



Modern Human Anatomy Program

UNIVERSITY OF COLORADO
ANSCHUTZ MEDICAL CAMPUS

2021

Capstone Project Presentations

Monday, April 21st

2021 Modern Human Anatomy Program Capstone Poster Presentations Agenda

April 21, 2021

9:00 AM **Welcome and overview, Dr. Ernesto Salcedo**

9:05 AM – 9:55 AM **Capstone Presentations for Session I**
Moderator: Dr, Ernesto Salcedo

<https://ucdenver.zoom.us/j/92657385066?pwd=WXdCV0EzU3Zrd1lNRldHNGszUEdSQT09>

Meeting ID: 926 5738 5066

Passcode: 842536

10:00 AM – 11:05 AM **Capstone Presentations for Session II**
Moderator: Dr. John Caldwell

<https://ucdenver.zoom.us/j/99521658290?pwd=Qlp5bmhUa3RqZzl5a1B0V0ZVUFpHUT09>

Meeting ID: 995 2165 8290

Passcode: 107044

11:10 AM – 12:15 PM **Capstone Presentations for Session III**
Moderator: Dr. John Thompson

<https://ucdenver.zoom.us/j/91906750694?pwd=c3hqQXpwejhLTDgwZzlYam5FQk5kQT09>

Meeting ID: 919 0675 0694

Passcode: 180362

Session I Presenters

9:05 AM – 9:55 AM

<https://ucdenver.zoom.us/j/92657385066?pwd=WXdCV0EzU3Zrd1lNRldHNGszUEdSQ09>

Meeting ID: 926 5738 5066

Passcode: 842536

Capstone Presenter	Presenter #	Abstract Page #	Presentation Title
Alexis MacDonald	1	6	Evaluation of 3D Printed Models on Cardiac Catheterization Staff Education of Single Ventricle Palliation poster
Marisa Flores	2	7	That costs How Much: 3D printing a female pelvic ultrasound phantom
Conner Secora	3	8	Traumatic Brain Injury Exacerbates Alzheimer's Disease in the Retina
Caleb Fiebig	4	9	We're on the right tract: Diffusion tensor imaging assessment of epileptogenic zone using depth electrode locations to investigate white matter networks. poster
Kimberly Thies	5	10	Targeting Effects of rZI vs. STN in Deep Brain Stimulation for Parkinson's Disease. poster

Session II Presenters

10:00 AM – 11:05 AM

<https://ucdenver.zoom.us/j/99521658290?pwd=Qlp5bmhUa3RqZzl5a1B0V0ZVUFpHUT09>

Meeting ID: 995 2165 8290

Passcode: 107044

Capstone Presenter	Presenter #	Abstract Page #	Presentation Title
Jessica Bryant	1	11	Animating and 3D Printing the Cranial Nerves poster
Lauren Wahl	2	12	Evaluation of 3D Digital Models in Head and Neck Anatomy poster
Hailey Angus	3	13	What the head and neck? A study of integrated gross anatomy with embryology and its effect on learning and retention. poster
Marissa Hight	4	14	Change of Heart: Virtual Embryonic 3D Heart Model with Interchangeable Conotruncal Septa Promotes Clinically Oriented Learning. poster
Andrew Hull	5	15	Embryorigami: The Educational Value of 4D Virtual Embryo Models on Student Learning and Confidence. poster
Peter Therriat	6	16	Anatomy Educators' Ethical Views on the Re-creation of Human Tissue via 3D Printing Technology. poster

Session III Presenters

11:10 AM – 12:15 PM

<https://ucdenver.zoom.us/j/91906750694?pwd=c3hqQXpwejhLTDgwZzlYam5FQk5kQT09>

Meeting ID: 919 0675 0694

Passcode: 180362

Capstone Presenter	Presenter #	Abstract Page #	Presentation Title
Eliza Biondi	1	17	Can you stand it? A comparison of vertical ground reaction force in patients with osteoarthritis. poster
Cassandra Gonzalez	2	18	Long-term Cardiometabolic Risk Among Acute Lymphoblastic Leukemia Childhood Cancer Survivors Treated by Bone Marrow Transplant
Zachary Zylstra	3	19	Assessment of Cone Beam CT Accuracy for Creating Digital Scale Models: an Essential Step for Actualizing 3D Printed Dental Implants poster
Deion Peña	4	20	Heart Grew Three Sizes: Improving the Health Literacy of Patients Utilizing 3D Heart Model of Hypoplastic Left Heart Syndrome
Canaan Kerr	5	21	Integrating Endoscopy: Visual Scoring and Lung Fluid Cellularity Associated with Eosinophilic Esophagitis. poster
Rawan Jarrar	6	22	Neural correlates behind selective attention and visual conflict monitoring using a Stroop task

Posters can also be found here in this [ONEDrive folder](#)

Thank you to faculty and industry experts serving on capstone committees, as these projects would not be possible without your commitment to the success of our students.

MSMHA Student	Capstone Committee Chair	Capstone Mentor	Committee Member
Angus, Hailey	Caley Orr, PhD	Lisa Lee, PhD	Jennifer Stratford, PhD
Biondi, Eliza	Chelsea Lohman Bonfiglio, PhD	Jennifer Stevens-Lapsley, PT, PhD	Jacob Capin, DPT, PhD
Bryant, Jessica	John Thompson, PhD	Ernesto Salcedo, PhD	Jake Shearer, MS
Fiebig, Caleb	Ernesto Salcedo, PhD	John Thompson, PhD	Jennifer Stratford, PhD
Flores, Marisa	Caley Orr, PhD	Juliana Wilson, DO	Chelsea Lohman Bonfiglio, PhD
Gonzalez, Cassandra	John Caldwell, PhD	Jill Kaar, PhD	Hesham Eissa, MD
Hight, Marissa	Ernesto Salcedo, PhD	Lisa Lee, PhD	Nicholas Jacobson, MDesD
Hull, Andrew	Ernesto Salcedo, PhD	Lisa Lee, PhD	Jennifer Stratford, PhD
Jarrar, Rawan	John Thompson, PhD	Isabelle Buard, PhD	Peter Teale, MSEE
Kerr, Canaan	Thomas Finger, PhD	Emily DeBoer, MD	Joel Friedlander, MD
MacDonald, Alexis	Chelsea Lohman Bonfiglio, PhD	Jenny Zablah, MD	Michael Shorofsky, MD
Peña, Deion	Caley Orr, PhD	Michael DiMaria, MD	Jenny Zablah, MD
Secora, Conner	Chelsea Lohman Bonfiglio, PhD	Natalia Vergara, PhD	Ernesto Salcedo, PhD
Therriat, Peter	Chelsea Lohman Bonfiglio, PhD	Daniel Goldberg, JD, PhD	John Caldwell, PhD
Thies, Kimberly	Caley Orr, PhD	John Thompson, PhD	Drew Kern, MD
Wahl, Lauren	Danielle Royer, PhD	Caley Orr, PhD	Jake Shearer, MS
Zylstra, Zachary	Chelsea Lohman Bonfiglio, PhD	Thomas Greany, DDS	Kerri Font, DDS

Session I: 9:05 AM – 9:55 AM

Presenter #1 Alexis MacDonald

Evaluation of 3D Printed Models on Cardiac Catheterization Staff Education of Single Ventricle Palliation

Capstone Committee: Chelsea Lohman Bonfiglio, PhD (chair), Jenny Zablah, MD (mentor), Michael Shorofsky, MD

ABSTRACT:

Three-dimensional printed models (3DPM) have applications in medicine that have seen rapid growth and diversification in the past decade. Education has been a large area of application, with patient and medical student learning extensively evaluated. Less investigated has been the usefulness of 3DPM in clinical staff education. The objective of this study is to assess the value and efficacy of using 3DPM of the heart for clinical education of cardiac catheterization laboratory staff. The complex and changing anatomy of patients with a single ventricle deformity presents the condition as a good case for the use of 3DPM. In particular, the 3 stages of single ventricle palliation were selected to be used as a model in testing the efficacy of 3DPM printing for staff member education. In this study, three-dimensional rotational angiography (3DRA) was used to create 3D printed models of each stage of single ventricle palliation. The aim of this study is to identify how 3DPM are perceived and understood by trained staff members as well as investigate how they may be useful in the future for both staff and cross-discipline training. We hypothesized that cardiac catheterization laboratory and pre/post-operative unit staff members will perceive 3D printed models to be more useful in understanding the anatomy of all stages of single ventricle repair than 2D angiograms, a more traditional form of depicting variations of congenital heart disease. Staff members associated with either the cardiac catheterization laboratory or cardiology pre/postoperative unit were given a pre-educational survey, participated in both two-dimensional and three-dimensional educational modalities, and asked to reassess their knowledge in a post-education survey. The deidentified participant data was analyzed using a Kruskal Wallis test for non-parametric data followed by a thematic analysis performed on survey comments received. We found the reported ratings of knowledge at each stage of single ventricle repair after the 3DPM module to be significantly higher from the pre-educational values at all stages (all $p < 0.05$). The post-2D module values were not statistically different from the pre-educational survey ($p > 0.05$) suggesting that 3DPM could be a strong educational modality for staff members. Lastly, the thematic analysis of participants comments allowed us to identify strengths and weaknesses of 3DPM in congenital cardiology for staff education which may have future significance and implications on staff member training. This study implicates that 3DPM could play a larger future role in staff education and may have other benefits in training applicable to interventional congenital cardiology.

