Head Holder for MR-Guided Drug Delivery

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Outline

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Convection-Enhanced Drug Delivery (CED)

- Deliver drugs directly into brain tissue via continuous infusion through intracranial catheters [1]

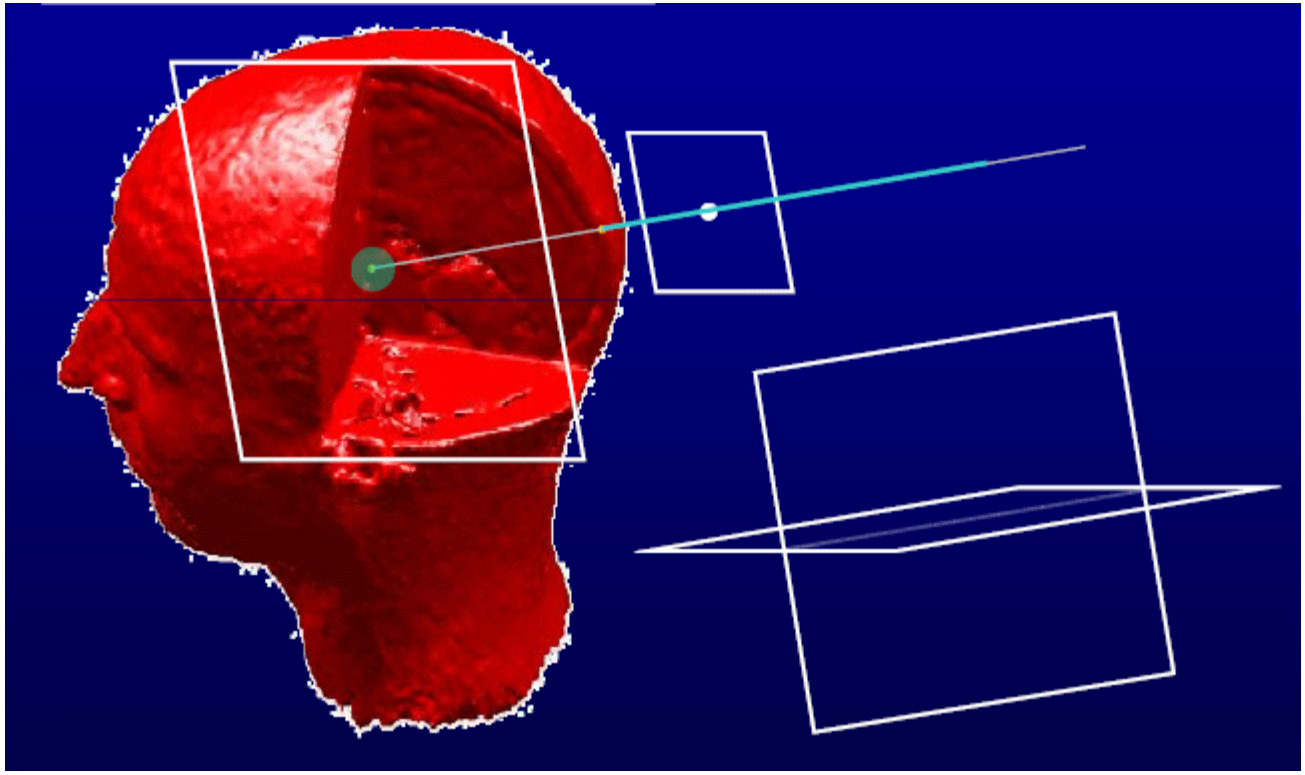


Figure 1: Sketch of CED [2].

CED (cont.)

- Target specific site → Achieve high localized drug concentrations
  - Overcome blood brain barrier
  - Avoid systemic toxicity
- Many variables: More research needed
- Difficult to monitor convection → add MRI contrast agents to injection → observe injection with MRI [1]

Magnetic Resonance Imaging (MRI)

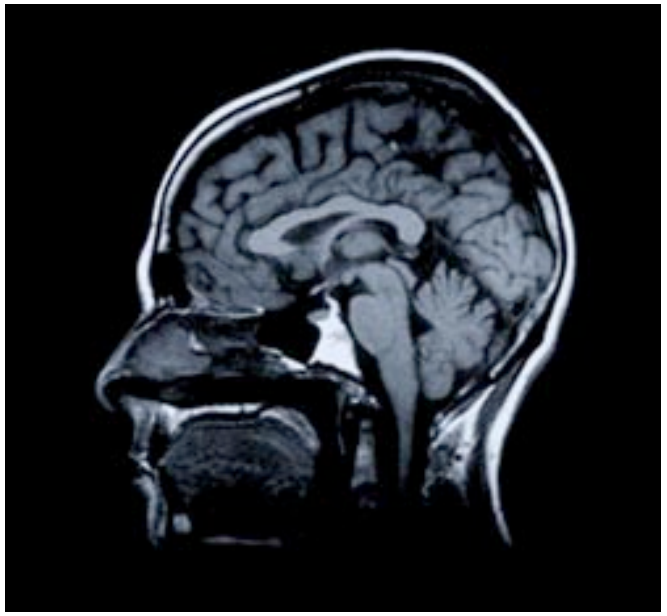


Figure 2: MRI scanner [3] and MRI image of brain [4].

