

Model for Pre-Surgical Intracerebral Hemorrhage Planning

Overview: The Phantom Brain

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Problem Statement

- It is difficult to characterize brain clots before removal.
 - Characteristics of different clots vary.
 - The differences in rigidity can affect the clinical approach used.
- A possible solution to this is a gel model that simulates the interior of the brain with various clots.



Background Material

- Currently not a lot is done for people with ICH besides stabilization.
- Other work has been done with brain phantoms, but nothing that we have found with the rigidity of brain clots.
- Two main methods of evacuating clots (drug based & evacuation)



PDS

- The phantom needs to mimic the structure and rigidity of a brain.
- White matter, gray matter, clots, and CSF.
- Durable for a long period of time.
- The Phantom must be able to handle powerful magnetic fields (no metal).
- represent a brain?

Biomaterial Design Matrix

Criteria	Alginate		Agarose		Gelatin	
Ease of Fabrication (25)	4/5	20	4/5	20	5/5	25
Biomimicry (25)	5/5	25	4/5	20	2/5	10
Cost (15)	4/5	12	4/5	12	5/5	15
Duration (15)	2/5	6	3/5	9	1/5	3
Thermostability (10)	5/5	10	3/5	6	1/5	2
Safety (10)	4/5	8	4/5	8	5/5	10
Total (100)	81		75		65	

Alginate

Criteria	Alginate	
Ease of Fabrication (25)	4/5	20
Biomimicry (25)	5/5	25
Cost (15)	4/5	12
Duration (15)	2/5	6
Thermostability (10)	5/5	10
Safety (10)	4/5	8
Total (100)	81	

- Structurally similar to human tissue
- Very biocompatible
- Low toxicity
- Easy to make
- Customizable

Agarose

Criteria	Agarose	
Ease of Fabrication (25)	4/5	20
Biomimicry (25)	4/5	20
Cost (15)	4/5	12
Duration (15)	3/5	9
Thermostability (10)	3/5	6
Safety (10)	4/5	8
Total (100)	75	

- High gel strength
- Nontoxic
- Thermoreversible
- Cannot handle high temperatures



Gelatin

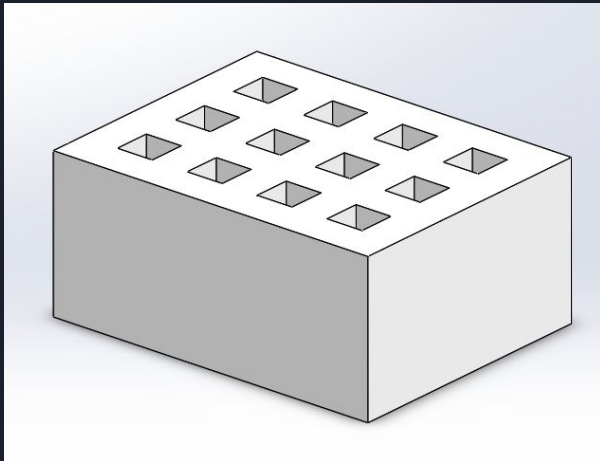
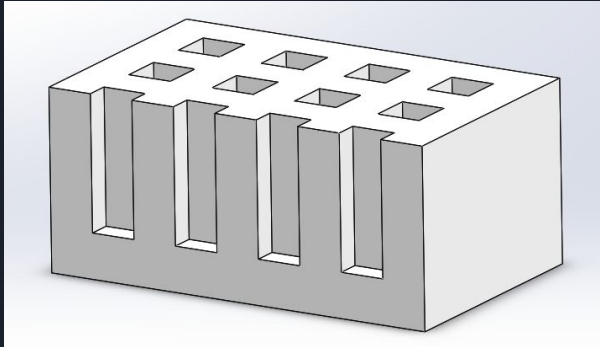
Criteria	Gelatin	
Ease of Fabrication (25)	5/5	25
Biomimicry (25)	2/5	10
Cost (15)	5/5	15
Duration (15)	1/5	3
Thermostability (10)	1/5	2
Safety (10)	5/5	10
Total (100)	65	

