



Regional Summit

2008  NAFEMS

2020 Vision of Engineering Analysis and Simulation

October 29 - 31, 2008 | Hampton, Virginia

Expanding engineering analysis tools to biomedical applications

Brian Barnum

Optimal Solutions Software



Engineering Analysis in Biomedical Applications:

a case study in septal deviations

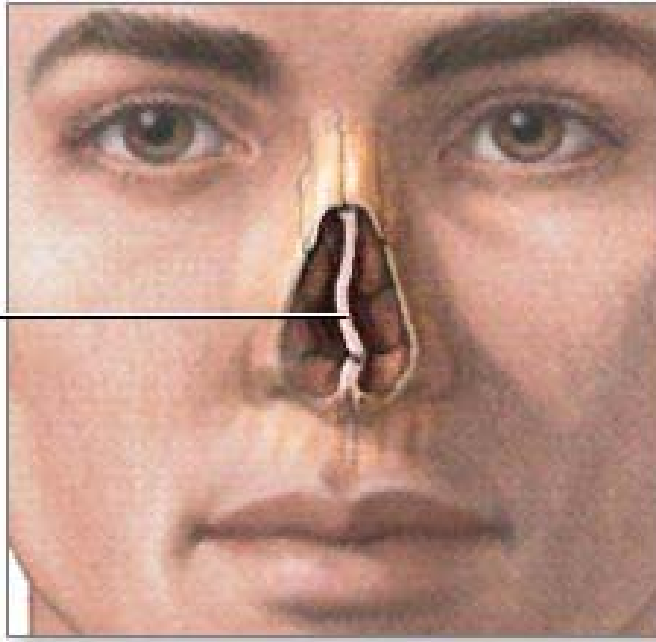


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Septal Deviations

Deviated
or irregular
nasal septum



<http://adam.about.com/reports/septal-deviaton.htm>

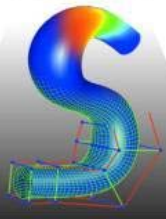
The Septum

- Septum divides nasal passage into right and left nostrils
- Septal deviations result from crooked or irregular setpums
- Septal deviations **CAN** reduce airflow to individual and increase risk of infection



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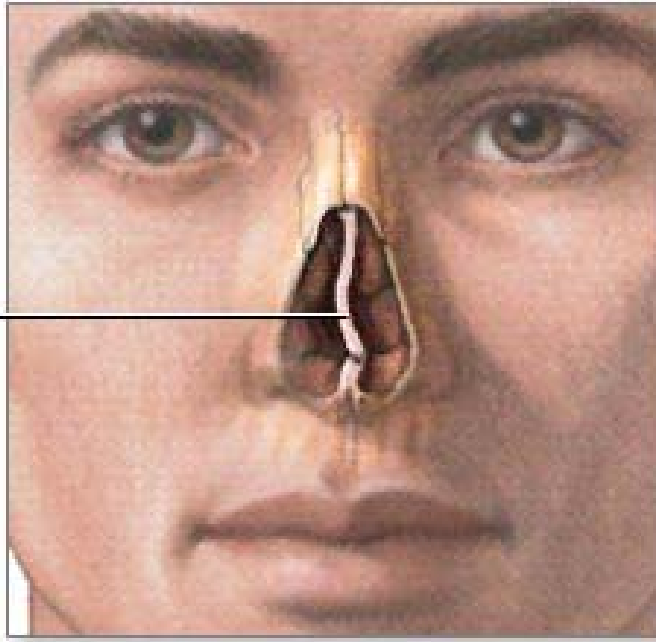


OPTIMAL SOLUTIONS



Septal Deviations

Deviated
or irregular
nasal septum



<http://adam.about.com/reports/septal-deviaton.htm>

Current Treatment

- Current diagnosis and treatment lacks significant quantitative data
- Available data highly erratic
- Correction requires septoplasty
- Relies heavily on physician experience and ability