- Commonly used clinically to image soft tissues
- Uses large magnetic fields to excite protons, measures response, creates high contrast images

Current Head Holder

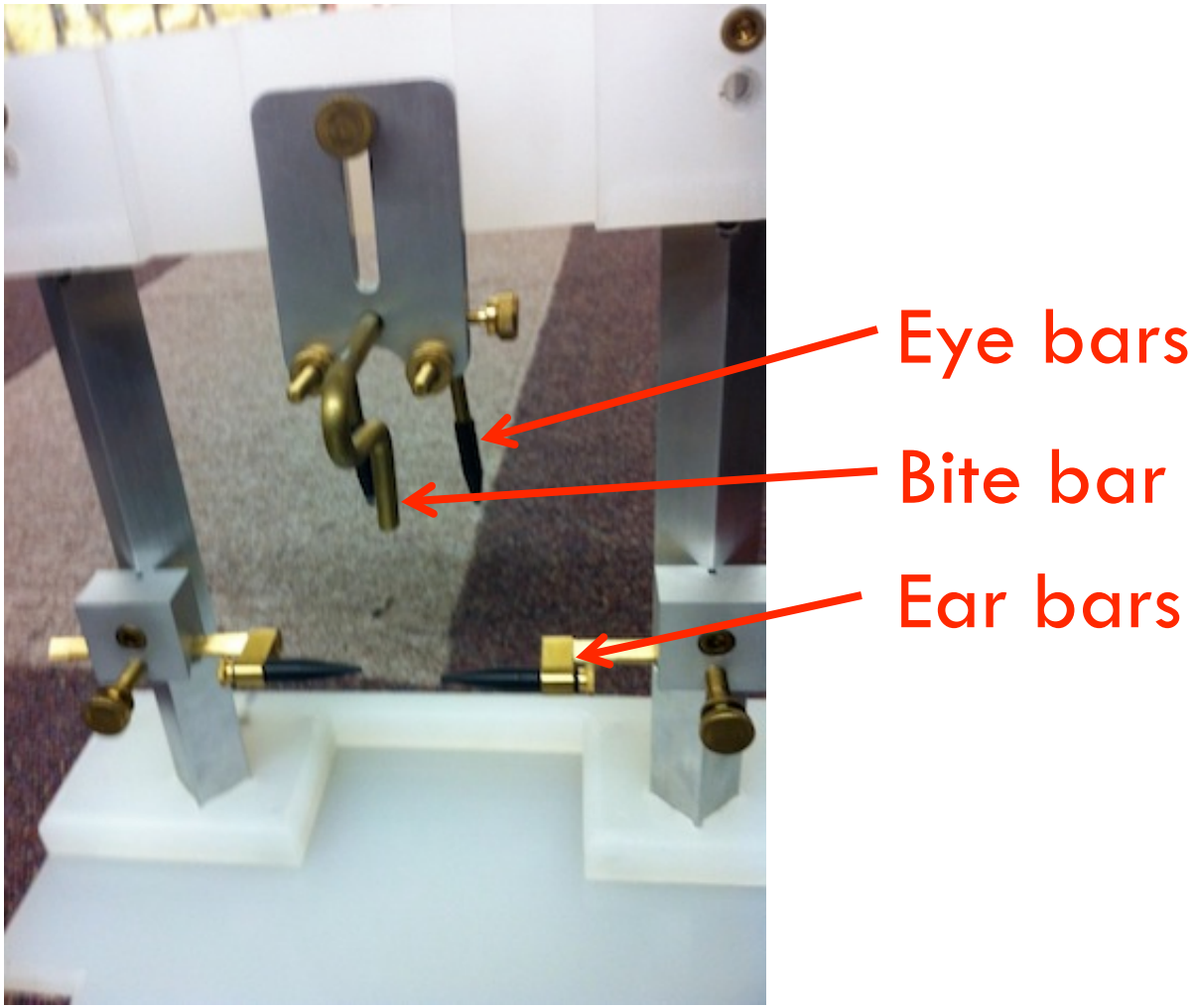


Figure 4: Current head holder. Photo taken by Hope Marshall [5].

Problem Statement

- Software requires use of MRI antenna array
- Current head holder uses ear bars
  - Interfere with antenna array

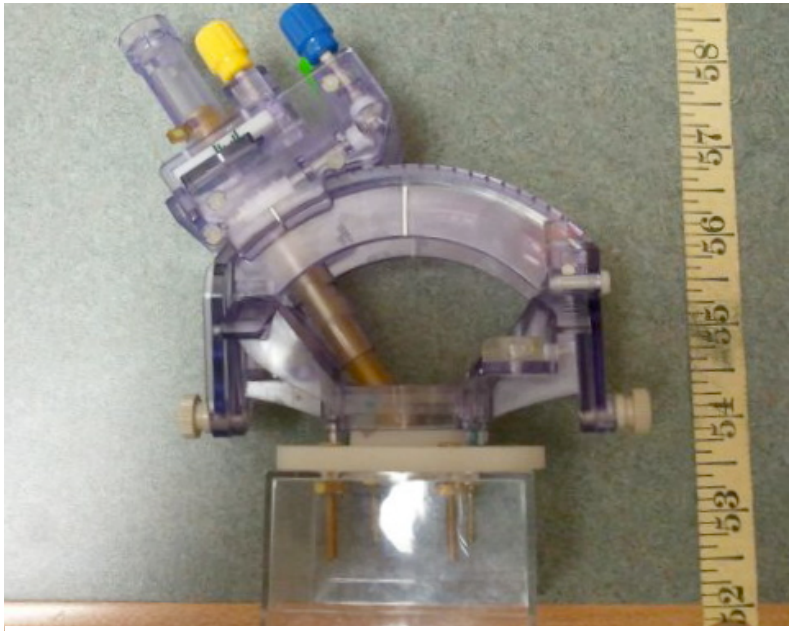


Figure 5: MRI Interventions Port. Photo taken by Kevin Beene [6].

