Determination of the Effects of Novel Bio-Loom Parameters on the Permeability of Woven Meshes

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Statement of Purpose:

Tissue engineering has been defined as the application of multidisciplinary principles toward treatment development for regeneration of functional tissue.[1] Often, these treatments involve the combination of cells with polymeric scaffolds. One area of focus in polymeric scaffold engineering has been in surgical mesh development. Surgical mesh efficacy is related to mesh configuration, filament structure, and biomaterial considerations.[2] Researchers have focused on pore characteristics such as porosity, pore size, pore shape, and permeability.[3]

The goal of this work was to examine the effect of variable bio-loom specifications on permeability of woven polymeric meshes. Meshes were varied by material type, weave configuration, and fiber geometry. Permeability was measured for correlation to pore size, porosity, and fluid wicking results in accompanying work. The ability to affect permeability may be used to tune the fluid dynamics directing nutrient and waste transport in *in vivo* and *in vitro* tissue engineering systems.

Methods:

Meshes were woven on a novel automated bio-loom powered pneumatically with electronic components driven via National Instruments LabVIEW (National Instruments). The weave configurations tested were 50/50 and 75/25 compositions in an over/under pattern. Woven meshes consisted of the following two synthetic polymer combinations of warp and weft fibers: polylactide (PL; Natureworks LLC, 2003d biopolymer, ~ 228,000 Da):PL, PL:poly-l-lactide-co-caprolactone (PLCL; Purac, Purasorb PLC 7015, ~ 154,500 Da). Mesh fiber geometry was varied between round (RND) cross-section fibers and deep groove (4DG) cross-section fibers. Meshes were then cut and surface area, A [cm^2], was measured. Permeability was measured using a direct permeation experiment in which a fixed volume of water (15 mL) was passed through each scaffold. The amount of time for the fluid to pass through each scaffold was recorded and used to calculate the mean flow rate, q (1.35 mL/s) and the permeability coefficient, k [cm^2], according to Darcy's Law in Equation (1).[3,4] L [cm] is equal to length of the water column. μ [Pa·s], is the fluid viscosity. P [Pa] is the pressure at the hydraulic head.

$$k = \frac{qL\mu}{PA} \qquad (1)$$

Results:

The automated bio-loom facilitated the creation of meshes with varying permeability based on weave configuration, material type, and fiber geometry. The graph in Figure 1 illustrates preliminary data showing the relationship between mesh parameter combinations and permeability coefficient, k. Differences between groups are statistically non-significant for fiber geometry (p-value=0.0721), weave configuration (p-value=0.2633), and material type (p-value=0.6497). Sample size (n) for each mesh combination was 3, except for 4DG-50/50-PL:PL, the sample size of which was 6.

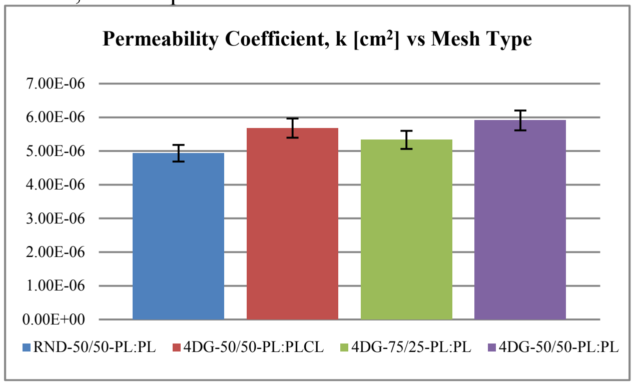

Figure 1: Permeability coefficient (k) for meshes with varying bio-loom parameter combinations. Combinations are denoted "fiber geometry-weave configuration-material type."

Conclusions:

While these preliminary results reveal non-significant differences, the difference between the permeability coefficient of the meshes constructed with round fibers versus that of meshes constructed with 4DG fibers is approaching significance (p=0.0721). This result is expected due to the increased capillary action of the 4DG fibers. The wicking action of these fibers may move fluid across the mesh, as opposed to allowing fluid only to pass straight through the mesh, as occurs with round fibers. This phenomenon may be advantageous during cell culture as nutrients may be dispersed throughout the scaffold via the organized network of capillary fibers. Similarly, 75/25 meshes seem to be more permeable than 50/50 meshes with identical fiber geometry. This result may be due to increased pore size and porosity for 75/25 meshes which may translate into differing cell attachment, proliferation, and differentiation outcomes for *in vitro* or *in vivo* studies. Future work should accommodate increased sample numbers and wicking studies. .

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