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ABSTRACT BOOK

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AN INTEGRATED MODELLING FRAMEWORK FOR OPTIMIZING NEGATIVE PRESSURE WOUND THERAPY

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Introduction: Negative pressure wound therapy (NPWT) is clinically effective in managing both acute and chronic wounds. However, little is known about the optimal settings and combination of treatment parameters e.g. the wave-shape of the negative pressure, frequency of pressure changes and importantly, how these translate to target tissue strains and stresses that would result the fastest healing, buildup of good-quality tissues and no keloid scarring. Work is underway in our group to develop an experimental-computational modelling framework for better understanding of the mechanobiology of cells and tissues at the peri-wound and wound-bed under NPWT.

Methods: From an experimental perspective, we developed a versatile cell culture stretching system which can replicate any static or dynamic deformation regime produced by existing or future NPWT systems, in terms of tissue deformation wave shapes and frequencies. From a computational perspective, we developed three-dimensional open wound and surgical incision finite element (FE) models that contain skin, adipose and skeletal muscle tissue layers and are used to determine the states of tissue strains and stresses around the aforementioned wound when subjected to NTPW. This FE modelling further facilitates studies of the influence of the foam dressing properties such as its stiffness on the dynamic strain and stress states generated in the tissues.

Results: Our mechanobiology work in fibroblast cultures revealed that these cells are irresponsive to low strains below 0.5%, however, fibroblast may accelerate their collective migration towards a damaged site in response to strains above 3%. Given that our published work demonstrated that the plasma membranes of cells may be damaged above strains of ~12%, there must be a strain sweet spot within the 0.5-12% range for optimally stimulating fibroblasts to migrate in response to NPWT. The strain state in peri-wound skin, stimulating fibroblasts to migrate and repair damaged tissues, can be potentially controlled by either adjusting the negative pressure level or the stiffness of the foam dressing. Interestingly, our FE modelling showed that the skin strain state is considerably more sensitive to the pressure level than to the stiffness of the foam dressing: Stiffer and softer foams over an order of magnitude around the mean industry standard yielded indistinguishable skin and adipose (peri-wound) strains.

Conclusions: Our integrated experimental-computational approach indicated that the strain state induced at the peri-wound tissues, particularly skin, can be more effectively controlled by adjusting the pressure level than by varying the stiffness of the foam dressing.

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