- Easy to make
- Cheap (\$8/kg)
- Safe
- Doesn't have as good properties.
- Poor thermostability

Container Design Matrix

Criteria	Brain Model with 3D Case		Anatomically Correct Model with CSF Fluid		Simple Container	
Compatibility with US and MRI (25)	4/5	20	5/5	25	4/5	20
Ease of Fabrication (20)	2/5	8	2/5	8	3/5	12
Accurate Stiffnesses (20)	5/5	20	4/5	16	4/5	16
Ease of Use (15)	4/5	12	2/5	6	5/5	15
Ability to Hold Multiple Clots (10)	4/5	8	4/5	8	5/5	10
Compactness (10)	5/5	10	4/5	8	4/5	8
Total (100)	78		71		81	

Simple Container



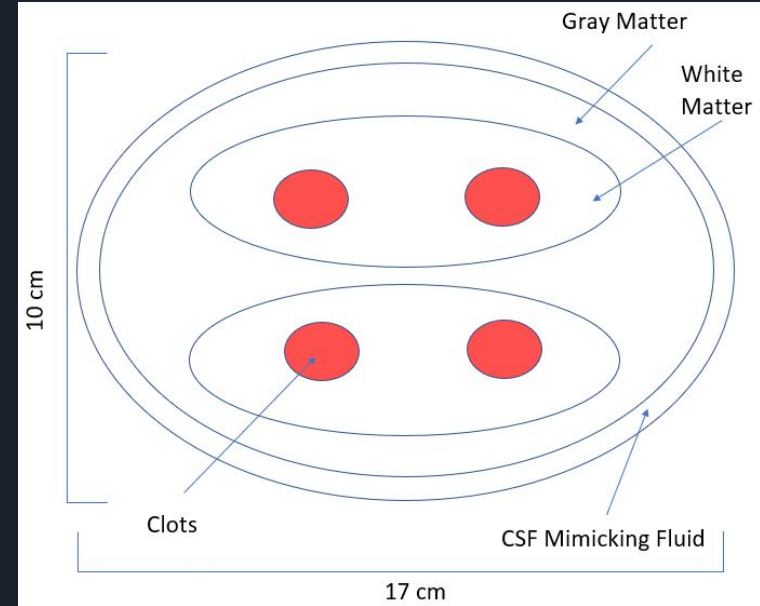
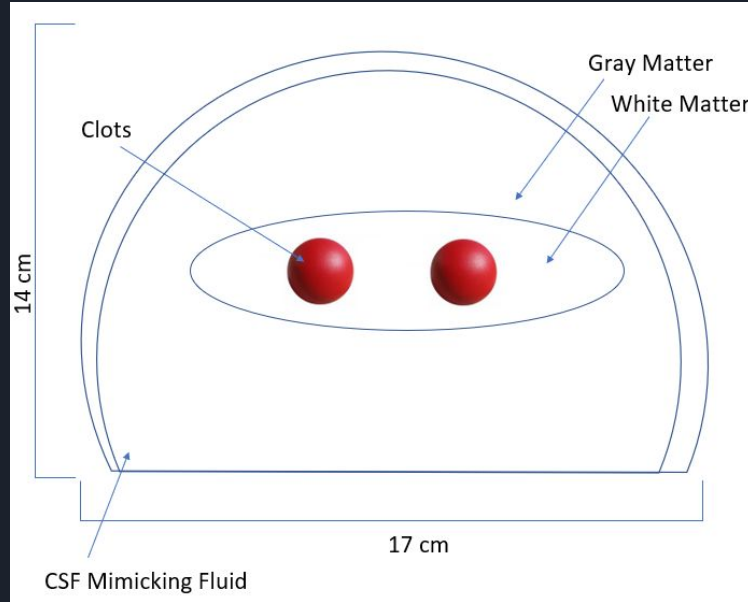
Criteria	Simple Container	
Compatibility with US and MRI (25)	4/5	20
Ease of Fabrication (20)	3/5	12
Accurate Stiffnesses (20)	4/5	16
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Compactness (10)	4/5	8
Total (100)	81	

