4th Annual Undergraduate Research Day

March 21

2014

Biomedical Engineering
FLORIDA INTERNATIONAL UNIVERSITY

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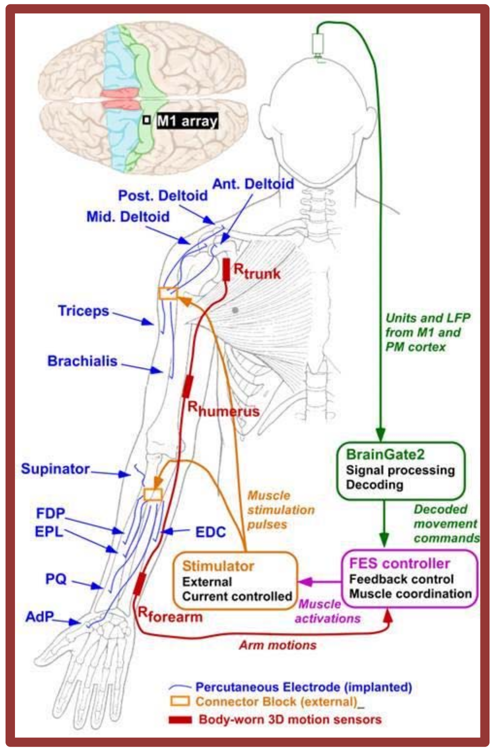

Keynote Lecture:

Generating and Controlling Arm Movements Using Functional Electrical Stimulation

FRIDAY- MARCH 21, 2014

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Executive Director
Functional Electrical Stimulation Center of Excellence
of the Department of Veterans Affairs

Presented by:

Department of Biomedical Engineering

Wallace H. Coulter Biomedical Engineering Distinguished Lecture Series

Engineering Center 2300 , Florida International University
10555 W Flagler Street, Miami, FL 33134
Map: http://campusmaps.fiu.edu/#/loc/EngineeringCenter

FIU Biomedical Engineering
FLORIDA INTERNATIONAL UNIVERSITY

Keynote Lecture:

“Generating and Controlling Arm Movements Using Functional Electrical Stimulation”

About 20% of all spinal cord injuries result in high tetraplegia - complete paralysis below the neck due to high cervical (C1-C4 level) spinal cord injury. These individuals are highly disabled and are typically entirely dependent on outside assistance for every activity essential for daily life. The currently available options for improving the functional independence of these individuals are extremely limited. Our group has been working for more than 15 years to develop an implanted neuroprosthesis that uses functional electrical stimulation (FES) to activate the paralyzed muscles of the shoulder, arm, and hand in a coordinated manner that restores the ability of the recipient to use their upper extremity in functional activities. This presentation will summarize the activities of my group to develop this approach, including: (1) the use of modeling and simulation to establish initial feasibility of the FES system, to develop feedback control systems, and to provide a virtual arm interface for initial evaluations of user interfaces, (2) the evaluation of several novel user command interfaces (including implanted brain recordings) to allow the user to direct the actions of their arm and hand , and (3) the final integration of all these components into a functional system that has been surgically deployed in two individuals with high tetraplegia.

Program:

11:00 am (EC 2300):	Speaker Lunch with FIU BME Students
11:45 am	Poster Setup (Panther Pit)
12:00 pm	Poster Session (Panther Pit)
3:00 pm	Keynote Lecture (EC 2300)
4:30 pm	Poster Award Ceremony (EC 2300)
5:00 pm	Reception (Panther Pit)

Abstracts

P1: High Oscillatory Shear Stress and Steady-Flow Effects On Marrow Stem Cell Valvulogenesis

Ana G. Villegas, Sasmita Rath, Glenda Castellanos, Sharan Ramaswamy
Department of Biomedical Engineering, Florida International University

