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Department of Biomedical Engineering

Graduate Research Day

Friday, February 2nd, 2018

Nathalie Nuñez, MS

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Monica Perez, Ph.D.

Associate Professor, Department of Neurological Surgery

University of Miami

"Neural Control of Grasping After Spinal Cord Injury"

Presented by:

Wallace H. Coulter Biomedical Engineering Distinguished Lecture Series

FIU Department of Biomedical Engineering

Florida International University, Engineering Center 2300

10555 W Flagler Street, Miami, FL 33174

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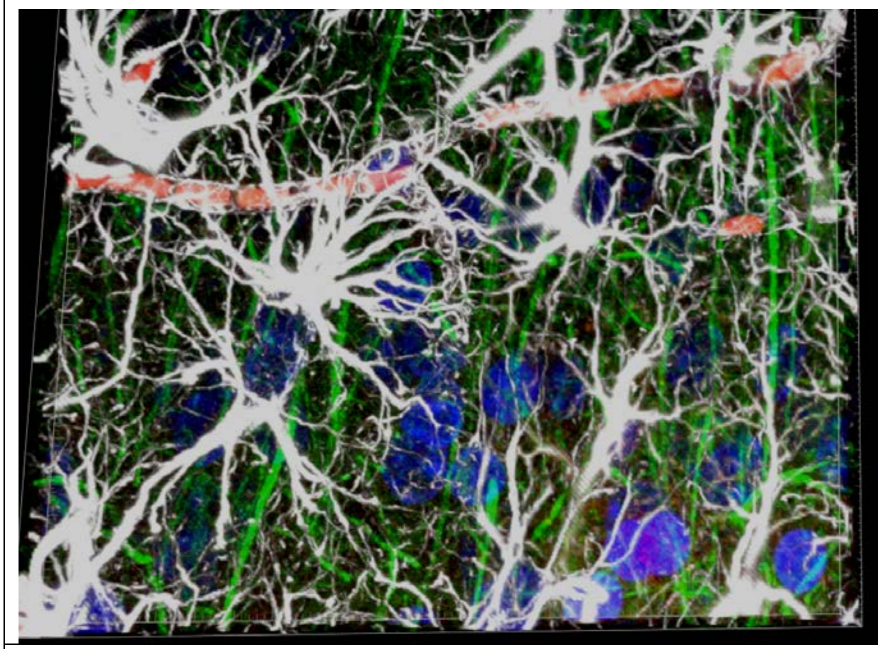
Network Architecture & Connectivity Analysis of Cortical Brain Tissue through Simultaneous Immunofluorescent Staining of Neurons, Astrocytes, Vasculature and Nuclei

Authors

Jared Leichner

Faculty Adviser Dr. Wei-Chiang Lin



Abstract

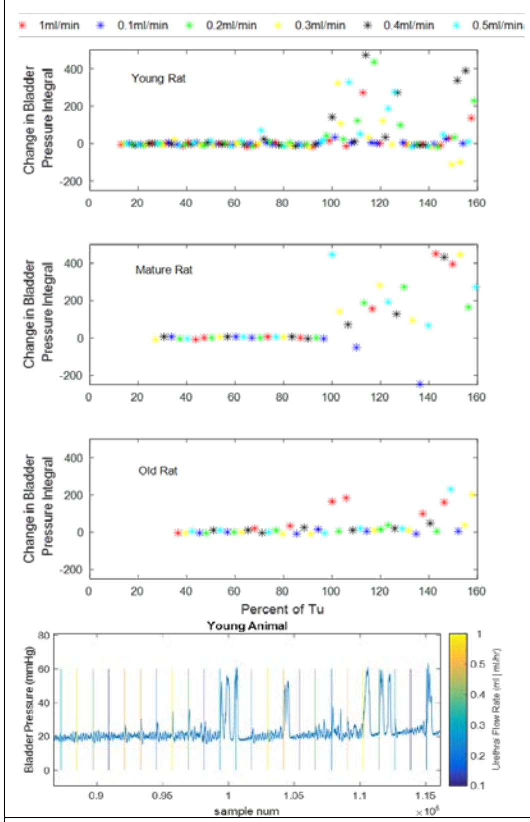
Comprehending the interwoven network architecture of neurons, astrocytes and vasculature within cortical brain tissue requires a resolution fine enough to identify detailed cellular morphology and a stitched multi-panel dataset large enough to extract tissue-level characteristics. These goals are accomplished through confocal fluorescence microscopy. This project proposes a novel combination of simultaneous immunofluorescent staining targets alongside an optimized staining and imaging methodology for cortical brain tissue that highlights four key components – neurons, astrocytes, vasculature and nuclei – while collecting large cortical column datasets [800 µm x 3 mm x 70 µm] at extremely fine spatial resolutions [0.2 µm x 0.2 µm x 1 µm]. Utilizing the morphological cellular information generated from this sprawling topology, network analysis is performed to identify quantifiable changes in cellular connectivity that can serve as unique 'fingerprints' for specific brain regions. These region-specific characteristics will ideally aid in later identifying specific regions of diseased tissue within a larger cortical zone. An additional facet of this work is the use of point-spread-function analysis and deconvolution to analytically sharpen the microscope images and remove the effects of anisotropic broadening of fluorescence emission due to aberration induced defocusing. Through a novel depth-dependent PSF collection scheme, the large cortical column datasets can be iteratively de-convolved to ensure a morphologically accurate final volumetric rendering of individual cellular processes. This technique is similarly tested for deconvolution of large [1 mm x 1 mm x 1 mm] data cubes of immunofluorescently stained cortical vascular networks.

Degradation of Reflex Pathways in Rats Aged Related Neuropathy

Authors

Arezoo Gerami Pour, Zachary Danziger

Faculty Adviser Zachary Danziger



Abstract

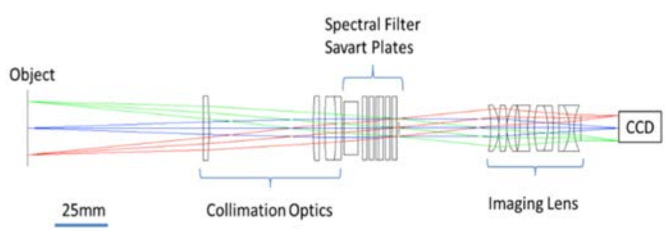
Underactive bladder (UAB) is a condition in which the strength or duration of bladder contraction decreases. A large portion of elderly people (9-48%) have UAB [1] because of the reduction in detrusor contractility or disturbances in sensory and motor nerves [2]. The focus of this study was to investigate the mediation of lower urinary tract reflexes by sensory information in older animals and their role in UAB.
Three groups of young (n=7, 4-7 month), mature (n=6, 11-14 month), and old (n=3, 19-24 month) urethane-anesthetized female Sprague-Dawley rats were used to investigate bladder and urethra reflexes in the urinary tract. The bladder was filled slowly at a constant flow rate and independently the urethra was infused with different flow rates using computer-controlled infusion pumps.
The results showed that when there is a critical volume in the bladder, fluid infusion into the urethra can trigger a bladder contraction. However, in old animals, a higher urethra flow rate is required to evoke bladder contractions than in young and mature rats. This may be caused by sensitivity loss in the urethra in older rats. In conclusion, reduced function of the urethra to bladder reflex in old animals can be a possible cause of UAB.

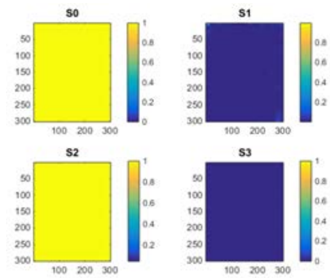
Low Cost, Portable Mueller Matrix Polarimeter for Cervical Health Determination

Authors

Mariacarla Gonzalez, Karla Montejo, Karl Krupp, Vijaya Srinivas, Edward DeHoog, Joseph Chue-Sang, Purnima Madhivanan, and Jessica Ramella-Roman

Faculty Adviser Jessica Ramella-Roman





Abstract

Cervical cancer is the fourth most common cancer for women worldwide, responsible for 260,000 deaths in 2012. That same year, in India and Eastern Africa 15 and 42.7 per 100,000 women, respectively, were diagnosed with cervical cancer. Moreover, the highest mortality comes from less developed countries, where 9 out of 10 cases result in death. Lack of regular screening and preventive care are responsible for the high incidence of cervical cancer in less developed countries. We propose a low-cost, portable Mueller Matrix polarimeter aimed for the diagnosis of cervical cancer in low resource settings. We present results of a pilot study conducted to determine the feasibility and ease of use of the device.

