Final Proposal

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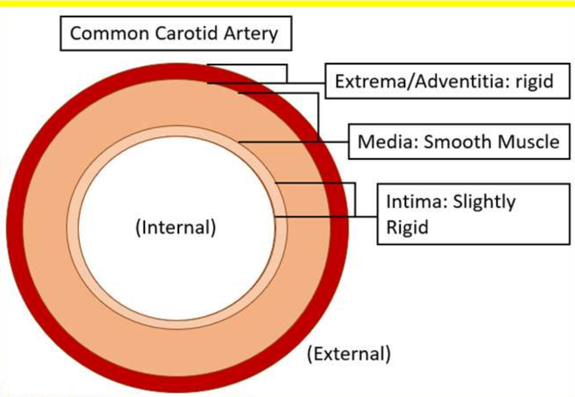
Aditya Ponugupaty – Isaac Smith

Project Description

Team BDL/Aneuvas 3D Printing is tasked with:

Create a 3D printed model that replicates organic tissue measurable to the human carotid artery.

Human Carotid Artery



Conduct Tests:

- Tension of specimen
- Specimen compliance
- Lubricity of specimen interior
- Compressive Modulus
  - Shear Modulus
- Specimen Hardness (?)

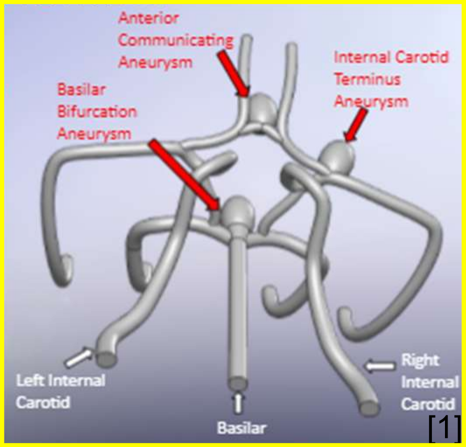
Deliverables

Qualitative data on material properties for each test.

Repeatable:
- Manufacturing
- laboratory implementation

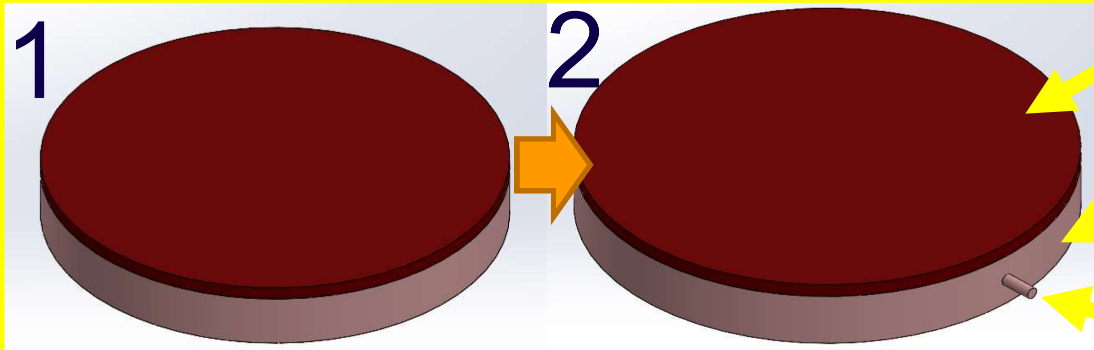
Design Description

Original System



Proof of Concept Model

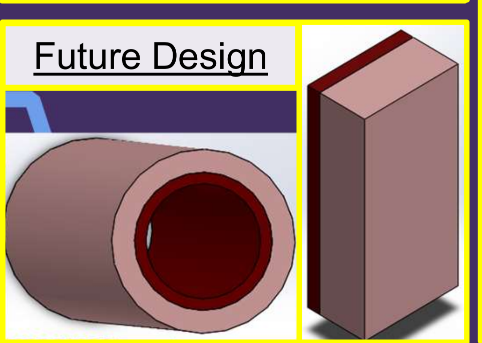
Final Prototype



Subsystems:

- Tunica Intima
- Tunica Media
- ID "Nub"

Future Design



Prototype Function

- Cannot analyze original system, so we use a smaller specimen for testing.
- Allows for mechanical tests to be conducted with a Rheometer.
- Easy storage and soak – testing requires a 4-day PBS soak.
- Cheap to print; low material usage
- Layers replicate the human vascular layers (Tunica media and intima).
- 8mm diameter, 1.2mm depth; Intima: .26mm, Media: .94mm.

