior turbinate reduction, and septoplasty with bilateral inferior turbinate reduction (**Figure S2**).

CFD Simulations

Our CFD modeling methods have been described in detail elsewhere.[23,24,34] Steady-state inspiratory laminar airflow simulations were conducted in Fluent 14.0 (ANSYS, Inc.) with the following boundary conditions: (1) air velocity set to zero at stationary walls, (2) pressure inlet at the nostrils with gauge pressure set to zero, and (3) a constant pressure at the outlet. The outlet pressure was different in each model; its value was such that a constant transnasal pressure drop (17.4 Pa from nostrils to choana) was applied in all models. In other words, inhalation rates were different in each model, but the same pressure drop was used in pre-surgery and virtual surgery models. The outlet pressure required to obtain a pressure of -17.4 Pa at the choana was estimated by running preliminary simulations to quantify the relationship between outlet pressure and choana pressure. The transnasal pressure drop of 17.4 Pa was selected because it provided a flowrate of 15 L/min (typical breathing rate in an adult at rest) in a CFD model based on the patient's actual post-surgery CT scan.[23] Heat transfer simulation methods are described in detail in prior studies.[24,34]

Question	Scale	Mean	Std Dev
How well does this virtual surgery model replicate what you could realistically perform in the operating room?	**1 - 5**	**3.4**	**0.5**
How well does this virtual surgery model replicate what would be a realistic anatomic outcome after completion of healing?	**1 - 5**	**3.4**	**0.5**
How much does this additional information make you reconsider or change your original decision?	**1 - 5**	**2.6**	**1.6**

Table S1: Surgeon feedback on acceptability of virtual surgery models. Likert scale: 1-Not at all, 2-A little bit, 3-Somewhat, 4-Quite a lot, 5-Completely

Topic	Scale	Mean	S.D.	Cronbach's Alpha
Perceived Usefulness	**1 - 7**	**5.1**	**1.1**	**0.9**
Using virtual surgery/CFD would improve my performance as a surgeon		4.8	1.3	
Using virtual surgery/CFD would be useful in my job		4.9	0.9	
Using virtual surgery/CFD would make it easier to do my job		5.0	1.1	
Using virtual surgery/CFD would enable me to make better surgical decisions		5.7	1.0	
Attitude Towards Using	**1 - 7**	**5.7**	**0.9**	**0.8**
I believe it is a good idea to use virtual surgery/CFD		5.4	1.0	
I like the idea of using virtual surgery/CFD		5.7	1.0	
Using virtual surgery/CFD is a positive idea		6.1	0.8	

Table S2: **Surgeon feedback on perceived usefulness and attitude towards using.** Likert scale: 1-strongly disagree, 2-moderately disagree, 3-slightly disagree, 4-neutral, 5-slightly agree, 6-moderately agree, 7-strongly agree.

