BME Design-Spring 2025 - Lance Johnson
Complete Notebook

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Dan Altschuler (daltschuler2@wisc.edu)

on

Apr 29, 2025 @11:10 PM CDT

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Team contact Information

Dan Altschuler (daltschuler2@wisc.edu) - Feb 06, 2025, 8:47 PM CST

Last Name	First Name	Role	E-mail	Phone	Office Room/Building
Meyerand	Beth	Advisor	memeyerand@wisc.edu		2154 ECB
Schroeder	Kristopher	Client	kmschro1@wisc.edu		
Johnson	Lance	Leader	ltjohnson4@wisc.edu	858-220-2743	109 S Randall Ave.
Sheridan	Matt	Communicator	mjsheridan2@wisc.edu		
Kryzer	Cody	BSAC	ckryzer@wisc.edu	763-614-4885	
Altschuler	Dan	BWIG & BPAG	daltschuler2@wisc.edu	203-640-9321	

Project description

Dan Altschuler (daltschuler2@wisc.edu) - Feb 10, 2025, 4:03 PM CST

Course Number: BME 301

Project Name: 3D Printing Airway Trainers

Short Name: 3D Printing Airway Trainers

Project description/problem statement:

Airway management is an integral part of keeping a patient stable in many medical environments. While training medical practitioners with simple airway trainers has improved patient outcomes, this has not had the same effect on patients with abnormal airways. The use of 3D printing from existing patient imaging to create realistic and individualized airway manikins would assist medical professionals, allowing them to practice airway management skills on lifelike models.

About the client:

Dr. Kristopher Schroeder is a UW Health anesthesiologist and a professor in the Department of Anesthesiology in the University of Wisconsin School of Medicine and Public Health. He specializes in treating acute pain resulting from trauma and surgery.

Client Meeting 1/28

Lance Johnson - Jan 30, 2025, 12:40 PM CST

Title:

Date: 1/28/2025

Content by: Cody Kryzer

Present: Whole team and Kris Schroeder

Goals: Learn about the project

Content:

- Shroder, anesthesiologist for 18 years
- Simulators exist but aren't exact for what you're doing that day
- Tumors, large tongue, immobile? jaw are some issues
- Last semester had issue with imaging
- Radiology department is maybe willing to let us 'crash' their MRI scanner to get some images
    - Mouth open, mouth neutral, neck neutral, neck extended etc.
- The MRI would be used for patients with tumors or other pathology where you would want to practice
- Kids with Arthrograntosis? which contorts their airway
- Down syndrome big tongues
- Some other disease with shorter than usual airway
- ankulosusspondolitis - joints become stiffer over time, bamboo spine, no space between vertabrae
- Some pateints can poen mouth only a cm or so
- Someday if could find a way to not need to 3D print things, Navigate in a virtual world with oculus or similar
- Would love to meet in person and get sown how to put in breathing tubes
- Richard Gelgon 13 year anestesiologist
    - primary focus airway management
    - board of diretors for SAM (something airway management)
    - background in some engineering at Hopkins
    - very useful
- 7 sigma is a leader in this field
    - Have a variety of airway training mannekins
- Jim Decanto works at st lukes in miluakee
    - Championed idea of salad technique
    - vomitting manekin
- Ask about access to CT scans
    - Maybe we can get early acccess
    - Preexisting scans dont have people contorting airway the way you would to put in airway tube so its a small
    - The scans are typically a closed mouth zero airway space
    - These images wouldnt allow to construct a useable mannekin
- Should we get our own scans in ideal positions?
    - Yes, neck extended chin up, 'mlehhhhh'
- Antiquated ways...
    - used to Pick up toungue and peer into airway to align axes and use a curved blade, Now use camera to align and peek around corner
    - Long camera on pencil sized stick can go down their airway to where the trachea splits and then put the thing over it
- Should we include facial anatomy on top is it a priority?
    - Not a lot of impact, at most go up to the nose
- Airway of the month club to get differnet ways to practice that would work with existing mannequins
- Getting a working prototype would be the best first step
    - Prototype of what idk
- Any improvements we should focus on from last semester? materials? segmenting scans? major focus?
    - Get the images of the prototype airway, segment so it can be put into 3D scanner, if at the end we can hav e a 3D printed prototype that would be great
    - Along the way learna bout anatomy and airway management
- Are there models you have we could use to understand?
    - Yes, last group came in in person adn got to practice airway management techiniequs and disected mannekin
    - One in his living room we could take home and play with

    - Not really, department has some number of funds. not forthcoming. Most projects for BMES dont worry about it
    - Dont buy a car
    - creating a jello man is chill
- Meeting in person, asap please what times work
    - Mondays tuesdays thursdays are typically pretty available
    - Can stick around in afternoon if that works better
    - Meet at the main UW campus hospital
    - anestasialogy department is 3rd floor
- Dr Gelgon could maybe meet in the evening, he commutes a lot
- Schroeder could be the one to get imaged. not us

Conclusions/action items:

Hopefully will meet in person next Tuesday at 6:30. Schroeder will reach out to radiology folks. We can get the mannequin from him when we meet. We should take inventory of what we have before then.

Client Meeting 2/4

Cody Kryzer - Feb 10, 2025, 4:13 PM CST

Title: Client Meeting 2/4

Date: 2/4/2025

Content by: Lance Johnson

Present: Whole team + Kris Schroeder

Goals: Learn about airway management, discuss goals

Content:

- Use of bag-valve mask(BVM), reach behind mandible to open the airway/create airspace
- gum elastic bougie stops at carina(where trachea splits)
- bronchoscope(camera on a stick) shows airway on screen and can be controlled remotely as the scope is passed through the airway
- endotracheal(ET) tube is the final goal for airway management
- intubation involves anesthetic to put patient to sleep/relax the muscles of the airway, then laryngoscope is used to hold open epiglottis and insert ET tube
- video laryngoscope(2007) helps "peer around the corner" to place ET tube
- these techniques cover 99% of airway management
- Larval? has adjustable tongue turgor, anaphalaxis has tongue complications, adjust jaw opening
- most common source of anaesthesiology litigation is dental injuries
- short chin and limited neck extension can increase difficulty of intubation
- interns practice 50 times on each mannikin with different techniques and tools
- 0.4% of cases present difficulty with intubation
- problem arises when mask ventilation AND intubation cannot be accomplished, when one or the other can be done there isn't a big issue
- still many surgeries require breathing tubes, shorter interventions commonly use mask ventilation
- George Arnt?- has patented an anaesthetic device before
- giraffe airway = final goal?

Project Goals:

- analyze MRI scans to differentiate tissues and reflect tissue properties in filament choice
- reach out to radiology contact to discuss segmentation

Conclusions/action items:

Moving forward, the team should get in contact with radiology ASAP to begin learning segmenting process. The team also needs to start considering different design ideas for modular mannikins and the printing process based on what we learned in our discussion with Dr. Schroeder.

1/31/25 TA Meeting

Cody Kryzer - Jan 31, 2025, 1:28 PM CST

Title: TA meeting

Date: 1/31/2025

Content by: Cody and Lance

Present: whole team and Abbylee

Goals: Discuss the project and receive feedback

Content:

- Reach out to last semesters group
- Get stuff from green room closet
- Goal: 3D print anatomical airway and have the process well documented
- Focus problem statement on what we want to accomplish - be reasonable. have problem statement on Monday (we meet Tuesday)
- Each have two good entries a week in labarchives
- Utilize tables from research articles about airway anatomy sizes in PDS
- Test prototype on peers(beginners), and doctors? to get data on various skills levels

Conclusions/action items:

Now and going forward, include more content in research notes in lab archives. Do the progress report for this week. Meet with advisor on Monday at 4 in ECB room 1055.

2/3/2025 Advisor Meeting

Dan Altschuler (daltschuler2@wisc.edu) - Feb 03, 2025, 4:21 PM CST

Title: Advisor Meeting

Date: 2/3/2025

Content by: Dan

Present: Team

Goals: Make first contact with our advisor and ask questions about the PDS due Thursday

Content:

- Team first did some introductions with our advisor and learned a bit about her
- The team is looking to create a proof of concept airway trainer
- Professor Meyerand asked the team if we could possibly patent our project
    - Is it possible to patent this project or even just the process behind our project?
- We were then asked about our budget
    - we were told by the client that we do not really need to worry about the budget
- For the PDS, make sure we have down the parameters for our testing on this project
- How can we ensure the 3D printed airway trainer is anatomically accurate -- try to assign some type of a number in the PDS to base our testing off of
- Focus on the syntax for the PDS as it is a Comm B class
- Our PDS is going to look a lot like the PDS from the team before us, but make sure to have all our sources properly cited
- Preliminary report is going to be a lot longer than we typically are used to in design
- Next weeks assignment is to make a decision matrix
    - For this, we have a few options for defining our process on this matrix
    - There are many different ways to approach this project -- look into these different processes that the team could follow
    - Could also use the material
        - Would make sense to make two different design matrices for these two facets of the project
    - Focus on one for the assignment
- 5 pages on the PDS would be sufficient, but make it fit to our project
- We can get hooked up with someone in the radiology department from Professor Meyerand if we can't get one
- When to approach WARF for a patent?
    - Need a final narrowed down design to get a patent
    - This would likely come at the end of the semester
    - Would be a good experience for the team to learn about the patent process

Conclusions/action items:

- Get the rest of the client requirements and also the design requirements from the meeting tomorrow
    - also approach the client with a question about patenting the process
    - ask the client for the last semester work
- Make sure to quantify our PDS -- include numbers and look to define our testing parameters
- Complete the PDS and get it in by Thursday at midnight

2/10/2025 Advisor Meeting

MATTHEW SHERIDAN - Feb 10, 2025, 4:18 PM CST

Title: Advisor Meeting

Date: 2/10/2025

Content by: Matt

Present: Team

Goals:

Content:

- Just do one design matrix for Thursday, either choose method or material
- Category shouldn't score the same all the way across, there needs to be variation; if not its a bad category
- Email design matrix to them on Thursday with the design matrix
- Include categories, category description, why things won
- Presentation is 1 week from Friday
    - Prelim pres outline and rubric on Canvas (outline doesn't have everything that's on rubric)
    - Can bring a draft to our Monday meeting next week to go over our presentation (doesn't have to be finished)
- Detailed feedback on PDS by end of the week, need to use this feedback and upload before preliminary report (due Wed after presentation)
- Should be able to know everything you need to know from research based on content in labArchives, shouldn't need to open link

Conclusions/action items:

- Turn in resume, design matrix, and get research in by the end of the week. We also need to get more research in by the end of this week and make headway on our preliminary presentation.

2/13/25 Meeting w/ Dr. Christopher Brace

Lance Johnson - Feb 13, 2025, 10:44 PM CST

Title: Meeting w/ Dr. Christopher Brace

Date: 2/13/2025

Content by: Lance

Present: Lance

Goals: To get a radiology professor's opinion on the project and see if he can connect our team with specific radiologists that can help us

Content:

Dr. Christopher Brace - BME & Department of Radiology --> also my BME 535 prof

- CT scans may be better for airway definition than MRI, are better for showing air/tissue boundaries

- department of radiology offers a service(Radius) that can pull anonymous files(HIPAA compliant?) and segment and 3D-print them for a cost: ("Using the Department of Radiology Image Requests service, researchers from across campus can place requests for limited-data and fully deidentified research images for a small fee.")

- PACS is a database that stores all patient imaging scans --> IT team can help make it HIPAA compliant

- scans are saved DICOM(Digital Imaging and Communications in Medicine) images that can be opened to show 3D volumes and are segmented for 3D printing

- cost of segmenting a bone through Radius was ~$165

- Sylvana Garcia(garcia1@wisc.edu) - runs the printing service

Conclusions/action items:

Email Sylvana Garcia about getting an inside look into Radius program to see if we can be shown/taught to segment DICOM images for our purposes. It was also interesting to hear my professor talk about the use of MRI vs CT, and while I understand our client doesn't want to expose himself to unnecessary radiation, maybe using CT scans to print our airways could be better long-term.

2/17/25 Advisor Meeting

Cody Kryzer - Feb 17, 2025, 4:25 PM CST

Title: Meeting with Advisor and TA

Date: 2/17/2025

Content by: Cody

Present: Whole team and Abbylee and Meyerand

Goals: Discuss preliminary presentation and other things going on with the project

Content:

- Sometimes materials will shrink after 3D printing
- prototype with cheaper material because it will likely fail first try
- Feel the materials at the makerspace
- What resolution will we need for 3D printing?
    - Formlabs have the highest and we can change the thickness
    - Use resolution for process matrix. Part of which will be picking a printer
- Include method of choice in report and presentation without an unnecessary design matrix. Describe the method in detail (quantitative)
- Things to include in preliminary presentation
    - Problem statement needs to have quantitative specs (numbers)
    - Bring physical props
    - Good detailed drawing with dimensions
    - Figure captions
    - Design matrix needs table caption
    - Bring TPU and mail delivered sample for presentation
- Color code preliminary report
- Use 6x6 rule for slides. No complete sentences or single hanging bullets
- For images it's ok to cite the website.

Conclusions/action items:

Set up meeting with radiologist for Friday. We will likely not be able to include information learned on the presentation but we can on the preliminary report. Come to class Wednesday with printed slides. Carefully review the requirements for the presentation slides before Friday.

2/21/25 Dr. Sylvana Garcia-Rodriguez

Lance Johnson - Mar 02, 2025, 10:02 AM CST

Title: Meeting w/ Dr. Garcia-Rodriguez

Date: 2/21/2025

Content by: Lance

Present: All members, Dr. Garcia-Rodriguez

Goals: To get a radiology research professor's opinion on the project and learn more about MRI segmenting techniques and softwares

Content:

Dr. Garcia-Rodriguez - Department of Radiology / Radius

- hourly price to run the scanner and requires a thorough vetting process

- can maybe get information/scans from the database, de-identify the scans then segment

- patient information is sacred

- Dr. Garcia-Rodriguez has an stl file of an airway(may not be in the proper position)

- Mimics software has a subscription paid for by the research group

- ITK-Snap is a free, open-source image processing software

- ITK-Snap is used in Medical Physics(Mesh-mixer)

- Prof. Meyerand may have more information/a contact that knows more about the software

- in the 3d-model, there are inconsistencies in the surface --> needs to be transported to a different software(3matic, a sister software with mimics) to clean up the inconsistencies and step gaps

- the segmentation of the airway is relatively easy compared to other tissues --> air appears black on on the scan

- a range of gray colors(voxels) is selected and it creates a mask

Mimics Software Demo:

- axial, coronal, and sagittal viewing planes

- create mask --> thresholding is choosing a range of grays --> rename the mask

- verification of anatomical accuracy should be done in the segmentation software

- geometries in the body are never ideal or simple

- software may be able to perform a contour and smoothing

- number of slices depends on the type of scan/what dimension is important

- smoothing can also be done in mesh mixer software

- CAD functions can be performed

- import STL back into the medical images to verify the accuracy --> don't over-smooth

- Dr. Garcia-Rodriguez showed us very cool 3d-printed models --> crazy heart

- potential IRB approval

Conclusions/action items:

Dr. Garcia-Rodriguez provided some extremely helpful information for our team. We need to do a little more research into segmenting softwares now that we know what capabilities/features we will most likely want to use when we segment our scans. Once we do that, we can choose a segmenting software/set of softwares that we can move forward with. The team also needs to send a thank you message to Dr. Garcia-Rodriguez for her time and help.

Comments

beth meyerand Mar 01, 2025, 2:47 PM CST

@Lance_Johnson "patient information is scared" what do you mean?

3/10/25 Advisor Meeting

Cody Kryzer - Mar 10, 2025, 4:23 PM CDT

Title: Advisor Meeting

Date: 3/10/2025

Content by: Cody Kryzer

Present: Whole team and Meyerand and Abbylee

Goals: Discuss plan for the rest of the semester, specifically show and tell

Content:

- Schroeder re-contacted radiology department
- Consider splitting up learning between members and slicing softwares - have 2 experts on ITK and 2 experts on 3D whatever the other one was
- Ask about slicing softwares for show and tell
    - A lot of them have experience 3D printing CT and MRI scans
    - Lung phantom teams
    - Heart scans
- Show and tell
    - Fill out a questionare
    - 402s will pick teams they want to talk to
    - 15 minute rotations, we don't move or give feedback
    - make a notebook entry to summarize
    - Prepare good questions, perhaps a mini powerpoint with background info
    - Feedback is the first hour, then 1:05 - 2:05 is slotted for team discussion
    - Take good notes and have good discussion before entering spring break mode
- Protocol development (testing/fabrication plan) is due next Tuesday
- Work on testing protocols
    - Have professionals test and give feedback (lots of great qualitative but find a way to get numbers too)
    - Repetitive intubations
    - Attachment points will be the most vulnerable
    - Time to intubate
    - Time to attach the print to the model
- Executive writing
    - Why is our design worthy of excellence and the Tong award
    - Brief and concise, one page
    - Include market aspects
    - Do some market research for notebook check
    - Awards are at like 3:30 after poster pres

Conclusions/action items:

We hope to get scans soon, 3D printing will be quick as long as it works as intended. Wait times at the makerspace will start to get longer especially after Spring Break. Prepare questions for show and tell. Write testing/fabrication protocol BEFORE doing it, update afterwards.

3/17/25 Advisor Meeting

Cody Kryzer - Mar 17, 2025, 5:14 PM CDT

Title: Advisor Meeting

Date: 3/17/2025

Content by: Lance Johnson

Present: Whole team and Meyerand and Abbylee

Goals: Talk about show and tell expectations, getting scans

Content:

- currently a little stuck with getting scans
- need to wait another week to talk to radiology about getting scans :(
- makerspace staff can help us print a paper-thin stl file
- put together slides with background/anatomy, questions, testing for show and tell
    - slides just need to have info, not refined slides at all
    - ask question about intubation testing to 402s(how many intubations do we need?)
    - testing slides can have questions but also our tentative answers/thoughts so they can see them
    - make a google doc for taking notes during show & tell(multiple conversations will be happening at once)
    - casual attire, bring prototype
- lecture this week will be about writing testing protocols
    - document with bolded: name of test, materials, protocol, data collection sheet(table)
- all progress reports in
- testing will not work the first time so account for extra testing time
- develop backup plan for if we don't get images/scans from radiology
- 3d printers will be backed up in final two weeks
- Ask for a double wash, SLA wash will get rid of sticky layer
    - can rub with isopropyl alcohol to get rid of sticky layer post-printing

Conclusions/action items:

In lecture on Wednesday, the team will finish up some testing and fabrication protocols as well as finalize questions we wish to ask at show and tell on Friday. The team will go 3D print an airway to bring to show and tell.

4/7/25 Advisor Meeting

Cody Kryzer - Apr 07, 2025, 4:19 PM CDT

Title: Advisor Meeting

Date: 4/7/2025

Content by: Cody Kryzer

Present: Whole team, Abbylee, Meyerand

Goals: Review progress and layout a plan for the rest of the semester

Content:

- Print as much as possible, all 4 of us in 4 different materials. Use all of our money
- Backup plan
    - Work with the manikin
    - As much testing as possible with the print(s) we have.
    - Focus on material testing
    - Rely on future work section
    - Focus on prep work
    - have example scans in 3D slicer or ITK-Snap that we could print out, could be anything
- We need the scan by this Friday if we want time for testing and working on the poster
- Incorporate feedback from 402s
- Familiarize ourselves with 3D slicer software
- Perhaps use both softwares, one for post-processing
- Email client and CC advisors, mark urgent

Conclusions/action items:

Currently just waiting for a scan. In the meantime print more airways with more materials. Work on the manikin as much as possible. Show the process through 3D slicer to print with literally anything.

4/11/25 - MRI Scan w/ Dr. Vigen

Lance Johnson - Apr 12, 2025, 12:26 PM CDT

Title: MRI Scan w/ Dr. Vigen

Date: 4/11/2025

Content by: Lance, Matt

Present: Lance, Matt, Dr. Karl Vigen

Goals: Take an MRI scan of a volunteer's airway in the sniffing position to get the DICOM file we need

Content:

- The MRI scanner is a GE Heathcare device, used primarily for research purposes
- Spacers were put into the MRI head coil to allow for neck extension
- Foam pads put under the neck and upper back to get volunteer into the sniffing position
- Body coil placed over the upper chest
- Blanket put over volunteer to keep warm
- Scan window focused over mouth, airway, and upper chest
- 1mm x 1mm voxel size
- Mouth closed scan ~3 minutes
- Mouth open scan ~5 minutes
- MRI done in coronal plane, but can be reformatted for axial or transverse planes for slicing/segmentation purposes
- Dr. Vigen told us that he felt the MRIs turned out well, but that he would have time next week to do another scan if needed

Conclusions/action items:

The DICOM files for both the mouth open and mouth closed scans can be accessed and imported to both 3D Slicer and ITK-Snap. We now need to segment the scan to isolate the airway and prepare it for printing.

4/14/25 - Advisor Meeting

Lance Johnson - Apr 14, 2025, 8:17 PM CDT

Title: Advisor Meeting

Date: 4/14/2025

Content by: Lance

Present: All members, Abbylee

Goals: Determine next steps in the project and how to prioritize testing in the final week

Content:

- Got scans from MRI/radiology team, began segmenting
- Print as much as possible
    - Print --> segment --> print --> segment
- Testing:
    - the most important/can you intubate testing is the most important
    - test attachment points?
    - put on a movie and practice intubating and keep track of number of intubations
- For final executive summary- put what testing we have done in, mention future work
- Work time during Wednesday lecture this week?, and peer review next week Wednesday
- Final report due Wednesday after presentations
- Final meeting Monday after presentations
- 100 of 120 notebook points going towards team notebook
    - try our best to keep detailed notes of fabrication plan, testing plans, how printing goes, learning during segmenting, etc.

Conclusions/action items:

PRINT PRINT PRINT - Get segmenting done and start printing because we'll learn the most through printing.

4/21/25 - Advisor Meeting

MATTHEW SHERIDAN - Apr 21, 2025, 4:24 PM CDT

Title: Advisor Meeting

Date: 4/21/2025

Content by: Matt

Present: All members, Abbylee, Beth Meyerand

Goals: Share prints that we have finished, get ideas for testing

Content:

- We printed out of TPU, flexible resin, elastic resin; the elastic resin seems by far the best just by feel compared to the manikin.
- Flexible resin broke during printing, hoping that they will reprint this.
- For connection, thinking about duct tape, hose clamps,
    - Could possibly use rubber bands to print.
- Went in to print the new airway with an esophagus hole, but they are out of resin, likely will not be done by the end of the week.
- Should have most of poster done by Wednesday to get peer reviewed and Abbylee can look at it as well.
- Testing
    - Ideally, have residents or med students use it and see how well it works compared to existing trainers.
    - Best option is to do some type of material testing
        - Compressive test comparing the elastic vs. flexible materials
        - Have the printed portion fixed, do repeated simulated intubation on this portion, record any damage after many trials
    - Compare the results of testing back to the PDS to say if the materials are feasible to move forward with.
    - Take very detailed pictures of the material surfaces before and after intubation to compare results, either from inside or outside
    - Whatever we can make work we should do.
- Make the poster fit our project

Conclusions/action items:

Just need to finish the poster, make it match our project to share what we learned this semester, and what we can do in the future as well.

4/28/25 - Advisor Meeting

Cody Kryzer - Apr 28, 2025, 4:07 PM CDT

Title: Advisor Meeting

Date: 4/28/25

Content by: Cody

Present: Whole team

Goals: Wrap up the semester

Content:

- No class this Wednesday
- Due Wednesday
  - Final Report
  - LabArchives
  - Feedback Fruits
- Due Sunday
  - Feedback Fruits

Conclusions/action items:

Email Puccinelli to make sure our project is carried over as a 400 project

2/11/2025 Design Matrix Team Meeting

Lance Johnson - Feb 13, 2025, 10:00 PM CST

Title: Design Matrix Team Meeting

Date: 2/11/25

Content by: Dan

Present: Matt, Cody, Lance, Dan

Goals: Complete the design matrix prior to the deadline this Thursday, February 13th

Content:

- The first order of business for the team is deciding on exactly what materials the team is going to include in the design matrix
- Lance had done some preliminary research on the different materials that we could use for the 3D print, but we can decide on exactly what material we want to use by making our design matrix
- We are for sure going to include the material that team used last semester as that seemed to work fairly well for them
- Matt did some research into the different materials that we could use as a team and he landed on TPE as another possible material
- The team was struggling to come up with some other facets of the design matrix
    - The team eventually landed on visual similarities and compatibility with lubricant as categories beyond the standard mechanical properties and the cost
- Once all the categories were decided on the team split up the research on the different materials so that we can come back and score them well researched ideas
- Once the research is all done and the categories are accurately scored, then the team will move into explaining each category and explaining why each material scored how it did.

Conclusions/action items:

Research topics: Matt-TPE, Dan-TPU, Lance-Formlabs. Once the team does the research we will be able to fill out the design matrix. The team plans to meet Thursday afternoon to complete the design matrix.

2/13/2025 Design Matrix Team Meeting

Cody Kryzer - Feb 13, 2025, 9:14 PM CST

Title: Design Matrix

Date: 2/13/2025

Content by: Cody Kryzer

Present: Cody, Matt, Dan, Lance

Goals: Complete the design matrix

Content:

- There is a formlabs printer on campus
- Desired modulus: 3.2-23 KPa
- Desired hardness: 60-90 A
- We are realizing that our categories for grading our designs are not the most helpful. There are three or four that are very important, but beyond that, there isn't much to differentiate these materials that actually matter for our design.
- We switched our material choices. Removed TPE and TPU and added a specified version of TPU as well as silicone casting
- We also switched criteria. Design matrix now includes printer availability and durability.

Conclusions/action items:

TPU 95A scored the highest in our design matrix. It is likely that we will use both TPU and Formlabs 80A when 3D printing later in the semester since it won't cost us a whole lot and will help us gather twice as much information than just using one material. It will also allow the client to have more options, and if one is bad, it will make the other look better. Moving forward, we need to remember to have the bag of supplies at all of our team meetings.

2/18/2025 Preliminary Presentation Meeting

Dan Altschuler (daltschuler2@wisc.edu) - Feb 19, 2025, 12:13 PM CST

Title: Preliminary Presentation Meeting

Date: 2/18/2025

Content by: Dan

Present: Cody, Matt, Lance, Dan

Goals: Get the preliminary presentation draft complete for the sake of peer feedback in 301 lecture tomorrow, Wednesday, 2/19

Content:

- The team was not exactly sure what template we wanted to use
    - We eventually decided that it made the most sense to just use the general BME template that Lance had from his last years presentation
- While we do want to use the outline, there are some differences in the presentation style that we are going to use
- Since we do not really have designs to talk about and instead the materials and methods we are planning on using, our presentation is going to be a bit different than any presentation we have done before
- Cody created a workflow diagram for our presentation that will go on the slide that explains what we are going to do from imaging to the final print at the end
- It has been a little bit difficult to make our slides 6 by 6, but we were able to do that for a lot of the intro slides
- We also decided on who is going to present which slide
- It made the most sense for the team to make a slide for each material so that we can give a brief overview of information we used to work on our design matrix for the materials, and then give a brief explanation of the actual design matrix
- With a good draft of our presentation we can get some feedback during the peer review, and then apply that to finalize our presentation

Conclusions/action items:

The team will meet one more time to go over timing of the presentation and also to finish up the rest of the presentation that is yet to be complete. The team will be ready to present on Friday, 2/21 in front of the class, and be prepared to answer any questions posed by peers or advisors.

2/26/2025 Universal Design

MATTHEW SHERIDAN - Feb 26, 2025, 2:05 PM CST

Title: Universal Design

Date: 2/26/2025

Content by: Matt, Cody, Dan, Lance

Present: Matt, Cody, Dan, Lance

Goals: Discuss universal design in the context of our design

Content:

1. Equitable use

Make the process as cheap as possible so that patients can have this covered by insurance

Make sure that the trainer can be changed to imitate individuals of varying races, conditions, etc.

