Movement Disorders
CLINICAL PRACTICE

CASE REPORT

# Thalamic Tremor Following Focused Ultrasound Thalamotomy for the Treatment of Essential Tremor

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Magnetic Resonance Guided Focused Ultrasound Thalamotomy, (MRgFUS) is an FDA-approved treatment for refractory Essential Tremor (ET).[1] Previous reports have documented the development of tremor, dystonia, and myoclonus after a thalamic lesion,[2–5] but these conditions have not been previously observed after MRgFUS or other lesional treatments of tremor. Here we describe a patient who developed a novel unilateral right hand tremor with dystonic posturing after MRgFUS.

A 70-year-old right-handed man presented to our clinic in 2009 with a previous diagnosis and family history of ET. His tremor started at the age of 17, mainly affecting his upper extremities and voice. Neurologic exam showed postural and kinetic tremor in both upper extremities with a 1–2 cm amplitude (Video S1) and no signs of dystonia or parkinsonism. A tremor study showed a bilateral central 6 Hz action and postural tremor (R > L; Fig. 1A).

MRgFUS to the left thalamus was performed in 2016 at an outside institution. Ten months after the procedure, exam showed a reduction in right hand action and postural tremor. Seventeen months after MRgFUS, he experienced a change in his symptoms. Exam revealed new dystonic posturing and a new low frequency, low amplitude tremor in his right hand during posture, action, intention, and while walking (Video S2). There were no signs of parkinsonism.

A post-MRgFUS tremor study showed a 3 Hz tremor of the treated right hand and a 5 Hz tremor of the left hand during posture and with weight loading (Fig. 1B). There was no rest tremor of the upper limbs, although the accelerometers recorded a bilateral 5 Hz signal. This signal stemmed from volume transduction of a truncal tremor in the 5 Hz range, which was clinically evident during sitting.

An MRI was also performed, revealing a lesion between the ventroposteriorlateral, ventroposteriomedial, ventrolateral, and mediodorsal nuclei of the thalamus (Fig. 1C–E). DTI and tractography analysis revealed projections between the lesioned area and left SMA, left primary motor cortex, and red nucleus (Fig. 1F).

We attribute the new low-frequency tremor with dystonic posturing to a dystonic tremor syndrome secondary to his ultrasound-induced thalamic lesion. To our knowledge, this is the first case of tremor and dystonia following MRgFUS. Given the latency in onset, Holmes Tremor (HT) was in the differential diagnosis but was considered unlikely given the absence during rest.[6]

The localization of the MRgFUS lesion is a region known to cause tremor and dystonia, potentially developing due to plastic changes or maladaptive rearrangement in the thalamus after lesion.[3,4] These areas are also understood to project to sensory cortices, and thus the dystonic tremor may be due to disruption of sensory-motor integration at the level of the thalamus and/or the cortex.[4,7]

This case identifies a development of a new dystonic tremor as a potential adverse event of lesioning therapies such as MRgFUS for the treatment of tremor. Since this is a relatively new method of treating tremor syndromes, more long-term studies of delayed effects are needed. ■

## Author Roles

(1) Research Project: A. Conception, B. Organization, C. Execution; (2) Statistical Analysis: A. Design, B. Execution,

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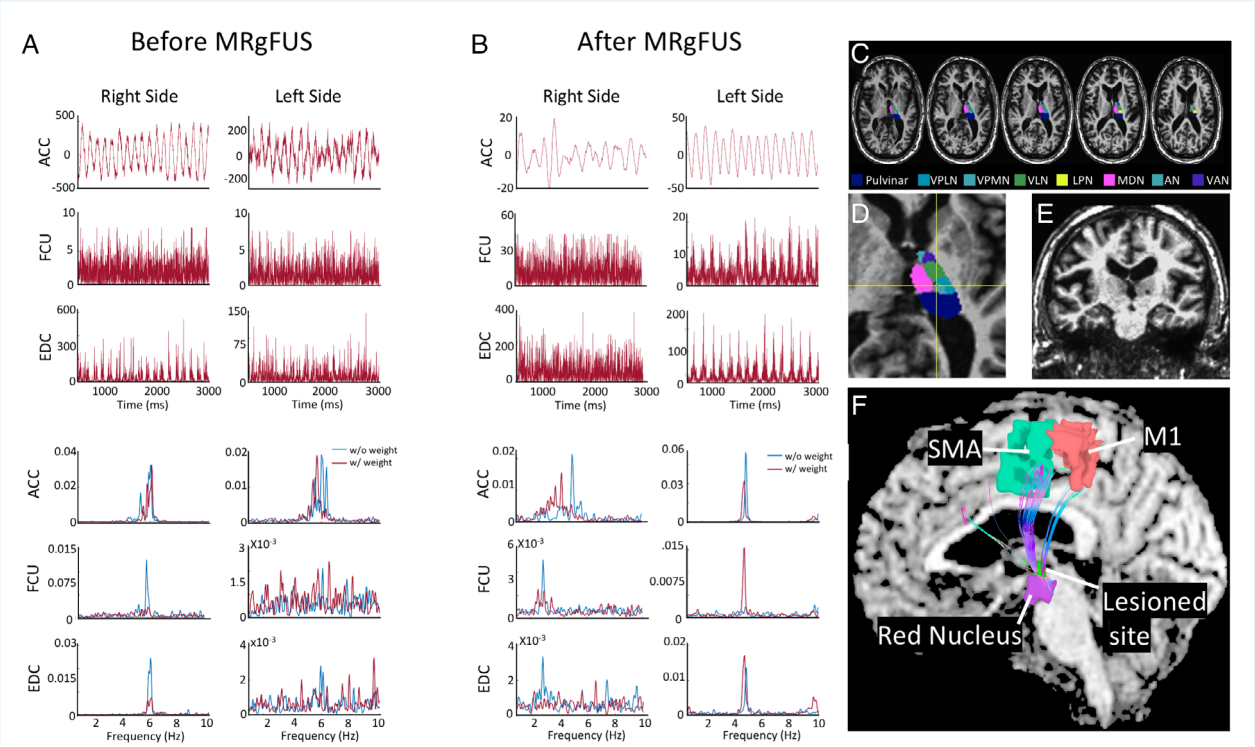


