Mouse Positioning Device for Longitudinal Cancer Research

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Abstract

The Small Animals Imaging Lab at the Wisconsin Institutes for Medical Research uses a Siemens Inveon micro PET/CT scanner to identify the locations of cancerous growths within the body of an animal model. During some scans, mice must be secured to the scanner bed with their limbs restrained and their noses secured in a nose-cone. Lab personnel currently restrain mice by taping them to a rectangular cardboard bed, which is then taped to the carbon fiber scanner bed. The lab needs a more precise, hassle-free device for restraining mice during scans that would allow personnel to accurately reposition mice for serial scans in a timely manner. The new design is simple and consists of a grid-like peg system made from ABS plastic. With this device, the animal is restrained by placing a horseshoe peg around each limb and three horseshoe pegs around the body. The average time for animal placement is less than three minutes and the reproducibility of each scan is less than a millimeter.

Need for a New Method

- UW Carbone Cancer Center and Small Animal Imaging Lab
- Animal models used as a mechanism for understanding human cancer detection and screening
- Serial scans over a period of 2-3 weeks
- Scans are compared to track differences in cancerous growths
  - Registration process is inefficient when animal position is not replicated
  - Time is wasted on registration and is not used for analyzing results
  - Repositioning with current method is not accurate enough for a serial study

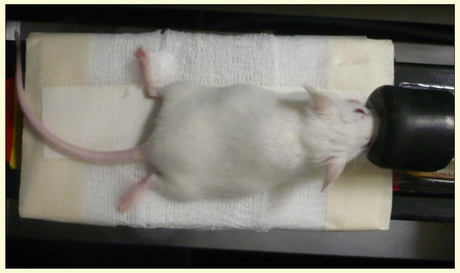

Figure 1. Current restraining method for mouse model used in longitudinal cancer studies.

Animal Restraint Systems

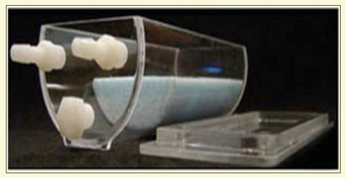

Figure 2. Mouse Imaging Chamber from Numira [1].

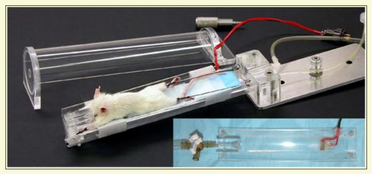

Figure 3. Custom Imaging Chamber [2].

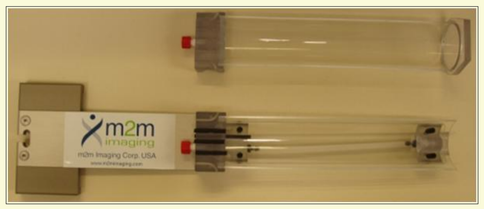

Figure 4. m2m Imaging Chamber [3].

Design Criteria

- Restrains mouse in case anesthesia fails
- Replicates position within 1 mm
- Positioning of animal takes 5-10 minutes
- Minimize interference with PET/CT imaging by using a material with Hounsfield Unit less than 40
- Easy to clean, no permanent cloth
- Attaches to existing carbon fiber bed
- Multiple scans of 3-10 mice over multiple 2-3 week periods
- $100 budget

New Positioning Device

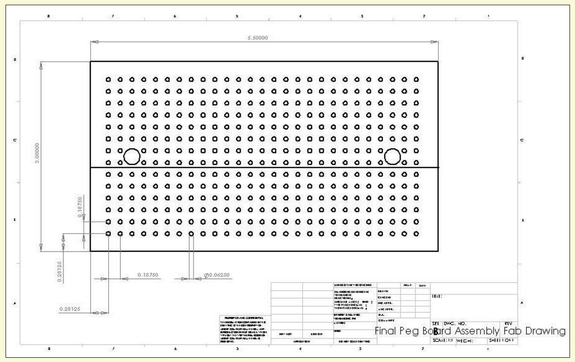

Figure 5. SolidWorks drawing of Final Design

ABS Peg Board Dimensions

- Length: 5 1/2”
- Width: 3”
- Thickness: 1/8”
- Peg hole diameter: 1/16”
- Peg hole spacing: 1/8”