Abstract

One of the limitations of current heart valve replacements is their inability to remodel. For this reason, tissue engineered heart valves serve as a potential permanent treatment with the possibility of adapting using the patient's own cells. Bone marrow stem cells (BMSC) have been explored for several tissue-engineering applications. In heart valve tissue engineering, however, the unique challenge is that both the endothelial cell and smooth muscle cell/fibroblast phenotype must be supported. In order to obtain the target valve phenotype, BMSC are being subjected to steady flow environment in custom-built bioreactor and the effect after a period of two weeks is being analyzed. Native heart cells are initially subjected to fluid-induced oscillatory stresses. Based on literature evidence, oscillatory shear stress may also play a critical role in heart valve tissue engineering by promoting bone marrow stem cell differentiation towards the valve phenotype. Thus, this project will also investigate the effect that high oscillatory shear stress has on bone marrow stem cell differentiation.

P2: Optimizing Elastomeric Heart Valves via Ceramic Particulate Reinforcement

Angie Estrada, Makensley Lordeus, Danique Stewart, Cheng Zhang, Rupak Dua, Arvind Agarwal, Sharan Ramaswamy
Department of Biomedical Engineering, Florida International University

Abstract

Heart valve disease is classified as the third most common heart complication in the United States (Northwestern Memorial Hospital, 2013). Prosthetic replacements such as mechanical and fixed-tissue xenograft valves are now commonplace but have severe limitations, including the need for lifelong anti-coagulant therapy and the tendency for substantial calcification, respectively. Elastomeric valves have the potential to overcome these limitations and concomitantly deliver on hydrodynamic functionality owing to their similar material response to native valve tissues. However, such valves are prone to early leaflet tearing. In this study, we proposed that the incorporation of ceramic particulate reinforcement to the silicone substrate would result in a composite material that could be formed into a valve with significantly improved tensile properties, which in turn could lead to enhanced durability. Specifically, we examined the utility of graphene nanoplatelets to serve as the ceramic reinforcing component. Graphene nanoplatelets were introduced to silicone in 10:1, 3:1, and 1:1 ratios. The composite materials were then subjected to tensile testing (Bose Electroforce 3200, Bose Inc., Eden Prairie, MN) and compared to corresponding silicone-only controls. Testing was subsequently repeated in saline solution at 37°C. The results demonstrated that the composites exhibited stronger and stiffer material properties compared to silicone alone. We are currently fine-tuning the fabrication process of the composite materials so that they can be formed into the shape of tri-leaflet valves for hydrodynamic evaluation. In addition, we are exploring the use of carbon nanotubes as an alternative particulate reinforcement for silicone, whose response may be similar to collagen fibrils in native heart valve tissues when subjected to tensile loads. In the future, elastomeric composite valves could serve as prosthetics independent of blood-thinning treatments and repeated, life-threatening open heart surgeries.

P3: Novel In-Vitro Model of Epilepsy Using iPSC Techniques

Anthony Giordano, Jared Leichner, Wei-Chiang Lin
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Abstract

Epilepsy is a neurological conditioned most associated with excessive unprovoked seizures. It is believed that genetic mutations play a vital role in causing epileptic seizures. To prove this the project focuses on creating an in-vitro model of epilepsy using iPSC techniques. This involves obtaining neural tissue from rats, converting them into stem cells, and then regrowing them in a petri dish to see if they keep the same genetic mutations that were present in the epileptic neural tissue. To validate the model the project will use Western Blot and RTPCR to study the presence of the genetic mutations and the affected proteins they encode. Due to time limitations (as the time the poster was written) we were not able to create the model using iPSC.

P4: Large Scale Analysis of Ion Channel Gene Expression in Rat Aortic Smooth Muscle Cells and Rat Mesenteric Artery Tissue

Daniel A. Rodriguez, Isabella G. Febbo, Adam Kapela, Nikolaos M. Tsoukias
Department of Biomedical Engineering, Florida International University