Assessment of Growth of Mitral Valves Fabricated from Porcine Small-Intestinal Submucosa in a Nonhuman Primate Model

Authors

Brittany Gonzalez, Lazaro Hernandez, Steven Bibevski, Frank Scholl, Vincent Brehier, Mike Casares, Jennifer Bibevski, Krishna Rivas, Pablo Morales, Jesus Lopez, Joseph Wagner, Sharan Ramaswamy

Faculty Adviser Dr. Sharan Ramaswamy

Table 1: Growth Potential of Baboon Patient with PSIS Mitral Valve Replacement

Patient	ECHO Date	Regurgitation	Left:Right Atrium Ratio	Leaflet Length (mm)	Growth Ratio	ECHO Follow-Up
16P29	7/21/17	mild	1.61	13.7		post-operation
16P29	10/6/17	trivial	1.31	15.9	0.46	3 months
16P29	11/13/17	mild	0.90	17.4	0.73	4 months

Abstract

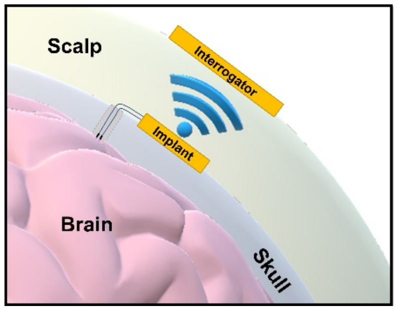
Congenital heart defects (CHD) are the most common type of birth defect affecting 8 out of every 1,000 newborns. CHD occur when there is a problem with the structure of the heart at birth, which in many cases presents in malformed heart valves. This is extremely concerning, yet more effective treatment strategies for this type of valve replacement are lacking. There are two main replacement methods to treat valve defects currently, which include a mechanical or bioprosthetic valve but neither option has the potential to grow nor are they available in sizes for infants suffering from critical congenital heart valve diseases. Tissue engineering heart valves (TEHVs) may overcome current barriers of growth, self-repair, infection resistance and could therefore provide a permanent solution to treatment of critical congenital valve disease in children. In this study, a porcine-small intestinal submucosa (PSIS) valve was implanted in the mitral valve (MV) position of one infant nonhuman primate (Hamadryas Baboons). This animal was monitored longitudinally via echocardiography (ECHO) to observe function and growth of the PSIS-valves. Our preliminary findings suggest that the growth ratio, i.e., the potential of the PSIS MV to grow, increases with the time of implanting and approaches 1, which is ideal growth.

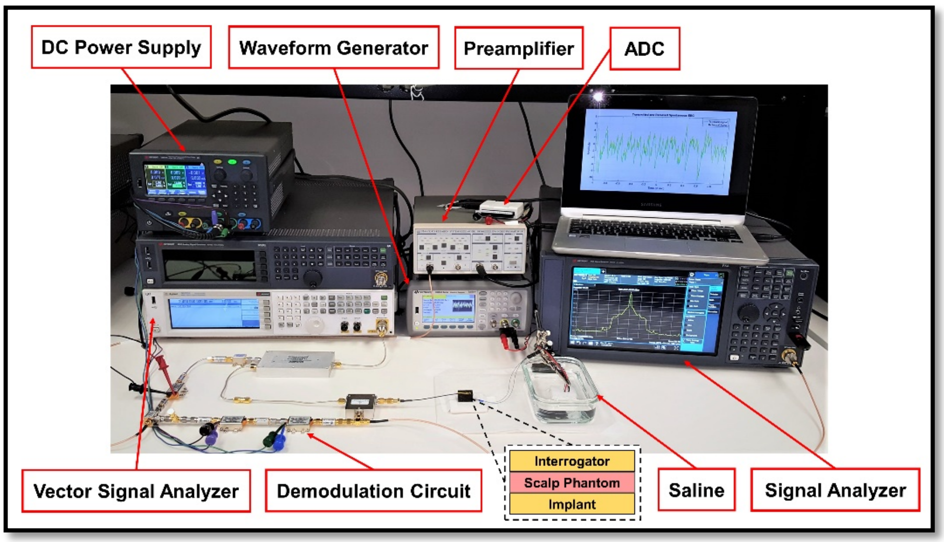
Improved Probes for Fully-Passive Wireless Recording of Neural Activation in Wistar Rats

Authors

Carolina Moncion, Satheesh Bojja-Venkatakrishnan, Jorge Riera Diaz, John L. Volakis

Faculty Adviser Dr. Jorge Riera Diaz





Abstract

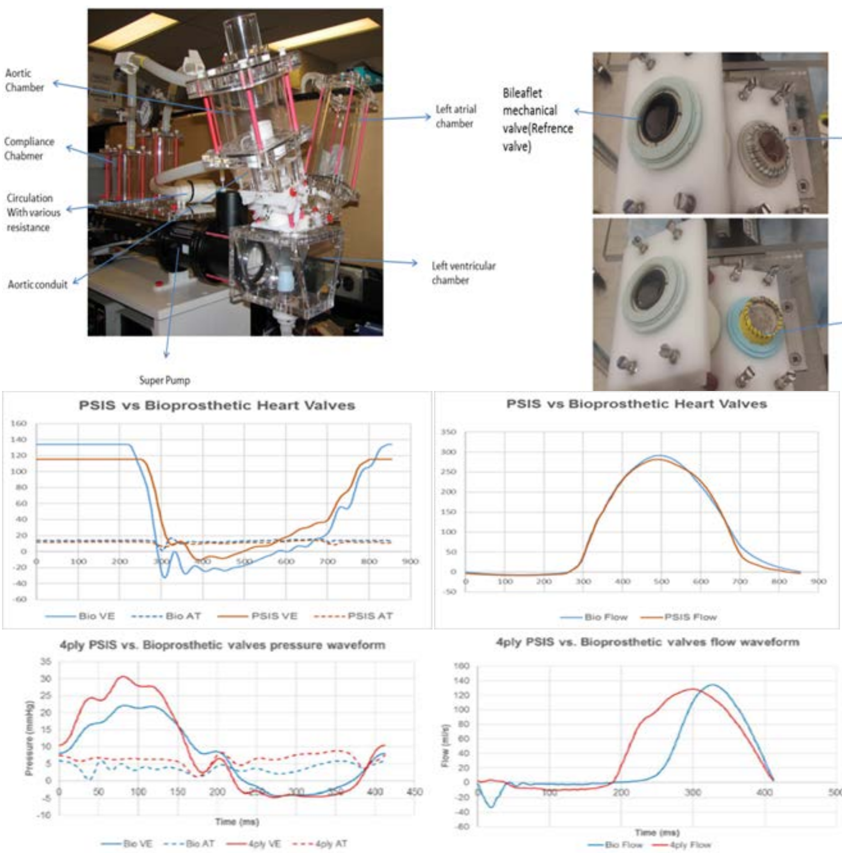
To enable continuous and localized brain electrical activity recordings, implantable neurosensing systems are often used. However, current implants entail highly-invasive procedures that can interrupt day-to-day activities. The proposed wireless and battery-less device is the first miniature implant developed and experimentally tested to obtain subdural electroencephalographic data without hindering the quality of life. For the first time, we present the design and application of a new set of neural probes specially designed for a fully-passive wireless brain implant. The integration of these neural probes to the neurosensing system provided for enhanced impedance matching to allow sensing neural signals as low as 15 µVpp to consequently improve the RF sensitivity to ~ -135 dBm. As such, all neural activity can be recorded, a concept being demonstrated with in vivo experiments in Wistar Rats.

Bioscaffold Mitral Valve Hydrodynamic Evaluation in Child versus Adult Hemodynamic Settings

Authors

Elnaz Pour Issa, Omkar V. Mankame, Lazaro Hernandez, Lilliam Valdes-Cruz, Steven Bibevski, Frank Scholl, Sarah M Bell, Ivan Baez, Sharan Ramaswamy

Faculty Adviser Dr. Sharan Ramaswamy



Abstract

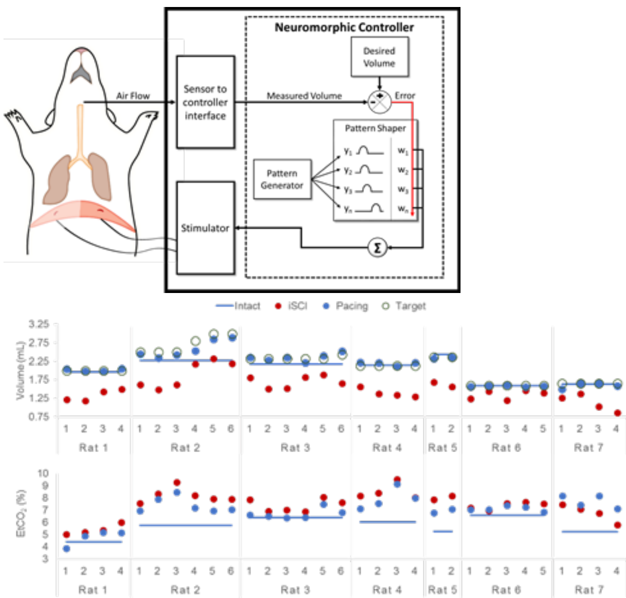
Valve replacement in the treatment of congenital valve disease is limited in children suffering from the condition. We have investigated the PSIS (Porcine Small Intestinal Submucosa) valves for pediatric valve replacement. The hydrodynamic functionality of PSIS valves is different in adult and pediatric patients. We evaluated the cardiovascular conditions for both the child and adult settings at the mitral position. Valves were inserted in the mitral location of a pulse simulator. Saline solution was poured into the atrial compartment as the fluid with a concentration of 0.9 mg/ml. Two pressure transducers were connected to the atrial and the ventricular chambers. A pump facilitated a physiologally-relevant pulsatile flow profile. The values used for the stroke volume and the heart rate were 25 ml and 145 bpm for pediatric conditions; corresponding adult conditions were 80 ml and 70 bpm respectively. Flow and pressure data were logged onto a computer. A t-test was conducted to determine if statistical significance occurred between child and adult groups ($p < 0.05$). Significant differences ($p < 0.05$) were observed in the forward flow rates and effective orifice areas (EOAs). Conversely the transvalvular pressure drop (ΔP), regurgitation fraction (Rf) and Energy Loss were not significantly different ($p > 0.05$).