Presenter #2 Marisa Flores

That costs How Much: 3D printing a female pelvic ultrasound phantom

Capstone Committee: Cale Orr, PhD (chair), Juliana Wilson, DO (mentor), Chelsea Lohman Bonfiglio, PhD

ABSTRACT:

Objective: Point of care ultrasound (POCUS) exams have demonstrated to lead to more timely and accurate diagnosis. Although most physicians begin ultrasound training in medical school, most emergency medicine residents complete their first female pelvic and transvaginal ultrasounds on emergency room patients as residents. Ultrasound phantoms have been proven to be a reliable educational resource. Unfortunately, female pelvic ultrasound phantoms on the market can be cost-prohibitive in ultrasound training. This study aims to test the hypothesis that a 3-dimensional (3D) printed self-assembled female pelvic phantom embedded in ballistic gel will prove to be a cost-effective and adequate resource for student training of female pelvic ultrasound.

Methods: In this study, we digitally modeled, and 3D printed a uterus, ovaries, and female pelvic bones. First models were created using a perishable material to test the reliability of the 3D printed models under ultrasound scans. The final phantom is to be composed of ballistics gel for longevity.

Results: The different materials used during the printing process did not show a significant density difference between structures under ultrasound. As currently constructed, the phantom is perishable, but imaging results suggest that it is an adequate design warranting the development of our more permanent version using ballistics gel.

Conclusions: The overall cost and quality of the new phantom model suggests it is a suitable resource for student training while also being more cost-effective than other phantoms currently on the market.



Presenter #3 Conner Secora

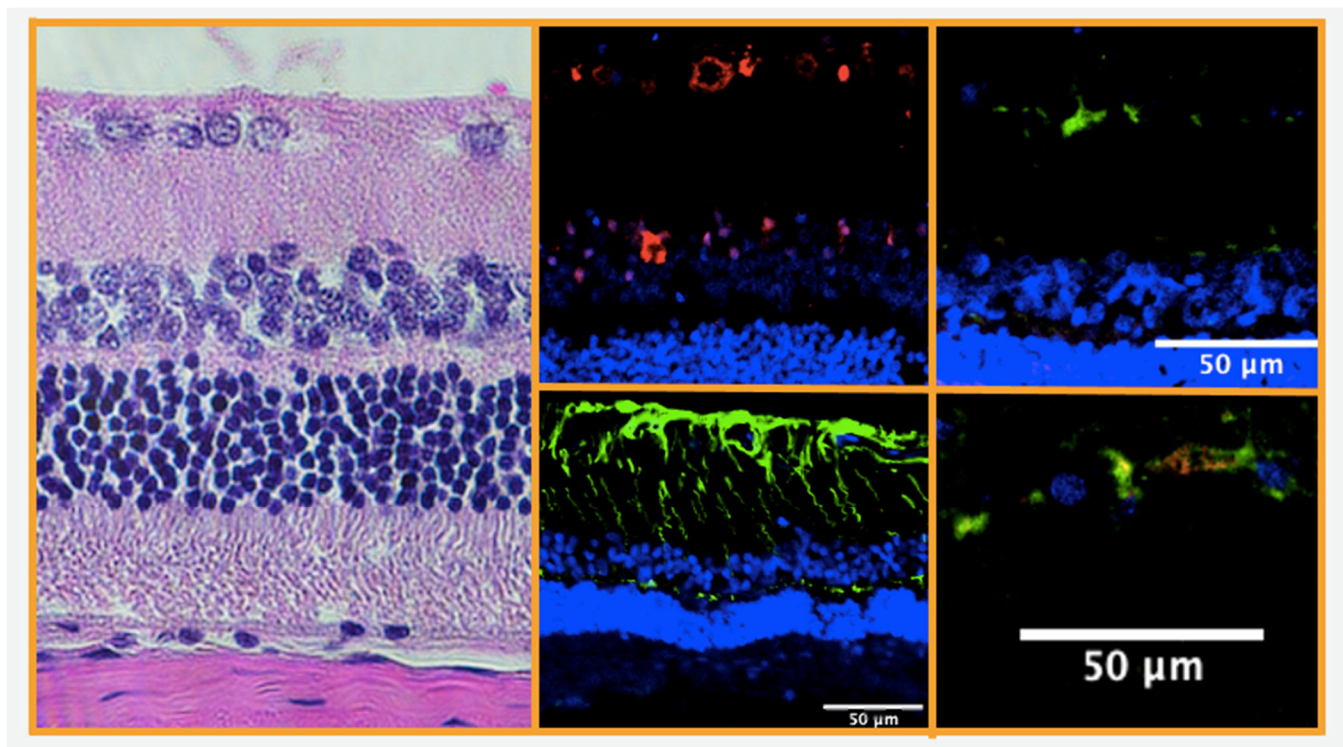
Traumatic Brain Injury Exacerbates Alzheimer's Disease in the Retina

Capstone Committee: Chelsea Lohman Bonfiglio, PhD (chair), Natalia Vergara, PhD (mentor), Ernesto Salcedo, PhD

ABSTRACT:

Alzheimer's disease (AD) is a neurodegenerative condition that affects 5.7 million people in the U.S. alone, representing the leading cause of dementia. Additionally, traumatic brain injury (TBI), which can arise from sport concussions, military combat and other causes, is associated with a 2.3-fold higher risk of developing AD and AD-related dementias. Moreover, AD can also lead to visual impairment, and recent studies have found that AD histopathology manifests in the retina, which is an extension of the central nervous system. However, the pathophysiological link between TBI and AD remains poorly understood. In this study we set out to evaluate the effects of TBI, AD, and their combination, on retinal histopathology.

Several animal models have been developed to investigate the mechanisms of AD but have been limited by imperfect recapitulation of human pathology. Here we take advantage of a transgenic rat model (Tg-F344) that more faithfully mimics human AD pathology, and subject it to a TBI paradigm. Wild-type and transgenic rats were randomly selected to undergo a two-time unilateral controlled cortical impact (2xCCI). At 16 months of age, the rats were sacrificed and the eyes subsequently removed, fixed, and processed. Retinas were sectioned and analyzed using immunofluorescent and standard histological staining techniques. Our results confirm the presence of AD markers in transgenic retinas, and an increased severity of AD pathology due to TBI. This has meaningful implications in understanding the pathophysiology of AD in relation to TBI within the retina, which could lead to better treatments and to the development of retinal biomarkers for improved AD diagnosis.



Presenter #4 Caleb Fiebig

We're on the right tract: Diffusion tensor imaging assessment of epileptogenic zone using depth electrode locations to investigate white matter networks.

