Modern Human Anatomy Program

UNIVERSITY OF COLORADO
ANSCHUTZ MEDICAL CAMPUS

Capstone Project Presentations

Monday, April 22

2024

2024 Modern Human Anatomy Program
Capstone Project Presentations
April 22, 2024

12:00 PM – 1:00 PM **Lunch**
Education 2 Bridge

1:00 PM – 1:05 PM **Introduction and Overview**
Education 2 North, Room 1107

1:05 PM – 3:00 PM **Capstone Project Presentations**
Education 2 North, Room 1107

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Thank you to faculty 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
Kerry Barba	Ernesto Salcedo, PhD	Chelsea Lohman, PhD	Jennifer Stratford, PhD
Tara Hobbs	Paul Morse, PhD	Caley Orr, PhD	Anna Warrener, PhD
Ruby Martini	Ernesto Salcedo, PhD	John Thompson, PhD	Erin Radcliffe, BS
Isabella Mattingly	Maureen Stabio, PhD	Jenny Zablah, MD	Natalie Soszyn, MD
Keanan Sather	John Caldwell, PhD	Vera Fridman, MD	Aurélie Ledreux, PhD
Zachary Stetter	Chelsea Lohman, PhD	Maureen Stabio, PhD	Jake Shearer, MS
Alex Suarez	Paul Morse, PhD	Nicholas Jacobson, MDesS	Brooke French, MD
Hailey Wilkinson	Caley Orr, PhD	Briauna Blezinski Johnson, MS	Debra Szuster, MS

Presenter #1 Ruby Martini

Correlating Kinematics with Beta Frequency in the Subthalamic Nucleus for Patients with Parkinson's Disease

Capstone Committee: Ernesto Salcedo (chair), John Thompson (mentor), Erin Radcliffe

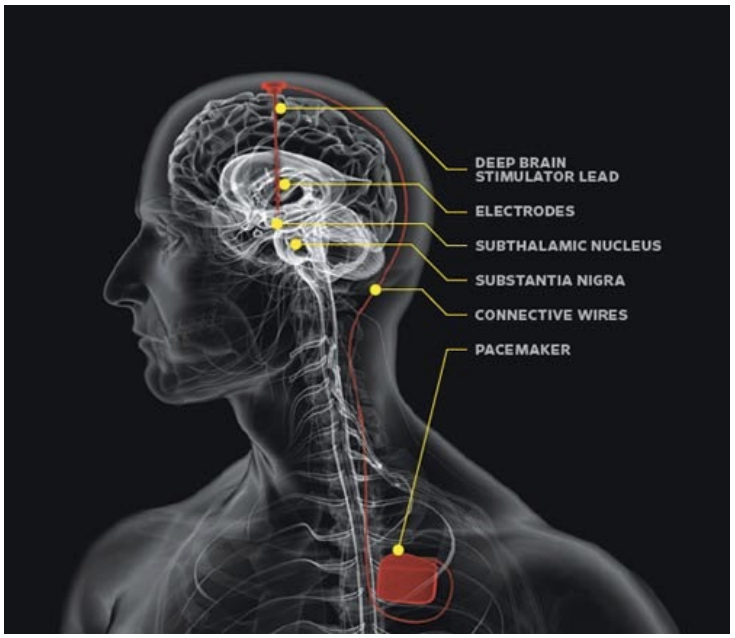
ABSTRACT:

Intro: Deep brain stimulation (DBS) of the subthalamic nucleus (STN) affects movement-related activity in patients with Parkinson's Disease (PD). Neural recordings from PD patients suggest that there is elevated beta power in the STN, increased beta synchrony in basal ganglia-thalamocortical circuits, and prolonged beta burst durations. However, beta modulation in varying regions of the STN has not yet been well established as a reliable biomarker for PD.

Objective: The primary objective of this study is to correlate motor response with beta frequency in the dorsal STN and ultimately determine how kinematic symptoms, primarily bradykinesia and rigidity, can be associated with these beta oscillations in varying regions of the STN.

Methods: Single neuron analysis was completed using microelectrode recordings from interoperative kinematic trials. Patients were asked to perform a series of upper limb movements (hand open/close, arm pronation/supination, and elbow flexion/extension) while electrodes were implanted in three distinct regions of the STN (top, center, bottom). These interoperative kinematics were quantified by analyzing amplitude of movement as well as intra-movement and inter-movement timing. LeadDBS software was used to confirm electrode placement in the dorsal (top) versus ventral (bottom) STN for each patient post-operatively. ANOVA tests with Tukey Post-Hoc tests and Pearson's Correlation tests were run using Jamovi software.