Design Requirements

CRs with relative weights:

- **Size (3%)**
- **Easy to connect (8%)**
- **Hard interior/Soft exterior (Layered) (25%)**
- **Lightweight (3%)**
- **Material selection (25%)**
- **Retains shape (8%)**
- **Similar properties to organic tissue (25%)**
- **Cost within budget (3%)**

Top 3 CR's are satisfied

Hard interior/Soft exterior (25%)

- Layered design provides the ER's for this criterion.

Material selection (25%)

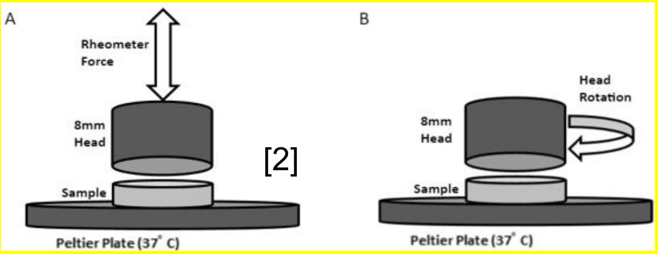
- Agilus and VC form a good base for human organic tissue

Similar properties to organic tissue (25%)

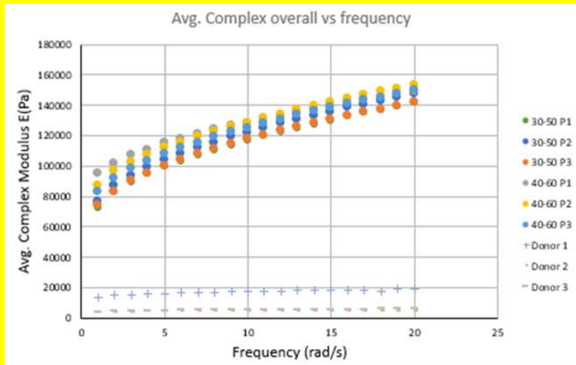
- Design considers the layer pattern of organic tissue
- Design proposes that material will help the mechanical properties to match organic tissue
- Design is safe to operate

Proof of Concept

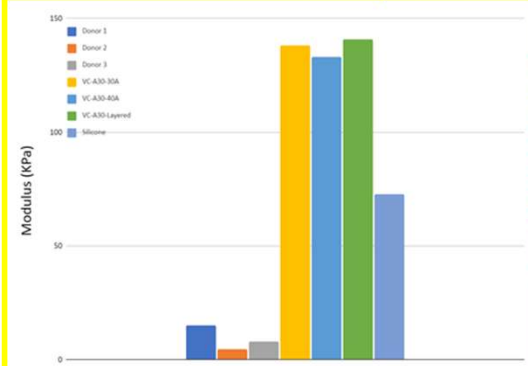
Compression (A) & Shear (B)