Abstract

Membrane bound proteins such as ion channels, transporters and receptors found in vascular endothelial cells (ECs) and smooth muscle cells (SMCs), have been recognized as key regulators of vascular tone and may contribute to the hypertensive phenotype. This study aims to examine the mechanisms that regulate gene expression of membrane proteins associated with Ca^{2+} mobilization, cell electrophysiology and vessel tone. Cultured rat aortic microvascular SMCs (LRASMC) and rat mesenteric artery tissue were harvested and dissected, respectively, in order to obtain purified RNA and cDNA. Primers were constructed for genes such as Transient Receptor Potential ion channels (TRPM, TRPC), inward rectifier Potassium channels (Kir), Voltage regulated Calcium channels (Cav), and Housekeeping genes, (Acta2, β-actin. PECAM-1). A Real-Time PCR System (Applied Biosystems' StepOne™) was used to record gene expression. This study will investigate expression changes in cells exposed to stresses. A detailed mathematical model will assess the effect of altered gene expression on cell phenotype.

P5: Development of an Organ-Level Heart Valve Bioreactor

Gina Brignola, Daria Tarighy, Diego Ramirez, Daniel Guyton, Shaaran Ramaswamy
Department of Biomedical Engineering, Florida International University

Abstract

There is a need in clinical medicine for tissue-engineered heart valve replacements. In order to grow functional valve replacements, stem cells and growing tissue must be exposed to the proper in vivo conditions, including applicable stresses and strains. In the in vitro setting, this is done through devices called bioreactors. The majority of bioreactors on the market today are capable of conditioning tissue, however they are extremely complex and costly devices and often cannot accommodate the full-organ structure. Therefore, there exists a demand for a less-complex, less costly device capable of conditioning the full organ structure properly. This project focuses on the development of such a device. The bioreactor system consists of a cylindrical valve-containing unit that houses a developing full-sized tri leaflet valve. The unit is connected to a blood pump that simulates the action of the left ventricle, delivering a set volume of fluid per unit time. Also included in the system are pressure transducers that are capable of monitoring transvalvular pressure and a flow probe that will be used to assess flow through the valve. Tissue development will be assessed in three valve samples via a collagen assay.

P6: Quantitative assessment of neuromechanical control in lower limb amputees during prosthetic limb fitting sessions

Juan Loayza, Anil Thota, Ranu Jung
Department of Biomedical Engineering, Florida International University

Abstract

In US alone, approximately 1 million individuals are living with lower Limb (LL) amputations due to various pathological and traumatic conditions such as diabetes and auto accidents. A significant number of amputees opt for fitting a prosthetic limb that provides mobility and increases their ability to perform activities of daily living (ADL) (e.g. shopping). Early adaptation to use of the prosthetic limb can help the amputee perform ADL efficiently could lead to faster re-integration into society after amputation and improve their quality of life. To obtain a good fit, the prosthetists make iterative adjustments to the several alignment parameters of the prosthetic limb. Evaluation of the adjustments (goodness of fit) are made by the prosthetist through visual inspection for abnormalities in sitting, standing, walking and balancing motor tasks performed by the amputees while wearing the prosthesis. They also rely on verbal feedback from the amputee. Because of this subjective assessment, the fitting process is highly variable between prosthetists and the goodness of fit has not been quantified yet.

P7: Calibration of a Spectroscopy Imaging System for Intraoperative Brain Tumor Demarcation

Lashawnta Goss, Yinchen Song, Arnold Joasil, Wei-Chiang Lin,
Department of Biomedical Engineering, Florida International University

