Accuracy Index of Minimally Invasive MRI-guided Stereotactic Laser Amygdalohippocampotomy

Mark Russell Witcher MD, PhD; Alaine Keebaugh; Robert E. Gross MD PhD; Jon Timothy Willie MD PhD

Emory University School of Medicine, Departments of Neurological Surgery and Neurology, Atlanta, GA

assfn 2016 BIENNIAL MEETING June 18-21 | Chicago, IL

EMORY UNIVERSITY

Introduction

MRI-guided **Stereotactic Laser Amygdalo-hippocampotomy (SLAH)** for mesial temporal lobe epilepsy may reduce collateral injury and cognitive morbidity normally associated with open temporal lobe surgery. Given the long trajectories and narrow anatomical corridors required for the safe and effective application of this therapy, however, **accurate device placement and trajectory control is critical**. Notably, the accuracies of various stereotactic methods reported in the literature may be for relatively shorter trajectories (e.g. biopsies, deep brain stimulation), **necessitating a standardized assessment of accuracy relative to trajectory length**. To assess the stereotactic accuracy of an MRI-compatible percutaneous skull-mounted miniframe (ClearPoint ScalpMount and SmartFrame, MRI Interventions, Irvine, CA) designed to accommodate minimally invasive access (twist drill craniostomy) while **maintaining accuracy at both the target and entry point**, we have defined the **'Accuracy Index'**, a proposed measure of 2D target accuracy relative to trajectory length.

Figure 1- Preoperative trajectory estimate and positioning prone in interventional MRI

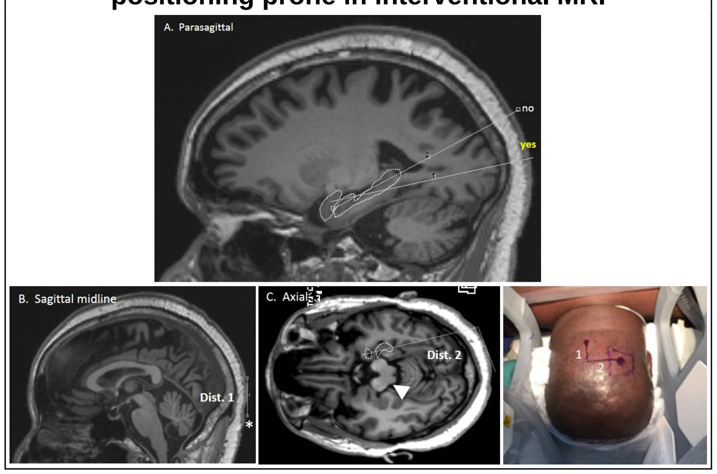
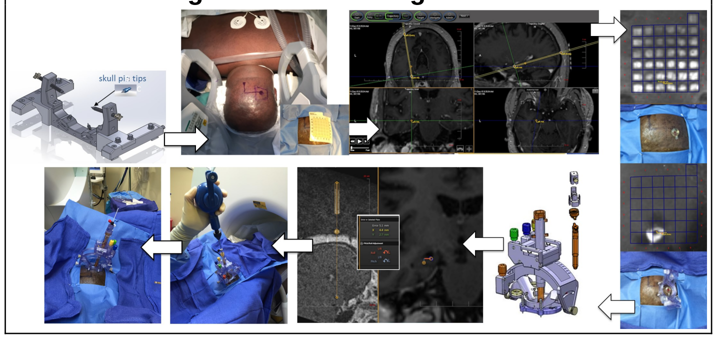


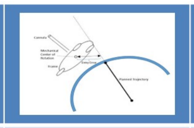
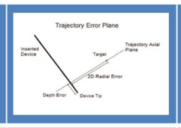
Figure 2- Performing the SLAH



Methods

We utilized a miniframe to perform 41 procedures targeting the amygdalohippocampal complex for laser ablation in an interventional MRI suite. Trajectory planning and stereotactic navigation were completed at time of procedure and accuracy metrics were assessed postoperatively.

Figure 3- Calculation of the Accuracy Index

			Accuracy Index = 2D Radial Error ÷ trajectory distance
	Entry Point Error (mm)	2D Radial Error (mm)	Accuracy Index
Mean	2.66	0.98	
SEM	1.4	0.07	0.009
n	38	41	

Results

The miniframe facilitated a stab incision and 3.2mm twist drill craniostomy (improving over a previous version that necessitated a larger incision and craniostomy) for SLAH. At mean **trajectory length** from bone outer table to target of 109.45 ± 8.29mm, the mean coronal 2D radial **target error** was 0.98 ± 0.7 mm **[Accuracy Index = 0.009]**. The mean Euclidian distance between the initially planned and actual scalp entry point (**entry error**) was 2.66 ± 1.4 mm.

Figure 4- Previously reported stereotactic accuracies

Reference	Procedures	Stereotaxic Device	Trajectories	Entry point error	Target error	Trajectory length	Accuracy Index
Dorward et al, 1999	21 biopies	EasyGuide Neuro System + custom stereotactic guide	13		4.8 ± 2		
Hamid et al., 2005	27 DBS (STN)	Leksell	54		3.02		
Fitzpatrick et al., 2005	DBS	StarFix	20		2.7		
Holloway et al, 2005	38 DBS	NEXframe	47		3.2+1.4		
Varma and Eldridge et al, 2010	19 Biopsies + 3 catheter implantations	Neuromate robotic system	22		2.9		
Kelman et al, 2010	90 DBS	CRW	70		2.65±0.22		
		NEXframe	69		2.78±0.25		
Shamir et al, 2011	15 catheter implantations	StealthStation/Treon/Vertek	15	3.3±1.9	5.9±4.3		
Chatillon et al, 2011	13 SEEG	StealthStation/Treon/Vertek	80	4.1	5.8		
	6 SEEG	ROSA	37	3.2	3.3		
Cardinale et al, 2013	91 SEEG	Neuromate + Talairach frame	1050	0.86±0.54	2.04±1.31		
Attaar et al., 2015	72 laser placements	StealthStation/Precision Aiming Device/Skull pin	90		0.9± 1.6	95.3± 26.0	0.009443861
Mohyeldin et al., 2015	5 Biopsy	ClearPoint	5		1.3±1.1	71.3	0.018232819
Chittiboina et al., 2015	3 Convection Enhanced Delivery	ClearPoint	6		1.0±0.5		
Present study	**41 laser placements**	**ClearPoint**	**41**	**2.66 ± 1.4**	**0.98±0.72**	**109.45±8.29**	**0.009**

Conclusions

The miniframe accommodates minimally invasive MRI-guided stereotactic neurosurgical procedures while affording **accuracy at both scalp entry and the intended intracranial target, even at relatively longer trajectories. Accuracy Index is a proposed measure of target accuracy over distance.** Performing the entire procedure in the MRI suite provides immediate visualization of target anatomy and recognition of deflections or other sources of inaccuracy.

Learning Objectives

By the conclusion of this session, participants should be able to: 1) Describe the importance of stereotactic accuracy relative to overall trajectory needs, 2) Understand the potential advantages of a percutaneous skull-mounted frame for MRI- guided procedures, and 3) Develop a sense of comparative accuracy to other frame-based and frameless stereotactic methods.