Low-profile remote targeting alignment tool for use in MR-guided rigid device insertion

Benjamin Grabow[1], Chris Ross[2], Ethan Brodsky[1], Ken Kubota[3], and Walter Block[1]
[1]*Medical Physics, University of Wisconsin, Madison, WI, United States,* [2]*Engineering Resources Group, Inc, Hialeah, FL, United States,* [3]*Kinetics Foundation, Los Altos, CA, United States*

TARGET AUDIENCE
This work will appeal to those interested in MR-guided interventional procedures, particularly in the neurological field.

PURPOSE
MRI has been recently adapted to the task of trajectory guidance for neurosurgical rigid device insertion procedures, including convection enhanced delivery (CED). Real-time manipulation of simple FDA-approved MR-compatible ball-and-pivot joint brain port allows for fast and intuitive alignment of rigid infusion catheters. We have previously presented work with these systems, but performing these procedures can be challenging due to limited access to the patient when at the center of the bore in scanners not specifically designed for interventional use. Our previous work involved a system that requires the interventionalist to reach into the center of the bore and manually move a MR-visible aiming guide (Fig. 1). We have now developed a hardware system that enables remote manipulation of the guide without reaching into the bore.

MATERIALS AND METHODS
The interventional apparatus was a rigid catheter aimed and inserted through the Navigus pivot-point-based aiming system (Medtronic; Minneapolis, MN), which includes a skull-mounted ball-joint pivot base and an MR-visible external trajectory guide. In preparation for a rigid device insertion in the brain, a small burr hole is drilled in the subject's skull and the pivot base is affixed with titanium screws. An MR-visible alignment stem is inserted into the ball and socket base, permitting two degrees of rotational freedom. Previously this stem was manipulated directly by an interventionist reaching into the center of the bore. Our primary addition to this system is a low-profile Remote Targeting Alignment Tool (RTAT) which attaches to the Navigus ball and socket base, and is actuated via copper cable mechanical linkage to a two-axis remote control. The RTAT, shown in Figures 2 and 3, is attached using a friction lock-ring and provides additional reinforcement to hold the alignment stem and catheter insertion apparatus in place once the trajectory has been set.

We use a previously demonstrated a real-time MR guidance software platform [1] to identify a target location within the brain and prescribe a corresponding insertion trajectory. The system automatically calculates physical scan location for a real-time "aiming plane" perpendicular to the desired trajectory guide orientation and outside the body. This plane is automatically scanned with a real-time T_1-weighted GRE sequence that acquires a 20 cm FOV with 0.8 mm resolution in a 1.4 s scan time, with the desired guide position overlaid with a colored "aiming point" marker. The interventionalist stands outside the magnet bore and adjusts the two knobs on the RTAT remote control to center the guide, either by monitoring its position on an in-room MR-compatible display screen or in response to vocal commands from an operator viewing a monitor in the control room. After aiming the device, a remote introducer is installed, a fused silica catheter is inserted and advanced to the indicated depth, and an infusion is performed, all while being monitored with real-time MR.

RESULTS AND DISCUSSION
This apparatus has been used to perform twenty targeted infusions in five animal subjects. Targeting time is under two minutes and radial accuracy of 1.5 mm has been maintained. The system has proven to be very robust, with no failures in operation, and is less sensitive to the skill of the operator compared to direct manual manipulation of the alignment guide. Without the RTAT it is extremely challenging for a person less than six feet tall to manually manipulate the alignment guide without disturbing table position, and the increased rigidity of the RTAT has reduced the likelihood of disturbing device alignment during the installation of the remote introducer, a problem we had repeatedly faced in earlier experiments.

CONCLUSIONS
Providing a means to manipulate the aiming apparatus without reaching into the bore has saved time and simplified performing interventional procedures.

REFERENCES
[1] Brodsky EK, *et al.*, Proc. IEEE BSEC 3:63 ('11)

Figure 1

Figure 2

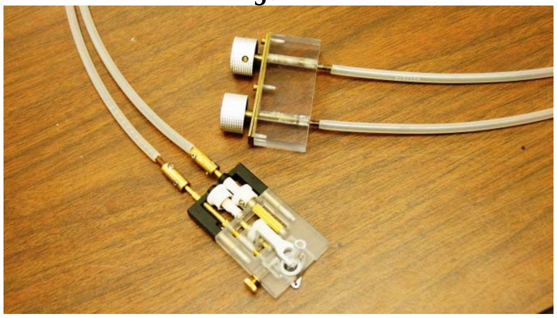

Figure 3

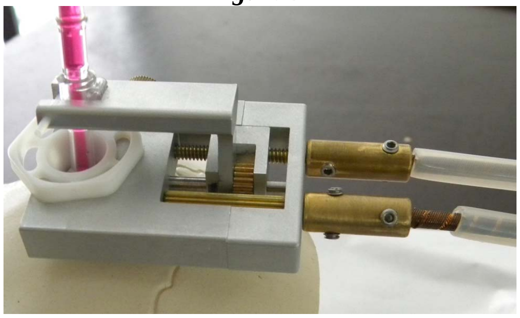

Figure 1*: We had previously been working with a system that required an interventionalist to reach in to the center of the bore (while viewing images on a real-time display monitor) and manually manipulate an MR-visible alignment guide.*

Figure 2*: The RTAT allows an interventionalist to manipulate (top) the alignment guide (bottom) from a comfortable position with the in-room monitor visible, without having to lean into the bore and risk disturbing the table or the subject.*

Figure 3*: The RTAT provides additional rigidity to the alignment apparatus, reducing the risk of disturbing alignment while installing the remote introducer assembly.*