Abstract

Brain tumors for the most are indiscriminate of age, however, they can be particularly devastating to one of the most vulnerable groups in our society, children. According to the American Cancer Society, brain tumors are the second most frequent form of cancer in children with nearly 4,000 new cases diagnosed every year. Common treatments for brain tumors include radiation therapy, chemotherapy, and surgery. Of these three modalities, surgery is the most preferred method for children. In order to achieve complete brain tumor eradication and minimize the impact on normal brain tissues during surgery, accurate brain tumor demarcation must be performed pre- and intra-operatively. This can be done with the aid of CT/MRI studies, physical inspection, ultrasonography, or intraoperative MRI. However, each of the methods possesses crippling drawbacks such as lack accuracy, high cost, and extreme invasiveness. A spectroscopy imaging system has been developed by our research group to perform intraoperative brain tumor demarcation. It differentiates between healthy and tumorous brain tissue based on their varying optical properties, specifically the absorption and scattering coefficients. In order to accurately measure optical properties from in vivo brain tissue, the spectroscopy imaging system was carefully calibrated using optical tissue phantoms. The phantoms were prepared using India ink (absorber), polystyrene microspheres (scatterers) and polydimethylsiloxane. An optical system was developed to measure diffuse reflectance (Rd(lamda)) as a function of source-detector separation (d) from the tissue phantoms. The measured Rd(lamda,d) were then converted to absorption and scattering coefficients by employing a Monte Carlo simulation model for photon migration, which formed a set of standardized values for calibration. The optical properties of the tissue phantoms were again measured using the spectroscopy imaging system, and they were compared with the standardized values to ascertain the accuracy of the system. This calibration process allows the guiding system to precisely discern tumors at the resection front, potentially increasing the successfulness of brain tumor surgery and improving overall patient well-being.

P8: Practicing Preksha Meditation affects Cognitive and Pulmonary Function

Laura Anderson[1], Gabrielle Roman[1], Samani Unnata Pragya[2], Amy K. Starosciak[1], Mohamed Abdelghani[1], Noah DeLone[1], Oceanna Marr[2] , Ranu Jung[1]

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Abstract

Meditation has been used as a means of increasing relaxation, cognitive ability, emotional well being, and health. It is hypothesized that by learning the correct method of Preksha Meditation a significant change will be observed in the subject's pulmonary and cognitive function. Physiological and cognitive testing was performed on 47 randomly selected university students. The tests were performed before the meditation session began as well as after the last meditation session was completed. Participants were trained in one of two meditation styles for 9 weeks. In each case, the meditation session lasted approximately 20 minutes. At the end of 9 weeks, subjects practiced there taught style of meditation while EEG was recorded, followed by post assessment tests for cognitive function that included the Connors test for attention, Automated Working Memory Assessment (AWMA) , and PANAS (Positive and Negative Affect Schedule). Pulmonary function assessments were performed utilizing the MircroLife PF 100 to measure Peak Expiratory Flow and the EasyOne Plus Frontline Spirometer to measure lung function. Cognitive and pulmonary test data were analyzed using SPSS software to determine if any significant changes were observed in respiratory or cognitive ability. To measure EEG, a recording cap with 64 Ag-AgCl electrodes in the international 10/20-configuration scalp (Waveguard 64 cap, ANT-Neuro, Netherlands) was placed on the head and electrode gel was used to make contact with the scalp. The EEG signals were analyzed (ASA Software, ANT-Neuro) by performing a Fast Fourier Transform (FFT). Preliminary results of the PANAS test indicated that some participants reflected a significant decrease in their overall negative emotional state while the AWMA indicated an enhancement in memory. No significant improvement was seen from the Connors attention test nor for any of the pulmonary assessments. In the EEG analysis, theta and beta but not alpha waves were seen to have an increase from the baseline recording. These results indicate that Preksha meditation brings forth a neutral emotional state while enhancing working memory.

P9: Bio-electrical Signal Acquisition from Excitable Cells Derived from Pluripotent Stem Cells Using Field Programmable Analog Array (FPAA)

Liset Rodriguez, Yen-Chih Huang
Department of Biomedical Engineering, Florida International University