Adaptive control of ventilation through respiratory pacing following spinal cord injury

Authors

Ricardo Siu, James Abbas, Brian Hillen, and Ranu Jung

Faculty Adviser Ranu Jung



Abstract

Cervical spinal cord injury can cause ventilatory impairment because of reduced or lost motor drive to ventilatory muscles. To maintain sufficient ventilation, mechanical ventilators or respiratory pacing devices are often required. Commercially-available respiratory pacing systems work in an open-loop manner and are thus unable to account for changes in muscle fatigue and metabolic demand during pacing. We have developed a neuromorphic adaptive closed-loop controller for respiratory pacing capable of self-tuning stimulation to achieve and maintain a desired breath volume via a pattern shaper (PS). This adaptive PS was implemented in an incomplete cervical spinal cord injury (iSCI) rodent model to assess controller behavior under iSCI conditions.

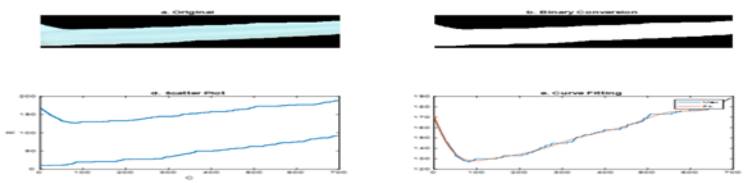
Anesthetized Sprague-Dawley rats (n=7) received a lateral C2 hemisection to create a cervical iSCI injury model. Airflow was monitored via a pneumotachometer and integrated to obtain breath volume. A CO2 analyzer monitored end-tidal CO2 (etCO2) The pre-injury volume profile served as the desired volume profile during pacing. Intramuscular stimulating electrodes were implanted bilaterally in the diaphragm. The results show that the PS controller restored breath volume to pre-injury values. A decrease in etCO2 was also observed. These results indicate that the PG/PS controller could be used to restore ventilation after impairment of ventilatory function.

A rapid and accurate assessment of aortic valve leaflet curvature

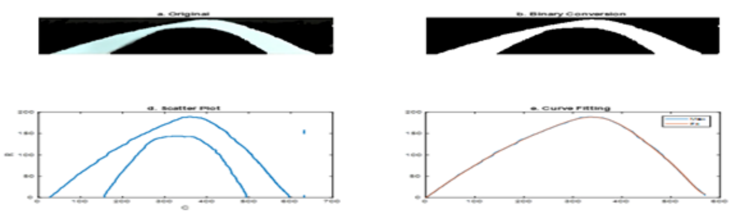
Authors

Melake Tesfamariam, Daniel Chaparro , Joshua Hutcheson, Sharan Ramaswamy

Faculty Adviser Sharan Ramaswamy



Fig(1): Unconstrained valve leaflet strip



Fig(2): Maximally- bent valve leaflet strip

Abstract

Calcific aortic valve disease (CAVD) is a major contributor to cardiovascular morbidity and mortality with its progression characterized by extracellular matrix remodeling, leading to structural abnormalities and improper valve function. In order to develop a non-invasive therapeutic strategy for CAVD, diagnostic approaches are needed to detect early valve changes before the remodeling progresses to irreversible late stages. The objective of the current study was to develop an image analysis algorithm to assess aortic valve leaflet curvature as a function of flexure. Changes in curvature may allow for noninvasive assessment of valve structure, thereby serving as a biomarker for early CAVD. In this case, valve leaflets were excised from the aortic root of porcine aortic valves and cut into rectangular segments (L x W = 12 x 3 (mm)) from each leaflet. The leaflet strips were mounted into a loading chamber and secured, which were then photographed at two configurations: unconstrained, and maximally-bent. Images were processed in MATLAB to quantify the mean curvature of the valve and the results obtained were 0.9 and 1.3 (mm-1). Since matrix components such as elastin and collagen are altered during early onset CAVD a methodology to quantify leaflet curvature like this could serve as an objective measure for early diagnosis of CAVD.

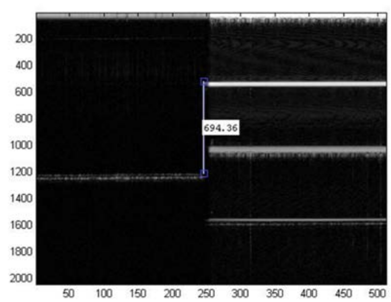
Measuring the Refractive Index of Biological Tissues Using OCT

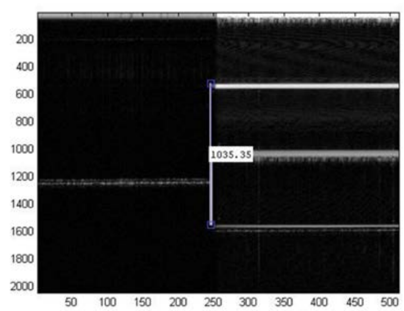
Authors

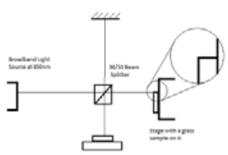
Leon Dawson

Faculty Adviser **Dr. Shuliang Jiao**

	Average	Literature	Standard Deviation	% Error
BK7	1.5035	1.5098	0.0137	0.4157
Borofloat	1.4691	1.4650	0.0170	0.2802
Fused Quartz	1.4520	1.4525	0.0045	0.0370







Abstract

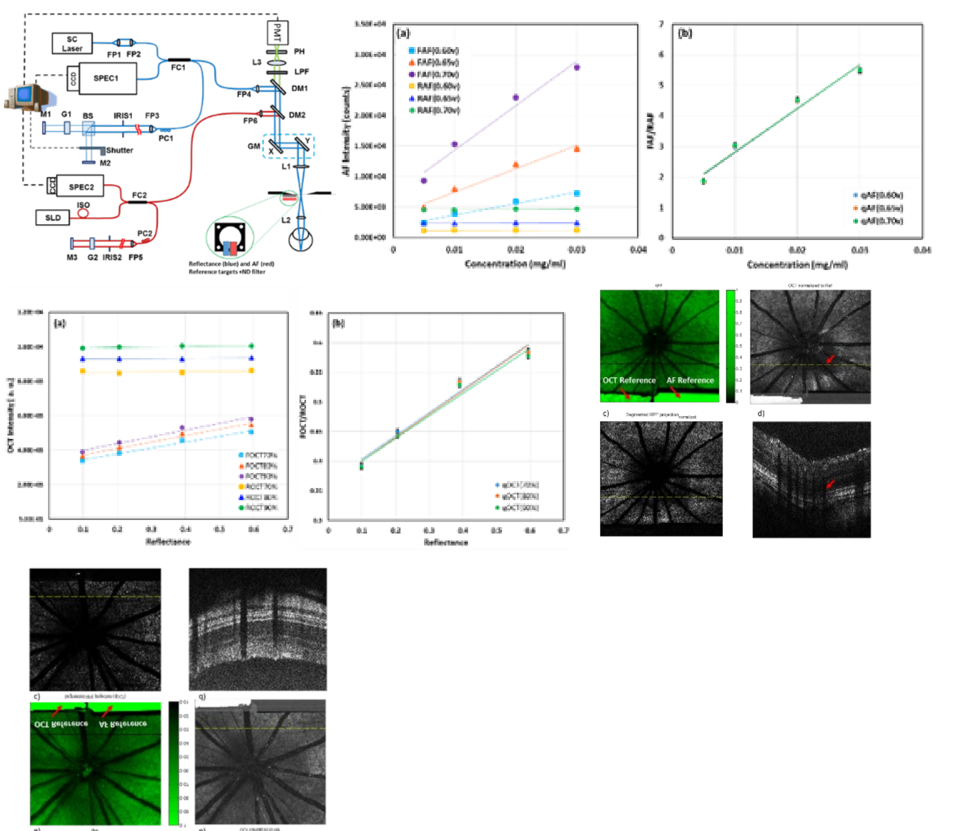
The purpose of this study is to the check the validity of the use of OCT to measure the refractive index of biological tissues as a diagnostic tool. The justification for this is that there is evidence in prostate cancer tumors causing higher refractive index variances than normal tissue regions, and a study found the presence of colorectal cancers by detecting them by measuring the refractive index. Within my research, several reference samples were measured and the average refractive index at the center wavelength of 850nm and a bandwidth of 50nm was calculated using the equation that came from Tearney et. al. The reference materials where measured; BK7, Borofloat, and fused quartz. The average value for them were 1.5035, 1.4691, and 1.4520 respectively. In future experiments, the refractive index of rat brains will be investigated with the refractive indices of the grey, and white matter being measured as well as the combination of the two. Using OCT to differentiate the refractive index of biological tissues is feasible and since certain diseases affect the structure of the tissue (such as cancer) then it should be useful in detecting the presence of certain cancers and differentiate between healthy and diseased tissues.

