STUDY OF CELL MICRO/NANO-MECHANICS WITH A POLYMER MEMS-BASED DEVICE

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Cells and tissues in living organisms are constantly exposed to mechanical stresses and strains. These stresses and strains play an important role in many biological processes, such as development, organization, pathogenesis, and remodeling of living tissues. Understanding the relationship between the dynamic mechanical environment of cells and their functions is essential to analyze these complex processes and develop strategies to manipulate them. Cardiovascular tissue is of particular interest as it experiences complicated strain conditions caused by the blood flow in vivo and requires precise alignment and mechanical connection to function properly. The aim of our study is to investigate the response of individual smooth muscle cell and cell-cell adhesion to strain microgradients, and thus gain insight to cellular and molecular mechanisms during muscle growth, hypertrophy and damage processes.

To test the mechanical properties and responses of smooth muscle cells, flexible membrane stretching devices made by FlexerCell® will be modified and used in conjunction with novel polymer MEMS-based silicone elastomer membranes. These membranes contain structures such as microgrooves that align the cells with strain-gradient provided by the flexure device. The dimension of these microstructures allows for varying cell spacing, whereas the orientation provides different types of strain gradients. Cellular and subcellular behaviors under mechanical stimuli are detected and quantified for the determination of parameters to optimize a certain cellular response (e.g. contractile fiber expression). In addition to strain magnitude and type, the duration and frequency of applied strains is also explored for further optimization. Mathematical and finite element analysis models are incorporated into experimental design and final data simulation to give further insight on the effect of stain on cellular tissue.

Results from this study hope to provide two-dimensional mechanical strain optimization, containing both eqi-biaxial and non-eqi-biaxial strain profiles. A new approach to the study of cell and tissue mechanics is demonstrated, and results will be potentially used to explain biomechanical conditions observed in cardiovascular tissue physiology and pathology.

Keywords: Cell-mechanics, MEMS, Strain, Cardiovascular