Numerical Modeling of Airflow in Tissue Engineered Trachea

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INTRODUCTION: Post fixation tissue engineered traceal segment is an important period during when the construct have chances of dis-integrated from the site of fixation. The situation become more vulnerable in presence of foriegn particles of different viscosities like aerosols, polutant, etc. A numerical modeling of Tissue Engineered Trachea has been presented with modification in the designing of the constructs to prevent the dis-integration of the sample.

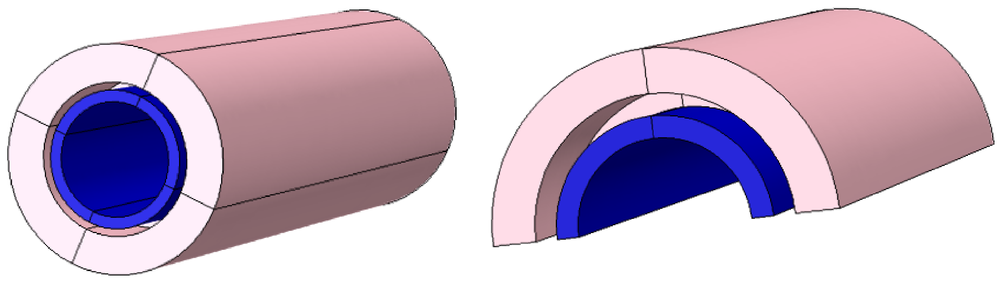

Figure 1. Fixator end grooved Tissue Engineered Construct designing

COMPUTATIONAL METHODS: Continuity equation, and N-S equations in cylindrical coordinate system were solved using COMSOL Multiphysics® and CFD modules to determine the velocity stream function, turbulent kinetic viscosity function, and pressure distribution throughout the defined geometry to evaluate the wall shear stress distribution. Figure 2 shows the discrete model which was finalised after mesh-optimization.

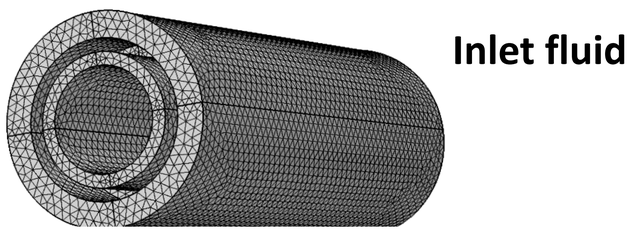

Figure 2. Mesh diagram of the tracheal segment

Further, the vortices in results of turbulence of particulates in pollutant environment, within the tracheal segment was realised by culturing the cell on the developed scaffold at in-vitro condition, following the agitated dynamic oscillatory motion of the media. The schematic of the condition was also numerically evaluated for optimizing experimental conditions.

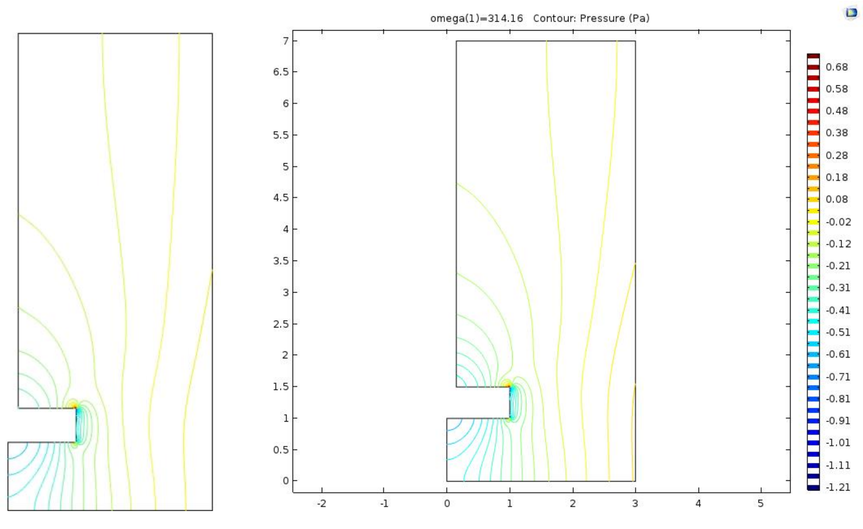

Figure 3. Pressure distribution of the media along the height of the culture in 3D scaffold

RESULTS: Figure 3-5 shows the pressure distribution, velocity field function, turbulent kinetic enrgy, and wall shear stress distribution of the media in the tissue engineered scaffold while the media was agitated at two different magnitudes.