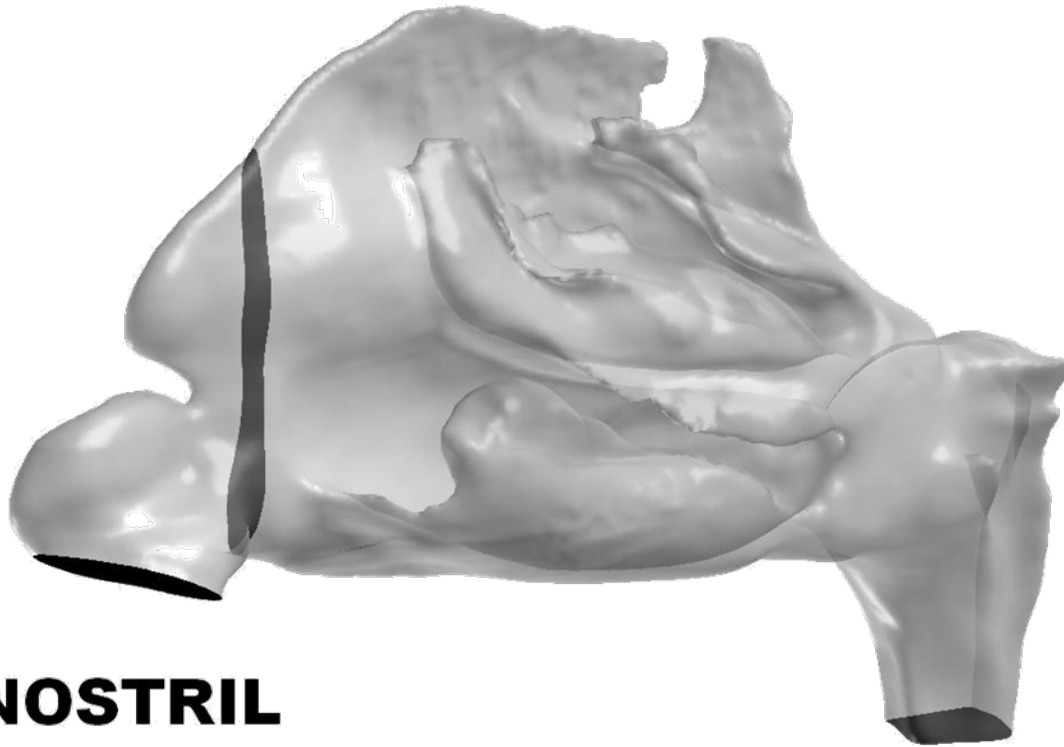
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OPTIMAL SOLUTIONS

Nasal Cavity



NOSTRIL

NASOPHARYNX



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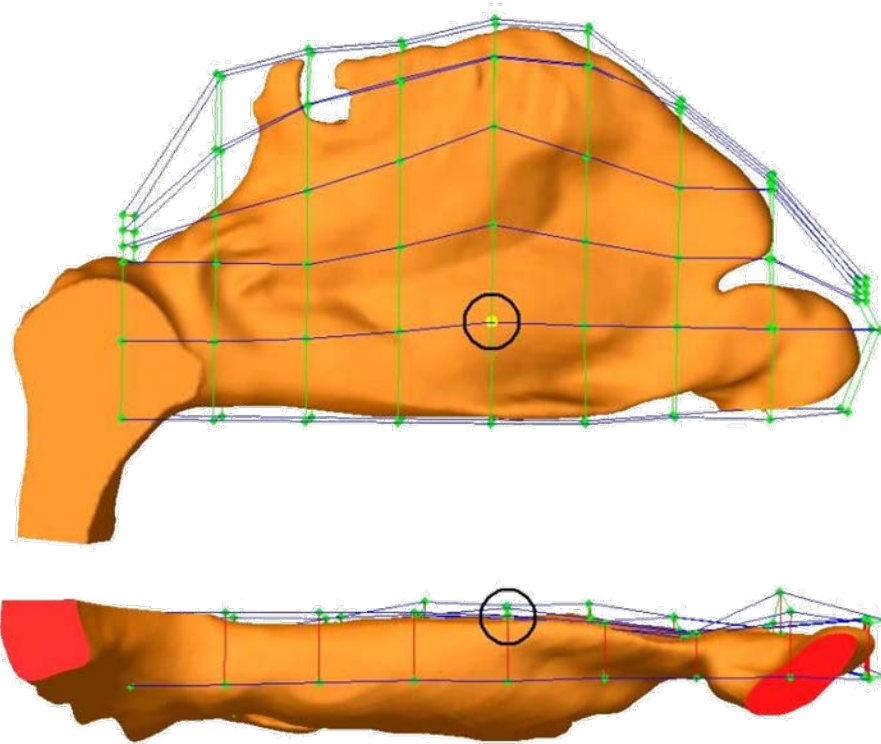
The Biological Challenge

Modeling Challenges

- Organic shapes
- ‘Infinite’ unique geometries
- Geometry modification
- Model timeliness



Deformation with Sculptor



TOP: Septal view before deformation.

