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SUB CRUCE LUMEN

Numerical Optimisation of Biomedical Implant Characteristics for Increased Service Life

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ABSTRACT

The research presented in this thesis focuses on the development of a numerical optimisation technique with the aim to decrease implant stress shielding which in turn could increase Total Hip Arthroplasty (THA) service life and reduce patient discomfort by employing a distributed stiffness along implant length.

THA is a frequently performed operation, in which the natural hip joint is replaced with a mechanical joint that requires implantation of a 'stem' within the femoral shaft. While THA is generally regarded as a successful method of restoring limb function, it is possible to improve current implant design and consequently increase service life to accommodate increasing human life expectancy and the decreasing age of THA recipients.

Initially, various numerical models of intact femora are constructed and studied in order to obtain an appreciation of the parameters (such as loading and boundary conditions) that influence solution accuracy. The results of which are the generation of accurate and efficient intact femoral numerical models, based on extracted cadaveric specimens.

Commercially available THA stems are assessed for their stress shielding (reduction in stress level post implantation) characteristics using the parameters specified within the previously constructed intact numerical models. The implanted femoral model containing the THA stem that demonstrated the most favourable stress shielding characteristics was used as a platform for numerical optimisation techniques.

Numerical optimisation techniques were applied to the implanted femoral model to generate homogeneous and distributed THA stem stiffness values that minimised stress shielding without exceeding maximum allowable stresses within the cement, which acts to locate and restrain the implanted THA stem.

The research presented here has found that through distributing stiffness along THA stem length, significant reductions in stress shielding can be achieved without exceeding maximum allowable stresses within the cement, possibly extending service life in comparison to homogeneous THA stems.

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