Figure 6: Carotid coils. Photo taken by Kevin Beene

Design Criteria

- MRI Compatible
  - Non-ferrous materials
  - Fit in MRI bore (34 cm x 60 cm)
- Compatible with experimental setup
  - MRI antenna array
  - MRI Interventions port
  - Breathing tube
- Restrict translational movement to 1mm
- Adjustable based on testing subject

Eye Bar Design

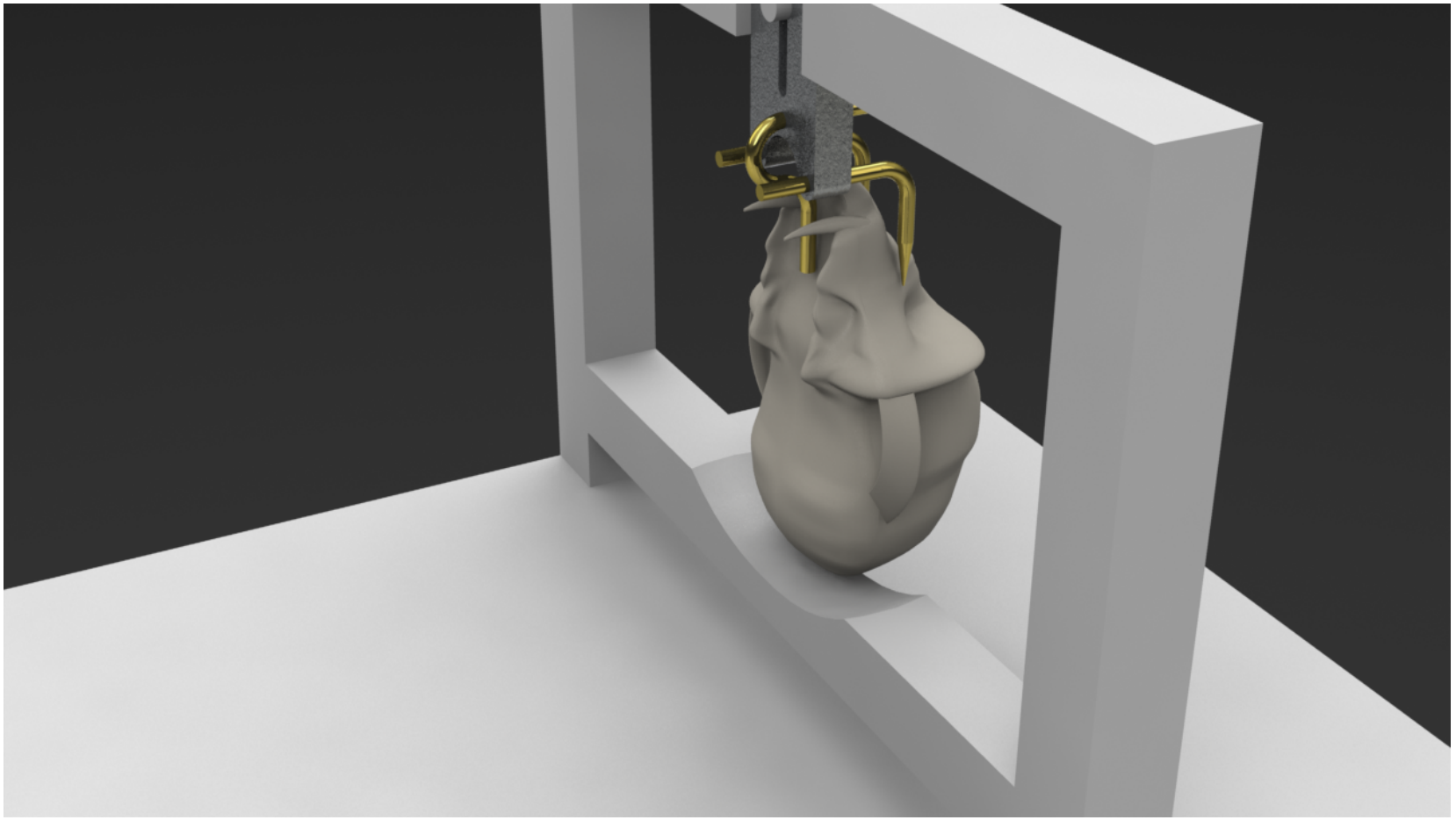
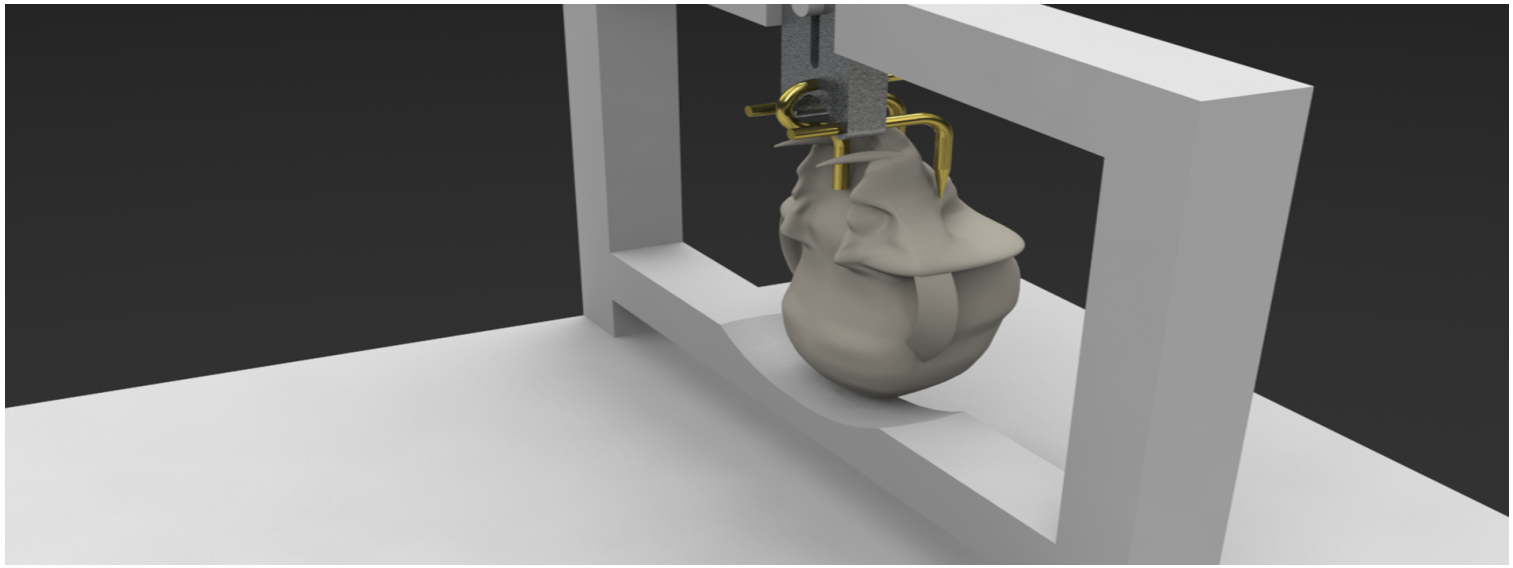