Results: There was no significant difference in firing rate between the STN depths, and significant difference in the beta power between top and center STN. However, there was a significant difference in movement speeds across all three STN depths, specifically with improvement in motor symptoms at the bottom depth of the STN than top or center depths. While firing speed and beta frequency were highly correlated across all STN depths, neither physiological outcome correlated to movement speed.



Conclusion: Due to the lack of correlation between neurophysiological and kinematic symptoms, the improvement in movement speed is likely due to the Microlesion Effect (MLE). Repeated studies with a larger sample size would be useful to yield more statistically significant results.

Presenter #2 Alex Suarez

Development of a 3D printed task trainer for alveolar bone graft procedure

Capstone Committee: Paul Morse (chair), Nicholas Jacobson (mentor), Brooke French

ABSTRACT:
Evolving technologies have driven advances in anatomical visualization since the 1400s, in the modern day, 3D printing allows for further innovation in development of surgical training tools. Alveolar Bone Graft (ABG) is a complex surgery performed on patients 6-12 years old presenting with alveolar cleft. A series of high-consequence maneuvers involving the periosteum and mucosal tissues, which are susceptible to tearing and crushing, make the procedure difficult to teach. Current surgical training models replicating alveolar clefts are produced as an assembly of parts from 3D printing, silicon injection molding, and adhesives. Bitmap printing allows for a single piece model to be produced leading to increased resolution and tissue variation to create training models with layers replicating the feel of living tissue. However, replication of oral cavity tissues for surgical training is not well established because mechanical properties of oral mucosa described in the literature are not representative of the expert feel of tissues surgeons develop, leading to proper tissue handling during the procedure.

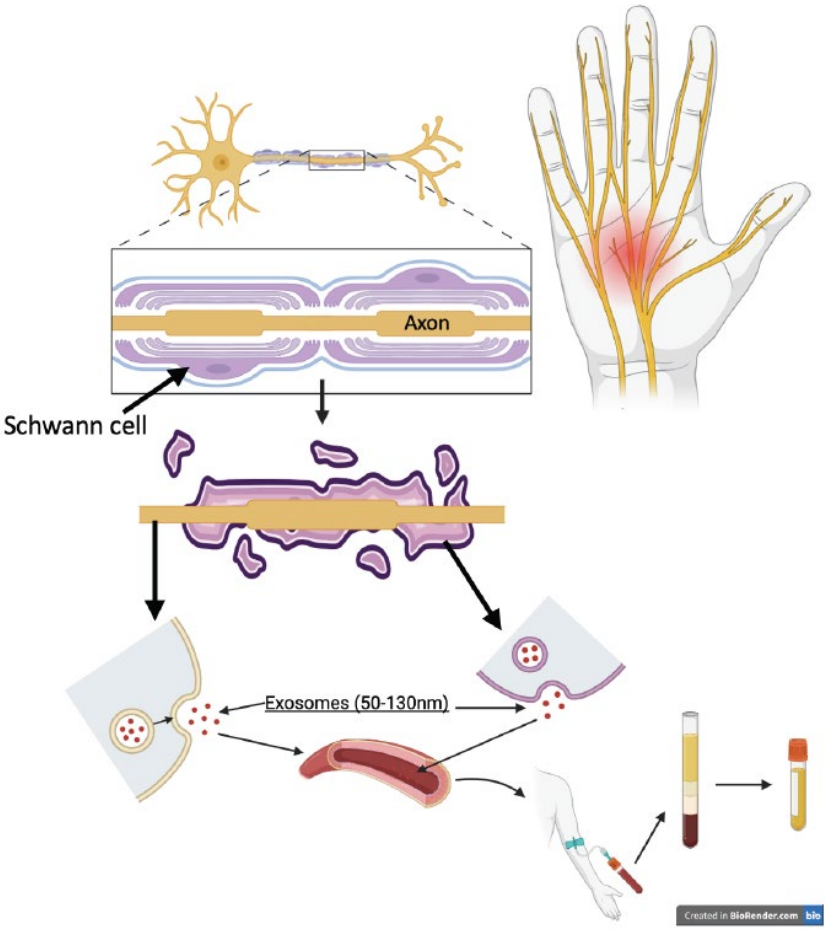
Using CT scan segmentation, filament deposition modeling (FDM), clay, 3D scanning, surface-based mesh and voxel modeling, and multi-material bitmap printing; we have created a training model that replicates an alveolar cleft and the feel of mucosal flaps intended to enhance teaching of the procedure. The layers are printed using standard materials for bone and custom mixtures for periosteum and mucosal layers. With guidance from an expert surgeon, the model's layers are assessed for appropriate feel during cutting, elevation and suturing. Elastic modulus of the printed material is compared to literature values. Voxel printing allows for the development of a task trainer with materials mimicking the feel of real tissue. This fidelity increases the trainability of complex procedures with delicate tissue layers, and combined with task trainers, leads to better trained surgeons and improved surgical outcomes for patients.