Visible Light OCT-based Quantitative imaging of Lipofuscin in the Retinal Pigment Epithelium with Standard Reference Targets

Authors

ZAHRA NAFAR, AND SHULIANG JIAO

Faculty Adviser SHULIANG JIAO



Abstract

Lipofuscin, a byproduct of the vision cycle of photoreceptors, is the major source of the fundus auto-fluorescence (FAF) in the Retinal Pigment Epithelium (RPE). Lipofuscin accumulates with aging and in certain pathological disorders and is thus a biomarker for degenerative retinal diseases. Lipofuscin quantification is challenged by light attenuation caused by the media anterior to the RPE which is subject to inter-individual and intra-individual differences. Further, various illumination power and detection sensitivity of different imaging systems can also affect the detection of the FAF.

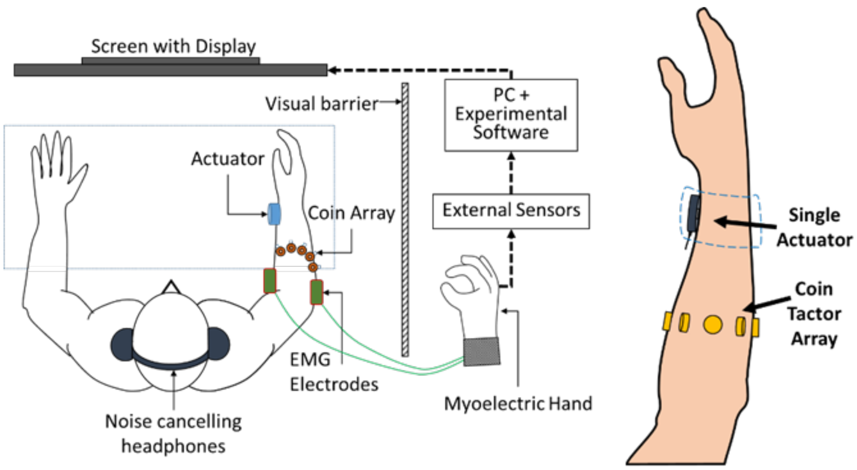
We developed a technology for quantitative retinal Auto-Fluorescence (AF) imaging for quantifying lipofuscin in the retinal pigment epithelium (RPE). The technology is based on simultaneous visible light Optical Coherence Tomography (VIS-OCT) and AF imaging of the retina and a pair of reference standard targets at the intermediate retinal imaging plane with known reflectivity for the OCT and fluorescence efficiency for the AF. The technology is able to eliminate the pre-RPE attenuation in AF imaging by using the simultaneously acquired VIS-OCT image. With the OCT and AF images of the reference targets the effects of illumination power and detector sensitivity can be eliminated. The system was calibrated and tested *in vivo*.

Effect of vibrotactile feedback and grasp interface compliance on grasp force and hand opening control of a sensorized myoelectric prosthetic hand

Authors

Andres Pena, Liliana Rincon-Gonzalez, James Abbas, Ranu Jung

Faculty Adviser Ranu Jung



Abstract

Current myoelectric prosthetic limbs are limited in their ability to provide direct sensory feedback to users, which increases attentional demands and reliance on visual cues. Vibrotactile sensory substitution is a non-invasive feedback approach which has demonstrated only limited improvement in myoelectric hand control. In this work, we investigate the effect of vibrotactile paradigms and added grasp interface compliance on the quality of control of grasp force and hand-opening by able-bodied participants using an instrumented myoelectric hand. We developed a system that delivers vibratory patterns to the forearm based on sensor readings from a prosthesis, using a single burst-rate modulated actuator, or an array of five spatially activated coin-shaped tactors. We tested the accuracy of myoelectric control and level discrimination performance during virtual target tasks. Eight participants completed force and hand-opening tasks, receiving feedback from the actuator or the array. We found that feedback from the array seems to help improve myoelectric control, as opposed to a single actuator. Next, ten participants reached force targets while grasping a stiff or compliant interface. We found that added compliance could potentially improve myoelectric control quality, depending on the feedback approach provided. These results can potentially inform the design of non-invasive feedback-enabled prostheses for combined grasp force and hand opening feedback.

Supported by NIH-R01-EB008578 and DARPA-W911NF-17-1-0022

*wave*CSD: A method for estimating transmembrane currents originated from propagating neuronal activity in the neocortex: Application to study cortical spreading depression

Authors

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Faculty Adviser Dr. Nikolaos Tsoukias/Dr. Jorge Riera

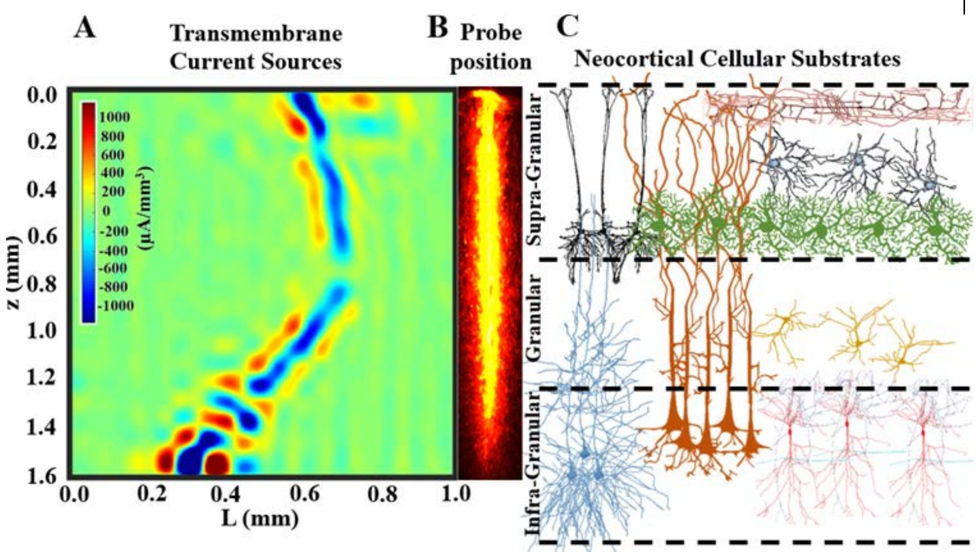


Figure 1- A) CSD analysis of transmembrane current sources during a cortical spreading depression event in rats. B) The histology image showing proper position and penetration depth of the probe in the neocortex. C) Schematic of representative neuronal populations in different layers of the rat neocortex

Abstract

Recent years have witnessed an upsurge in the development of methods for estimating current source densities (CSDs) in the neocortical tissue from their local filed potential (LFP) reflections. Among these, methods utilizing linear arrays work assume that CSDs vary as a function of cortical depth; while they are constant, infinitely or in a confined cylinder, in the tangential direction. This assumption is violated in the analysis of propagating neuronal activity, e.g. propagation of alpha waves or cortical spreading depression associated with migraine aura. In this study, we developed a novel mathematical method (waveCSD) for the CSD analysis of LFPs associated with a planar wave of neocortical neuronal activity propagating at a constant velocity. Results show that the algorithm is robust to the presence of noise in the LFP data and uncertainties in the knowledge of the propagation velocity. Simulations indicate that the waveCSD method has a significantly higher reconstruction accuracy in comparison with the inverse CSD method (iCSD) in the analysis of transmembrane CSDs originating from the propagation of neuronal activity. Finally, using in vivo experimental recordings from the rat neocortex, we utilized the waveCSD method to characterize, for the first time, the transmembrane currents associated with cortical spreading depressions.