Capstone Committee: Ernesto Salcedo, PhD (chair), John Thompson, PhD (mentor), Jennifer Stratford, PhD

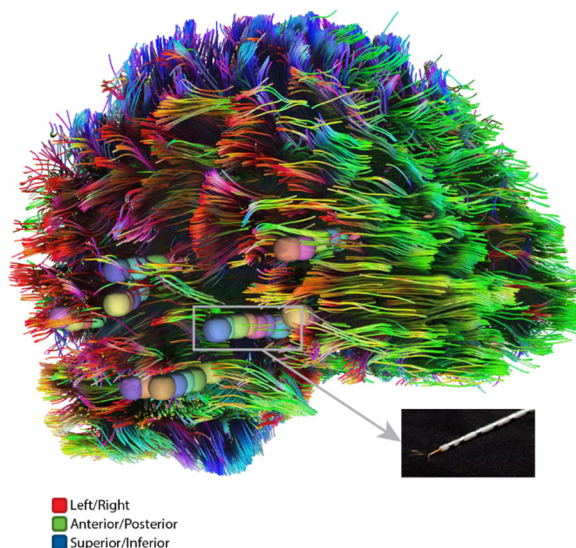
ABSTRACT:

Background: In patients with drug-resistant epilepsy, it can be difficult to pinpoint the precise regions of the brain that create and propagate abnormal brainwave activity. Stereoencephalography (SEEG) is a minimally invasive approach with reliable accuracy in the localization of the epileptogenic zone in patients with drug-resistant epilepsy (Serletis et al., 2014). Diffusion tensor imaging (DTI) has been used to estimate and model white matter tracts of the brain, allowing for 3D visualization of brain region connections and networks. To date, the combination of patient-specific brain imaging and 3D extracted depth electrode contacts and white matter tracts has not been used to build patient-specific seizure network models. The goal of this project is to utilize the combination of these methods to define the epileptogenic zone in order to investigate and potentially locate shared networks across patients with drug-resistant epilepsy that predict susceptible networks.

Methods: Human participants (N=10) in an IRB-approved protocol underwent SEEG along with pre- and post-operative imaging. Implanted probes were segmented from the post-operative images and 3D white matter tracts were generated from the pre-operative DTI. A novel structural analysis approach was applied to extrapolated association fiber bundles representing the major known human white matter tracts. This structural shape analysis was also applied to the fiber bundles derived from SEEG electrode contacts. An independent t-test was run on 23 canonical fiber bundles with associated shape parameters in comparison to hippocampal tract data to determine the probability that fiber bundles were shared between the structures.

Results: 8 of the 23 canonical fiber bundles were indicated in sharing a significant number of fibers with the hippocampus-associated tracts.

Conclusion: This study indicates that the combination of DTI tractography along with SEEG data can bridge the gap between the anatomical and physiological components of the brain, allowing us to better understand and study neuropathologies such as drug-resistant epilepsy.



Presenter #5 Kimberly Thies

Targeting Effects of rZI vs. STN in Deep Brain Stimulation for Parkinson's Disease

Capstone Committee: Caley Orr, PhD (chair), John Thompson, PhD (mentor), Drew Kern, MD

ABSTRACT:

Parkinson's Disease (PD) is one of the most common neurodegenerative disorders with a range of associated motor and nonmotor symptoms. There is currently no cure for this disease, and treatment of PD mainly focuses on symptom management. Deep brain stimulation (DBS) surgery is a highly efficacious therapy for several movement disorders, including PD, as it modulates pathologic brain activity in deep brain structures. The main targets for DBS in PD are the subthalamic nucleus (STN) and globus pallidus interna (GPI) because of their regulating function in basal ganglia output. However, STN-targeted DBS has been associated with the onset of adverse effects including dyskinesias (involuntary/continuous movements) and neuropsychiatric manifestations. Another deep brain structure located dorsal to the STN is the zona incerta (ZI). Limited research has been published on the use of ZI as a target for DBS in PD. The rostral zona incerta (rZI) is of particular interest in this study due to its location of many converging white matter pathways important for motor related activity. The aims of the current study include (1) to localize electrodes and build a trajectory model within each patient's bilateral STN using neuroradiology data and 3D imaging software, (2) to evaluate each patient in a double-blind clinic visit while on three different optimized DBS stimulation settings: STN alone, rZI alone, and STN + rZI co-stimulation using rating scales defined by the Movement Disorder Society (MDS-UPDRS and UDysRS), and (3) to incorporate these optimized stimulation parameters into a software creating a volume of tissue activated (VTA) model for each patient. Within STN, DBS stimulation parameters induce an electric field with a unique geometric shape modeled as a VTA for each patient. By quantifying this VTA, clinicians can estimate the percent of STN activated and elucidate how this stimulation is spreading to other areas of the brain such as rZI. Methods of this study tested the hypothesis that a contact in the region of rZI further improves the benefit patients obtain with DBS compared with STN stimulation alone. Findings suggest no significant differences in outcome data between the three stimulation settings, likely because sensitivity of the rating scales used may not be amenable to the acute transitions that took place in this study. However, it was found that--of the three conditions--patients largely preferred (50%) STN + rZI stimulation which is highly clinically meaningful. These results show therapeutic equivalence across the three stimulation paradigms and demonstrate no adverse effects occurring with rZI stimulation. These results, if replicated in larger studies, have important implications for current DBS therapy of PD and point to a promising target area for future neurosurgical interventions.

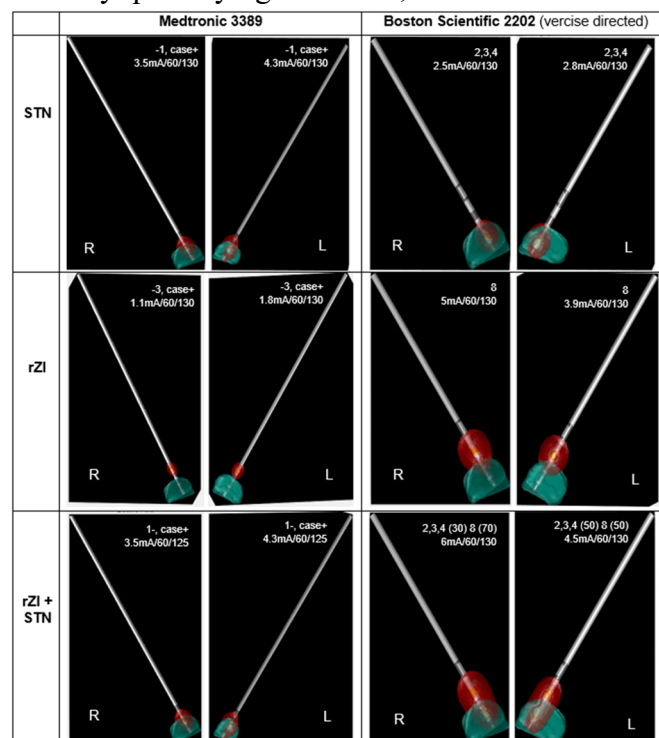


Figure 1: Volume of tissue activated (VTA) models for two study patients. The teal structure represents STN & the red structure represents VTA

Session II: 10:00 AM – 11:05 AM**Presenter #1 Jessica Bryant*****Animating and 3D Printing the Cranial Nerves***

Capstone Committee: John Thompson, PhD (chair), Ernesto Salcedo, PhD (mentor), Jake Shearer, MS

ABSTRACT:

Cranial nerves are widely taught in health science education yet lack a complete learning resource. Students require a complete visualization of the anatomy of the cranial nerves, which is not widely available in education. Learners typically rely on dissection that destroys the passage of the nerves or textbook images showing only a 2D rendering. This project sought to develop a new virtual and 3D printed educational resource depicting the passage of the cranial nerves through the skull to bridge that educational gap. This project segmented the cranial nerves, and 3D modeled them from origin to endpoint using the Visible Human Male (VHM) dataset kindly provided by Touch of Life Technologies (Toltech). The VHM models provide better realism than others available, as they are compiled from real cadaveric sections. The 3D models were animated in Maya to create a short summary video highlighting each cranial nerve. The animations were uploaded to a YouTube playlist and provided to first and second-year Modern Human Anatomy (MHA) students. The entire model was also 3D printed using clear resins on a Form2 printer. The skull printed successfully after 41 hours, while the brainstem and attached nerves failed after 19 hours. The physical models will thus be provided to students later. Students filled out a survey rating the effectiveness of the animations as a learning resource and comparing it to other methods available. Feedback from students proved difficult to garner during COVID-19. The results were analyzed to determine if it is more effective for graduate level students learning anatomy and if it represented a complete learning resource for the cranial nerves. Different methods of printing, including collaborating with Inworks, are being explored as different approaches to the project. Until a 3D print can be provided in conjunction with the cranial nerve animations, the hypothesis regarding them being a complete learning resource could not fully be evaluated. However, early survey data provides promising results showing that the project has the potential to be a complete learning resource in the future.