Presenter #3 Keanan Sather

Evaluating Exosome Biomarkers in Peripheral Neuropathy

Capstone Committee: John Caldwell (chair), Vera Fridman (mentor), Aurélie Ledreux

ABSTRACT:
Peripheral neuropathies are highly prevalent and debilitating diseases with the most common forms being diabetic neuropathy (DN) and Charcot-Marie-Tooth disease (CMT), affecting millions of individuals worldwide. While there have been notable advancements in understanding the mechanisms of peripheral neuropathy, there are currently no disease modifying treatments available and blood-based biomarkers have major limitations when it comes to tracking disease severity, having any clinical relevance, as well as being elevated in both peripheral nervous system (PNS) and central nervous system (CNS) diseases. Recently, studies utilizing methods of extracellular vesicle (EV) extraction from blood plasma have shown promising potential for analyzing tissue specific biomarkers in CNS diseases including Alzheimer's, Downs syndrome, Parkinson's disease, and traumatic brain injury. These EVs called exosomes are released by all cell types and are found in all bodily fluids, making them an easily accessible liquid biopsy and potential resource for biomarker analyses. More importantly they contain proteins, RNAs, metabolites, and other cellular molecules. They also play significant roles in cell-cell communication and their cargo can reflect the physiological status of the cell they originate from. Overall, peripheral neuropathies are currently lacking in non-invasive, clinically meaningful, tissue specific biomarkers. This project aims to adapt current EV enrichment methods for the PNS and identify Schwann cell (SC) and peripheral neuron (PN) derived EVs using cell specific markers. The enrichment of PNS-derived EVs would allow for identification of new biomarkers for peripheral neuropathies and could facilitate future clinical studies and the development of therapies for individuals with this debilitating disease.

