Nano/Meso-scale surface engineering for designing orthopedic implants

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Infection is one of the most catastrophic complications in medicine, esp. orthopedic field. Since in almost all orthopedic surgeries, we implant a device in the patient's body, if an infection happens, due to biofilm formation and attachment of bacteria to the surface of the implant, removal of the implant is almost always a must. Many attempts have been done to prevent this attachment and biofilm formation, like bactericidal silver coating or antibiotic coating, but none of them had a promising result. So, we decided to try to solve this problem with another approach. If we can prevent the biofilm formation, all the attachment mechanisms of the bacteria are disrupted. For this goal, we developed a computational software for multiscale multiphysics simulation of metallic medical devices to design medical devices mainly from nano and micro scale which is connected to macroscale features. Several nanoscale/microscale/mesoscale physicochemical phenomena could be simulated in this software i.e. protein and bio-ingredients adhesion, local corrosion (Pitting and Crevice), mechanically assisted corrosion cracks/microcracks, wear mechanisms, ions release via corrosion, surface electrostatic charges, local stress concentration, oxide layer formation/passive layer, biomaterials microstructural evolution in contact with human body and etc. Macroscale computational features in the software are algorithms for mechanical stress and fluid dynamics calculations. We have developed a 3D Graphical User Interface (GUI) for designing overall simulation domain details and for post-processing. Main computational algorithms and modules in the software are macroscale stress strain evolution (numerical solution of conservative equations), biomaterials microstructural evolution (cellular automata and phase field), fluid dynamics of human body (numerical solution of conservative equations), studying corrosion (multiscale and multiphysics approach), microcracks formations under stress and corrosive environment (multiscale and multiphysics approach), dynamics of bio ingredients in human body i.e. bacteria and protein (Newtonian approach), simulating infection physically (multiscale and multiphysics approach).

Speaker Biography

Hamid Reza Seyyedhosseinzadeh is an orthopedic surgeon and an associate professor at Rowan University and leads the Orthopedic Research Group. His special expertise is in Hip and Knee arthroplasty and designing Implants for hip and knee. During the past 6 years, he has conducted a large, multi-institutional study on "Ethnic Knee Design". Now he is leading the orthopedic research group at Rowan University, with great emphasis on biomechanical and engineering aspects of orthopedics. In this group, a novel approach to implant material is underway by designing new "Metamaterials" for orthopedic implants.

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