School of Biomedical Engineering

Research Day 2023

Scientific Program

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Dear Colleagues,

Welcome to our highly anticipated 2023 School of Biomedical Engineering Research Day! We are thrilled to gather once again to celebrate the outstanding achievements and discoveries made by our talented graduate students, as well as foster a sense of collaboration and knowledge sharing within our department.

This year's Research Day promises to be an exceptional event, showcasing the breadth and depth of our department's cutting-edge research. Research day provides a platform for you to share your research projects, insights, and discoveries with your colleagues. Your contributions play a pivotal role in cultivating a culture of research excellence and propelling our department to new heights. I encourage everyone in attendance to engage in conversations and embrace the opportunity to learn from one another. By fostering an environment of cross-disciplinary ideas and expertise, we can unlock new possibilities and drive significant advancements in our respective fields.

I also have the distinct pleasure to welcome our two Distinguished Keynote Speakers for this year's event. Our academic speaker, Dr. James Drake, is a renowned neurosurgeon and professor of neurosurgery at the University of Toronto. He will be presenting his work on developing new robotically controlled image guided therapeutic technology for treatment of pediatric brain pathologies. Our industry focused keynote speaker is SBME alumni Sara Sparavalo from Nova Scotia Health's Research, Innovation and Discovery office. She will be sharing her personal journey from a Biomedical Engineering graduate student to her current role as a business development manager and provide insights into the various career pathways for biomedical engineering graduates.

I would like to extend my deepest gratitude to all of the students who have contributed to this booklet, the organizing committee (and Sandra Pereira) for their tireless efforts in making this event possible. Lastly, I would like to express our sincere appreciation to our esteemed guests for their support, which affirms our commitment to advancing the frontiers of knowledge. I hope that you will enjoy the enriching experience that Research Day offers. Let us celebrate our achievements, foster new connections, and inspire one another to reach even greater heights in our research pursuits!

With warm regards,

Jeremy Brown, acting Director, School of Biomedical Engineering

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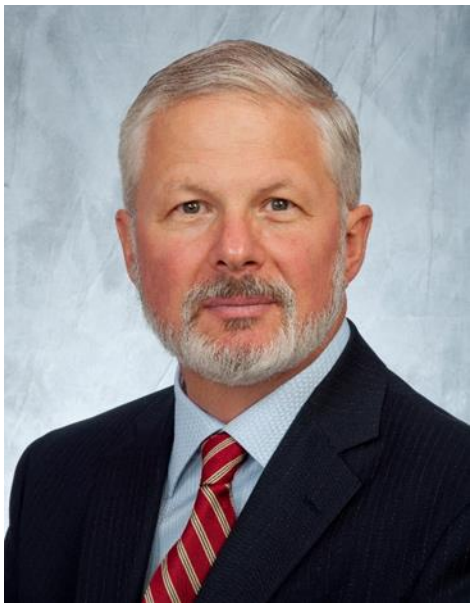
School of Biomedical Engineering

Research Day 2023

DISTINGUISHED ACADEMIC LECTURE



James Drake, MD

Robert B. Salter Chair in Surgery, SickKids

Professor, Department of Surgery,
University of Toronto

"Developing Technology Interventions for Pediatric Patients – Robots, Tools, Simulators and Image Guided Interventions"

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DAL.CA

"Developing Technology Interventions for Pediatric Patients – Robots, Tools, Simulators and Image Guided Interventions"

James Drake, MD
Robert B. Salter Chair in Surgery, SickKids
Professor, Department of Surgery,
University of Toronto

Abstract: Pediatric patients are not "little adults". They have unique physiology, anatomy, pathologies and require specialist expertise for optimal outcomes. The impact of disease on pediatric patients is much greater than for adults given their life expectancy, although much of the medical technology for procedural interventions is designed for the larger adult medical market leaving a large gap for pediatric patients. The Poslins Centre for Image-Guided Innovation and Therapeutic Intervention is directed towards developing novel technological solutions for pediatric patients for a wide variety of pediatric disorders. Situated in the Hospital for Sick Children, a collaborative of Physicians, Surgeons, Engineers, and Computer Scientists, with graduate and undergraduate students from the same background, drives technological solutions to clinical problems in pediatric health care, with the ultimate goal of bringing the technology to the patient. With a focus on Robotics, Tool development, Simulation, and MR guided Interventions, including MR guided Focused Ultrasound, solutions for Neurosurgery, Craniofacial Surgery, Orthopedic Surgery, Cardiac Surgery, General Surgery, Critical Care Medicine, and Fetal Medicine are under development and in some cases implemented. There is a broad interest in the Academic Health and Physical Sciences in developing medical technology that should be harnessed to bring new technologies to Canadian Patients.

