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NEW MULTISCALE BIOMECHANICAL MODELS FOR PERIPHERAL NERVE TISSUE

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Summary: It is estimated that 2.8% of trauma patients [1] suffer damage to the peripheral nervous system, leading to loss of function, chronic pain and permanent disability. The current gold standard treatment of nerve autographs is estimated to have a success rate of 40-50% [2] depending on the scale of the injury. The UCL Centre for Nerve Engineering is developing new treatments for peripheral nerve injury as well as improving our understanding of the function and regeneration of nerves.
Treatments being developed include the use of a collagen scaffold to replace the lost tissue and improve nerve regeneration. For this to be an effective treatment the scaffold's mechanical properties must closely match those of the native nerve tissue to prevent localised regions of excessive strain prone to failure. Previous experimental work [3] has shown a link between the mechanical properties of the nerve and the structural features of the nerve. Additionally, there are ultrastructural data on collagen fibril density and diameter in nerves, however, the extent to which these affect the mechanical properties of the nerves remains unclear. There seems to be little evidence in the current literature of mathematical models of the mechanical properties of peripheral nerves.

Asymptotic homogenisation is an analytical mathematical technique that incorporates the microscale geometry and interactions of a composite material into homogenised macroscale equations. It has been used in a variety of engineering problems. In biomedical modelling, asymptotic homogenisation has been used in a range of situations including light absorption in tissues [4], and drug transport in tumours [5].
Here, the approach is used to describe macroscale mechanical properties of the nerves in relation to the collagen sub-structure. This allows for models to be developed which explore the ultrastructural data to gain insight into the mechanical properties of peripheral nerves.

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