Topology Optimisation of Hip Prosthesis to Reduce Stress Shielding

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Abstract

This work presents the application of topology optimisation method to the hip implant design. Three-dimensional implanted femur was modelled and defined as a design domain. The implant, modelled as type 1, was optimised while other materials i.e. cement (type 2) and bone (type 3), were not be optimised. The domain was subjected to a load case, which corresponds to the loads applied when walking. Loads were employed at the proximal end of the implant and the abductor muscle. Loads from other muscles were not considered. The goal of the study was to minimize the energy of implant compliance subjected to several sets of volume reduction. Reductions were set to be 30%, 40%, 50%, 60%, and 70% from initial volume (V_o). Result of each set was cut into several sections about x-y plane in z-direction to observe the topology inside the stem. It was found that implants with 30% V_o, 40% V_o, and 70% V_o had developed open boundaries whereas 50% V_o and 60% V_o had closed boundary and produced possible shape. Therefore, these designs (50% V_o and 60% V_o) were chosen and refined. Both were analysed using the same boundary conditions as before they were optimised. Results of stresses along medial and lateral line were plotted and compared.

Keywords: topology optimization, hip prosthesis, stress shielding, FE analysis

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