Presenter #2 Lauren Wahl

Evaluation of 3D Digital Models in Head and Neck Anatomy

Capstone Committee: Danielle Royer, PhD (chair), Caley Orr, PhD (mentor), Jake Shearer, MS

ABSTRACT:

Head and neck anatomy has been regarded as one of the most difficult subjects of human anatomy to learn and mentally visualize. Appropriate models and three-dimensional (3D) representations of this complex anatomy are either unaffordable and/ or do not detail the advanced anatomy of the head and neck regions that professional students in a human anatomy graduate program are required to know (Park et al 2018). The lack of proper detailed and affordable 3D resources for advanced head and neck anatomy leaves a gap in the kinds of resources that professional students in anatomical sciences have voiced that they prefer to learn and study from for an anatomical region that is more difficult to visualize and view in a 3D representation outside of traditional lecture or laboratory materials (cadaveric dissection, lecture slide decks, etc.). The goal of this project was to create a 3D representation of the parasympathetic cranial nerve fiber distribution within the head and neck as an example of complex anatomy professional students are required to know and evaluate whether using this 3D representation had any effect on student assessment performance and confidence. In order to generate a useful 3D resource of complex head and neck anatomy that detailed anatomy sufficient for the studying purposes of a professional student in anatomical sciences, a 3D digital resource of the parasympathetic cranial fiber distribution was crafted from a microcomputed tomography dataset, segmented in 3D Slicer, further modeled and developed in Maya, and uploaded to an Sketchfab, an open-access online platform, for easy student access. In an IRB-approved protocol, students were then randomly selected to use either the 3D digital model or traditional lecture resources in an optional review session to complete a worksheet on cranial nerve parasympathetics and were also given pre-review and post-review content assessments and confidence questionnaires to gauge their mastery and comfort level with the material. With a total $n = 23$, no significant differences were found in pre- versus post-review assessment scores ($p = 0.590$) nor in pre- versus post-review confidence ratings ($p = 0.478, 0.416, 0.274$). These results were expected as previous literature on similar studies have produced similar results; however, feedback from students indicated that the 3D digital resource was “easy to visualize”, “helpful and easy to connect to 2D resources”, but they also commented that it could be improved by “overlaying sympathetic as well” and “changing opacity gradients and nerve colors”. Future directions of this study include incorporating a 3D printed model for more hands-on student learners and testing the efficacy of these 3D resources on other professional students at the same institution. Ultimately, this study shows that affordable 3D models that represent complex anatomy that is required for mastery by professional anatomy students can be helpful ancillary educational tools.

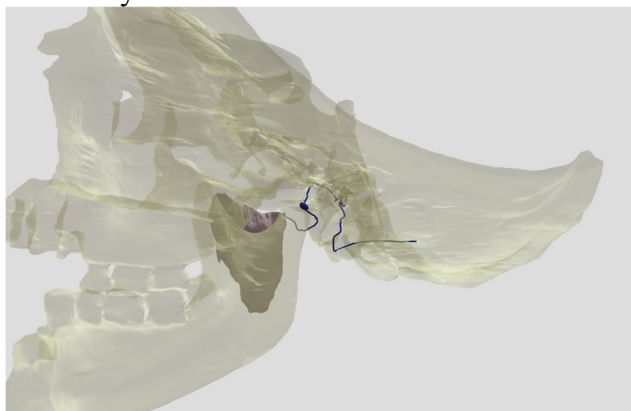


Figure 1. Glossopharyngeal parasympathetic fiber distribution to the parotid gland.

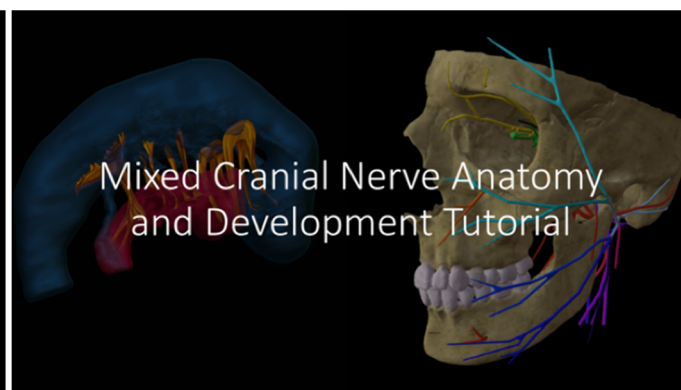
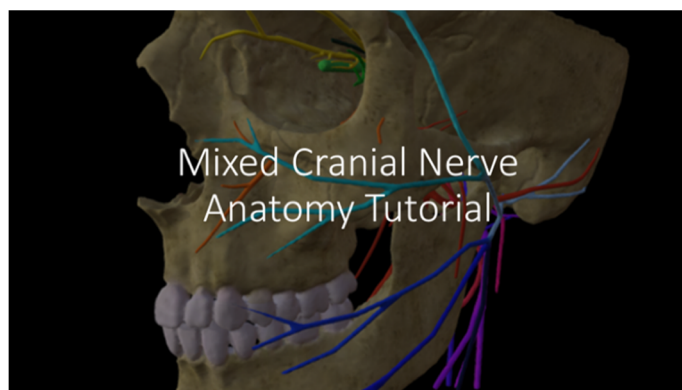
Presenter #3 Hailey Angus

What the head and neck? A study of integrated gross anatomy with embryology and its effect on learning and retention.

Capstone Committee: Caley Orr, PhD (chair), Lisa Lee, PhD (mentor), Jennifer Stratford, PhD

ABSTRACT:

Horizontal integration in curricula is the combining of basic science courses together to give students a better understanding of how the different sciences work together. Integration is thought to improve student learning and retention. Many health professional schools are switching to integration in the first two years to combat reduced contact hours in the basic sciences. Along with integration, the introduction of online resources for students is growing, especially within this last year thanks to the Covid-19 pandemic. There is evidence to suggest that integrated curriculums benefit student learning, but it is not well studied if integration of embryology alone in gross anatomy content improves student understanding of gross anatomy. It is also not known how this applies in the use of online resources. In addition, few studies have focused on these effects in dental student populations. This study was designed to determine if integration of embryology in an online gross anatomy tutorial led to better learning, retention, and confidence in cranial nerve anatomy for dental students than a stand-alone gross anatomy tutorial. To that end two digital tutorials on cranial nerve anatomy were created with the only difference between the two being integrated embryology content in the experimental video. First- and second- year dental students at CU Anschutz were recruited to participate in this single blind randomized study. Participants took a pretest, watched the assigned tutorial, and took a posttest. After data analysis, no differences in scores, score improvement, perceived learning, or confidence was found between control and experimental groups. This demonstrates that embryology integrated content may not improve gross anatomy understanding. This offers a new insight into how integration affects student learning. Although there were not differences between the control and experimental groups, there were significant improvements in student performance, confidence, and perceived learning in all groups and cohorts. Adding to research in favor of using digital resources. Student feedback in open-ended questions reiterates benefits of digital resources, integration, and some of the difficulties that coincide with their use. Finally, this study offers a model of study design that is repeatable, brief, and widely distributable for educational research.



