Design of a biomimetic polymer-composite hip prosthesis

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Aseptic prosthetic loosening is a major cause of failure of arthroplastic surgery. This serious problem is often related to the production of wear debris at the hip joint and micromotions at the prosthesis-bone interface. A novel biomimetic composite hip prosthesis was designed to obtain properties similar to those of the host bone, in particular stiffness, to allow normal loading of the surrounding femoral bone. Such a hip prosthesis would reduce excessive stress shielding and resulting bone loss. The developed composite is molded into different configurations to match the properties of host tissue. The obtained modulus ranged between 8-36 GPa and the mechanical strengths between 134-565 MPa. Prototypes of total hip prosthesis (THP) were manufactured from a continuous carbon fiber (CF) reinforced polyamide12 (PA12) composite using inflatable bladder compression molding, in which an internal core is injected .The proximal surface of the stem prototypes was plasma-sprayed with a very thin layer of hydroxyapatite (HA) coating. Nonlinear three-dimensional analysis of composite hip prosthesis was carried out to compare the performance of CF/PA12 composite with a titanium alloy (Ti-6Al-4V) prosthesis, and also to assess the effect of core stiffness and ply configuration. Results show that the stress in CF/PA12 stem is lower than that in the Ti stem and conversely, the composite prosthesis generates high stress in the femoral bone than the one inserted with Ti. Furthermore, micromotions in the composite stem are less than those found in Ti stem over the entire bone-implant surface. The increase of the core stiffness reduces micromotions and stresses in the prosthesis.

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