2. Flexibility in use

3. Simple and intuitive use

Make the trainer as similar to existing trainers as possible so that the doctor is used to the basic structure, with difficult airways changing.

4. Perceptible information

Be simple to use by the doctor; this should be pretty straight forward.

5. Tolerance for error

Make the device durable so that it doesn't break when intubated on

Make the device accurate to the human airway so that people don't die.

6. Low physical effort

Match the tissue properties of a human so that intubation is not restricted by friction that wouldn't exist in the individual

7. Size and space for approach and use

Conclusions/action items:

A lot of these categories are not very applicable to our design project. Throughout our design process we will actively make sure that we are not creating an inaccessible design.

2/26/2025 Preliminary Report Team Meeting

Cody Kryzer - Feb 26, 2025, 8:48 PM CST

Title: Priliminary Report Team meeting

Date: 2/26/25

Content by: Cody Kryzer

Present: Cody, Matt, and Lance

Goals: Complete a high quality preliminary report

Content:

- Dan is not present since he already finished a large portion of the document but he's available via text
- The group read over each others writing and provided feedback
- The group was able to discuss formatting and references which can be difficult while working on a shared document
- We think that our final report is well done and reflects the amount of learning and research we have done thus far
- Sections like testing and results are difficult to write since we have not made it to that point yet in the semester, not that we are behind, but a lot of background learning has been required for this project.

Conclusions/action items:

Being together as a team is very helpful when writing reports to help reduce redundancies. We are also able to connect our writing to the sections that our teammates are writing and make sure we are not missing information and that the reader would understand the flow of our report.

3/16/25 Show and Tell Team Meeting

Dan Altschuler (daltschuler2@wisc.edu) - Mar 16, 2025, 8:37 PM CDT

Title: Show and Tell Meeting

Date: 3/16/25

Content by: Dan

Present: Dan, Lance, Matt, and Cody

Goals: Plan for show and tell and prepare for the advisor meeting tomorrow

Content:

- We are considering printing out the STL file that was sent to us by Dr. Garcia
- We are not exactly sure what we would get out of that since the airway is not hollow on the inside
    - we could use this as an opportunity to get some practice with the printing
    - we could also use this as an opportunity to work with the makerspace
- We have found out that the trachea is hollowed out with the end pieces cut off
- because of this, we are going to go print it out this week and bring it with us to show and tell
- Dan has been doing some practice with ITK-SNAP and the software is making a lot more sense
- With more practice after spring break and hopefully acquiring the scan from our client we will
- Cody and Dan are going to practice with ITK-SNAP and Matt and Lance are going to practice using 3D Slicer
    - once both teams have practiced using these software, we can share what we learned and make a decision on if we are just going to use one, or both, and which will be the preprocessing and which will be the post
    - we can also learn about different segmentation, with one person trying manual and another trying automatic
- for considering how to connect the device since people will have different length tracheas we can make the bottom part adjustable
    - we could also add something to the bottom part before the print
    - nothing should be added to the top because that will directly impact the intubation process
- Now we are going to discuss what we want to get from Show and Tell
    - If people have insights on printing coming from a DICOM and moving into an STL
    - We can ask about the common problems people have had with scanning and printing i.e. the inside scoop
    - We could also ask about how to connect the airway to the existing part (mechanical engineering)
    - We could also ask if people have used 3D slicer or ITK-SNAP and see if they have any tips using it to segment
    - We could ask what people what they think we can test (time for intubation - repeated intubation)

Conclusions/action items:

The team is each going to write a testing/fabrication protocol before class on Wednesday. Some members of the team are also going to work on generating a powerpoint before show and tell so we can quickly go over the background of our project and what we are looking for from the seniors. We have a good idea of the questions we want to ask, but we can discuss these more during our meeting tomorrow.

3/21/25 Show and Tell

Lance Johnson - Mar 21, 2025, 2:56 PM CDT

Title: Show and Tell

Date: 3/21/25

Content by: Everyone

Present: All 301s and 402s

Goals: Receive feedback from 402s on our project

Content:

Show n' Tell Notes:

Converting between files types can cause glitches

Use a handheld scanner to “backtrack” to get an editable file type

There’s 3D scanners in the TeamLab where we can scan either other airways or random items to practice the process of going from scan to a printable file

Reset boundaries or delete them, lots of ways to get around errors in SolidWorks

Use magnets to attach a printed airway. They’d have to be really strong probably

Have overlap for fixing the airway, then clamps or straps

4 other groups have used 3D slicer for a similar process

Minute details can be fixed in solidworks, adding or altering small bits

Just use duct tape to attach prints

MIM is a good slicing software but it isn’t free

See if we can go to the hospital physically to use automated softwares

Alan Mcmillan - his lab has an algorithm that converts a CT scan to an STl file

Code can be used

I gave some guy my email who texted alan about it

Dont use clear V5 resin, its very brittle

Feel all the samples in the makerspace

Check github for existing code

Conclusions/action items:

The consensus from the seniors we talked to was that 3D Slicer is the best software to move forward with. However, multiple 402s also mentioned using automated segmenting softwares that could potentially reduce our workload if we can gain access to them(most of them appear to be costly but may be accessible if we go to the hospital or research facility).

4/14/2025 Segmentation Team Meeting

Dan Altschuler (daltschuler2@wisc.edu) - Apr 14, 2025, 9:54 PM CDT

Title: Segmentation Team Meeting

Date: 4/14/2025

Content by: Dan

Present: Lance, Matt, Cody, Dan

Goals: Get a rough segmentation done of the recently acquired DICOM file from the MRI, so that we can start printing

Content:

- Matt is going to upload a zipped version of all the DICOM files onto the lab notebook so that anyone can access them at anytime
- This will help make sure that anyone who may be trying to segment the scan will have access
- Lance, Dan, and Cody are going to take whatever rough segmentation that we have done and try to 3D print it tomorrow using Formlabs 80A resin and TPU 85A
- Matt has been doing a bit of work segmenting the scans using 3D slicer but he has not gotten very far yet
- The team is debating how we are going to attach our airway to a manikin
- The general consensus is that we want to use hose clamps to attach the airway, but this would lead to problems with compressing the airway
    - We could possibly remedy this by using some duct tape to attach the airway and then using some hose clamps
    - We are considering printing our first segmentation and then if that is difficult to attach, then we can add some extra material to the bottom end of the airway so that it will not interrupt the actual airway
- Lance brought up a good point that we could do testing on the speed that people intubate and generate a "learning curve" as a proof that our device helps people learn how to intubate
- This would be a good proof of concept for the validity of our method, because if we can teach people whom have never intubated before then we can be confident that it would be helpful for medical residents if we do not have enough time to test with them like we were considering
- Cody, Matt and Lance tried to work on 3D slicer while I have been experimenting with ITK-SNAP

Conclusions/action items:

Dan was able to segment using ITK-SNAP and Matt was able to segment using 3D Slicer. Images of both are attached below. Tomorrow, the team will print the two STL files in the makerspace. Ideally, each will be printed with both TPU and Formlabs Resin.

ITK-SNAP First Go

4/14/25 3D Slicer Segmenting Process

Lance Johnson - Apr 14, 2025, 10:17 PM CDT

Title: 3D Slicer Segmentation Process

Date: 4/14/25

Content by: Matt Sheridan

Present: Matt Sheridan

Goals: Figure out how to segment the MRI scan into an STL using 3D slicer

Content:

Initial attempts at a protocol, with much aid from ChatGPT:

- Imported the DICOM file folder, selected scan 4 from the MRI scans
- Looked through each individual view to get a good idea of where the airway is that we are looking to scan
- Once i found the part I wanted, I went to crop volumes under the Converters module, and cropped to just the section surrounding the airway and saved this as a new source volume
- Then I went to Segment Editor and selected Threshold and chose a range from 0-70.92 to select the regions of air and pressed Show 3D to see the model that was generated.
- This resulted in a general model that had a lot of extra little portions that were included in the threshold. I used the islands tool to remove small islands that were separate from the main airway and therefore didn't need to be included. I also used the scissors tool to remove any obvious excess pieces. This was a lot of nitpicky work to get it down to just the airway we wanted.
- Next, to convert this air into a solid region around it, I used logical operators to copy the first segment onto a new segment, so now there are two segments of the same size. Then, I used margin to grow the second segment by 3.00mm, and selected "allow overlap" under "Modify other segments" so that both segments could exist at the same time. Finally, I used the subtract feature on logical operators to subtract the original region from the new grown region.
- Now that I had the 3D model of the airway I converted it to an STL file and exported.

Main issues: I'm not sure if all regions were perfectly converted into the segmented file. Specifically, where the epiglottis is, I don't think it perfectly captured the air around it to be able to make a little flap like the epiglottis. This may just require a little bit more work cleaning up around certain areas, but should be solvable. There are also other scans that may be a little easier to work with.

Conclusions/action items: This was a good start on segmentation, and although there were some issues, it was able to be converted into an STL file that is printable and can be tested on. Very happy with this first attempt at segmenting, and hopefully I will be able to perfect a repeatable segmentation protocol the next time I segment.

4/17/25 Fabrication Meeting

Dan Altschuler (daltschuler2@wisc.edu) - Apr 17, 2025, 8:43 PM CDT

Title: Fabrication Meeting

Date: 4/17/25

Content by: Dan

Present: Cody, Lance, Matt, Dan

Goals: Work on segmenting for the final design and submit the executive summary

Content:

- We need to finish work on the segmentation of our MRI and consider making the opening to the airway a bit bigger
    - We are not sure if it would be able to be intubated on because it is not as flexible as the manikin, and also the airway opening is a lot smaller
    - Matt has worked on segmenting the scan with the mouth open but this has lead to some challenges converting the STL to the .3mf file using Fusion
    - We are working through the kinks here, but the print from TPU would be a fine back up plan in the end
- The executive summary needs a bit of work done on it from the feedback we got on the draft
- People edited their specific sections and we talked about the phrasing of our testing so that we do not say we did things without actually completing them
- Making the deadline for the summary tonight is unbelievably silly
- Matt is going to fill in the protocol for segmenting, but we have most of our process documented in the notebook which is good
- I wrote a short protocol about segmenting using the ITK-SNAP software but since we did not move forward with using it, this protocol is not as important
- We have fully written 3D printed protocols and STL --> .3mf so that is all complete
- the focus is getting the prints picked up by EOW and submitting more prints once Lance can hopefully convert the STL to a solid object
- All of this work will be completed this weekend to provide ample time for testing and data analysis for the poster

Conclusions/action items:

The team will continue working on printing and testing so that we are ready for the final poster presentation. We are hoping to have multiple prints done for the poster presentation so that people viewing our poster can see the different airways.

4/22/25 Testing Meeting

Dan Altschuler (daltschuler2@wisc.edu) - Apr 22, 2025, 10:01 PM CDT

Title: Testing Meeting

Date: 4/22/25

Content by: Dan

Present: Dan, Matt, Lance, Cody

Goals: Complete testing and finish up the poster for Wednesday night

Content:

- We are not entirely sure what we are going to do for testing
- The team is considering using before and after images for intubating on one of the airways to represent the slow degradation of the airway material as it is intubated on
- The team has moved over to the Tong Lab to use the MTS machine to do compression testing on the different airways that we have printed out
- Lance is still waiting to hear from the Makerspace on the print we submitted on Friday which is meant to be our final design airway
- Lance and Matt performed MTS compression testing on all three of the airways that we printed on
    - They also performed testing on the trainer that was given to us by our client
    - A protocol and the raw data will be uploaded into LabArchives once extracted and ready
- We have begun to put some finishing touches on our poster in preparation for the peer review tomorrow
- We are hoping to get some good feedback on our poster so we can implement these changes before presentation
- Cody and Lance found a mouth in our bag of things so we ziptied an airway to this mouth and the team is going to intubate on this

Conclusions/action items:

Now that the poster is in its draft form, we will take the advice given to us from the peer review tomorrow and implement it before printing tomorrow evening.

Final Expense Sheet

Dan Altschuler (daltschuler2@wisc.edu) - Apr 24, 2025, 9:41 PM CDT

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	QTY	Cost Each	Total	Link
Prints										
TPU1	First TPU print - Dr. Garcia STL	n/a	n/a	n/a	n/a	3/18	1	$1.09	$1.09	n/a
TPU2	Team's model TPU print	n/a	n/a	n/a	n/a	4/15	1	$1.72	$1.72	n/a
Flexible1	First flexible resin print using team model	n/a	n/a	n/a	n/a	4/15	1	$22.98	$22.98	n/a
Elastic1	First elastic resin print using team model	n/a	n/a	n/a	n/a	4/15	1	$21.23	$21.23	n/a
FlexibleFinal	Final flexible print using updated team model	n/a	n/a	n/a	n/a	4/21	1	$26.98	$26.98	n/a
								TOTAL:	**$74.00**	

3/16/25 3D Printing Protocol

Cody Kryzer - Apr 15, 2025, 11:15 AM CDT

Title: 3D Printing protocol

Date: 3/16/25

Content by: Cody Kryzer

Present: Whole team

Goals: Write a protocol for 3D printing an airway

Content:

This protocol will begin with an already segmented and sliced STL file that is ready to print

Materials necessary: 3D printer, 3D printing material, Personal computer, Makerspace computer

- Download file as a 3mf file on personal computer
- Put file onto a flash drive, be sure to give the file an appropriate name and put it in a folder for your design project
- Remove the file from the flash drive onto the makerspace computer, or whatever other computer that works with the 3D printer being used.
- Open the file with Bambu software
- Print on bunny printer for TPU
- Select appropriate infill, thickness, and material
- Orient the file and apply supports
- Print to the desired printer
- If printing with resin, request makerspace to double wash the finished print
- Return to collect part and remove supports

Notes:

- A mesh wont export as an actual object. Turn the mesh into a solid part.
- Use 80-100% infill
- When making the object from a mesh to a solid, it no longer is hollow
- When using a mesh, edit the view in the software to not show edge lines which will make things load faster

Conclusions/action items:

Later this week we will try printing the Airway STL File from Dr. Sylvia that are in the project files folder. We'll update this protocol as necessary.

3/18/25 First 3D Printed Airway

Lance Johnson - Apr 14, 2025, 9:42 PM CDT

Download

TracheaV1_v2.3mf (897 kB)

Cody Kryzer - Apr 14, 2025, 9:41 PM CDT

Title: Printing an airway

Date: 3/18/25

Content by: Dan

Present: Dan and Lance

Goals: Print the airway that Dr. Garcias sent us

Content:

Lance was able to convert the mesh to an object which had caused us trouble yesterday when trying to print.

The 3mf file used to print is attached below.

It took 2 hours to print with TPU

Conclusions/action items:

The final print turned out well with good shape and clean edges, but we think it is too hard.

4/14/25 - ITK-SNAP Segmenting Protocol

Dan Altschuler (daltschuler2@wisc.edu) - Apr 17, 2025, 8:33 PM CDT

Title: ITK-SNAP Segmentation Protocol

Date: 4/14/25

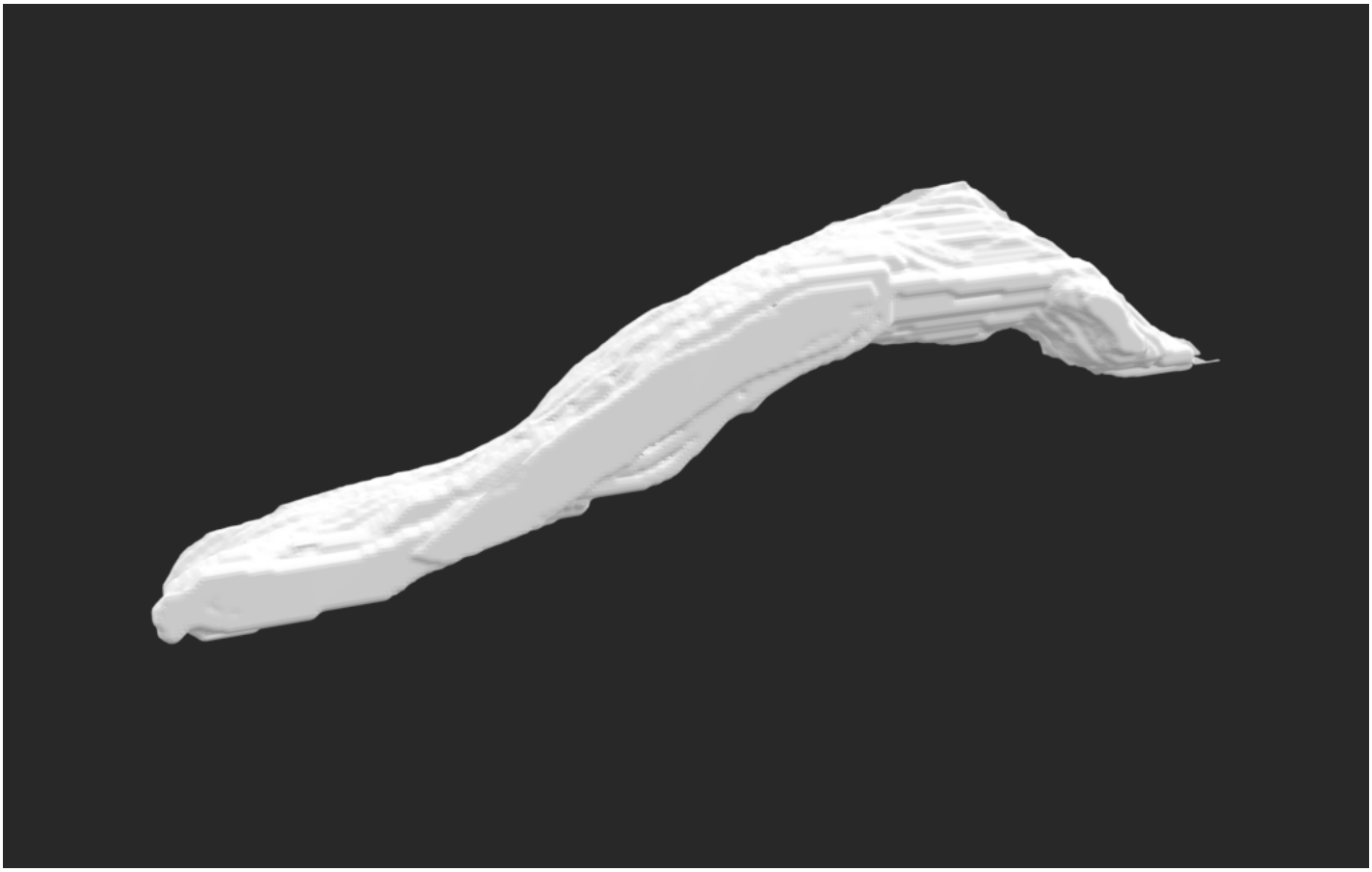
Content by: Dan

Content:

1. Collect your MRI into one zip file that can be downloaded onto a computer
2. Once you have unzipped the file and located it on your computer, launch the ITK-SNAP application and select "open main image" to select the first image from the MRI
3. Once your image is open on ITK-SNAP and you can see the three different planes as well as the 3D rendering box segmentation is almost ready to occur
4. Change the contrast on the image using the 'tools' then 'image contrast' and move the line up until desired contrast is reached
5. Approach the scan from the sagittal plane using the polygon tool with a segment length of '8' and the 'smooth curve' setting selected
6. Go layer by layer of the MRI to segment each part of the airway working from the furthest image on either side until you reach the middle portion of the scan as denoted in the axial plane image
7. Smooth each polygon using the paintbrush tool at desired brush size (6 worked well) and also select the '3D' box
8. Continue this process until reaching the opposite side of the scan and then select 'update' on the 3D render (this can be done after each scan to ensure a model is being generated)
9. Once the MRI is fully segmented, move into the 3D rendering box to begin post-processing
10. Using the 'slicing' and 'spray can' tool will help smooth out the model until the desired render is achieved
11. Consider using other 3D rendering software such as '3D Slicer' for further post processing, but if not, then export the render as a surface mesh under the 'Segmentation' tab on top of the screen
12. Export this file as an STL for printing on Makerspace equipment

Conclusions/action items:

Use this protocol to continue segmenting until a desired model is generated.



4/14/25 - 3D Printing Prep Protocol

Lance Johnson - Apr 15, 2025, 12:54 AM CDT

Title: 3D Printing Prep Process

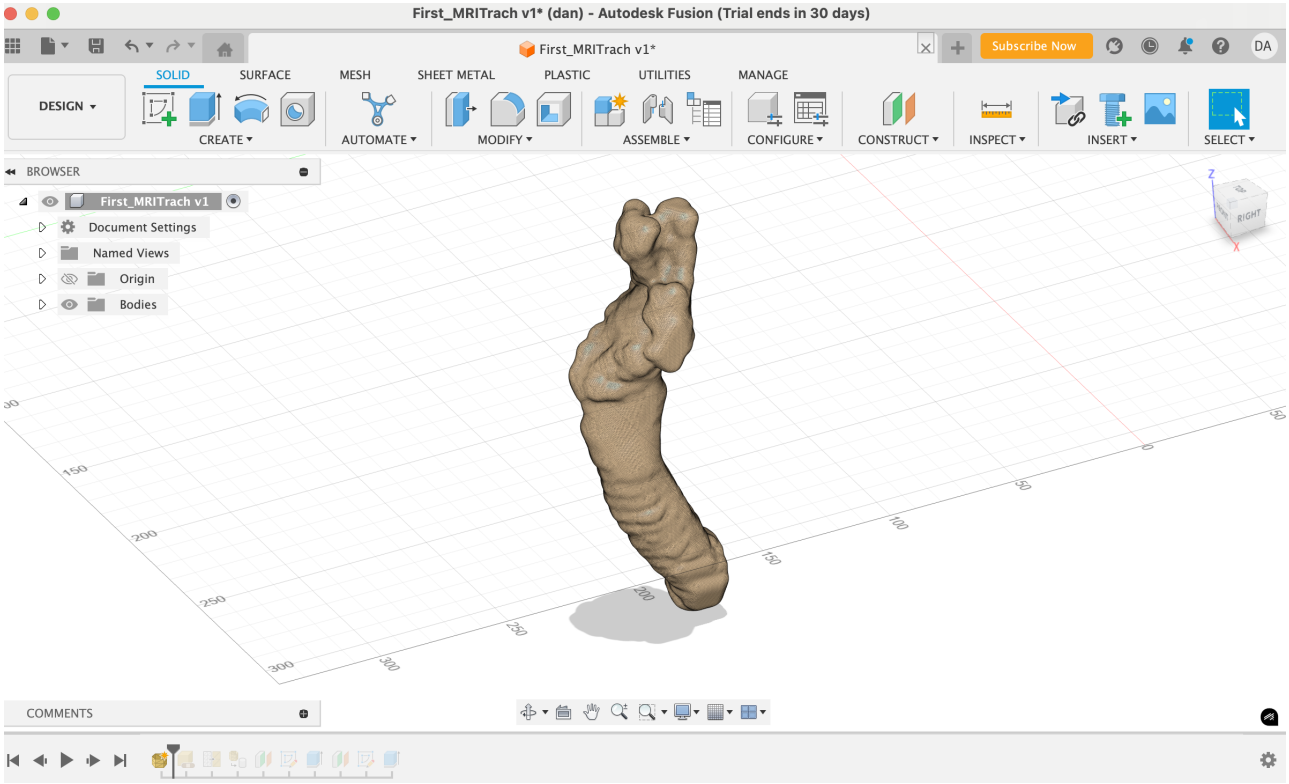
Date: 4/14/25

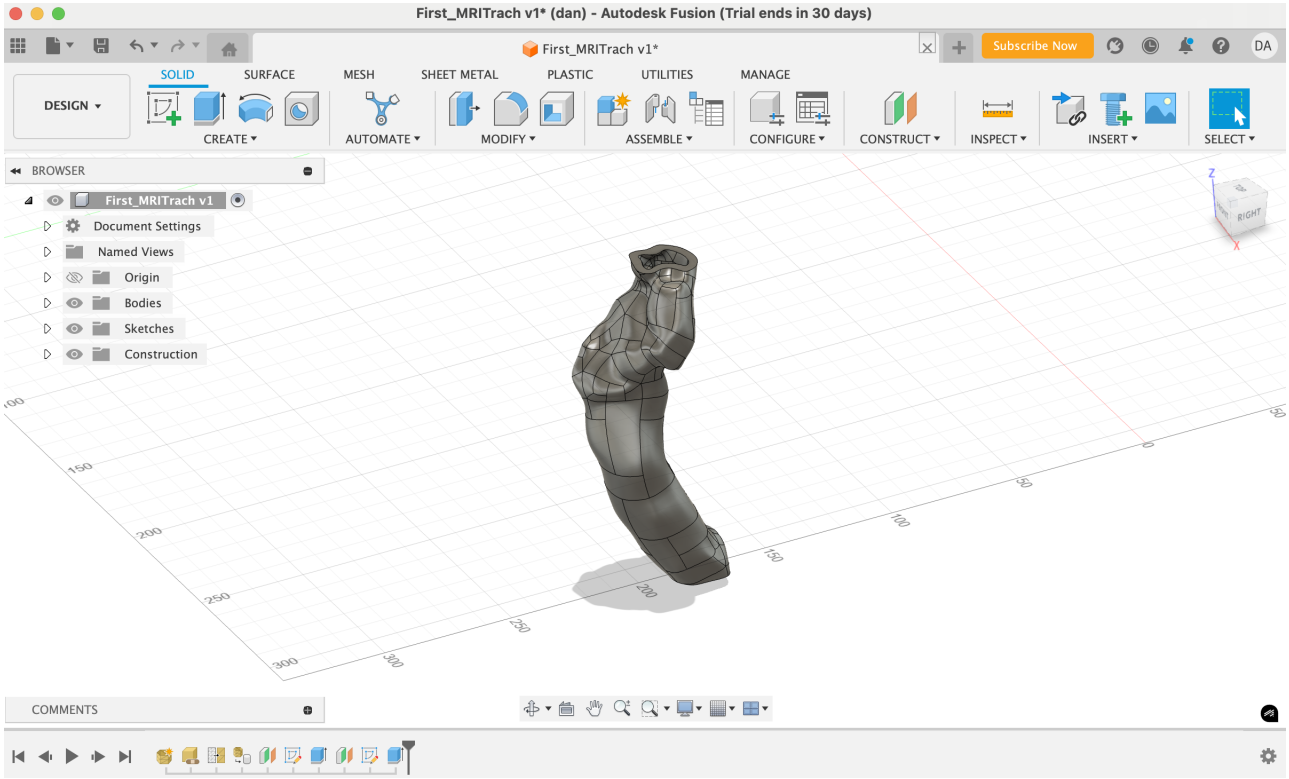
Content by: Lance

Present: Lance

Goals: Lay out a step-by-step process to turn the meshes produced from segmentation into printable files

Content:

- 



- load .stl file from segmentation into Fusion 360
  - "Insert Mesh" --> choose mm
- "Prepare" --> "Repair"
- "Modify" --> "Reduce" --> 9950 facets
- "Modify" --> "Convert Mesh" --> "Parametric" --> "Organic"
- Cut ends (create offset plane, then sketch + cut)
- export as .3mf or .stl

Conclusions/action items:

This took way to long than it should have but now the process is repeatable as long as the Fusion 360 Student account with the extension is available. Potentially looking into using SolidWorks for this purpose would be useful for my teammates who are more comfortable with SolidWorks.