Our data

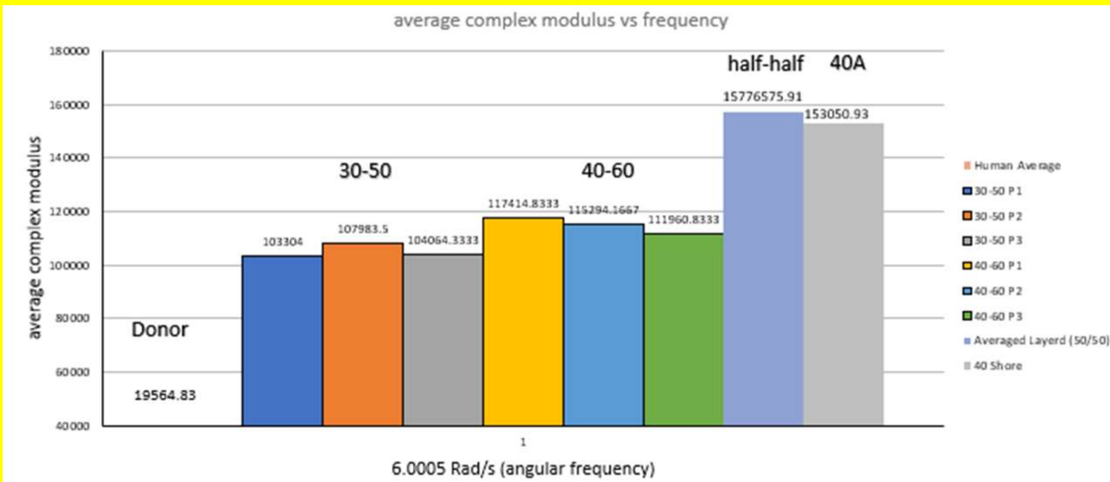


Prior Research Graph



Conclusion

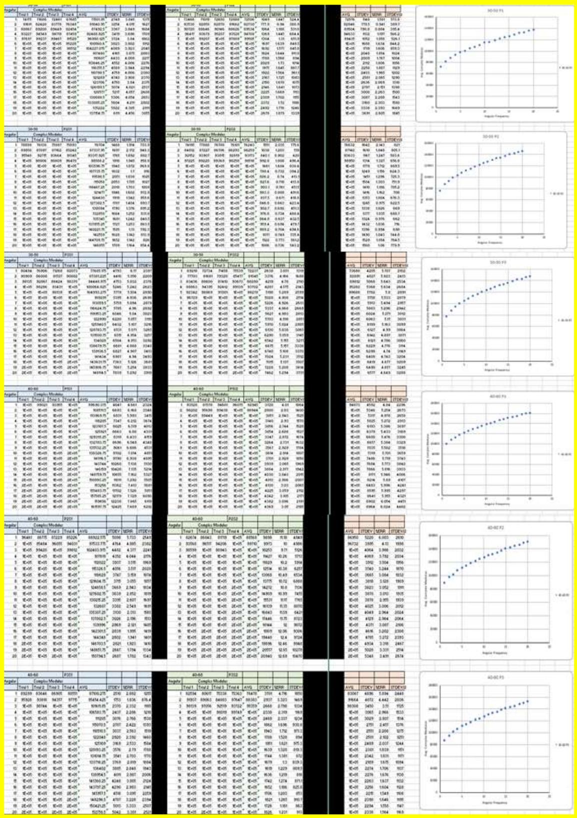
- Shear in polymers is significantly greater than shear in vasculature.
- Our ratio came closer to human shear than previous studies.
- Proof of concept: Validated that ratio change may influence the polymer reaction to be closer to human vascular response.
- Compression is the next test to be conducted.



