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Transdentinal Micro-fluidics: a Computational Fluid Dynamics Based Model

Passos, A.D., Tziafas, D., Paras, S.V.

Abstract

Objectives: The understanding of the fluid flow patterns and molecular diffusion mechanisms inside the dentinal tubules has recently attracted attention in designing regenerative treatment modalities of the dentin-pulp complex. The aim of the present study is to develop a reliable computational model in order to approach transdentinal fluid flow characteristics.

Methods: The analysis is performed by conducting Computational Fluid Dynamics (***CFD***) simulations. ***CFD*** simulation has been proved to be a reliable as well as convenient tool for studying momentum, mass and heat transfer in micro-conduits. The simulation software comprises the design of a typical tubule geometry followed by the discretization and solution of the appropriate differential transport equations. Direct Numerical Simulation (*DNS*) is employed both to visualize the velocity field and the temperature distribution and to estimate the heat transfer characteristics along the tubule. The fluid inside the tubule is considered to have the thermophysical properties of water. Two cases are considered, namely:

- ***Case A***: estimation of the outflow from a tubule, whose one side is exposed to the environment, whereas on the other (pulp side) a constant pressure is imposed.
- ***Case B***: study of the potential heat transfer mechanisms when a temperature gradient is applied between the enamel and the pulp side of the tubule.

Results: In case ***A*** the results confirmed the recognized mechanisms: the flow inside a single tubule is laminar and consequently the velocity exhibits a parabolic profile. The mass flow can be calculated for various pressure values at the pulp side of the tubule. However, in case ***B***, preliminary *CFD* results, indicate at least a partial deviation from the dominant hypothesis on heat transfer mechanism in the dentine-pulp complex.

Conclusion: The ***CFD*** simulation seems to be a promising tool for predicting transdentinal fluid flow characteristics. Present results need to be further validated using experimental data.

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