4/15/25 3D Printing Protocol 2.0

Cody Kryzer - Apr 28, 2025, 4:46 PM CDT

Title: 3D Printing Protocol

Date: 4/15/25

Content by: Cody

Present: Whole Team

Goals: Print the segmented MRI scan

Content:

- File was transferred from a mesh to a 3mf (refer to 3D Printing Prep Protocol in Design Process folder)
- Put file onto a flash drive
- Remove the file from the flash drive onto the makerspace computer, or whatever other computer that works with the 3D printer being used.
- Open the file with Bambu software for TPU or Preform software for Formlabs Resin
- Select appropriate infill, thickness, and material
- Orient the file and apply supports
- Print to the desired printer
- Return to collect part and remove supports

Notes

- Print on bunny printer for TPU
- tree supports work well to keep the airway oriented upright and sometimes can prevent the need for supports being printed inside the airway
- If printing with resin, request makerspace to double wash the finished print

Conclusions/action items:

Printed same file (First Airway Attempt) in TPU (15% infill), Formlabs elastic and formlabs flexible

4/17/25 - 3D Slicer Segmentation Protocol

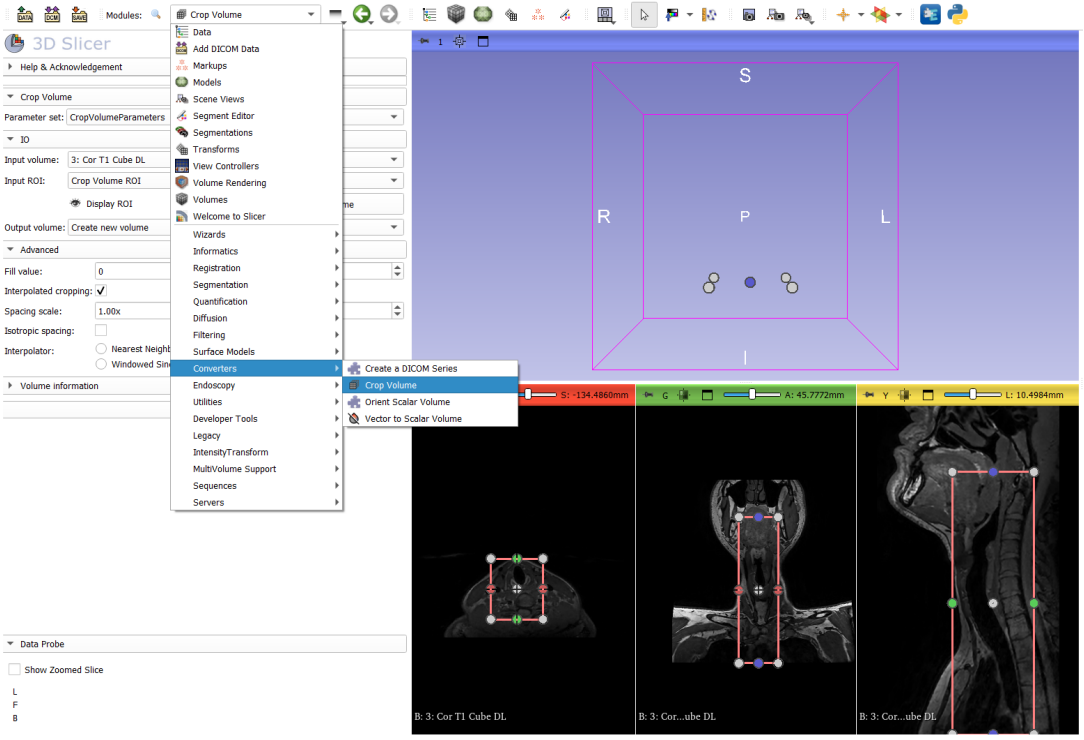
MATTHEW SHERIDAN - Apr 17, 2025, 9:56 PM CDT

Title: 3D Slicer Segmentation Protocol

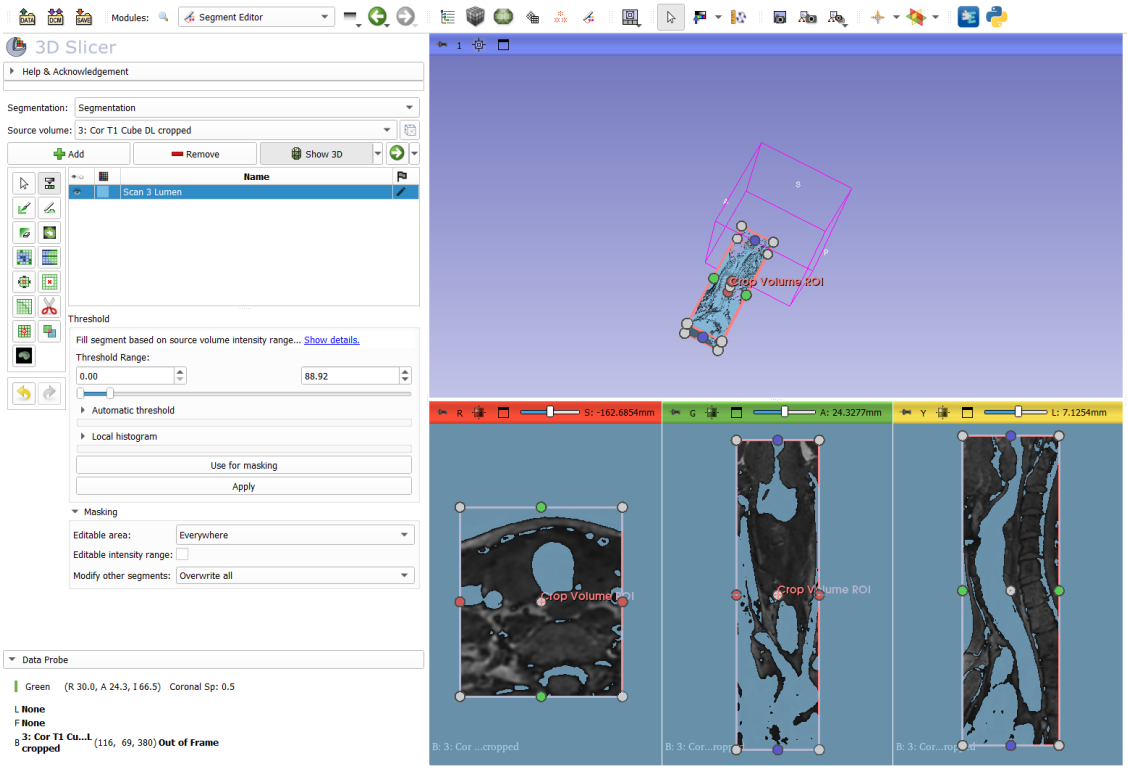
Date: 4/17/25

Content by: Matt Sheridan

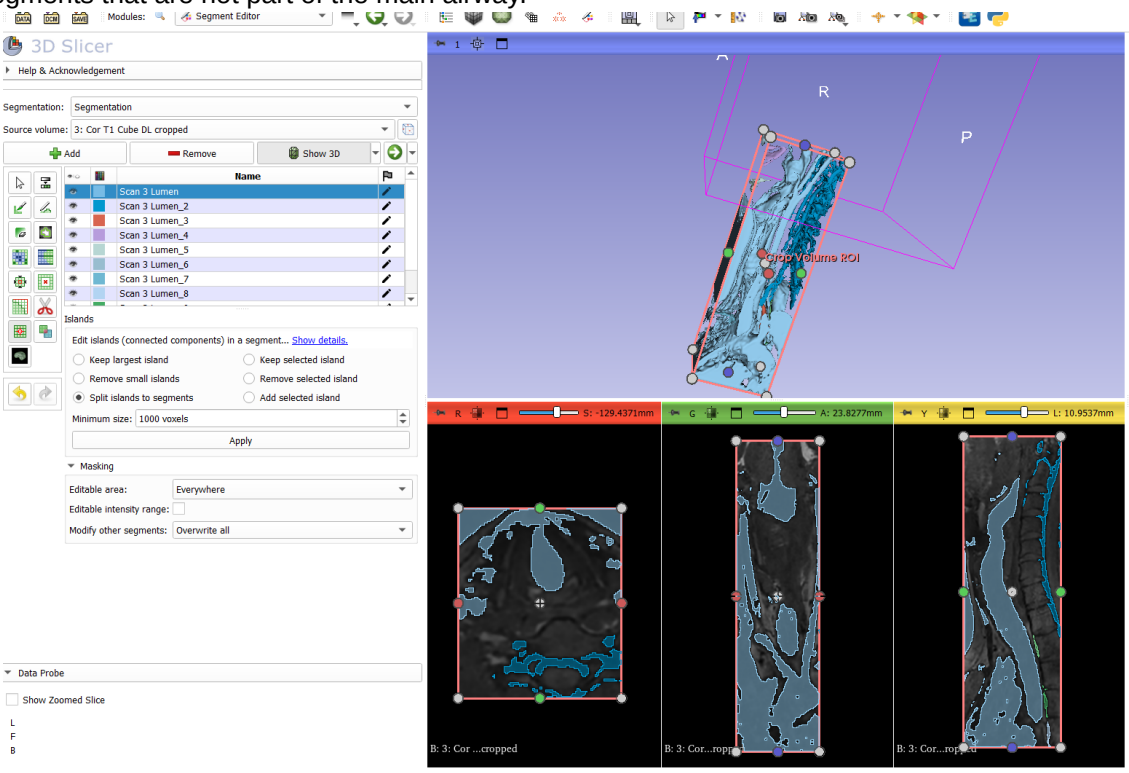
Content:

1. Upload DICOM files from MRI scans by selecting add DICOM data, and select desired scan by double clicking
2. Look through the three views (coronal, sagittal, and transverse) to ensure that the scan looks good, and use the crop volume module to crop the scan to only include the airway from just superior to the epiglottis to just inferior to the carina(split in the trachea). In this module you will need to select "Create New ROI", choose the desired region, and then select apply to create the new cropped volume.


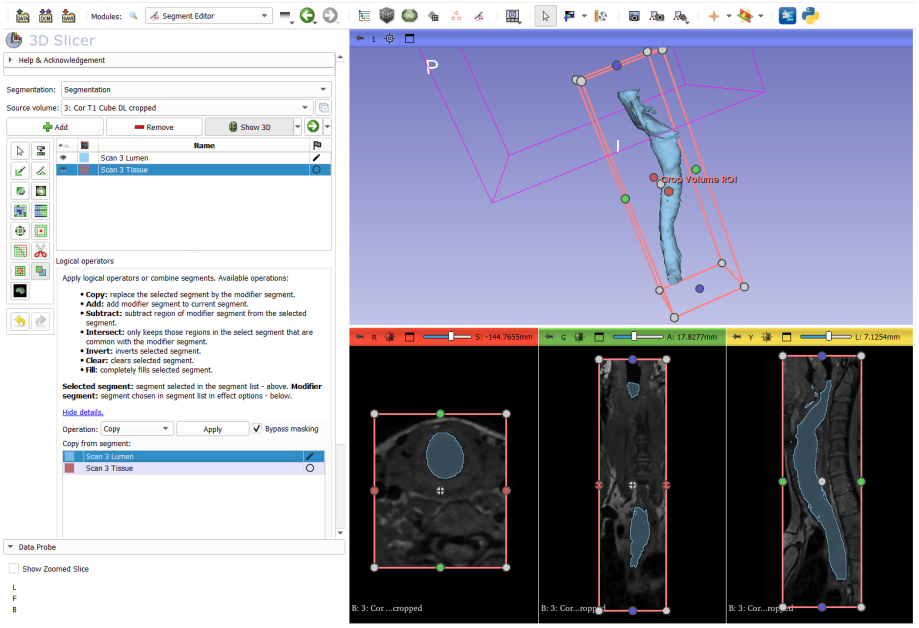
3. Under the segment editor module, select the source volume that you just created (should say the scan name and then cropped), and select Add to create a new segmentation. Rename this segment to something you will remember represents the air (I used Scan 3 Lumen). Then select Threshold from the options on the left side and change the low end of the range to 0, and the high end to something around 90. This will depend on the scan, so look through each view to ensure that all air within the airway is highlighted. When the thresholding looks good, press Apply.

1. 

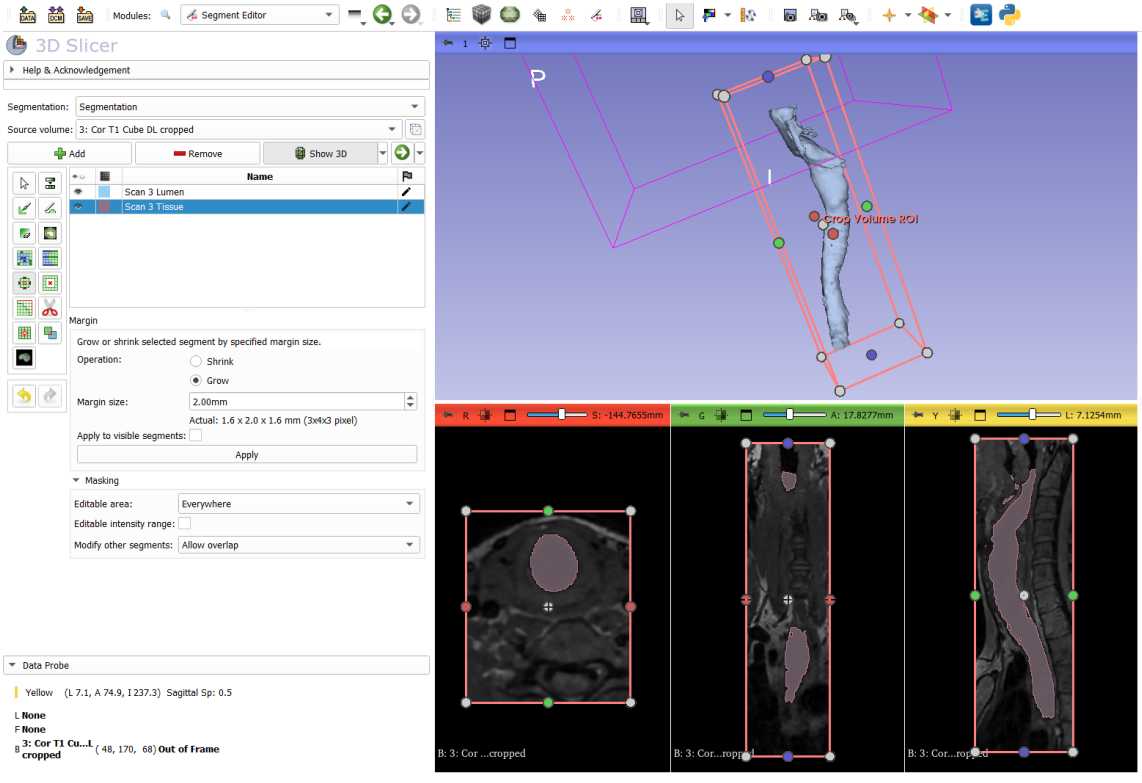
4. To begin cleaning up the segment, select Islands from the left side, and then Split islands to segments. You can adjust the minimum voxel size to include more islands. Once you split it into segments, you can remove any segments that are not part of the main airway.

1. 

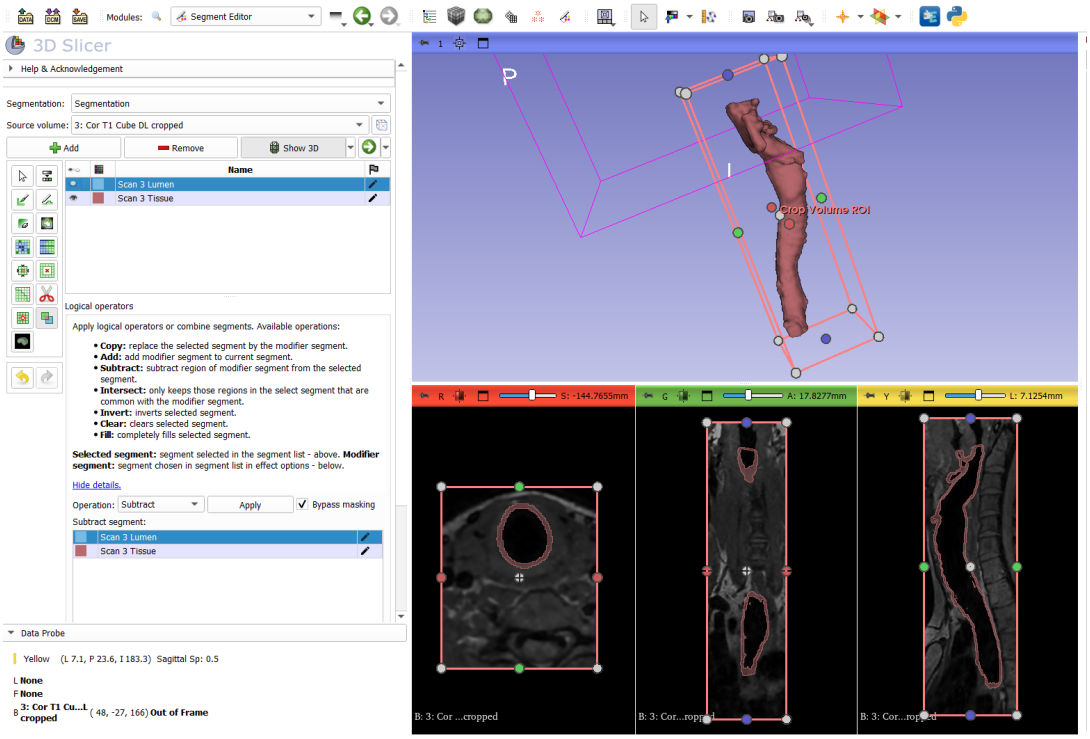
5. At this point, there will still be a lot of undesired segments still included, so you will need to use the Scissors tool to cut out sections that should not be included. This can be done by cutting small parts where the desired and undesired portions are connected to create an island, and then using the Split islands to segments feature from step 4 to remove them. This will be the longest step.
6. Once the airway is cleaned up, you will need to make the tissue around it. To do this, you need to go to logical operators, and then press Add to create a new segment, and name it something like Scan 3 Tissue. Then press Copy, and select Scan 3 Tissue up above, and Scan 3 Lumen below, then press Apply. At this point, you should have 2 identical segments.

1. 

7. Next, take this new segment and go to Margin on the left side, select Grow, and make the margin size 2 mm. Then make sure to select Allow overlap under modify other segments at the bottom! Then press Apply, and this segment should be slightly bigger than the other one.

1. 

8. Finally, in Logical Operators, select subtract, and select the tissue as your chosen segment at the top and subtract the air from the tissue. This should leave you with a hollow shell of the airway!

1. 

9. Next, go to the Segmentations module, and under Export/Import models and labelmaps, select Export and Models and then Export to the desired folder.
10. Finally, go to the Data module, select the Airway, and export as an STL file.

Conclusions/action items:

With this STL file, you can follow the 3D printing protocol to convert to a .3mf printable file.

3/17/25 - Volume Testing Protocol (copy)

Lance Johnson - Apr 14, 2025, 8:22 PM CDT

Title: Volume Testing Protocol

Date: 3/17/2025

Content by: Lance

Present: N/A

Goals: To outline and write a testing protocol to test the inside airway volume of the printed airways against the mathematical volume calculated from the DICOM image by the slicing software

Content:

Volume Testing Protocol:

1) Gather two tall beakers and an Eppendorf pipet.

2) Fill one beaker with water to add to the airway.

3) Place the printed airway vertically in the other beaker, using light adhesive to seal the bottom edge of the airway to the beaker or waterproof paper if needed to prevent water leakage.

4) Fill the inside of the airway with water, making sure to measure and record exact amounts as they are added.

5) Use an Eppendorf pipet to precisely fill the airway to the top, then total the volume of water added.

6) Repeat filling and measuring two more times for a total of three trials, recording total volume each time.

7) Open the airway file in 3D Slicer software and use volume measurement tool to determine inner airway volume of the mesh and compare to the measured values

Conclusions/action items:

This is still a rudimentary protocol and will need more refining as we start to use and understand the 3D Slicer software more. Additionally, the porosity of the print will impact the results of this test so understanding how porous the prints are in our desired materials will be important moving forward.

4/14/25 - Durability Testing Protocol

Lance Johnson - Apr 14, 2025, 8:58 PM CDT

Title: Durability& Speed Testing Protocol

Date: 4/14/25

Content by: Lance

Present: N/A

Goals: To develop a testing protocol to determine the durability and intubation speed of the printed airway in situations of varying user experience

Content:

Durability & Speed Testing Protocol:

1) Record the subject name and experience level in the data table

2) Attach the printed airway to the airway manikin by fully securing the airway with duct tape and hose clamps as needed

3) Prepare all the intubation tools required: laryngoscope, endotracheal(ET) tube, bougie, bag-valve mask(BVM)

4) Perform an intubation and record: 1) time taken to intubate, 2) any significant damage to the trainer after intubation

5) Log the above data as shown in the table using the example below

Durability & Speed Testing Data	Subject Name: Bucky Badger	Subject Experience Level: None
Trial	**Time (sec)**	**Damage Observed**
1	104	None
2	85	None
3	75	Airway dettached from manikin

6) After 5 intubation attempts, complete the table and generate results.

Conclusions/action items:

Based on this test, the team can determine how well the printed airways stand up to successive intubations performed by users of different skill levels(i.e. a beginner might be more rough on the mannikin than an experienced user). Additionally, the team will be able to generate learning curves from the times taken per intubation for each individual to show how well the user adapts to the trainer(If the trainer is good, the curves for experienced users should be relatively flat and should show a speed increase from beginner/intermediate users. In other words, the trainer shouldn't impede experienced individuals from performing roughly the same over time but should allow beginners a constant environment for growth).

4/14/25 - Pure Durability Testing

Lance Johnson - Apr 14, 2025, 9:13 PM CDT

Title: Pure Durability Testing Protocol

Date: 4/14/25

Content by: Lance

Present: N/A

Goals: To develop a testing protocol to determine the durability of the printed airway and its integration into the airway training manikin over a longer period of time

Content:

Durability & Speed Testing Protocol:

1) Place the airway and manikin in a normal inside environment(temperature, humidity)

2) Attach the printed airway to the airway manikin by fully securing the airway with duct tape and hose clamps as needed

3) Prepare all the intubation tools required: laryngoscope, endotracheal(ET) tube, bougie, bag-valve mask(BVM)

4) Perform an intubation and record any noticeable damage to the trainer after each intubation

5) Log the above data as shown in the table using the example below

Durability Testing Data	Subject Name:
Trial	**Observed Damage**
1	None
2	None
3	None
4	None
5	Airway Punctured

6) After 100 intubation attempts, complete the table and generate results

Conclusions/action items:

Based on this test, the team can determine how well the printed airways stand up to successive intubations over many intubations. This data can be used to determine how well the material stands up to repeated use and if the attachment points are secure enough. While industry standard airway trainers are very durable, it is okay for our design to be less durable because its intended use is for single-patient practice.

4/22/25 - Compression Testing Protocol

MATTHEW SHERIDAN - Apr 22, 2025, 10:32 PM CDT

Title: Compression Testing Protocol

Date: 4/22/25

Content by: Matt Sheridan

Present: Whole team

Content:

- Swap tensile clamps for compression attachment on MTS machine.
- Open TestSuite software on computer
- Place airway on the bottom attachment so that compression can be done in the sagittal plane
- Lower the upper attachment until it begins touching the airway, and then zero the force and the displacement.
- Lower the upper attachment until the force value reaches roughly 24.5 Newtons and record the displacement value.
- Repeat for all airways

Conclusions/action items:

This was a simple yet effective way to test the material properties of each of the different materials that we printed with, as well as the silicone on the existing manikin. We gathered good information about which materials match a human airway in properties the best, and repeated intubation tests will now test durability.

4/22/25 - Repeated Intubation Protocol

Cody Kryzer - Apr 22, 2025, 10:25 PM CDT

Title: Repeated Intubation Protocol

Date: 4/22/25

Content by: Cody Kryzer

Present: Whole team

Goals: Plan a way to test the airways with repeated intubations

Content:

- One repetition involves inserting a metal laryngoscope into the airway roughly 3cm or to where the airway would split into the trachea and esophagus and holding it with upward force for about 5 seconds.
- This process was repeated until significant damage to the airway occurred or until roughly 50 intubations
- Only the laryngoscope was used because the other materials used to intubate were observed to not scratch or stretch the airway
- The laryngoscope was in the airway for 5 seconds because it is removed quickly into the intubation process which takes at least 15 seconds

Conclusions/action items:

This is a good way to test the important aspects of our printed airways and how the materials differ. We don't want our airways to become damaged too badly because we need them for poster presentation, but realistically only excessive force that would not simulate intubation would do such damage.

4/22/25 - Repeated Intubation Testing

Dan Altschuler (daltschuler2@wisc.edu) - Apr 28, 2025, 4:20 PM CDT

Title: Repeated Intubation Testing

Date: 4/22/25

Content by: Cody Kryzer

Present: Whole team

Goals: Intubate our airways over and over and see how they respond

Content:

The TPU airway lasted 50 full repetitions and had no major damage but slight deformity in the airway opening (50 total)

The Flexible airway developed a tear down the side after the seventh intubation that was enlarged in the following four intubations and then stopped growing larger. (15 total)

The Elastic airway developed a small tear in a different spot than the flexible airway on the fourth intubation. The tear lengthened for the next three intubations until a secondary tear developed originating from the same spot. This tear lengthened over the next two intubations after which testing was ceased (9 total)

Conclusions/action items:

TPU is more resistant to tearing than either of the resins. If the openings were larger I think that the airways would not have torn.

4/22/25 - Compression Testing

Dan Altschuler (daltschuler2@wisc.edu) - Apr 28, 2025, 4:20 PM CDT

Title: Compression Testing

Date: 4/22/25

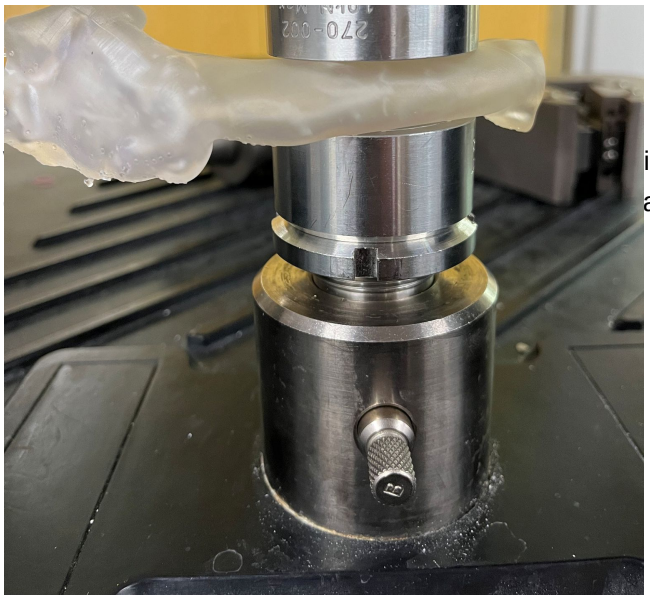
Content by: Cody

Present: Whole Team

Goals: Follow the protocol for compression testing

Content:

- We used the MTS machine in the ECB lab
- Placed each airway in the machine with the designated applied load of 24.6N
- The elastic resin performed most similarly to the manikin
- The TPU did not deform much at all
- The flexible resin deformed a moderate amount.



inted with elastic resin. This way we can ensure proper training airway.

2/13/2025 Material Design Matrix

Cody Kryzer - Feb 13, 2025, 9:20 PM CST

Design Criteria (Weight)	Design 1: Formlabs 80A Resin 		Design 2: Silicone Casting 		Design 3: Thermoplastic Polyurethane (TPU) 95A 	
Mechanical Properties (25)	5/5	25	2/5	10	4/5	20
Cost (20)	2/5	8	5/5	20	5/5	20
Ease of Fabrication (20)	4/5	16	1/5	4	3/5	12
Durability (15)	5/5	15	3/5	9	4/5	12
Resemblance to Trachea (10)	3/5	6	5/5	10	4/5	8
Printer Availability (10)	2/5	4	5/5	10	4/5	8
Total Score (100)	**74**		**63**		**80**	

Mechanical Properties (25): In order to create an accurate trainer, the 3D-printed airways need to mimic the patient's airway as accurately as possible and therefore need to possess the same mechanical properties of the airway. Young's modulus and Shore hardness were determined to be the most important properties for the airway as they quantify the strength and flexibility of the airway. Based on these factors, the accuracy of the biomechanical properties was deemed the most important category in our matrix.

Cost (20): Cost references the dollar per gram of the material. It is important for the material to be relatively cheap since a new airway will need to be printed for each patient; the product is essentially a one time use. 80A Resin can be purchased for $0.29 per gram. Silicone can be purchased for $0.05 per gram. TPU can be purchased for $0.05 per gram.