Developing a mathematical model for functional uncoupling in the stomach

Authors

Ashfaq Ahmed (Polit), Ranu Jung

Faculty Adviser **Dr. Ranu Jung**

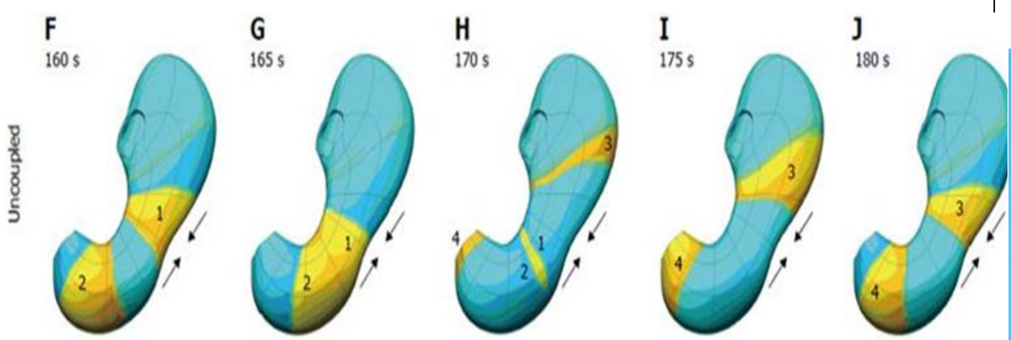


Figure: Representation of functional uncoupling in stomach

Abstract

The stomach exhibits a characteristic slow wave of contraction. Slow waves originate from dominant pacemaker cells within the stomach wall along the greater curvature in the mid-corpus and spread aborally through the antrum to the pyloric sphincter. These slow waves exhibit three primary patterns of propagation. Under normal slow wave activity, the antrum slow wave, whose intrinsic frequency is less than that originating from the corpus, is entrained by the slow wave originating in the corpus. Under some pathological states, Interstitial Cells of Cajal (ICC) in the myenteric plexus within the antral region become local pacemakers. The slow waves generated there propagates backwards and collides with the waves coming from the corpus resulting in disruption of gastric peristalsis and delayed gastric emptying (gastroparesis). This scenario is called functional uncoupling of the contractions of the stomach.

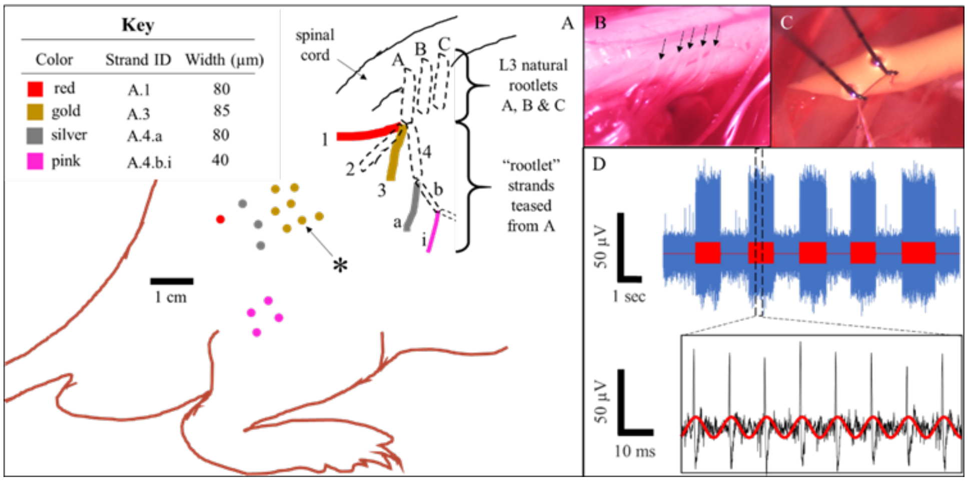
To better understand the mechanisms underlying the functional uncoupling, we are computationally modeling the slow waves as being generated either by a chain of coupled oscillators or as a chain of interconnected biophysical circuits of networks of cells. The oscillator model is based on Aliev's work2 which models the intestine as a syncytium of ICC and longitudinal muscle cells. The biophysical circuit model is based on the work by Corrias and Buist3 to mimic the propagation of the slow wave. The cells will be modeled with a frequency gradient with the rostral most cell having the highest frequency and caudal most cell having the lowest frequency. The cells will then be coupled so that all of them are entrained at the same frequency. After establishing the chain model, uncoupling will be introduced by changing the concentration of inositol trisphosphate (IP3) at different locations in the biophysical model which is supposed to change the intrinsic frequencies accordingly and changing the excitability of different cells in oscillator model.

Recording from individual axons in teased spinal cord rootlets

Authors

iian Black, Ranu Jung

Faculty Adviser Ranu Jung



Abstract

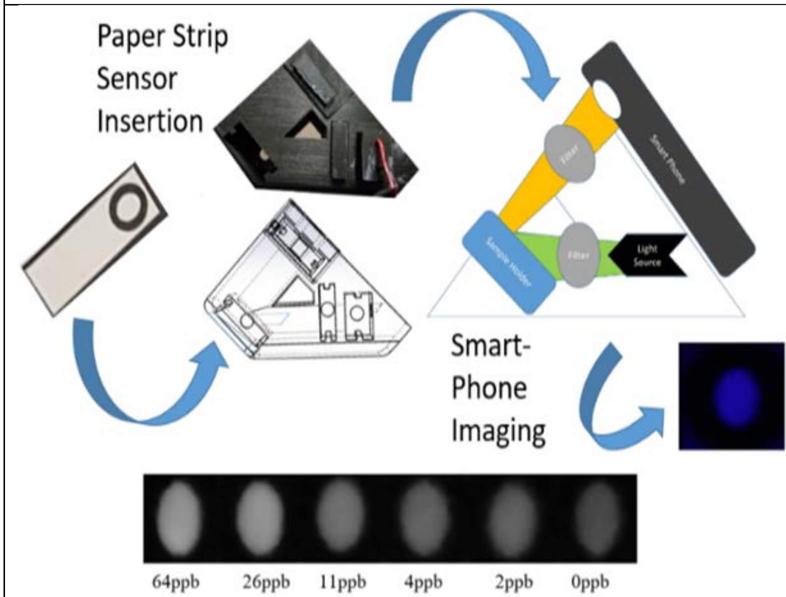
The ability to record from individual or small groups of axons in peripheral nerves is typically achieved using electrodes that penetrate the nerve. Less invasive, extraneural recording techniques, such as cuff electrodes that surround the nerve are typically unable to achieve this same degree of selectivity. However, selectivity can be improved when the diameter of the nerve is reduced. This work presents methods for teasing spinal cord rootlet nerves into smaller-sized bundles and demonstrates the ability to record from individual axons using an extraneural recording technique.

Smart-Phone Paper-Based Fluorescent Sensor for Ultra-Low Inorganic Phosphate Detection

Authors

Mehenur Sarwar, Ghinwa M. Naja, Chen-zhong Li

Faculty Adviser Chenzhong Li



Abstract

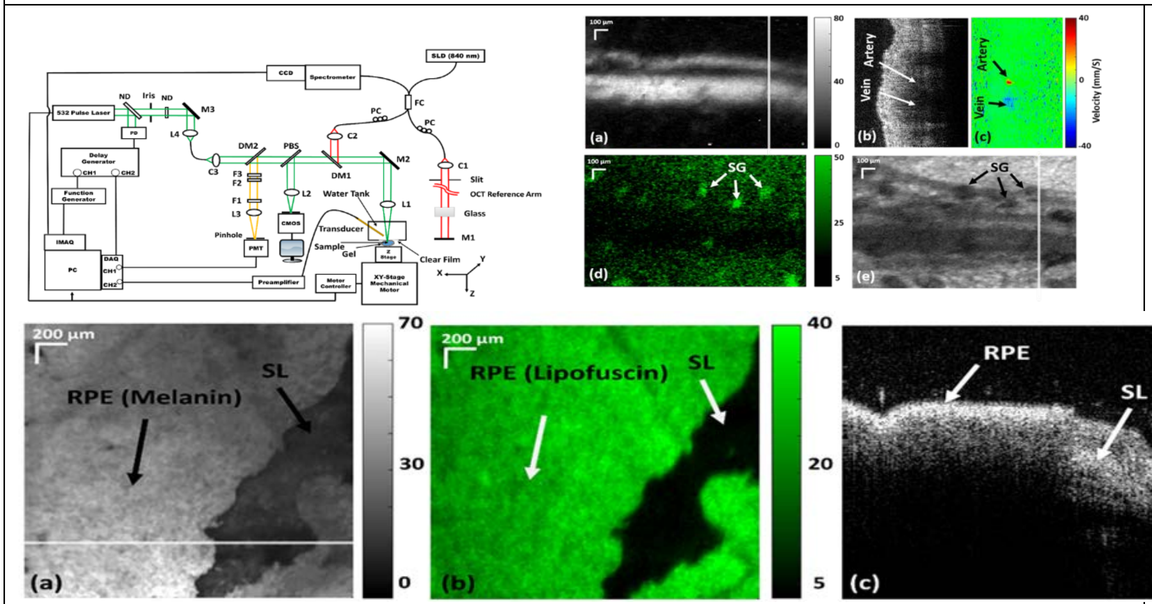
High levels of phosphate are one of the main causes for the growth and spread of algae blooms and the reduction of dissolved oxygen that accompanies eutrophication. Subsequent downstream effects of toxic algae can produce dangerous toxins which can sicken or kill humans and animals, creating dead zones in the water. The best way to reduce the incidence of these occurrences is through consistent tracking of water quality. Unfortunately, no validated technique exists until now that allow researchers to test inorganic phosphate levels at the point-of-need at the extremely low concentrations required to monitor the analyte within the relevant range. To solve this challenge, a paper-based smart-phone enabled low-cost fluorescent sensor that utilizes an environmentally-sensitive fluorophore to monitor inorganic phosphate levels was developed. The designed instrument is the only currently available method to (1) allow for point-of-need testing ("PONT") (2) of inorganic phosphate within a range encompassing the low EPA threshold (3) while allowing for instantaneous response times and (4) GPS mapping of each measurement with (5) little interference by common anions and cations. The limit of detection was found to be 150 ppt, with a linear range up to at least 80 ppb and a near-instantaneous response time.

