Introduction
Magnetic Resonance High Intensity Focused Ultrasound (MR-HIFU) is a noninvasive medical procedure which uses focused energy to heat up and eliminate tumors without surgery (Fig. 1).

Treatment workflow (Fig. 2) is as follows:
1. Clinician selects region of the tumor to be treated, also known as sonication areas, on a 3D MRI image.
2. As each sonication area is treated, temperature and thermal dose data is collected and displayed.
3. Success of the treatment is verified through analysis of regions without blood flow, suggesting tumor death.

Results

Objective
Previous System:
- MR-HIFU treatment phase 2, or the display of thermal dose data, is accurate when all of the sonications areas are in the same plane, with similar orientations (Fig. 3).
- It cannot display total thermal dose for more complicated treatment plans which span multiple planes

The goal of this project is to display thermal dose for all sonications at once in a 3D dataset to reduce the risk of burns or undertreatment.

Methods
A MATLAB algorithm was created which:
1. Acquires 3D MRI base images, thermal dose data, and orientation information for each sonication area
2. Rotates and positions thermal dose heat maps over the 3D MRI dataset
3. Uses the shape of the tumor to calculate the portion of the tumor that has been heated to a lethal level and how much off-target heating occurred

This algorithm was tested on the data of 7 pediatric patients within an ongoing clinical trial.

Discussion

- To further improve this algorithm, it is necessary to increase the sample size, correct for estimation errors within the algorithm, and fully automate retrieval of images and position data.
- Moving forward, this project has the potential to analyze where burns or undertreatment have occurred and determine why.
- It can be used to correct the inadequacies found in the current MR-HIFU system and improve the field of interventional radiology and noninvasive pediatric tumor ablation.

Conclusion
The algorithm created this summer improves MR-HIFU treatment guidance by displaying:
- The 3D MRI images of the tumor
- Total tumor volume
- Volume of areas that have no blood flow after treatment, suggesting tumor death
- This 3D dataset can be utilized to:
  - Quantify effectiveness of treatment
  - Calculate any off target heating that may have occurred (Table 1)

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References