Ease of Fabrication (20): The ease of fabrication category refers to the simplicity of printing each material. Also considered in this category is the ability to accurately print using each material, especially given the broader scope of the project requiring widely accessible prints for many different airways. A higher score in this category represents an airway material that is both easy to work with and can output accurate prints.

Download

Design_Matrix_2_13_25.pdf (720 kB)

2/22/25 Airway STL Files from Dr. Sylvana Garcia

Cody Kryzer - Feb 26, 2025, 5:39 PM CST

Download

FullAirway.stl (4.15 MB)

Cody Kryzer - Feb 26, 2025, 5:39 PM CST

Download

Trachea_ver4.STL (422 kB)

4/11/25 MRI Scan DICOM Files

MATTHEW SHERIDAN - Apr 14, 2025, 8:11 PM CDT

Download

BME_Vol01.zip (279 MB LA S3)

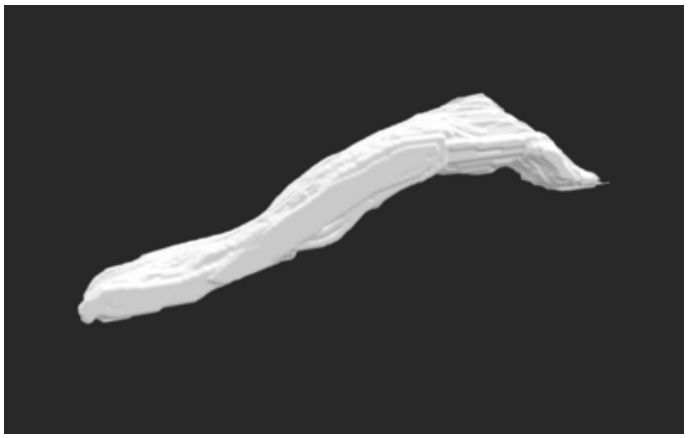
4/14/25 First ITK-SNAP Segmentation STL

Dan Altschuler (daltschuler2@wisc.edu) - Apr 14, 2025, 9:55 PM CDT

Download

First-ITKSNAP-Airway.stl (35.1 MB)

Dan Altschuler (daltschuler2@wisc.edu) - Apr 14, 2025, 9:57 PM CDT



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Screenshot_2025-04-14_at_9.53.17_PM.png (93.3 kB)

4/14/25 First Airway Attempt

MATTHEW SHERIDAN - Apr 14, 2025, 9:44 PM CDT

Download

shell.stl (13.5 MB)

4/15/25 Airway from Scan 5

MATTHEW SHERIDAN - Apr 15, 2025, 2:37 PM CDT

Download

Scan_5_Shell.stl (16.3 MB)

4/17/25 Scan 3 Airway

MATTHEW SHERIDAN - Apr 17, 2025, 9:53 PM CDT

Download

Scan_3_Tissue.stl (15.7 MB)

4/18/25 Scan 3 Simplified

MATTHEW SHERIDAN - Apr 18, 2025, 1:09 PM CDT

Download

Model_3.stl (7.83 MB)

MATTHEW SHERIDAN - Apr 18, 2025, 1:25 PM CDT

Download

Model_5.stl (7.8 MB)

MATTHEW SHERIDAN - Apr 18, 2025, 2:17 PM CDT

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3dpea.com_Model_3_Clean.3mf (6.9 MB)

MATTHEW SHERIDAN - Apr 18, 2025, 2:18 PM CDT

Download

Model_3_Clean.stl (7.83 MB)

1/30 VSAT Simulator

Cody Kryzer - Feb 10, 2025, 8:50 PM CST

Title: Virtual Airway Skills Trainer (VAST) Simulator

Date: 1/30/2025

Content by: Cody

Present: Cody

Goals: Learn about virtual airway trainers

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC5033599/

Citation:

[1] Doga DEMIREL *et al.*, “Virtual Airway Skills Trainer (VAST) Simulator,” *Studies in health technology and informatics*, vol. 220, p. 91, 2016, Accessed: Jan. 31, 2025. [Online]. Available: https://pmc.ncbi.nlm.nih.gov/articles/PMC5033599/

Content:

The text outlines a test where people used a virtual simulation to perform airway management in two different ways. One being very simple, and the other being very complex.

- Practicing on cadavers is a one time use thing
- Manikins are not realistic and are not applicable to difficult situations like the ones we are focusing on
- VR is risk free and low cost and reflective of OR setting
- 'Active gamers' were 20% faster using the VAST
- Those trained on Advanced Trauma Life Support (https://pubmed.ncbi.nlm.nih.gov/24502986/) were slower than those trained on manikins

Conclusions/action items:

Dr. Schroeder mentioned that simulators like these exist, but aren't always helpful for practice since they are not applicable to what one might be doing that day. It is helpful to know how these simulators are helpful so we can emulate that in our design.

1/30 Airway Trainer Accuracy

Cody Kryzer - Feb 10, 2025, 8:50 PM CST

Title: Anatomic accuracy of airway training manikins compared with humans

Date: 1/30/25

Content by: Cody

Present: Cody

Goals: Learn about the airsim airway trainer

Link: https://doi.org/10.1111/anae.15238

Citation:

[1] M. B. Blackburn *et al.*, "Anatomic accuracy of airway training manikins compared with humans*," *Anaesthesia*, vol. 76, no. 3, pp. 366–372, Aug. 2020, doi: https://doi.org/10.1111/anae.15238.

Content:

The study compared three different airway manikins, SynDaver , Laerdal and AirSim to real human anatomy. CT scans with recorded values were used. Every manikin was proven to have too large a space between the epiglottis and posterior pharyngeal wall. The most commonly used manikins are often the most low cost and thus most likely to have inaccuracies.

Measurement	Mean (SD)	Value (percentile)		
	Human participants	SynDaver	Laerdal	AirSim
Tongue to PPW	12.22 (5.42)	19.9 (0.96[a])	24.0 (> 0.99[a])	16.8 (0.86[a])
Epiglottis to PPW	7.94 (3.35)	15.4 (0.99[b])	23.5 (> 0.99[b])	11.3 (0.84[a])
Tip of tongue to vallecula	71.49 (6.01)	50.7 (< 0.01[b])	73.6 (0.64)	63.9 (0.1[a])
Tip of tongue to tongue dorsum	34.38 (5.25)	29.7 (0.18)	23.2 (0.02[b])	28.7 (0.14[a])
Vallecula to epiglottis	14.64 (4.2)	16.0 (0.62)	16.3 (0.66)	8.7 (0.08[a])
Base of epiglottis to PPW	11.84 (3.1)	23.9 (> 0.99[b])	28.7 (> 0.99[b])	16.0 (0.91[a])
Vertical distance of soft palate	26.50 (7.71)	15.5 (0.08[a])	41.3 (0.97[a])	11.1 (0.02[b])
Soft palate to laryngeal inlet	60.64 (9.97)	66.2 (0.71)	112.0 (> 0.99[b])	82.8 (0.99[b])
Uvula to epiglottis	21.40 (7.88)	28.1 (0.8)	28.4 (0.81)	25.0 (0.68)

Measurement	Mean (SD)	Value (percentile)		
	Published human values	SynDaver	Laerdal	AirSim
Height mouth opens; cm [17]	4.78 (0.83)	5.98 (0.93)	4.52 (0.38)	8.10 (> 0.99)
First tracheal ring width; mm [18]	1.9 (0.6)	2.44 (0.82)	1.52 (0.26)	1.92 (0.51)
Trachea length; cm [19]	8.6 (1.1)	9.54 (0.80)	3.27 (< 0.01)	7.83 (0.24)
Neck circumference; cm [20]	36.6 (3.5)	33.4 (0.18)	43.55 (0.98)	41.23 (0.91)
Tongue to PPW; mm [16]	16.0 (0.7)	23.0 (> 0.99)	35.7 (> 0.99)	23.2 (> 0.99)

Measurement	Mean (SD)	Value (percentile)		
	Published human values	SynDaver	Laerdal	AirSim
Epiglottis to PPW; mm [16]	9.0 (0.4)	16.7 (> 0.99)	35.4 (> 0.99)	14.8 (> 0.99)

These tables show the differences in spacing at different relevant points in the human and manikin anatomy. They can be used as references in the future and goals for creating our design.

Conclusions/action items:

This study has tables depicted every measurement tested which may be useful in the future. It also references other articles which also tested the anatomical accuracy of airway trainer manikins. At first I was shocked that some measurements were so inaccurate, but to ne honest it makes sense because our project is to use the CT scans (which are for sure accurate) to 3D print our own airways.

1/30 Airway Anomalies

Cody Kryzer - Feb 10, 2025, 8:50 PM CST

Title: Airway Anomalies

Date: 1/30/2025

Content by: Cody

Present: Cody

Goals: Learn about types of airways we might have to work with

Link: https://doi.org/10.1016/j.clp.2018.07.002

Citation: A. M. Landry and M. J. Rutter, “Airway Anomalies,” Clinics in Perinatology, vol. 45, no. 4, pp. 597–607, Dec. 2018, doi: https://doi.org/10.1016/j.clp.2018.07.002

Content:

The article focuses on deformities in the larynx, subglottis, and trachea. It specifically depicts congenital subglottic stenosis, laryngeal webs, laryngeal cleft, and tracheal stenosis and how to present in a human.

- Congenital Subglottic Stenosis
  - Shrinking diameter without history of intubation
  - Due to abnormal cartilage shape or the thickening of the membrane
- Anterior Glottic Webs and Laryngeal Atresia
  - "result of failure of the laryngeal lumen to recannulate after epithelial obliteration" meaning something interupted the healing process
  - 65% of the time this condition is due to a deletion in the 22nd chromosome
- Laryngeal Cleft
  - Four types
    - 1 - the cleft extends to the vocal chords, can be remedied with feeding therapy (is exactly what it sounds like)
    - 2 through 4 - worsen from 2 to 4, extend past vocal cords, require surgical treatment
- Congenital Tracheal Stenosis
  - Instead of tracheal cartilage forming in a C shape, full rings form
  - Extremely rare. 1 in 65 thousand
  - Likely will require surgical procedure

Conclusions/action items:

For the sake of this project, I am not so concerned with the cause and effect of these conditions. however, the images are very useful to for visualizing different kinds of airways. And the descriptions of the shapes and properties are helpful to consider when choosing biomaterials.

2/14 Image Segmentation

Cody Kryzer - Feb 26, 2025, 8:53 PM CST

Title: What is image segmentation?

Date: 2/14/25

Content by: Cody Kryzer

Present: Cody

Search Term: Image segmentation

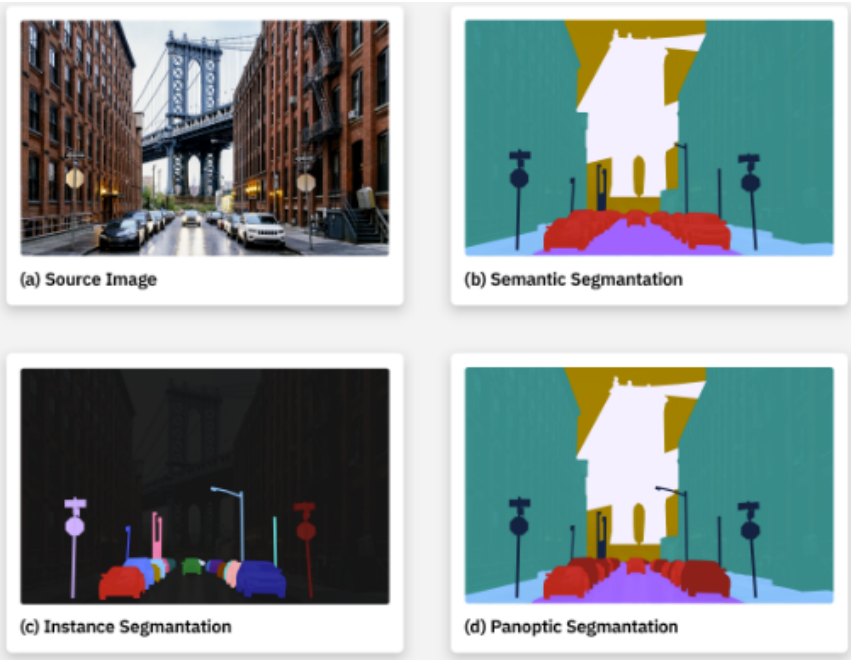
Citation: IBM, “Image Segmentation,” *Ibm.com*, Sep. 15, 2023. https://www.ibm.com/think/topics/image-segmentation

Link: https://www.ibm.com/think/topics/image-segmentation#:~:text=Image%20segmentation%20is%20a%20computer,faster%2C%20more%20advanced%20image%20processing

Goals: Learn how image segmentation works

Content:

- Uses computer vision to partition images into discrete groups of pixels in specific shapes
- very useful in machine learning and artificial intelligence
- Image segmentation can classify and categorize features
- Object detection can localize regions and approximate height and width
- Some techniques use color and brightness while others use pattern recognition
- Used for 3 techniques - semantic segmentation, instance segmentation and panoptic segmentation
    - Semantic
        - Identify pixels as belonging to the sky or a car etc
        - May group multiple of the same object together as one object
    - Instance
        - Separates 'things' from 'stuff'
        - More difficult to isolate overlapping objects that are multiple instances of each other
    - Panoptic
        - Accomplish goals of both semantic and instance segmentation
        - Each pixel is given an ID and is determined to belong to a specific thing
        - If the pixel belongs to 'stuff' the ID is ignored



Conclusions/action items:

Segmentation is very a very interesting process. It is fortunate that software exists to do it for us. However, MRI images may be a bit more challenging than regular photos.

Amira and Dragonfly are two segmentation softwares to look into.

1/30 Modifications to trainer Intubation Head (copy)

Cody Kryzer - Feb 10, 2025, 8:50 PM CST

Title: Modifications to the Airway Management Trainer Intubation Head for Training in Difficult Airway Recognition Through a Comparative Study With the Airsim® Intubation Head

Date: 1/30/2025

Content by: Cody

Present: Cody

Goals: Learn about airway trainers

Link: https://doi.org/10.1097/sih.0000000000000018

Citation:

[1] V. Farré, C. Añez, V. Serrano, N. Aragonès, M. Camps, and I. de Molina, "Modifications to the Airway Management Trainer Intubation Head for Training in Difficult Airway Recognition Through a Comparative Study With the Airsim® Intubation Head," *Simulation in Healthcare: The Journal of the Society for Simulation in Healthcare*, vol. 9, no. 2, pp. 136–140, Apr. 2014, doi: https://doi.org/10.1097/sih.0000000000000018.

Content:

Researchers made modifications to an airway management trainer to make it more difficult to use. These modifications were easy to make. This trainer was then compared to the Airsim trainer and deemed to be similar.

Experienced anesthesiologists were tested on time, ease, and need for maneuvers.

Conclusions/action items:

The full text in unavailable to view as of right now. But like we discussed in lecture on Wednesday, I can reach out to a librarian for access. I also plan to use this article to find related articles to help with my research. I also will look into the Airsim trainer as a potential competing design

2/6 Trucorp Airway Trainers

Cody Kryzer - Feb 07, 2025, 1:55 PM CST

Title: Trucorp Difficult Airway Trainers

Date: 2/6/2025

Content by: Cody Kryzer

Present: Cody

Citation: “Difficult Airway Trainers - TruCorp,” *Trucorp*, 2024. https://trucorp.com/en/procedure/difficult-airway-trainers/

Link: https://trucorp.com/en/procedure/difficult-airway-trainers/

Goals: Learn about competing airway trainers

Content:

- Three different manikins including an adult and child version
- Two manikins coming soon
- All manikins are meant to imitate an abnormal airway that is difficult to intubate.
- Inflatable tongue can replicate conditions like obesity, down syndrome, and craniofacial abnormalities
- Manikins have adjustable mobility in the neck and spine as well as the ability to displace the larynx

Conclusions/action items:

This is a very good option if looking for difficult airway trainers. I do not know exactly how accurate it is but it can replicate most abnormalities that our client has said are difficult to deal with. Still is unable to be patient specific though like what we are aiming for.

2/6 Laerdal Airway Management Trainer

Cody Kryzer - Feb 07, 2025, 1:47 PM CST

Title: Laerdal Airway Management Trainer

Date: 2/6/25

Content by: Cody Kryzer

Present: Cody

Citation: "Laerdal Airway Management Trainer products | Laerdal Medical," *Laerdal Medical*, 2025. https://laerdal.com/us/products/skills-proficiency/airway-management-trainers/laerdal-airway-management-trainer/shop#shop (accessed Feb. 07, 2025).

Link: https://laerdal.com/us/products/skills-proficiency/airway-management-trainers/laerdal-airway-management-trainer/shop#shop

Goals: Learn about competing airway trainers

Content:

- Can be used to practice ventilation, intubation, and suction techniques
- Includes features like induced vomiting, pressure sensitive teeth, and separate handheld anatomical models
- Used by UW-Health and the Anesthesia department to train residents
- Costs nearly 3,000 dollars, the one the client had was 5,000

Conclusions/action items:

The Laerdal model is a very strong choice for an airway manikin. However, it only replicates ideal conditions. It cannot be used to practice for difficult intubation scenarios or unusual airways.

3/3 ITK SNAP

Cody Kryzer - Mar 03, 2025, 1:54 PM CST

Title: ITK-SNAP

Date: 3/3/2025

Content by: Cody Kryzer

Present: Cody

Search Term: itk snap

Citation:

Link: http://www.itksnap.org/pmwiki/pmwiki.php

Goals: Learn about itk snap and if it is a good segmentation software for us to use

Content:

- It is FREE
- Semi automatic as well as manual feature
- designed to be easy to learn and use
- My laptop is having trouble downloading :(

Conclusions/action items:

3/16 Airway Connections

Cody Kryzer - Mar 16, 2025, 8:45 PM CDT

Title: Hose Clamps

Date:

Content by:

Present:

Search Term:

Citation:

Link:

Goals:

Content:

Conclusions/action items:

Chemical, Biosafety, and Human Subjects Training

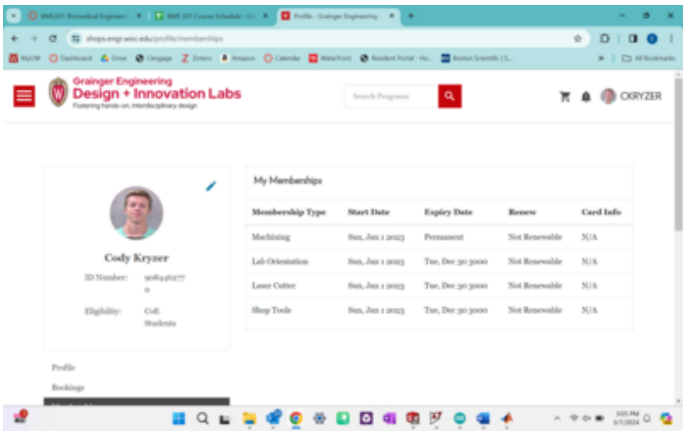
Cody Kryzer - Feb 13, 2025, 8:10 PM CST

Download

Screenshot_61_.png (310 kB)

Shop Tools Training

Cody Kryzer - Feb 10, 2025, 8:55 PM CST



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Screenshot_32_.png (329 kB)

1/30/25 Smooth Muscle in Abnormal Airways

Dan Altschuler (daltschuler2@wisc.edu) - Jan 31, 2025, 2:04 PM CST

Title: Smooth Muscle in Abnormal Airways

Date: 1/30/25

Content by: Dan

Search Term: Google Scholar: abnormal airways

Link: https://www-sciencedirect-com.ezproxy.library.wisc.edu/science/article/pii/S2468867321000377?casa_token=1kSNmlusfeQAAAAA:gHy7XG3wYVgeA-pC5ACkFTxe1REUjMWXMoLcvtaCgtd6DCRvk2hnejgu03Z8YRbQmLT2e9Ln9w

Citation:

Y. Bossé, “Smooth muscle in abnormal airways,” Current Opinion in Physiology, vol. 21, pp. 1–8, Jun. 2021, doi: https://doi.org/10.1016/j.cophys.2021.03.002.

Goals: Learn about the smooth muscle in abnormal airways

Content:

Airway responsiveness tends to be measured by the contraction of the smooth muscle in an airway (ASM), but this does not take into account other contributing factors to airway shrinkage, such as diseases or age. ASM that is considered to be normal size and have a normal contractile limit can trigger warnings in airway responsiveness in abnormal airways. For many individuals, it is possible that they have completely normal ASM, but can still show the signs of AHR. While this is the case, it is also important to note that normal ASM does not necessarily mean that there are not other problems in the airway. There is a lot of literature on ASM defects, but this study shows that there may be more to observe with AHR problems.

Conclusions/action items:

This information is important for designing our airway trainer, as we are going to be dealing with abnormal airways, so understanding the mechanism by which an airways responsiveness is regarded is helpful.

1/30/25 Difficult Airways

Dan Altschuler (daltschuler2@wisc.edu) - Jan 31, 2025, 2:08 PM CST

Title: Difficult Airways

Date: 1/30/25

Content by: Dan

Search Term: 3d printing abnormal airways

Link: https://pubmed.ncbi.nlm.nih.gov/33358011/

Citation:

D. Ormandy et al., “Difficult airways: a 3D printing study with virtual fibreoptic endoscopy,” British Journal of Oral and Maxillofacial Surgery, vol. 59, no. 2, pp. e65–e71, Feb. 2021, doi: https://doi.org/10.1016/j.bjoms.2020.08.045.

Goals: Learn about the use of 3D printing in difficult airways, and how that can impact patient outcomes

Content:

The thorough study of abnormal airways during the preoperative phase can improve patient outcomes. 3D printing these abnormal airways is an important growing field for assisting doctors with this study. These models allow the doctor and the anesthesiologist to choose the correct intubation approach for the surgery. CT scans were done on patients airways and then these scans were moved to 3D rendering software. These softwares (OsiriX, Primeo) can be helpful for our project if we are looking for some form of a rendering service.

Conclusions/action items:

Using this resource to consider the patient outcomes for individuals with abnormal airways will be crucial for writing about the background and motivation for this project.

1/30/25 Out-of-Hospital Endotracheal Intubation Experience and Patient Outcomes

Dan Altschuler (daltschuler2@wisc.edu) - Feb 01, 2025, 10:06 PM CST

Title: Out-of-Hospital Endotracheal Intubation Experience and Patient Outcomes

Date: 1/30/25

Content by: Dan

Goals: Get some numbers on general intubation patient outcomes for background information

Search Term: patient outcomes in intubation

Link: https://www.annemergmed.com/article/S0196-0644(09)01841-1/fulltext

Citation:

H. E. Wang, G. K. Balasubramani, L. J. Cook, J. R. Lave, and D. M. Yealy, “Out-of-Hospital Endotracheal Intubation Experience and Patient Outcomes,” Annals of emergency medicine, vol. 55, no. 6, pp. 527-537.e6, Jun. 2010, doi: https://doi.org/10.1016/j.annemergmed.2009.12.020.

Content:

As observed in Pennsylvania statewide emergency medicine services, the patient survival rate for out of hospital intubation is associated with rescuer experience with the difficult process of intubation. This is only the case for cardiac and medical non-arrest patients, not for trauma non-arrest patients. Tracheal intubation is an incredibly complex process for any medical professionals, and is increasingly difficult for individuals that do not have practice with standard intubation procedures. By increasing the access to practice trainers or manikins, there was shown to be an improvement in overall patient outcomes. The uncontrolled out of hospital setting poses many risks, so wide access to training for EMS is integral to making a difference in patient outcomes.

Conclusions/action items:

Using this information, it seems very clear that there is a link between intubation experience and patient outcome. Since the major goal of the project is to make these airway trainers accessible so many people can practice, there is a definite link between our project and improved patient outcome.

1/30/25 Management of difficult tracheal intubation

Dan Altschuler (daltschuler2@wisc.edu) - Feb 01, 2025, 10:11 PM CST

Title: Management of difficult tracheal intubation: a closed claims analysis

Date: 1/30/25

Content by: Dan

Search Term: doctor intubation practice

Citation:

A. M. Joffe, M. F. Aziz, K. L. Posner, L. V. Duggan, S. L. Mincer, and K. B. Domino, “Management of Difficult Tracheal Intubation,” Anesthesiology, vol. 131, no. 4, pp. 818–829, Oct. 2019, doi: https://doi.org/10.1097/aln.0000000000002815.

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC6779339/

Goals: Learn about medical malpractice as it relates to tracheal intubation

Content:

Inadequate airway planning and judgement errors were considered to be the largest contributors to patient harm in this study. There continues to be a need for further practice for medical practitioners on tracheal intubation. Since there was shown to be a considerable link between practitioners comfort with the intubation process and morbidity and malpractice in the hospital setting, there needs to be an increase in trainers on the market. While trainers are also shown to be helpful for improving patient outcomes, the improvements in the guidelines for difficult airway management can also lead to increased outcomes for patients.

Conclusions/action items:

Looking at this study, there still exists a great need for further airway trainers be made available on the market. While it is not possible to prepare practitioners for every single airway they may face, widely accessible abnormal airway trainers will improve patient outcomes.

2/6/2025 Laerdal Airway Management Trainer

Dan Altschuler (daltschuler2@wisc.edu) - Feb 06, 2025, 9:16 PM CST

Title: Laerdal Airway Management Trainer

Date: 2/6/2025

Content by: Dan

Search Term: airway trainers

Citation: “Laerdal Airway Management Trainer,” Laerdal Medical.

Link:

https://laerdal.com/us/products/skills-proficiency/airway-management-trainers/laerdal-airway-management-trainer/

Goals: Learn about a competing design that is currently used in the UW Hospital for teaching.

Content:

- This is the airway trainer that is currently used in the UW Hospital
  - Medical residents are trained on this specific trainer
- The client touched on a few of the qualms that he had with this design
  - Firstly, the price for one of these trainers was around $3000 which is a very steep price according to the client
  - Secondly, this airway trainer, while it does have the ability to remove the airway, does not have the ability to replace the base airway with an abnormal airway
- This trainer realistically stimulates an adult airway according to the website
  - It also has a removable airway demonstration model, which can be examined closer once removed from the trainer
- It also has a lifelike upper torso and facial structure which can be useful for practicing intubation, ventilation, and suction techniques.
- The trainer can be easily cleaned and comes with a cleaning kit
- There are also simulated vomit contents which can be helpful for simulating this common occurrence during airway management
- Some of the airway features include endotracheal tubes, oral and nasal fiberoptic intubation, and realistic chest rise and fall

Conclusions/action items:

Examining this airway trainer, it becomes incredibly clear why it is one of the top trainers on the market. There a lot of key components that differentiate this airway trainer from any of the others on the market, but it does fall short in the abnormal airways market. If the team is able to solidify a plan for 3D printing an airway, then this untapped market even by the top trainer on the market could be explored.

2/28/25 HIPAA Privacy Rule

Dan Altschuler (daltschuler2@wisc.edu) - Feb 28, 2025, 4:59 PM CST

Title: HIPAA Privacy Rule

Date: 2/28/25

Content by: Dan

Present: n/a

Search Term: HIPAA summary

Citation:

U.S. Department of Health and Human Services, “Summary of the HIPAA privacy rule,” HHS.gov, Oct. 19, 2022.