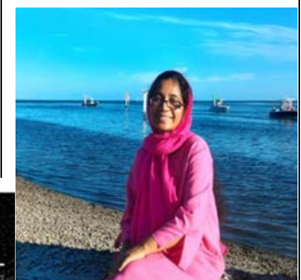
A multimodal imaging platform with integrated simultaneous photoacoustic microscopy, optical coherence tomography, optical Doppler tomography and fluorescence microscopy

Authors

Nusrat Yeasmin, Arash Dadkhah, Jun Zhou, Shuliang Jiao

Faculty Adviser **Shuliang Jiao, Ph.D.**





Abstract

Various optical imaging modalities with different optical contrast mechanisms have been developed over the past years. Although most of these imaging techniques are being used in many biomedical applications and researches, integration of these techniques will allow researchers to reach the full potential of these technologies. Nevertheless, combining different imaging techniques is always challenging due to the difference in optical and hardware requirements for different imaging systems. Here, we have developed a simultaneous multimodal microscopic optical imaging system with the capability of providing comprehensive structural, functional and molecular information of living biological tissues. This imaging system integrates photoacoustic microscopy (PAM), optical coherence tomography (OCT), optical Doppler tomography (ODT) and fluorescence microscopy in one platform. We have tested the imaging system on biological tissues both in vivo and ex vivo. The imaging studies demonstrated the capability of our developed multimodal imaging system to provide comprehensive microscopic information of biological tissues. Integrating all the aforementioned imaging modalities for simultaneous multimodal imaging has promising potential for preclinical research and clinical practice in the near future.

Computation of Oscillatory Fluid-Induced Shear Stresses on Mesenchymal Stem Cells – for Heart Valve Phenotypic Development

Authors

Alex Williams, Sana Nasim, Dr. Michael Sukop, Dr. Sharan Ramaswamy

Faculty Adviser **Dr. Sharan Ramaswamy**

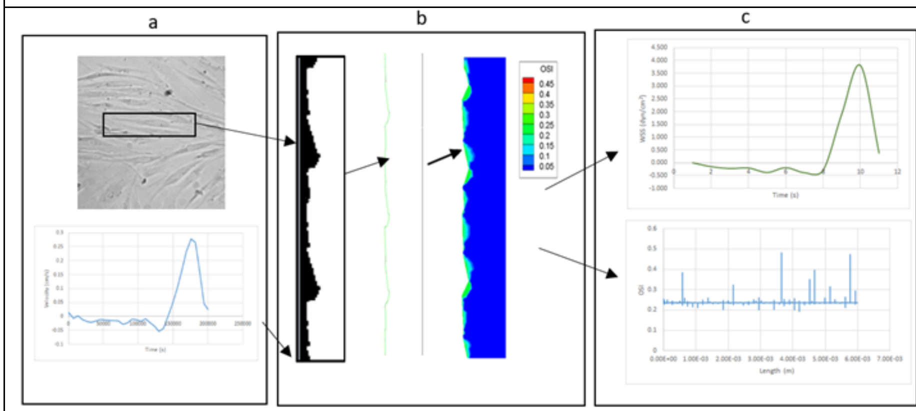


Fig. 1.: (a) Top: Cell Culture of Mesenchymal Stem Cells, Bottom: Aortic Velocity Inlet Profile (cm/s), (b) Left: Cell-seeded channel model, Middle: CFX channel geometry, Right: OSI contour of channel, (c) Top: WSS results (dynes/cm2), Bottom: OSI results

Abstract

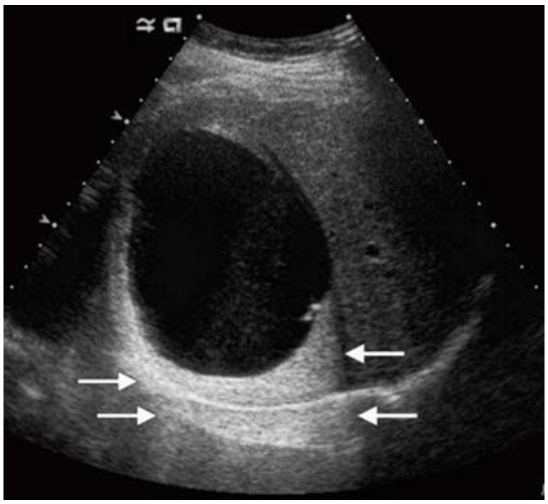
Recent studies have demonstrated that physiological blood flow induces oscillatory shear stresses (OSS), which support valvular matrix remodeling. However, there remains a need to delineate the physics present at the cellular scale since the direct triggering mechanisms via OSS-induced stimuli on mesenchymal stem cells is unknown. In the current study, we undertook a computational approach to quantify OSS microscale environments on cell morphology of relevance to heart valves. Results of time-averaged wall shear stress (TAWSS) and an oscillatory shear index (OSI), were determined. Our current model established that with physiological conditions utilized, the OSI field across the microfluidics channel plated with a monolayer of stem cells was very close to the physiological OSI range found at the valve tissue scale (0.18-0.23). This could imply that the oscillatory flow dynamics found to optimize valvular tissue phenotypic expression could similarly activate certain mechanobiological mechanisms at the cellular scale. Further investigations are currently being executed to establish the accuracy of the Navier-Stokes based numerical solution here versus approaches intended specifically for microscopic (cellular) scales (e.g. Lattice Boltzmann method).

Understanding the mechanism of the acoustic enhancement artifact for the use of ultrasound in intraoperative neurosurgery

Authors

Mohamed Almadi and Anthony Giordano

Faculty Adviser Wei-Chiang Lin, Ph.D



Mohamed Almadi: Anthony Giordano

Abstract

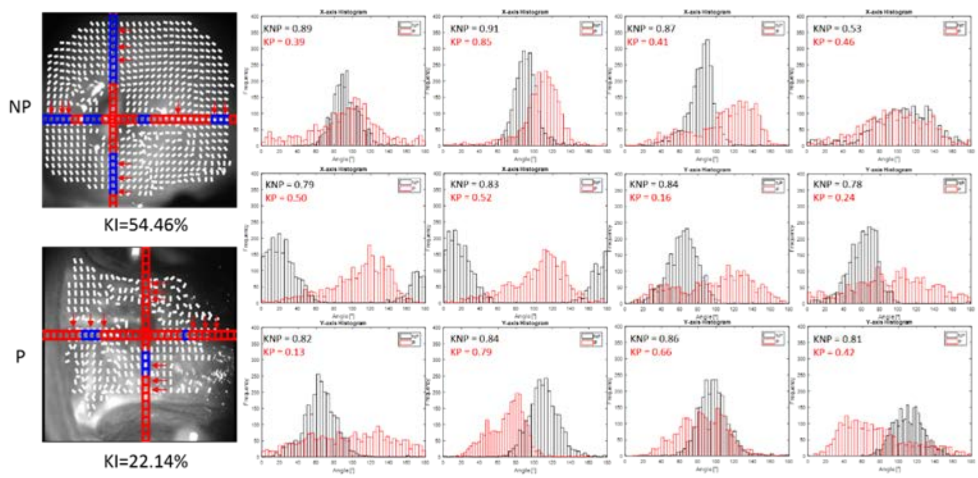
Even though ultrasound is a widely used imaging technique, there are still limitations that need to be overcome to optimize its potential in neurosurgery. One of those limitations is the hyperechoic artifacts appearing at the resection margins. This artifact limits the neurosurgeon's ability to differentiate healthy and tumorous tissue. The major goal of this project is to understand the mechanisms of the enhancement artifact so that an engineering solution can be developed to reduce or eliminate it. To accomplish this goal, a computer model was developed to simulate acoustic wave propagation in the brain under various conditions. The results of the simulation suggest that the difference in the acoustic attenuation coefficient between brain tissue and saline is the primary cause of the hyperechoic artifact. This finding was verified experimentally with the development of poly-vinyl chloride plastisol (PVCP) photoacoustic brain phantoms. The phantoms were characterized using an apparatus developed in house, to confirm that the acoustic properties of the phantom is comparable to those of the brain found in literature. Currently these brain phantoms are being scanned using a portable ultrasound system under various conditions to reproduce the hyperechoic effects. In addition, a computer algorithm is being developed to reduce or eliminate the hyperechoic artifacts in ultrasound imaging.