School of Biomedical Engineering

Research Day 2021

DISTINGUISHED INDUSTRY LECTURE

Sara Sparavalo, MASc

Business Development Manager,
Nova Scotia Health

"What Do You Want to Be When You Grow Up - How I Found My Passion Through Biomedical Engineering"

"What Do You Want to Be When You Grow Up - How I Found My Passion Through Biomedical Engineering"

Sara Sparavalo, MASc

Business Development Manager, Nova Scotia Health

Abstract: In this talk, Sara will share her journey from biomedical engineering to her current career in healthcare innovation, highlighting the key points and insights that have helped shape her professional trajectory. Sara will discuss the challenges and opportunities she encountered on the way, as well as the transferable skills and experiences that have proven valuable throughout her career. Drawing on personal experiences, Sara will offer some practical advice and strategies for those looking to pivot from traditional career paths in biomedical engineering and explore different options. Whether you are just starting your path in biomedical engineering or are about to graduate, this talk will provide valuable insights and hopefully some inspiration for navigating the ever-changing career landscape.

Previous Winners of the Community Builder Prize in Biomedical Engineering

2008

Marianne Ariganello

2011

Adrian West

2013

J. Michael Lee

2015

Eleanor Seaman-Bolton

2017

Rishima Agarwal

2018

Kristin Robin Ko

2019

Tyler Herold

2020

Meghan Martin

2021

Alyne Teixeira

Previous Winners of the Annual Teaching Prize in Biomedical Engineering

2008

Geoff Maksym

2009

J. Michael Lee

2010

Jeremy Brown

2011

Paul Gratzer

2010

Rob Adamson

2013

Janie Astephen-Wilson

2015

Daniel Boyd

2016

Sarah Wells

2017

Jeremy Brown

2018

John Frampton

2020

Jeffrey Woodacre

2021

Rob Adamson

2022

Sarah Wells

Previous Winners of the George W. Holbrook Prize in Biomedical Engineering

2010

Richard Roda

2011

Graeme Harding

2013

Matthew Walker

2014

Pouya Amiri

2015

Lauren Kiri

2016

Brandon Scott

2017

Kristin Robin Ko

2018

Rishima Agarwal

2020

Nicky Tam

2021

Lindsey Power

2022

Mireya C. Gonzales

Previous Winners of the Allan E. Marble Prizes in Biomedical Engineering

2002
Sean Margueratt

2003
Anna Dion

2005
Doctoral: Mark Glazebrook
Pre-doctoral: Carolyn Lall

2006
Doctoral: Scott Landry
Pre-doctoral: Scott MacLean

2007
Doctoral: Janie Astephen
Pre-doctoral: Andrew Moeller

2008
Doctoral: Marianne Ariganello
Pre-doctoral: Vargha Talebi

2009
Doctoral: Jack Fairbank
Pre-doctoral: Jennifer Krausher

2010
Derek Rutherford

2012
Del Leary

2013
Andre Bezanson

2014
Caitlin Pierlot

2015
Arash Momeni Boroujeni

2016
Dan MacDougal

2017
Brett Dickey

2019
Alyne Teixeira

2020
Katherine Latham

2021
Kathryn Young-Shand

2022
Matt Mally

School of Biomedical Engineering

Research Day 2023 Scientific Program

Friday, March 26th, 2023

Irving Oil Auditorium, Richard Murray Design Building

Morning Session	
8:45 am to 8:55 am	Welcome: Dr. Jeremy Brown, Director, School of Biomedical Engineering
8:55 am to 9:00 am	Opening Remarks: Dr. Ben Davis, Dean of Dentistry

Scientific Session 1 Chairs: Andrew Smith and Sarah Spencer	
9:00 am to 9:15 am	***"Design of Experiments Approach for Optimizing a Chitosan-Polyphosphate Based Material for Trauma Treatment"*** Jonah Glazebrook (MASC Student) and M. Filiaggi
9:15 am to 9:30 am	***"Objective Tracking of Physical Activity in Knee Osteoarthritis Patients Awaiting Joint Arthroplasty"*** Kaitlin Genge (MASC Student) M. Dunbar, G. Richardson, A. Laudanski, and J. Astephen Wilson
9:30 am to 9:45 am	***"Implementing Design Control for Medical Devices: A Graduate Studies Perspective"*** Christine Andrea (PhD Student), and D. Boyd
9:45 am to 10:00 am	***"A Repeatability Analysis of a Novel In-Clinic Markerless Motion Capture System for Patient Gait Kinematic Analysis"*** Stephanie Civiero (MASc Student) C. Richardson, M. Dunbar, A. Laudanski, and J Astephan Wilson

Coffee Break (10:00 am – 10:15 am)