BOTTOM: Inferior view before deformation.



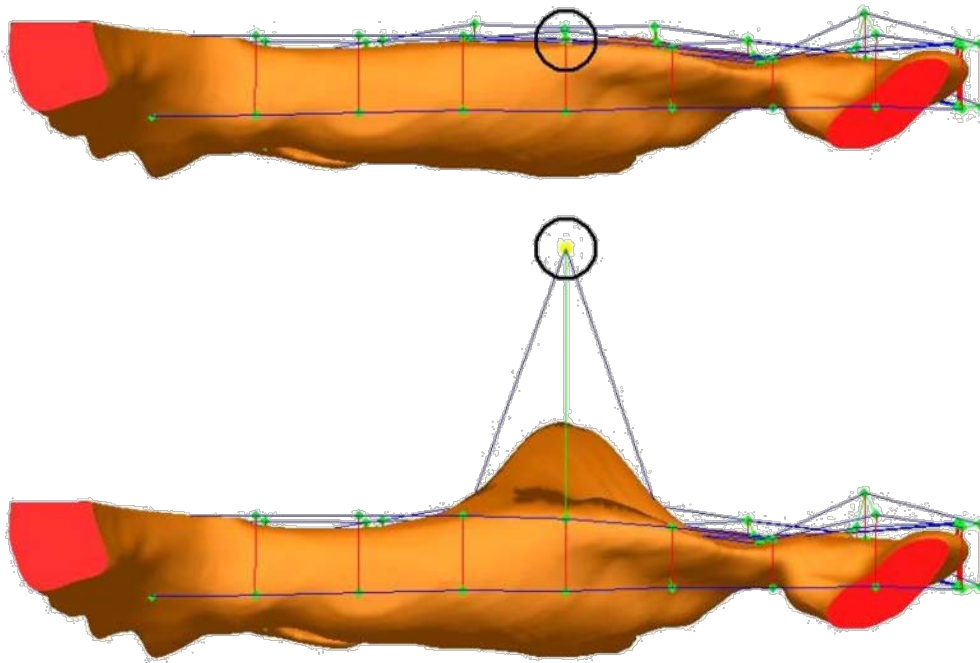
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OPTIMAL SOLUTIONS

Deformation with Sculptor



TOP: Inferior view before deformation.

BOTTOM: Inferior view after deformation.

