Nanoscale properties of collagen in ageing

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Introduction: Collagen is the most abundant structural protein in the human body. It is highly conserved across species and is found in our skeleton, tendons, cornea, and skin for example. Although collagen has been widely studied over the past 30 years, the relationship between its structural behaviour and its mechanical properties with ageing still remains poorly understood especially at the molecular level (nano-scale). This research looks at a novel approach to quantify the effects of collagen cross-linking due to ageing at the molecular scale by using both engineered / aged biomimetic collagen matrices. This is an inter-disciplinary approach integrating fields of nanotechnology, tissue engineering and systems biology.

Methodology and Results: There is evidence of the role of non-enzymatic glycation (NEG) cross-linking in collagen as part of the ageing process in tendons. A model system that mimics this behaviour is used enabling empirical assessment of this effect at molecular level. The model incorporates collagen matrices constructed using a standard protocol of collagen gel compression in accordance with that demonstrated by Brown et al. (2005), the gels are subsequently functionalised and aged photo-chemically.

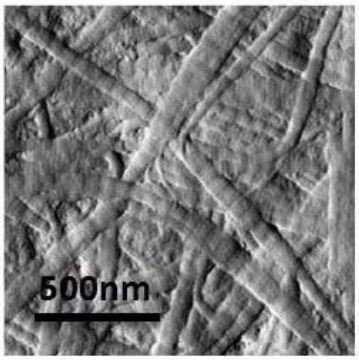

Fig 1. Plastically compressed Collagen Type I matrix with characteristic D-banding (67nm) periodicity

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hydrogel resulting in improved mechanical stability. This technique alone is however incomparable with the enhanced mechanical integrity generated through formation of NEG cross-linking. The mechanical behaviour of these collagen gels is determined quantitatively using single molecule stretching experiments performed on an Atomic Force Microscope, providing data for a supportive mathematical model. AFM, an established technique in nanotechnology, makes possible 3-dimensional imaging (Fig 1.) and quantitative mechanical response assessment (Fig 2.) of collagen at each hierarchical level that is from single molecule (nm) through to bulk tissue macro- scales.

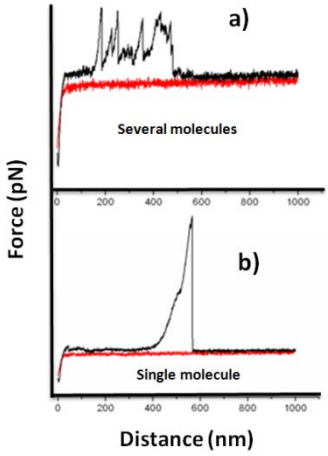

Fig 2. Single molecule force distance curve

vitro model
ies of AFM
e structural
and mechanical properties of isolated single collagen molecules in relation to other neighbouring collagen molecules within its host fibrils, specifically in the context of ageing.

References: U. Cheema, M. Wiseman, C.B. Chuo, R.A. Brown & S.N.Nazhat. (2005). *European Cells and Materials*, **10**, 39.

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