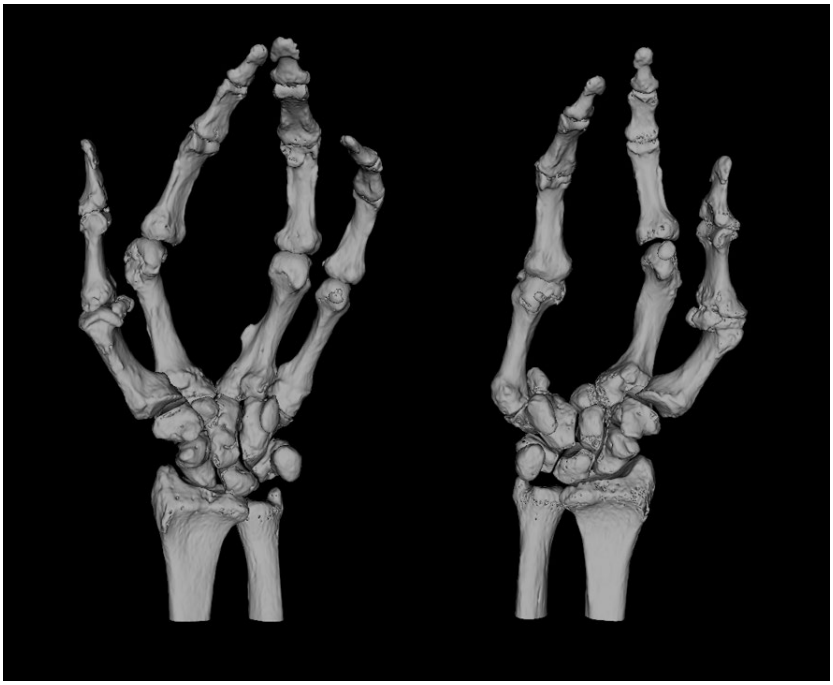


Presenter #4 Tara Hobbs

Congenital Bilateral Cleft Hand Condition: An Anatomical Case Study

Capstone Committee: Paul Morse (chair), Caley Orr (mentor), Anna Warrener

ABSTRACT:
Typical cleft hand malformation is characterized by a large V-shaped fissure extending into the palm in the absence of one or more central digits. This congenital disorder is discussed in the literature with a primary focus on morphological classifications (of which variable systems are defined) and correcting aesthetic implications of the malformation. Markedly fewer describe potential corrective surgeries to rectify the mechanical difficulties of the condition. Case studies on cadaveric donors are very rare with missing information on the anatomy of the brachium and antebrachium. The dual purposes of this study are to provide a comprehensive, descriptive account of the muscle attachments, blood supply, and innervation of nonuniform, bilateral typical cleft hands and to gain a better understanding of what morphological accommodations have been established. A layered dissection methodology was used to visualize the following: anterior and posterior compartments of the brachium; superficial, intermediate, and deep compartments of the antebrachium; and the contents of the superficial, thenar, adductor, hypothenar, and interosseous compartments of the hand. An Artec Space Spider Scanner was used to generate 3D models of each layer and observations of tendon attachment points and neurovascular distribution were recorded. Computed tomography images of each upper limb were taken to visualize osteological morphology. While the brachium and antebrachium exhibit typical anatomy in soft tissue and osteology, the hands show relatively typical neurovasculature arrangements and significant musculoskeletal variations. Where central metacarpals are absent in the hands, tendons of the antebrachium create elaborate, fibrous networks in the cleft. Additionally, flexor tendons and extensor tendons of the forearm are observed to be attached to each other instead of to bony elements where rays are absent. Osteoarthritis and hypermobility of the 2nd digit are seen in the right hand, presumably due to compensatory hand movements because of the missing osteological features. Misshapen and bipartite carpals can be observed in both hands. This project contributes to the scientific understanding of how musculoskeletal features and neurovasculature have codeveloped under dramatic structural modifications of typical cleft hand morphology.



Presenter #5 Hailey Wilkinson

The Skeletonization and Toe-tal Neutralization of Formalin Embalmed Human Donors after Anatomy Course Dissection

Capstone Committee: Caley Orr (chair), Briauna Blezinski Johnson (mentor), Debra Szuster

ABSTRACT:
The study of osteology is a critical component of learning human anatomy for budding anatomists, healthcare professionals, anthropologists, etc. Human skeletal collections remain the gold standard for anatomical detail and variation. However, few protocols exist for skeletonizing previously embalmed donors, a resource many institutions have. This study aimed to develop an effective skeletonization protocol that produced clean, formalin-neutral bones, and to evaluate treatment effects. Donors (n=14) underwent formalin arterial embalming and were used in dissection-based gross anatomy courses at the University of Colorado Anschutz Medical Campus and Regis University. Bilateral fourth metatarsals (n =24) were collected and imaged individually using computed tomography pre- and post-treatment. The skeletonization protocol included neutralization, maceration, and degreasing. Each CT scan was cropped into a proximal epiphysis, diaphysis, and distal epiphysis, prior to bone microarchitecture analysis. A paired t-test compared pre- and post-treatment values for each region of interest, revealing a statistically significant difference only in the distal epiphysis mean cortical bone density (p=0.003). While qualitative analysis showed major surface features remained intact (n=20). These study results indicate that this novel protocol can effectively skeletonize previously embalmed human donors. However, bone incurs damage throughout the process, potentially impacting the length of time the bones remain an effective educational tool. Other institutions may replicate and adapt this protocol to create ethical skeletons from previously embalmed post-dissection course donors. Future studies will implement the protocol with bones of varying shapes and densities and assess where in the process bone damage is most likely to occur.