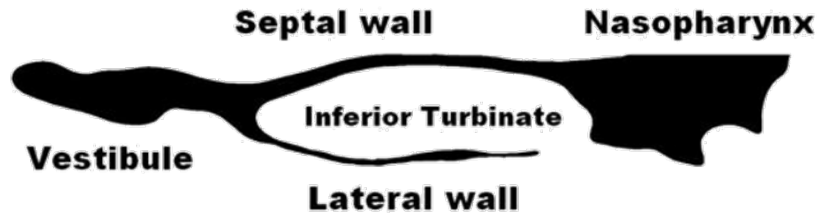


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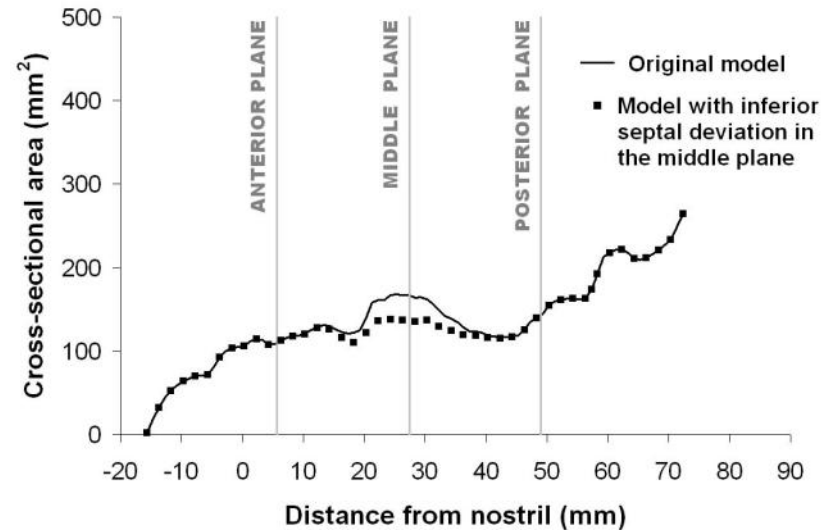
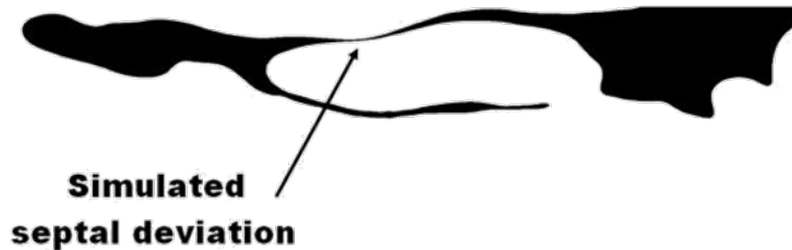


Inf. Deviation

ORIGINAL
GEOMETRY

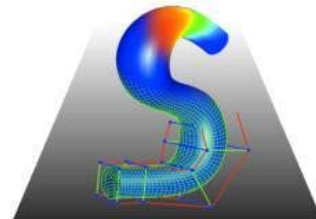


INF. DEVIATION
MIDDLE PLANE



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OPTIMAL SOLUTIONS

Generated Models



**ORIGINAL
GEOMETRY**

**INFERIOR
DEVIATION**

**MIDDLE
DEVIATION**

**SUPERIOR
DEVIATION**

3 deviations in 3 nasal planes
9 deformed models total
30 mm² cross-sectional area reduction



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OPTIMAL SOLUTIONS



Analysis Summary

Geometry Acquisition: Mimics, Materialise

Mesh: ICEM CFD, Ansys

Independent > 976k nodes

AR > .3

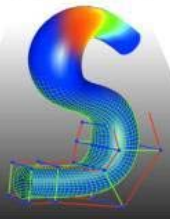
Deformation: Sculptor, Optimal Solutions Software

Solver: Fluent, Ansys



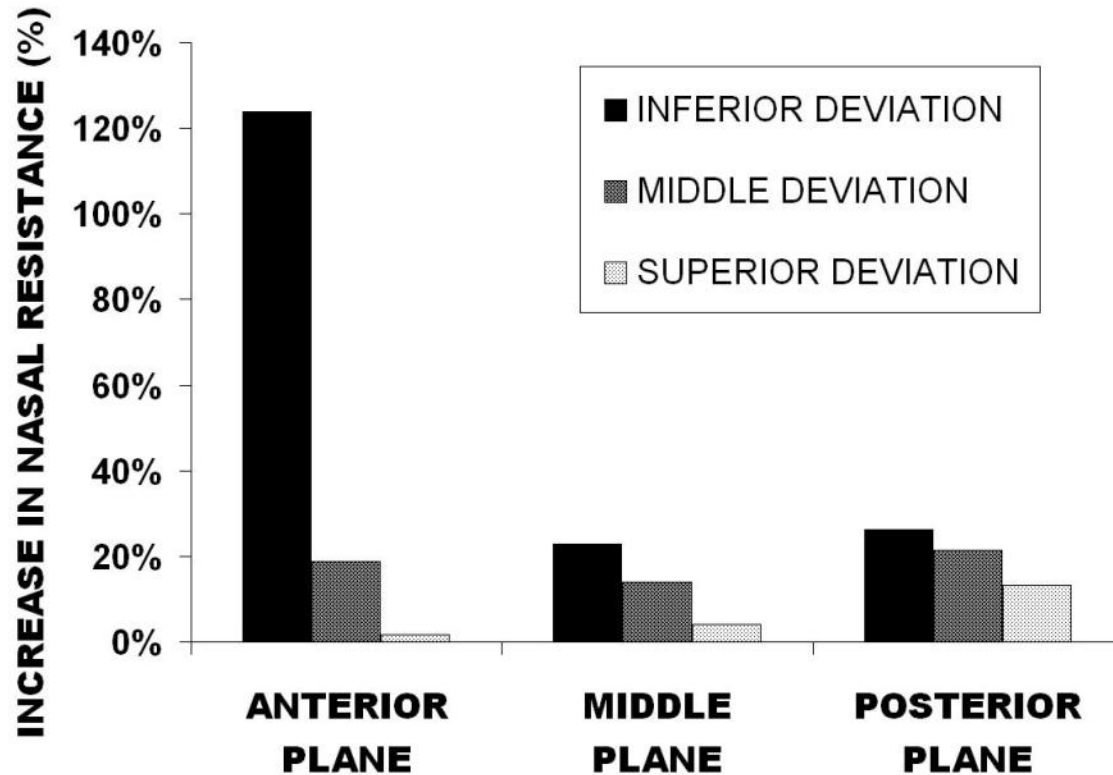
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OPTIMAL SOLUTIONS