Luke, 11/1/2021, BDL/Aneuvas, 21F05

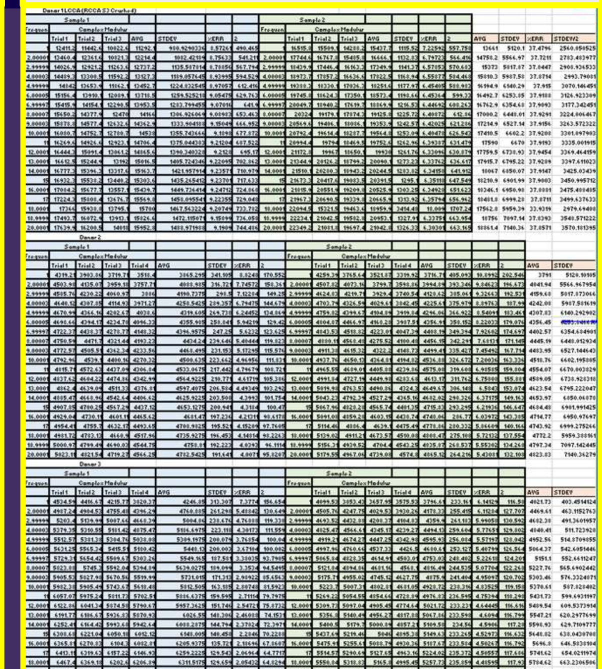
Data Accumulation/ Proof of Analysis

Our Data Collection



Graph Analysis

Comparison Data



- Plus more from comparison data

Design Validation

Testing Procedures

- Lubricity: a wire is looped through a tube sample that is secured to a wheel that is placed on a table a distance away from the rheometer and a water filled syringe is tied to the end of the wire, as the syringe slowly lowers, the friction force of the sample is measured
- Tension: a sample is pulled until it experiences an axial force of 100 mmHg to measure how resistant the sample is to stretching
- Compliance: a tube sample is slowly filled with thick liquid, increasing volumetric pressure, and images are taken with the x-ray to see how much the sample can swell from internal pressure
- Compression: axial force of .9-1.4 N is applied to the sample to measure the elastic modulus of the sample
- Shear: a continuous oscillation force is applied to the sample to measure the sample's shear modulus

Location

Bioengineering Lab

Equipment

- Rheometer
- X-ray
- Polyjet Printer

Kathryn, 11/1/2021,
BDL/Aneuvas, 21F05

Potential Failure Mode and Effects Analysis

Potential Failure Mode	Potential Effect(s) of Failure	Potential Causes and Mechanisms of Failure	RPN	Recommended Action
impact deformation	deforms puck	Prevents pucks from testing properly	56	0
Tearing	rips puck	Prevents pucks from testing properly	16	0
Imncopentent mesh	creates holes in model	Improper complicane testing	8	0

Fig 13: Simplified FMEA

Potential Failures

- Experiencing excess force during testing, causing deformities of the samples
- The materials not fully meshing while printing, causing leakage in the models
- Tearing or popping during testing, ruining the sample
- Two are the failures are caused by human error

Failure Prevention

- Check samples right after printing to ensure completed meshing
- Work slowly when testing to make sure that samples don't experience more force than they can handle

