Damage Model of Porcine Aortic Tissue under Cyclic Loading

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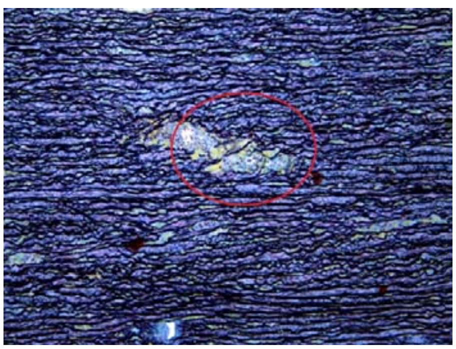
Aneurysm is a lethal cardiovascular disease in which the wall of arteries weakens and dilates permanently [1]. Current clinical criteria for decision making about surgical interventions appear to be not well correlated with the rupture propensity. In this study, we assume that degenerated vascular tissue accumulates damage according to Lemaitre theory [2]. Fatigue damage evolution causes the reduction of the static toughness of the material (exhaustion) eventually causing the rupture. This hypothesis is studied in-vitro by subjecting tissue specimens to increasing fatigue loading and measuring the area of micro-cracks. Porcine heart samples were harvested from a local slaughterhouse. Displacement-controlled experiments were done at 37°C and 15 Hz with the samples kept in Krebs-Ringer saline. To assess void growth, tissue samples were formalin-fixed, paraffin-embedded, and stained by Modified Movat's Pentachrome (Fig 1). The images are processed using Image-J software [3]. A damage index is defined as $D = S_D/S$ showing the effective surface density of micro-defects, with S_D is the effective area of voids [4]. The results of Fig.1, illustrate that the damage-index is monotonically increasing. The damage evolution data can be approximated by an exponential curve presented in Fig. 1. Considering the study by Duyi and Zhenlin [4], the next step of this work will be to connect the static toughness of the aortic samples to the fatigue damage evolution.



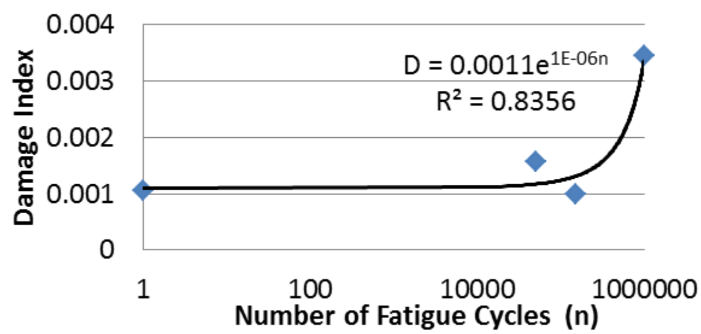


Fig 1. Stained tissue showing the voids initiation after the fatigue cycles (left) and the damage index evolution (right)

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