Target-Specific Thermal Dynamics in MR-Guided Focused Ultrasound for Movement Disorders: A Prospective Analysis of 39 Patients from Argentina

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Abstract

Introduction: Magnetic resonance-guided focused ultrasound (MRgFUS) has emerged as a non-invasive, incisionless option for treating medically refractory movement disorders. Despite its growing clinical use, limited evidence exists on how diagnosis and anatomical targeting influence technical demands and treatment efficacy. Clarifying these differences is crucial to improving patient-specific protocols.

Method: We conducted a prospective analysis of 39 patients (mean age 70.6 ± 10.7 years; 56.4% male) who underwent MRgFUS for essential tremor (ET, n=21) or Parkinson's disease (PD, n=18) at our center in Argentina, between December 2024 and June 2025. Target nuclei included the ventral intermediate nucleus (VIM, n=30), nucleus subthalamicus (NST, n=8), and dual targeting (NST+VIM, n=1). Technical parameters -number of sonications, energy delivery, thermal profiles- were compared across diagnostic and anatomical subgroups. Pearson correlation and t-tests analyses assessed associations or differences among procedural variables ($p<0.05$ considered statistically significant). Objective and subjective clinical improvements were recorded post-procedure. Patient consent was obtained to share this information.

Results: All ET patients received VIM targeting, whereas PD cases were distributed between VIM (50.0%), NST (44.4%), and combined targeting (5.6%). The average number of sonications was consistent across groups (6.6 ± 1.8). Thermal parameters showed strong internal consistency, with maximum average temperature highly correlated with peak temperature ($r=0.900$, $p<0.001$). In contrast, energy delivery was moderately and inversely associated with thermal outcomes ($r=-0.556$ to -0.591, $p<0.001$), highlighting real-time thermal control as the principal procedural endpoint. ET cases required significantly greater energy delivery (25.30 ± 14.56 J) compared to PD (18.28 ± 7.87 J), a 38.4% increase ($p=0.066$), despite achieving slightly lower thermal thresholds (mean maximum average temperature: 54.5 ± 3.4°C vs 56.3 ± 2.2°C, $p=0.059$; mean maximum temperature: 58.0 ± 5.0°C vs 60.2 ± 3.4°C, $p=0.128$). Time at peak temperature was also shorter in ET (6.0 ± 2.0 s) than in PD (6.5 ± 1.7 s), a reduction of 8.4% ($p=0.364$). When comparing anatomical targets, NST ablations required longer thermal exposure than VIM (6.9 ± 1.7 s vs 6.1 ± 1.9 s; +12.7%, $p=0.292$) while utilizing 11.8% less energy (20.16 ± 10.15 J vs 22.86 ± 13.03 J, $p=0.593$), suggesting distinct thermodynamic demands based on target anatomy. Clinically, the cohort achieved substantial benefit, with a mean objective improvement of 92.9% ± 7.5 ($p<0.001$) and a mean subjective improvement of 91.5% ± 8.1 ($p<0.001$), supporting both technical efficacy and high patient satisfaction.

Discussion: MRgFUS demonstrates high efficacy for both ET and PD, with over 90% average improvement in objective and patient-reported outcomes. Procedurally, consistent sonication counts support protocol standardization; however, energy and thermal requirements vary by diagnosis and target nucleus. While the reported differences did not reach statistical significance, we consider them worth presenting given that this is one of the first reports of this novel technique in Argentina.

Conclusions: These findings reinforce thermal control -rather than maximal energy- as the determinant of success and support individualized treatment planning grounded in anatomical and pathophysiological context.

References

1. Segar DJ, Lak AM, Lee S, Harary M, Chavakula V, Lauro P, et al. Lesion location and lesion creation affect outcomes after focused ultrasound thalamotomy. Brain. 2021;144(10):3089-3100. doi: 10.1093/brain/awab176.

PMID: 34750621.

2. Arcadi A, Aviles-Olmos I, Gonzalez-Quarante LH, Gorospe A, Jiménez-Huete A, de la Corte MM, et al. Magnetic Resonance-Guided Focused Ultrasound (MRgFUS)-Thalamotomy for Essential Tremor: Lesion Location and Clinical Outcomes. Mov Disord. 2024;39(6):1015-1025. doi: 10.1002/mds.29801. Epub 2024 Apr 14. PMID: 38616324.
3. Gallay MN, Moser D, Federau C, Jeanmonod D. Radiological and Thermal Dose Correlations in Pallidothalamic Tractotomy With MRgFUS. Front Surg. 2019;6:28. doi: 10.3389/fsurg.2019.00028. PMID: 31157233; PMCID: PMC6533852.
4. Zhang DY, Pearce JJ, Mazza J, Petrosyan E, Borghei A, Patel N, Sani S. Initiating a Magnetic Resonance-Guided Focused Ultrasound Program: Comprehensive Workflow and Lessons Learned from the Initial 116 Cases. Stereotact Funct Neurosurg. 2023;101(2):101-111. doi: 10.1159/000528925. Epub 2023 Mar 2. PMID: 36863325.
5. Cesarano S, Pistoia F, Catalucci A, et al. Staged magnetic resonance-guided focused ultrasound thalamotomy for the treatment of bilateral essential tremor and Parkinson's disease related tremor: a systematic review and critical appraisal of current knowledge. Front Neurol. 2024; 20:15:1409727. doi: 10.3389/fneur.2024.1409727. eCollection.
6. Khu KJO, Jamora RDG, Aguilar JA, Pascual JSG, Chan KIP, Espenido TMR, Mata JL, Nievera AMP, Legaspi GD. Establishing and developing a magnetic resonance-guided focused ultrasound program in a resource-limited setting: the Philippine experience. Neurosurg Rev. 2024;47(1):372. doi: 10.1007/s10143-024-02624-5. PMID: 39078417.
7. Zong R, Li X, Yin C, He J, Zhang D, Bian X, et al. Magnetic resonance-guided focused ultrasound for essential tremor: a prospective, single center, single-arm study. Neural Regen Res. 2024;19(9):2075-2080. doi: 10.4103/1673-5374.391192. Epub 2024 Jan 12. PMID: 38227538; PMCID: PMC11040308.