Scientific Session 2 Chairs: Lindsey Power and Kennedy Quigley	
10:15 am to 10:30 am	***"Low-Field MRI with Motion-Corrected Reconstruction for Cholesteatoma Detection"*** Ally Klassen (MASc Student), J. Rioux, C. Bowen, C. Wiens, M. Schmidt, D. Volders, A. Cora, D.P. Morris, S. Clarke, and S.D. Beyea
10:30 am to 10:45 am	***"Predicting the Properties of Soluble and Insoluble Glasses for Use in Medicine"*** Brenna Kettlewell (PhD Student) and D. Boyd
10:45 am to 11:00 am	***"Assessing the Therapeutic Potentials of Bacteria for Preventing Chemotherapy-Induced Oral Mucositis"*** A.S. Magana-Lama (MASc Student), and B. Leung

11:00 am to 11:15 am	***"Validation of Structured Light 3D Scanning for Measurement of Tibial Bone Defects in Revision Total Knee Arthroplasty"*** **Shar Seddigh (MASc Student), R. Adamson, and M. Dunbar**

Distinguished Academic Lecture

11:15 am to 12:15 pm	**Dr. James Drake, MD.** **Robert B. Salter Chair in Surgery, SickKids** **Professor, Department of Surgery, University of Toronto** ***"Developing Technology Interventions for Pediatric Patients – Robots, Tools, Simulators and Image Guided Interventions"*** **Introduction: Dr. Rob Adamson**

Catered Lunch (12:15 pm – 1:15 pm)

Distinguished Industry Lecture

1:15 pm to 2:15 pm	**Sara Sparavalo, Business Development Manager, Nova Scotia Health** ***"What Do You Want to Be When You Grow Up - How I Found My Passion Through Biomedical Engineering"*** **Introduction: Dr. Sarah Wells**

Scientific Session 3 Chairs: Adam Dorrance and Kelsey Gsell

2:15 pm to 2:30 pm	***"Chitosan-Polyphosphate Scaffold Loaded with Copper for Endodontic Regeneration"*** **Dr. Hanan Moussa (Postdoctoral Fellow), B. Leung, and M. Filliagi**
2:30 pm to 2:45 pm	***"An Angled, High-Frequency Ultrasound Imaging Endoscope for Minimally Invasive Spine Surgery"*** Theresa Gu (MASc Student), T. Landry, and J. Brown
2:45 pm to 3:00 pm	***"Engineered Small Airway Microtissues for the Study of Paracrine Signaling in Asthma"*** **Jonathon Tjong (PhD Student), T.A. Quinn, G. Maksym, and J. Frampton**
3:00 pm to 3:15 pm	***"Assessment of routine clinical exam protocols on low field MRI for imaging passive neural implants"*** **Robert Weaver (MASC Student), C, Bowen, K. Brewer, S. Clarke, J, Rioux, D.Volders, E.A. Cora, and S.D. Beyea**

Coffee Break (3:15 pm – 3:30 pm)

Career Panel Q&A	
3:30 pm to 4:15 pm	**Student Questions and Answers and Career Advice with our Distinguished Speakers and one of our BME Faculty** **<u>Panelist:</u>** **Dr. James Drake, Robert B. Salter Chair in Surgery, SickKids** **Professor, Department of Surgery, University of Toronto** **Sara Sparavalo, Business Development Manager, Nova Scotia Health** **Dr. Alex Quinn, Department of Physiology and Biophysics and School of Biomedical Engineering** **<u>Moderators:</u>** **Mady Thompson, SBME Ph.D. Candidate, Dalhousie University** **Kelsey Gsell, SBME Ph.D. Candidate, Dalhousie University**

Awards and Closing	
4:15 pm to 4:30 pm	**School of Biomedical Engineering Awards and Closing Remarks** **Director: Dr. Jeremy Brown**

School of Biomedical Engineering

Research Day 2023 Abstracts

SCIENTIFIC SESSION 1

DESIGN OF EXPERIMENTS APPROACH FOR OPTIMIZING A CHITOSAN-POLYPHOSPHATE BASED MATERIAL FOR TRAUMA TREATMENT

J. Glazebrook[1], and M.Filiaggi[1,2].

[1]School of Biomedical Engineering, Dalhousie University; [2] Department of Applied Oral Sciences, Faculty of Dentistry, Dalhousie University.

Introduction: When treating traumatic wounds, blood loss is the most immediate threat to the patient's life. Once bleeding is controlled, the priority shifts to mitigating the chance of infection. The initial on-site treatment of trauma patients to address both challenges utilizes wound dressings. Our research aims to create a bioactive wound dressing material using polyphosphate, an inorganic polymer shown to accelerate coagulation; chitosan, a naturally sourced polymer that exhibits hemostatic and antibacterial effects; and copper, a notable bactericidal metal ion.