Presenter #6 Zachary Stetter

Access has Resin: A mixed-method 3D printing protocol for crafting affordable anatomical casts for organ model production

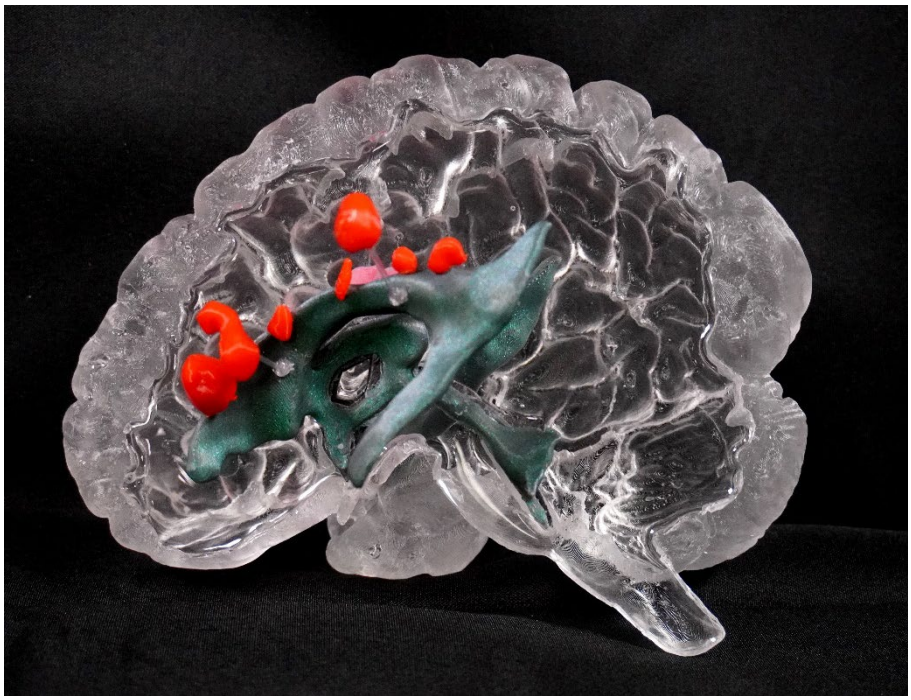
Capstone Committee: Chelsea Lohman (chair), Maureen Stabio (mentor), Jake Shearer

ABSTRACT:
Three-dimensional (3D) models are a valuable teaching tool in the anatomy educator toolbox. Physical models help students visualize spatial relationships and are vital for institutes without access to cadaveric donors; however, the cost of commercial models is prohibitive for large classes (ranging from $100 - $1000/model). Moreover, commercial models are not customizable and often have lower fidelity to real human anatomy.

The recent expansion of 3D printing technology can overcome some disadvantages of traditional plastic models, but prices of 3D printers range from $200 for small single filament printers to $24,000 for large multi-filament printers. Protocols that use low-cost printers are key to increasing accessibility. Here, a protocol was created to scale the production of low cost, durable anatomical models by combining single-filament 3D printing, silicone molding, and resin casting.

The multi-use ability of silicone mold allows for greater scalability at reduced cost for accurate, consistent, and durable anatomical models when paired with the deep pour resin. This mixed method approach can be adapted to different organs, structures, or pathology.

Lower cost models may increase access and inclusion of anatomy education for a greater population of students. Institutions can adapt this approach to meet the various needs of their curricula further expanding access to otherwise unavailable resources. The models created have been evaluated by students, and suggestions were given to show more structures and color different segments of the modes.