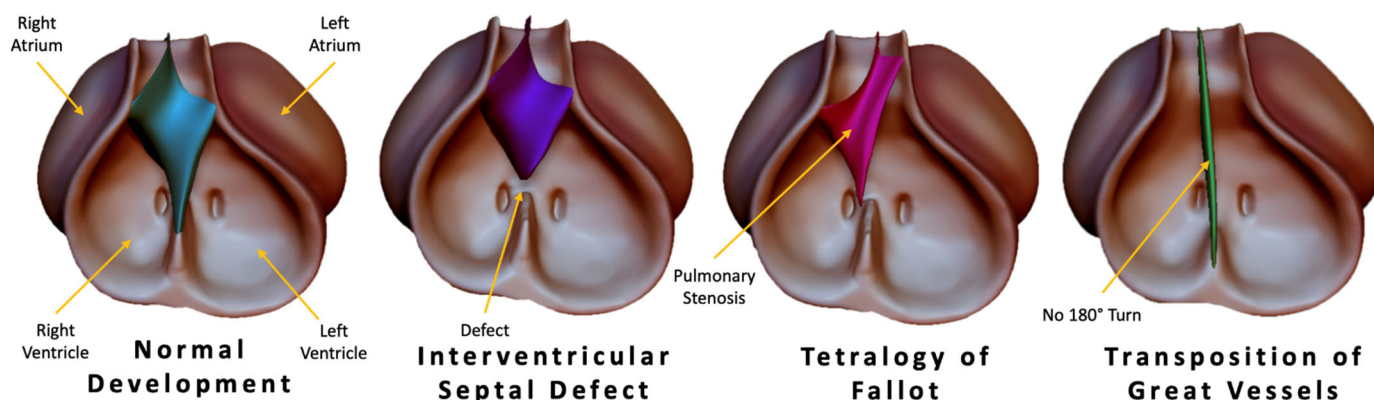
Presenter #4 Marissa Hight

Change of Heart: Virtual Embryonic 3D Heart Model with Interchangeable Conotruncal Septa Promotes Clinically Oriented Learning

Capstone Committee: Ernesto Salcedo, PhD (chair), Lisa Lee, PhD (mentor), Nicholas Jacobson, MDesD

ABSTRACT:

One of the most challenging and clinically relevant concepts in embryology is the heart outflow tract septation involving 180-degree spatial rotation and precise alignment of the growing septa that can often go awry, resulting in various congenital cardiac septal defects. Teaching and learning embryology pose challenges due to the rapid and complex developmental changes that occur across time and space. . Previous investigations have shown that virtual and 3D printed embryo models increase learning outcomes and interest in embryology. Unfortunately, there are no visual aids that effectively demonstrate heart outflow tract septation in 3D. Towards this end, we created a 3D embryonic virtual heart development model (EVH) with interchangeable conotruncal septa. The educational efficacy of this virtual tool was tested in a COMIRB exempt (# 20-2124), randomized single-blind study with the first-year medical students completing a flipped-classroom embryology active learning event occurring in a virtual platform due to COVID-19 restriction. As a part of the course requirement, all students first watched a pre-recorded lecture video and completed a test on their own before attending the synchronous virtual active learning event. During the active learning event, students were randomized into control or experimental breakout session groups. Experimental breakout session groups (16 groups, n=80) were provided access to the EVH with accompanying prompts designed to reinforce 3D spatial orientation and congenital septal defects demonstrated by the EVH. The control groups (14 groups, n=70) were tasked to complete a similar learning activity but on a different developmental process. All students completed a second test and a survey after the active learning event. Data analysis revealed that pre-test and post-test scores were not significantly between groups (Two-Way ANOVA $F(1,151) = 0.16$, $p=0.69$); however, survey data revealed that students positively perceived the educational value of the EVH, especially for demonstrating embryonic heart development (4.6 ± 0.84 on a 5-point agreement scale). Students also felt the EVH helped in understanding spatial and developmental changes (4.8 ± 0.80). Consistently, thematic analysis of the survey comments indicated that the spatial and visual aspects of the EVH demonstrating the congenital defects were perceived as essential. The significantly higher learning outcomes immediately after the resource interaction with EVH and the perceived favorability of the EVH warrant further development and research. A future aim of this project is to enhance the EVH to represent the sequelae of abnormal conotruncal septum formation. Group and virtual classroom effects are other confounds that should be reduced in future studies.



Presenter #5 Andrew Hull

Embryorigami: The Educational Value of 4D Virtual Embryo Models on Student Learning and Confidence

Capstone Committee: Ernesto Salcedo, PhD (chair), Lisa Lee, PhD (mentor), Jennifer Stratford, PhD

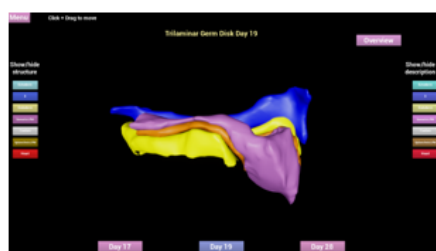
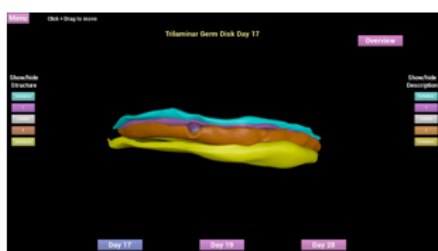
ABSTRACT:

In human development, normal formation of the body cavity involves intricate interplay of tissues folding from a flat disc form into a complex tube-within-tube 3D structure over a short period of time. Understanding the normal body cavity formation is imperative to understanding anatomic organizations, variations, and congenital conditions. Unfortunately, resources that effectively demonstrate changing body cavity anatomy during the folding process are sparse and their educational effectiveness is not well understood. Therefore, an interactive digital resource, the “Virtual Folding Embryo” (VFE), demonstrating the 4-dimensional transformation of the folding embryo (Figure 1) was created and its educational value was assessed in a COMIRB exempt (#20-2125) randomized single blind study. As a part of the flipped curriculum, 155 first-year medical students enrolled in an integrated anatomy course first viewed a pre-recorded lecture on embryology of the thorax then completed a quiz to test their foundational knowledge before attending a synchronous online active learning session conducted on the Zoom platform. Students were randomized into small breakout groups of 4-5 students and half of the groups were given access to the VFE (Figure 2), while the other half were given access to a resource demonstrating a different embryonic process. After 15 minutes, all students completed a quiz and an optional survey.

A two way repeated measures ANOVA showed there were no statistical differences between the control and VFE groups for pre or post quiz containing all questions, nor were there differences in post quiz scores between control and VFE groups, $F(1,151) = 0.28$, $p=0.59$. Additionally, no difference in pre quiz score between control and VFE groups when measuring body cavity quiz items only $F(1,151)= 1.06$ $p=0.3$ (Figure 4).

Descriptive statistics on the qualitative survey analysis indicate that students positively perceived the VFE for visually elucidating the transformation of the body cavity ($n=74$ mean Likert score = 4 on 5 point agreement scale; $sd=0.81$) and its spatial relationship to organ systems (mean=3.83; $sd=0.93$). Despite the favorable perception of VFE and improved quiz performance, students rated their level of confidence in the material low (mean=2.18, $sd=0.37$). Thematic analysis of survey comments reinforced positive perception of the VFE and indicated desire for more time for VFE interaction.

These results do not conclusively demonstrate direct correlation between the VFE and learning outcomes. However, qualitative results warrant further development and investigation of the VFE under different educational circumstances to determine efficacy. Virtual 4D resource such as VFE, designed for active learning may hold potential to enrich student engagement in the post COVID-19 era, and serve as a model for creating similar resources in the future.