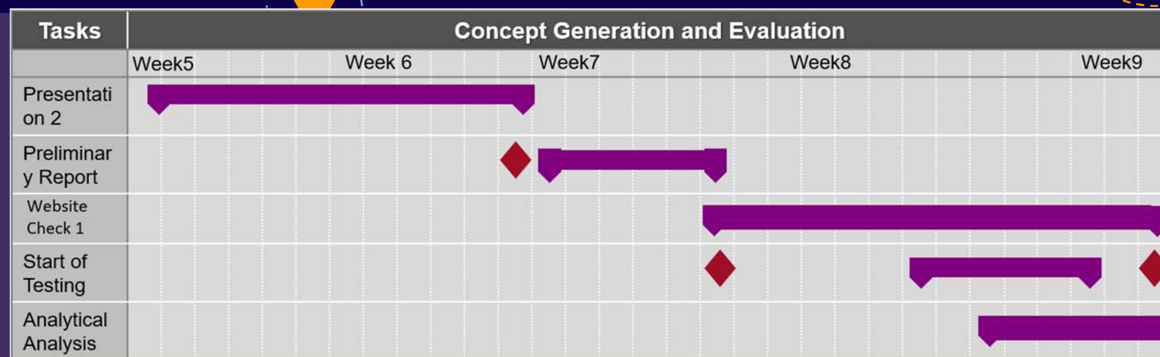
Schedule

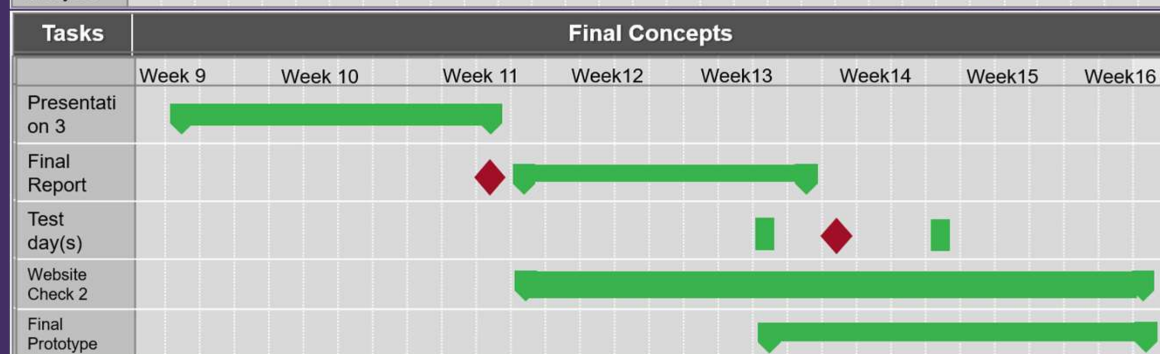
Ahead of Schedule!

Future schedule includes testing, testing, and more testing!