Methods: A design of experiments approach was taken to better understand the contributions of chitosan, polyphosphate, and copper to physical and biological properties as a basis for optimizing their use in a wound dressing application. Materials were made by freeze-drying a polyelectrolyte complex of polyphosphate solution and chitosan/copper solution to form a mesh; variable processing parameters included solution concentrations and polyphosphate degree of polymerization. Resulting properties such as elemental composition, handling characteristics, apparent density, absorption capacity, copper/phosphorous elution, blood clotting, and cytotoxicity were used as responses.

Results: Chitosan to polyphosphate ratio had the biggest impact on the resulting physical properties of the material. Polyphosphate and copper content had a strong negative correlation coefficient (-0.654) suggesting there is competition for the chitosan interaction sites. Cytotoxicity had a strong negative correlation (-0.656) with copper content, and samples that had no copper inclusion in the formulation were the least cytotoxic.

Conclusion: Results from the design of experiments suggest a freeze-dried chitosan-polyphosphate complex could be an effective material for a trauma wound dressing. Subsequent work will identify an optimal material formulation using the design space model for comparison to an existing commercial chitosan wound dressing.

OBJECTIVE TRACKING OF PHYSICAL ACTIVITY IN KNEE OSTEOARTHRITIS PATIENTS AWAITING JOINT ARTHROPLASTY

K. Genge[1], M. Dunbar[1,2], G. Richardson[2], A. Laudanski[1], and J. Astephen Wilson[1,2]

[1]School of Biomedical Engineering, Dalhousie University and [2]Division of Orthopedics, Department of Surgery, Dalhousie University and Nova Scotia Health

Introduction: Physical activity (PA) is an important part of overall health, yet activity levels in end-stage knee osteoarthritis (OA) patients who are awaiting knee arthroplasty are significantly lower than in healthy age-matches. Historically, clinicians and researchers have attempted to capture patients' PA levels using subjective measures, such as questionnaires, however these may be biased by individual patient factors and can fail to reflect the true activity levels of the patient. Objective tracking of PA may help identify changes in patients' behavior throughout the pre-operative period that could negatively impact their health, well-being and surgical outcomes.

Methodology: Ten end-stage knee OA patients were recruited from the participating surgeons' knee arthroplasty wait lists. Inertial measurement units (Axivity, AX6) were placed on the shin of the surgical leg of participants during a regularly scheduled clinic visit. Raw accelerometer data were collected over 7-day periods, which was inputted into a custom MATLAB (version 9.13) code to calculate step counts. Data for the central 6 days of collection were processed to calculate means and standard deviations for each participant, as well as the larger group.

Results and discussion: Preliminary results on the first 5 participants (4F/1M) show an average daily step count of 10768 ± 7439 across all participants. This large standard deviation can be attributed to daily variability in physical activity, as well as large variability between participants. The maximum mean daily step count value recorded was 20760 ± 3513, and the minimum was 1238 ± 327.5. Given the significant variability between patients, we believe that understanding individual changes in PA throughout the wait period will be beneficial in identifying those individuals demonstrating the greatest PA decline.

Conclusions: Shin-mounted accelerometers are a feasible way to measure objective patient PA levels. Continuous monitoring will be used to help identify patient-specific characteristics relating to physical decline throughout the peri-operative period and to examine if objectively measured PA and PA decline pre-operatively is significantly associated with surgical outcomes. Future efforts should focus on combining these findings with patient-reported pain, PA levels, mental health scores, and demographics, to provide clinicians with a more detailed assessment of pre-operative function with respect to physical activity.

IMPLEMENTING DESIGN CONTROLS FOR MEDICAL DEVICES: A GRADUATE STUDIES PERSPECTIVE

C. Andrea[1] and D.Boyd[1,2]

[1]School of Biomedical Engineering, Dalhousie University, Halifax, NS, Canada, [2]Department of Applied Oral Science, Faculty of Dentistry, Dalhousie University, Halifax, NS, Canada

Introduction: Design controls offer an essential framework of checks and balances in the design and development of medical devices. Graduate students may benefit from utilizing these controls to identify design deficiencies and discrepancies between proposed designs and user needs on their research projects. Implementing design controls allows for early detection and correction of issues, increasing the likelihood of creating devices suitable for their intended use. Using direct graduate student experience, this presentation will discuss the principles of design controls and provide real life examples (student perspective) on how valuable these systems are for research projects.

Methods: SBME graduate students exercised an iterative approach to medical device design; including the implementation of early design controls (21 CFR 820.30 and ISO13485), establishing user needs, and conducting continuous project meetings and design review boards to ensure compliance with user requirements, standards, and regulations.

Results & Discussion: Establishing the principles of design controls in appropriate SBME research projects may yield positive outcomes for design transfer from student projects to industry.

Conclusion: The experience gained from direct experience of design controls in graduate school is valuable for enhanced career opportunities and provides a critical framework to accelerate the development of graduate research.