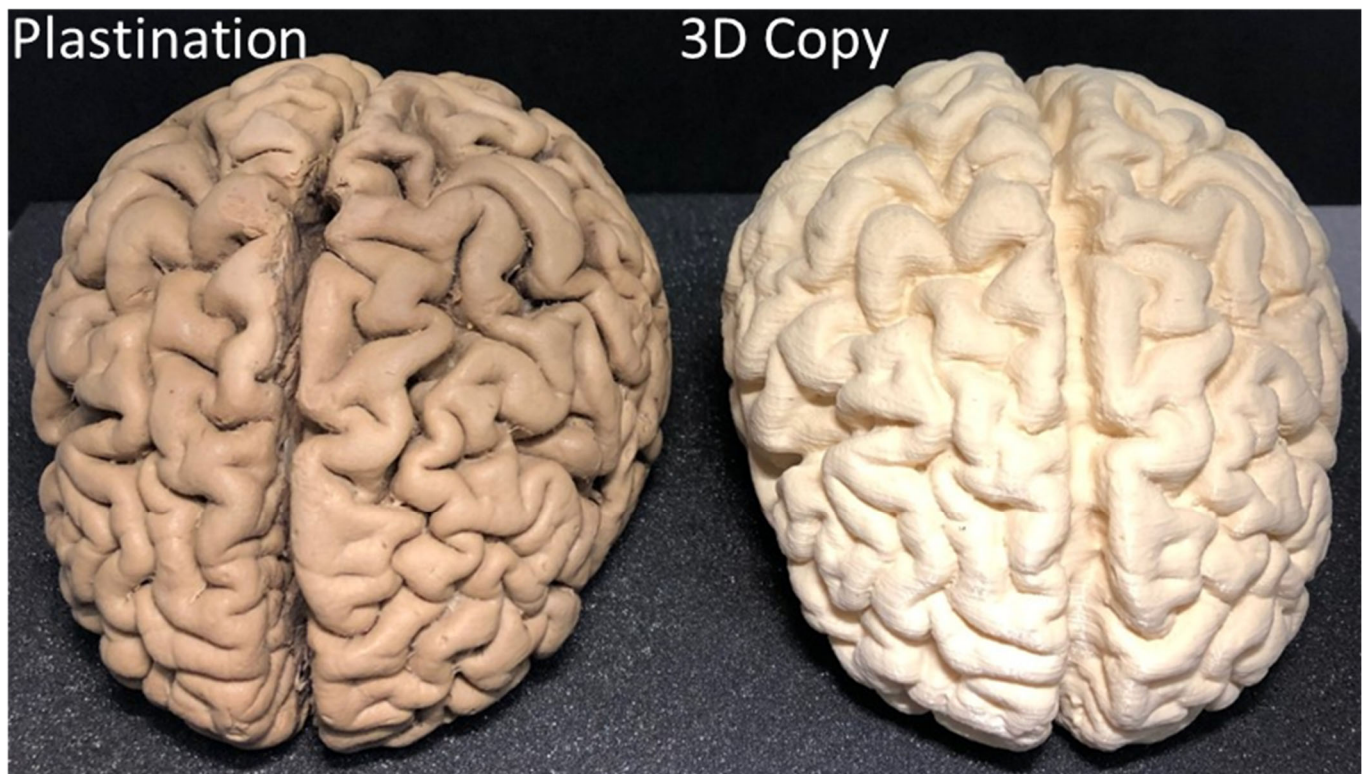


Presenter #6 Peter Therriat***Anatomy Educators' Ethical Views on the Re-creation of Human Tissue via 3D Printing Technology***

Capstone Committee: Chelsea Lohman Bonfiglio, PhD (chair), Daniel Goldberg, JD, PhD (mentor), John Caldwell, PhD

ABSTRACT:

Cadavers are the gold standard in teaching anatomical education. Contact hours in labs have decreased, which has created a need for different methods of teaching anatomical education. 3D printing has emerged in tandem with plastination to offer a tactile approach to learning anatomy, but with their emergence, ethical issues have arisen. 3D printing has not had the same ethical scrutiny that plastination has seen up until the present. Current ethical guidelines may not properly cover 3D printed re-creations; therefore, the aims of this study are to determine what ethical guidelines anatomy educators find most critical in the re-creation of human tissue via 3D printing for the purpose of training future health professionals. Overall findings suggest that anatomy educators find that the informed consent process could be updated on body donation forms, respect should be on a similar level as plastinations and other cadaver data sets, and accessibility/ownership of data from body donors may be decided on a case-by-case basis.

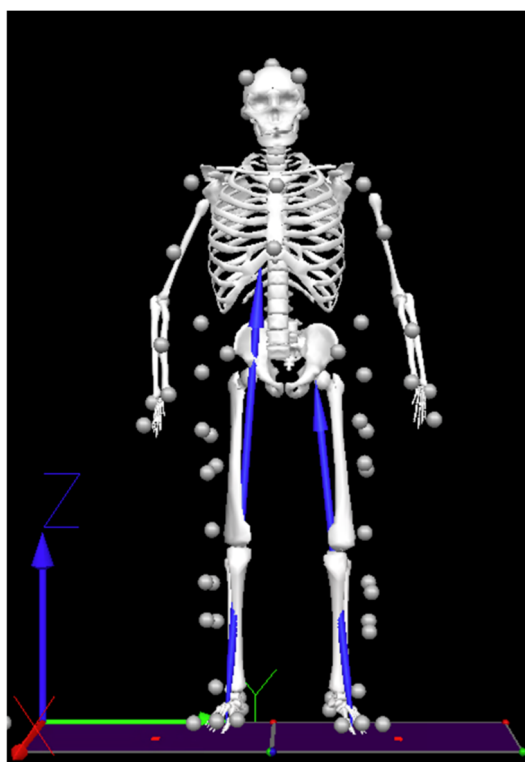


Session III:**11:10 AM – 12:15 PM****Presenter #1 Eliza Biondi*****Can you stand it? A comparison of vertical ground reaction force in patients with osteoarthritis.***

Capstone Committee: Chelsea Lohman Bonfiglio, PhD (chair), Jennifer Stevens-Lapsley, PT, PhD (mentor), Jason Capin, DPT, PhD

ABSTRACT:

Weight bearing asymmetry (WBA) between limbs is present in patients with advanced osteoarthritis (OA) and can be quantified using 90-second quiet standing trials. Causes of WBA include habitual movement patterns, pain, and reduced muscle strength. Studies that have previously examined quiet standing trials have approached quantifying asymmetries by averaging the entire time sequence, or a specific section in the trial. While these approaches work, the objective of this project was to examine variation in weight distribution throughout every section of a trial. 77 patients with OA were included in the study (mean age=65). Vicon Nexus was used to collect force plate data, Visual3D was used to process vertical ground reaction force (vGRF) data and export to MATLAB. These trials were then split into three even sections (first 30 seconds, middle 30 seconds, last 30 seconds), normalized by patients' body weight, and used to calculate an asymmetry ratio. The ANOVA showed no differences between groups ($p=0.99$). These results demonstrate that there is no variation in WBA from the beginning to end of a 90-second quiet standing trial. However, participants do exhibit WBA immediately and continuously during the trial suggesting this is a habitual stance not related to pain or muscle fatigue.



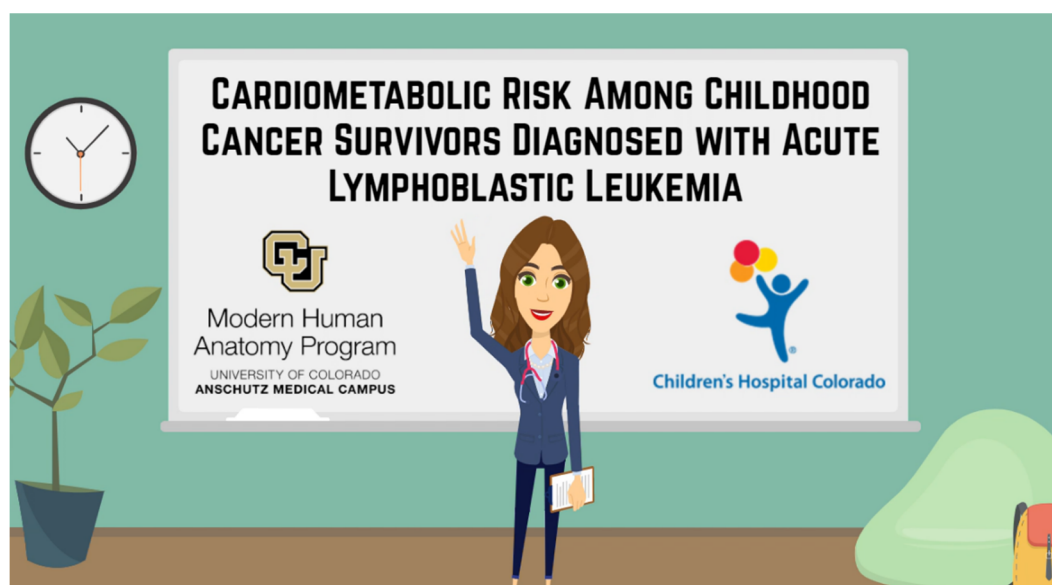
Presenter #2 Cassandra Gonzalez

Long-term Cardiometabolic Risk Among Acute Lymphoblastic Leukemia Childhood Cancer Survivors Treated by Bone Marrow Transplant

Capstone Committee: John Caldwell, PhD (chair), Jill Kaar, PhD (mentor), Hesham Eissa, MD

ABSTRACT:

Acute lymphoblastic leukemia (ALL), is the most prevalent of all childhood cancers with the majority of patients experiencing long term survival rates. Childhood cancer survivors (CCS) are at greater risk for developing cardiometabolic disease later in life compared to non-CCS. More specifically, disorders of the endocrine system such as obesity, type 2 diabetes, and metabolic syndrome. However, little is known regarding the health of ALL survivors who were treated by bone marrow transplant (BMT). The goal of this study will fill this research gap by examining cardiometabolic health outcomes in a sample of ALL survivors at Children's Hospital Colorado (CHCO). The outcomes will identify early cardiometabolic risk factors and document the need for improved treatment and clinical care for ALL survivors. We hypothesized that children who undergo more invasive treatments, such as BMT, will have a higher incidence of cardiometabolic risk factors compared to the general population. A COMIRB approved retrospective chart review of 68 patients diagnosed with ALL and treated with BMT between January 2008 to October 2020 was conducted via electronic medical records in the EPIC database. Demographics, comorbidities, treatment protocols, and clinical outcomes including height, weight, blood pressure, fasting glucose, HbA1c, HDL, triglycerides, and liver enzymes were collected at baseline, pre-BMT, and subsequent visits up to 24 months (3-, 6-, 9-, 12-, and 24-months) post-transplant. Preliminary data show survivors were predominantly non-Hispanic (59%), white (60%), and male (68%) between the ages of 6-22 at the time of transplant. The mean age at the time of transplant was 11 years old. At baseline, 37% of the population was overweight/obese and over 24 months post-transplant, this value was maintained. This study highlighted the need for ALL survivors at CHCO to receive a full metabolic workup beginning 2 years post-transplant. Survivors diagnosed with cardiometabolic risk factors will be placed in an intervention for treatment. An animated educational resource will accompany the intervention to enhance patient and parent understanding of cardiometabolic diseases.