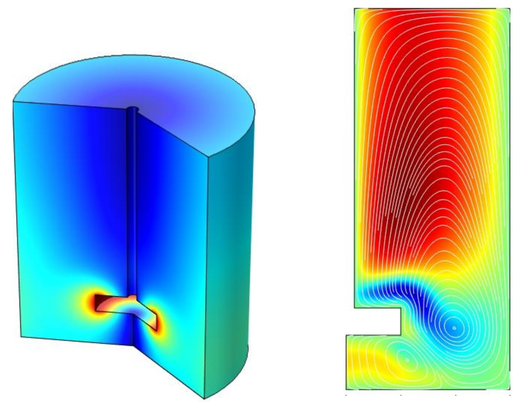

Figure 4. Velocity field and Turbulent intensity field distribution of media along the height of the scaffold with respect to agitation of the media

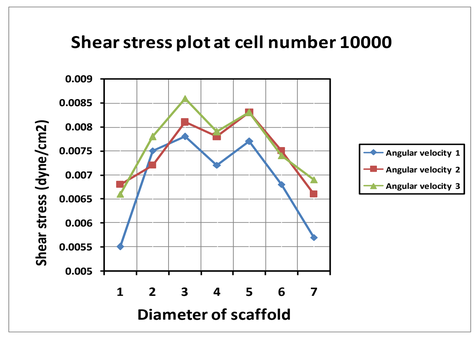

Figure 5. Shear stress plot at different rate of agitation near the wall of the scaffold with respect to the radial distance of the scaffold

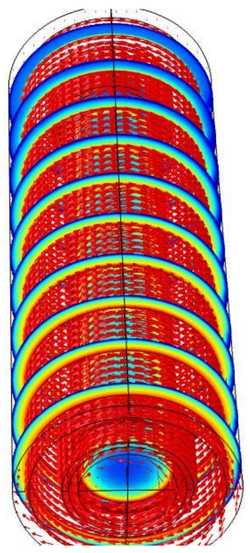

Figure 6. Title of the table

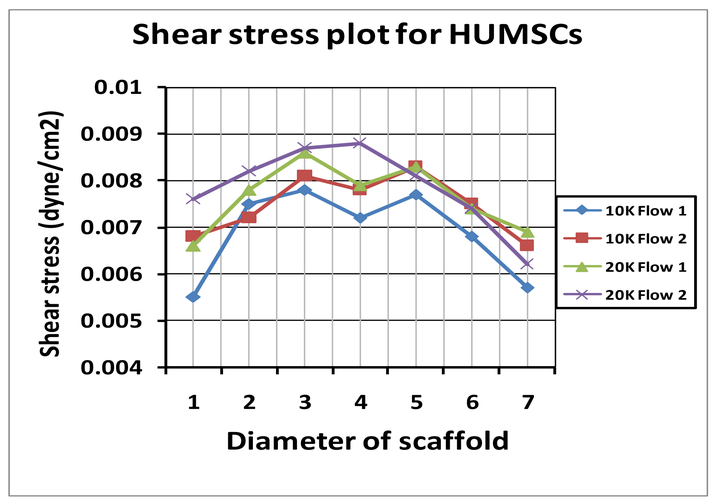

Figure 7. Title of the figure

Figure 6 and 7 represents the velocity field distribution at different depth of the tracheal segment and shear stress variation with respect to radial distance within the scaffold for different flow rates of the simulated working fluid.

CONCLUSIONS: It has been observed that agitated media plays a significant roles for optimizing the cell viability at post-implanted conditions of the tissue engineered tracheal segment. Also, it was observed that the grooves at the terminal ends of the scaffold play a crucial role in formation of least stressed region which may results in dissociation of the scaffold from the original organ. It can be seen from the numerical results obtained in figure 6 and 7. Therefore, an alteration to the existing design of fixative column scaffold for the tissue engineered tracheal segment might be considered as shown in figure 8.

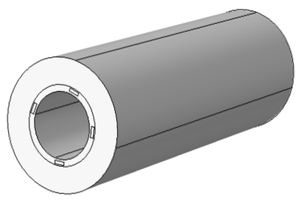

Figure 8. Proposed modification in the designing of the tracheal segment for tissue engineering

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