A REPEATABILITY ANALYSIS OF A NOVEL IN-CLINIC MARKERLESS MOTION CAPTURE SYSTEM FOR PATIENT GAIT KINEMATIC ANALYSIS

S. M. Civiero[1], C.G. Richardson[2], M.J. Dunbar[1,2], A.F. Laudanksi[1], and J. Astephan Wilson[1,2]

[1]School of Biomedical Engineering, Dalhousie University; [2]Department of Surgery, Dalhousie University and Nova Scotia Health

Introduction: In the end stages of knee osteoarthritis (OA), surgical intervention by total knee arthroplasty (TKA) is the final treatment option. Many patients with significant pre-operative functional gait deficits experience minimal improvement in their post-operative gait biomechanics. While gold-standard human motion measurement approaches have been limited to motion analysis laboratories, the objective of this study was to design and evaluate a motion capture system within an orthopaedic clinical environment to efficiently capture objective gait outcomes relevant to arthroplasty surgery planning.

Methods: An innovative markerless gait analysis system, which pairs optical motion capture with an AI-based human pose estimation algorithm, was setup and validated in the Halifax Infirmary orthopaedic clinic. Walking gait trials were performed within a twenty-foot by eight-foot walkway. To evaluate the system accuracy, gait data from healthy participants (n=20) over three sessions were collected. Hip, knee, and ankle sagittal and frontal plane joint angles were calculated for each subject, and standard deviations of the intra-session averages for all joint angles were calculated.

Results and Discussion: A combination of ten time-synched digital cameras (Sony, Model RX0ll) was selected for this biomechanical analysis in order to maximize collection volume within the clinical environment. Initial results from 5 healthy subjects' (3F/2M) sagittal and frontal plane joint angles calculated from the markerless software display intra-session repeatability with a maximum joint angle standard deviation of 7.84° and 4.51° within the knee sagittal and frontal planes for all subjects, respectively.

Conclusion: The installed markerless motion capture system and clinical gait protocol is viable for in-clinic measurement of objective kinematic gait data, producing repeatable joint angle metrics that are relevant to arthroplasty outcomes from data recorded with optical video cameras and analyzed with an AI-based human pose estimation algorithm.

School of Biomedical Engineering

Research Day 2023 Abstracts

SCIENTIFIC SESSION 2

LOW-FIELD MRI WITH MOTION-CORRECTED RECONSTRUCTION FOR CHOLESTEATOMA DETECTION

A. Klassen [1], J. Rioux [2], C. Bowen [2], C. Wiens [3], M. Schmidt [2], D. Volders [2], A. Cora [2], D.P. Morris[4], S. Clarke[2], and S.D. Beyea[1,2]

[1]Biomedical Engineering, Dalhousie University; [2]Diagnostic Radiology, Dalhousie University; [3]Synaptive Medical, [4]Division of Otolaryngology, Dalhousie University

Introduction: Accurately identifying the presence or absence of a recurrent growth with non-invasive imaging is of interest to prevent unnecessary surgeries. Cholesteatoma, an abnormal mass of skin tissue originating around the tympanic membrane, demonstrates restricted diffusion and is detectable with diffusion-weighted echo planar magnetic resonance imaging (DW-EPI MRI). However, precise localization is challenging due to the complex anatomical environment, in which susceptibility-induced field gradients distort EPI images. Multi-shot EPI reduces distortion, but inter-shot patient motion necessitates motion correction with multiplexed sensitivity encoding (MUSE). Low-field systems also reduce susceptibility distortion for improved localization, but at the cost of lower produced signal, which may represent an obstacle to accurate MUSE reconstruction. This work investigated the signal-to-noise limits for MUSE at low field.

Methods: A MUSE pipeline for low-field data (0.5T Synaptive MRI) was developed in Matlab. The algorithm modified the established SENSE parallel imaging logic that estimates full-FOV images from under-sampled data. Phase errors due to motion were calculated for each shot and applied to the derived coil sensitivities before solving for the final images. Optimization of in-plane resolution and background noise were discussed with clinical experts.

Results and Discussion: MUSE reconstruction of phantoms and healthy volunteers with the developed pipeline demonstrated qualitatively reduced motion artifact compared to uncorrected images. A comparison to 3T images showed reduced susceptibility-induced distortion in the ear canal at 0.5T.

Conclusions: An evaluation of the signal-to-noise limits at 0.5T in phantoms and healthy volunteers demonstrates that low-field multi-shot DW-EPI with MUSE is feasible.