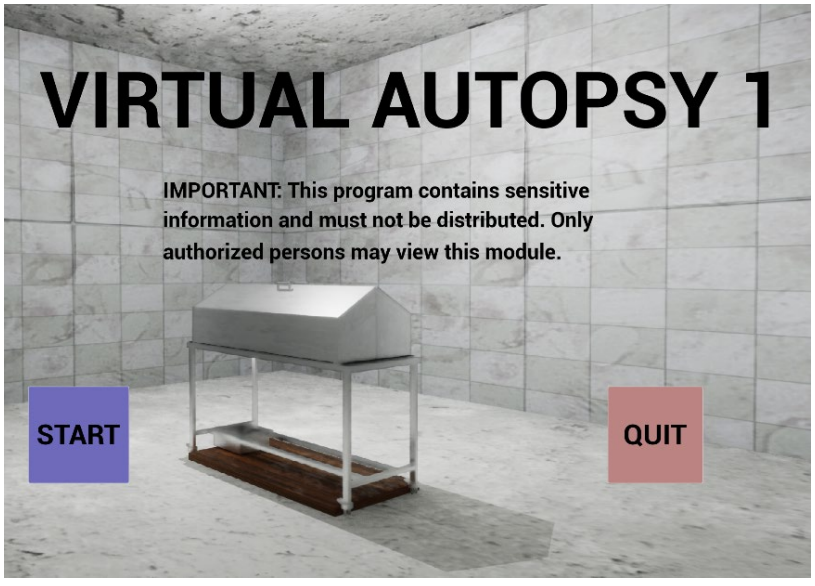


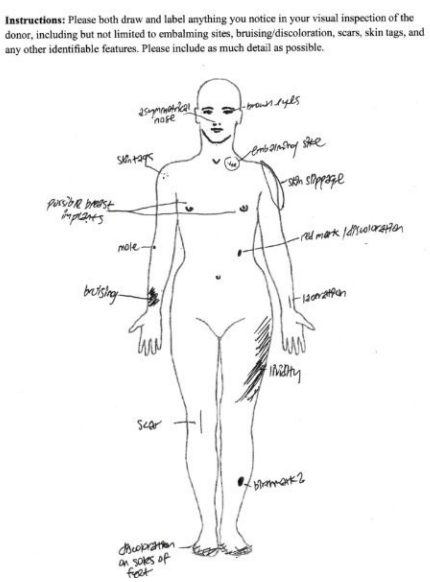
Presenter #7 Kerry Barba

Compassion in the Cadaver Lab: When Donor Gender Identity and Virtual Learning Intersect

Capstone Committee: Ernesto Salcedo (chair), Chelsea Lohman (mentor), Jennifer Stratford

ABSTRACT:
Transgender people often encounter uncompassionate medical care. As learning from cadaveric donors is fundamental for clinical education, lab-based anatomy courses can foster compassion; however, access to donors is limited and many institutions use virtual approaches for anatomy. This study aimed to investigate differences in compassion levels between students who engage with a transgender donor who received gender affirming care versus a cisgender donor, and differences when engagement takes place in-person or virtually. 26 graduate anatomy students were recruited and randomly split into four groups: 1) in-person cisgender, 2) in-person transgender, 3) virtual cisgender, and 4) virtual transgender. Participants performed an external surface examination on their assigned donor, completing a visual inspection sheet with findings: in-person groups in lab, and virtual groups using virtual simulations. Simulations were created with 3D scans of the donors converted into realistic 3D models using ARTEC Studio. Next, using Maya and Unreal Engine, a virtual simulation was created, resulting in a video-game-like simulation where participants could virtually examine a donor. Pre- and post-surveys quantified compassion levels, and quantitative and thematic qualitative analyses were conducted. Participants had high baseline compassion levels and many participants self-reported an increase in compassion although no significant increases were identified across groups. No participant correctly identified the transgender donor as a transgender man, limiting conclusions about how gender identity impacts compassion towards donors. There were no significant differences across groups in engagement levels or number of identifiable features found, suggesting that virtual simulations may be a realistic alternative to in-person lab activities.





Presenter #8 Isabella Mattingly

Putting the AR in PulmonARy Valve Replacement

Capstone Committee: Maureen Stabio (chair), Jenny Zablah (mentor), Natalie Soszyn

ABSTRACT:
Percutaneous transcatheter pulmonary valve replacements (TPVR) are performed regularly by congenital interventional cardiologists. Patients with congenital cardiac anomalies affecting the pulmonary valve function undergo TPVR in the cardiac catheterization laboratory (cath lab). Proceduralists prepare by studying the patient's history and pre-operative imaging. Pre-operative imaging and case discussions allow proceduralists to plan for one approach but cannot account for intraoperative findings that may change the operative course. Live fluoroscopy generates a vague idea of relevant cardiac anatomy and landmarks but also exposes proceduralists and patients to radiation. Therefore, to combat uncertainty and facilitate TPVR success, advanced imaging can be used including fusion imaging, virtual reality for pre-procedural planning, or augmented reality for pre-procedural and intraprocedural planning. These technologies need segmentation of patients' pertinent anatomy from pre-operative cross-sectional imaging to create 3-D reconstructions compatible with advanced imaging softwares. We aim to evaluate the use of augmented reality in procedural guidance during TPVR, including the assessment of improved visualization of the relevant cardiac anatomy and valve selection. We believe that using AR imaging in addition to live fluoroscopy during clinical procedures increases patient and staff safety, improves the visualization of the patients' cardiac anatomy, and allows important intraoperative procedural planning adjustments.