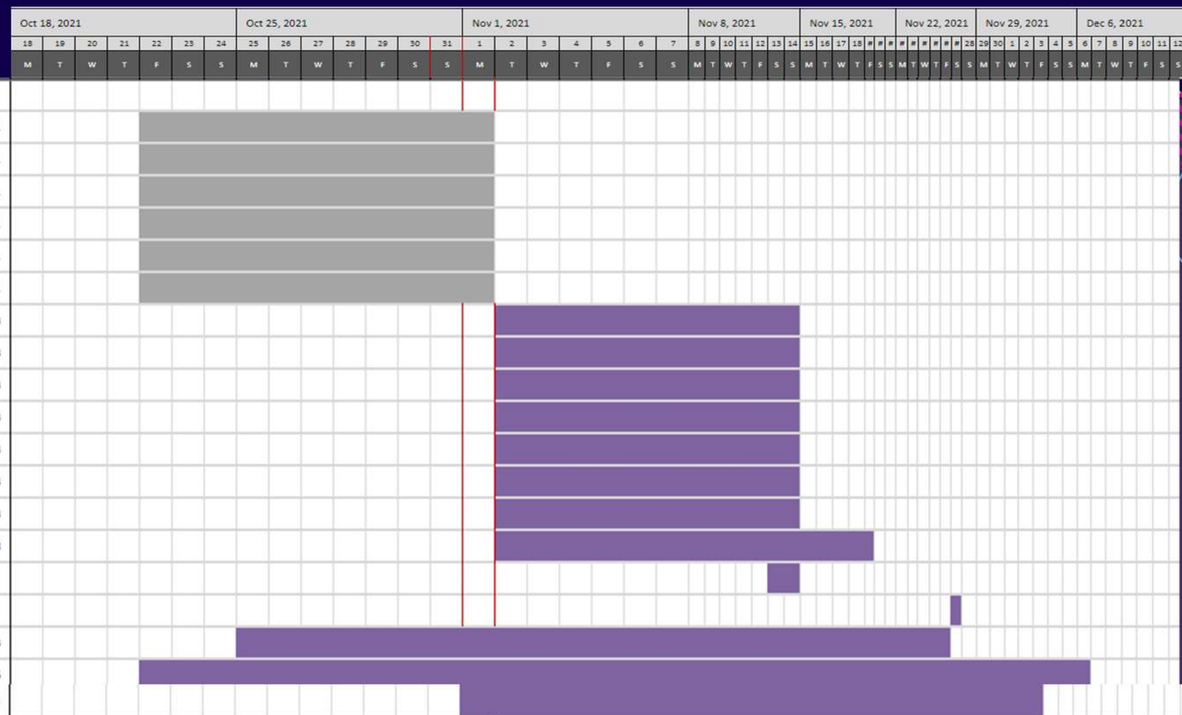
Work Breakdown

Testing:
Isaac & AP
Data Analysis:
Kathryn & Luke





Final Concepts for Semester 1					
Presentation 3	All	100%	10/22/2021	11/1/2021	11
Project Description	Issac	100%	10/22/2021	11/1/2021	11
Design Description	Issac	100%	10/22/2021	11/1/2021	11
Design Requirements	AP, Luke	100%	10/22/2021	11/1/2021	11
Design Validation	Luke	100%	10/22/2021	11/1/2021	11
Scedule And Budget	AP,Katheryn	100%	10/22/2021	11/1/2021	11
Final Concept Report	All	0%	11/2/21	11/14/21	13
Backgroud	All**	0%	11/2/21	11/14/21	13
Customer and Engineering Requirements	All**	0%	11/2/21	11/14/21	13
Testing Procedures	All**	0%	11/2/21	11/14/21	13
Risk Analysis and Mitigation	All**	0%	11/2/21	11/14/21	13
Design Selection	All**	0%	11/2/21	11/14/21	13
Conclusion	All**	0%	11/2/21	11/14/21	13
Final Bill of Materials and CAD	all	0%	11/2/21	11/19/21	18
Test Day: Compression	All	0%	11/13/21	11/14/21	
Test day: Lubricity and Compliance	All	0%	11/27/21	11/27/21	
Individual Analytical Analysis	All	0%	10/25/21	11/26/21	33
Website Check 2	Luke	0%	10/22/21	12/6/21	46
Final Prototype	All	0%	11/1/21	12/3/21	33



Luke, 11/1/2021, BDL/Aneuvas, 21F05

Schedule for 2nd semester

BDL/ANEUVAS CAPSTONE Semester 2

NAU ME Capstone
Project Lead: Isaac Smith

Project Start: Mon, 1/10/2022
Display Week: 1

** As of date of making

TASK	ASSIGNED TO	PROGRESS	START	END	DAYS
Semester 2 Start-up					
Talk to client	All		1/14/2022	1/14/2022	1
Post Mortem of Final report from S1	All		1/14/2022	1/14/2022	1
Delegate testing days and start on final design	AP		1/14/2022	1/14/2022	1
Project Update and First report delegation	Issac		1/14/2022	??	#####
Website Updates	Luke		1/14/2022	1/14/2022	1
Finalize BOM for testing with client	Katheryn		1/21/2022	1/21/2022	1
Individual Analytical Analysis	All		1/10/2022	2/1/2022	23
Midpoint Presentation and Report	All		2/1/2022	??	#####
Testing days	Issac, AP		Multiple Days: TBD	Multiple Days: TBD	#####
Test data analysis	Luke,Katheryn		Dependent on above	Dependent on above	#####
Final Product and Design Summary	All		4/1/2022	4/15/2022	15
Final Report	All		4/15/22	5/6/22	22

Budget

This Semester	
Current Amount Spent	
Initial Instruments Prep.	$16.85
Newest Sample Mat.	$1.65
Total	$18.50
Potential Spending for Rest of Term	
Possible Printed Models	$61.90
Total Spent:	
With models	$80.40
No Models	$18.50
Leftover:	
With Models	$919.60
No Models	$981.50

Next Semester	
Potential Prints	
3 Full Models	$185.70
10 Samples	$185
Additions	
Equipment Rent	$300
Total Spent:	
With Models	$751.10
No Models	$503.50
Leftover:	
With Models	$248.90
No Models	$496.50

References

[1] C. Settanni, "In Vitro Neurovascular Model Development for Liquid Embolic Implant Simulation," *Google*. [Online]. Available: https://docs.google.com/presentation/d/14mdgqx2XWuA98fz6Ufh07s_CHWN_08-w/edit#slide=id.p9. [Accessed: 10-Oct-2021].

[2] N. G. Norris, W. C. Merritt, and T. A. Becker, "Application of nondestructive mechanical characterization testing for creating in vitro vessel models with material properties similar to human neurovasculature," *Journal of biomedical materials research. Part A*, 17-Sep-2021. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/34617389/. [Accessed: 13-Oct-2021].


The End