Final Report for Period: 08/2009 - 07/2010
Submitted on: 11/05/2010
Principal Investigator: Gleason, Rudolph L.
Award ID: 0726274
Organization: GA Tech Res Corp - GIT
Submitted By:
Gleason, Rudolph - Principal Investigator
Title:
BioMechanics & Remodeling of PGS-Derived Tissue Engineered Arteries

Project Participants

Senior Personnel

Name: Gleason, Rudolph
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wang, Yadong
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Name: Howell, Daniel
Worked for more than 160 Hours: Yes
Contribution to Project:
Daniel is pursuing his PhD in Bioengineering at Georgia Tech and has been the lead student on this project.

Undergraduate Student

Name: Skala, Alison
Worked for more than 160 Hours: Yes
Contribution to Project:
Alison has spent two semesters in our lab. Alison has designed and built two bioreactors and helped to modify our existing device to incorporate an ultrasound system to measure vessel wall thickness.

Name: Chaudhury, Rafeed
Worked for more than 160 Hours: Yes
Contribution to Project:
Work under the direction of Daniel Howell to construct PGS scaffolds and participate in cell culture used to generate the tissue engineered blood vessels.

Name: Zhao, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:
Work under the direction of Daniel Howell to construct PGS scaffolds and participate in cell culture used to generate the tissue engineered blood vessels.

Name: Zhu, Andy
Worked for more than 160 Hours: Yes
Contribution to Project:
Andy assisted in fabricating PGS scaffolds and scaffold-derived tissue engineered blood vessels.

Name: Skelton, Sarah

Worked for more than 160 Hours: Yes

Contribution to Project:

Sarah assisted with cell culture for use in scaffold-derived tissue engineered blood vessels.

Name: Tian, Harvey

Worked for more than 160 Hours: Yes

Contribution to Project:

Harvey assisted with several aspects of this project, including fabrication of the PGS scaffolds for tissue engineering and cell culture. This was Harvey's first research experience as an undergraduate. He plans on pursuing a graduate degree in Bioengineering at Cornell next Fall.

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

University of Pittsburgh

Yadong Wang, the co-PI, moved from Georgia Tech to Pittsburgh during this award period. Dr. Wang synthesized the PGS in their lab and sent it to Georgia Tech, where Dr. Gleason's (PI) laboratory group fabricated PGS-scaffolds for tissue engineered blood vessels.

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

The research objectives of this proposal are to develop unified mathematical and experimental frameworks to characterize remodeling TEBVs derived by seeding smooth muscle and endothelial progenitor cells on a biodegradable polyglycerol sebacate (PGS) scaffolds. In particular, this work will characterize the role of scaffold mechanical properties and multidirectional mechanical stimuli on the evolution of the microstructural organization and biomechanical behavior of PGS-TEBVs throughout culture.

This project has two specific aims, with a total of five milestones. We have made significant steps toward completing these aims. We expect this proposal to generate four peer-reviewed publication. One already published and three in press. Although the fund period is over, the Ph.D. student supported by this award will be supported by Georgia Tech on a Teaching Assistantship until these papers are completed and the student graduates.

Findings:

1. We have greatly improved the design of our bioreactor and biomechanical testing device to allow for proper performance of the proposed experiments. These findings were presented in Zaucha et al., 2009. In addition, we have built several simpler bioreactors that allow for parallel culturing of several TEBV to provide a mechanism of screening different experimental protocols.

2. We have developed a mathematical model and are performing simulations for remodeling of these PGS scaffold derived TEBV in response to altered mechanical loading and altered scaffold mechanical properties. With these simulations, we plan to computationally test competing hypotheses regarding the underlying mechanisms of the remodeling process and perform parametric studies to identify key parameters that may be adjusted in our experimental protocols to identify the most insightful experiments to be performed. The publication presenting these findings

is current in preparation; we expect to submit this paper in January 2011.

3. We have conducted studies to quantify the role of scaffold fabrication temperature and time on the mechanical properties and degradation rates of PGS-derived scaffolds for tissue engineered blood vessels. In these studies, we systematically varied the curing temperature and curing time and quantified scaffold degradation rates and mechanical properties. This data are currently lacking in the literature, and are essential in controlling scaffold behavior. We expect to submit this paper in March 2011.

4. We have conducted numerous experiments to culture the PGS scaffold derived tissue engineered blood vessels (TEBV) under altered mechanical loading. These experiments have required numerous iterations to trouble-shoot our experimental device to allow for successful completion of the experimental protocol. The load control protocols originally proposed were deem challenge. As a result, we have modified the experimental protocol to strain-controlled experiments of PGS-derived tissue engineered blood vessels. These experiments are underway and are yielding exciting results. We have additional experiments to run, but we expect that these findings will be submitted for publication in May 2011.

Training and Development:

Daniel Howell, PhD student. Daniel has gained a great deal of new training from this project, including cell and tissue culture techniques, experimental device design, LabView programing, biomechanical testing, and applied modeling in mechanics. In addition, Daniel has had the opportunity to oversee the activities of one undergraduate student conducting research.

Alison Skala, Undergraduate student. This was Alison's first research experience in her career. Alison learned basic cell and tissue culture techniques, biomechanical testing, and experimental device design. During her time in our lab, Alison designed and built two bioreactors that offer simpler set-up and higher through-put of vessels for screening experimental protocols. This experience has, in part, motivated Alison to pursue a graduate degree in Bioengineering. She went on to completer her M.S. from Stanford.

Rafeed Chaudhury, Undergraduate student. This is Rafeed's first research experience. He has learned cell culture techniques and methods for fabricating PGS scaffolds for tissue engineering applications. Rafeed plans to continue research this summer and apply for a Presidential Undergraduate Research Award at Georgia Tech to work on this project. He has gone on to pursue a PhD in Bioengineering at Arizona State University.

Michael Zhao, Undergraduate student. This is Michael's first research experience. He has learned cell culture techniques and methods for fabricating PGS scaffolds for tissue engineering applications.

Sarah Skelton, Undergraduate student. This is Sarah's first research experience. She has learned cell culture techniques and tissue engineering applications.

Harvey Tian, Undergraduate student. This is Harvey's first research experience. He has learned cell culture techniques and methods for fabricating PGS scaffolds for tissue engineering applications. Harvey will begin pursuing a PhD at Cornell in Bioengineering.

Andy Zhu, Undergraduate student. He has learned cell culture techniques and methods for fabricating PGS scaffolds for tissue engineering applications.

Outreach Activities:

Journal Publications

Zaucha M, J Raykin, W Wan, R Gauvin, FA Auger, L Germain, RL Gleason, "A Novel Biaxial Computer Controlled Bioreactor and Biomechanical Testing Device for Vascular Tissue Engineering", Tissue Engineering, p. 33, vol. 15, (2009). Published, 10.1089/ten.tea.2008.0369

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

We are developing a new paradigm for mechanically stimulating tissue engineered blood vessels that involves experimental and computational components and incorporates multiaxial mechanical loading and optimization of scaffold mechanical properties. Successful realization of this paradigm will provide a new and greatly improved protocol for development of tissue engineered blood vessels.

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Conference Proceedings

Categories for which nothing is reported:

Activities and Findings: Any Outreach Activities
Any Book
Any Web/Internet Site
Any Product
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering
Any Conference