PREDICTING THE PROPERTIES OF SOLUBLE AND INSOLUBLE GLASSES FOR USE IN MEDICINE

B. Kettlewell[1] and D. Boyd[1,2]

[1]School of Biomedical Engineering, Dalhousie University; [2] Department of Applied Oral Sciences, Faculty of Dentistry, Dalhousie University

Introduction: Bioactive glasses provide a remarkable opportunity to discover and develop structurally simple, yet functionally complex materials for use in medicine. However, there are over 10^{300} possible glass formulations, and based on traditional trial and error or one variable at a time approaches used to characterize these materials, the development of new glass materials is extremely slow and unsustainable. Therefore, the objective of this research is to support the accelerated and sustainable design of new glass materials by utilizing predictive modelling to study the integration of therapeutic inorganic ions in both soluble and insoluble glass networks.

Methods: 23 novel glass formulations were established within the borate anomaly region. The glasses were synthesized and characterized in terms of their physical and chemical properties, dissolution properties, and cytocompatibility. Finally, a response surface optimization study was conducted, in which two new glass formulations were designed based on a set of optimization criteria and subsequently characterized to validate the predictive power of the model.

Results and Discussion: Using a Design of Mixtures regression analysis, it was possible to derive statistically valid polynomial equations that quantitatively established and predicted the individual and interactive effects of glass constituents on the density, glass transition temperature, relative percentages of B3 and B4 structural units, superstructural units, percent crystallinity, mass change and rate of ionic dissolution in tris buffered saline (TBS), and the % cytotoxicity for all 23 glasses. These models permitted the optimization of two new glass formulations that were validated to meet optimization criteria within 2%.

Conclusions: The Design of Mixtures approach provided quantitatively predictive models on the composition-structure-property relationships within these soluble glass materials and permitted the design of new optimal glass formulations tailored to a set of desirable properties. Unlike traditional trial and error style approaches for materials discovery, this form of predictive modelling enables the prediction of preferred material chemistries for a wide range of applications and has the potential to drastically accelerate the discovery, development, and deployment of new glass materials.

ASSESSING THE THERAPEUTIC POTENTIALS OF BACTERIA FOR PREVENTING CHEMOTHERAPY-INDUCED ORAL MUCOSITIS

A.S. Magana-Lama[1], and B. Leung[1,2]

[1]School of Biomedical Engineering, Dalhousie University; [2] Department of Applied Oral Sciences, Faculty of Dentistry, Dalhousie University

Introduction: Chemotherapy-induced oral mucositis (CIOM) is characterized by the ulceration of oral mucosal tissues caused by the systemic cytotoxic effects of chemotherapy. It is considered a major side-effect that may lead to interruptions of cancer treatment and can comprise the treatment prognosis for patients. Recently, there has been interest in exploring the potential of bacteria to treat CIOM, primarily driven by the promising effects of probiotics in reducing the severity of intestinal mucositis. The application of probiotics for treating CIOM has not been properly explored due to the lack of adequate study models and clear mechanisms through which probiotics exert their benefits. This research aims to establish a study model that allows the mechanistic analysis of the effects of *Streptococcus salivarius* and *Levilactobacillus brevis* in an *in vitro* organotypic co-culture model of the oral mucosa.

Methods: We fabricated an engineered oral mucosal construct using NIH 3T3 fibroblasts and OKF6-TERT2 basal keratinocytes, and then treated it with methotrexate aiming to recapitulate the histopathological traits of CIOM. The establishment of the microbe-mammalian co-culture was achieved using an aqueous-two phase system (ATPS), a liquid-based scaffold of polyethylene glycol and dextran.

Results and Discussion: This research fills the knowledge gap in our understanding of the mechanistic effects of probiotics in CIOM. It elucidates some of the mechanism behind the benefits of probiotics that past studies have demonstrated in clinical trials and using *in vivo m*odels.

Conclusions: This is the first study to test *in vitro* the effects of probiotics in an oral mucositis model, furthermore, allowing mammalian-polymicrobial interactions while mimicking a heterocellular microenvironment.

VALIDATION OF STRUCTURED LIGHT 3D SCANNING FOR MEASUREMENT OF TIBIAL BONE DEFECTS IN REVISION TOTAL KNEE ARTHROPLASTY

S. Seddigh[1,2], R. Adamson[2], and M. Dunbar[1,2]

[1]Department of Orthopaedic Surgery, Nova Scotia Health Authority, Halifax
[2]School of Biomedical Engineering, Dalhousie University, Halifax

Introduction: Failures of Total Knee Arthroplasty (TKA) may be associated with significant bone loss. Restoration of bone loss is critical for success of revision TKA and depends on location and size of bone defects. Currently there is no method of measuring bone defects intraoperatively. The aim of our study is to utilize Structured Light (SL) 3D scanning to quantitatively measure volume of bone defects. Our primary objective is to compare accuracy of SL 3D scanning to micro Computed Tomography (µCT) for measurement of tibial bone defect volumes in simulated revision TKA.