Peg Attachments

- 1/16” dia. plastic cord with ends sanded to fit in holes
- 3/16” dia. orthodontic elastic bands glued to pegs to restrain animal’s limbs
- 1/4” pegs attaching device to carbon fiber bed

Method of Animal Restraint

- 4 small pegs will restrain the mouse’s arms and legs
- 3 large pegs will restrain the mouse’s body
- Peg position will be noted using the letter-number coordinate system for body position replication
- Groove in the center of device allows for animal repositioning

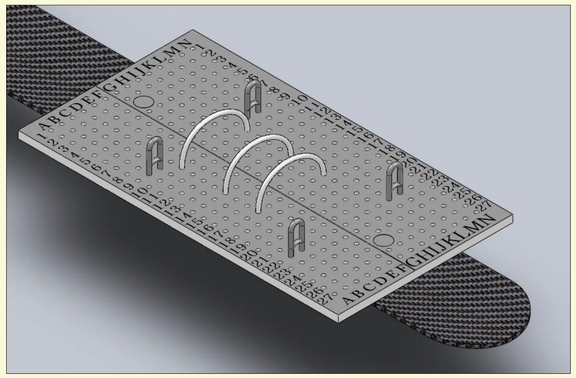

Figure 6. SolidWorks Model of Final Design

Figure 7. Mouse positioned on final device prior to CT scan.

Device Attachment to Scanner Bed

- One peg 11/16” from the top of the device and another the same distance from the end of the device
- Pegs fit into connectors that have been glued to scanner bed
- Board is not raised to prevent any type of rotation

Cost Analysis

- $1.66 per prototype

Testing Results

Table 1. Hounsfield Units for common materials and those used in the device.

Material	Attenuation Coefficient (HU)
Air	-1024
Carbon Fiber	-825
ABS Plastic	-800
Soft Tissue	-200
Water	0
Plastic Pegs	40
Bone	> 400

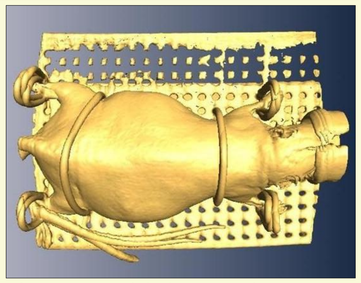

Figure 8. Model of mouse after registration of three separate scans.

Table 2. Repositioning comparison of new device to past method. All measurements show significant improvements with the new device.

	Translation (mm)		Distance (mm)	Rotation (degrees)		
	X	Z	X-Z	X	Y	Z
Past Method	1.67±0.83	3.31±4.10	3.88±4.01	0.90±1.50	2.62±2.66	1.44±2.20
New Device	0.15±0.12	0.82±1.55	0.93±1.49	0.07±0.11	0.15±0.30	0.25±0.25

- The average time for mouse positioning of eight scans was 2 minutes and 49 seconds.

Future Considerations

- To obtain 95% power, complete at least 29 serial scans with new device
- Design and fabricate heating mechanism compatible with new device
  - Half cylinder dome which is compatible with any board
  - Thermoregulation system which monitors air temperature
  - Incorporates anesthesia tubes
- Small box to hold pegs which attaches to scanner
- Make larger device for use with rats
- Further test attachment time and compare to previous method
- Test if device restrains mouse effectively
- Test durability of pegs

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References

[1] "Multi-Modality Imaging Chamber." Numira Biosciences. Numira Biosciences. 9 Oct. 2009 <http://www.numirabio.com/carousel.html>.

[2] Chow, Patrick L., David B. Stout, Evangelia Komisopoulou, and Arion F. Chatziioannou. "A Method of Image Registration for Small Animal." Physics in Medicine and Biology (2006): 381-83.

[3] "Split Top Mouse Chamber for Preclinical Imaging Systems." m2m Imaging. 13 Oct. 2009 http://www.m2mimaging.com/index.html.