Figure 7: SolidWorks drawing of Eye Bar design. Drawing created by Gabe Bautista [7].

Eye Bar Design (cont.)

- Pros
  - Components from standard design
  - Durability
- Cons
  - Ease of construction
  - Uncertain accuracy



Band/Track Design

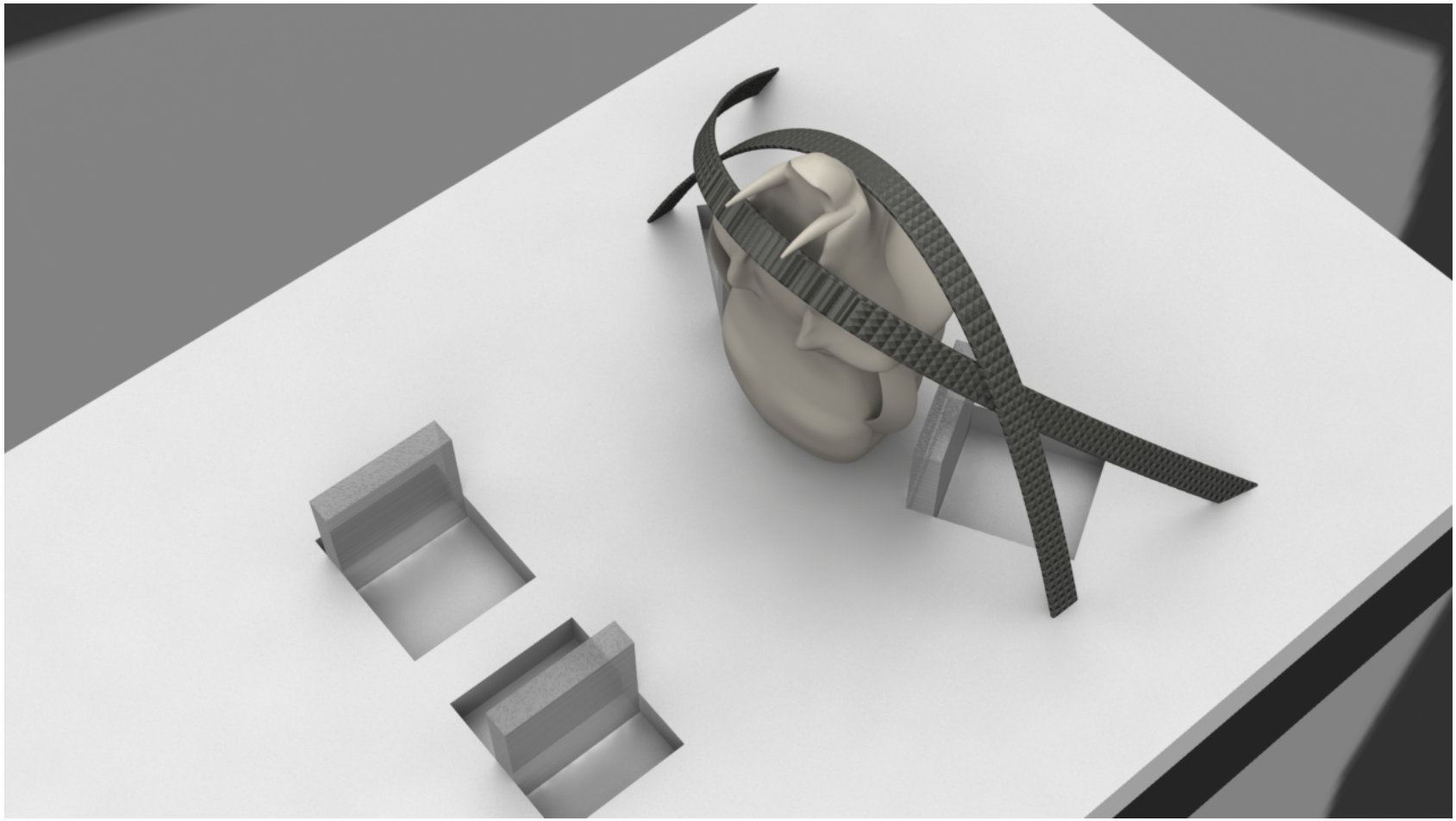
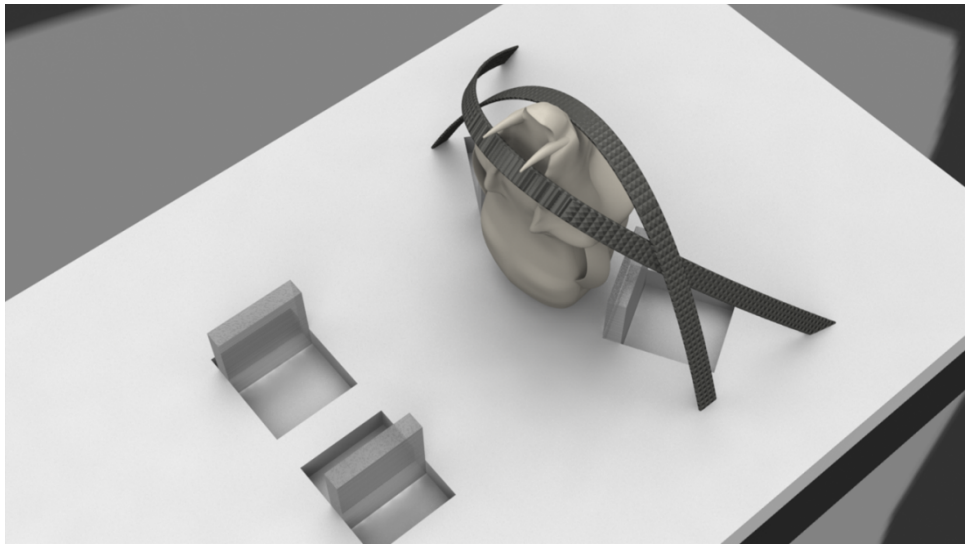


Figure 8: SolidWorks drawing of Band/Track design. Drawing created by Gabe Bautista [7].

Band/Track Design (cont.)

- Pros
  - Band stabilizes z direction
  - Adjustments
    - Accuracy
    - Versatile
  - Low cost
  - Easy to use
    - Quick adjustments
- Cons
  - Durability of band material
  - Manufacturability



