ADVANCED FEATURES TO TAKE INTO ACCOUNT TO ASSESS ATHEROMA PLAQUE VULNERABILITY

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Introduction

The aim of this study is to evaluate the influence of features such as the presence of microcalcifications and the type of atheroma plaque remodelling (positive and negative) on the risk of plaque rupture by means of a parametric finite element (FE) models. For this purpose, firstly, a parametric FE model to assess the influence of microcalcifications on the stresses in the fibrous cap using an idealized coronary vessel with one microcalcification included has been carried out [Vengrenyuk, 2006]. In addition, we investigate the biomechanical interaction between the most influential parameter of the vessel geometry, the fibrous cap thickness, and the size and the position of the microcalcification in the mechanical risk factor of vulnerable plaque. Secondly, a parametric FE study has been accomplished in order to test the hypothesis that coronary artery plaques with positive growth are more vulnerable than those with negative growth [Varnava, 2001]. Therefore, the effect of positive and negative growth on plaque stability by considering the arterial growth process that occurs in response to plaque growth has been investigated.

Methods

For the first parametric study, the geometrical parameters used to define and design the idealized cross-sectional coronary plaque anatomy and the microcalcification were as follows: (i) the fibrous cap thickness; (ii) the microcalcification ratio; (iii) the microcalcification angle and (iv) the microcalcification eccentricity. And for the second one, various idealized cross-sectional plaque morphologies, mimicking different stages and variations in atherosclerotic lesion growth, were modelled. The possible relevant anatomical diversity was simulated by continuously varying the most influential values of the diseased vessel geometry: (i) the fibrous cap thickness, (ii) the stenosis ratio, (iii) the lipid core dimensions and (iv) the plaque distribution (eccentric or concentric).

Results

Figure 1 compares the MPS contour maps between a positive growth model and the negative growth models with concentric and eccentric plaques. The three cases presented have the same general dimensions.

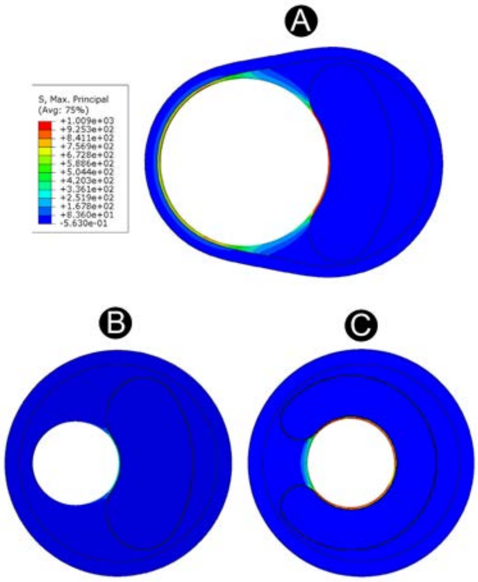

Figure 1: MPS contour maps

Discussion

This study shows that microcalcifications could cause an important increase in peak stress, but it might depend on other geometrical factors that also affect the location of points of maximum stress. Moreover, the performed parametric study strongly suggests that coronary arteries that undergo positive growth are more vulnerable to rupture than those diseased arteries that remodel inwards.

References

Bluestein *et al*, J Biomech, 41:11-18, 2008.

Varnava *et al*, Heart, 86: 207-211, 2001.

Vengrenyuk *et al*, PNAS, 103: 14678-14683, 2006.