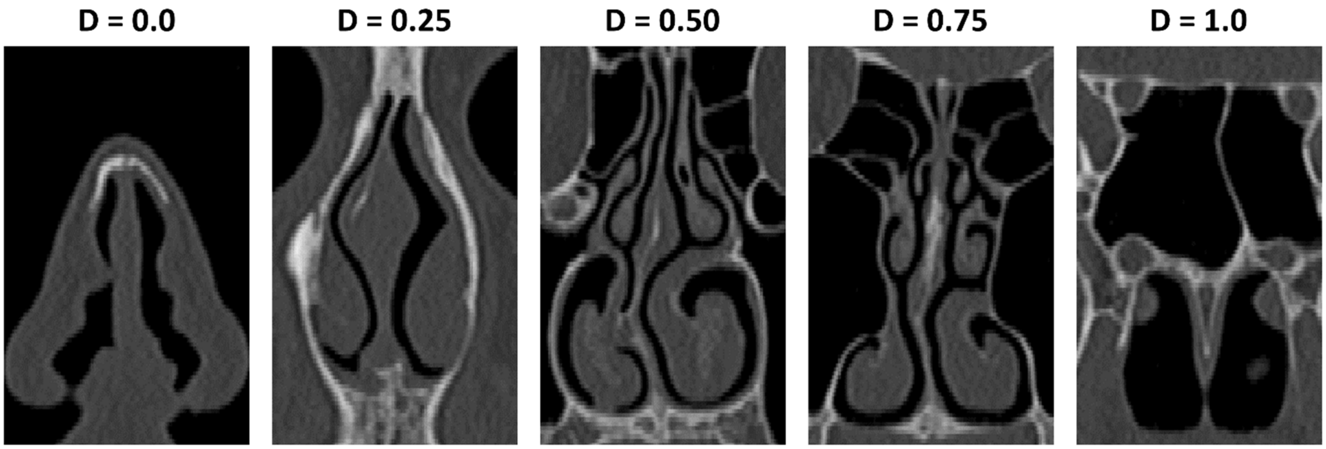

Figure S1: Pre-surgery coronal CT of NAO patient. The relative distance along the nasal cavity (D) is shown at the top of each panel. The posterior end of the nostrils are defined as D=0 and the choana (posterior end of the septum) is defined as D=1.