Link: https://www.hhs.gov/hipaa/for-professionals/privacy/laws-regulations/index.html

Goals: Learn about the HIPAA privacy rule and how it relates to the scans needed for the longterm scope of our project

Content:

This entry reflects research done to edit the "Patient Related Concerns" portion of the PDS - this is a brief summary of HIPAA factors that are relevant to the scans from our project

- The main goal of HIPAA is to make sure that patient information is protected while also maintaining the regular flow of information for medical benefits of patients
- Another major factor is to define and limit the flow of thow his information may be used or disclosed by covered entities
- There are two ways to work around the HIPAA privacy rule
    - One is to simply follow the permitted use regulations outlined by the rule
        - These include (1) To the Individual (unless required for access or accounting of disclosures); (2) Treatment, Payment, and Health Care Operations; (3) Opportunity to Agree or Object; (4) Incident to an otherwise permitted use and disclosure; (5) Public Interest and Benefit Activities; and (6) Limited Data Set for the purposes of research, public health or health care operations (from the website)
    - Another way around it is to use de-identified patient information
        - to de-identify patient info an entity can either be determined by a qualified statistician that there are no key markers to distinguish a person from their data, or just be removing specific identifiers that link info to patient
        - This seems like a feasible way for us in our project to make sure that we are not in violation of HIPAA in the long term scope of our project
- In the team's conversation with Dr. Garcia she was able to de-identify data within a minute of sitting down at her desk, so it does not seem like a very difficult process
- If we have any questions about this process we can reach out to Dr. Garcia again, or continue to do more research into the qualifications of de-identified data

Conclusions/action items:

This was important information that needed to be considered in the patient related concerns portion of our PDS. While this does not necessarily apply to this semester's work, if the team is to continue with this project then we will need to be aware of patient confidentiality from the scans of their airways. This would be integral for the surgical use case of our device.

3/9/25 7-Sigma

Dan Altschuler (daltschuler2@wisc.edu) - Mar 09, 2025, 1:23 PM CDT

Title: 7-Sigma

Date: 3/9/25

Content by: Dan

Search Term: 7-Sigma airway trainer

Citation: “Home,” 7S3, Dec. 14, 2021.

Link: https://7-s3.com/

Goals: Learn about another competing design for our project

Content:

- 7-Sigma is known for their high quality polymeric printing which can be used for airway management trainers
- While there is no price listed for the modular airway trainer, it can be understood that these cost upwards of $3000 from different sources than the manufacturer
- The manikin has realistic facial features and an accurate skin tone which can vary for the different trainers
- The trainer also claims to have realistic biomechanics of the jaw, neck, tongue and epiglottis which is integral for successful intubation training
- The modularity of this trainer can make it very useful for training intubation in different positions
- The neck is able to move around and tilt to make the process harder, especially with the modulation of the airway in these different positions
- The tissue of the airway is also supposed to simulate true human tissue which makes the intubation practice more realistic
- It is possible to purchase a "normal" or a "rugged" airway, but after some searching there was not much information on what this really meant
    - This seems to be where our project steps into usefulness as compared to a device like this
    - While the manikin is very good and does the job, the lack of different airways that can be placed in the trainer makes the ability to practice very limited
    - Our team could almost combine the goals of our project with the manikin of a trainer like this to take what is good from both sects
    - The team is looking to have our airways be able to be moved in and out of a standard airway trainer manikin, so the dimensions of this trainer could be a good baseline
- The full mankin also weighs up to 50.5 lbs, which is a bit heavier than what our client was hoping for, so this could be a good area for improvement with different material choice
- The fact that the teeth retain trauma similar to human teeth is another important feature that should be considered for our design

Conclusions/action items:

After looking at the 7-Sigma trainer, the manikin seems to be more important for sale than the modularity of the airways that can be placed into the trainer. The limits put on the training from just having two "standard" airways to use the device makes our project both useful and necessary.

2/11/25 TPU Filament

Dan Altschuler (daltschuler2@wisc.edu) - Feb 11, 2025, 9:30 PM CST

Title: TPU Filament

Date: 2/11/25

Content by: Dan

Present: n/a

Search Term: TPU Filament

Citation:

B. O'Neill, "What is TPU Material in 3D printing: material properties, applications, and technologies," Wevolver, May 12, 2119.

Link: https://www.wevolver.com/article/what-is-tpu-material-in-3d-printing-material-properties-applications-and-technologies

Goals: Learn about the properties of TPU filament as a possible material for our design matrix

Content:

- Thermoplastic polyurethane (TPU) is a polyurethane plastic belonging to the thermoplastic elastomer family
- The shore hardness of TPU can range from 60A all the way up to 80D, which means it fits within the range of shore hardness defined in the team's PDS
- TPU, in general, offers good mechanical properties like flexibility and resistance to abrasion
    - it is seen as a combination of the powerful properties of a rubber and the workability of a plastic
- TPU filaments exist in many different shore hardness ratings, but the 85A is a standard filament that exists at many different places
    - This material would be very flexible, but only moderately durable
    - It has a soft touch which could be useful for the team in defining our visual similarity to airway smooth muscle
- TPU is known to be very difficult to work with, however, as it is considered a material very difficult to have successful prints with
- attached is also a sheet for TPU 95A which details some of the mechanical properties of the material
    - These properties fall within the ranges outlined in the PDS, specifically the Young's Modulus
    - This 95A shore hardness does fall out of the range of the hardness as defined in the PDS, but this is only by around 4, which could be close enough if the team decided to go ahead with TPU
- Since TPU is abrasion resistant and also chemical resistant, it would be somewhat compatible with standard water based lubricants used to practice intubation
- The 95A shore hardness filament shows very high durability, but this limits the flexibility of the material
- 90A seems like the best option of the group, as it also has a young's modulus that falls within the range outlined in the PDS, shows some durability, although less than the 95A, but is flexible
    - This shore hardness also falls within the range outlined in the PDS
- There is another sheet attached which outlines the mechanical properties of TPU 90A referenced above

Conclusions/action items:

Using this information on the mechanical properties of TPU, the design matrix criteria can be scored. There might need to be further research into the durability of the material beyond the original website used, but this is a good starting point for the properties of the material.

Dan Altschuler (daltschuler2@wisc.edu) - Feb 11, 2025, 9:29 PM CST

Bambu Filament

Technical Data Sheet V1.0

TPU 95A HF

- **Basic Info**

Bambu TPU 95A HF is an optimized TPU filament designed for high-speed 3D printing. Compared to regular TPU 95A, TPU 95A HF offers an impressive 3x faster printing speed, effectively addressing the common problem of lengthy prints associated with other TPU filaments. TPU 95A HF maintains exceptional interlayer adhesion, impact resistance, flexibility, and cold-temperature resilience, just like traditional TPU filaments. Experience faster TPU printing without any compromises.

- **Specifications**

Subjects	Data
Diameter	1.75 mm
Net Filament Weight	1 kg
Spool Material	PC + ABS (Temperature resistance 90 °C)
Spool Size	Diameter: 200 mm; Height: 67 mm

- **Recommended Printing Settings**

Subjects	Data
Drying Settings before Printing	Blast Drying Oven: 70 °C, 8 h X1 Series Printer Heatbed: 80 - 90 °C, 12 h
Printing and Storage Humidity	< 20% RH (Sealed with desiccant)
Nozzle Size	0.4, 0.6, 0.8 mm
Nozzle Temperature	220 - 240 °C
Build Plate Type	Cool Plate, Engineering Plate, High Temperature Plate or Textured PEI Plate
Bed Surface Preparation	Glue
Bed Temperature	30 - 35 °C
Cooling Fan	Turn on
Printing Speed	< 200 mm/s
Retraction Length	0.8 - 1.4 mm
Retraction Speed	30 - 40 mm/s
Chamber Temperature	25 - 45 °C

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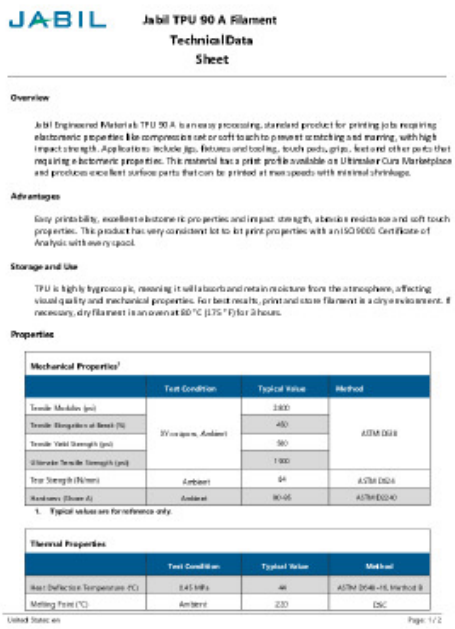
58df32731eab4c90a7dac9b12e13ba88.pdf (341 kB)

Dan Altschuler (daltschuler2@wisc.edu) - Feb 11, 2025, 9:29 PM CST



JABIL

Jabil TPU 90 A Filament Technical Data Sheet

Overview

Jabil Engineered Material's TPU 90 A is an easy processing, standard product for printing jobs requiring elastomeric properties like compression set or soft touch to prevent scratching and marring, with high impact strength. Applications include jigs, fixtures and tooling, touch pads, grips, feet and other parts that requiring elastomeric properties. This material has a print profile available on Ultimaker Cura Marketplace and produces excellent surface parts that can be printed at max speeds with minimal shrinkage.

Advantages

Easy printability, excellent elastomeric properties and impact strength, abrasion resistance and soft touch properties. This product has very consistent lot to lot print properties with an ISO 9001 Certificate of Analysis with every spool.

Storage and Use

TPU is highly hygroscopic, meaning it will absorb and retain moisture from the atmosphere, affecting visual quality and mechanical properties. For best results, print and store filament in a dry environment. If necessary, dry filament in an oven at 80 °C (175 °F) for 3 hours.

Properties

Mechanical Properties[1]

	Test Condition	Typical Value	Method
Tensile Modulus (psi)	XY orientation, Ambient	2800	ASTM D638
Tensile Elongation at Break (%)		450	
Tensile Yield Strength (psi)		980	
Ultimate Tensile Strength (psi)		1900	
Tear Strength (lb/inch)	Ambient	84	ASTM D624
Hardness (Shore A)	Ambient	90-95	ASTM D2240

1. Typical values are for reference only.

Thermal Properties

	Test Condition	Typical Value	Method
Heat Deflection Temperature (°C)	0.45 MPa	44	ASTM D648-16, Method B
Melting Point (°C)	Ambient	220	DSC

United States en

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jem-tpu-90a.pdf (130 kB)

2/12/25 Guide to TPU 3D Printing

Dan Altschuler (daltschuler2@wisc.edu) - Feb 13, 2025, 12:11 AM CST

Title: TPU 3D Printing

Date: 2/12/25

Content by: Dan

Present: n/a

Search Term: How to print using TPU

Citation:

C. Guide, “Complete Guide to TPU 3D Printing,” Formlabs, 2025. (accessed Feb. 13, 2025).

Link: https://formlabs.com/blog/complete-guide-tpu-3d-printing/?srsltid=AfmBOopkkXAew0WkEWIB5qn1OPsixnWM8_1SKeZZ6wg7kNzrilPbIYmX

Goals: Learn about the process for 3D printing using TPU

Content:

- TPU is ideal for for situations where it needs to be compressed and bent repeatedly
  - The material combines the high durability of plastic parts with the elasticity of rubber parts
- TPU can be 3D printed on either FDM or SLS 3D printers (the makerspace has an FDM printer available)
- While using an FDM printer is not as accurate or reliable as an SLS 3D printer, there are not 3D printers in UW-Madison that can use the TPU material
- FDM TPU filament is inexpensive and the prints are anisotropic, which means the strength across different axes varies
- FDM printers also use a typical 95A shore hardness which would be usable for our project
  - 90A is also very usable in these cases, which might be the better material for our project
- There are some listed problems with accuracy of the prints and the clogging of the material because the soft and stretchy filament can clog the extruder on the machine
  - We would need to employ the help of the people at the Makerspace with our print as it seems to be slightly complicated
- Using an FDM printer is considered good for proof of concept materials, so this means it could be useful for our project in the shorter scope, but another material might need to be selected for the long term outlook of our project

Conclusions/action items:

After reading this article about 3D printing using TPU, it has shown that TPU is a very usable material for our project. The material is durable enough and reliable enough to be considered as a final material for the project. There are some glaring problems with the accuracy of the prints that could pose problems for the broader scope of our project. In the short term, TPU seems like a great material for our airway print proof of concept, but it could make sense to go another direction because of the limitations of accuracy in the print and the biomechanical comparison to airway cartilage.

2/21/25 ITK-SNAP

Dan Altschuler (daltschuler2@wisc.edu) - Feb 21, 2025, 3:41 PM CST

Title: ITK-SNAP

Date: 2/21/25

Content by: Dan

Present: n/a

Search Term: ITK-SNAP

Citation:

P. A. Yushkevich, Y. Gao, and G. Gerig, “ITK-SNAP: an interactive tool for semi-automatic segmentation of multi-modality biomedical images,” Conference proceedings : ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Annual Conference, vol. 2016, pp. 3342–3345, Aug. 2016, doi:

Link: https://doi.org/10.1109/EMBC.2016.7591443.

Goals: Learn more about the use of ITK-SNAP in medical imaging segementation

Content:

- Segmentation in medical imaging is the use of software to find and outline structures of interest
    - There are fully automatic segmentation softwares that can be used to do this, but these can lack in areas with underdeveloped algorithms
    - Using a manual option is also feasible, but this requires medical imaging experts for the most part, although an amateur could develop the skills needed to segment an elementary tissue or bodily structure
- Many softwares can be used for the automatic segmentation, but not many exist that also allow for a manual option to work with the automatic option
- ITK-SNAP is a software that allows for both automatic and manual segmentation
- While manual segmentation is useful, it relies on the user to make the big picture decisions
    - this can lead to abnormalities in the segmentation
    - this can also lead to problems where there is too much of the image cut off, or on the flip side, not enough of the image is cut off
- Post processing is needed during all segmentation, but is often needed more when the manual methods are used
- The manual tools of ITK-SNAP include a polygon tool that allows the user to generate shape to pull the segment from, or a standard paintbrush tool
- ITK-SNAP assigns distinct integer values to each voxel in the image volume
- A non-zero value in this definition would represent a tissue/location of interest
- For the post processing capabilities within ITK-SNAP, a 3D render is immediately shown from the segments pulled
- These can then be partitioned using cut planes to trim down a render
- The semi-automatic segmentation using ITK-SNAP has been shown to be comparable to the completely automatic implementation

Conclusions/action items:

ITK-SNAP is a free software that is open source on the internet and free to download on any computer. This seems like a feasible software that the team could use to segment if we do not have access to the radiology department mimics software. While there can be

some post processing of the render done within the ITK-SNAP software, it appears that it would make more sense to look into other post processing 3D software to smooth down tissue and transform our file into an STL for printing.

3/9/25 3D Slicer

Dan Altschuler (daltschuler2@wisc.edu) - Mar 09, 2025, 1:05 PM CDT

Title: 3D Slicer

Date: 3/9/25

Content by: Dan

Search Term: 3D Slicer

Citation:

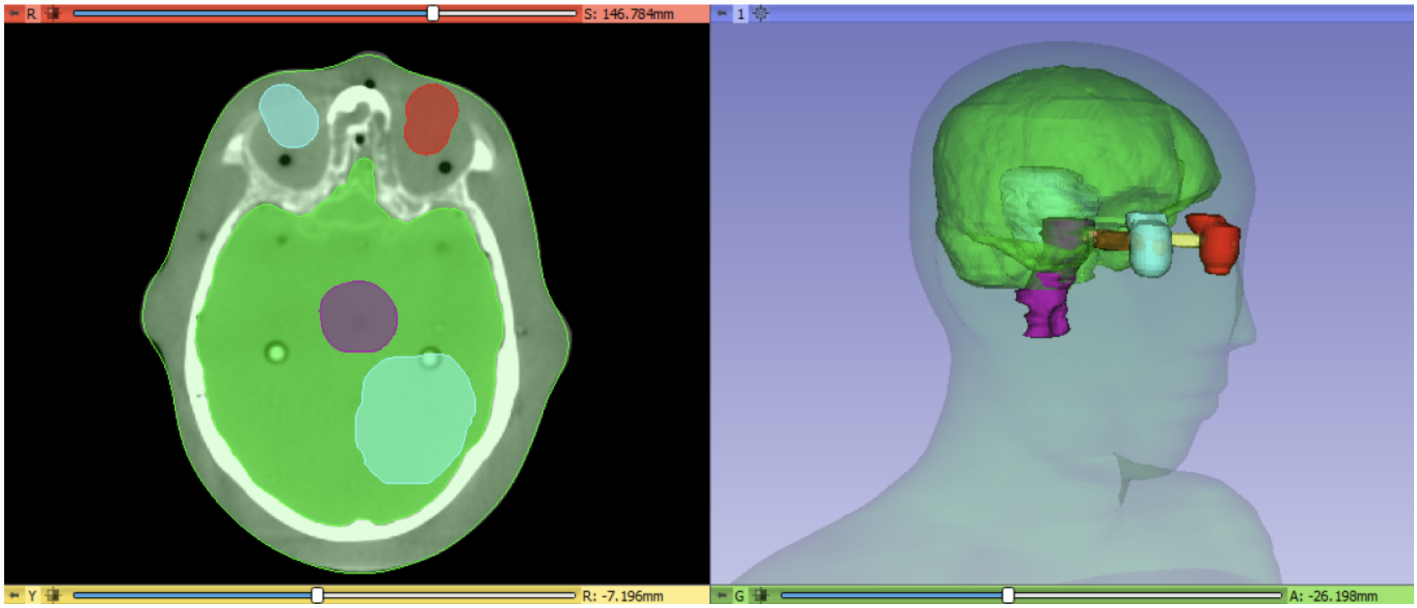
“About 3D Slicer — 3D Slicer documentation,” slicer.readthedocs.io.

Link: https://slicer.readthedocs.io/en/latest/user_guide/about.html

Goals: Learn about the 3D Slicer Software and how it can be used for our project

Content:

- 3D Slicer is a software that can be used for image segmentation
- It can be used to segment any image from 1-4D
- The resource has restrictions on the use of the free software which does not permit it to be used in the clinical software
- While our project does have a clinical component, the first print that we do will not be used in any clinical setting as we are attempting to research how to make our design.
- We would then move onto a different software once we decide on what works and what doesn't work for our process
- Much like ITK-SNAP, there is both an automatic and a manual setting for segmenting medical images
- The manual segmentation process involves iterating between each image manually and drawing contours for the software to recognize and delineate different parts of the anatomy
- The result of the all the different "segments" is stored in the "segmentation" node
    - These segments can have different properties such as color, name, and DICOM file capabilities
    - These segments are also allowed to overlap each other in space
- There are four different representations allowed by 3D slicer
- The representation that probably makes the most sense for our project would be the closed surface since it has the greatest resolution for 3D segmentation
- The other representations are easier to edit, but assuming we have enough time in the preprocessing using ITK-SNAP, then the editing capabilities in 3D slicer would just be to smooth down and integrate the different pieces of material in our design
- There also exists a "representations" node which stores the automatically computed other representations
- This could be helpful to examine our design in 2D with closed contours to work on smoothing down and processing our final design
- There also exists a segment statistics capability which will compute the intensity and geometric properties of the different voxels saved in the segmentation folder
- This is another helpful resource for post-processing which solidifies 3D slicer's role as the secondary processing software as compared to ITK-SNAP



Conclusions/action items:

After researching how to use 3D slicer and the different capabilities of the software, it has become increasingly obvious that this would be a great tool to utilize for post processing. We could attempt to use it as the first software with our imaging just to test it out, but it seems like the tools in 3D slicer would be more useful for the team to utilize once we have already generated a render in ITK-SNAP.

3/16/25 ITK-SNAP Training Course

Dan Altschuler (daltschuler2@wisc.edu) - Mar 16, 2025, 5:09 PM CDT

Title: ITK-SNAP Training

Date: 3/16/25

Content by: Dan

Goals: Take a short course on ITK-SNAP

Link: https://www.youtube.com/watch?v=-tjVN5GwjKg

Content:

Attached will be takeaways from a short course I took on ITK-SNAP manual segmentation from their website

- Main idea for ITK-SNAP is going from imaging data to quantitative measures
- ITK-SNAP takes the image as a cartesian volume, therefore a 3D volume image
    - Diffusion tensor imaging in 4D is also supported, but this is not very applicable to our project
- For every voxel in the volume, ITK-SNAP assigns it a label -> the task of segmentation is assigning labels to voxels
- Once the segmentation is complete, you can find volumes and also export meshes which would be helpful for creating our design
- There are 3 windows shown in the segmentation process at the beginning
- These represent the sagittal, coronal, and axial views of the object
- Then a 4th window shows the 3D render that is being created from the segmentation
- The labels that are assigned to voxels are labels which tend to be numbers
- The main control panel is on the left of the UI -> organized into 4 areas
    - on top there are 6 tools to select the active tool (what is being used)
    - then cursor inspector below it to help give info on the active tool
    - below that is tools for selecting labels during segmentation
    - on the bottom is the 3D render toolbar
- Crosshairs tool and zoom/pan tool are most often used
    - crosshairs helps move cursor in an out of plane
    - zoom helps pan around and zoom in and out of the image
    - updating one view updates all the views (looking at the same voxel in all 3 slice tools)
- Also a window and level adjustment tool which can help generate contrast in the image to change the grayscaleT
- two tools for manual segmentation (paint brush and polygon)
    - polygon tool you can click around and make a segmentation
    - paintbrush tool can help you clean up these images generated from the polygon tool
- label editor tool
    - create a set of labels unique to task
    - give them different colors to distinguish different regions of interest
    - labels can also be hidden in the 2D or 3D window
- last tool mentioned is the volume and stats window
    - not as helpful for our project, but still pretty interesting

Conclusions/action items:

After going through the basics of ITK-SNAP I am going to use the free handout they gave at the end of this seminar to practice my segmentation skills. I will also use some of the free datasets that are on the software to continue to practice using this software.

3/17/25 ITK-SNAP Practice

Dan Altschuler (daltschuler2@wisc.edu) - Mar 17, 2025, 3:03 PM CDT

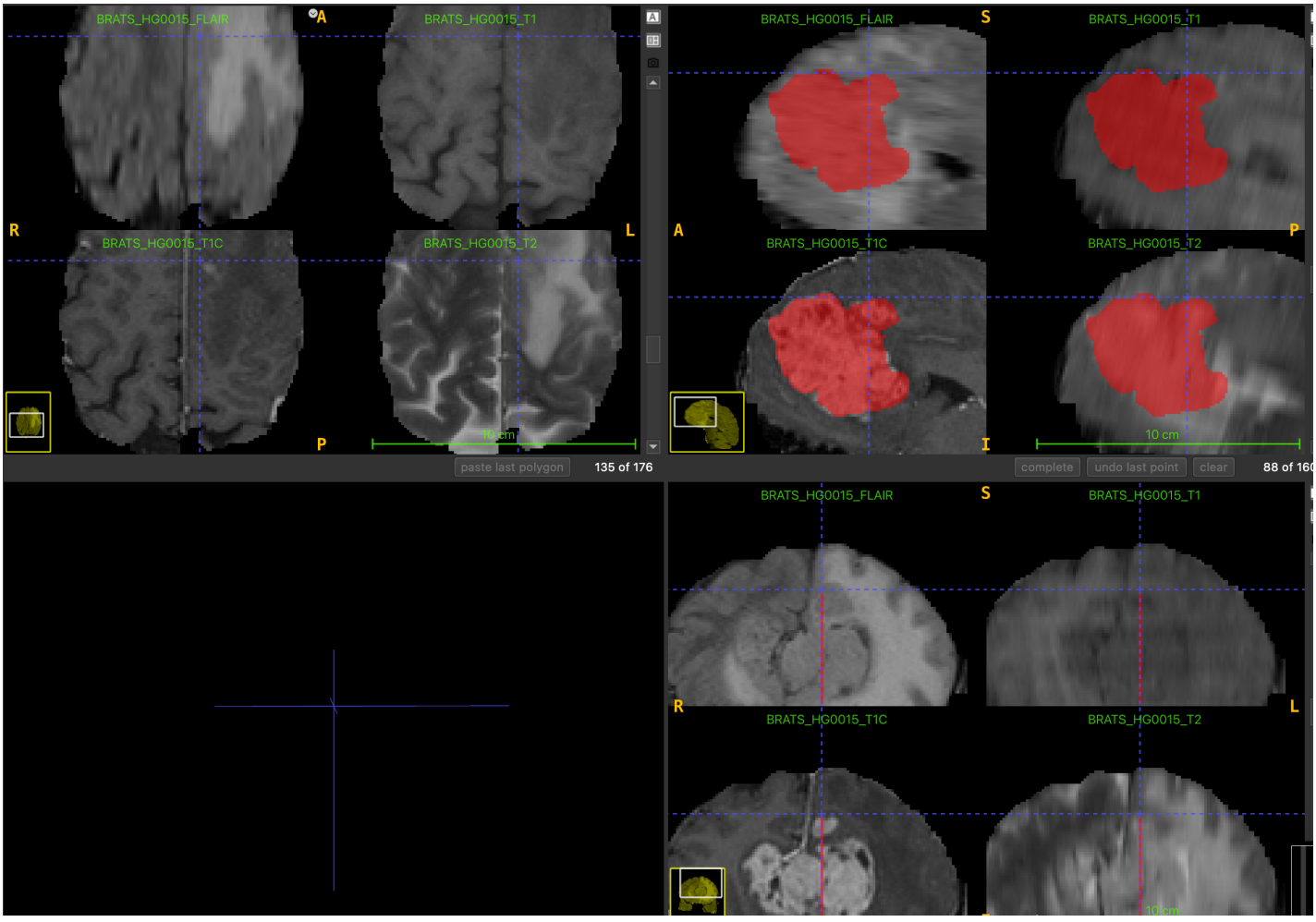
Title: ITK-SNAP

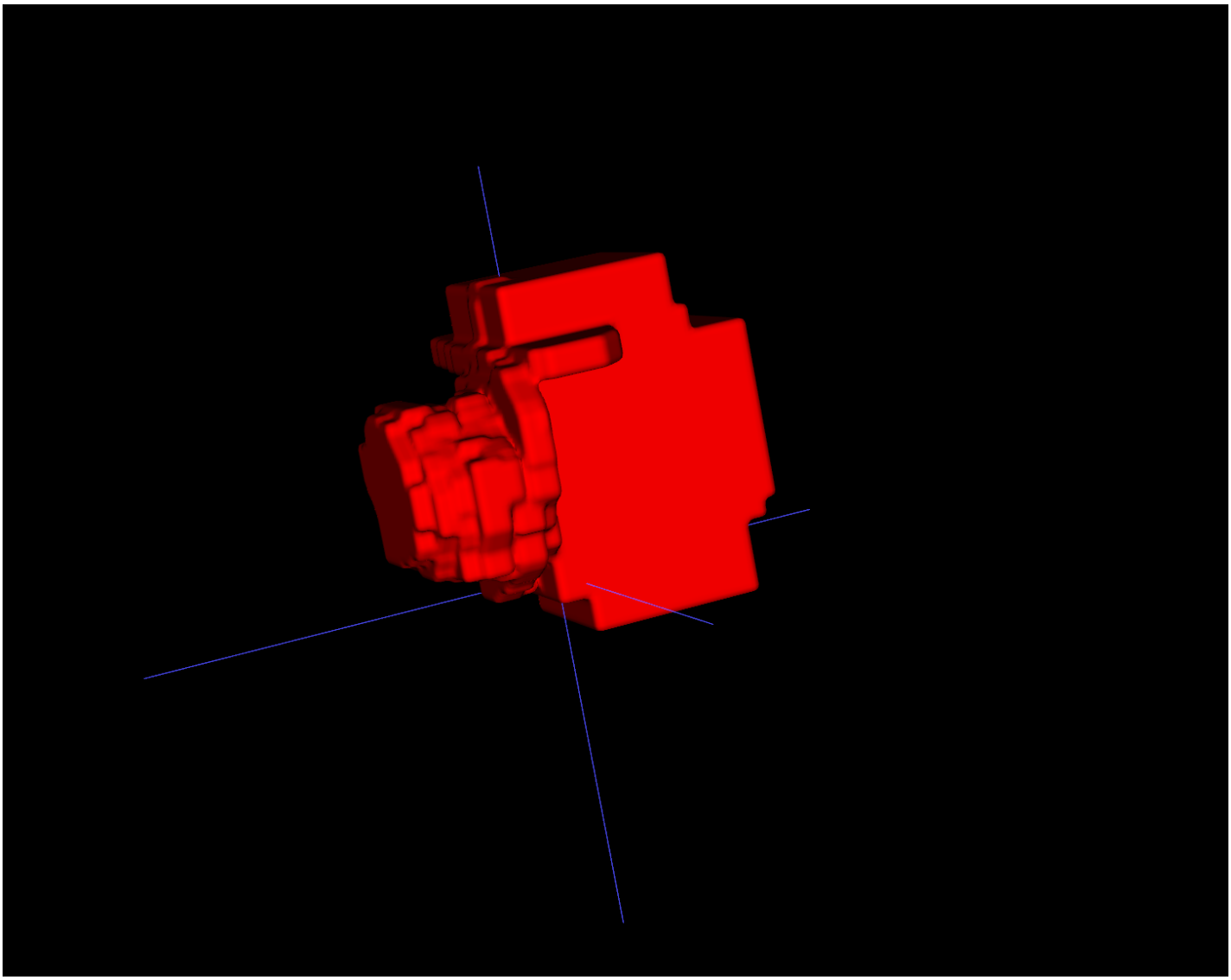
Date: 3/17/25

Content by: Dan

Goals: Practice using ITK-SNAP using one of their training documentation

Content:





- Obviously I need a lot more practice on the fine usage of these tools, but I learned a lot more about the keystrokes and how to generate a 3D model from the different slices of the image
- Some of the blockiness could also be eliminated using another 3D processor but not a lot of time was spent generating this model
- I feel much more confident about the general use of this software after doing some practice, but will continue to practice this week

Conclusions/action items:

After learning about ITK-SNAP by doing this work I am feeling a lot more comfortable operating the software and generating models. I feel confident in teaching any of my teammates the basic principles of manual segmentation using ITK-SNAP. I will continue to practice more during this week and once we return from spring break and hopefully be ready to spend time to segment the scan from our client.