**FIG. 1.** A tremor study was performed both before (**A**) and after (**B**) the MRgFUS procedure. During both visits, electromyographic (EMG) electrodes were placed bilaterally over the extensor digitorum communis (EDC) and flexor carpi ulnaris (FCU) muscles and accelerometers (ACC) were placed on the dorsum of each hand. Data was recorded during posture with both hands outstretched and arms supported, as well as the same posture with 1 pound weight loading. Raw ACC and rectified EMG recordings during posture are shown. EMG and ACC data were also converted into the frequency domain using a Fast Fourier Transform to calculate the power in the tremor frequency for both the posture (w/o weight) and posture with weight loading (w/ weight) conditions. (**C**) Thalamic nuclei from a standardized atlas were registered to subject space and overlaid on T1 weighted images; (**D**) Cross-hair shows lesion is at the edge of four nuclei, the motor and sensory nuclei (VPLN and VPMN), and sensory MDN and VLN; (**E**) T1 weighted image shows that the lesion is located in the left thalamus (MNI coordinates –16, –18, 2; corresponding to a distance of 14 mm right, 6.9 mm anterior, 3.6 mm below the mid-commissural point) and estimated to be 26 $mm^3$. It may be smaller due to partial volume effect; (**F**) DTI tractography seeded at the lesion. Data were collected with a 3T MRI scanner with a 32 head channel coil, with 10 b0 images and 35 diffusion directions with diffusion weightings of b = 300 and 1000 $s/mm^2$, for each of two opposite phase encoding directions, voxels size = 1.875 × 1.875 × 2.5 mm and overlaid onto the patient anatomical (T1) scan. The analysis revealed projections from the lesioned site mainly to left supplementary motor area (SMA) but also to M1 and red nucleus. VPLN, Ventral Posterior Lateral Nuclei; VPMN, Ventral Posterior Medial Nuclei; VLN, Ventral Lateral Nuclei; LPN, Lateral Posterior Nuclei; MDN, Medial Dorsal Nuclei; AN, Anterior Nuclei; VAN, Ventral Anterior Nuclei.

C. Review and Critique; (3) Manuscript: A. Writing of the first draft, B. Review and Critique.

T.O.: 1B,1C, 3A,3B
P.M.: 1B,1C,3A,3B
P.B.: 1C,3B
S.H.: 1C,3B
D.E.: 1C,3B
D.H.: 1A,1B,1C,3B

# Disclosures

**Ethical Compliance Statement:** Data acquisition were in accordance with our institutional ethics committee – the Combined Neurosciences National Institutes of Health Institutional Review Board – and were in line with the Declaration of Helsinki. The patient presented in this manuscript signed a written consent for the case, and all procedures were verbally described to the patient before signing. All authors have read and approved this manuscript. We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this work is consistent with those guidelines.

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# Supporting Information

Supporting information may be found in the online version of this article.

**Video S1.** A 70-year-old man with Essential Tremor (ET), with postural and kinetic tremor in both upper extremities with a 1–2 cm amplitude. There were no signs of dystonia, parkinsonism, or other abnormal movements.

**Video S2.** Patient developed a new low frequency tremor and dystonic tremor after left Magnetic Resonance Guided Focused Ultrasound Thalamotomy to treat his ET. Tremor and dystonic posturing can be seen in the right hand while patient is holding hands outstretched, when walking, and while standing. ET can be clearly seen in the left hand during posture and kinetic movements.