The Characterization of Lesion Volume by MRI from Transcranial MRI-Guided Focused Ultrasound Thalamotomy

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Learning Objectives

By the conclusion of this session, participants should be able to:
1. Understand possible mechanisms for how transcranial MR-guided focused ultrasound (TcMRgFUS) thalamotomy is effective in tremor reduction for essential tremor.
2. Describe the physical and temporal characteristics of thermal lesions produced by transcranial MR-guided focused ultrasound.
3. Identify possibilities for why lesion volume was not correlated to tremor relief.

Introduction

MR-guided focused ultrasound (FUS) is a new, transcranial method for subcortical lesioning. In this procedure, MR thermography is used to verify lesion location and intensity. The objectives of this study are to characterize FUS thalamotomy lesions over time and determine if there is a correlation between lesion volume and relief of tremor.

Methods

This is a retrospective study of 15 patients who underwent stereotactic FUS thalamotomy in a pilot study for treatment of essential tremor at the University of Virginia. MRI scans were obtained at 1 day, 1 week, and 1 month postoperatively. Lesion volumes and diameters were measured on T2, MPR, DWI/ADC, and SWI MR images. Procedural details including number of sonications, final power, final energy, and peak voxel temperature were collected. Tremor severity was graded by the CRST preoperatively, at the time of MRI, and 1 year postoperatively. Statistical analysis was performed using Wilcoxon rank sum tests, Fisher's exact tests, and univariate analysis.

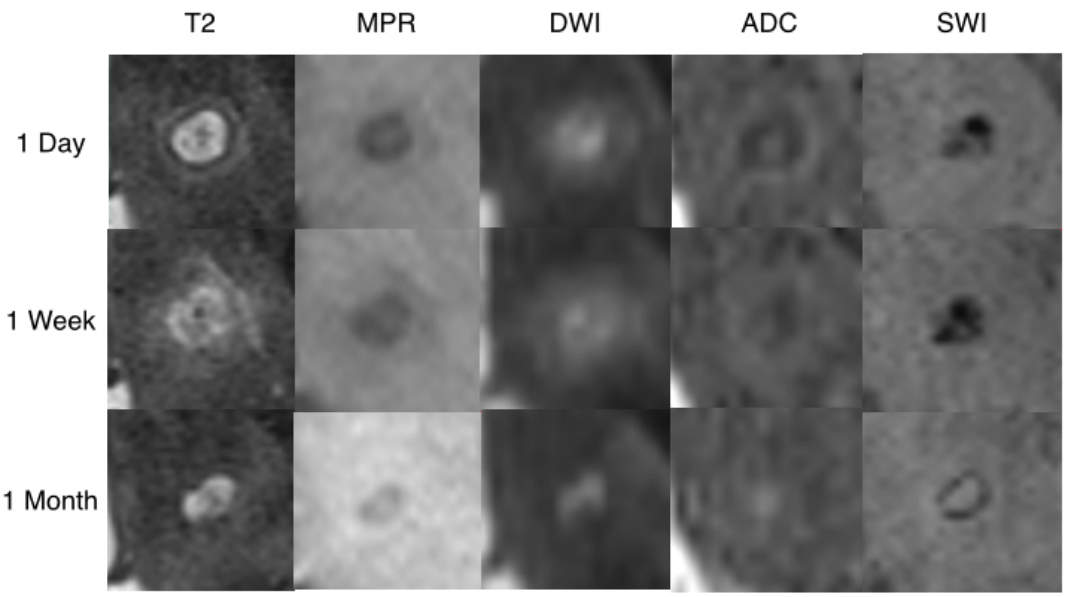
Results

FUS lesions can be divided into three zones according to imaging appearance and histological characteristics **(Fig 1)**. Zones 1+2 correspond to the area of coagulative necrosis, and zone 3 corresponds to vasogenic edema. Average zone 1+2 volumes on T2 MR images were 248, 338, and 144mm3 at 1 day, 1 week, and 1 month, respectively. Average zone 3 volumes were 1207, 1171, and 186mm3 at the same time points **(Fig 2)**. There was no statistically significant correlation between treatment conditions, lesion volume, lesion diameter, and tremor relief or transient adverse symptoms. MPR measurements closely approximated those on T2. Size of high and low signal on DWI and SWI respectively directly correseponded with zones 1+2 on T2 over the one month period.

Conclusions

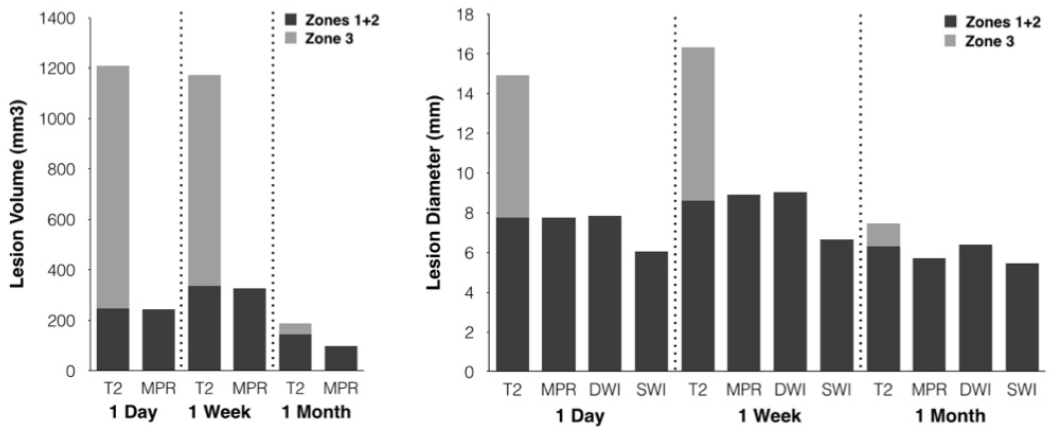
Effective lesion volumes calculated on T2-weighted imaging on postoperative day #1 ranged from 130-460 mm3. Lesion volumes peaked at 1 week and decreased thereafter. DWI/ADC and SWI findings suggest that zones 1+2 on T2 MRI represent coagulative necrosis. There was no correlation of lesion size with tremor relief.

Figure 1



Evolution of TcMRgFUS thalamotomy on T2, MPR, DWI/ADC, and SWI sequences. Zones 1+2 (representing coagulative necrosis) and zone 3 (representing perilesional, vasogenic edema) increase in volume from 1 day to 1 week and collapse at 1 month.

Figure 2



Mean zone 1+2 and 3 volumetric and diameter measurements of lesions at 1 day, 1 week, and 1 month postoperatively for 15 patients who underwent TcMRgFUS thalamotomy.