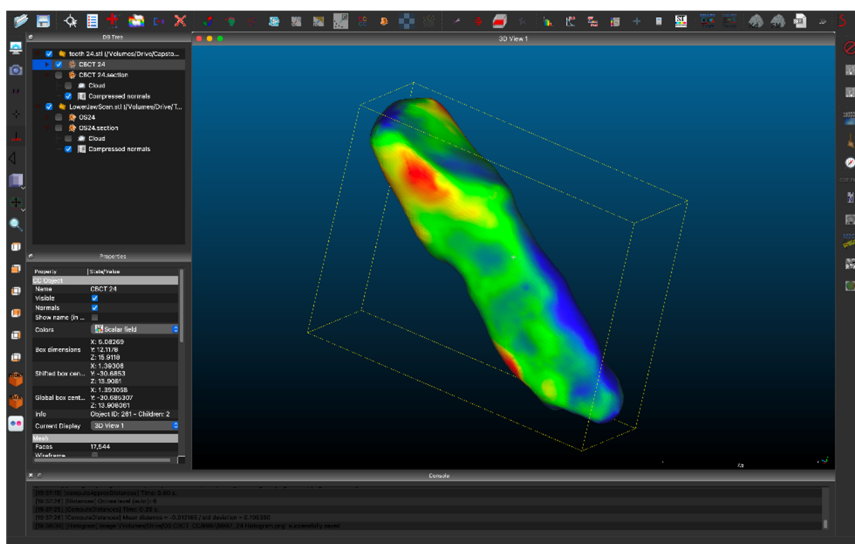
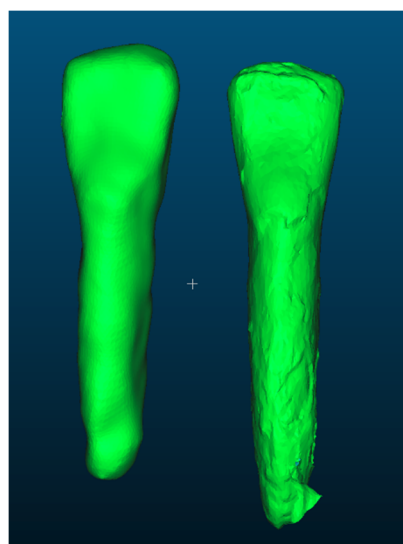


Presenter #3**Zachary Zylstra*****Assessment of Cone Beam CT Accuracy for Creating Digital Scale Models: an Essential Step for Actualizing 3D Printed Dental Implants***

Capstone Committee: Chelsea Lohman Bonfiglio, PhD (chair), Thomas Greany, DDS (mentor), Kerri Font, DDS

ABSTRACT:

Although there are many forms of preventative care for a patient, dental implants can play an incredible role in restoring someone's mouth and protecting both their self-image and livelihood from orofacial trauma, disease, or even following orthodontic treatment. However, dental implant therapy still lacks solutions for shortening the timeline of the therapy as a whole: extraction, bone grafting, implant placement, and healing abutment placement. In addition, controlling the cost of these various procedures, maintaining peri-implant tissue architecture, gingival embrasure cleansability, and delivering the aesthetic of a properly contoured coronal emergence profile remains top priority for dental professionals. Recently, Cone Beam Computed Tomography (CBCT) images have been used to diagnose bone volume and density in establishing a treatment plan that may involve dental implants. This study has shown that those same CBCT images can be used beyond diagnostics in dentistry to build a three-dimensional (3D) model of a patient's existing dentition and root structure. Using open GL software (CloudCompare), both CBCT and Medical Computed Tomography (MEDCT) segmentation models (3D Slicer) were overlaid onto digital impressions (TRIOS) of identical human cadaveric tooth samples in order to develop a standard of measurement through Boolean subtraction techniques. This comparative study gives a perspective on how well CBCT and MEDCT diagnostic techniques align in regard to their precision and accuracy. In addition, this model analysis is the first step in creating a 3D printed dental implant model that duplicates the patient's existing root structure morphology well enough to replicate ideal esthetics and function while shortening the restorative timeline and eliminating potentially unnecessary procedures.



Presenter #4 Deion Peña

Heart Grew Three Sizes: Improving the Health Literacy of Patients Utilizing 3D Heart Model of Hypoplastic Left Heart Syndrome

Capstone Committee: Caley Orr, PhD (chair), Michael DiMaria, MD (mentor), Jenny Zablah, MD

ABSTRACT:

Hypoplastic left heart syndrome (HLHS) is a congenital heart disease that is the underdevelopment of the left side of the heart and can lead to worsening complications if not treated appropriately. Symptoms that could occur from HLHS include cyanosis (bluish skin coloring), weak pulse, and shortness of breath. The treatment of HLHS is done through three surgical procedures that are the Norwood procedure, the Glenn procedure, and the final surgery that is the Fontan procedure. Due to the relatively high mortality rates and the complexity of Hypoplastic Left Heart Syndrome (HLHS), quality educational resources are needed to assist patients and their families to manage their treatment effectively. The current standard for patient education was through either diagrams or 3D models that were not effectively showcasing the anatomy affected. We hypothesized that by creating a 3D heart model that represents the anatomy of HLHS, this could be used as an educational resource to improve the health literacy of patients and families who are being treated at the Single Ventricle Heart Clinic at Children's Hospital Colorado. The effect of the 3D heart model was then evaluated with a survey that consisted of basic anatomical concepts of a normal heart and a heart that had HLHS. It was then evaluated if the 3D model was helpful for understanding HLHS and if there was an overall improvement in the understanding HLHS. There was an improvement of the averages of the survey scores after the educational intervention, but there was no statistical significance within the study. This was able to show that a 3D model has the capability to improve the understanding of a congenital heart disease while guiding patients through an active educational discussion.



