

A QA device for checking the gating function of Gamma Knife's HDMM system

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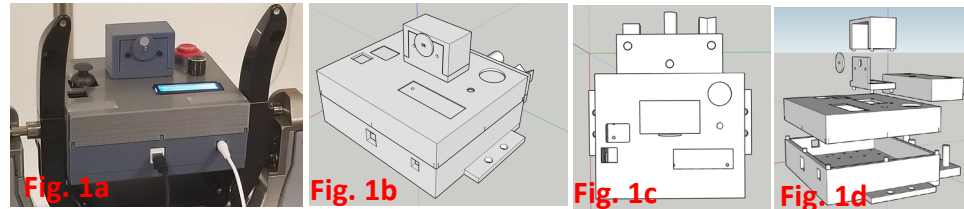
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Introduction:

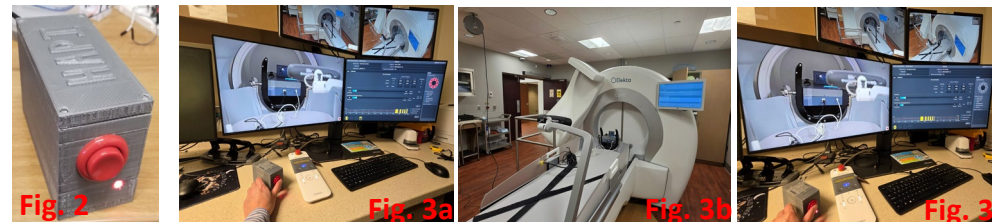
- Gamma Knife's High-Definition Motion Management (HDMM) system is a key device for monitoring a patient's motion and automatically manage the radiation beam to be on and off (gating) during mask-based Gamma Knife radiosurgery. When a patient's motion exceeds the preset tolerance, the radiation beam is automatically shut off while the patient swings back within the tolerance window, and the radiation beam is automatically resumed.
- The HDMM system has a built-in feature - in either of the following circumstances the Gamma Knife unit will automatically pause the treatment, and the couch will move out to home position outside the shielding door for the treatment team to check the patient's position: (1) at the sixth time the patient deviates from the treatment position and beyond the tolerance, or (2) if the patient has deviated beyond the tolerance from the treatment position continuously for 30 seconds.
- Performing routine Quality Assurance (QA) checks on this gating function of the HDMM system is crucial for the safety and the success of the treatment. Currently there is not a QA device available on the market, nor a user-friendly device provided by the manufacturer to perform this QA easily.
- We invented a device dedicated to performing the routine QA check on the gating function of the Gamma Knife HDMM system.

Method and Materials:

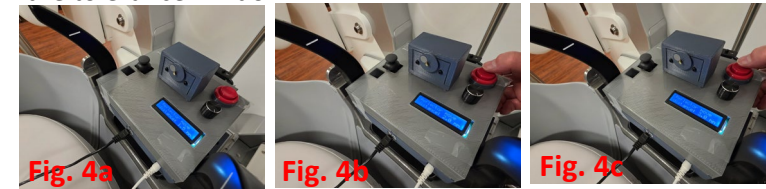
- The QA device was designed and built with two major components as shown in **Fig. 1**: (1) *the motion simulator* (**Figs. 1a, 1b, 1c, 1d**), and (2) *the deviation controller* (**Fig. 2**). The base of the motion simulator has two holes on the left and right side so that the motion simulator can be buckled with the mask adapter to immobilize the device during a simulation treatment process. **Figs. 1b and 1c**: the 3D printing schematics of *the motion simulator*: diagonal and top views. **Fig. 1d**: the CAD schematics of *the motion simulator*: the base, the top, the top and bottom housing the motor, the disk, and the mask adapter attachment.



- *The deviation controller* (**Fig. 2**) is located outside the treatment vault near the treatment console. It is run by the operator to control the reflector/sticker to be moved outside or within the preset HDMM tolerance window: press the red button once, the reflector/sticker jumps outside the tolerance window; and then pressing the red button again, the reflector/sticker swings back within the tolerance window. The communication between *the motion simulator* and *the deviation controller* is carried out through an ethernet cable, as shown in **Figs. 3a, 3b, and 3c**.



- The red button on *the motion simulator* (**Figs. 4a, 4b, and 4c**) can be used to preset the reflector/sticker deviated by 1.5 mm, 2.0 mm, and 3 mm. *The motion simulator* has been calibrated so that the distance is accurate. While the tolerance window can be chosen in the HDMM system on the treatment console computer monitor, pressing *the deviation controller's* red button can swing the reflector/sticker outside and back within the tolerance window.



Results and Summary:

- The invented QA device has the capability to easily test the two crucial built-in HDMM gating functions: (1) at the sixth time the patient deviates from the treatment position and beyond the tolerance, or (2) if the patient has deviated beyond the tolerance from the treatment position continuously for more than about 30 seconds.
- The device has been used for about 4 years in our Gamma Knife routine QA checks. Our experience indicates that the performance of this user-friendly device is excellent and it is worth commercialization and recommendation to the Gamma Knife community.

References

- US Patent App. 19/107,370. Title: Methods and systems for measuring and controlling radiosurgery systems. J Mathews, L Lu, M MEINEKE, N GUPTA.
- US Patent App. 19/107,370. Publication of US20260054097A1 (2/26/2026).