Results

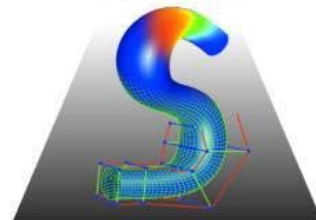


Percentage nasal resistance increase over baseline



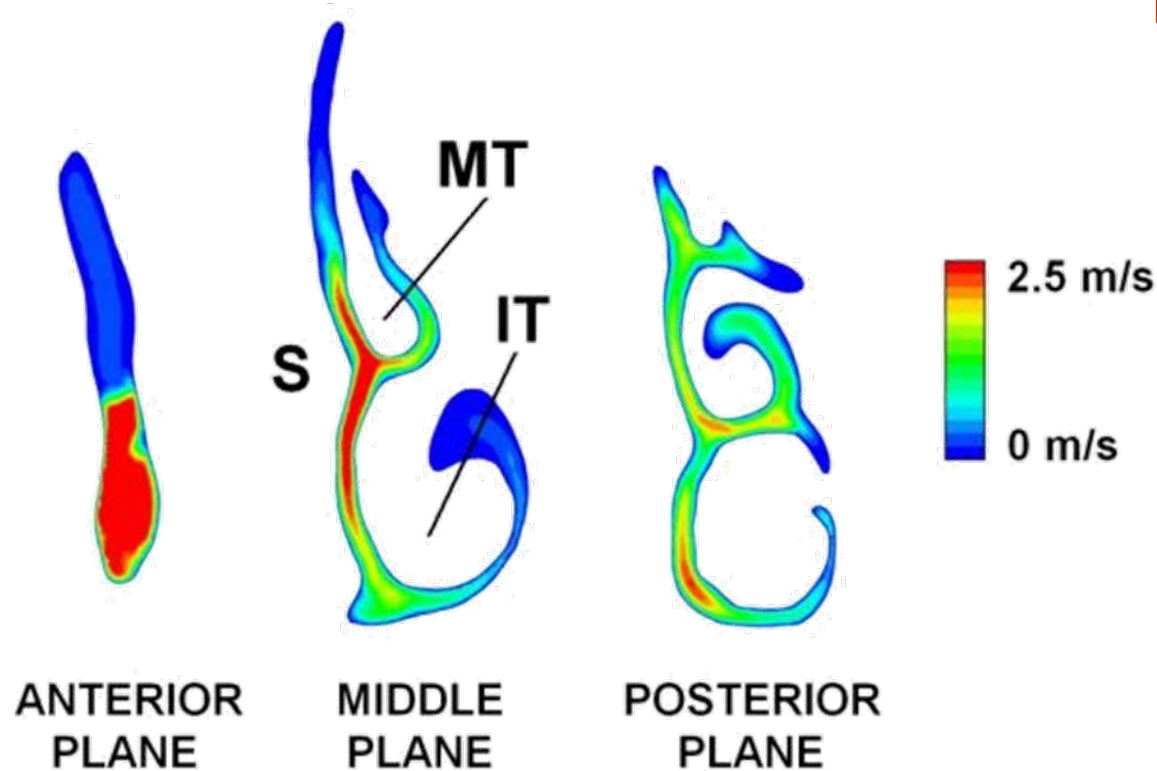
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OPTIMAL SOLUTIONS