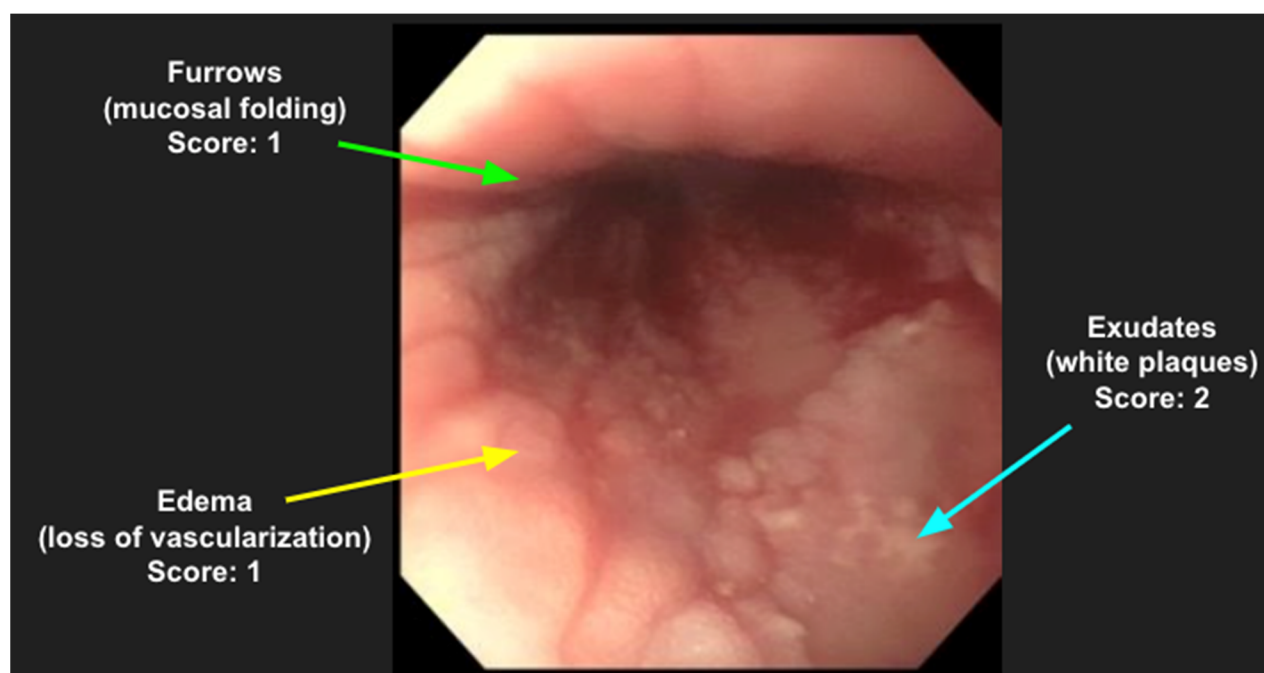
Presenter #5 Canaan Kerr

Integrating Endoscopy: Visual Scoring and Lung Fluid Cellularity Associated with Eosinophilic Esophagitis

Capstone Committee: Thomas Finger, PhD (chair), Emily DeBoer, MD (mentor), Joel Friedlander, MD

ABSTRACT:

Eosinophilic esophagitis (EoE) is a disease characterized by an invasion of eosinophils within the lining mucosa of the esophagus and is diagnosed via histological analysis of esophageal tissue. While there is a basic understanding of how EoE presents clinically, how EoE co-occurs and presents in children with multi-system aerodigestive disorders is less clear. In multidisciplinary aerodigestive clinics, diagnostic procedures such as flexible bronchoscopy may be able to enhance the diagnostic capability of upper intestinal endoscopy with biopsy. We hypothesized that eosinophilic esophagitis would cause clinically relevant gross presentations in the upper digestive and lower respiratory gross anatomy as well as increase lung fluid cellularity. To explore this question, this study analyzed bronchoscopies and esophagogastroduodenoscopies (EGDs) from ten pediatric aerodigestive patients with eosinophilic esophagitis (+EoE) and ten patients without eosinophilic esophagitis (-EoE) to evaluate presentations of EoE in the lower airway. Two validated visual scoring systems to assess the bronchoscopies and EGDs were used. The bronchoscopy scoring method analyzed secretion amount and mucosal appearance throughout nine regions of the bronchial tree. Bronchoalveolar lavage (BAL) fluid was also collected during bronchoscopies and analyzed for cellularity. The EoE Endoscopic Reference Score (EREFS) assessed the esophagus based on mucosal appearance. Based on bronchoscopy scores, we found that secretion amount and ridging of the mucosa varies between +EoE and -EoE patients. Based on EGD scores, we found that severity of exudates and furrows also varies between the two groups. Based on BAL cell counts, there was no significant difference in cellularity between +EoE and -EoE patients. These promising preliminary findings permit us to advocate for expansion of this analysis to increase sample size and integrate other variables including sex and the presence of comorbidities.



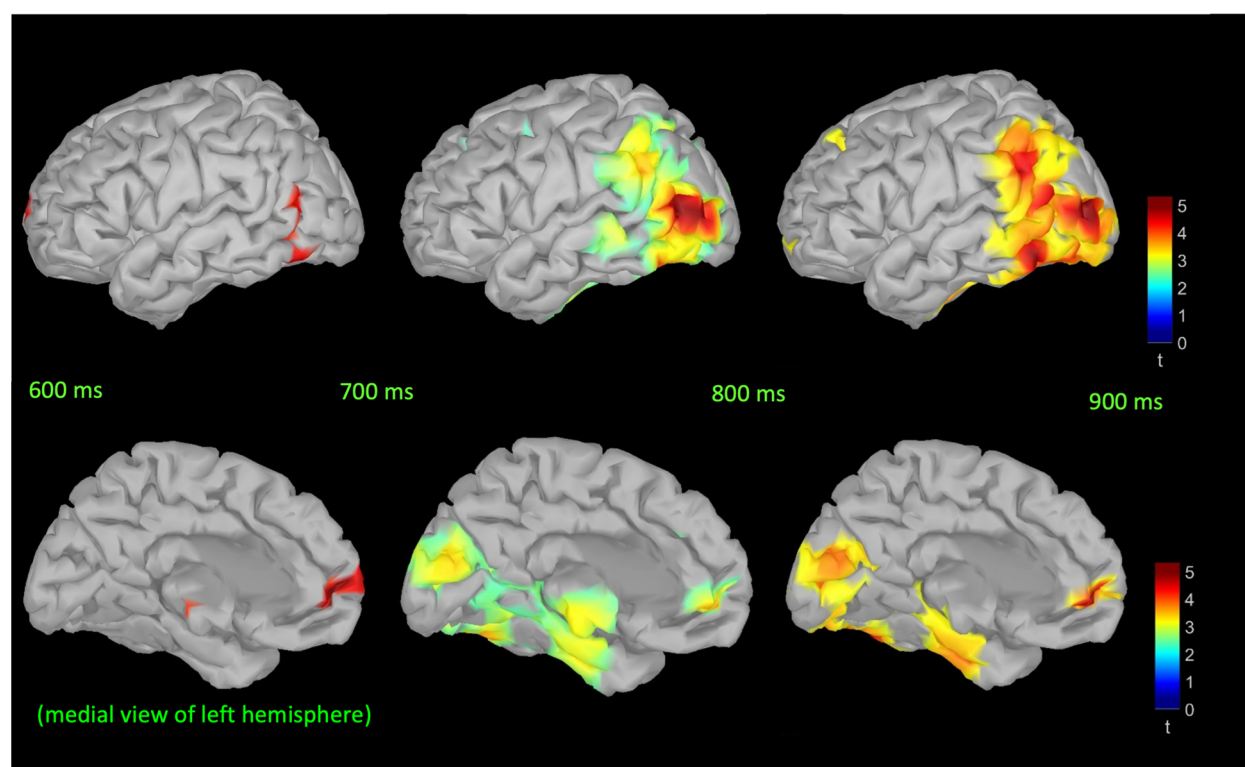
Presenter #6 Rawan Jarrar

Neural correlates behind selective attention and visual conflict monitoring using a Stroop task

Capstone Committee: John Thompson, PhD (chair), Isabelle Buard, PhD (mentor), Peter Teale, MSEE

ABSTRACT:

Selective attention and conflict monitoring are phenomena that humans use every day, yet the neurological underpinnings behind these processes are not yet fully understood. This study was an attempt to identify the spatial and temporal activity of the neural networks behind selective attention and conflict monitoring using a Stroop task. Evoked magnetic fields (EMFs) from a group of 28 healthy adults between the ages of 19 and 36 were measured while performing a computerized cued switch Stroop task using magnetoencephalography (MEG). We hypothesized that there would be stronger activation in the left dorsolateral prefrontal cortex (DLPFC) in the incongruent-neutral color contrast and stronger activation in the left anterior cingulate cortex (ACC) in the incongruent-congruent color contrast. Results revealed sustained, simultaneous activity in the left DLPFC and the left temporoparietal junction (TPJ) between 700-800ms post stimulus onset in the incongruent versus congruent contrast for the color condition, with no activation of the left ACC. The incongruent-neutral contrast revealed activation in the left ACC during the 600-700ms averaged time window, followed by activation in posterior brain regions, which supports a top-down biasing model of selective attention and conflict resolution. MEG has demonstrated to provide valuable insight into the spatial and temporal dynamics of these processes and should be implemented into standard practice for studying neural phenomena.



Cortical map of left hemisphere showing patterns of activation based on local maximum t-values with $p < 0.05$ FDR in a paired contrast of incongruent and congruent conditions for the color identification task.