Fork Support Design

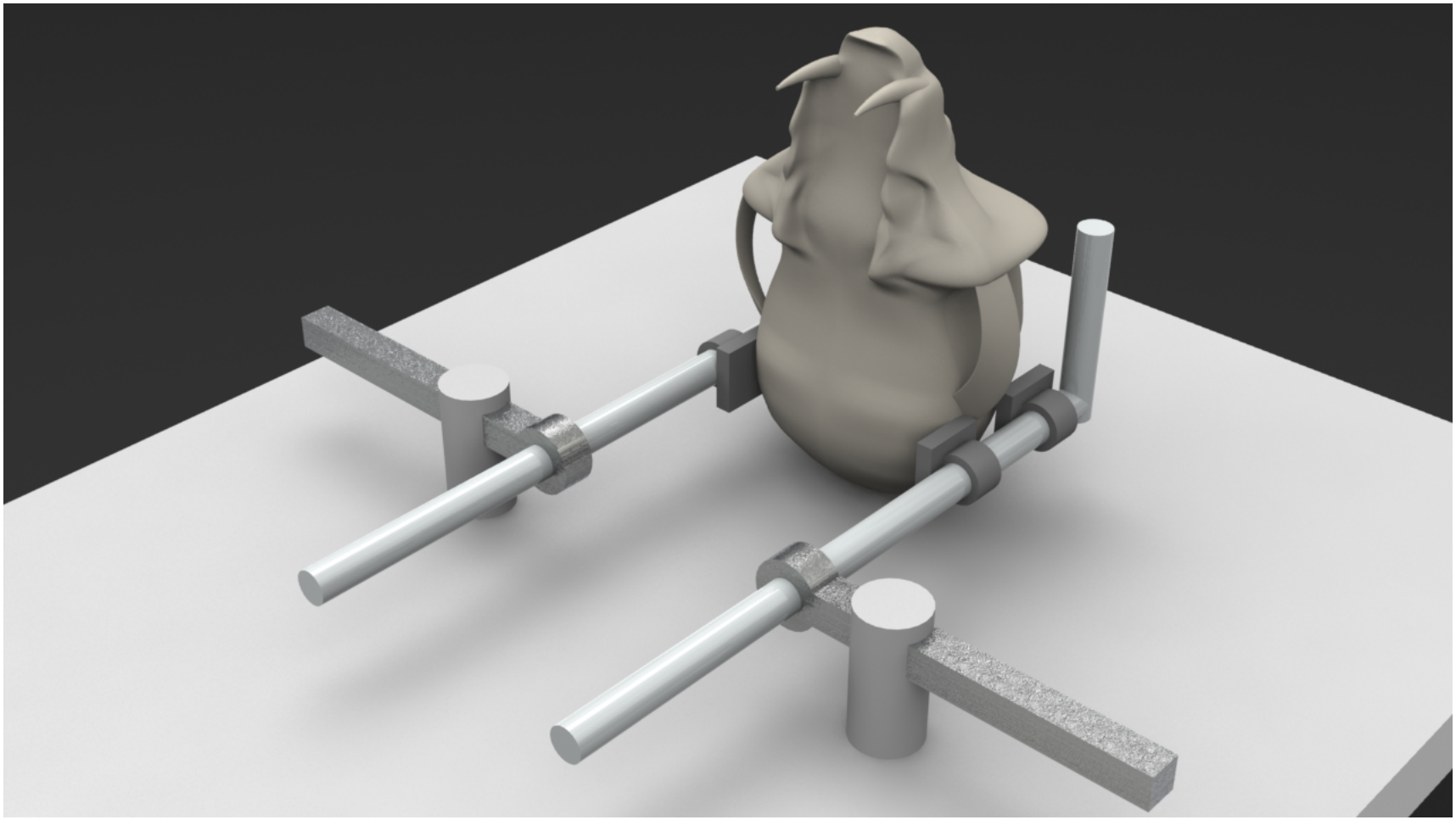
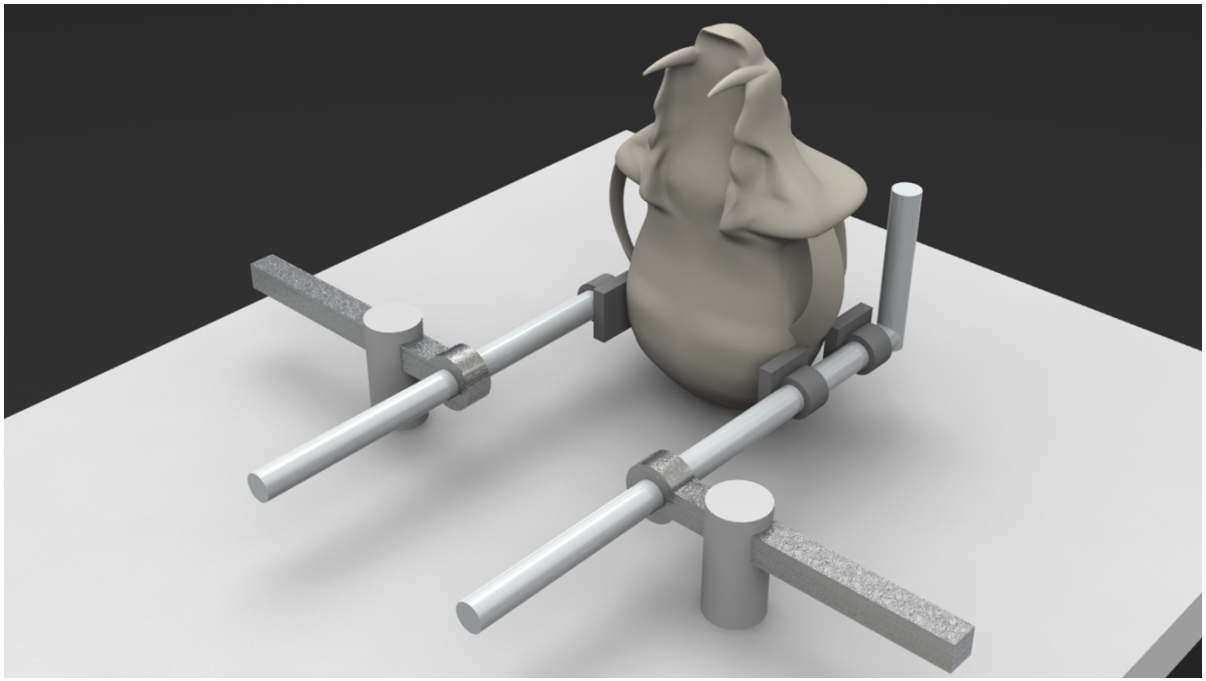


Figure 10: SolidWorks drawing of Fork Support design. Drawing created by Gabe Bautista [7].

Fork Support (cont.)