Comparison of collagen orientation and distribution in-vivo between non-pregnant and pregnant human cervix using Mueller Matrix polarimetry

Authors

Joseph Chue-Sang, Mariacarla Gonzalez, Nola Holness, Ilyas Saytashev, Amir Gandjbakhche, Viktor V. Chernomordik, Jessica C. Ramella-Roman

Faculty Adviser Jessica C. Ramella-Roman



Abstract

Preterm birth (PTB) presents a serious medical heath concern throughout the world and maintains a high incidence rate in both developed and developing countries ranging between 11-15%, respectively. PTB can be caused by many different morbidities and ultimately results in the disorganization of cervical collagen and the premature alteration of the cervix mechanical properties. Changes in cervical collagen orientation and distribution may prove to be a predictor of PTB. Polarization imaging is an effective means to measure optical anisotropy in birefringent materials such as those rich in collagen. Non-invasive, in-vivo full-field Mueller Matrix polarimetry (MMP) imaging was conducting using a modified colposcope in a clinical study comparing collagen orientation and distribution between non-pregnant and pregnant patients. Six patients threatening PTB were imaged at the Jackson Memorial Hospital Triage Unit and six non-pregnant patients were image at Florida International University STAR center. In pregnant women collagen distributions changed depending on patient age and number of pregnancies in the non-pregnant population age played an important role in collagen organization.

Optochemical Carbon Dioxide Sensor for Respiratory Feedback

Authors

Francis, Teshaun ; Lin, Wei-Chiang

Faculty Adviser Dr. Wei-Chiang Lin

Abstract

With the introduction of diaphragm pacing (or diaphragm stimulation), respiratory function can be partially restored to those who suffer from neuromuscular disorders. What these systems lack, however, is a feedback mechanism to adjust the tidal volume and breathing rate under changing cardiovascular conditions. Carbon dioxide in the blood and cerebrospinal fluid is a strong indicator of respiratory health, and thus makes the perfect target analyte for a continuous feedback system. Our aim is to design an optochemical sensor that can reliably monitor carbon dioxide levels in vivo. In this presentation, we describe the materials and methods used to fabricate our prototype fluorescent-based sensor, and we demonstrate its performance in response to physiologically relevant concentrations of carbon dioxide.

Tissue Oxygenation Measurements Aid Callus Removal in Patients with Diabetes

Authors

Kacie Kaile, Jagadeesh Mahadevan, Kevin Leiva, Edwin Robledo, Richard Schutzman, Cristianne Fernandez, Dinesh Khandavilli, Sivakumar Narayanan, Varalakshmi Muthukrishnan, Mohan Viswanathan, and Anuradha Godavarty

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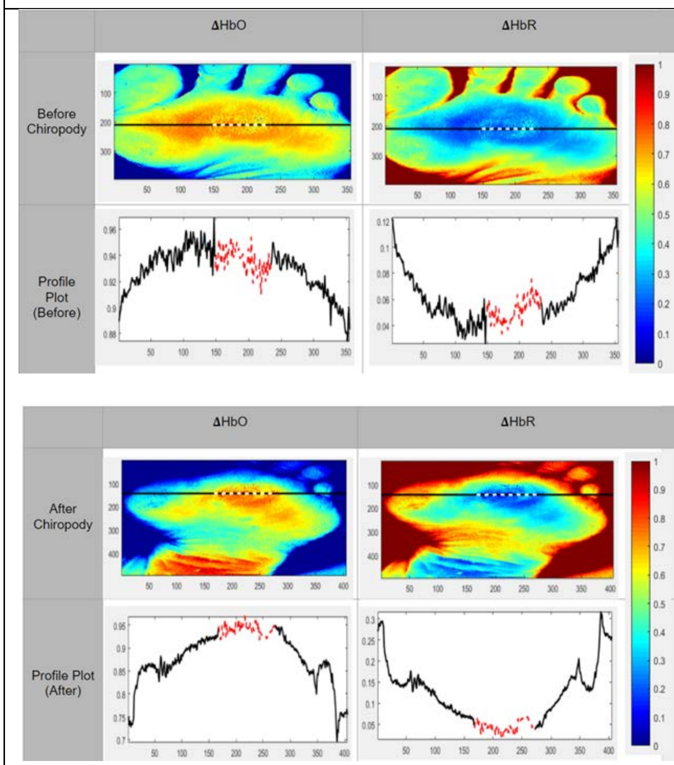


Abstract

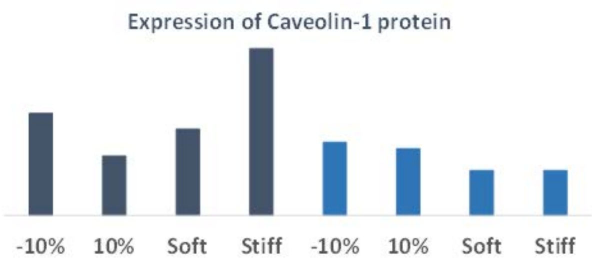
Diabetic foot ulcers (DFU's) affect more than 80% of diabetic patients, which are often associated with centralized keratin buildup, or callus. Buildup blocks surrounding tissue from normal oxygen supply and shields the practitioner from witnessing potentially severe developments beneath the callus. Scalpel debridement (or chiropody) is commonly used to remove inimical tissue, but the delicate process and its effectiveness can be limited to surgeon performance. A non-contact, handheld, near infrared, optical scanner (NIROS) is utilized to quantify changes of oxy-hemoglobin (**Δ** HbO) and de-oxy hemoglobin (**Δ**HbR), within tissues surrounding callused sites. Subjects were imaged before and after chiropody to determine if oxygenation in the callus increased through treatment. Images were analyzed for changes in oxy/deoxy-hemoglobin using modified Beer-Lambert's Law and relative tissue oxygenation maps (in terms of **Δ**HbO and **Δ**HbR) were determined. Profile plots of **Δ**HbO (and **Δ**HbR) across the callus were compared and it was found that **Δ**HbO increased (or **Δ**HbR decreased) with callus removal, except in cases with blood clots or ineffective debridement. On a long term, this non-contact portable near-infrared optical device can be used to quantify changes in tissue oxygenation, aiding in effective debridement, and potentially reducing the onset of severe, diabetic ulcer.

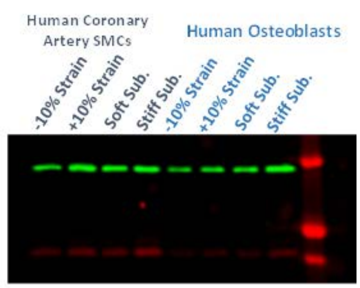
Effect of Cyclic Strain on Cell Membrane Rearrangement: Human Coronary Artery Smooth Muscle Cells vs. Human Osteoblasts

Authors

Amirala Bakhshiannik, Walter Heatherly, Joshua D. Hutcheson

Faculty Adviser Dr. Joshua D. Hutcheson





Abstract

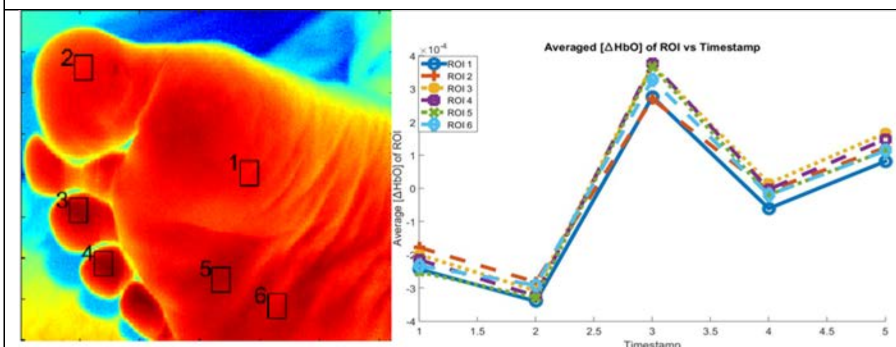
Cardiovascular diseases are the leading global cause of death. Cardiovascular morbidities can manifest as many different forms but the unifying problem is pathological remodeling of cardiovascular tissues that comprise mechanical performance. In response to pathological stimuli, human coronary artery smooth muscle cells (HCASMCs) adopt an osteogenic phenotype. Interestingly, the resultant calcification in cardiovascular tissues associates with a decrease in bone mineral density. We hypothesized that remodeling responses occur as cells attempt to regulate the mechanical environment and cellular membrane plays a role in how cells experience and respond to external stresses. Bone and cardiovascular tissues undergo different mechanical loads, which may explain the contrasting remodeling responses to pathological cues. The aim of this study is to compare the behavior of HCASMCs with human osteoblasts under various mechanical environments. To address this aim, both cell types were cultured on either soft or stiff substrates or under the application of cyclic mechanical strains (±10%) for 24 hours. Caveolin-1 protein aids in the formation of invaginations in the cell membrane, which buffers the membrane to changes in tension. The results indicate that the highest and lowest levels of Caveolin-1 protein expression are found in cells on stiff and soft substrates, respectively.

