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Multiscale Modeling of Implants for Mechanobiological Characterization

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Surface topography of implant plays a key role in determining osseointegration in a time dependent fashion. This paper aims to develop effective computational models to characterize mechanobiological responses of bony tissues to different patterns of surface morphologies. To overcome the difficulty of modelling geometrical and topological features in implants, different length scales are considered and incorporated in biomechanical models involving cortical bone, cancellous bone, fibrous tissues, and vascular network. Specifically, the macroscopic scale model that ignores the surface microscopic features is first created for different time steps in osseointegration. The macroscopic model provides the kinematical and fluidic boundary conditions for microscopic models that allow capturing topographical feature in micron meter length scale at a particular time step. As such the roles played by surface morphologies can be characterized. We test a number of typical surface patterns, such as particle coating, acid itching and microfabrication etc. The mechanobiological responses of strain energy density, Tresca shear stress, bone-implant-contact, diffusivity and oxygen concentration etc are characterized through such multiscale models, thereby assessing their effects on short and long term outcome of implantation.

Keywords: Multiscale, finite element, implant topography, remodeling and osseointegration.