Chemical and Biosafety Lab Training

Dan Altschuler (daltschuler2@wisc.edu) - Feb 06, 2025, 9:25 PM CST

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Training_for_430.pdf (82.4 kB)

Red and Green Permit

Dan Altschuler (daltschuler2@wisc.edu) - Feb 06, 2025, 9:27 PM CST

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Screenshot_2025-02-06_at_9.27.12_PM.png (183 kB)

Human Subjects Training

Dan Altschuler (daltschuler2@wisc.edu) - Feb 10, 2025, 4:06 PM CST

UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	8/28/2024	8/28/2027

Download

Screenshot_2025-02-10_at_4.04.51_PM.png (30.7 kB)

HIPAA Privacy and Security Training

Dan Altschuler (daltschuler2@wisc.edu) - Apr 24, 2025, 9:42 PM CDT

Download

Screenshot_2025-04-24_at_9.42.24_PM.png (25 kB)

1/30/25 Difficult Airway General Knowledge

MATTHEW SHERIDAN - Jan 30, 2025, 3:38 PM CST

Title: Difficult Airways

Date: 1/30/25

Content by: Matt Sheridan

Search Term: ChatGPT Prompt: Can you find any articles that outline specific conditions that make intubation difficult?

Link: **http://www.ncbi.nlm.nih.gov/books/NBK470224/**

Citation:

[1] B. R. Kollmeier, L. C. Boyette, G. B. Beecham, N. M. Desai, and S. Khetarpal, “Difficult Airway,” in *StatPearls*, Treasure Island (FL): StatPearls Publishing, 2025. Accessed: Jan. 30, 2025. [Online]. Available: http://www.ncbi.nlm.nih.gov/books/NBK470224/

Goals: Gather general information about what makes certain airways difficult to see different conditions that we could look to simulate.

Content:

Important Factors:

- Tongue size
- Adequacy of mouth opening
- Condition/presence of teeth and uvula (uvula more visible=easier)
- Thyromental distance
  - Closer the chin to the chest wall with head in mid-position = More difficult intubation
- Drastic overbite = difficult intubation
- Obesity can contribute to a difficult airway

Most common form of failed intubation is inadvertent esophageal intubation. This is more common in obese patients as it is difficult to recognize abdominal distension from gastric expansion.

Conclusions/action items:

It is important to have knowledge of the different factors that can make intubation difficult, as we will be attempting to simulate some of these this semester.

1/31/25 Rare Upper Airway Anomalies

MATTHEW SHERIDAN - Jan 31, 2025, 12:17 PM CST

Title: Rare Upper Airway Anomalies

Date: 1/31/25

Content by: Matt Sheridan

Search Term: Google Scholar: Airway Anomalies

Link: 10.1016/j.prrv.2015.07.001

Citation:

[1] A. Windsor, C. Clemmens, and I. N. Jacobs, “Rare Upper Airway Anomalies,” *Paediatric Respiratory Reviews*, vol. 17, pp. 24–28, Jan. 2016, doi: 10.1016/j.prrv.2015.07.001.

Goals: Gather specific information about rare airway anomalies that can occur and are difficult to deal with.

Content:

- Pyriform Aperture Stenosis
  - Narrowing of Nasal Airway due to bony overgrowth
  - Results in aperture width of less than 11mm
- Laryngeal Cleft
  - Abnormal connection between larynx and esophagus caused by failure of fusion of various tissues/cartilage
  - Varies in severity from Types I-IV
- Laryngeal Stenosis, Webs, and Atresia
  - 75% of these are in the glottic region
  - Webs that restrict airway, can vary in severity from mild hoarseness to requiring emergency surgery.
- Complete Tracheal Ring Deformity
  - Most common cause of stenosis
  - Complete absence of posterior membranous wall of trachea
  - Trachea usually has C-shaped rings, but with this deformity the rings are completely circular
- Tracheal Agenesis
  - Trachea partially or completely absent; very high mortality rate.

Conclusions/action items:

These are just some of the many anomalies that airways can have, and doctors performing surgery must have practice on airways specific to these cases. Being able to manipulate the shape of the airway on the trainer to match these conditions would be ideal.

MATTHEW SHERIDAN - Jan 31, 2025, 1:04 PM CST

Paediatric Respiratory Reviews

Mini-symposium: Upper airway abnormalities

Rare Upper Airway Anomalies

Alanna Windsor [1,2], Clarice Clemmens [1], Ian N. Jacobs [1,2,*]

EDUCATIONAL AIMS

- To discuss the normal embryology of the upper airway and how missteps in these complex developmental pathways give rise to various congenital defects
- To describe the clinical presentation of a select group of rare airway anomalies, including their effect on the functions of breathing, feeding, and phonation
- To review the diagnostic tools used for workup of these disorders and briefly discuss surgical and medical management strategies

A broad spectrum of congenital upper airway anomalies can occur as a result of errors during embryologic development. In this review, we will describe the clinical presentation, diagnosis, and management strategies for a few select, rare congenital malformations of the cervical. The diagnostic tools used in workup of these disorders range from prenatal tests to radiological imaging, swallowing evaluations, indirect or direct laryngoscopy, and rigid bronchoscopy. While these congenital defects can occur in isolation, they are often associated with disorders of other organ systems or may present as part of a syndrome. Therefore workup and treatment planning for patients with these disorders often involves a team of multiple specialists, including pediatricians, otolaryngologists, pulmonologists, speech pathologists, gastroenterologists, and geneticists.

INTRODUCTION

The upper aerodigestive tract extends from the nose and mouth proximally to the trachea and oesophagus distally and is critical to the functions of breathing, feeding, and speech. A variety of congenital anomalies can occur at any point in this system, having variable effects on these functions. These anomalies are the result of embryologic missteps during organogenesis. Here, we will briefly review the normal development of the upper airway and then describe several rare congenital anomalies affecting the upper airway.

EMBRYOLOGY OF THE UPPER AIRWAY

Development of the face, neck, and pharynx begins early in the fourth week of embryologic development with the appearance of the pharyngeal arches [1]. These accumulations of tissue on either side of the foregut consist of an outer ectodermal layer, a middle mesenchymal layer, and an inner endoderm al layer; the arches are separated externally by pharyngeal clefts and internally by pharyngeal pouches. Development of the face involves the formation and fusion of two pairs of maxillary and mandibular prominences, derivatives of the first pharyngeal arches, and the fronto-nasal prominence, a product of neural crest cell expansion from the midbrain and forebrain. These prominences form the boundaries of the primitive oral cavity. As these structures grow and fuse, they form the structures of the face. Incorrect fusion can result in the various congenital facial clefts. Ultimately, the fronto-nasal prominence forms the forehead and dorsal and apical part of the nose; the lateral nasal prominences go on to form the nasal alae; the medial nasal prominences form the nasal septum,

* Corresponding author. Tel.: +1 215 590 1183; fax: +1 215 590 3660.
E-mail addresses: windsora@email.chop.edu (A. Windsor), clemmens@email.chop.edu (C. Clemmens), jacobsi@email.chop.edu (I.N. Jacobs).

http://dx.doi.org/10.1016/j.prrv.2015.07.001
1526-0542/© 2015 Published by Elsevier Ltd.

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1-s2.0-S152605421500041X-main_1_.pdf (748 kB)

2/7/25 Human Trachea Mechanical Properties

MATTHEW SHERIDAN - Feb 08, 2025, 12:55 PM CST

Title: Mechanical Characterization and Constitutive Modeling of Human Trachea: Age and Gender Dependency

Date: 2/7/25

Content by: Matt Sheridan

Search Term: PubMed: Trachea Modeling

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC5456771/pdf/materials-09-00456.pdf

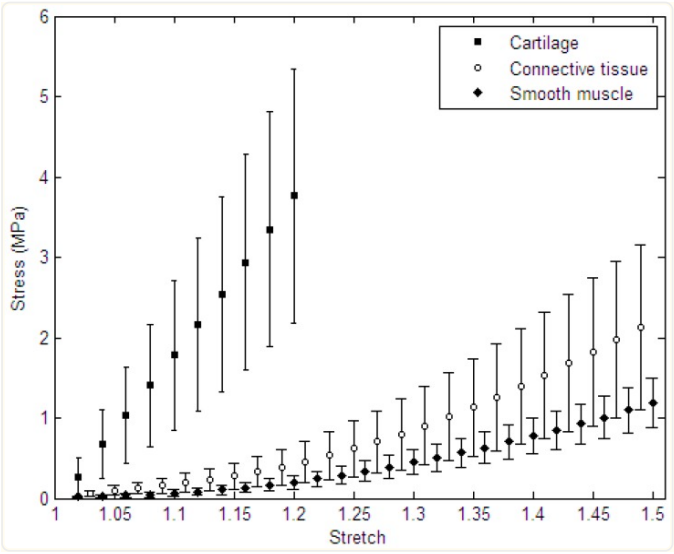
Citation:

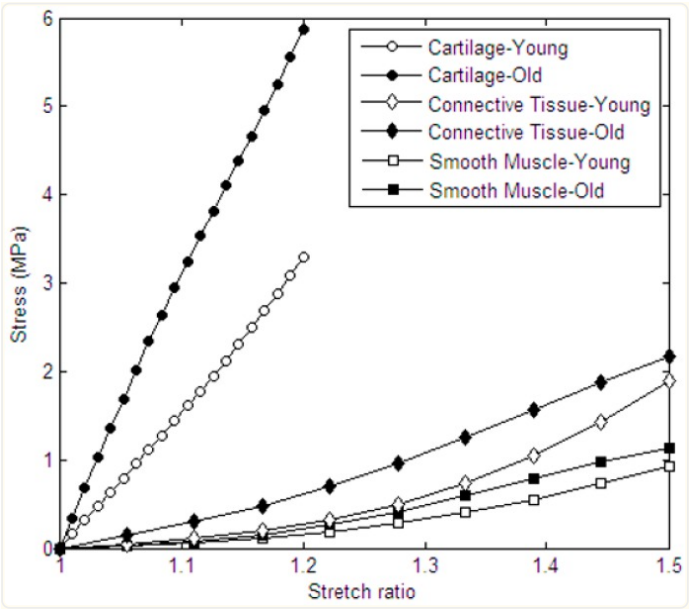
[1] F. Safshekan, M. Tafazzoli-Shadpour, M. Abdouss, and M. B. Shadmehr, "Mechanical Characterization and Constitutive Modeling of Human Trachea: Age and Gender Dependency," *Materials (Basel)*, vol. 9, no. 6, p. 456, Jun. 2016, doi: 10.3390/ma9060456.

Goals: Get information about the mechanical properties of the human trachea to give us values to aim for in our model.

Content:

- Trachea components
  - C-shaped cartilage rings, smooth muscle, connective tissue
  - Cartilage gives structural integrity, muscle + connective tissue give flexibility.
- Mechanical Properties
  - Young's Modulus
    - Cartilage: 16.92 ± 8.76 MPa, but ranges from 5 to 39 MPa depending on age and gender;
    - Smooth muscle stiffens nonlinearly, increasing in stiffness at a faster rate as strain increases
    - Connective tissue is also nonlinear in the same way.
  - Age dependency
    - Stiffness increases with age, seen most predominantly in cartilage
      - Young Cartilage Modulus: 13.30 ± 5.72 MPa
      - Old Cartilage Modulus: 20.71 ± 10.17 MPa
    - This is due to ossification of cartilage and fibrosis in connective tissue
  - Gender dependency
    - No significant differences seen between male and female
- How testing was performed
  - Uniaxial stress testing, 2kN load cell used
  - Samples hydrated with a physiological saline solution
  - 6 loading/unloading cycles performed as a preconditioning phase to remove residual stresses
  - Tensile testing was done with uniaxial tension until failure
    - .5mm/min for cartilage
    - 1mm/min for smooth muscle and connective tissue
  - Hyperelastic material models (Yeoh & Mooney-Rivlin) were used to describe non-linear elastic behavior
    - If we need to do this testing, I will do more research into it and find the best way to use these models.





Conclusions/action items:

We should do our best to match typical values for the young's modulus of the cartilage in the trachea, and must keep in mind that the stiffness changes with age. Additionally, thinking about the three different components of the trachea may be important, as we need to find materials that can either match all three or at least be a good model of how the three all interact. This provides a good baseline of values to shoot for with regards to stress and strain. It also gives a good testing model to match to ensure similar testing conditions to better compare results.

1/30/25 Adjustable Difficulty Intubation Simulator

MATTHEW SHERIDAN - Jan 30, 2025, 3:26 PM CST

Title: Validation of a difficult endotracheal intubation simulator designed for use in anaesthesia training

Date: 1/30/25

Content by: Matt Sheridan

Search Term: ChatGPT Prompt: I am in a biomedical engineering design class, and our group is tasked with designing a customizable airway trainer that can be adjusted to individuals with complications in their airway or other things that would make it difficult to intubate. Can you find me a few scholarly articles that relate to this topic to help give our team some initial information/knowledge about airway trainers and intubation.

Link: https://journals.sagepub.com/doi/epdf/10.1177/0310057X1704500213

Citation:

[1] "Validation of a Difficult Endotracheal Intubation Simulator Designed for Use in Anaesthesia Training." Accessed: Jan. 30, 2025. [Online]. Available: https://journals.sagepub.com/doi/epdf/10.1177/0310057X1704500213

Goals: Look at an already existing solution to make challenging airways for simulation work.

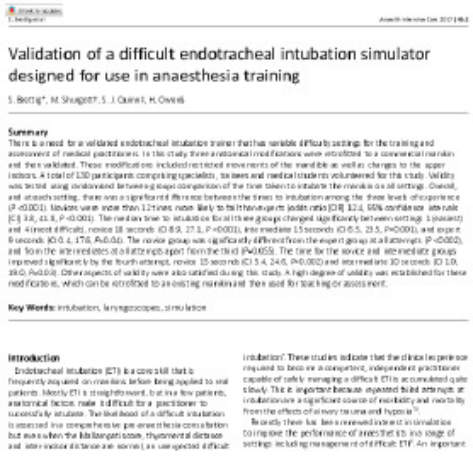
Content:

A manikin was created that had varying levels of difficulty. The first modification was long upper incisors, the second was the posterior movement of the lower jaw, constricting area to access the airway, and the third was limiting the gap between upper and lower teeth to 3 cm. Individuals at varying skill levels were tested with the first modification, then the first and second together, then the first second and third together. Wing nuts were used to adjust the anterior/posterior position of the lower jaw and a steel lock prevented mandible opening. Steel weights were used to accurately simulate the weight of a head.

Conclusions/action items:

The design considerations for this design could help us in our design, as we may want to allow for differing "levels of difficulty", or at least allowing our trainer to match unique circumstances.

MATTHEW SHERIDAN - Jan 30, 2025, 3:27 PM CST



Validation of a difficult endotracheal intubation simulator designed for use in anaesthesia training

S. Bertig*, M. Shuggott*, S. J. Quinet, H. Owens

Summary

Introduction

Download

brettig-et-al-2017-validation-of-a-difficult-endotracheal-intubation-simulator-designed-for-use-in-anaesthesia-training.pdf (528 kB)

1/31/25 Modular, Customizable Airway Trainer

MATTHEW SHERIDAN - Jan 31, 2025, 12:29 PM CST

Title: Development of a Modular, Provider Customized Airway Trainer

Date: 1/31/25

Content by: Matt Sheridan

Search Term: Google Scholar: Customizable Airway Trainers

Link: https://apps.dtic.mil/sti/citations/AD1007828

Citation:

[1] R. Sweet, “Development of a Modular, Provider Customized Airway Trainer,” University of Minnesota Medical School, Nov. 2015. Accessed: Jan. 31, 2025. [Online]. Available: https://apps.dtic.mil/sti/pdfs/AD1007828.pdf

Goals: Look at an existing product that accomplishes very similar goals to the scope of our project.

Content:

This person created a model with difficulty options that included a burnt and swollen airway model and one with a recessed chin and facial hair. He also developed a tissue hydration system that would simulate the natural lubrication of the airway to more accurately simulate a human airway. Additionally, sensors were integrated into the manikin to provide real-time feedback to the individual performing the intubation on the model.

Conclusions/action items:

While some of these changes may be beyond the scope of our project, thinking about things like facial hair, swelling, as well as lubrication may be important for our project. These are all things that can change from individual to individual, so allowing the surgeon access to a model such as this that can be extremely customized to the individual for better preparation can be vital.

MATTHEW SHERIDAN - Jan 31, 2025, 1:00 PM CST

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY) 25-11-2015
2. REPORT TYPE FINAL
3. DATES COVERED (From - To) 19 SEP 2013 - 25 Sep 2015

4. TITLE AND SUBTITLE
Development of a Modular, Provider Customized Airway Trainer

5a. CONTRACT NUMBER
W911NF-13-2-0033
5b. GRANT NUMBER
5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Sweet, Robert M., MD, FACS
rsweet@umn.edu
5d. PROJECT NUMBER
5e. TASK NUMBER
5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Regents of the University of Minnesota
Sponsored Projects Administration
200 Oak Street SE
Minneapolis, MN 55455
8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US Army Research Laboratory - Orlando
Jack Northrop
12423 Research Parkway
Orlando, FL 32826-3274
10. SPONSOR/MONITOR'S ACRONYM(S)
ARL
11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This award was for a Collaborative Agreement between Army Research Laboratory and the University of Minnesota for the further development of an Airway Part Task Trainer. The goal of the development project was to create a family of training systems with multiple levels of sophistication ranging from an inexpensive manual trainer to a fully instrumented, sensored system with feedback. The Cooperative Agreement fostered this development and provided for expansion of the project to

address other options for the development of a modular, provider customized airway trainer.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (include area code)
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2/8/25 CT Scan Lung Segmentation

MATTHEW SHERIDAN - Feb 08, 2025, 1:49 PM CST

Title: CT Scan Lung segmentation

Date: 2/8/25

Content by: Matt Sheridan

Search Term: PubMed: CT Scan Segmentation

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC8796745/pdf/10278_2022_Article_593.pdf

Citation:

[1] D. Negroni *et al.*, “COVID-19 CT Scan Lung Segmentation: How We Do It,” *J Digit Imaging*, vol. 35, no. 3, pp. 424–431, Jun. 2022, doi: 10.1007/s10278-022-00593-z.

Goals: Learn more about how segmentation of CT scans works and how it can be used

Content:

- This article focuses on the lungs, and was used to look for a few different things in lungs for use in COVID patients
  - (1) well-aerated parenchyma
  - (2) interstitial lung disease, including both ground glass opacities and crazy paving
  - (3) parenchymal consolidation.
- These were obtained by the percentage of extension of the alterations of the lung parenchyma(functional tissue of lung)
- Segmentation was done by open-source 3D slicer software, using "Segment Editor" and "Segment Quantification"
- There are many options outlined in a Mansoor et al. paper, including:
  - (a) thresholding-based
  - (b) region-based
  - (c) shape-based
  - (d) neighboring anatomy–guided
  - (e) machine learning–based methods
- In this study, they decided to use thresholding-based segmentation. This was done by using the density difference between air and lung tissue, which allows the software to very easily and quickly differentiate between the two.
- One step of the volumetric analysis of the lungs was actually to segment the trachea and bronchi by themselves, so it is clearly able to be done. I believe that using this segmentation, the team should be able to 3d print a good model.

Conclusions/action items:

This paper shows me that taking a CT scan and segmenting the trachea is very easily doable using free software. What needs to be looked further into is the ability to differentiate between specific parts of the trachea, if this is actually necessary, and also what materials to be used/if they are printable.

2/8/25 Segmentation Methods

MATTHEW SHERIDAN - Feb 08, 2025, 2:11 PM CST

Title: Segmentation and Image Analysis of Abnormal Lungs at CT: Current Approaches, Challenges, and Future Trends

Date: 2/8/25

Content by: Matt Sheridan

Search Term: Paper was cited by Negroni, et al. paper (2/8/25 CT Scan Lung Segmentation in this notebook)

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC4521615/pdf/rg.2015140232.pdf

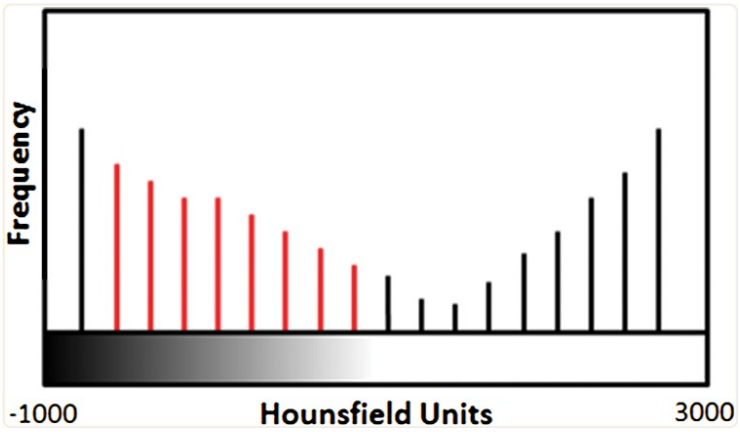
Citation:

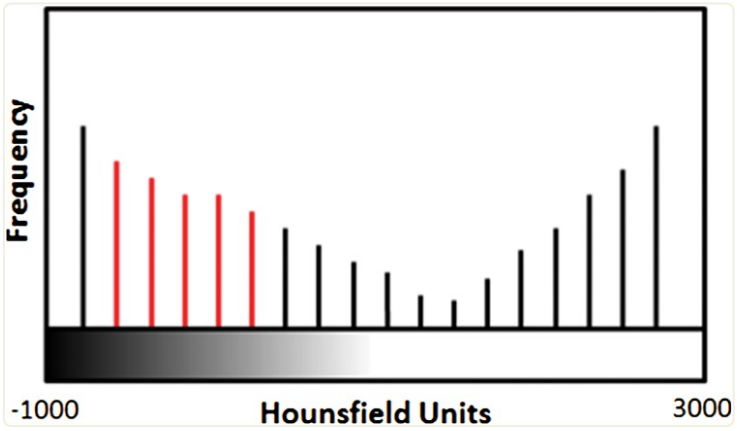
[1] A. Mansoor et al., “Segmentation and Image Analysis of Abnormal Lungs at CT: Current Approaches, Challenges, and Future Trends,” Radiographics, vol. 35, no. 4, pp. 1056–1076, Jul. 2015, doi: 10.1148/rg.2015140232.

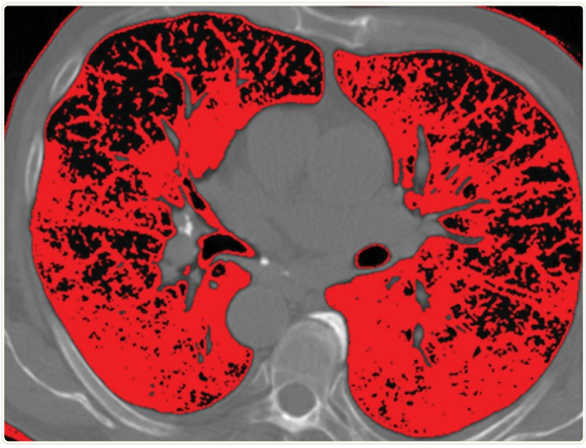
Goals: Learn about various segmentation methods to decide upon a method/methods that could be used for our project.

Content:

- This article outlines 5 main segmentation methods that have been used for lung segmentation, which is relatively similar to what we are attempting to do.
    - Thresholding-Based Methods: Utilize pixel intensity values to differentiate lung tissue from other structures.
        - I'm focusing most on this as it seems the easiest/most feasible, and was used to segment the trachea in a different study
        - Threshold levels that depend upon Hounsfield Units (HU), which are a measure of how much X-ray is absorbed by various tissues, which is dependent upon their density. Certain tissues will lie in different regions, and these thresholds must be chosen and adjusted to get accurate segmentation.
        - Below, the first two photos are correct thresholds, and the resulting scan, and the second two are incorrect threshold values with its corresponding segmentation.







    - So, if this method is used, we must make sure to accurately choose the threshold values to ensure accurate segmentation
- Region-Based Methods: Involve techniques like region growing, starting from seed points and including neighboring pixels based on specific criteria.

        - Can work well, and given that there wouldn't be parts of the trachea that are separated from the main body (like we see in the lung above), it could be a viable option. It basically has a point in the middle, and expands out until conditions are changed. It could also possibly be used in combination with the thresholding method.
    - Shape-Based Methods: Employ models that incorporate prior knowledge of lung shape to guide segmentation.
    - Neighboring Anatomy–Guided Methods: Use the spatial relationships between the lungs and adjacent anatomical structures to inform segmentation.
    - Machine Learning–Based Methods: Apply algorithms trained on labeled data to automatically segment lung regions.

Conclusions/action items:

The team will look into thresholding-based segmentation and region-based methods, and hopefully we can use one or both of these methods to get an accurate model of the trachea that can be converted into a printable file.

3/3/25 3D-Slicer vs. Mimics vs. syngo.via

MATTHEW SHERIDAN - Mar 03, 2025, 1:24 PM CST

Title: Comparison of 3D-Slicer, Mimics, and syngio.via Frontier

Date: 3/3/25

Content by: Matt Sheridan

Search Term: 3D Slicer Comparison

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC9323631/

Citation:

[1] M. Mandolini, A. Brunzini, G. Facco, A. Mazzoli, A. Forcellese, and A. Gigante, “Comparison of Three 3D Segmentation Software Tools for Hip Surgical Planning,” *Sensors (Basel)*, vol. 22, no. 14, p. 5242, Jul. 2022, doi: 10.3390/s22145242.

Goals: Compare 3D-Slicer to other possible options for segmentation and STL file creation

Content:

For these first two comparisons, a non-contact 3D scanner was used on a post-surgery femoral head, giving a fully accurate 3D geometrical model that could be compared to segmented models from the three different softwares. The geometric quality was measured by looking at the deviations at points throughout the geometry to get a number that could be used to compare, which was the average deviation. The dimensional measurement was a bit easier as it just used important diameter measurements across the femoral head.

Geometric Quality: geometric deviation between the reference and test geometries of the femoral head. Each of the three softwares were compared to a reference scan, which was done using a 3D scanner on an actual printed femur.