- Pros
  - Cost
  - Durability
    - Strength of material
- Cons
  - Ease of construction
  - Safety of animal
    - Uncertain accuracy



Design Accessories

- Water markers for alignment in MRI
- Head elevation system

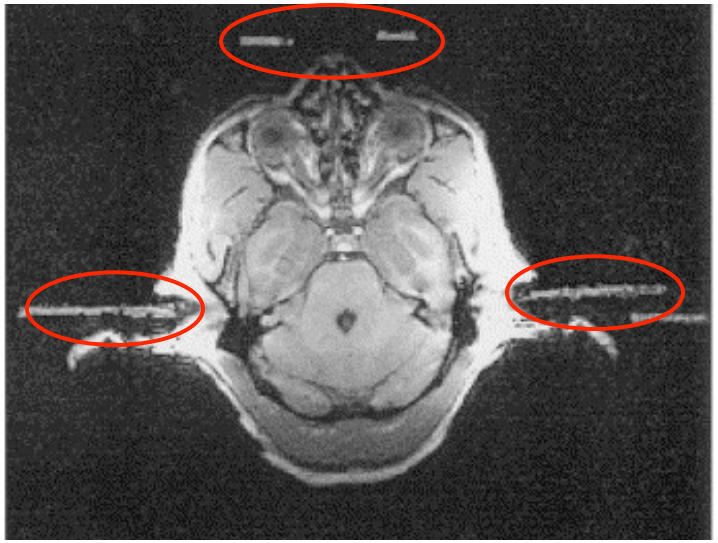


Figure 11: MRI with markers in ear bars [8].

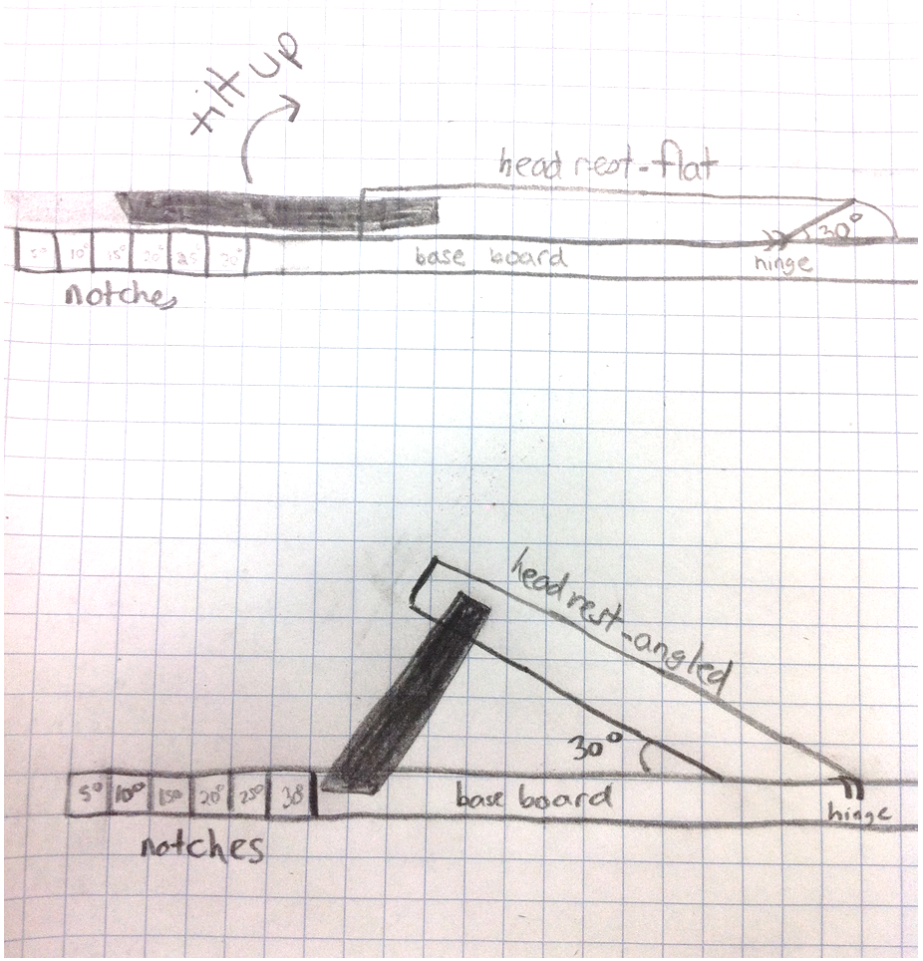
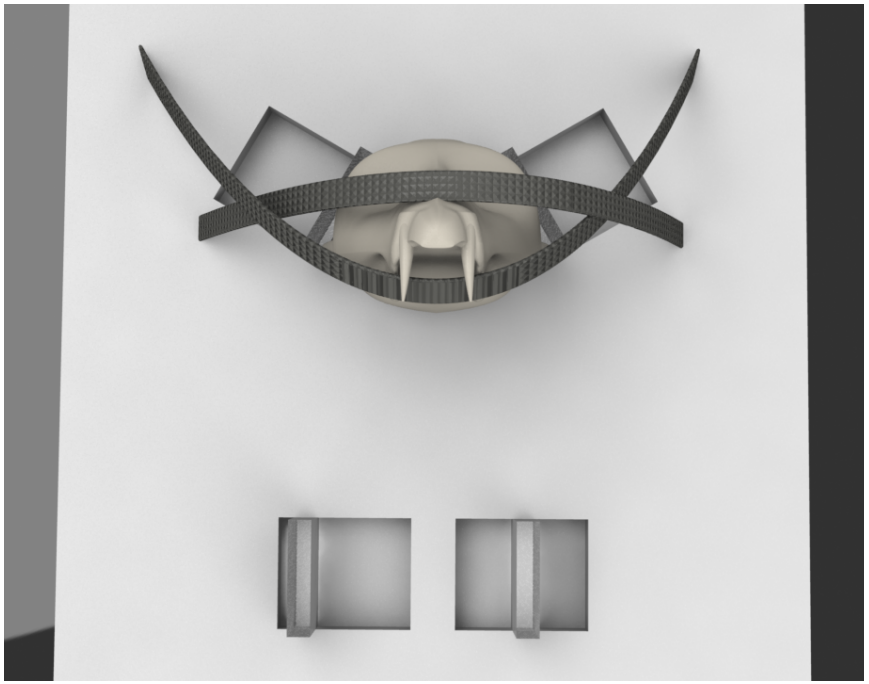