Results



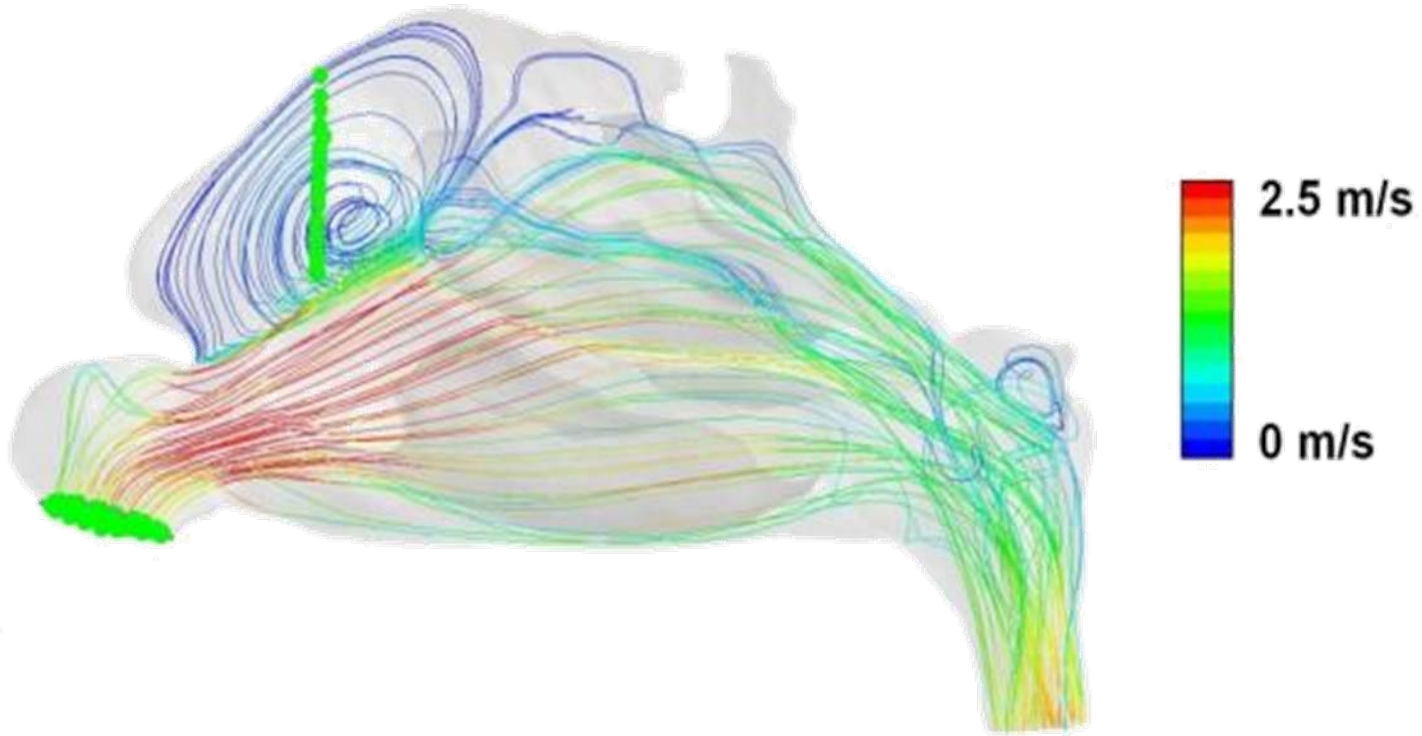
Color-maps of velocity magnitude in the anterior, middle and posterior coronal planes of the original nasal model for an airflow rate corresponding to resting breathing.



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Results

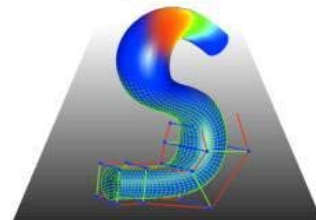


Sagittal view of streamlines in nasal passage colored by velocity magnitude



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OPTIMAL SOLUTIONS



Conclusions

- Analysis yielded similar results to in-vivo trials
- Application of mesh deformation technology makes biological analysis practical
- Mesh deformation allows organic geometry modifications
- Mesh deformation allows rapid model generation



Looking Forward

- Engineering tools allow analysis as part of an individualized treatment package
- Individualized geometries stored in generic models
- Optimization of surgical procedures



Questions



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