Methods: Revision TKA was simulated on four native knees in two cadavers. Contained tibial defects were prepared using 38-44mm acetabular reamers. Bone defects were scanned *in situ* with SL scanner and subsequently with µCT. Volumes of reconstructed 3D models were measured six times for each specimen. Agreement between SL and µCT volumes were analyzed using Bland-Altman plots with µCT as gold standard. Measurement bias and limits of agreement were calculated with Stata software (17.0). A priori mean difference of 5mL was set as threshold for clinical significance.

Results: Bone defect volumes ranged from 33.79 mL (SD 0.11mL) to 40.84 mL (SD 0.07 mL) as measured by µCT and from 33.04mL (SD 0.11 mL) to 40.32 mL (SD 0.26 mL) as measured by SL. Bland-Altman analysis revealed a mean difference of 0.47 mL (95% CI 0.36 to 0.58 mL) between µCT and SL measurements. Limits of agreement ranged from -0.06 mL (95% CI -0.31 to 0.09 mL) to 0.99mL (95% CI 0.84 to 1.24 mL).

Conclusion: Based on mean difference of µCT and SL volume measurements being smaller than the a priori threshold and all the measurements falling within the limits of agreement, we conclude that SL 3D scanning is an accurate method to measure bone defects intraoperatively.

School of Biomedical Engineering

Research Day 2023 Abstracts

SCIENTIFIC SESSION 3

CHITOSAN-POLYPHOSPHATE SCAFFOLD LOADED WITH COPPER FOR ENDODONTIC REGENERATION

Dr. H. Moussa (Postdoctoral Fellow)[1], Brendan Leung[1,2], Mark Filiaggi[1,2]

[1]Department of Applied Oral Science, Faculty of Dentistry, Dalhousie University

[2]School of Biomedical Engineering, Dalhousie University

Introduction: Regenerative endodontics show promise to repair immature teeth with necrotic pulp. The procedure involves replacing infected pulp tissue with viable tissue to restore tooth structure and function. It involves disinfecting the root canal and recruiting and activating stem cells. A scaffold that facilitates cell migration directly to the root tip is crucial to this approach. The objective of this study is to develop a copper-loaded chitosan/polyphosphate scaffold that supports stem cell differentiation and provides short-term infection control.

Methods: The scaffold preparation began with the addition of copper (Cu) to either chitosan or polyphosphate solution. After that, the other component (polyphosphate or chitosan) was added. The scaffold was then freeze-dried and characterized for elemental composition, chemical structure, Cu and phosphorous elution, antibacterial property, and cytotoxicity.

Result: A 3D conical scaffold shaped like a root canal was achieved through polyelectrolyte complexation and lyophilization. The phosphate and Cu content of the scaffold can be controlled by altering the process conditions. A higher proportion of phosphate ions was incorporated into scaffolds containing Cu. As the Cu level increased, the antibacterial effect also increased, reaching 99% growth inhibition after 24 hr in a scaffold composed of 3.5 % Cu. However, Cu content negatively correlated with cell viability. It was found that a scaffold containing 0.6 % Cu showed a strong antimicrobial effect and an 80 % cell viability.

Conclusion: This scaffold could control infection and stimulate pulp regeneration in permanent immature teeth with pulpal necrosis. Further study of the physical properties, degradability and ability to stimulate odontogenic differentiation of stem cells will be carried out.

AN ANGLED, HIGH-FREQUENCY ULTRASOUND IMAGING ENDOSCOPE FOR MINIMALLY INVASIVE SPINE SURGERY

T.L.Gu[1], T.G. Landry[1], and J.Brown[1]

[1]School of Biomedical Engineering, Dalhousie University

Introduction: The spine is prone to degenerative diseases, metastases, and trauma that can compress the spinal cord, nerves, or nerve roots. While many can be solved non-invasively, surgery may be necessary, and as many surgeons move towards minimally invasive surgery, it becomes prudent to provide better methods of visualization within the narrow surgical corridor.

Methods: A miniature, angled, high resolution ultrasound transducer with a long form factor (endoscopic) was designed, fabricated and tested in-lab to provide ultrasound visualization during minimally invasive spinal decompression surgeries. The tests performed in-lab include those to characterize performance (electrical impedance, pulse echo response, and focused radiation patterns) and for safety testing (acoustic and thermal testing). Real-time in-vivo images taken include topical images of nerves and vessels from healthy participants and if available, intra-operative spinal anatomy including the dura, CSF, spinal cord/nerves, will be presented.

Results and Discussion: Performance of two probes was characterized. The on-resonance element impedance magnitude and phase was measured to be 194.1 ohms and -35.7 degrees respectively and the two-way pulse bandwidth was 69% centred at 29.5 MHz. The axial and lateral resolution was measured to be 33um and 125um respectively. The probes were deemed safe to operate for surgical guidance after a battery of standardized IEC safety tests. The probes have now been approved for patient testing.