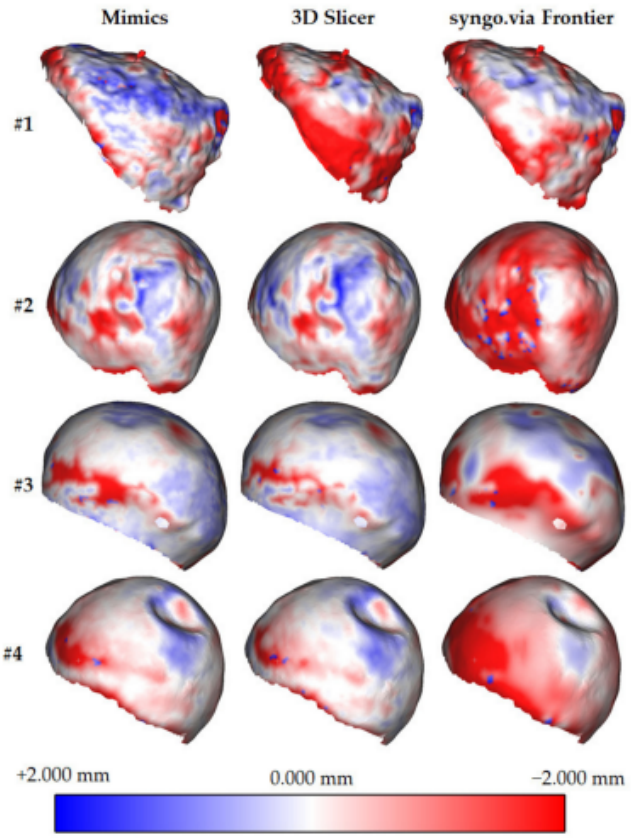


Figure 4. Signed Euclidean distance between the reference (*G_D*) and test (*G_A*, *G_B*, and *G_C*) geometries for patients #1, #2, #3, and #4. The deviation is represented in the reference geometry. Red: −2.000 mm deviation. White: 0.000 mm deviation. Blue: +2.000 mm deviation.

Case	Mimics (mm)			3D Slicer (mm)			Syngo.via Frontier (mm)		
	Average	Absolute	Std. Dev.	Average	Absolute	Std. Dev.	Average	Absolute	Std. Dev.
#1	−0.353	0.353	1.068	−0.800	0.800	1.024	−0.583	0.583	0.971
#2	−0.163	0.163	0.719	−0.156	0.156	0.686	−0.982	0.982	0.698
#3	−0.032	0.032	0.639	−0.037	0.037	0.556	−0.337	0.337	0.824
#4	−0.369	0.369	0.568	−0.237	0.237	0.524	−0.921	0.921	0.637
#5	−0.245	0.245	1.000	−0.198	0.198	0.794	−0.670	0.670	0.913
#6	−0.662	0.662	0.482	−0.482	0.482	0.652	−0.670	0.670	0.664
#7	−0.328	0.328	0.730	−0.168	0.168	0.782	−0.357	0.357	0.743
#8	−0.360	0.360	0.612	−0.317	0.317	0.559	−0.598	0.598	0.608
Mean	**−0.314**	**0.353**	**0.727**	**−0.299**	**0.299**	**0.697**	**−0.640**	**0.640**	**0.757**

Dimensional Quality: the femoral head diameters' deviation between the reference and test geometries.

	Signed Deviation (mm) = $Mean_{G\_X}$ − $Mean_{G\_D}$			*Absolute Deviation (mm)* = | *Signed Deviation* |			*Signed Percentage Deviation (%)* = *Signed Deviation*/$Mean_{G\_D}$			*Absolute Percentage Deviation (%)* = *Absolute Deviation*/$Mean_{G\_D}$		
	Mimics	**3D Slicer**	**Syngo.via Frontier**	**Mimics**	**3D Slicer**	**Syngo.via Frontier**	**Mimics**	**3D Slicer**	**Syngo.via Frontier**	**Mimics**	**3D Slicer**	**Syngo.via Frontier**
#1	−0.545	−3.475	−2.410	0.545	3.475	2.410	−1.1%	−7.0%	−4.9%	1.1%	7.0%	4.9%
#2	0.545	1.615	−1.415	0.545	1.615	1.415	1.1%	3.1%	−2.7%	1.1%	3.1%	2.7%
#3	0.735	0.950	−0.565	0.735	0.950	0.565	1.5%	1.9%	−1.1%	1.5%	1.9%	1.1%
#4	−0.425	−0.015	−1.910	0.425	0.015	1.910	−1.0%	0.0%	−4.4%	1.0%	0.0%	4.4%
#5	−2.095	−0.225	−1.805	2.095	0.225	1.805	−3.9%	−0.4%	−3.3%	3.9%	0.4%	3.3%
#6	−1.020	−1.660	−0.675	1.020	1.660	0.675	−2.4%	−3.8%	−1.6%	2.4%	3.8%	1.6%
#7	−0.680	−0.465	−1.335	0.680	0.465	1.335	−1.2%	−0.8%	−2.4%	1.2%	0.8%	2.4%
#8	−0.890	−1.935	−1.995	0.890	1.935	1.995	−2.1%	−4.5%	−4.6%	2.1%	4.5%	4.6%
Mean	**−0.547**	**−0.651**	**−1.514**	**0.867**	**1.293**	**1.514**	**−1.1%**	**−1.4%**	**−3.1%**	**1.8%**	**2.7%**	**3.1%**
Std. Dev.	**0.895**	**1.646**	**0.646**	**0.533**	**1.133**	**0.646**	**1.8%**	**3.4%**	**1.4%**	**1.0%**	**2.4%**	**1.4%**

Usability: this test used several metrics (e.g., automatisation degree, segmentation time, training time), which are helpful for surgeons to evaluate the segmentation tools globally.

Objective	**Mimics**	**3D Slicer**	**Syngo.via Frontier**	**Weight**	**Mimics**	**3D Slicer**	**Syngo.via Frontier**
1. Automatisation degree	High	Average	Low	10	1	2	3
2. Segmentation time	30 min	45 min	40 min	8	3	1	2
3. Training time	300 min	300 min	180 min	8	1	1	3
4. Cost	High	Freeware	Embedded in the CT	8	1	3	2
5. 3D visualisation	High	High	High	6	3	3	3
6. Supported Operative System (OS)	Windows—macOS—Linux	Windows—macOS—Linux	Windows	6	3	3	1
7. Potential extension (plugins)	No	No	No	4	1	1	1
Total				**50**	**1.80**	**2.00**	**2.28**

Conclusions/action items:

Looking at these three comparisons, it was concluded that Mimics and 3D slicer are very comparable in terms of geometrical accuracy, and given that 3D slicer is free and open-source, it is very likely the choice that the team will be using for this semester. Being able to compete very closely with the accuracy of Mimics (which Dr. Garcia uses) is very important. It was shown that 3D slicer has a rather high training time, but given that the team will be using it, and new people would not need to be trained on it, that should not be an issue. If this would need to get integrated at a larger scale, with lots of individuals needing to do this a lot of times, then Syngo.via Frontier may be a better option, but 3D slicer is established and accurate, so the team will be moving forward using that.

3/3/25 Comparing Segmentation Software

MATTHEW SHERIDAN - Mar 03, 2025, 1:39 PM CST

Title: Review of 3D Segmentation Software Tools for MRI

Date: 3/3/25

Content by: Matt Sheridan

Search Term:

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC7064712/

Citation:

[1] A. Virzì *et al.*, “Comprehensive Review of 3D Segmentation Software Tools for MRI Usable for Pelvic Surgery Planning,” *J Digit Imaging*, vol. 33, no. 1, pp. 99–110, Feb. 2020, doi: 10.1007/s10278-019-00239-7.

Goals: Compare ITK-SNAP to other possible MRI segmentation options

Content:

- Software Tools
  - ITK-SNAP – Best for usability and fast segmentation. It has a clear GUI, making it easy to use. It features interactive 3D segmentation based on deformable models. However, it lacks tractography tools.
  - 3D Slicer – Best for complete patient modeling, including nerve fibers. It offers many segmentation tools, advanced 3D visualization, and tractography support, but has a steeper learning curve.
  - Myrian Studio – Fastest segmentation software. It has powerful 2D-to-3D interpolation tools, reducing segmentation time. However, it is Windows-only and does not support tractography.
  - Seg3D – Strong in usability, but segmentation time is longer compared to ITK-SNAP or Myrian Studio.
  - OsiriX – A DICOM viewer with some segmentation tools, but not as advanced as 3D Slicer or ITK-SNAP.
  - MIPAV – Supports segmentation but is better suited for 2D image processing rather than full 3D modeling.
  - FSL / Freesurfer – Mainly focused on brain imaging; lacks general usability for pelvic MRI segmentation.
  - MedInria / Olea Sphere – Includes tractography tools but has limited segmentation automation.
  - ImageJ – A powerful image-processing tool, but not optimized for MRI segmentation.
- Comparison of Results
  - Segmentation Accuracy: ITK-SNAP, 3D Slicer, and Myrian Studio provided the most precise segmentations.
  - Usability: ITK-SNAP and Seg3D were the most user-friendly.
  - Segmentation Speed: Myrian Studio was the fastest, followed by ITK-SNAP. 3D Slicer was slower but more feature-rich.

    - Tractography (Nerve Fiber Modeling): Only 3D Slicer provided comprehensive tractography tools.
    - Software Extensibility: 3D Slicer, ImageJ, and Myrian Studio allowed for plugin development.
- Key Takeaways
    - For fast and efficient segmentation → ITK-SNAP or Myrian Studio.
    - For full 3D modeling, including nerve fibers → 3D Slicer.
    - For ease of use → ITK-SNAP or Seg3D.
    - For research and extensibility → 3D Slicer, ImageJ, Myrian Studio.

Table 2 Software comparison

Software	Automatization	Usability	3D visualization	Segmentation time	Registration	Tractography
3D Slicer	3	3	4	15th	x	x
Anatomist	1	1	1	> 25 h		
AW Server	3	3	3	> 20 h	x	x
Freesurfer	2	2	1	> 20 h	x	x
FSL	1	1	2	> 25 h	x	x
ImageJ	2	2	1	> 25 h	x	
ITK-SNAP	3	4	4	10 h		
Mango	1	3	2	> 20 h	x	
MedInria	3	3	3	> 20 h	x	x
MIPAV	3	2	2	> 20 h	x	x
Myrian Studio	3	3	4	9 h	x	
Olea Sphere	3	33	4	> 20 h	x	x
OsiriX	3	3	4	> 20 h	x	
Seg3D	2	4	3	20 h		

Conclusions/action items:

From this review of varying software tools for 3D models, it really seems that ITK-SNAP and 3D Slicer are the best options, and it may be possible to just use 3D slicer rather than using ITK-SNAP first and then importing it into Slicer. Although it is slightly slower and more difficult to use than ITK-SNAP, it may be more efficient overall to just use 3D Slicer, as like was seen in the prior article, it is very accurate, and accuracy is of utmost importance to us in the scope of this project. While it was somewhat helpful to look at other options, I don't think that any of them will accomplish what we want them to at a high enough level.

2/13/25 EcoFlex Research

MATTHEW SHERIDAN - Feb 20, 2025, 4:26 PM CST

Title: EcoFlex 00-50 Initial Research

Date: 2/13/25

Content by: Matt Sheridan

Search Term: ChatGPT: can you find me a good article about ecoflex 00-50 silicone

Link: file:///C:/Users/msher/Downloads/Thesis_Lavazza.pdf

Citation:

[1] J. Lavazza, “A Study on the Mechanical Behaviour of Ecoflex 00-50 Silicone Elastomer,” Politecnico Milano, file:///C:/Users/msher/Downloads/Thesis_Lavazza.pdf.

Goals: Gather information about the mechanical and other properties of EcoFlex silicone

Content:

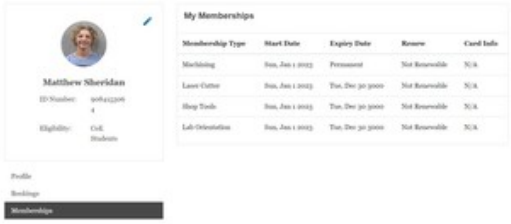
- Young’s Modulus (Elastic Modulus)
  - Very low Young’s modulus
  - Values reported are typically in the range of 10–50 kPa
  - Highly non-linear behavior, the modulus changes quite a bit with strain, so hard to give a specific value, but the range that it is in is very low compared to the desired values for a trachea.
- Shore Hardness
  - Shore hardness 00-50 (measured on the Shore 00 scale).
  - This would roughly translate to 5 on the shore A scale.
- Cyclic Testing (Hysteresis and Fatigue Behavior)
  - Good resilience: Can stretch several times its original size and return without permanent deformation.
  - Hysteresis: Some energy loss occurs during cyclic loading, meaning that the material exhibits viscoelastic behavior.
  - Fatigue resistance: long-term cyclic loading can cause permanent deformation over time, this may be an issue after lots of iterations of intubation.
- Stress-Strain Behavior
  - Highly hyperelastic: Significant strain-softening (stress decreases slightly after initial deformation).
  - Can stretch up to 900% before failure, so will definitely not fail.
- Temperature Dependence
  - Maintains flexibility across a wide temperature range, but mechanical properties can change with temperature.
  - At higher temperatures (~40°C and above), modulus decreases further, making it even softer.
  - At colder temperatures (~0°C), material stiffens slightly

Conclusions/action items:

Although Ecoflex would be a good material for durability, its Young's modulus is significantly lower than what we would've expected. It is good to include in our design matrix as a possibility in case the other materials don't end up working, but probably not ideal for this project.

Machining Certificates

MATTHEW SHERIDAN - Feb 10, 2025, 11:14 PM CST



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Machining_Certificate.jpg (105 kB)

Chemical, Biosafety, and Human Subjects Training

MATTHEW SHERIDAN - Feb 10, 2025, 11:13 PM CST

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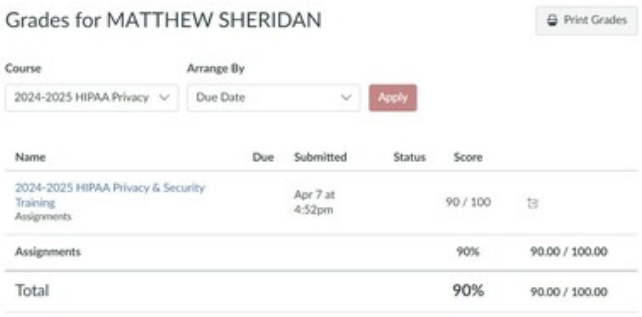
Chem_Bio_Human_Training_Documentation.jpg (155 kB)

HIPAA Training

MATTHEW SHERIDAN - Apr 07, 2025, 4:55 PM CDT



Grades for MATTHEW SHERIDAN

Print Grades

Course: 2024-2025 HIPAA Privacy

Arrange By: Due Date

Apply

Name	Due	Submitted	Status	Score	
2024-2025 HIPAA Privacy & Security Training Assignments		Apr 7 at 4:52pm		90 / 100	
Assignments				90%	90.00 / 100.00
Total				90%	90.00 / 100.00

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1/30/25 - "Airway Anomalies"

Lance Johnson - Feb 02, 2025, 1:27 PM CST

Title: "Airway Anomalies"

Date: 1/29/25

Content by: Lance

Present: N/A

Goals: To better understand what abnormalities are common in airways and how we can emulate these conditions in our custom airways

Link: **https://www-clinicalkey-com.ezproxy.library.wisc.edu/#!/content/playContent/1-s2.0-S0095510818313885?returnurl=null&referrer=null**

Citation:

A. M. Landry and M. J. Rutter, “Airway Anomalies,” Clinics in Perinatology, vol. 45, no. 4, pp. 597–607, Dec. 2018, doi: https://doi.org/10.1016/j.clp.2018.07.002.

Content:

The paper discusses a variety of airway anomalies including congenital subglottic stenosis(SGS), anterior glottic webs, laryngeal atresia, laryngeal clefts, and tracheal stenosis. These conditions outline the majority of airway anomalies that have impacts not only on patient health but on medical teams pre- and post-operatively. A number of surgeries can be performed to reconstruct these airways but making sure the medical teams undergo proper planning is crucial- which is where out project comes in.

- common symptoms of airway anomalies include difficulty/noisy breathing, cyanosis(skin color change due to lack of perfusion), apneas, retraction, and feeding difficulties among others

Congenital Subglottic Stenosis(SGS)

- narrowing of the vocal chords caused by membrane thickening or abnormal cartilage

Anterior Glottic Webs

- incomplete recanalization of the laryngeal lumen(larynx doesn't fully open during fetal development)

Laryngeal Atresia

- complete closure of the larynx--> usually requires immediate interventions

Laryngeal Clefts

- malformed tracheoesophageal septum --> requires surgical repair

Congential Tracheal Stenosis

- narrowing of the trachea, often co-occurs with bronchial and cardiac abnormalities

- a variety of common surgical procedures are used to repair these abnormalities: laryngeotracheal reconstruction, anterior glottic web repair, laryngeal cleft repair, slide tracheoplasty

- operative considerations include intubation/extubation, feeding tubes, mucous plugging, airway restenosis

Conclusions/action items:

We need to do further research on these conditions and discuss the most common ones with our client to determine which airway conditions we should prioritize developing airway trainers for.

Lance Johnson - Feb 02, 2025, 1:27 PM CST

April M. Landry, MD[a,*], Michael J. Rutter, MD[b]

KEYWORDS

- Airway anomalies • Laryngeal cleft • Complete tracheal rings
- Congenital subglottic stenosis • Laryngeal atresia • Glottic web

KEY POINTS

- Airway anomalies are potential life-threatening and life-altering abnormalities that require a high degree of suspicion in diagnosis.
- Anomalies of the airway are frequently found in association with other system abnormalities, as well as several common syndromes.
- There is a wide range of management and surgical options based on the severity and type of airway abnormality.
- Close communication of postoperative care and potential complications are required following surgical treatment of these diseases.

INTRODUCTION

Congenital airway anomalies are rare but potentially life-threatening conditions. The focus of this article is on anomalies of the larynx, subglottis, and trachea. These anomalies often present with noisy breathing, cyanosis, apnea, retractions, feeding difficulties, and recurrent aspiration. Failure to recognize and diagnose the cause of the symptoms could lead to failure to thrive, recurrent or persistent respiratory distress, chronic aspiration with resultant lung damage, and possible death.

Embryology

A review of the embryology of the aerodigestive tract helps us to understand the formation of these abnormalities. The respiratory diverticulum develops from the primitive foregut. The tracheoesophageal folds invaginate to form the tracheoesophageal septum. This septum divides the foregut from the respiratory diverticulum and fusion occurs in the caudal to cranial direction.[1] Incomplete formation of the tracheoesophageal septum leads to laryngotracheal clefts.[2] When the embryo is in development, an epithelial structure called the epithelial lamina obliterates the lumen of the primitive larynx. The laryngeal lumen begins recanalization after obliteration from caudal to cranial

Disclosure Statement: A.M. Landry: No disclosures. M. Rutter: Consultant and patent holder Aeris Balloon Dilator, Bryan Medical Rutter Suprastomal Stent, Boston Medical Products.

[a] Department of Otolaryngology Head and Neck Surgery, Emory University, 1600 Tullie Road NE, Atlanta, GA 30329, USA; [b] Department of Otolaryngology Head and Neck Surgery, University of Cincinnati, 3333 Burnet Avenue, Cincinnati, OH 45229, USA

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1/30/25 - "Advanced airway management strategies for severe OSAS and craniofacial anomalies"

Lance Johnson - Feb 02, 2025, 2:00 PM CST

Title: "Advanced airway management strategies for severe OSAS and craniofacial anomalies"

Date: 1/30/25

Content by: Lance

Present: N/A

Goals: To understand how airway management changes with patients with craniofacial anomalies and learn how some strategies can be applied to airway anomalies.

Link: https://www.sciencedirect.com/science/article/abs/pii/S0196070916302447?via%3Dihub

Citation:

A. Gungor, “Advanced airway management strategies for severe OSAS and craniofacial anomalies,” American Journal of Otolaryngology, vol. 38, no. 1, pp. 77–81, Jan. 2017, doi: https://doi.org/10.1016/j.amjoto.2016.09.016.

Content:

This paper looks at advanced ways to manage airway problems in kids with sleep apnea and craniofacial issues. It stresses the importance of thorough checks for multiple airway problems (called SALs) that often come with these conditions, and suggests techniques like mandibular glossopexy for tongue obstruction. However, the main takeaway from this paper in my eyes is the highlighting of the importance of communication between medical teams undertaking these surgeries and interventions- it shows that in surgery for airway management, extra care is needed to understand each patient's anatomy.

Pediatric OSAS(obstructive sleep apnea syndrome) and craniofacial malformations

- requires multi-specialty management(ENT, pediatric surgery, OMF, plastic surgery) for complex airway issues(tongue-base obstructions, nasal vault problems)

Synchronous Airway Lesions(SALs)

- many children with craniofacial anomalies have multiple airway obstructions(layngomalacia, SGS)

- comprehensive evaluation methods including flexible laryngeal endoscopy or rigid bronchoscopy under anesthesia are necessary in many cases

Tongue-Lip Adhesion(TLA) and mandibular glosspexy(MGP)

- traditional TLA often fails due to poor tongue-base control whereas modified MGP which uses sutures provides better results with fewer complications like dysphagia

Nasal obstructions

- nasal obstruction in neonatal children can lead to severe respiratory distress

- temporary solutions include stents, nasal trumpets, saline but severe cases may require balloon dilation or surgery

Choanal atresia and stenosis(CNPAS)

- choanal atresia is a neonatal emergency --> some bilateral cases require surgery

- treated with balloon dilation or surgical enlargement

Lingual tonsillectomy

- lingual tonsils may contribute to pediatric OSA, especially in individuals with craniofacial anomalies

- treated with adenoidectomy or radiofrequency/laser treatment(decreases scarring)

Conclusions/action items:

The surgical techniques and evaluation methods are very similar to non-craniofacial airway anomalies in the needs for anesthetics. While the exact surgical techniques are not exactly relevant to our airway trainer project, the fact that the same claims being made by our client are also

being made in the literature shows the importance of our project.

Lance Johnson - Feb 02, 2025, 1:29 PM CST

Feature article

Advanced airway management strategies for severe OSAS and craniofacial anomalies

Anil Cunger, MD*

Department of Otolaryngology Head & Neck Surgery, Louisiana State University School of Medicine, Shreveport, LA

ARTICLE INFO

Article history:
Received 16 August 2016

ABSTRACT

Pediatric OSAS and craniofacial malformations present challenges that require innovative approaches and comprehensive treatment strategies. Synchronous airway lesions, craniofacial malformations, obstructive anomalies of the tongue base, nasal cavity and cleanse are commonly addressed by subspecialists from various clinical and surgical academic traditions who practice variable levels of required communication. This is not a mere social requirement but an important requisite for intelligent and effective airway management. Membership of dedicated airway, sero digestive or craniofacial teams are desirable but not required. I report this clinical brief to help many brilliant clinicians in their pursuit of perfection.

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1. Introduction

Pediatric OSAS and craniofacial malformations present challenges that require innovative approaches and comprehensive treatment strategies. Synchronous airway lesions, craniofacial malformations, obstructive anomalies of the tongue base, nasal cavity and cleanse are commonly addressed by subspecialists from various clinical and surgical academic traditions who practice variable levels of required communication. This is not a mere social requirement but an important requisite for intelligent and effective airway management. Membership of dedicated airway, sero digestive or craniofacial teams are desirable but not required. I report this clinical brief to help many brilliant clinicians in their pursuit of perfection.

2. Synchronous airway lesions (SALs)

Craniofacial anomalies, syndromic or not, usually present with predictable sites of obstruction apparent from clinical exam and respiratory behavior during the first few days of life. In practice however, up to 10% of children with craniofacial anomalies presenting with respiratory distress have multiple airway problems that need to be addressed in order to achieve satisfactory results [1]. The false belief in the predictability of a 'single' problem 'single site' is likely showing up in reports of varying success levels addressing 'single sits' or 'single' problems.

In today's medical environment, many surgical subspecialties are competitively involved with the treatment of neonatal and pediatric airway obstruction (ENT, pediatric ENT, OMS, pediatric surgeons, plastic surgery etc) with different skill sets and procedural competencies that should best be complementary to each other. It is important to have a skilled specialist trained in the evaluation and treatment of the entire airway, since a comprehensive, dynamic airway evaluation under general anesthesia in essential before treatment plans are made.

Reports from children's centers in Pittsburgh and Chicago have been revealing synchronous airway lesions (SALs) are

* Corresponding author at Department of Otolaryngology Head & Neck Surgery, Louisiana State University School of Medicine, Shreveport, LA 71130.
E-mail address: [redacted]

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advancedairwaymanagement.pdf (226 kB)

1/30/25 - "Degrees of Reality : Airway Anatomy of High-fidelity Human Patient Simulators and Airway Trainers"

Lance Johnson - Feb 02, 2025, 2:25 PM CST

Title: "Degrees of Reality : Airway Anatomy of High-fidelity Human Patient Simulators and Airway Trainers"

Date: 1/30/25

Content by: Lance

Present: N/A

Goals: To understand the discrepancies between real human airway anatomy and the trainers used for airway management

Link: **https://pubmed.ncbi.nlm.nih.gov/22481118/**

Citation:

K. Schebesta, M. Hüpfl, B. Rössler, H. Ringl, Michael P. Müller, and O. Kimberger, “Degrees of Reality,” Anesthesiology, vol. 116, no. 6, pp. 1204–1209, Jun. 2012, doi: https://doi.org/10.1097/aln.0b013e318254cf41.

Content:

The study looked into the airway anatomy of high- and low-fidelity manikins and real human patients and found some pretty dramatic differences. For example, the pharyngeal airspace in humans averaged 13.5 +/- 7.7 cc, while it was much larger in manikins, such as SimMan(68.5 cc) and Laerdal Manikin (65.9 cc). Other measurements, like tongue diameter and the distance from the epiglottis to the posterior pharyngeal wall also differed notably. This validates the work being done in our project as it shows the need for more accurate and difficult airway trainers.

- the goal of the study was to evaluate the realism and accuracy of airway anatomy in 4 high-fidelity and 2 low-fidelity human patient simulators(HPS)

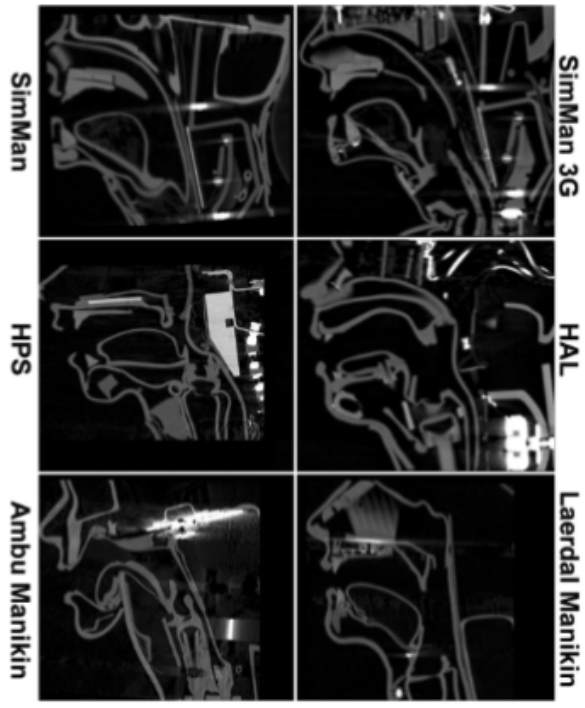
- radiographic measurements were used to quantify the accuracy of the trainers against 20 CT scans of actual trauma patients

- a variety of predefined distances, cross-sectional areas, and volumes were assessed

- the pharyngeal airspace(volume of the upper airspace) was significantly larger in the the simulators than in actual patients (68.5 cc vs. 13.5 cc)

- many simulators lacked basic anatomical features which made comparisons very difficult

- conclusions made that manikin-based training may not be effective in preparing medical professionals for real-life clinical situations



Conclusions/action items:

Seeing how the airway trainers weren't really even that accurate to average anatomy makes it evident why intubating and managing the airways of individuals with more unusual anatomies is very difficult and leads to many challenges. We will use this information to inform and evaluate our design.

