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Abstracts Topic: Conceptual design and simulation of medical device performance

Design and Simulation of a Biomimetic Hip Resurfacing Implant

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PURPOSE: Hip resurfacing requires minimal bone resection during surgery compared with conventional Total Hip Arthroplasty. This approach is becoming very interesting for a later revision of the arthroplasty. Currently, used metallic implants fail to withstand the problems of aseptic loosening, mostly caused by stress shielding and migration.¹ Polymers/Composites, on the other hand, prove to reduce these problems.² The objective of this article is to present an integrated biomimetic concept for hip resurfacing implant design and to compare its performance with conventional hip resurfacing and biomimetic Total Hip Arthroplasty (THA).

METHOD: Femur FE-Models were set up based on CT-scans using a linear solid element mesh (ANSYS 10.0, SOLID185). The femoral head was reamed and embedded with 2 types of hip resurfacing implants. The first one is made of Ti, while the second is composed of 3 mm thick substructure made of several layers of carbon fiber Polyamide 12 composite in which a thin layer of Titanium alloy surrounds the femoral head to avoid wear debris effects (Fig. 3). The CF/PA12 was meshed with 4 nodes SHELL99, while the Ti was meshed with 4 nodes SHELL181. Bounded conditions were assumed to exist at bone-implant interface. Materials properties were derived from previous work.² Calculations were performed for each FE model under a single limb stance load and the results were compared.

RESULTS: The maximum main stresses in the femur with the Ti and CF/PA12 resurfacing implants are shown in Figure 4a and b. For the biomimetic resurfacing implant the main stress inside the femur was higher than that using the Ti. Also both hip resurfacing implants generate higher stress inside the femur than the biomimetic THA² which is beneficial for bone remodeling (Fig. 4c).

DISCUSSION: This investigation found that the biomimetic hip resurfacing reduced the amount of stress shielding and hence lower bone resorption compared with conventional hip resurfacing and biomimetic THA.

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Figure 3. Concept design of the biomimetic hip resurfacing implant.

Figure 4. Maximum main stress (MPa) in the femur using, a) CF/PA12 biomimetic hip resurfacing, b) titanium hip resurfacing and c) CF/PA12 biomimetic THA.