Abstract

Stem cell research provides the potential therapeutic solutions for the current untreatable diseases such as heart failure, diabetes, osteoarthritis and different neurological diseases. Especially, pluripotent stem cells (PSCs) have the unlimited self-renewal capability and are able to differentiate into any cell types in the body. Therefore, human PSCs are not only the valuable cell sources for regenerative medicine, but also offer the useful model for understanding the underlying mechanisms of diseases. However, following the embryonic development process for differentiating pluripotent stem cells, the differentiated cells mostly exhibit as immatured phenotypes as compared to the differentiated cells in the adult tissues. Therefore, how to characterize the cell phenotypes and evaluate their function is the important task. For excitable cells like neural and muscle cells, the evaluation of electrophysiological functions provides important data for understanding the behaviors of the differentiated cells. In this research, we use a novel hardware called Field Programmable Analog Array (FPAA) to acquire, process and analyze electrical signals from excitable cells derived from PSCs. FPAA with the build-in analog blocks (CAB) and interconnections enables the user to configure the device suitable for different analog signal acquisition, process and analysis. The program configured in the FPAA was validated by using simulated signals from the functional generator. Finally, the configured FPAA device is used to acquire, process and analyze the extracellular electrical signals obtained from differentiated cells such as neurons and cardiomyocytes.

P10: Engineering human auricular cartilage derived from human pluripotent stem cells

Sandra Bernaza, Yen-Chih Huang
Department of Biomedical Engineering, Florida International University

Abstract

Tissue engineered cartilage has been shown to be a promising solution for pathologies such as arthritis, defects in the joints or even cleft palate. Engineering auricular cartilage can be very useful for the treatment of patients who suffered from trauma in the ear or who were born with defects on their native auricular cartilage such as microtia. Previous research has been focused on the development of auricular cartilage using scaffold materials and chondrocyte derived from cartilage or other sources. This approach has been unsuccessful because the cells are not able to generate sufficient extracellular matrix to support themselves, therefore once the scaffold material degrades the structure collapses. The objective of this study was to develop a method for engineering auricular cartilage by using human pluripotent stem cells and a scaffold-free approach. We already developed the method to differentiate human pluripotent stem cells into the lineage of chondrocytes and the differentiated chondrocyte could further assembly into 3D aggregates to form cartilage tissues growing from micrometer size to centimeter size. Based on the data of real-time PCR, immuno- fluorescent staining and alcian blue staining, the engineered cartilage exhibits most characteristics typically found in the native cartilage. Therefore, we hypothesized that small pieces of engineered cartilages derived from human pluripotent stem cells can fuse together to generate the shape of auricular cartilage and maintain their structure if they are placed in a mold, without the need of scaffold materials. Paraffin was used to create the mold of an ear in a reduced scale and then Polydimethylsiloxane (PDMS) was used to create a negative mold that was used to support the formation of auricular cartilage. Aggregates of cartilages were deposited in the mold and allowed to proliferate and deposit extracellular matrix while forming the ear structure. When the small pieces of cartilage aggregated together, they fused and generated enough extracellular matrix to maintain the whole structure. In summary, this scaffold-free approach may provide a novel way to generate the auricular cartilage in the full size form.

P11: Cognitive and Metabolic Effects of Nanoparticles on Deep Brain Activity

Winnie Medina[1*], Vidya Sagar[2*], Hong Ding[2], Jared Leichner[1], Jihye Bae[1], Karla Munoz Caamano[2], Madhavan Nair[2], Jorge J. Riera[1]
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* Equal Contributions

Abstract

Metallic nanoparticles (MeNP) offer an effective mechanism for the treatment of induced neurological dysfunctions caused by opiate abuse and HIV infection (Nair et al, 2011). They offer an efficient and targeted drug delivery to the central nervous system (CNS) by promoting blood brain barrier (BBB) entry and migration. This study encompasses a proteomic and behavioral analysis of mice treated with a MeNP dose and the effects caused on deep brain homeostasis and behavioral patterns. The purpose was to enhance targeted and specific treatment route while avoiding adverse metabolic and cognitive activity. It was hypothesized that the proposed dose will not cause altered hypothalamic homeostasis and function on treated mice. This premise was verified with the analysis of glutathione synthetase expression and CNS impairment. In addition, a behavioral study on spatial memory and psychophysical variables evaluated the presence of cognitive deficits on the mice upon treatment. It was concluded the existence of relevant toxicity on the MeNP and the administered dose must be re-evaluated on further studies. This study served as a significant method of assessing multiple variables that indicate the effects exerted by pharmacological drugs on neurological activity.

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