The Use Of Small Angle Light Scattering For The Characterisation Of Collagen Fibre Orientation In Arteries

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Cardiovascular disease (CVD) is the leading cause of mortality worldwide and as such carries a huge economic burden. CVDs cover a range of health issues with many of these diseases affecting arteries within the body. Arteries are composed of layers of fibre-reinforced tissue whereby collagen fibres provide structural strength to the vessel. Maladaptive remodelling caused by diseases, such as atherosclerosis and aneurysms, can alter the alignment of these fibres and consequently the strength of these vessels. A greater understanding of the vascular remodelling process may provide a better insight into arteries at risk of disease and how arterial repair may be induced.

Small angle light scattering (SALS) utilises light scattering principles to determine structural information of fibrous test specimen. SALS has previously been used in the characterisation of collagen fibres within a number of biological tissues. Most of this work has looked at thin, highly organised tissue structures, such as bovine pericardium and porcine aortic valve tissue [1]; whilst, SALS has yet to be applied to collagen fibre characterisation in arterial tissue. There are many advantages to the suggested SALS technique which make it a promising proposition for fibre characterisation in arterial tissue. SALS allows for the large-scale, automated determination of fibre orientation within tissue samples without the need for histological staining procedures. While this technique also avoids the subjectivity associated with many existing methods, its major advantage is its ability to characterise fibre orientation during the dynamic testing of samples.

An in-house SALS system is currently being built which incorporates an unpolarised 5mW HeNe laser (λ = 633nm) in conjunction with two focusing lenses to pass a light beam through a tissue sample held in custom-made grips. The resulting scattered light pattern is recorded by a CCD camera as it is collected on a scattering plate. The scattering pattern is analysed using a purpose built Matlab code allowing for the determination of predominant collagen fibre directions. The sample is interrogated sequentially in 250 x 250µm sections and the image data combined to fully characterise the sample. Work to date has focused on sectioned samples of arterial tissue whilst further work will consider the viability of SALS, as the sample thickness increases. Future work will also focus on automating the device to allow for large-scale data collection as well as focussing on how fibre orientation changes under load.

The SALS system will allow for validation of previously developed collagen remodelling algorithms in healthy and diseased tissue, permitting improved *in silico* modelling of patient specific arteries. These results can pave the way for the development of new medical devices which can induce regenerative collagen remodelling, halting or reversing the onset of CVDs.

References

[1] Billiar, K., and Sacks, M., 1997, J. Biomech., **30**(1), pp. 753–756.