Computational analysis and optimisation of coronary stents

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Abstract

Coronary Heart Disease (CHD) is a severe disease and a cause of death affecting more than 6 million people worldwide. Its treatment uses coronary stents to unblock the narrowed vessels commonly observed in CHD. Despite the success of stents, there are still possibilities of failure due to high elastoplastic deformation experiencing in stent implantation and high-cycle dynamic loading in operation. The design of the stent is a key factor which can lead to minimum damage to blood vessel and maximum fatigue life of the device. Hence, design analysis and optimisation of stent signifies a critical issue to ensure longevity of clinical outcomes.

Computational modelling has been a relatively new technique to study the performance of stents. While most existing studies have focused on the stent expansion, modelling of the balloon and interaction between stents and vessel walls, only few literatures have explored the design optimisation of coronary stents [1]. Furthermore, a clear description on the methodology for modelling stent expansion and optimisation has not been well established in the current literature.

The study has carried out a 3D finite element analysis by considering material and geometric nonlinearity first, in which the stent was modelling as an elastoplastic material and blood vessel was modelled as a hyper-elastic material. Second, the design optimisation was carried out for optimising the stent dimension for a given structural configuration, in which the Design of Experiment (DoE), surrogate modelling (response surface method) and multi-objective optimisation were adopted. A number of finite element runs were performed to formulate the design space. The optimisation results demonstrate the significant improvement in the mechanical performance induced by the stent deployment.

Keywords: **FEA, stent, response surface, kriging model, optimisation, fatigue**

Reference

[1] S Tammareddi, G Sun, Q Li (2016) Multiobjective Robust Optimization of Coronary Stents. Materials & Design 90, 682–692