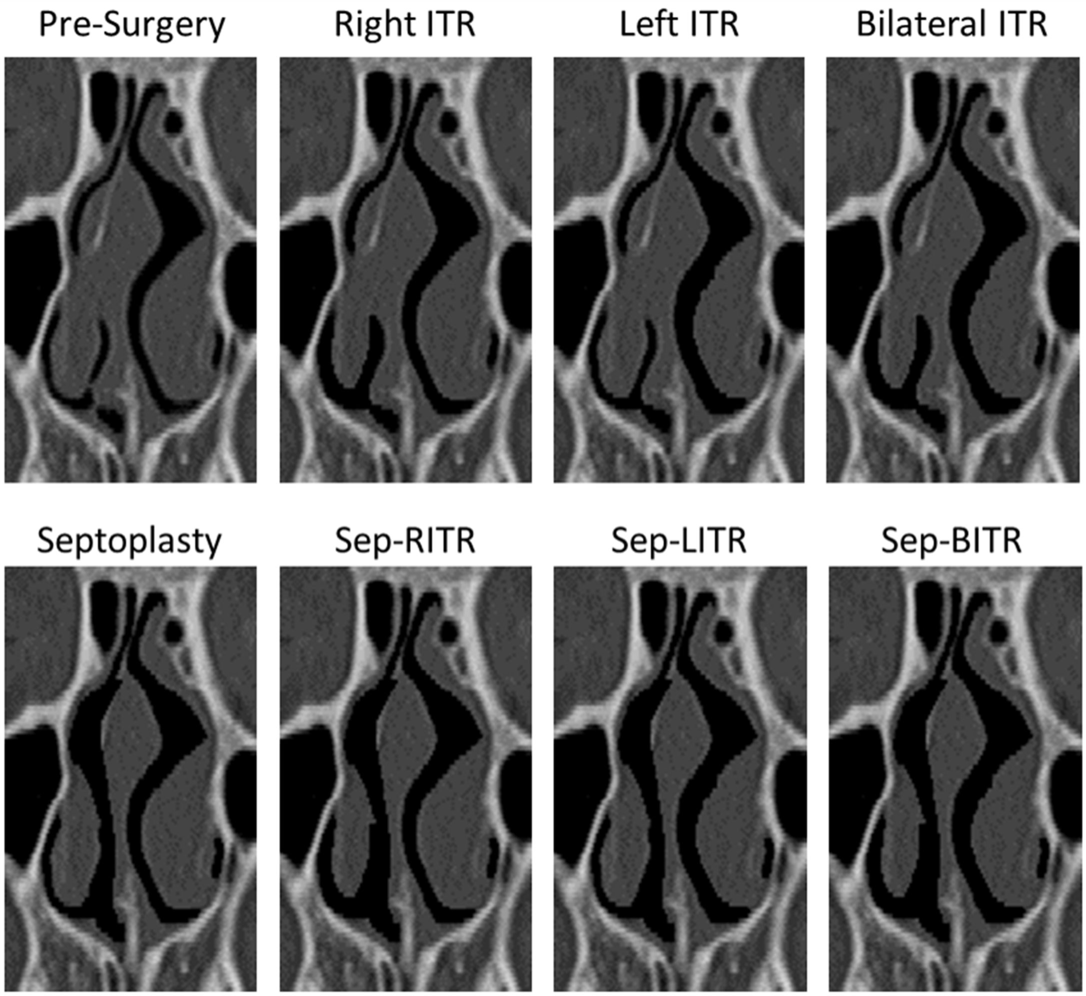

Figure S2: Coronal CT images illustrating the pre-surgery nasal anatomy and the seven different virtual surgery scenarios. The seven possible combinations of inferior turbinate reduction and septoplasty are illustrated. The dashboard included coronal CT images at 3 selected locations and access to the full virtual CT (full length of the nasal cavity) for all virtual surgery models. ITR=inferior turbinate reduction. Sep=Septoplasty. RITR=right inferior turbinate reduction. LITR=left inferior turbinate reduction. BITR=bilateral inferior turbinate reduction

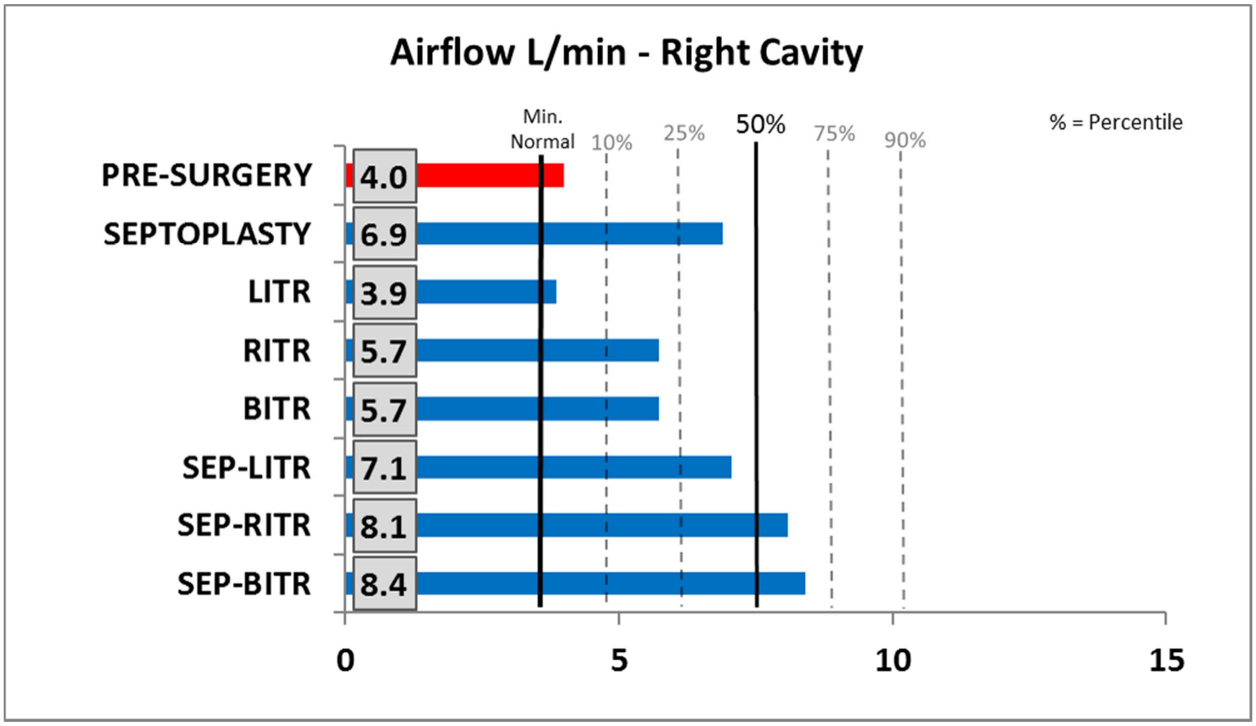

Figure S3: **Graph used on the dashboard to summarize the CFD results for all virtual surgery scenarios.** The CFD variables presented to surgeons were unilateral airflow (shown here), airflow partition between nostrils, and unilateral mucosal cooling, presented separately for each nostril. Values for airflow are in liters/min with numerical values in the boxes and corresponding graphical representation. Percentiles listed are based on normative ranges estimated from a sample of 47 healthy individuals.[26,35] SEP=septoplasty, LITR=left inferior turbinate reduction, RITR=right inferior turbinate reduction, BITR=bilateral inferior turbinate reduction.