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Comparing Stent Design Using Computational Fluid Dynamics to Predict Wall Shear Stress Based Parameters

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COMPARING STENT DESIGN USING COMPUTATIONAL FLUID DYNAIMCS TO PREDICT WALL SHEAR STRESS BASED PARAMETERS

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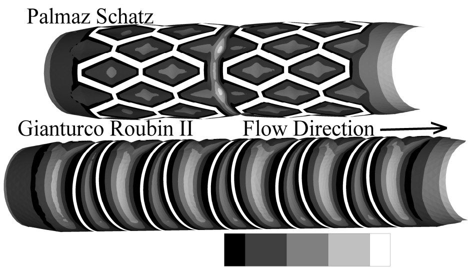
INTRODUCTION

Coronary stent implantation can improve blood flow in an artery that has been narrowed by the build up of arterial plaque. However, the haemodynamic effects of the stents presence and alteration of the vessel wall are unclear. The redistribution of flow induced vessel low wall shear stress (WSS), high wall shear stress gradient (WSSG), high wall shear stress angle deviation (WSSAD), and high wall shear stress angle gradient (WSSAG) may directly contribute to restenosis (re-blockage). In this work computational fluid dynamics (CFD) is used to identify these parameters in the left anterior descending (LAD) coronary artery implanted with either a Palmaz Schatz (PS) stent (Johnson & Johnson, PA, USA) or a Gianturco Roubin II (GRII) stent (Cook, IN, USA). The objective is to compare the haemodynamic performance of the stents.

MATERIALS AND METHODS

The computational domains representing the stented arteries are created using automated construction algorithms implemented in ANSYS Workbench Version 11 (Canonsburg, PA).
The unstructured finite volume meshes are generated using the advancing front method with approximately six million elements representing each model. The steady state computations are conducted on a HP xw6400 64 bit workstation with quad Intel (Xeon) 2 GHz processors with 6 GB of RAM and 80 GB hard disk. The governing equations are discretised using a high resolution advection scheme and solved using parallel processing with a MeTiS multilevel weighted k-way partitioning algorithm. The WSSG describes the spatial variation of the magnitude of the WSS. The WSSAD and WSSAG use different methods to describe the spatial variation of the WSS direction. These variables and their influence on intimal hyperplasia and restenosis are described in detail elsewhere [1].

RESULTS



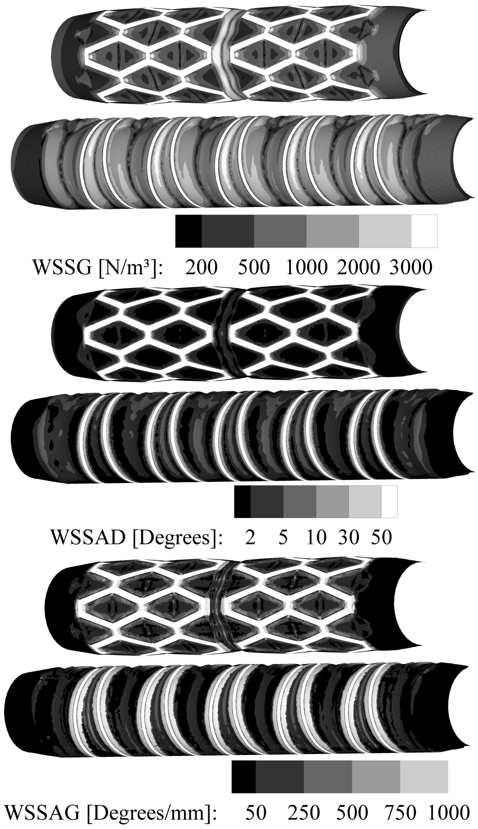


Figure 1: Contour plots of WSS, WSSG, WSSAD and WSSAG for arteries implanted with a PS or GRII stent.

DISCUSSION

The PS and GRII stents were compared in a multicentre randomized clinical trial with 755 patients and found to have restenosis rates of 20.6% and 47.3% respectively [2]. The results of this work show the PS stent performs significantly better if the variable thresholds for haemodynamic performance are set at <0.5 N/m^2 for WSS, >1000 N/m^3 for WSSG, >5 Degrees for WSSAD and >500 Degrees/mm for WSSAG. These variable thresholds may be useful for CFD analyses of future stent designs with the ultimate goal of minimising restenosis.

REFERENCES

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