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Modeling Lung Micromechanics

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Background

Current models of lung microstructure represent alveoli as a space filling collection of truncated octahedrons(1.) Previous attempts at the ABI of modeling lung microstructure have included manual generation of the alveoli, before simulation in abaqus (2.).

This project aimed to bypass the manual creation of the alveoli by building on the previous work of Dr Kelly S. Burrowes. The aim was to convert a dynamically created alveolar surface mesh into a STL model with wall thickness, then importing the STL model into abaqus to model the dilation in response to some internal gauge pressure.

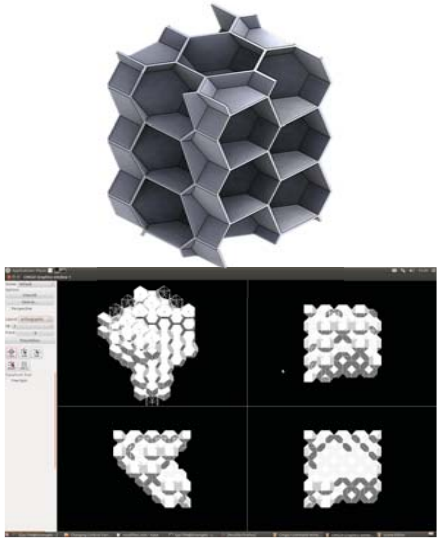

Fig 1. The Alveolar geometry generated manually(top) And the Alveolar surface generated By Dr Burrowes

Method

A python script was written to read in the exelem and exnode files previously generated by Dr Burrowes, the script then cleaned the collection of nodes and elements so that near identical nodes were collapsed in on each other and one dimensional elements were eliminated. The faces were then extruded in the direction of the normal vector. Using the extruded nodes and normals, extruded nodes were collapsed into adjacent convex nodes to ensure the geometry was continuous (fig 3).

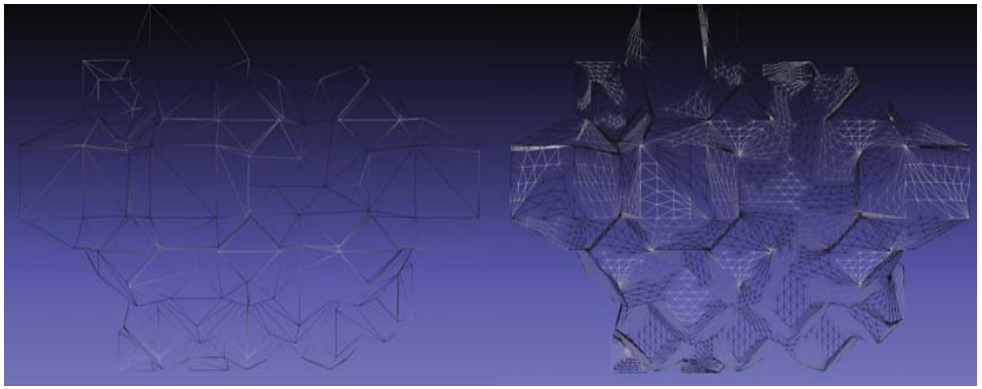

Fig 2. coarse STL surface created by the python script (Left) complex STL surface created by CM(Right)

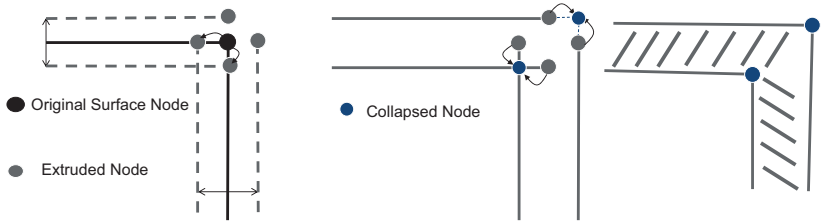

Fig 3. A simplified example showing the collapsing of extruded nodes in two dimensions

The thickened surface was then converted into a geometry (.igs file) and imported into abaqus where the model was modeled with a hyperelastic material, parameterized using experimental tensile data. Pressure was then manually applied to the internal faces and the dilation was examined.

Summary

The thickening of simple surfaces and their subsequent modeling in abaqus was successful, however the script needs to be extended to cope with internal walls .

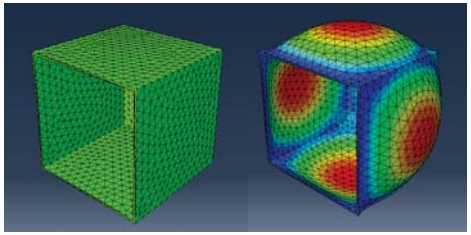

Fig 4. The dilation of a thickened unit cube in response to an internal pressure

The modeling process in abaqus currently uses manual selection of internal faces and should be scripted to minimize the need for manual set up.

References

1. Merryn H. Tawhai, Kelly S. Burrowes. Developing Integrative Computational Models of pulmonary Structure
2. Claas Seelhorf. Micromechanical Simulation of Lung Tissue

Acknowledgements

Dr Kerry Hedges, Dr Alys Clark, Dr Merryn Tawhai