Lance Johnson - Feb 02, 2025, 2:05 PM CST

Degrees of Reality

Airway Anatomy of High-fidelity Human Patient Simulators and Airway Trainers

Karl Schebesta, M.D.,* Michael Hüpfl, M.D.,† Bernhard Rössler, M.D.,* Helmut Ringl, M.D.,‡ Michael P. Müller, M.D.,§ Oliver Kimberger, M.D.‖

ABSTRACT

Background: Human patient simulators and airway training manikins are widely used to train airway management skills to medical professionals. Furthermore, these patient simulators are employed to standardized "patients" to evaluate airway devices. However, little is known about how realistic these patient simulators and airway-training manikins really are. This trial aimed to evaluate the upper airway anatomy of four high-fidelity patient simulators and two airway trainers in comparison with actual patients by means of radiographic measurements. The volume of the pharyngeal airspace was the primary outcome parameter.

Methods: Computed tomography scans of 20 adult trauma patients without head or neck injuries were compared with computed tomography scans of four high-fidelity patient simulators and two airway trainers. By using 14 predefined distances, two cross-sectional areas and three volume parameters of the upper airway, the manikins' similarity to a human patient was assessed.

Results: The pharyngeal airspace of all manikins differed significantly from the patients' pharyngeal airspace. The HPS Human Patient Simulator (METI®, Sarasota, FL) was the most realistic high-fidelity patient simulator (6/19 [32%] of all parameters were within the 95% CI of human airway measurements).

Conclusion: The airway anatomy of four high-fidelity patient simulators and two airway trainers does not reflect the upper airway anatomy of actual patients. This finding may impact airway training and confound comparative airway device studies.

What We Already Know about This Topic

- Manikins are a tool for education, training, and research of human airway management, but the fidelity of these devices is typically low

What This Article Tells Us That Is New

- Computed tomography scans of the upper airway revealed that the airway dimensions of the manikins significantly differed from those of humans
- Training, education, and research using this manikins should be reconsidered

AIRWAY management is a key skill in anesthesiology and emergency medical practice. Because failure to manage an airway is associated with a high risk of morbidity and mortality, many anesthesia researchers have focused their educational and research efforts on airway management techniques and devices.[1,2] After the introduction of human patient simulators in the early 1960s, airway management training could be performed, even in high-risk airway situations, without putting actual patients at risk.[3–5] These human patient simulators are now widely used not only for training purposes but also as an innovative way to answer scientific questions in airway management research.[6,7] The ability to simulate either a difficult or normal airway has granted a better understanding of different airway maneuvers and has helped with the assessment of new airway de-

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Degrees_of_Reality_Airway_Anatomy_of_High-fidelity_Human_Patient_Simulators_and_Airway_Trainers.pdf (592 kB)

1/30/25 - Trucorp Difficult Airway Trainers

Lance Johnson - Feb 02, 2025, 2:24 PM CST

Title: Trucorp Difficult Airway Trainers

Date: 1/30/25

Content by: Lance

Present: N/A

Goals: To understand the design and function of an existing difficult airway trainer

Link: **https://trucorp.com/en/procedure/difficult-airway-trainers/**

Citation:

“Difficult Airway Trainers - TruCorp,” Trucorp, 2024. https://trucorp.com/en/procedure/difficult-airway-trainers/ (accessed Jan. 31, 2025).

Content:

TruCorp has a range of difficult airway trainers designed for medical professionals to practice airway management including intubation, obstruction, and cricothyroidotomy(incised emergency airway). Their AirSim X models which are designed using real patient CT DICOM data, are certified for over 20,000 intubation cycles and come with a 5-year warranty. The trainers are designed to help medical professionals prepare for cases involving craniofacial abnormalities, obesity, and aging-related airway changes but are not designed to mimic common airway abnormalities that our client is keen on having trainers for.

- the TruCorp difficult airway trainers are meant to help medical professionals train for challenging airway management situations

- trainers are designed primarily for assessment, obstruction, intubation, supraglottic device insertion, and cricothyroidotomy practice

- inflatable tongues can simulate edema, a supposed enhancement of realism

- the trainers are designed using CT scans fro real patients to ensure anatomical accuracy

- TruCorp trainers are known for durability and realism

- TruCorp offers trainers for particular airawy anomalies such as the AirSim Pierre Robin X which is designed for infants with Pierre Robin Sequence(PRS)

- the airway trainers are effective in supporting difficult tracheal intubation(DTI), difficult mask ventilation(DMV), laryngoscopy, and nasal intubation practice

- cost between ~$5000-7000

Conclusions/action items:

While the TruCorp trainers seem to provide realistic and durable solutions, it seems that our project will provide a solution for a more niche market with tremendous health benefits that our client is exploring. The cost of our design also projects to be less than that of the TruCorp trainers.

2/7/25- Patent CN105616043A

Lance Johnson - Feb 08, 2025, 2:02 PM CST

Title: Patent CN105616043A - 3D printing and injection molding based silicone individualized airway stent preparation technology

Date: 2/7/25

Content by: Lance

Present: N/A

Search Term: 3D printing AND airway

Citation:

“CN105616043A - 3D printing and injection molding based silicone individualized airway stent preparation technology - Google Patents,” Google.com, Mar. 18, 2016. https://patents.google.com/patent/CN105616043A/en (accessed Feb. 06, 2025).

Link: https://patents.google.com/patent/CN105616043A/en

Goals: To understand one of the patents existing in the space that we are exploring with our product

Content:

- The patent discusses the technology used and process of making personalized airway stents using CT scans of patient's airways

Background:

- the incidence of airways issues from diseases and injuries are increasing, and when stents are needed, they often don't fit well

- current stents sometimes fail to match the airway structure which can often leave gaps between the stent and tracheal wall --> bacteria can grow in these gaps which can lead to infections and blockages

- sub-optimal stent fitting can cause restenosis(airway narrowing) due to stressed breathing

- The patent emphasizes the use of **casting silicone** as the material for personalized airway stents using 3D-printed molds derived from CT scans

- The patent outlines 5 steps in this process:

1) The patient's ariway is scanned with a CT scanner, which creates a 3D model

2) The model is adjusted to smooth out narrow areas and expand it to a normal size

3) The airway model is altered to turn it into a mold for a stent

4) The airway model/mold is 3D-printed

5) The mold is filled with medical-grade silicone, and once solid, creates the personalized stent

Conclusions/action items:

While this patent seems very similar to what we are trying accomplish with our design, I actually don't think we will come close to infringing on this patent because we don't plan on using the 3D-prints are molds for silicone casting, rather we want to use the 3D-prints as the actual medical device(custom airway). Nonetheless, it will be important to continue looking at patents and standards as we continue designing as we don't want to create conflicts in the case the client wants to patent.

3/2/25 - "3D printing from MRI Data: Harnessing strengths and minimizing weaknesses"

Lance Johnson - Mar 03, 2025, 12:25 PM CST

Lance Johnson - Mar 03, 2025, 12:37 PM CST

Title: "3D printing from MRI Data: Harnessing strengths and minimizing weaknesses"

Date: 3/2/25

Content by: Lance

Present: N/A

Search Term: 3D printing AND MRI

Citation:

B. Ripley et al., “3D printing from MRI Data: Harnessing strengths and minimizing weaknesses,” Journal of Magnetic Resonance Imaging, vol. 45, no. 3, pp. 635–645, Nov. 2016, doi: https://doi.org/10.1002/jmri.25526.

Link: https://pubmed.ncbi.nlm.nih.gov/27875009/

Goals: To learn more about some of the difficulties associated with converting DICOM images to 3d printable file types

Content:

Artifacts:

- Motion artificats are a common issue in MRI, especially for dynamic regions like the heart and abdomen(airway?)

- Motion compensation methods like ECG triggering and respiratory navigators can help reduce motion-related artifacts

- Higher MRI resolution increases scan time and may worsen motion artifacts, so a balance is needed

- Metallic implants distort MRI data—> creating significant artifacts

- New acquisition techniques reduce these distortions, but they are often only partially corrected

- Gradient field nonlinearity(?) can cause inaccuracies in the model

- Careful MRI protocol design and sequence selection can help minimize artifacts —> using spin-echo for less metallic distortion and shimming can improve image quality

3D vs 2D acquisition:

- 3D acquisitions support higher resolution but are more prone to motion artifacts

- 2D acquisitions may be better for moving structures like the heart —> 3D data can be reconstructed from 2D

Conclusions/action items:

Once the team decides on a software system, we need to learn the segmentation techniques so we can understand the limitations of the software. From there we can idealize the scanning process(3d vs 2d & protocol design) for our application and communicate that with Dr. Schroeder.

2/13/25 - Formlabs Flexible 80 A Resin

Lance Johnson - Feb 13, 2025, 10:26 PM CST

Title: Formlabs Flexible 80 A Resin

Date: 2/13/25

Content by: Lance

Present: N/A

Citation: “Flexible 80A Resin,” Formlabs. https://formlabs.com/store/materials/flexible-80a-resin/

Link: https://formlabs.com/store/materials/flexible-80a-resin/

Goals: To understand the advantages and disadvantages of one of potential material choices

Content:

- Formlabs Flexible Resin is a SLA(stereolithography) filament--> this means that the filament is a liquid resin that gets solidified by a high energy laser

- Because of the unique properties of the resin, Formlabs resin is only compatible with Formlabs SLA printers, specifically the Form 2, Form 3, Form 3+, Form 3B, Form 3B+, Form 3L, Form 3BL, Form 4, Form 4B, Form 4L, Form 4BL

Mechanical Properties:

	METRIC[1]	
	Green	Post-Cured[2]
Mechanical Properties		
Ultimate Tensile Strength[3]	3.7 MPa	8.9 MPa
Stress at 50% Elongation	1.5 MPa	3.1 MPa
Stress at 100% Elongation	3.5 MPa	6.3 MPa
Elongation at Break	100%	120%
Shore Hardness	70A	80 A
Compression Set (23 °C for 22 hours)	Not Tested	3%
Compression Set (70 °C for 22 hours)	Not Tested	5%
Tear Strength[4]	11 kN/m	24 kN/m
Ross Flex Fatigue at 23 °C	Not Tested	>200,000 cycles
Ross Flex Fatigue at -10 °C	Not Tested	>50,000 cycles
Bayshore Resilience	Not Tested	28%
Thermal Properties		
Glass transition temperature (Tg)	Not Tested	27 °C

- color dyes can be added to the translucent resin to achieve different colored prints(pink for our airways)

- flexible 80 A resin is ideal for creating elastomeric and durable parts that can mimic rubber or stiffer flexible materials

- Formlabs Flexible 80 A resin requires post-processing steps including a 10-minute curing period and 2, 10-min washing cycles in TPM solvent

- should be considered as a good alternative to silicone molds for cartilage, tendon, and ligament anatomy

Conclusions/action items:

I ordered a test sample of the 80 A resin to see how it feels and if it seems reasonable for our project. Another consideration to make when we begin printing airways is to research and adjust infill patterns and infill densities which will all affect the mechanical properties of the print. While there are Formlabs SLA printers on campus, we will need to look into the availability of the printers and price of the filament, as well as if they can add dye to create more accurate colors.

2/23/25 - Airway Trainer Modification

Lance Johnson - Feb 23, 2025, 10:08 PM CST

Title: Airway Trainer Modification

Date: 2/23/25

Content by: Lance

Present: N/A

Goals: To fix the "floppiness" of the current airway trainer head/neck connection

Content:

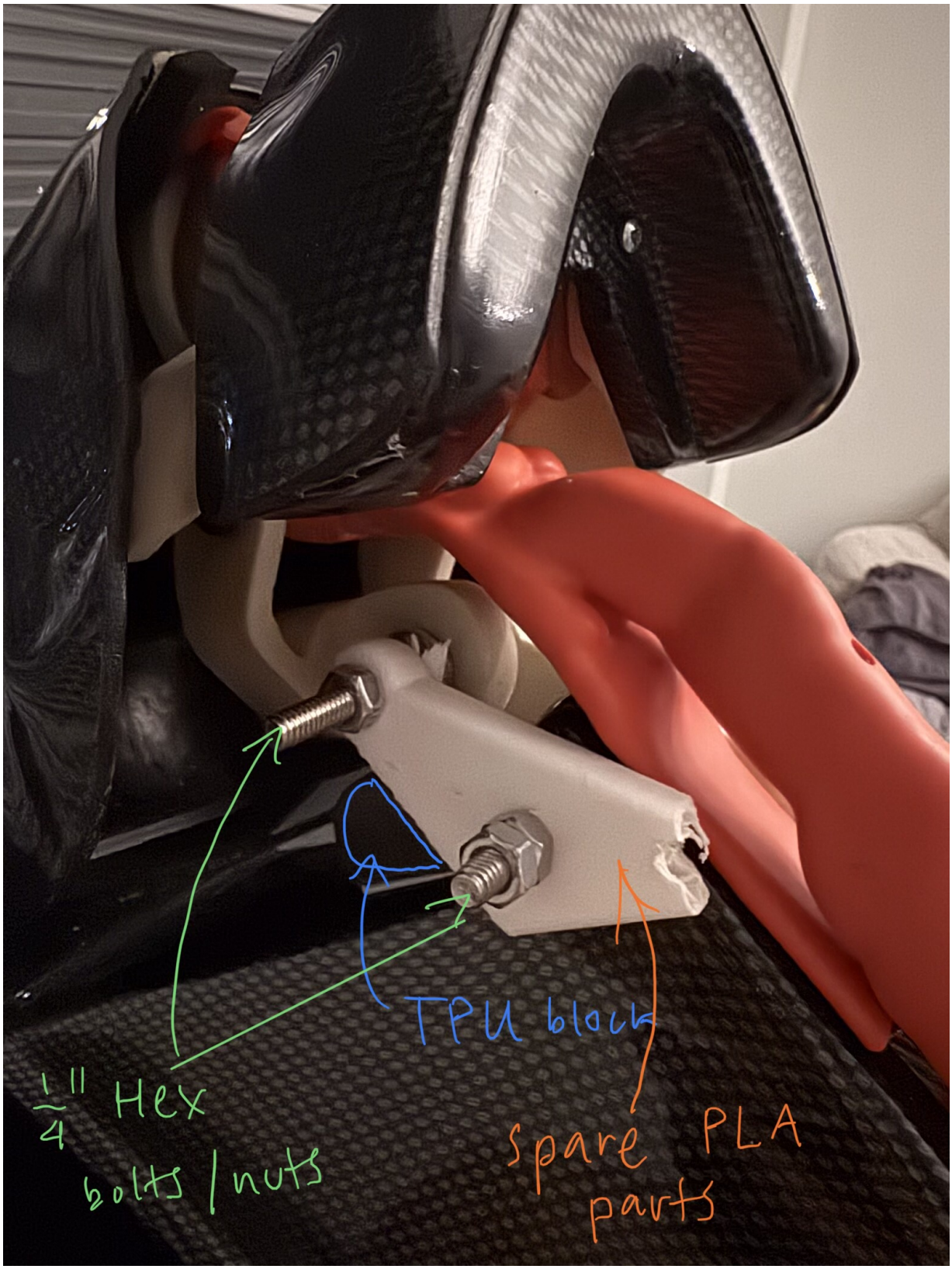
- The airway trainer given to us by the client currently is very floppy as the head can move freely, which is a problem particularly during intubation practice

- In order to become more effective as a trainer and restore some of the functionality, the head should be reattached to be more stable during intubation

- Holes were drilled in spare PLA prints using a 5/16" drill bit in matching locations

- 2 - 3" x 1/4" Hex bolts, 4 washers, and 4 1/4" Hex nuts were used to sandwich and secure the head and body assemblies

- a spare TPU block was used to create a stop for the head in the sniffing position so that the head cannot over-extend and face too far backwards



Conclusions/action items:

In order to confirm the fix works, I need to get the intubation supplies from Dan & Cody so that I can make sure the trainer is good to go for the presentation on Friday. It is also possible that later in the semester we will need to redo this fix with non-spare prints to improve the stability of the trainer.

3/16/25 - 3D Slicer Software

Lance Johnson - Mar 17, 2025, 12:24 AM CDT

Title: 3D Slicer

Date: 3/16/2025

Content by: Lance

Present: N/A

Goals: To understand what 3D slicer does, what features it has, and how we can use it for our project

Content:

- 3D Slicer is an open-source software platform for processing, visualizing, and analyzing medical images— commonly used in research, clinical applications, and education, supporting various imaging modalities such as CT, MRI, and ultrasound

- 3D Slicer can handle and integrate data from multiple imaging modalities, including CT, MRI, PET, and ultrasound, offering flexibility in medical image analysis

- It provides powerful visualization tools, enabling 3D, 2D, and even 4D visualizations(?), which allow for detailed inspection and interpretation of medical imaging data

- includes both semi-automatic and manual segmentation tools to isolate and analyze specific regions of interest within medical images

- 3D Slicer offers a variety of quantitative tools to measure volume(useful for later testing), surface area, and other important parameters, aiding in detailed analysis of structures within medical images

- Has plugins for specialized tasks such as surgical planning, radiotherapy, and research applications

- UI is highly customizable and allows users to adapt the workspace for their needs

Advantages:

- 3D Slicer is free to use and is open-source, which means it also has a large and active support community

- It’s highly extendable with the ability to add custom modules and plugins, making it suitable for specialized workflows and research applications

- 3D Slicer offers detailed documentation, tutorials, and a strong user community, providing ample support for both beginners and advanced users

- works on all major operating systems(Windows, macOS, Linux)

- It supports complex visualizations, including multi-dimensional and multi-modal data, which is essential for detailed medical image analysis

Disadvantages:

- Due to its advanced features and broad functionality, 3D Slicer can be overwhelming for new users, especially those without a background in medical imaging.

- The software can be slow, particularly when processing large datasets or performing complex analyses on suboptimal hardware which can impact its effectiveness in time-sensitive cases like ours

- The UI can be overly complex for users who only need to perform basic image viewing or simple analysis

Conclusions/action items:

3d slicer will be a valuable for our team as it should complement what we are able to do within the ITK-SNAP software. Additionally, I think the volume measurement features will be really helpful during our testing phase.

3/17/25 - Volume Testing Protocol

Lance Johnson - Mar 17, 2025, 2:20 PM CDT

Title: Volume Testing Protocol

Date: 3/17/2025

Content by: Lance

Present: N/A

Goals: To outline and write a testing protocol to test the inside airway volume of the printed airways against the mathematical volume calculated from the DICOM image by the slicing software

Content:

Volume Testing Protocol:

1) Gather two tall beakers and an Eppendorf pipet.

2) Fill one beaker with water to add to the airway.

3) Place the printed airway vertically in the other beaker, using light adhesive to seal the bottom edge of the airway to the beaker or waterproof paper if needed to prevent water leakage.

4) Fill the inside of the airway with water, making sure to measure and record exact amounts as they are added.

5) Use an Eppendorf pipet to precisely fill the airway to the top, then total the volume of water added.

6) Repeat filling and measuring two more times for a total of three trials, recording total volume each time.

7) Open the airway file in 3D Slicer software and use volume measurement tool to determine inner airway volume of the mesh and compare to the measured values

Conclusions/action items:

This is still a rudimentary protocol and will need more refining as we start to use and understand the 3D Slicer software more. Additionally, the porosity of the print will impact the results of this test so understanding how porous the prints are in our desired materials will be important moving forward.

3/17/25 - Airway Print Preparation

Lance Johnson - Mar 17, 2025, 2:19 PM CDT

Title: Airway Print Preparation

Date: 3/17/2025

Content by: Lance

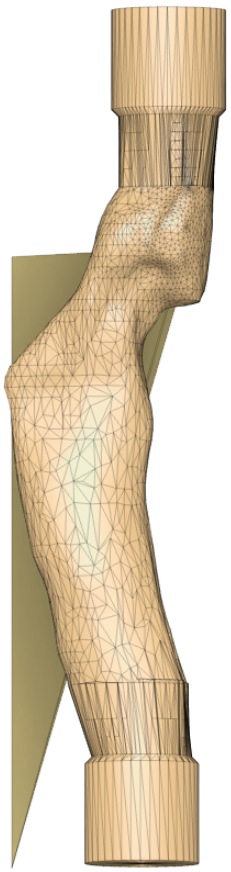
Present: N/A

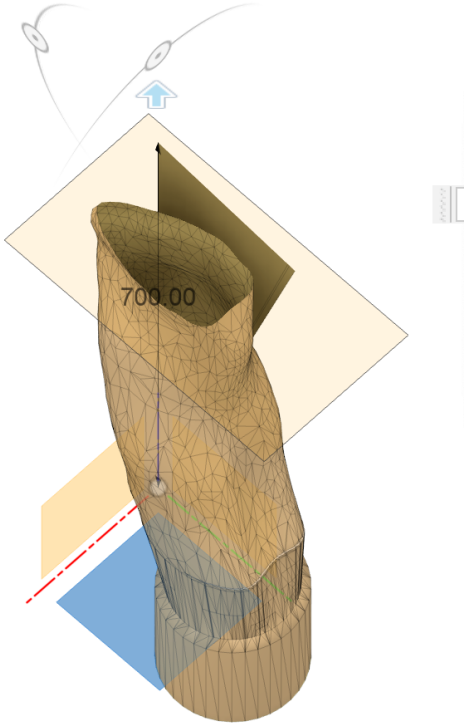
Goals: To see if the airway file given to us by Dr. Garcia-Rodriguez is hollow and if it is, prepare it for printing

Content:

- I opened the airway stl file in Autodesk Fusion 360 to visualize what it looks like

- Performed a section analysis to see if the airway is hollow

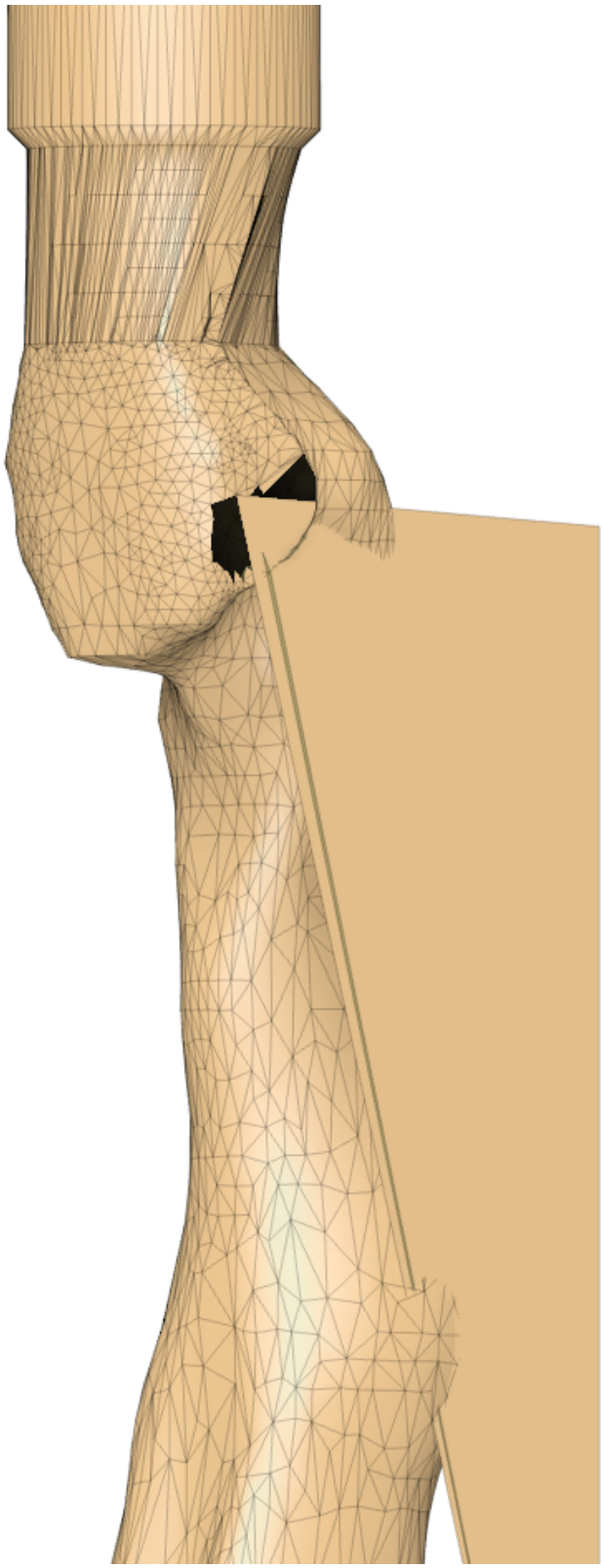




- the airway file is hollow, but the wall thickness of the airway seems to be very thin. One way I believe this could be remedied is by dramatically increasing the wall thickness during the slicing process before printing to ensure the airway walls are even thick enough to support the rest of the airway as it prints.

- I tried converting the airway to a step(.stp) file so I could edit the wall thickness in Fusion, but the conversion didn't work properly

- Another concern is an apparent hole in the airway and a weird plane that may both cause issues during printing(see below)



Conclusions/action items:

The team will attempt to print the stl file at the Makerspace, and will consult the Makerspace staff to get advice on fixing the hole, weird plane thingy, and increasing the wall thickness- hopefully all of which can be fixied through the slicer software because we don't actually have an editable file format.

Training Documentation - Lance

Lance Johnson - Feb 13, 2025, 8:12 PM CST

Lance Johnson

ID Number: 9084318329

Eligibility: CoE Students

My Memberships

Membership Type	Start Date	Expiry Date	Renew	Card Info
Access Fee	Mon, May 22 2023	Sun, Dec 31 2023	Not Renewable	N/A
Machining - Training Eligible	Sun, Jan 1 2023	Tue, Dec 30 3000	Not Renewable	N/A
Lab Orientation	Sun, Jan 1 2023	Tue, Dec 30 3000	Not Renewable	N/A
Laser Cutter	Sun, Jan 1 2023	Tue, Dec 30 3000	Not Renewable	N/A
Shop Tools	Sun, Jan 1 2023	Tue, Dec 30 3000	Not Renewable	N/A

Lance Johnson - Feb 17, 2025, 4:07 PM CST

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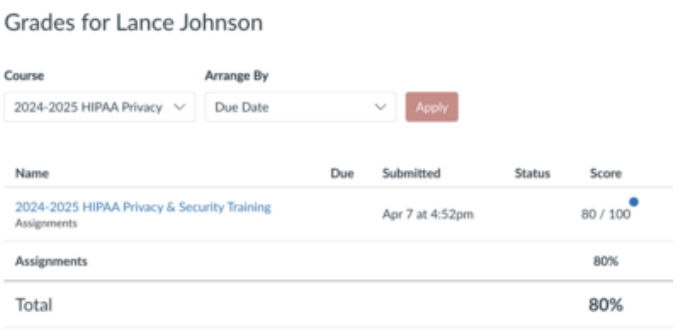
This certifies that Lance Johnson has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	2/17/2024	2/17/2029
Chemical Safety: The OSHA Lab Standard	Final Quiz	2/17/2024	
Risk Communication in Animal Facilities	Risk Communication in Animal Facilities Quiz 2023	9/19/2023	
Safety for Personnel with Animal Contact	Animal Contact Personnel Quiz 2023	9/19/2023	9/19/2028
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	2/13/2025	2/13/2028

Data Last Imported: 02/17/2025 04:05 PM

4/7/25 - HIPAA Training

Lance Johnson - Apr 07, 2025, 4:54 PM CDT



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Screenshot_2025-04-07_at_4.53.15_PM.png (108 kB)

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity. subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

Cody Kryzer - Apr 28, 2025, 4:15 PM CDT

Title:

Date:

Content by:

Present:

Search Term:

Citation:

Link:

Goals:

Content:

Conclusions/action items:

BME Design- Fall 2024 Notebook

Lance Johnson - Jan 24, 2025, 12:39 PM CST

BME Design-Fall 2024 - MARIBEL GLODOWSKI
Complete Notebook

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on
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