Academic Proposal 2008/2009
Looking at Mechanical Properties of Stem Cells to Promote Osteogenesis and Chondrogenesis

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Electrospinning tissue engineering scaffolds that will support ligament regeneration has been my main research objective this past summer. Electrospinning is a novel scaffold design method that produces a nanofiber matrix on which cells can proliferate and produce collagen matrices. Over the summer, I evaluated the mechanical properties of silk fibroin scaffolds and scaffolds blended from silk fibroin and polycaprolactone. These scaffolds were seeded with ADSCs (adipose derived stem cells) to see if either of the two scaffolds would yield promising mechanical properties needed for ligament tissue regeneration. A collagen assay was also performed to determine the amount of collagen production by the ADSCs on the scaffolds. At this point, this investigation is still underway. Some mechanical results have been generated for scaffolds 1 week after seeding the stem cells. Tests performed on the ADSCs are currently inconclusive, and should be tested further at week 2 and 3 after cell seeding has taken place. However, all scaffold mechanical testing and other tests will be performed on the ADSCs in the next 2 weeks to learn about the implications of using the natural silk fibroin polymer as a mechanically promising scaffold polymer for ligament engineering applications.

On a successful scaffold, stem cells will produce collagen, and the scaffold will properly support the cells' regeneration of extracellular matrix (ECM). Research from Wang et al shows that silk fibroin scaffolds support the attachment, spreading, proliferation, and differentiation of human mesenchymal stem cells (MSCs). After MSCs were seeded onto silk fibroin scaffolds and placed in static culture for 21 days, significantly high amounts of tenascin-C, collagen type I and collagen type III, all of which are needed for ligament regeneration, had formed on the scaffolds.

Bone and cartilage related genes were not found on the scaffold, and this suggests that silk scaffolds are and excellent choice for reproducing cells needed for ligament regeneration [1].

Academic Year Goals

This summer I was not searching for bone and cartilage related genes on the scaffolds because I was looking for collagen production necessary for ligament tissue. However, I will be switching gears over the academic year to look for bone and cartilage genes on electrospun scaffolds in the cell mechanics lab at North Carolina State University. This lab's main research initiative is to study the effects of mechanical loads on MSCs in order to engineer skeletal tissue from differentiated MSCs that can withstand in vivo mechanical loads. Currently this lab is working to promote osteogenesis by applying tensile forces to MSCs and ADSCs. The cell mechanics lab is also working to promote chondrogenesis of MSCs and ADSCs by investigating the roles of hydrostatic pressure on the stem cells. The cell mechanics lab contains much of the same equipment I used in Dr. Bowlin's tissue engineering lab to work on my summer project. [2] Specifically, the lab hosts an electrospinner and several stem cell lines. It will be an excellent lab for me to explore the possibilities of working with other stem cell lines on electrospun scaffolds with mechanical properties related to bone, cartilage, or ligament. At this point, I cannot say for sure whether I will be continuing my work with silk as a candidate for ligament engineering scaffolds. However, it is a definite possibility. If I continue on this quest of researching preliminary results for great scaffold possibilities for ligaments, then I will electrospin different concentrations of silk fibroin blended with other polymers that will enhance the mechanical properties of the scaffolds.

After talking with the cell mechanics lab director, I will have a better idea of what I would like to do over the academic year. If it is possible, I would like to work with the mesenchymal stem cells to note the differences between MSCs and ADSCs that influence the mechanical properties of bone, cartilage, or ligament scaffolds for tissue engineering applications.

References

[1] Wang Y, et al 2006 Stem cell-based tissue engineering with silk biomaterials Biomaterials 27 6064-6082.

[2] Cell Mechanics Laboratory at NC State University <http://www.bme.ncsu.edu/labs/cml/>