Anatomical Model with CSF Fluid

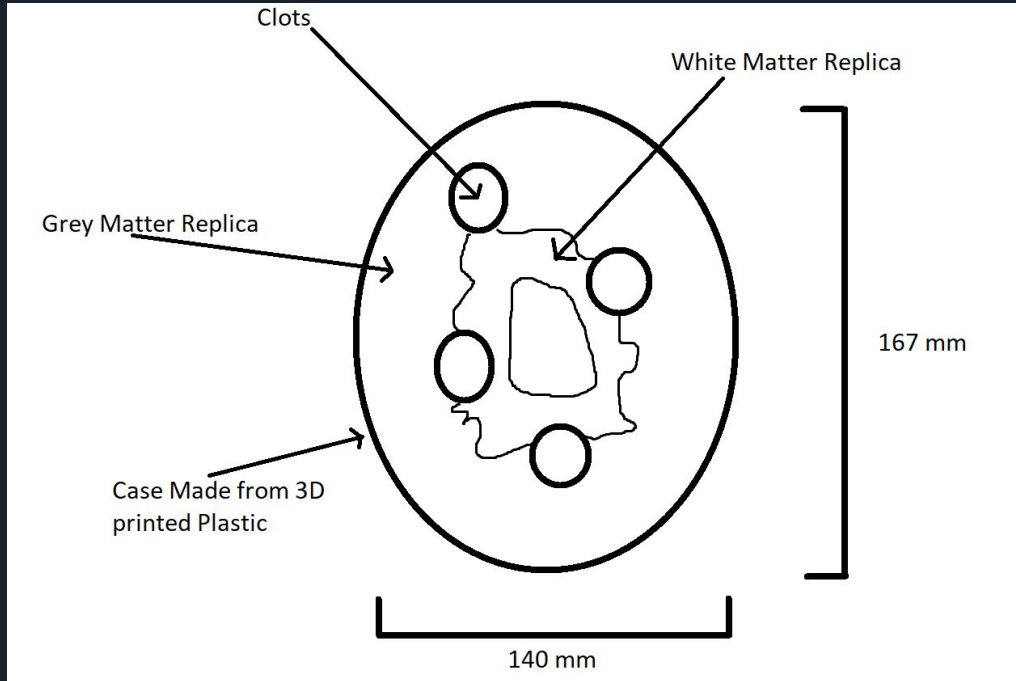
Anatomically Correct Model with CSF Fluid

5/5	25
2/5	8
4/5	16
2/5	6
4/5	8
4/5	8

71



Brain Model with 3D Case



Criteria	Brain Model with 3D Case	
Compatibility with US and MRI (25)	4/5	20
Ease of Fabrication (20)	2/5	8
Accurate Stiffnesses (20)	5/5	20
Ease of Use (15)	4/5	12
Ability to Hold Multiple Clots (10)	4/5	8
Compactness (10)	5/5	10
Total (100)	78	

Future Work

- Fabricate & Test Alginate
 - Various stiffnesses
- Create First Clot Models
- Integrate Clots in to “Brain” Matter
- Create a final model
 - Resembles Brain
- Increase accuracy of materials
 - T2 measurements
 - Biomimicry



<https://www.biodex.com/nuclear-medicine/products/phantoms/hoffman-3-d-brain-phantom%e2%84%a2>



References

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[3] Leibinger, A., Forte, A., Tan, Z., Oldfield, M., Beyrau, F., Dini, D. and Baena, F. (2014). *Soft Tissue Phantoms for Realistic Needle Insertion: A Comparative Study*. [online] NCBI. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4937066/> [Accessed 3 Oct. 2019].

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