Assessing regions of reduced oxygenation in diabetic foot ulcers using near-infrared optical imaging

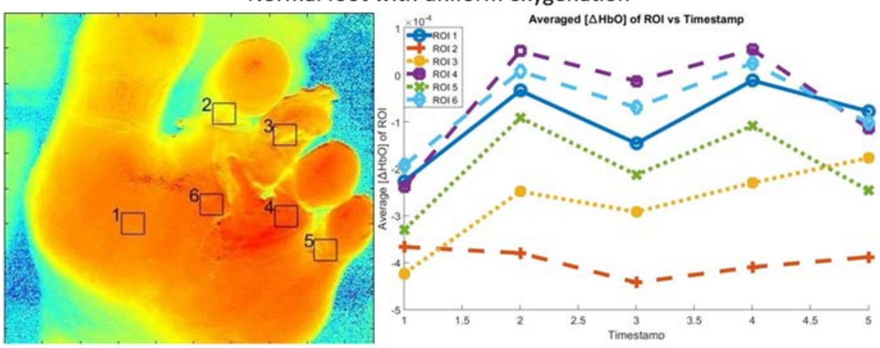
Authors

Kevin Leiva, Jagadeesh Mahadevan, Kacie Kaile, Richard Schutzman, Edwin Robledo, Dinesh Khandavilli, Sivakumar Narayanan, Varalakshmi Muthukrishnan, Mohan Viswanathan, Anuradha Godavarty

Faculty Adviser Dr. Anuradha Godavarty



Normal foot with uniform oxygenation



Diabetic foot ulcer with varied tissue oxygenation

Abstract

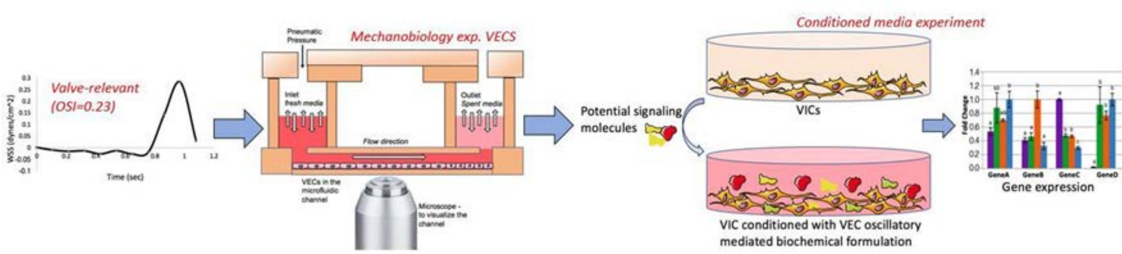
Diabetic foot ulcers (DFUs) are responsible for 20% of diabetic-related hospitalization and for 85% of diabetes related amputations. The gold-standard approach to determine how well a wound heals is based on visual inspection and is subjective to each clinician. In this study, we assess tissue oxygenation maps of diabetic foot ulcers and normal feet (controls) in order to determine regions of reduced oxygenation; which is physiologically used to assess wound healing. A near-infrared optical scanner (NIROS) is used to obtain changes in oxy- (ΔHbO) and deoxy-hemoglobin (ΔHbR) maps in normal feet and feet with diabetic foot ulcers, in response to an external stimulus of breath holding. Dynamic changes in these oxygenation maps were compared between DFU subjects and controls. Dynamic oxygenation changes were uniform across the entire region in normal feet, whereas they varied with reduced oxygenation around the wound for subjects with DFUs. This implies that dynamic tissue oxygenation maps can aid clinicians by determining regions of decreased oxygenation beneath the skin, better cater the treatment process, and potentially avoid amputations.

Valvular Interstitial Cell Exposure to Media Derived from Oscillatory Flow Conditioned Valve Endothelial Cells

Authors

Sana Nasim, Denise Medina Almora, Joshua Hutcheson, Sharan Ramaswamy

Faculty Adviser Dr. Sharan Ramaswamy



Abstract

The cellular make-up of aortic heart valve leaflets are highly organized and heterogeneous. The leaflets comprise of valve endothelial cells (VECs) and valve interstitial cells (VICs). VECs are present at the leaflet surface whereas VICs can be found deeper in the tissue, thereby maintaining valve homeostasis. VECs are exposed to side- specific pulsatile blood flow, where arterial side VECs are exposed to low shear and higher unidirectional oscillatory flow, whereas ventricular side VECs are exposed to high laminar flow. VECs via blood flow modulation promote distinct tissue remodeling processes on either side of the leaflet. Moreover, on the arterial side, VECs exhibit phenotypes distinct from the VECs on the ventricular side and experience unique mechanical forces, biochemical stimuli and ECM cues that regulate pathobiology [1]. Interestingly, explanted diseased valves have shown signs of endothelial cell damage, inflammatory molecule deposition and ECM abnormalities mainly on the arterial side while the ventricular side is relatively unaffected. It has been shown that oscillatory shear stresses (OSS) are a critical factor in heart valve development, including appropriate cellular communication, proliferation, protein-interaction, ECM production and maintaining phenotype [2]. OSS can be quantified using the oscillatory shear index (OSI) ranging from 0-0.5, where 0 refers to unidirectional flow and 0.5 is maximum oscillatory flow. Objective: The objective of this study was to evaluate gene expression responses of VICs after exposure to a valve relevant biochemical formulation that was created as a result of VEC-OSS exposure (OSI=0.23) of relevance to heart valves [4]. Methods: OSI condition were applied to VECs isolated from the arterial side. Steady state and static flow were performed as controls where the steady flow condition was taken as the temporal average of the OSS-inducing flow waveform. Media was stored at -80°C right after 48 hours of flow based conditioning. Next, VICs were cultured and treated with 50% conditioned media and 50% regular DMEM media for 48 hours. Conditioned VICs were subjected to RNA isolation and later for gene expression assessment. Fold change using ΔΔCt method was used for quantitative analysis. Runx2. TGFb1, a-SMA, Col1a1, MMP13, klf2a and ELN genes were analyzed Results & Discussion: Paracrine signaling between VECs and VICs led to distinct gene expression differences between the three flow conditions (OSS, steady, no flow). We conclude that changes in the local temporal oscillations in fluid shear stress leads to specific VEC autocrine and VIC-related paracrine events that potentially are associated with 3-dimensional tissue remodeling activity, which will have direct implications on valve homeostasis.

FIU Engineering & Computing

Department of Biomedical Engineering

About the Keynote Speakers:

Nathalie Nunez

Nathalie Nunez is an innovative leader in the medical device industry. As a University of Miami Biomedical Engineering BS/MS graduate she has successfully navigate through the corporate world. Through her career she has grown from intern to manager in her seven years with Medtronic HeartWare. During her tenure she has serviced patients from around the country, publish original research and even helped establish the internship program for legacy HeartWare. As MDR/Vigilance Manager she now leads the complaint handling team for Medtronic's Mechanical Circulatory Support Business Unit. Her background spans the areas of research and development, quality and compliance. She strives to be a change catalyst and wished to empower recent college grads reach their full career potential.

Monica Perez, Ph.D.

Monica A. Perez is an Associate Professor at the Department of Neurological Surgery and The Miami Project to Cure Paralysis at the University of Miami. She received her Ph.D. in physical therapy from the University of Miami School of Medicine in 2003. She completed postdoctoral fellowships at the University of Copenhagen (2003-2005) and at the National Institute of Neurological Disorders and Stroke (2005-2008). Dr. Perez' research interests focus on understanding how the brain and spinal cord control voluntary movements in healthy humans and in individuals with spinal cord injury. This theme is mainly investigated from a neurophysiological point of view, using a combination of transcranial magnetic stimulation (TMS) and peripheral nerve stimulation techniques. Single and paired-pulse TMS and spinal cord reflex protocols are used to examine and maximize transmission in residual motor pathways in humans with spinal cord injury.

Program:

10:00 AM	Seminar: Nathalie Nunez (EC 2300)
12:00 PM	Graduate Student Poster Presentation (Panther Pit)
4:00 PM	Seminar: Monica Perez, Ph.D. (EC 2300)
5:30 PM	Award Ceremony (EC 2300)

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