Conclusions: The ultrasound endoscopes have demonstrated to operate with high resolution and within safety limits. Preliminary real-time topical imaging on volunteers has demonstrated the ability to visualize nerves and vessels and if available, OR images will also be presented.

ENGINEERED SMALL AIRWAY MICROTISSUES FOR THE STUDY OF PARACRINE SIGNALING IN ASTHMA

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Introduction: Airway inflammation, bronchoconstriction, and extracellular matrix (ECM) remodeling are hallmarks of asthma that are present in the intact human airway but missing in many *in vitro* model systems. Toroidal ring tissue constructs provide a unique geometry that can better represent the structure and function of the airway smooth muscle tissue in the airways. In this work, we present the assembly and characterization of airway microtissue rings that provide a relevant and feasible model for the examination of the small airways and asthma-associated changes.

Methods: Airway smooth muscle (ASM) cells were aggregated to form tissue rings in custom polydimethylsiloxane (PDMS) molds pre-treated with a 1% w/v solution of Pluronic F-127. The tissue rings developed for up to 21 days in 1:1 DMEM/F-12 culture medium supplemented with 1% fetal bovine serum. Prior to the administration of exogenous signaling factors such as TGF-β1, the microtissue culture medium was supplemented with insulin, transferrin, and selenium without serum for 7 days. At given time points during the microtissue development, rings were collected to examine cell viability and to measure their physical dimensions by quantification of light microscopy images. Microtissues were stained using TRITC-conjugated phalloidin and imaged using fluorescence and confocal microscopy to visualize filamentous actin. To measure mechanical properties, live tissue rings were suspended between a linear motor and load cell, pre-stressed to 10-15% strain for 10 cycles, then extended to rupture. The expression of ECM,

contraction-associated proteins, and inflammation-associated factors was examined using semi-quantitative endpoint PCR.

Results and Discussion: ASM cells consistently formed tissue rings that were tunable in size (interior diameter and ring thickness) by varying mold dimensions and seeding densities. Cell metabolic activity decreased over time up to 7 days as the rings developed. Viable ASM cells with a spindle-like morphology were observed along the surface of the tissue, axially aligned along the circumference of the ring for up to 21 days. Ring strength and elastic modulus increased over 14 days, but this was not accompanied by significant changes in ring size. PCR analysis indicated stable expression of genes coding for ECM-associated proteins, including collagen I and laminins α1 and α4 over 21 days. Cells within the microtissue construct responded to TGF-β1 treatment at 10 ng/ml over 3 days, with observed increases in the expression of collagen I and fibronectin, as well as the contraction-associated smooth muscle myosin heavy chain and α-smooth muscle actin genes.

Conclusions: In this work, we developed ASM tissue rings in custom PDMS wells for the study of ASM phenotype and function in a 3D cell culture environment. This study demonstrates the ability to examine ASM cell mechanics and gene expression in a physiologically relevant format. This system may better facilitate the study of airway pathologies *in vitro*.

ASSESSMENT OF ROUTINE CLINICAL EXAM PROTOCOLS ON LOW FIELD MRI FOR IMAGING PASSIVE NEURAL IMPLANTS

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Introduction: The performance of a modern low field 0.5 Tesla (T) MRI scanner was compared with clinical field strength MRIs (1.5 T and 3 T) with respect to the size of metal artifact produced under standard clinical pulse sequences. The paramagnetic and ferromagnetic contributions to local magnetic field perturbations caused by a stainless-steel medical device were also evaluated.

Methods: Two passive metallic implants available for testing were an 316L stainless steel (MR-safe type) skin staple and a nitinol endovascular stent. The devices were tested in-vitro in general accordance with ASTM International F2119-07(2013). Artifact size was assessed using the sequences and parameters for routine brain health MRI examinations at our institution. Paramagnetic and ferromagnetic contributions to local magnetic field effects were assessed using repetition time-matched balanced steady-state free precession pulse sequences.

Results and Discussion: Low field MRI was found to produce images with less in-plane artifact in both total area and maximum length when compared to higher fields in five out of seven tested pulse sequences. In two of the tested pulse sequences, low field MRI produced larger artifact, possibly due to clinical protocolling decisions that aimed to limit artifact at the expense of other factors. The paramagnetic contribution was found to account for 92% of the local field perturbation at 3 T while only contributing 64% at 0.5 T. This illustrates the potential advantage of low field MRI for imaging near metal implants, even those having considerable saturated magnetic component.

Conclusions: Despite differences in protocolling decisions, clinically optimized sequences often produced images with less metal artifact at low field. Additionally, low field MRIs can provide an advantage in terms of metal artifact reduction, even for MRI-safe devices which exhibit some degree of saturated behaviour.