CELL-SEEDED SKIN TISSUE SUBSTITUTE: THE MATERIAL PROPERTIES OF SKIN TISSUE

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INTRODUCTION

Skin is the most abundant epithelial tissue in the body [2]. It has higher tensile and compressive strength compared to most other epithelial tissues in the body and is frequently exposed to cyclic stress in various orientations [1,3]. Current treatments for severely burnt skin involve the removal of skin tissue from a different area of the body—mostly the hips—to be used as skin graft. These graft do not include cells and therefore do not regenerate once implanted in situ [4]. The rapid growth of cell culture over the past 20 years has given rise to the development of cell-seeded skin tissue as a substitute for the current burnt skin replacement process. In order to produce cell-seeded tissue to replace burnt skin tissue, a good understanding of the material properties of the skin tissue is paramount. The main purpose of this research was to fully understand the material properties of skin tissues so as to replicate these properties in cell-seeded skin grafts.

METHODS

Ten full-thickness abdominal skin samples were obtained from the Foothills Medical Centre (Dr. V. Gabriel) and cut into square samples (sides 10–12 mm) with two edges, one (axis 1-3) parallel to the collagen fiber direction, and the other one perpendicular to it (axis 2-4). To retain their material properties, unused specimens were frozen, and then thawed in phosphate buffer saline (PBS) solution before they were tested. Biaxial testing was performed using the Bose Planar Biaxial system (Bose ElectroForce, Eden Prairie, Minnesota) with strain control and load control protocols reaching a maximum stretch of 40% on both axes. A frequency of 0.333 Hz over 10 cycles was used for each experiment. Using the acquired data, the first Piola Kirchhoff Stress was calculated as current applied force (F) per original Area (A_0), while the Green-Lagrange strain was the percent stretch at that point.

RESULTS

Figure 1 shows representative stress–strain curves for an abdominal skin tissue specimen. The cyan line represents the stress in the axis perpendicular (axis 2–4) to the collagen alignment of the tissue at different strain. It can be noticed that the stress–strain distribution is approximately linear. This is because the load bearing factor in this axis are the elastin fibres. On the other hand, the red line—which represents the stress in the axis parallel (axis 1–3) to the collagen alignment

of the tissue at different strain—can be described as two linear graphs connected by an elbow. This is based on the fact that in the initial portion of the graph, the load bearing factor is the elastin fibre. The elbow represents a region when the collagen fibres starts engaging. In the second linear portion the collagen fibers are fully engaged and are the main load bearing factor in that region.
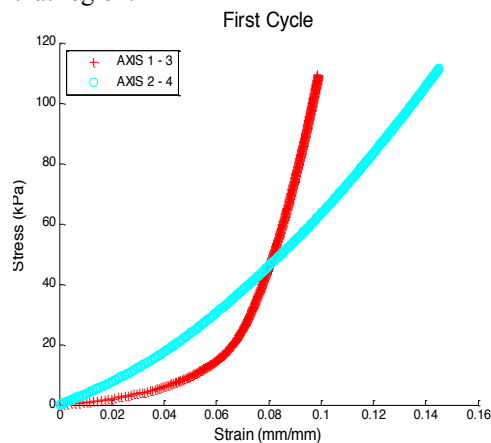

Figure 1. Abdominal skin tissue (40% strain control)—First Piola kirchhoff Stress and Green-Lagrange strain.

DISCUSSION AND CONCLUSIONS

Skin showed anisotropy for all the tested specimens, meaning the force required to acquire 40% strain was dependent on the direction of its application. We are currently imaging related tissues under a dual photon microscope to further understand the relationship between the anisotropy of the skin and collagen alignment. More protocols at different load ratios can be performed and the results used to develop mathematical constitutive models for skin and skin graft tissues.

ACKNOWLEDGEMENTS

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