Figure 12: Head elevation system [9].

Design Matrix

	Weight	Band/Track Design	Fork Support	Eye Bar Design
Cost	10%	10	8	8
Ease of Construction	15%	12	12	6
Ease of Use/ Ergonomics	20%	20	16	16
Durability	25%	15	20	25
Margin of Error	30%	30	12	24
TOTAL	100%	87	68	79

Final Design



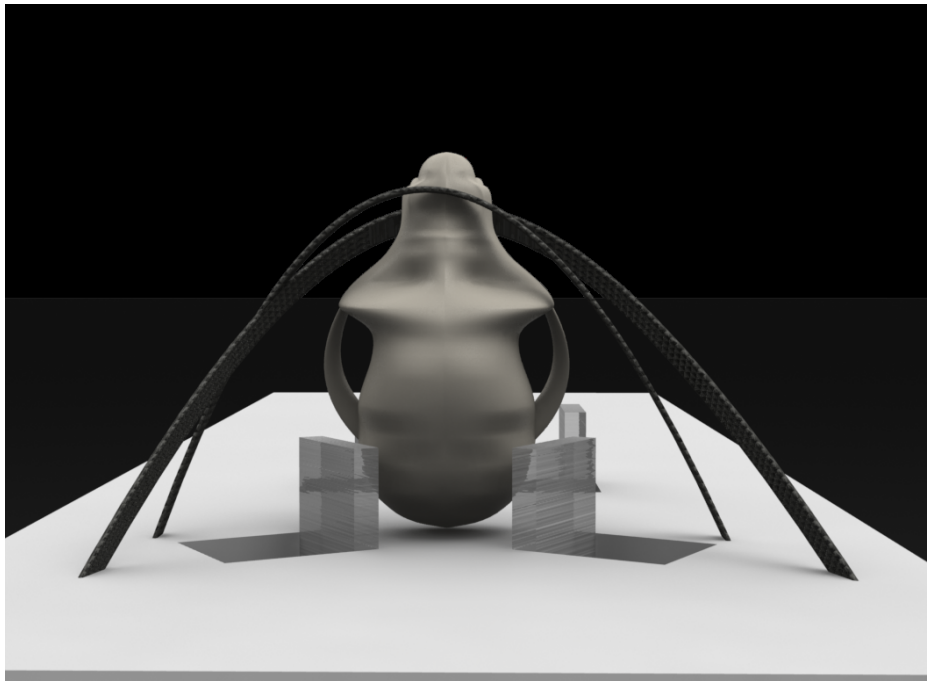


Figure 13: SolidWorks drawings of the final design. Drawings created by Gabe Bautista [7].

Future Work

- Meet with veterinarian to determine safety of final design
- More detailed SolidWorks models
- Begin constructing the final design
  - Obtain necessary materials
- Testing
  - In vivo testing
  - Assess accuracy of device

Acknowledgements

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- Nikki Goecks (collaborator)
- Ethan Brodsky (collaborator)
- Chris Ross (collaborator)
- Professor Yen (advisor)

References

[1] Mardor Y, Rahav O, Zauberman Y, et al. "Convection-Enhanced Drug Delivery: Increase Efficacy and Magnetic Resonance Imaging Monitoring." *Cancer Res* 2005; 65: 6858-6863.

[2] Brodsky EK, Block WF, Alexander AL, Emborg ME, Ross CD, and Sillay KA. "Intraoperative Device Targeting Using Real-Time MRI." *IEEE Biomedical Sciences and Engineering Conference (BSEC)*, 2011. https://www.ornl.gov/bsec_conferences/2011/presentations/Brodsky.pdf

[3] Innov8: Medical Equipment Innovators. http://www.usedctscannersandmri.com/ge-ct-mri.html

[4] Cedars-Sinai. "MRI Brain." 2011. http://www.cedars-sinai.edu/Medical-Professionals/Imaging-Center/Neuroradiology/MRI-Brain.aspx

[5] Marshall H. Current Head Holder. Photo. 2012.

[6] Beene K. MRI Interventions Port and Carotid Coil. Photos.

[7] Bautista G. SolidWorks Drawings of Designs. Photo. 2012.

[8] Baker SN, Philbin N, Spinks R, Pinches EM, Wolpert DM, MacManus DG, Pauluis Q, and Lemon RN. "Multiple single unit recording in the cortex of monkeys using independently moveable microelectrodes." *J Neurosci Methods*. 1999 Dec 15; 94(1): 5-17

[9] Marshall H. Head Elevation Mechanism. Photo. 2012.

Questions?