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STRAIN MEDIATED ENZYME DEGRADATION OF ARTERIAL TISSUE CHARACTERISED BY SMALL ANGLE LIGHT SCATTERING

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INTRODUCTION

Collagen fibre architecture is of critical importance in healthy arterial function. It is believed that maladaptive remodelling of this architecture may play a role in the development and progression of arterial disease [1]. To date, literature has focused on load induced fibre reorganisation with a clear lack of information available on collagen production and degradation in response to load in arterial tissue.

Previous studies on other soft tissues, such as bovine pericardium, have shown conflicting results on whether load inhibits [2] or enhances [3] enzymatic activity. It is hypothesised that meanical loading may also influence the enzymatic activity of collagenase in arteries, although further investigation is needed.

Small angle light scattering (SALS) is a technique which lends itself well to investigating load induced degradation as it allows structural information to be acquired non-destructively for fibrous test specimens. In fact, SALS has previously been used to identify the preferential degradation of unloaded collagen fibres in collagenase treated corneal tissue [4].

The aim of the present study is to use a SALS system to measure collagen fibre changes in intact arterial tissue and to identify whether a load induced degradation mechanism exists for arterial tissue.

MATERIALS AND METHODS

Porcine carotid arteries were dissected into 5 mm ring samples before being cut longitudinally to obtain planar samples. Samples were placed in a custom stretching device at a low (0%), medium (5%) and high (25%) circumferential strain level and incubated in bacterial collagenase (Clostridium histolyticum, Sigma Aldrich) at 37°C.

Samples were tested at 1-hour time points up to 5 hours using an in-house SALS system consisting of a 5mW HeNe laser (λ = 632.8 nm) and single focussing lens (f_l = 75 mm). Each sample was interrogated sequentially using a 150 µm beam diameter, controlled using LabVIEW.

RESULTS

SALS images of a sample exposed to 5% strain and collagenase for 5 hours showed increased fibre eccentricity, see Figure 1a) and 1b). Figure 1c) shows the relative change in SALS eccentricity under different loading conditions in the presence of collagenase for 5 hours.

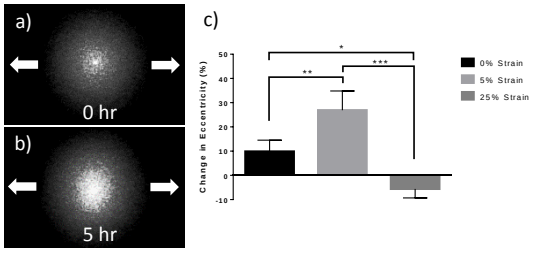

Figure 1 a) and b) SALS light distribution over 5 hours at 5% strain subjected to collagenase, c) relative change in SALS eccentricity over 5 hours at different load levels in the presence of collagenase. N=4, * $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

DISCUSSION

Results shown in Figure 1 suggest that strain mediated degradation mechanisms exist in arterial tissue which depend on the level of strain experienced.

The large relative increase in SALS eccentricity at 5% strain indicates increased fibre alignment over time and therefore preferential degradation of unloaded fibres. In contrast, a 25% strain resulted in a reduction in eccentricity suggesting less fibre alignment and consequently, the preferential degradation of loaded fibres. The relatively small increase in alignment in the 0% strain condition was attributed to a greater signal to noise ratio as sample density decreases over time. Interestingly, studies have found strain induced degradation to be even more pronounced under dynamic loading, an environment experienced by arteries *in vivo* [2].

Future work aims to explore a range of different loading regimes, including physiological and diseased conditions, to more fully investigate load mediated collagen degradation and production in response to mechanical stimuli. These results have clear applications in the design of intravascular devices, such as stents.

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